1st International and 16th National Conference on Machines and Mechanisms
(iNaCoMM 2013)

December 18 - 20, 2013

SOUVENIR

Organized by:
Department of Mechanical & Industrial Engineering
Indian Institute of Technology Roorkee
Roorkee – 247667, India
under the aegis of
Association for Machines and Mechanisms (AMM) &
International Federation for the Promotion of
Mechanism and Machine Science (IFToMM)

Welcome

Mechanical and Industrial Engineering Department, IIT Roorkee, under the aegis of Association for Machines and Mechanisms (AMM), and the International Federation for the Promotion of Mechanism and Machine Science (IFToMM) organized the 1st International & 16th National Conference on Machines and Mechanisms (iNaCoMM 2013) to be held at IIT Roorkee between December 18 to December 20, 2013.

About the Conference

iNaCoMM 2013 is the 16th in the series of biennial conferences organised under the aegis of AMM with international status being given from 2013. The conference aims at bringing together researchers, industry experts and students interested in various aspects of design and analysis of machines and mechanisms. This year the conference starts with a one-day workshop whose topics will be compliant mechanisms and multibody dynamics. The conference would consist of regular paper and poster presentations, and special talks by experts. Also included in the conference is the Students' Mechanism Design contest, an event that became part of NaCoMM in 2009. Selected papers from the iNaCoMM2013 will be submitted for possible publication in (i) Mechanism and Machine Theory, affiliated as an official IFToMM research journal, published by Elsevier (ii) Robotica, an official journal of the International Federation of Robotics, published by Cambridge University Press (iii) Industrial Robot: An International Journal published by Emerald (iv) Robotics and Computer-Integrated Manufacturing published by Elsevier.

About Association for Machines and Mechanism and IFToMM

The Association for Machines and Mechanism, India, is the national affiliate of IFToMM, an international body of about fifty member nations. India was one of the thirteen founder members when IFToMM came into being in the year 1969. The national body of AMM was founded in 1984. The main objective of AMM is to contribute to mechanical design at all levels starting from academic research to industrial initiatives, thereby enhancing the quality and reliability of indigenous machines. With this in view, AMM organises the National Conference on Machines and Mechanisms, NaCoMM, and the workshop, Industrial Problems on Machines and Mechanisms, IPRoMM, regularly.

About IIT Roorkee

The Indian Institute of Technology (IIT) Roorkee is the successor of the University of the Roorkee and is the oldest technical institution of the Indian sub-continent. It was established as the Roorkee College in 1847 and rechristened as the Thomson College of Civil Engineering in 1854. Recognizing its yeoman contribution for the development of the country for over 100 years, this temple of learning was elevated to the status of a University, the first technical university in India in 1949. The University of Roorkee was converted to IIT Roorkee as the nation's seventh Indian Institute of Technology by the Government of India on September 21, 2001, thereby further elevating it to an institute of national importance. Over the years, it has built up and maintained an excellent academic reputation. The outstanding achievements of its alumni especially in the field of water related subjects are a testimony to this. The IIT Roorkee has academic departments in the area of Engineering, Sciences, Architecture and Planning, Management studies and Humanities and Social Sciences besides many centres of higher education and research.

About Mechanical and Industrial Engineering Department

The Department of Mechanical Engineering came into being in the year 1946 and was renamed as Department of Mechanical & Industrial Engineering on its silver jubilee in 1971. At present it offers undergraduate courses in the area of Mechanical Engineering and Production and Industrial Engineering. The department offers Master of Technology courses in Machine Design Engineering, Production and Industrial Engineering, Thermal Engineering, CAD/CAM & Robotics and Welding Engineering. It runs Ph. D. program in all the areas of specialization. The department has completed a large number of sponsored R & D projects and a large number of consultancy works indicating its strength of competent faculty.

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Department of Mechanical & Industrial Engineering
Indian Institute of Technology Roorkee
Roorkee – 247 667
Uttarakhand, India

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International Federation for the Promotion of Mechanism and Machine Science

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Date: 04/12/2013

MESSAGE

On behalf of the Executive Council of IFToMM, I would like to welcome you to the 1st International & 16th National Conference on Machines and Mechanisms (iNaCoMM 2013) at Indian Institute Technology Roorkee, India.

With the distinguished guests I would like to congratulate Professor P.K. Jain, Chairman of Organizing Committee, Head of Mechanical and Industrial Engineering Department, IIT Roorkee, and his team for bringing together quality papers and participants from both academia and industry to make this world class conference.

The International Federation for the Promotion of Mechanism and Machine Science (IFToMM) was launched in 1969 to establish the world-wide network of scientists and engineers overcoming the Era of Cold-War. India was among thirteen founding members who signed the original constitution. Currently, IFToMM consists of 47 Member Organizations, each of which is a nation or a territory. Everyone who works/studies in or is from a Member Organization enjoys the full benefits of IFToMM. The activities of IFToMM are typically seen in those of 13 Technical Committees and 4 Permanent Commissions. IFToMMalso has 5 affiliated journals and 2 book series.

IFToMM proudly supports iNaCoMM 2013 as one of important international conferences for the Promotion of Mechanism and Machine Science.

I wish all the participants enjoy a wonderful time in IIT Roorkee to share the novel ideas, experimental data, new theories, and valuable conclusions on the cutting edge of Mechanism and Machine Science.

Prof. Yoshihiko NAKAMURA
President – IFToMM

ASSOCIATION FOR MACHINES AND MECHANISMS

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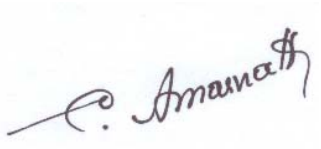
MESSAGE

As I look back over the past three decades I feel a bit overwhelmed by the fact that NaCoMM from being a national event has transformed into an international one. Prior to 1981 there were no exclusive conferences in the country addressing the area of M&M. Till then a couple of sessions at ISTAM conferences kept up interest in the area. With industrialization on the rise, the need for a larger forum to address R&D in M&M was felt - the Industrial Revolution after all could not have been heralded in but for developments in M&M. NaCoMM as an event was begun as a prelude to the IFToMM World Congress in New Delhi in 1984 and this provided us an opportunity to establish AMM and the rest is a (three decade old) history. With contributions from researchers world-wide increasing over the years the need to re-invent NaCoMM was felt and hence iNaCoMM, an event being rightfully organized by an apt institution - popularly known as "Roorkee" - an institution of eminence that promoted engineering and thereby the industrial revolution in the in the country for over a century.

Re-inventing NaCoMM as iNaCoMM would remain symbolic unless we follow up with action to re-invent our manufacturing base to meet the challenges of a globalized economy. Economists fear that India is increasingly being looked upon as one with a "service economy" which in the long run would be detrimental to alleviation of poverty. Wealth generation through industrialization is the need of the hour and it is here we could play a large role both as individuals and as an association. IPRoMM the parallel AMM conference is devoted solely to "Industrial Problems" with the hope that the two conferences would together contribute to both theory and practice in the M&M domain thereby furthering the promotion of industrialization in the country.

It is up to us to make this happen.



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IIT Roorkee

प्रो० प्रदीप्त बनर्जी, निदेशक
Prof. Pradipta Banerji, Director

12th November, 2013

MESSAGE

I am happy to know that the Mechanical and Industrial Engineering Department, IIT Roorkee, is organizing 1st International & 16th National Conference on Machines and Mechanisms (iNaCoMM 2013) at IIT Roorkee during December 18-20, 2013 under the aegis of Association for Machines and Mechanisms (AMM), and the International Federation for the Promotion of Mechanism and Machine Science (IFToMM).

Over the years machines and mechanisms area has evolved significantly and today even we are discussing about micro, nano-machines and mechanisms. It is interesting to note that the conference will have presentations on broad areas such as analysis and synthesis of mechanisms, compliant mechanisms, design and analysis of biomedical devices, dynamics and control of multi-body systems, vibration analysis in machines, fault diagnosis and health monitoring , mechanisms and machines for rural, agricultural and industrial applications, mechatronic systems, modeling and simulation, robotics, theoretical and computational kinematics, tribology and vehicle dynamics.

I congratulate the Association for Machines and Mechanism, India (national affiliate of IFToMM) for giving the international status to NaCoMM from 2013. It's a matter of pride that the first international version of NaCoMM is held at IIT Roorkee which has a glorious history of 166 years as the oldest institution of technical education in India.

I am confident that the topics of the conference enables the delegates to share their research experiences and ideas for the growth of technology and thus useful for academic enhancement and excellence. I do hope, at the end of the conference many useful conclusions will emerge out which will be beneficial to our country and international community.

I would like to warmly welcome all the participants at IIT Roorkee. Hearty congratulations to the organizers for hosting this conference.

I wish the conference grand success.

(Pradipta Banerji)
Director, IIT Roorkee

डॉ. प्रमोद कुमार जैन
प्रोफेसर एवं विभागाध्यक्ष
Dr. Pramod K. Jain
Professor & Head

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Dated: 20/11/2013

MESSAGE

It is a proud moment for the Department of Mechanical and Industrial Engineering, IIT Roorkee to host 1st International & 16th National Conference on Machines and Mechanisms (iNaCoMM 2013) after a span of 23 years, last one was held in March 1990. IIT Roorkee is also proud to make this prestigious conference an international conference to increase its reach in collaboration with International Federation for the Promotion of Mechanism and Machine Science (IFToMM).

Conference received a huge response from researchers in India and abroad. After a two tier review process, 120 papers are selected for oral presentation and 40 papers for interactive poster presentation. I wish that deliberations and presentations during the conference will infuse interest among the researchers community towards the science of machines and mechanism. Many interesting topics such as robotics, mechatronics, and compliant mechanisms etc. will be discussed during the conference.

I hope this conference will be a good forum for researchers to exchange their ideas and get direction for future research in area of machines and mechanisms. I also extend a warm welcome to all the delegates for sparing your valuable time to attend this conference.

The organising committee is thankful to sponsors who have been kind enough to support this conference.

(P.K. JAIN)
PROFESSOR AND HEAD

Welcome Message

On behalf of organising committee of 1st International & 16th National Conference on Machines and Mechanisms (iNaCoMM 2013) and IIT Roorkee, we extend a warm welcome to all the delegates from academia and industry. iNaCoMM 2013 is the 16th in the series of biennial conferences organised under the aegis of AMM and IFToMM with international status being given from 2013. The conference aims at bringing together researchers, industry experts and students interested in various aspects of design and analysis of machines and mechanisms. The conference would consist of workshop, regular paper and poster presentations, special talks by experts and students' mechanism design contest.

iNaCoMM 2013 received overwhelming response from authors. We received 372 abstracts of which finally 160 were selected and registered. Out of 160, 121 were selected for oral presentation and 39 were selected for poster presentation. The papers cover a wide range of topics such as analysis and synthesis of mechanisms, compliant mechanisms, dynamics and control of multi-body systems, dynamics and vibration analysis in machines, fault diagnosis and health monitoring, history of machines and mechanisms, mechanisms and machines for rural, agricultural and industrial applications, mechatronic systems, modelling and simulation, robotics, theoretical and computational kinematics, tribology and vehicle dynamics. Each paper was subjected to three blind reviews. For this we took the help of 250 reviewers. Also each reviewer was requested to review maximum three papers except few. We also checked each paper for plagiarism using turtin. The organising committee has decided not to accept any paper with more than 20% similarity index.

The conference includes three workshops on topics compliant mechanism, multi body dynamics and bond graphs modelling. These workshops are aimed at introducing these topics to delegates so that they get benefited by the sessions in these areas. There are two special sessions. First on multibody dynamics **o**rganised by Prof. S. K. Saha, IIT Delhi and Prof. Javier Cuadrado, Spain (Chair of IFToMM TC for Multibody Dynamics) and second on bond graph modelling of mechanical and mechatronic systems organised by Dr. A. K. Samantaray, IIT Kharagpur and Prof. Rochdi Merzouki, Ecole Polytechnique de Lille, France.

Many people contributed towards the success of this conference. We thank all the authors for contributing quality work to the conference. We also thank the reviewers for taking time in critically evaluating the manuscripts. The advisory committee also helped us in different tasks. We would like to thank the government agencies and private organisations for supporting the event through participation and sponsorship, and IIT Roorkee administration for providing facilities towards the organisation of the event. We would like to thank the colleagues in the organising committee, the faculty and staff of Mechanical & Industrial Engineering Department for their efforts towards organising this conference. We would also like to thank our students who helped for different activities of the conference.

We hope that your stay at IIT Roorkee is comfortable and professionally beneficial.

Pushparaj Mani Pathak

Organising Secretary, iNaCoMM 2013

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D. B. Karunakar	Indian Institute of Technology Roorkee, India
Jiri Krejsa	Inst. of Solid Mechanics, Brno UT, Czech Republic
Madhava Krishna	The International Institute of Information Technology, Hyderabad, India
Shankar Krishnapillai	Indian Institute of Technology Madras, Chennai, India
Satyabodh Kulkarni	National Institute of Technology Karnataka, Surathkal, India
Navin Kumar	Indian Institute of Technology Ropar, India
Rajeev Kumar	Indian Institute of Technology Mandi, India
Anil Kumar	Indian Institute of Technology Roorkee, India
Ajit Kumar	Indian Institute of Technology Delhi, India
C. S. Kumar	Indian Institute of Technology Kharagpur, India
Santosh Kumar	Indian Institute of Technology BHU, Varanasi, India
Sanjeev Kumar	Indian Institute of Technology Roorkee, India

Pradeep Kumar	Indian Institute of Technology Roorkee, India
Krishnendu Kundu	CSIR- Central Mechanical Engineering Research Institute, India
A. M. Kuthe	Visvesvaraya National Institute of Technology Nagpur, India
Manivannan M	Indian Institute of Technology Madras, Chennai, India
S. S. Mahapatra	National Institute of Technology Rourkela, India
Arun Mahindrakar	Indian Institute of Technology Madras, Chennai, India
S. K. Maiti	Indian Institute of Technology Bombay, Mumbai, India
Ashok Mallik	Indian Institute of Technology Kanpur, India
N. Mallik	Indian Institute of Technology BHU, Varanasi, India
S. K. Mangal	PEC University of Technology Chandigarh, India
G. Manikandan	Velammal College of Engineering and Technology, Madurai, India
Amol Marathe	Birla Institute of Technology and Science, Pilani, India
Pierangelo Masarati	Politecnico di Milano, Italy
S. P. S. Matharu	National Institute of Technology Raipur, India
Juana Mayo	University of Seville, Spain
N. K. Mehta	Indian Institute of Technology Roorkee, India
Rochdi Merzouki	Ecole Polytech-Lille, France
Bhanu Mishra	Indian Institute of Technology Roorkee, India
Arun Mishra	McGill University, Montreal, Quebec, Canada
Prasanta Mishra	Indian Institute of Technology Bhubaneswar, India
Sushil Mishra	Indian Institute of Technology Bombay, India
Manish Mishra	Indian Institute of Technology Roorkee, India
Mira Mitra	Indian Institute of Technology Bombay, Mumbai, India
S. V. Modak	Indian Institute of Technology Delhi, India
Jayant Modak	Priyadarshini College of Engineering, Nagpur, India
Garje C. Mohankumar	National Institute of Technology Karnataka, India
P. V. Mohanram	PSG College of Technology, Coimbatore, India
Amiya Mohanty	Indian Institute of Technology Kharagpur, India
Rahul Mulik	Indian Institute of Technology Roorkee, India
Sreekumar Muthuswamy	Indian Institute of Information Technology Design and Manufacturing Kancheepuram, India
M. Muzammil	Aligarh Muslim University, Aligarh, India
Praveen Nahar	National Institute of Design, India
Gora Nandi	Indian Institute of Information Technology Allahabad, India
B. L. Narasimharaju	National Institute of Technology, Warangal, India
Tarun-Kanti Naskar	Jadavpur University, Kolkata, India
Roger Ngwompo	University of Bath , United Kingdom
S. P. Nigam	Thaper University, Patiala, India
Belkacem OuldBouamama	Ecole Polytech Lille, France
N. P. Padhy	Indian Institute of Technology Roorkee, India
P. M. Padole	Visvesvaraya National Institute of Technology Nagpur, India
Sukhomay Pal	Indian Institute of Technology Guwahati, India
Kaushik Pal	Indian Institute of Technology Roorkee, India
S. K. Pal	Indian Institute of Technology Kharagpur, India
R. K. Pandey	Indian Institute of Technology Delhi, India
Ashok Kumar Pandey	Indian Institute of Technology Hyderabad, India
Saroj Panigrahi	CSIR- Central Building Research Institute, Roorkee, India
Mohit Pant	National Institute of Technology Hamirpur, India
Dayal Parhi	National Institute of Technology Rourkela, India
P. M. Pathak	Indian Institute of Technology Roorkee, India
Haresh Patolia	B.V.M. Engineering College, V.V.Nagar, India
Karali Patra	Indian Institute of Technology Patna, India
Victor Petuya	University of the Basque Country, Spain
G. N. Pillai	Indian Institute of Technology Roorkee, India

Charles Pinto	University of the Basque Country, Spain
Doina Pisla	Technical University of Cluj-Napoca, Cluj-Napoca, Romania
G. V. Prasannakumar	Assam University, Silchar, Assam, India
R. Prasanthkumar	Indian Institute of Technology Hyderabad, India
Dilip Pratihar	Indian Institute of Technology Kharagpur, India
Barun Pratiher	Indian Institute of Technology Jodhpur, India
Martin Pucheta	National Technological University, Córdoba, Argentina
Sangamesh R Deepak	Indian Institute of Technology Guwahati, India
Ahmed Rahmani	Ecolecentrale de Lille, France
P. Rajeshkanna	Velammal College of Engineering & Technology, Velammal Nagar, Tamil Nadu, India
K. Ramesh	Indian Institute of Technology Madras, India
T. Ramesh	National Institute of Technology Tiruchirappalli, India
V-Pandu Ranga	Indian Institute of Technology Bhubaneswar, India
Vikas Rastogi	Delhi Technological University, Delhi, India
Samarth Raut	The University of Texas at Austin, USA
Balaraman Ravindran	Indian Institute of Technology Madras, Chennai, India
Dip-Narayan Ray	CSIR-Central Mechanical Engineering Research Institute, Durgapur, India
Narayana Reddy	Indian Institute of Technology Guwahati, India
Dario Richiedei	Università di Padova, Italy
Gregorio Romero	Universidad Politecnica de Madrid, Spain
Bijay Kumar Rout	Birla Institute of Technology and Science Pilani, India
Haraprasad Roy	National Institute of Technology Rourkela, India
Subir Kumar Saha	Indian Institute of Technology Delhi, India
Anup Kumar Saha	National Institute of Technology Durgapur, India
R. P. Saini	Indian Institute of Technology Roorkee, India
A. K. Samantaray	Indian Institute of Technology Kharagpur, India
Ramon Sancibiran	ETSIIT – University of Cantabria, Spain
M. Santhakumar	Indian Institute of Technology Indore, India
S. Sanyal	National Institute of Technology Raipur, India
Dipankar Sanyal	Jadavpur University, Kolkata, India
V. H. Saran	Indian Institute of Technology Roorkee, India
Somnath Sarangi	Indian Institute of Technology Patna, India
Mihir Sarangi	Indian Institute of Technology Kharagpur, India
Prabir Sarkar	Indian Institute of Technology Ropar, India
Abhijit Sarkar	Indian Institute of Technology Madras, Chennai, India
P. K. Sarkar	Indian School of Mines (ISM) Dhanbad, India
Dhish Kumar Saxena	Indian Institute of Technology Roorkee, India
Anupam Saxena	Indian Institute of Technology Kanpur, India
Rakesh Sehgal	National Institute of Technology Hamirpur, India
Dibakar Sen	Indian Institute of Science Bangalore, India
Soumen Sen	CSIR-Central Mechanical Engineering Research Institute, Durgapur, India
Suril Shah	International Institute of Information Technology Hyderabad, India
Madhavan Shanmugavel	Monash University, Sunway, Campus, Malaysia
Satish C. Sharma	Indian Institute of Technology Roorkee, India
A. K. Sharma	Indian Institute of Technology Roorkee, India
Rajesh Sharma	National Institute of Technology Hamirpur, India
S. N. Shome	CSIR-Central Mechanical Engineering Research Institute, Durgapur, India
Indravir Singh	Indian Institute of Technology Roorkee, India
Inderdeep Singh	Indian Institute of Technology Roorkee, India
Akhilendra Singh	Indian Institute of Technology Patna, India
V. P. Singh	Indian Institute of Technology BHU, Varanasi, India
Narendra Singh	Indian Institute of Technology Roorkee, India
K. M. Singh	Indian Institute of Technology Roorkee, India

Ekta Singla	Indian Institute of Technology Ropar, India
Ashish Singla	Thapar University, Patiala, India
Pravin M. Singru	Birla Institute of Technology and Science Pilani, Goa Campus, India
S. Somashekhar	Indian Institute of Technology Madras, Chennai, India
Soh Song	Singapore University of Technology and Design, Singapore
A. Srinath	K L University, Vijayawada, India
J. Srinivas	National Institute of Technology Rourkela, India
Sujatha Srinivasan	Indian Institute of Technology Madras , Chennai, India
Ravindra Srivastava	Motilal Nehru National Institute of Technology Allahabad, India
Shankar Subramanian	Indian Institute of Technology Madras, Chennai, India
Christophe Sueur	Ecole Centrale de Lille, France
C. Sujatha	Indian Institute of Technology Madras, Chennai, India
N. Sukavanam	Indian Institute of Technology Roorkee, India
Puneet Tandon	PDPM Indian Institute of Information Technology, Design & Manufacturing Jabalpur, India
Tanio Tanev	Institute of System Engineering and Robotics, Bulgaria
Atul Thakur	Indian Institute of Technology Patna, India
Asokan Thondiyath	Indian Institute of Technology Madras, Chennai, India
Rajiv Tiwari	Indian Institute of Technology Guwahati, India
Rajneesh Tyagi	Indian Institute of Technology BHU, Varanasi, India
Rashmi Uddanwadiker	Visvesvaraya National Institute of Technology, India
M. Umapathy	National Institute of Technology, Tiruchirappalli, India
Sanjay Upadhyay	Indian Institute of Technology Roorkee, India
Akhil Upadhyay	Indian Institute of Technology Roorkee, India
Krishnan Vaidyabhushan L.	K. L. University, Vijayawada, India
Joseph Anand Vaz	Dr B R Ambedkar National Institute of Technology Jalandhar, India
R. Venkatarao	S. V. National Institute of Technology, Surat, India
B. Vinod	PSG College of Technology, Coimbatore, India
S. P. Yadav	Indian Institute of Technology Roorkee, India
Jung-Min Yang	Kyungpook National University, Daegu, South Korea

1st International & 16th National Conference on Machines and Mechanisms
Indian Institute of Technology Roorkee, Roorkee, India
18 - 20 December, 2013

PROGRAMME AT A GLANCE

Date	8:30 AM-9:00 AM	9:00 AM – 10:00 AM	10:00 AM - 10:30 AM	10:30 AM - 12:30 PM	12:30 PM – 1.30 PM	1:30 PM – 3:30 PM	3:30 PM – 3:45 PM	3:45 PM – 5:45 PM	5:45 PM-6:00 PM	6:00 PM – 7:00 PM	7:30 PM – 8:30 PM	8:30 PM-09:30 PM
18-12-13	Registration	Inaugural Function	High Tea	Workshop I	Lunch	Workshop II	Tea	Workshop III	Industry presentation	AMM GBM	Cultural programme	Dinner
Venue	MIED	O.P. Jain Auditorium			MIED Lawn	O.P. Jain Auditorium				MIED Committee Room	O.P. Jain Auditorium	MIED Lawn

Date	9:00 AM – 9:45 AM	09:45 AM-10:45 AM	10:45 AM-11:00 AM	11:00 AM-1:00 PM	1.00 PM-2.00 PM	2.00 PM – 2.45 PM	2:45 PM-3:45 PM	3:45 PM – 4:00 PM	4:00 PM– 5:00 PM	5:00 PM-6:00 PM	6:00 PM-7:00 PM	08:00 PM-09:00 PM
19-12-2013	Invited talk I B.M. Belgaumkar Memorial Lecture (O.P. Jain Auditorium)	Session MBD-I (MIED-Audi) Mechanism-I (252) Robotics-I (348) Mechatronics-I (216)	Tea Break (MIED Lawn)	Session Bond Graph-I (MIED Audi) Design-I (216) Mechanism-II (252) Robotics-II (348)	Lunch (MIED Lawn)	Invited talk II K. Lakshminarayana Memorial Lecture (O.P. Jain Auditorium)	Session MBD-II (MIED Audi) Mechanism-III (252) Tribology-I (216) Dynamics-I (348)	Tea Break (MIED Lawn)	Session Bond graph-II (MIED Audi) Design-II (216) Mechanism-IV (252) Robotics-III (348)		Invited talk III (New Lecture Hall Complex)	Conference dinner (MIED Lawn)
20-12-2013	Invited talk IV (O.P.Jain Auditorium)	Session MBD-III (MIED-Audi) Mechanism-V (252) Mechatronics-II (216) Dynamics-II (348)		Session Bond Graph-III (MIED Audi) Design-III (216) Mechanism-VI (252) Robotics-IV (348)		Student Mechanism Design Contest (MIED)	Poster Presentations (203, 205)		Session Machines-I (MIED Audi) Dynamics-III (348) Tribology-II (252) Mechatronics-III (216)	Valedictory Function (O.P. Jain Auditorium)		

Workshop I	Dr. Belkacem OULD BOUAMAMA, Ecole Polytechnique de Lille, France
Workshop II	Dr. G. K. Ananthasuresh, IISc, Bangalore, India
Workshop III	Dr. Javier Cuadrado , Univeridad de La Coruña, Spain

Paper Presentation: 20 minutes – 15 minutes presentation+5 minutes discussions

MIED - Mechanical & Industrial Engineering Department

Inaugural address	Dr. Y. Nakamura Univ. of Tokyo, Japan, President, IFToMM
Talk I	Dr. Ranjan Mukherjee Michigan State University, USA
Talk II	Dr. S. Guruprasad, Director, Research & Development Establishment(DRDO), India
Talk III	Dr. Satyandra K. Gupta , National Science Foundation, USA
Talk IV	Dr. D. P. Garg, Duke University USA

PAPER PRESENTATION SCHEDULE

19th December, 2013; 9:45 AM – 10:45 AM

Session: Multi Body Dynamics (MBD) - I **Session Chair: Prof. S. K. Saha**	**Session Date & Time: 19/12/2013; 9:45AM – 10:45 AM** **Venue: MIED Auditorium**
9:45 AM – 10:05 AM	**Development of Miniaturized Pneumatic Artificial Muscle for Surgical Device** Shanthanu Chakravarthy, Aditya K., Ashitava Ghosal
10:05 AM – 10:25 AM	**Minimization of Shaking Force and Shaking Moment in Multiloop Planar Mechanisms** Kailash Chaudhary, Himanshu Chaudhary
10:25 AM – 10:45 AM	**Forward Dynamics for Gait Analysis as an Intermediate Step to Motion Prediction** J. Cuadrado, U. Lugris, R. Pamies-Vila, J.M. Font-Llagunes

Session: Mechanism - I **Session Chair: Prof. S. Sanyal**	**Session Date & Time: 19/12/2013; 9:45AM – 10:45 AM** **Venue: 252**
9:45 AM – 10:05 AM	**Steering Linkage Optimization of Articulated Construction Equipment** Bharath Kumar Somi Thulasiraman, Gomathinayagam Arumugam, Narayana Govindarao Sadali, Igneshwaran Neelamegan
10:05 AM – 10:25 AM	**Method of Defining of Intervals of Joints' Initial Coordinates for Kinematic Synthesis of Planar Lever Mechanisms** N. Krokhmal, O. Krokhmal
10:25 AM – 10:45 AM	**Evaluating Bulk Stiffness of MCF-7 Cells using Micro-scale Composite Compliant Mechanisms** Santosh D. B. Bhargav, Nikhil Jorapur, G. K. Ananthasuresh

Session: Robotics - I **Session Chair: Prof. D. P. Garg**	**Session Date & Time: 19/12/2013; 9:45AM – 10:45 AM** **Venue: 348**
9:45 AM – 10:05 AM	**Neuro-Registration and Navigation Unit for Surgical Manipulation** Gaurav Bhutani, T. A. Dwarakanath, K. D. Lagoo, Aliasgar Moiyadi, Venkata P. P. K.
10:05 AM – 10:25 AM	**Kinematic Analysis and 3D Workspace Development of 3DOF Parallel Manipulator with a Rotary Base** Y D Patel, P M George
10:25 AM – 10:45 AM	**Realizing Positive Gait Stability of a Quadruped Robot Walking on Sloping Surface** Jung–Min Yang, Seong Woo Kwak, P. M. Pathak, M. M. Gor, A. K. Samantaray

Session: Mechatronics - I **Session Chair: Dr. Soumen Sen**	**Session Date & Time: 19/12/2013; 9:45AM – 10:45 AM** **Venue: 216**
9:45 AM – 10:05 AM	**Design and Development of Automatic Stirrup Bending Mechanism** Milan Virani, Jagdish Vekariya, Saurin Sheth, Ketan Tamboli
10:05 AM – 10:25 AM	**Modeling of Electro-Hydraulic Servo Valve and Robust Position Control Using Sliding Mode Technique** Shailaja Kurode, Prasad G. Desai, Ashpana Shiralkar
10:25 AM – 10:45 AM	**Q Learning Based Reinforcement Learning Approach to Bipedal Walking Control** Sudhir Raj, Cheruvu Siva Kumar

19th December, 2013; 11:00 AM – 1:00 PM

Session: Bond graph - I **Session Chair: Prof. Ahmed Rahmani**	**Session Date & Time: 19/12/2013; 11:00AM – 1:00 PM** **Venue: MIED-Auditorium**
11:00 AM – 11:20 AM	**Ride comfort and Vehicle handling of Quarter Car Model Using SIMULINK and Bond Graph** Anirban. C. Mitra, Nilotpal Benerjee
11:20 AM – 11:40 AM	**Dynamic Modeling and Simulation of Compliant Legged Quadruped Robot** M. M. Gor, P. M. Pathak, A. K. Samantaray, J-M. Yang, S. W. Kwak
11:40 AM – 12:00 Noon	**System Identification and Model based Performance Analysis of Hydrostatic Transmission System** Md Ehtesham Hasan, S. K. Ghoshal, K. Dasgupta
12:00 Noon – 12:20 PM	**Evaluation of Dynamics of Soft Contact Rolling using Multibond Graph Approach** Anand Vaz, Anil Kumar Narwal, K. D. Gupta
12:20 PM – 12:40 PM	**Modeling and Simulation of Dynamics of Differential Gear Train Mechanism using Bond Graph** Saurabh Goyal, Anand Vaz
12:40 PM – 1:00 PM	**Modeling and Simulation of Levitating Ball by Electromagnet using Bond Graph** Anand Kumar Mishra, Rashmi Raina, Sher BahadurYadav, Alok Verma, Somnath Sarangi, Anubhuti Saha

Session: Design - I **Session Chair: Prof. G. Saravana Kumar**	**Session Date & Time: 19/12/2013; 11:00AM – 1:00 PM** **Venue: 216**
11:00 AM – 11:20 AM	**Damage Detection on Structures using Transfer Matrix with Lumped Crack Properties** P. Nandakumar, K. Shankar
11:20 AM – 11:40 AM	**Design and Prototyping of a Low-Cost Manually Operated bamboo-Cored Incense-Stick Making Machine** G. Keshav, M. Damodaran
11:40 AM – 12:00 Noon	**Estimation of Strain Controlled Fatigue Properties of Steels Using Tensile Test Data** Ghanshyam Boob, A. B. Deoghare
12:00 Noon – 12:20 PM	**Comparative Finite Element Analysis of Reconstructed New and Worn Tooth of Spur Gear** Atul Kumar, P. K. Jain, P. M. Pathak
12:20 PM – 12:40 PM	**Study On Mesh Power Losses In High Contact Ratio (HCR) Gear Drives** Rama Thirumurugan, G. Muthuveerappan
12:40 PM – 1:00 PM	**Determination of Stress Intensity Factor and Interaction Behaviour of Opposite Surface Cracks in a Rectangular Bar** S. Suresh Kumar, G. Bhojanaga Sairam, M. Aravind Raj

Session: Mechanism - II **Session Chair: Prof. Sandipan Bandyopadhyay**	**Session Date & Time: 19/12/2013; 11:00AM – 1:00 PM** **Venue: 252**
11:00 AM – 11:20 AM	**Balancing of Linkages under Constant Loads** Gaurav Singh, G. K. Ananthasuresh
11:20 AM – 11:40 AM	**Test Rig Design for Bending Fatigue Performance Evaluation of Polymer Based Composite Gears** M. Kodeeswaran, R. Suresh, S. Senthilvelan
11:40 AM – 12:00 Noon	**Study of Kinematic Chains and Distinct Mechanisms** Ali Hasan
12:00 Noon – 12:20 PM	**Conjugate-Wheel Driven 'Staircase Climbing Wheelchair'** Girish Sudhir Modak, Manmohan M. Bhoomkar
12:20 PM – 12:40 PM	**Loop Based Algorithm for Automatic Sketching of Planar Kinematic Chains** Gurusharan Singh Bedi, Shubhashis Sanyal
12:40 PM – 1:00 PM	**A Study of Mechanical Advantage in Compliant Mechanisms** R. Gautham Kumar, G. K. Ananthasuresh

Session: Robotics - II **Session Chair: Prof. J.-M.Yang**	**Session Date & Time: 19/12/2013; 11:00AM – 1:00 PM** **Venue: 348**
11:00 AM – 11:20 AM	**Virtual Robot Simulation in RoboAnalyzer** Ratan Sadanand O. M., Rajeevlochana G. Chittawadigi, Subir K. Saha
11:20 AM – 11:40 AM	**Design and Synthesis of a Four Fingered Articulated Dexterous Robot Hand** Ritwik Chattaraj, Anirudha Bhattacharjee, Bikash Bepari, Subhasis Bhaumik
11:40 AM – 12:00 Noon	**Second Order Sliding Mode Control for Single Link Flexible Manipulator** Amruta A. Mujumdar, Shailaja Kurode
12:00 Noon – 12:20 PM	**Dynamic Gaits and Control in Flexible Body Quadruped Robot** P. Murali Krishna, R. Prasanth Kumar, S. Srivastava
12:20 PM – 12:40 PM	**Reconfigurable Mechanism for Mobile Robotic Platform** Riyaz Rafique
12:40 PM – 1:00 PM	**A Novel Modular Strategy for the Fabrication of Robotic Manipulators Based Upon Task-Based Designs** Ekta Singla, Satwinder Singh, Sameer Gupta

19th December, 2013; 2:45 PM – 3:45 PM

Session: Multi Body Dynamics (MBD) - II **Session Chair: Prof. Javier Cuadrado**	**Session Date & Time: 19/12/2013; 2:45 PM – 3:45 PM** **Venue: MIED-Auditorium**
2:45 PM – 3:05 PM	**Design of an Endoscopic Haptic Display System using an Integrated Ring-actuator** Shanthanu Chakravarthy, Avinash K., Ramu G., G. K. Ananthasuresh
3:05 PM – 3:25 PM	**Wheel Torque Optimization for a Compliant Modular Robot** Avinash Siravuru, Suril V. Shah, K. Madhava Krishna
3:25 PM – 3:45 PM	**Vibration Suppression of a Cart-Flexible Pole System Using a Hybrid Controller** Ashish Singla

Session: Mechanism - III **Session Chair: Prof. Anupam Saxena**	**Session Date & Time: 19/12/2013; 2:45 PM – 3:45 PM** **Venue: 252**
2:45 PM – 3:05 PM	**Synthesis of Adjustable Offset Slider-Crank Mechanism for Simultaneous Generation of Function and Path using Variable-Length Links** Souravik Dutta, Tarun Kanti Naskar
3:05 PM – 3:25 PM	**Towards Synthesis of Tensegrity Structures of Desired Shapes** Navaneeth Krishna R. P., G. K. Ananthasuresh
3:25 PM – 3:45 PM	**Effect of Change of the Orientation of Dyad Links on Kinematics of Stephenson-III Six-Bar Linkage** Tanmay Agrawal, Kushagra Upadhyay, Nitin Sharma, Rakesh Sehgal

Session: Tribology - I **Session Chair: Prof. A. K. Sharma**	**Session Date & Time: 19/12/2013; 2:45 PM – 3:45 PM** **Venue: 216**
2:45 PM – 3:05 PM	**A Review on the Excavator Tool Bits Wear** Shiv Prakash Singh, Tanweer Alam, Somnath Chattopadhyaya
3:05 PM – 3:25 PM	**Slurry Erosion Performance of Detonation Gun Sprayed Stellite-6 on 13Cr4Ni Hydroturbine Steel at two Different Angles under Hydro-Accelerated Conditions** Gurpreet Singh, Sanjeev Bhandari
3:25 PM – 3:45 PM	**Tribological Behaviour of Al-Si Alloy with Rare Earth and Manganese** Prabhkiran Kaur, D. K. Dwivedi, P. M. Pathak

Session: Dynamics - I **Session Chair: Dr. T. A. Dwarakanath**	**Session Date & Time: 19/12/2013; 2:45 PM – 3:45 PM** **Venue: 348**
2:45 PM – 3:05 PM	**Effect of Multiple Delamination on Composite Turbine Blade Subjected To Low Velocity Impact** Sudip Dey, Amit Karmakar
3:05 PM – 3:25 PM	**Missile Launcher System Dynamic Design Criteria** V. L. Chennakesavarao B., M. Janardhana Babu, K. E. Kapadia, P. C. Jain
3:25 PM – 3:45 PM	**Estimation of States of Seeker System of a Missile using Sliding Mode Observer and Kalman Filter Approaches - A Comparative Study** Bhagyashri Tamhane, Shailaja Kurode

19th December, 2013; 4:00 PM – 6:00 PM

Session: Bond graph – II **Session Chair: Prof. Shai Arogeti**	**Session Date & Time: 19/12/2013; 4:00 PM – 6:00 PM** **Venue: MIED-Auditorium**
4:00 PM – 4:20 PM	**Modeling Stiffness and Damping in Rotational Degrees of Freedom Using Multibond Graphs** Georges Tod, François Malburet, Julien Gomand, Pierre-Jean Barre
4:20 PM – 4:40 PM	**Bond Graph Modeling and Simulation of a Dexterous Hand** Yang Qian, Ahmed Rahmani
4:40 PM – 5:00 PM	**Bond Graph Modeling and Simulation of a Dual-Arm Mobile Manipulator** Yang Qian, Ahmed Rahmani
5:00 PM – 5:20 PM	**Bond Graph Aided Performance Analysis of Antilock Braking System for a Bicycle Vehicle Model with Camber Angle and Fork Angle** Tarun Kumar Bera, Adityabir Singh
5:20 PM – 5:40 PM	**Trajectory Control of a 3-link Planar Manipulator using Virtual Link Based Controller** M.K. Sutar, P. M. Pathak, N. K. Mehta, A. K. Sharma
5:40 PM – 6:00 PM	**Rolling Element Bearing Fault Modelling to Develop a Diagnosis Scheme for Oscillating and Non-uniform Shaft Rotation** Chintamani Mishra, Goutam Chakraborty, Arun Kumar Samantaray

Session: Design – II **Session Chair: Prof. Somnath Sarangi**	**Session Date & Time: 19/12/2013; 4:00 PM – 6:00 PM** **Venue: 216**
4:00 PM – 4:20 PM	**Integrated Approach of Ergonomics and FEM into Truck Drivers Seat Comfort** Kedar Chimote, Mahendra Gupta
4:20 PM – 4:40 PM	**An Experimental Driven Approach of Braille Embosser Print Head Design Using Analytical and Computational Techniques** S. Jain, S. Majumder, K. J. Uke
4:40 PM – 5:00 PM	**Formulation of Field Data Based Model for Productivity Improvement of an Enterprise Manufacturing Tractor Axle Assembly: an Ergonomic Approach** Manish Bhadke, K. S. Zakiuddin
5:00 PM – 5:20 PM	**The Influence of friction Force on Modified Gear Teeth and its Effect on Bearing Forces** S. S. Ghosh, G. Chakraborty
5:20 PM – 5:40 PM	**Performance Analysis of Oil Dashpot in Control and Safety Rod Drive Mechanism of Prototype Fast Breeder Reactor** L. Suresh, R. Vijayashree, V. Rajan Babu, S. Raghupathy, P. Chellapandi
5:40 PM – 6:00 PM	**Ductile Crack Growth Simulations under Mode-I Loading using CTOA Criterion** Sachin Kumar, I. V. Singh, B. K. Mishra

Session: Mechanism – IV **Session Chair: Prof. P. S. Gandhi**	**Session Date & Time: 19/12/2013; 4:00 PM – 6:00 PM** **Venue: 252**
4:00 PM – 4:20 PM	**Coupler-Curve Synthesis via Multi-Objective Optimisation Using NSGA-II** Jaideep Badduri, Rangaprasad Arun Srivatsan, Gurunathan Saravana Kumar, Sandipan Bandyopadhyay
4:20 PM – 4:40 PM	**Jacobian Based Kinematic and Static Analysis of Over-Constrained Mechanisms with Prismatic and Revolute Joints** Pramod Kumar Malik, Prasanta Kumar Samal, Amulya Ratna Swain
4:40 PM – 5:00 PM	**Detection of Fractionated DOF and its Varieties using Modular Kinematics** G. Kalyan Ramana, Dibakar Sen
5:00 PM – 5:20 PM	**Infinitesimal Mechanisms Analogy for Immobilization** Ramakrishna K., Dibakar Sen
5:20 PM – 5:40 PM	**Booster Attachment Mechanism for Pilotless Target Aircraft** V. K. Pandey, G. K. Sarkar
5:40 PM – 6:00 PM	**A Novel Approach for Detection of Isomorphism of Kinematic Chains** Purushottam Prajapati, Pratap B. Deshmukh, Arvind Kumar Shukla

Session: Robotics – III **Session Chair: Prof. Venkat Krovi**	**Session Date & Time: 19/12/2013; 4:00 PM – 6:00 PM** **Venue: 348**
4:00 PM – 4:20 PM	**Delay Handling for an Adaptive Control of a Remotely Operated Robotic Manipulator** Lerrel Joseph Pinto, Krishanu Roy, Bhaben Kalita, S. K. Dwivedy
4:20 PM – 4:40 PM	**Design and Development of a Spherical Robot (SpheRobot)** Deepak Pokhrel, Nutan Raj Luitel, Sukanta Das, Dip Narayan Ray
4:40 PM – 5:00 PM	**Kinematic-Chain of an Industrial Robot and its Torque Identification for Gravity Compensation** Abdullah Aamir Hayat, Arun Dayal Udai, Subir. K. Saha
5:00 PM – 5:20 PM	**Variable Impedance Actuator with Exponential Elasticity for Flexible-Joint-Robot and Estimation of the Joint Impedance** Soumen Sen, Chandan Har, Sananda Chatterjee
5:20 PM – 5:40 PM	**A Simple Design Approach for an Electro-Hydraulic Stewart Platform through MATLAB Simulation** Anirban Bose, Rana Saha, Kamalesh Majumdar, Dipankar Sanyal
5:40 PM – 6:00 PM	**A Strategy for Finding a 2D Stable Grasp and Learning** A. Das, U. Patkar, S. Datta, S. Majumder, S. Jain

20th December, 2013; 9:45 AM – 10:45 AM

Session: Multi Body Dynamics (MBD) - III **Session Chair: Prof. Ashitava Ghosal**	**Session Date & Time: 20/12/2013; 9:45 PM – 10:45 PM** **Venue: MIED-Auditorium**
9:45 AM – 10:05 AM	**Energy Optimum Reactionless Path Planning for Capture of Tumbling Orbiting Objects using a Dual-Arm Robot** S. V. Shah, A. Gattupalli, A. K. Misra
10:05 AM – 10:25 AM	**Dynamic Analysis of Impact of Ball on Cricket Bat and Force Transfer to the Elbow** Aayush Kant, P. M. Padole, Rashmi Uddanwadikar
10:25 AM – 10:45 AM	**Dynamics of a Spatial Multibody System using Equimomental System of Point-Masses** Vinay Gupta, Himanshu Chaudhary, Subir K. Saha

Session: Mechanism - V **Session Chair: Prof. S. P. Nigam**	**Session Date & Time: 20/12/2013; 9:45 PM – 10:45 PM** **Venue: 252**
9:45 AM – 10:05 AM	**Optimization of Design Parameters for Rotary Tiller's Blade** Subrata Kr Mandal, Basudev Bhattacharya, Somenath Mukherjee
10:05 AM – 10:25 AM	**Design and Analysis of an Orthotic Device with Torque Reducing Mechanism for Knee Joint during Normal Walking** Abhishek Rudra Pal, Dilip Kumar Pratihar, Sanjay Gupta
10:25 AM – 10:45 AM	**A Comparative Study of Various Methods for Identification of Isomorphism in Kinematic Chains** Rashmi Arora, S.P. Nigam

Session: Mechatronics - II **Session Chair: Prof. Ekta Singla**	**Session Date & Time: 20/12/2013; 9:45 PM – 10:45 PM** **Venue: 216**
9:45 AM – 10:05 AM	**Performance Analysis of Different Controller for a 2 DOF Electro-Hydraulic Motion Simulator** Bibhuti Bhusan Ghosh, Bikash Kumar Sarkar, Rana Saha
10:05 AM – 10:25 AM	**Color Guided Vehicle – An Intelligent Material Handling Mechatronic System** Priyam A. Parikh, Keyur D. Joshi, Saurin Sheth
10:25 AM – 10:45 AM	**Optimization of Size Parameters for Interconnected Pneumatic Cylinders Positioning System** Saravanakumar D, Mohan B

Session: Dynamics - II **Session Chair: Prof. Sanjoy Ghosal**	**Session Date & Time: 20/12/2013; 9:45 PM – 10:45 PM** **Venue: 348**
9:45 AM – 10:05 AM	**Deployment and Latching Simulation of Large Reflectors** Sidharth Tiwary, B. Lakshmi Narayana, B. P. Nagaraj, G. Nagesh, C. D. Sridhara
10:05 AM – 10:25 AM	**Mechanism of Nanoparticle Dispersion via Acoustic Cavitation in Highly Viscous Fluid** Sudipta Halder, P. K. Ghosh
10:25 AM – 10:45 AM	**Control of Whirling of a Rotating Shaft Using HSLDS Mountings** Siddhartha Bhowmick, Ranjan Kumar Mitra, Atul Krishna Banik

20th December, 2013; 11:00 AM – 1:00 PM

Session: Bond graph - III **Session Chair: Prof. Joseph Anand Vaz**	**Session Date & Time: 20/12/2013; 11:00 PM – 1:00 PM** **Venue: MIED-Auditorium**
11:00 AM – 11:20 AM	**Conceptual Modeling Using Bond Graph as a Unified Meta-Modeling Framework** Sampath Kumar Veera Ragavan, Madhavan Shanmugavel, Velappa Ganapathy, Bijan Shirinzadeh
11:20 AM – 11:40 AM	**Modeling and Simulation of Magnetorheological Damper through Bond Graph** Naveen Thakur, Amalendu Mukherjee
11:40 AM – 12:00 Noon	**Bond Graph Modeling, Simulation and Analysis of the Rotating Duct** P. K. Kaushik, S. C. Sati, Rajeev Jain, A. Mukherjee
12:00 Noon – 12:20 PM	**Improving Mode-Change and Fault Isolation of Hybrid System Using Instantaneous Sensitivity Matrices** Rami Levy, Shai Arogeti, Danwei Wang
12:20 PM – 12:40 PM	**Sommerfeld Effect Characterisation in Rotors with Non-ideal Drive from Ideal Drive Response and Power Balance** M. Karthikeyan, Alfa Bisoi, A. K. Samantaray, R. Bhattacharyya
12:40 PM – 1:00 PM	**A Stable Docking Operation by a Group of Space Robots** Vijay Kumar, Pushpraj M. Pathak

Session: Design - III **Session Chair: Prof. Santanu Das**	**Session Date & Time: 20/12/2013; 11:00 PM – 1:00 PM** **Venue: 216**
11:00 AM – 11:20 AM	**Numerical Simulation of Static Cracks using Extended Isogeometric Analysis** G. Bhardwaj, I. V. Singh
11:20 AM – 11:40 AM	**Design and Analysis of Picking Cam for High Speed Shuttle Loom** Umang S. Modi, B. A. Modi
11:40 AM – 12:00 Noon	**Study of Subjective Responses on Ride Comfort in Public Transport Uttarakhand State Buses** A. S. Prashanth, V. H. Saran, S. P. Harsha
12:00 Noon – 12:20 PM	**Design of Sprue Bush for a Plastic Injection Mould: A Machine Perspective** Muralidhar Lakkanna, Ravikiran Kadoli, G. C. Mohan Kumar
12:20 PM – 12:40 PM	**An Approximate Analysis for Hertzian Elliptical Wheel-Rail Contact Problem** Jay Prakash Srivastava, P. K. Sarkar, Vinayak Ranjan
12:40 PM – 1:00 PM	**Gear Shift Schedule Optimization and Drive Line Modeling for Automatic Transmission** Chinmay Kirtane, Sachin Ghodke, Shailaja Kurode, Prakash A. K., D. N. Malkhede

Session: Mechanism - VI **Session Chair: Prof. G. K. Anathasuresh**	**Session Date & Time: 20/12/2013; 11:00 PM – 1:00 PM** **Venue: 252**
11:00 AM – 11:20 AM	**Link Invariant Functions and Detection of Isomorphism and Inversions of Kinematic Chains** Jagpal Singh Bal, P. B. Deshmukh, A. Jagadeesh
11:20 AM – 11:40 AM	**Kinematic Analysis of the Double Wishbone Suspension System** Madhu Kodati, Sandipan Bandyopadhyay
11:40 AM – 12:00 Noon	**On Embedded Recursive Boundary Smoothing In Topology Optimization With Polygonal Mesh and Negative Masks** Prabhat Kumar, Anupam Saxena
12:00 Noon – 12:20 PM	**On the Novel Compliant Remote Center Mechanism** Prasanna S Gandhi, Rupesh S Bobade, Chao Chen
12:20 PM – 12:40 PM	**Dimensional Synthesis of Three-point Hitch Linkage System of Tractor – An Approach Based on Maximizing Mechanical Advantage** Prasanna Kumar G. V.
12:40 PM – 1:00 PM	**Comparative Evaluation of Particle Swarm Optimization Algorithms for the Optimal Dimensional Synthesis of Planar Four-bar Mechanism** Prasanna Kumar G. V.

Session: Robotics - IV **Session Chair: Prof. Ranjan Mukherjee**	**Session Date & Time: 20/12/2013; 11:00 PM – 1:20 PM** **Venue: 348**
11:00 AM – 11:20 AM	**An Integrated Computer Vision Based Approach for Driving Assistance to Enhance Visibility in All Weather Conditions** Manvi Malik, S. Majumder
11:20 AM – 11:40 AM	**Force-Torque Interpretation in Intermediary Telepresence for Remote Manipulation** Varsha Shirwalkar, T. A. Dwarakanath, Gaurav Bhutani
11:40 AM – 12:00 Noon	**Self-Calibration of a Camera Equipped SCORBOT ER-4u Robot** Gossaye Mekonnen Alemu, Sanjeev Kumar, Pushparaj M. Pathak
12:00 Noon – 12:20 PM	**Adult-Human Learning on a Robotic Wheelchair Using a Force Feedback Joystick** Vineet Vashista, Xi Chen, Sunil K. Agrawal
12:20 PM – 12:40 PM	**Input Shaper Design for Planar Parallel Manipulators** Madusudanan Sathia Narayanan, Venkat Krovi
12:40 PM – 1:00 PM	**Robonwire: Design and Development of a Power Line Inspection Robot** Milan Jayatilaka, Madhavan Shanmugavel, S.Veera Ragavan
1:00 PM - 1:20 PM	**Potential Function Based Formation Control of Mobile Multiple-Agent Systems** Devendra Garg, Gregory Fricke

20th December, 2013; 4:00 PM – 5:00 PM

Session: Machine – I **Session Chair: Prof. N. K. Mehta**	**Session Date & Time: 20/12/2013; 4:00 PM – 5:00 PM** **Venue: MIED-Auditorium**
4:00 PM – 4:20 PM	**Analysis of Leakage Flow characteristics in Bent Axis Motors** N. Kumar, K. Dasgupta, F. Ahmad
4:20 PM – 4:40 PM	**High Speed Machining of Ti-alloys- A Critical Review** Chakradhar Bandapalli, Bharatkumar M. Sutaria, Dhananjay V. Bhatt
4:40 PM – 5:00 PM	**Effect of Various Parameters on Material Removal Rate in Flashing Operation of Precision Steel Ball Manufacturing Process** Pratik J. Patel, Saurin Sheth

Session: Dynamics – III **Session Chair: Prof. A. K. Samantaray**	**Session Date & Time: 20/12/2013; 4:00 PM – 5:00 PM** **Venue: 348**
4:00 PM – 4:20 PM	**Spacecraft Motion Simulator and Associated Modeling for Realistic Hardware-In-Loop Simulation** A. Somanathan, Srinivasarao. Lakkoju, Murali Krishna Bhagavan G., P.Natarajan
4:20 PM – 4:40 PM	**Biodynamic Response to Random Whole Body Vibration in Standing Posture** Vikas Kumara, V. H. Saran, Raj Kumar Pawar
4:40 PM – 5:00 PM	**Unbalance Detection in Flexible Rotor Using Bridge Configured Winding Based Induction Motor** Natesan Sivaramakrishnan, Kumar Gaurav, Kalita Karuna, Rahman Mafidur

Session: Tribology – II **Session Chair: Prof. S. C. Sharma**	**Session Date & Time: 20/12/2013; 4:00 PM – 5:00 PM** **Venue: 252**
4:00 PM – 4:20 PM	**Dynamic Analysis Including Stability of Flexibly Supported Narrow Hydrodynamic Journal Bearings with Micropolar Lubricant** Vijender Kumar, A. K. Chattopadhyay
4:20 PM – 4:40 PM	**Influence of Texture Orientation on the Hydrodynamic Lubrication** Syed Ismail, M. Sarangi
4:40 PM – 5:00 PM	**Study of Surface Roughness Effects in Elastohydrodynamic Lubrication of a Finite Line Contact Using Probabilistic Model** S. P. Chippa, M. Sarangi

Session: Mechatronics - III **Session Chair: Prof. Haresh Patolia**	**Session Date & Time: 20/12/2013; 4:00 PM – 5:00 PM** **Venue: 216**
4:00 PM – 4:20 PM	**Simulation of Haptics Force Law using SimMechanics and Simulink** Majid H Koul, Subir K Saha, M. Manivannan
4:20 PM – 4:40 PM	**Teaching Mechanism Dynamics using a Haptic Device** Majid H Koul, Subir K Saha, M. Manivannan
4:40 PM – 5:00 PM	**Development of Monocular Vision based Targeting System for an Autonomous Defence Vehicle** Aakash Gupta, P. V. Manivannan, M. Singaperumal

Robotics to Estimate Human Sensation

Y. Nakumura

This talk will introduce robotics modeling, optimization, and computation applied to anatomical modeling of human body. The whole body musculoskeletal system we developed has nearly one thousand muscle wires. The computational method to estimate muscle tension from the motion capture data, contact forces, and selected EMG signals is discussed. In the current implementation, we can estimate all the muscle activities in realtime and visualize the result superimposed on the live video at the frame rate. Some examples of muscle activities analysis of various athletes and experts are to be shown. The modeling of neural network system for controlling human motion is also discussed. The speaker's group is involved in the national super computer project of Japan. We are currently working on development of the high-definition model of the whole body neuro musculoskeletal system. Some of the recent results are shown.

About the speaker

Yoshihiko Nakamura received Doctor of Engineering Degree from Kyoto University. He was Assistant Professor of Kyoto University, and then Assistant and Associate Professor of University of California, Santa Barbara. He is currently Professor at Department of Mechano-Informatics, University of Tokyo. Humanoid robotics, cognitive robotics, neuro musculoskeletal human modeling, biomedical systems, and their computational algorithms are his current fields of research. Dr. Nakamura is co-chairing IEEE-RAS Technical Committee on Robotics and Automation in Nuclear Facilities. He is Fellow of Japan Society of Mechanical Engineers, Fellow of Robotics Society of Japan, Fellow of IEEE, and Fellow of World Academy of Arts and Science. Dr. Nakamura currently (2012-2015) serves as President of International Federation for the Promotion of Mechanism and Machine Science (IFToMM). Dr. Nakamura is Foreign Member of Academy of Engineering Science of Serbia, and TUM Distinguished Affiliated Professor of Technische Universität München.

Control of Underactuated Mechanical Systems

Ranjan Mukherjee

Dynamical systems with fewer control inputs than the number of generalized coordinates are commonly referred to as underactuated systems. Examples of such systems are the pendubot and point-feet biped robots, which are subjected to second-order differential constraints; as well as nonholonomic systems, that are subjected to first-order differential constraints. The definition of underactuation becomes ambiguous for continuous systems since varying number of generalized coordinates can be used for finite degree-of-freedom representations; nevertheless, underactuation can be pursued in the spirit of using “fewer than the traditional number” of actuators. Underactuation may be purposely introduced in some systems to meet design constraints but it appears naturally in many others. This presentation will focus on the dynamics, control, design and analysis of a select few underactuated systems. The problems to be discussed include: swing-up control of the pendubot, trajectory control of a spherical mobile robot, design of a synthetic-wheel biped, vibration control through hybrid actuation and sensing, and dynamics of an underwater vehicle that uses a fluid-conveying fluttering tail for propulsion.

About the speaker

Ranjan Mukherjee is a Professor of Mechanical Engineering at Michigan State University (MSU). He received his B.Tech. degree from the Indian Institute of Technology, Kharagpur, in 1987 and his MS and PhD degrees from the University of California, Santa Barbara, in 1989 and 1991, respectively, all in Mechanical Engineering. Prior to joining MSU, he was an Assistant Professor in the Department of Mechanical Engineering at Naval Postgraduate School in Monterey, California, from 1991 to 1996. Ranjan Mukherjee is a Fellow of the ASME, a recipient of the 2008 Fulbright Research Scholar Award, and the 2011 MSU Withrow Distinguished Senior Scholar Award.

Dynamic Analysis of Mechanisms - Dealing with Complex Boundary Conditions

S. Guruprasad

Dynamic analysis of Mechanical Systems and Mechanisms is challenging task when the boundary conditions are non-linear or abruptly change. The actuators sometimes are highly sensitive to the dynamic response of the systems they are actuating and this coupling needs to be considered while analysing such systems. The conventional rigid body dynamics is an excellent tool to begin with but in complex situations the system needs to be modelled and simulated with much more details. A few examples of are discussed that need to consider flexibility of the body under motion and also the changes in boundary conditions. Simulation of systems with different energy domains is also a difficult task under dynamic conditions. A few examples of solutions are also covered. The flexibility of mechanical elements and systems need to be considered along with actuator dynamics also to provide to needs of the control system development.

About the speaker

Dr. S. Guruprasad is a Director R&DE(Engineers) of DRDO Pune, India. He did his B.E.(Mechanical) from University of Mysore, M.E.(Machine Design) from Banglore University and Ph.D.(Structural Dynamics) from IIT Bombay. He worked on multi-span mechanical Bridging System SARVATRA. For the first time Concurrent Engineering methodology was adopted for execution of the project. He also worked on Under Water systems especially in the area of shock dynamics. His research areas include Blast and Impact resistant Layered Structures in which he has number of publications. He also has number of patents to his credit. When the JV project was started for development of BrahMos he was appointed as Project Director PJ-10 for Ground Systems responsible design & development of Launchers on all platforms. For the first time a Single Vehicle Weapon System for BrahMos the Mobile Autonomous Launcher has been developed and has been inducted into services. An inclined launcher for INS RAJPUT was designed and installed. A Universal Vertical Launch Module (UVLM-8) has been developed and the first unit has been installed on INS RANVIR. As director of R&DE(Engineers), DRDO Pune, Dr. S.Guruprasad is leading R&D in Military Bridging, Mine warfare, Weapon launch systems, NBC protection systems, Composite materials, etc..

Design and Manufacturing of Biologically Inspired Robots

Satyandra K. Gupta

Taking inspiration from the nature offers new possibilities for realizing novel robots. Bio-inspired robotics has emerged as an important specialization within the field of robotics. Explorations in this area have included designing and building walking, crawling, and flying robots that take inspiration from their biological counterparts. This presentation will begin by introducing robotics terminology and reviewing limitations of the conventional robots. This presentation will then introduce the general principles behind taking inspiration from a biological source and converting the inspiration into implementable engineering concepts that can be incorporated into a robot. The following three case studies will be presented: bird-inspired robots, amphibious legged robots, and snake-inspired robots. These case studies will describe how useful features of the biological creatures were selected and simplified so that they can be implemented using the existing actuation, sensing, and manufacturing technologies. These case studies will focus on design and manufacturing aspects of the biologically inspired robots.

About the speaker

Dr. Satyandra K. Gupta is a Professor in the Mechanical Engineering Department and the Institute for Systems Research at the University of Maryland, College Park. He was the founding director of the Maryland Robotics Center. Prior to joining the University of Maryland, he was a Research Scientist in the Robotics Institute at Carnegie Mellon University. Currently, he is on an IPA assignment at National Science Foundation and serving as a program director in the Division of Information and Intelligent Systems. He manages National Robotics Initiative.

Dr. Gupta's interest is broadly in the area of automation. He is specifically interested in automation problems arising in Engineering Design, Manufacturing, and Robotics. His current research focus is mainly on simulation-based computational synthesis and automated planning. He is a fellow of the American Society of Mechanical Engineers (ASME). He has served as an Associate Editor for *IEEE Transactions on Automation Science and Engineering*, *ASME Journal of Computing and Information Science in Engineering*, and *SME Journal of Manufacturing Processes*.

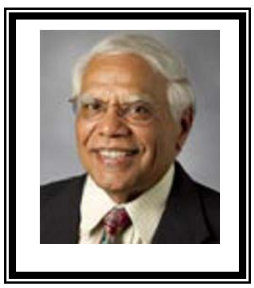
Dr. Gupta has received several honors and awards for his research contributions. Representative examples include: a Young Investigator Award from the Office of Naval Research in 2000, a Robert W. Galvin Outstanding Young Manufacturing Engineer Award from the Society of Manufacturing Engineers in 2001, a CAREER Award from the National Science Foundation in 2001, a Presidential Early Career Award for Scientists and Engineers (PECASE) in 2001, Invention of the Year Award in Physical Science category at the University of Maryland in 2007, Kos Ishii-Toshiba Award from ASME Design for Manufacturing and the Life Cycle Committee in 2011, and Excellence in Research Award from ASME Computers and Information in Engineering Division in 2013. He has also received six best paper awards at conferences and 2012 Most Cited Paper Award from *Computer Aided DesignJournal*.

Research Issues in Cooperative Control of Multiple Robot

Devendra P. Garg

Multiple manipulators are commonly used in current manufacturing environments where the tasks to be performed are beyond the capabilities of a single manipulator. In such situations, (for example, handling a single heavy object), multiple manipulators form a closed kinematic chain. Here, load sharing and internal force minimization become important issues in devising efficient strategies for control of fixed multiple robots working together to accomplish a desired objective. Uncertainty arises in the perception and modeling of the work environment, in the manipulation of robot arm and payload, and in the planning and execution of a specified task. In order to extend the abilities of a robot in an uncertain and flexible environment, appropriate sensor systems must be developed which can dynamically interpret the observations from the environment with respect to the performed task, while accounting for uncertainty, and obtaining an accurate model of the robot world. A multi-sensor system must use algorithms or strategies to model sensor inaccuracies, compensate for uncertainties, fuse information from multiple sensory sources and develop an accurate model of the environment. Control of complex and nonlinear robotic systems is an important and challenging area of research. At Duke University's Robotics and Manufacturing Automation (RAMA) Laboratory, research projects are carried out for developing intelligent control strategies involving stationary industrial robots operating in a flexible work-cell for performing cooperative tasks such as generating a multiple-part assembly. In addition, our research has emphasized coordination and control of mobile robots working cooperatively to carry out tasks such as perimeter detection and surveillance of hazardous spills. This talk will describe our research experience in this regard and will include the control of both fixed and mobile multiple robots.

About the speaker



Dr. Devendra P. Garg is Professor Emeritus of Mechanical Engineering at Duke University, Durham, North Carolina, USA, and is a Life Fellow of the American Society of Mechanical Engineers (ASME). He received his Bachelor of Science degree from Agra University in 1954 and Bachelor of Engineering degree from the erstwhile University of Roorkee in 1957. He earned his Master's degree in Mechanical Engineering from the University of Wisconsin, Madison and his Ph.D. degree from New York University, New York in 1960 and 1969, respectively.

Professor Garg started his career as a Lecturer and subsequently went on to become a Reader in Mechanical Engineering at the University of Roorkee from 1957 to 1964. He taught at New York University, and thereafter, moved to Massachusetts Institute of Technology (MIT) Cambridge,

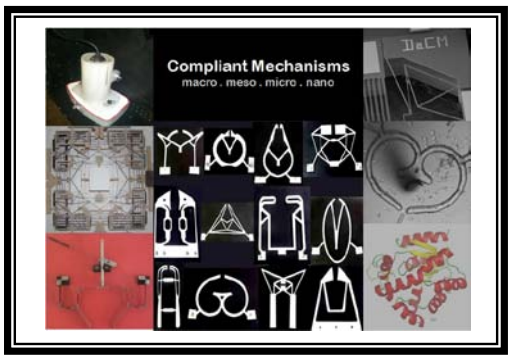
Massachusetts, rising from the ranks of an Assistant Professor at MIT to a tenured full Professor at Duke University within a very short period of three years (from 1969 to 1972). He became the Professor and Director of Duke University's Robotics and Manufacturing Automation (RAMA) Laboratory in 1972.

While on leave from Duke University, Dr. Garg devoted six years of his professional career with the United States National Science Foundation (NSF) as Program Director in the Directorate for Engineering. This funding agency has an annual operating budget of over seven (7) Billion US Dollars. Since the year 2000, he has been involved with the United States Army Research Office either as an Associate Program Manager or as a consultant. Professor Garg's active participation in the Department of Defense's program for the development and use of technology for both military and civilian sectors brought him the recognition from the White House. In his letter addressed to Professor Garg on January 31, 1994, President Bill Clinton wrote that "Your technical expertise has been invaluable in the selection of the most highly qualified proposals from among the thousands put forth. I commend you for your dedication in undertaking this task. Your efforts will contribute to a brighter economic future for our country."

Professor Garg has been extensively involved in global educational activities. As a Fulbright Senior Scholar in 1988, Dr. Garg was appointed as Visiting Professor in the Department of Automatic Control Engineering at the Georgian Technical University, Tbilisi, Republic of Georgia. He visited Japan in 1996 and 1999 for extended periods of time as a Senior Fellow under the sponsorship of the Japan Society for the Promotion of Science and as an Invited Fellow in 1997 under the sponsorship of the Japan Science and Technology Agency. Professor Garg's exemplary leadership contributions have been recognized by several prestigious awards bestowed upon him, notably the NSF's Outstanding Performance Award (1993), the Cooperative Team Effort Award (1993), NSF's Special Act or Service Award (1994), American Society of Mechanical Engineers (ASME) Dedicated Service Award (1996), ASME Leadership Award (1998), ASME Life Fellow Award (2000), ASME's Edwin F. Church Medal (2003), Hind Rattan Award (2007), Indian Institute of Technology (IIT) Roorkee's Distinguished Alumnus Award (2009), Duke University's Capers and Marion McDonald Award for Excellence in Mentoring and Advising (2011), and the ASME/DSCD Yasundo Takahashi Education Award (2011).

Workshop on Compliant Mechanisms

G.K. Ananthasuresh



Compliant mechanisms reply upon elastic deformation of their constituent members for transmitting force, motion, and energy. Owing to many advantages that arise due to the absence of kinematic joints and one-piece construction, many applications of compliant mechanisms have come up in the last two decades. Modeling and design methods that account for the geometrically nonlinear elastic deformation of compliant mechanisms are also developed. In this tutorial, we provide an overview of the field and highlight important aspects of modeling and design methods. They include mobility, kinetoelastostatic models, energetics, non-dimensionality, and different types of synthesis methods. Design methods will include kinetostatic loop-closure method; topology and shape optimization methods; selection-based design; building-block method; and constraint-based design. Important applications that include microsystems, consumer products, biomedical, automotive, and aerospace will be presented. A database of compliant mechanisms will be introduced and a simple kit with which one can easily design functional compliant mechanisms will be demonstrated.

About the speaker

G.K. Ananthasuresh (B. Tech. IIT-Madras, 1989; MS, U. Toledo, 1991; PhD, Michigan, 1994) is a Professor of Mechanical Engineering at the Indian Institute of Science, Bangalore, India. His previous positions include post-doctoral associate at the Massachusetts Institute of Technology, Cambridge, USA; Associate Professor at the University of Pennsylvania, Philadelphia, USA; and visiting professorships in University of Cambridge, UK, and Katholike Univesiteit, Leuven, Belgium. His current research interests include compliant mechanisms, kinematics, multi-disciplinary design optimization, microsystems technology, micro and meso-scale manufacturing, protein design, micromanipulation and bio-design. He served on the editorial boards of eight journals and is a co-author of 75 journal papers and 135 conference papers as well as two edited books, one text book, and 12 book-chapters. He has seven patents, three granted and six pending. He is a recipient of the NSF Career Award and SAE Ralph O Teeter Educational Award in the USA and the Swarnajayanthi Fellowship and Shanti Swarup Bhatnagar Prize in India as well as 10 best paper awards in international and national conferences.

Workshop on Bond Graph Modeling

Belkacem OULD BOUAMAMA

Bond graph is a powerful tool well known for dynamic modelling of multiphysical systems: This is the only modelling technique to generate automatically state space or non-linear models using dedicated software tools (CAMP-G, 20-Sim, Symbols, Dymola …). Recently several fundamental theories have been developed for using a bond graph model not only for modeling but also as a real integrated tool from conceptual ideas to optimal practical realization of mechatronic system. This workshop will discuss a synthesis of those new theories which exploit some particular properties (such as causal, structural and behavioral) of this graphical methodology. Based on a pedagogical example, it will be shown how from a physical system (not a transfer function or state equation) and using only one representation (Bond graph), the following results can be performed : modeling (formal state equations generation), Control analysis (observability, controllability, Structural I/O decouplability, dynamic decoupling, …) diagnosis analysis (automatic generation of robust fault indicators, sensor placement, structural diagnosability) and finally sizing of actuators. The presentation will be illustrated by real industrial applications: power station, clean intelligent transport and fuel cell systems.

About the speaker

Belkacem Ould Bouamama is full Professor and head of the research at “Ecole Polytechnique de Lille, France”. His main research areas developed at LAGIS laboratory CNRS8219 where he leads “Bond graph group”, concern Integrated Design for Supervision of System Engineering. Their application domains are mainly nuclear, energy, and mechatronic systems. He is at present leader of the topic group “Diagnostic of fuel cell system” in the framework of French research group “GDR Systéme PAC”. He is the author of several international publications in this domain. He is co-author of five books in bond graph modeling and Fault Detection and Isolation area. Research and teaching activities can be consulted at: http://www.mocis-lagis.fr/membres/belkacem-ould-bouamama/.

Workshop on Multi-body Dynamics

Javier Cuadrado

A multi-body system is simply a mechanical system, formed by several bodies, which is mobile or possesses mobile parts, i.e. what has traditionally been called a machine or mechanism. Multi-body dynamics refers then to the computer simulation of the dynamics of multi-body systems, and belongs to the general concept of virtual product development, within CAE tools. Multi-body dynamics can therefore be defined as computational mechanics of machines and mechanisms, being based on Mechanics, Mathematical Methods and Programming. It allows to solve, with the help of a computer, the forward dynamics (and the kinematics, and the inverse dynamics) of models of vehicles, machines and mechanisms as detailed as desired, thus being of application to industrial sectors as automotive, aerospatial, railway, naval, energy, heavy machinery, machine-tool, robotics, biomechanics, medical, sport, entertaining, etc. The workshop will show the main ingredients of multi-body dynamics: modelling, formulation of the equations of motion and numerical integration. Moreover, those attendees having a laptop with Matlab installed will have the opportunity to implement an example.

About the speaker

Javier Cuadrado is full-professor of mechanical engineering at University of La Coruña, and has been working on multi-body system dynamics for more than 25 years. Since March 2002 he is the Head of the Laboratory of Mechanical Engineering (http://lim.ii.udc.es), an academic group devoted to research in the mentioned discipline. Since September 2005 he chairs the IFToMM Technical Committee for Multibody Dynamics. He has been co-organizer of the ECCOMAS Thematic Conference Multibody Dynamics 2005, held in Madrid, Spain, and organizer of the EUROMECH Colloquium 476 Real-time Simulation and Virtual Reality Applications of Multibody Dynamics, held in Ferrol, Spain, in 2006. He is member of the editorial board of Multibody System Dynamics, Journal of Multi-body Dynamics, Mechanism and Machine Theory, and Mechanics Based Design of Structures and Machines.

PAPERS ABSTRACT: BONG GRAPH MODELING

Ride Comfort and Vehicle Handling of Quarter Car Model Using SIMULINK and Bond Graph

Anirban. C. Mitra[1], Nilotpal Benerjee[2]
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Suspension system design is always been a challenging task for the automobile designers in view of multiple control parameters, complex objectives and disturbances which are stochastic in nature. To maintain simultaneously a high standard of ride comfort and improved vehicle handling under all driving conditions is a necessity for good suspension design. These conflicting parameters pose a problem of a judicial compromise between these two and make the problem more complex. The present work aims at developing and applying a systematic methodology leading to optimum combinations of the suspension damping and stiffness parameters of a ground vehicle subjected to road excitation. A 4 DOF quarter car model has been developed to study important effects on Passenger body (Head, Thorax-pelvis), seating on a cushion seat using a Bondgraph model and SIMULINK model separately results of which are in good agreement with each other and also matching with the real life expectations. The effects of variations of suspension stiffness and damping coefficient on ride comfort, road holding and head displacement has been studied over wide range of road bump.

Dynamic Modeling and Simulation of Compliant Legged Quadruped Robot

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Quadruped robot has many advantages over wheeled mobile robots, but it is a discrete system in which joints of each leg has to operate in particular fashion to get the desired locomotion. So, dynamics plays an important role in the operation and control of quadruped robot. Proper conception of the dynamic formulation is must for the complex system like quadruped robot. Here, an attempt is made to generate three dimensional model of a quadruped using the bond graph technique. Bond graph is an efficient tool for system modeling from the physical model itself and various control strategies can be developed very efficiently. A quadruped robot configuration used for analysis is two links legged robot in which upper link is rigid and lower link is compliant. In a lower link, piston and piston rod is sliding inside the cylinder and movement is restricted by the internal hydraulic pressure of the cylinder which will generate compliance in the leg. Simulation of the various gait performed by the quadruped is carried out, which proves the versatility of the three dimensional model generated. The generated model can be used in research of various aspects pertaining to quadruped, the same thing is demonstrated by doing performance evaluation between compliant and rigid legged robot and also between two different gaits like trot gait and amble gait.

System Identification and Model based Performance Analysis of Hydrostatic Transmission System

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This article is aimed at system identification of a pedagogical hydrostatic transmission system (HST) through parameter estimation using constitutive relations and real measurements. A bondgraph model has been developed to analyze the performance of the system through system modeling and simulation. The characteristic curves for different components of the HST system were also obtained through simulation and validated experimentally.

Evaluation of Dynamics of Soft Contact Rolling using Multibond Graph Approach

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The dynamics of soft contact between a rigid body rolling over a soft material is quite challenging to be solved. Contact area and force distribution at the contact interface changes as the rigid body rolls over the soft material. The soft contact dynamics is modeled using multi bond graph approach integrated with finite element method. Stiffness and Inertia matrices for the soft material are calculated using finite element method. Stiffness and inertia matrices are used as C-field and I-field respectively in the bond graph model. In this work, as an example a circular disc rolling over a layer of silicon rubber is considered. The disc is moved with controlled force using proportional and derivative controller. Bond graph structure for the system is developed. MATLAB code is generated directly from the bond graph model. Model is validated with simulation which determines soft material deformation, contact area and forces distribution.

Modeling and Simulation of Dynamics of Differential Gear Train Mechanism using Bond Graph

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In this paper, dynamics of the well-known differential gear train mechanism is presented in a systematic manner using the unified approach of bond graph. The approach offers an alternative to the conventional energy based methods. The dynamics of the mechanism is also quite significant from the point of view of design. Reaction forces and moments at different locations, which are of interest from the design perspective, have been presented. Rigid body dynamics is applied to model each link of the mechanism. The links are constrained suitably based on the nature of interaction between consecutive links. In this work, the code for simulation is directly written from the bond graph, without formally deriving system equations. Simulation results provide insight into the dynamics of the differential mechanism.

Modeling and Simulation of Levitating Ball by Electromagnet using Bond Graph

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Magnetic Levitation has been a keen area of research, especially in the field of automotive where low losses due to friction and low energy consumption are important considerations. This paper offers the theoretical and experimental idea of the magnetic force control in the magnetic levitation system using the bond graph modeling approach considering the nonlinearities. The corresponding levitation apparatus comprises of an electromagnet, a ferroelectric material base, a steel ball and position sensors. The force generated by the electromagnet causes the levitation action over the ball by balancing the gravitational force exerted on the ball. The present work describes the linear and nonlinear model using signal flow graph and bond graph approach. Transfer function of the setup is obtained using signal flow graph and correspondingly the balancing action of the ball at its levitating position is performed using a PID controller. Lastly the overall system stability is validated using root locus approach.

Modeling Stiffness and Damping in Rotational Degrees of Freedom Using Multibond Graphs

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A contribution is proposed for the modeling of mechanical systems using multibond graphs. When modeling a physical system, it may be needed to catch the dynamic behavior contribution of the joints between bodies of the system and therefore to characterize the stiffness and damping of the links between them. The visibility of where dissipative or capacitive elements need to be implemented to represent stiffness and damping in multibond graphs is not obvious and will be explained. A multibond graph architecture is then proposed to add stiffness and damping in three rotational degrees of freedom. The resulting joint combines the spherical joint multibond graph relaxed causal constraints while physically representing three concatenated revolute joints. The mathematical foundations are presented, and then illustrated through the modeling and simulation of an inertial navigation system; in which stiffness and damping between the gimbals are taken into account. This method is particularly useful when modeling and simulating multibody systems using Newton-Euler formalism in multibond graphs. Future work will show how this method can be extended to more complex systems such as rotorcraft blades' connections with its rotor hub.

Bond Graph Modeling and Simulation of a Dexterous Hand

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This paper presents a methodology for dynamic modeling and trajectory tracking of a dexterous hand. Firstly, the kinematic model is set up based on modified D-H principle. Then we employ an energy-based approach for modeling and its bond graph notation ensures encapsulation of functionality, extendibility and reusability of each element of the model. A toolbox BG V.2.1 in Matlab/Simulink is used for simulation and validation. Simulation results are performed to illustrate the efficacy of the proposed dynamic model.

Bond Graph Modeling and Simulation of a Dual-Arm Mobile Manipulator

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This paper presents a methodology for dynamic modeling and trajectory tracking of a nonholonomic wheeled mobile manipulator with dual arms. First, the kinematic model is set up based on modified D-H principle. Then we employ an energy-based approach for modeling and its bond graph notation ensures encapsulation of functionality, extendibility and reusability of each element of the model. A toolbox BG V.2.1 in Matlab/Simulink is used for simulation and validation. Simulation results are performed to illustrate the efficacy of the proposed dynamic model.

Bond Graph Aided Performance Analysis of Antilock Braking System for a Bicycle Vehicle Model with Camber Angle and Fork Angle

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In most studies, braking of vehicle in a straight path has been considered. When vehicle moves in a curved path, the effect of camber angle and fork angle should be considered. The variable camber angle assists braking in a curved road but the turning radius of vehicle changes due to varying camber angle and fork angle. The antilock braking system (ABS) is used for enhancing vehicle directional stability and steerability. The bond graph model of bicycle vehicle model is developed to study the effect of camber angle and fork angle on the performance of ABS when it maneuvers a curved path.

Sommerfeld Effect Characterisation in Rotors with Non-ideal Drive from Ideal Drive Response and Power Balance

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Rotor dynamic systems are often analyzed with ideal drive assumption. However, all drives are essentially non-ideal, i.e., they can only provide a limited amount of power and their dynamics is coupled with the driven system's dynamics. One basic fact often ignored in rotor dynamics is that the motor power is not only spent to spin the rotor shaft but also to overcome the resistances to rotation and more importantly, to overcome the power dissipated in lateral vibrations during rotor whirl. Near the resonances, a flexible rotor with unbalance can attain several stable operating speeds for the same amount of input drive power. Increase in power input near resonance may contribute to increasing the transverse vibrations rather than increasing the rotor spin, i.e., the rotor spin may get caught near resonance for considerable range of power input and time. This classic symptom is referred to as the Sommerfeld effect. In this article, we generate the rotor response with finite element (FE) model by assuming an ideal drive. Thereafter, the ideal rotor system's response is used in a power balance equation to theoretically predict the characteristics of the non-ideal system. The non-ideal system with drive-rotor interaction is modeled in bond graph (BG) form whose transient analysis is used to validate the theoretical results. The Sommerfeld effect is studied near the first two critical speeds of the rotor and the passage through resonance conditions are investigated. The results are important from the point of actuator sizing for rotors.

Rolling Element Bearing Fault Modeling to Develop a Diagnosis Scheme for Oscillating and Non-uniform Shaft Rotation

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Rolling element bearings are widely used in rotating machines and their faults can lead to excessive vibration levels and/or complete seizure of the machine. Under special operating conditions such as oscillating rotor motion or full rotations with non-uniform speed, the available fault diagnosis methods cannot be applied for bearing fault diagnosis. Further to that, fault symptoms in some machines which operate at very slow speed in the range of fractional rpm cannot be extracted through usual measurement and signal processing techniques. Typical examples are LD furnace, heavy rolling mill, *etc*.

In extremely slow speed or variable speed operation, rolling element slip becomes predominant. In this article, we present a bond graph model of the rolling element bearing by taking into account the nonlinear contact stiffness, contact friction, cage dynamics, rolling element pre-compression and localized faults. The rotor is supposed to be either velocity or torque driven where the external load decides the rotor speed.

Simulation of the bond graph model developed here yields the vibration signatures corresponding to specific fault or combinations thereof. The simulation model outputs are used to fine-tune diagnosis scheme which consists of two post-processing steps. The vibration signature is concurrently acquired with the instantaneous angular velocity or position. For oscillating motion, we use a simple potentiometer with appropriate engagement with the rotor shaft. In the first step of post-processing, it is assumed that when a fault is encountered, impact leads to ringing the bearing natural frequencies. Thus, the generated time-domain vibration signal is filtered through a band-pass filter whose pass-band contains the bearing natural frequency. In the second phase, the vibration signature as a time-series data is converted to a dataset of vibration amplitude versus the angular position. The 360 degree angular position range is then segmented into small steps of 1 to 5 degree bands. The averaged vibration amplitudes at various angular position bands are then plotted in the form of a histogram. The features of this histogram are then compared to bearing characteristic angles (mapped form of bearing characteristic frequencies to eliminate explicit dependence on time or frequency) to isolate the faults.

Conceptual Modeling using Bond Graph as a Unified Meta-Modeling Framework

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In this paper we discuss an alternative Model Based Design approach which can be used to bridge the concept-implementation gap commonly encountered during the design of complex, software- intensive multidomain systems also known as Cyber Physical Systems (CPS). CPS differs from other mechatronic systems due to the close coupling between the physical and computing systems. The focus is on getting the physics right- the rest is mathematics. Existing Model based Development techniques are predominantly software based and use UML for modeling complex engineering systems leading to difficulties in Model validation and verification and code generation. We propose a novel and unified approach based on BG-UMF; a bond graph based Meta Modeling framework as a practical and viable alternative to OMGs UML/SysML/OCL combination for meta modeling CPS. The power of the framework is highlighted through an example scenario: Conceptual Design and Development of a UAV.

Modeling and Simulation of Magnetorheological Damper through Bond Graph

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Magnetorheological (MR) dampers have received great deal of attention in recent years as they are one of the most promising control devices. The MR damper is a class of semi-active devices that uses MR fluid to control damping. The MR fluids consist of micron-sized, magnetically polarizable particles dispersed in a carrier medium such as mineral or silicone oil. When a magnetic field is applied to the MR fluids, the particles form chains, resulting in fluid becoming semi-solid that exhibits viscoplastic behavior. This ability of MR fluid to reversibly change from a free-flowing, linear viscous fluid to a semi-solid with controllable yield strength on exposure to magnetic field is used to control the damping force. The MR damper involves interaction between different energy domains. Bond graph is a unified approach to modeling, simulation and synthesis of physical systems in different energy domains. This paper presents the modeling and simulation of MR damper through bond graph using Symbols Sonata software.

Bond Graph Modeling, Simulation and Analysis of the Rotating Duct

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This paper present bond graph modeling of the rotating duct. In this paper emphasis is given on the modeling of duct that is rotating about its axis and simultaneously discharging water. Basically this is the fluid dynamics problem, so first it is approximated as a hydraulics problem. The duct may be of any shape. The fluid flows through the duct by centrifugal body forces. The analysis of this complex situation is made tractable by use of bond graph modeling. The bond graph is created by taking pressure and torque as an effort variable in hydraulic and mechanical domain respectively. Discharge or volume flow rate and angular velocity as flow variable in hydraulic and mechanical domain respectively. Simulations are performed on software SYMBOLS Sonata [7] to study the effects of different geometric and operating parameters on the performance of the driving motor. In this paper simplified situation of the duct is considered and dynamics of the rotating mechanism is neglected. The practical application of the rotating duct is to find the power required to drive the radial flow pump assuming one duct as one sector of the impeller of the pump.

Improving Mode-Change and Fault Isolation of Hybrid System Using Instantaneous Sensitivity Matrices

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One approach to quantitative model-based fault detection and isolation (FDI) is based on analytical redundancy relations (ARRs) and fault signatures. Numerical evaluation of an ARR creates a residual, which then, provides online information on the consistency of the system and its nominal model. An inconsistency is represented by a signature. Traditionally in the quantitative approach, these signatures are binary vectors, where the term 0 means a residual is consistent and 1 means inconsistent. In this paper, the measured trend of residuals is utilized for FDI by a different type of signature, called sensitivity signature. In a sensitivity signature, the consistency of ARRs is represented by three terms; the term +1 indicates a residual is crossing an upper threshold, the term -1 indicates a residual is crossing a lower threshold and the term 0 means otherwise. The expected sensitivity signature related to a certain fault or to a mode change is taken from partial derivative of residuals. Fault isolation is a process where the measured signature is compared to signatures from the set of expected signatures. Since consistency, in the sensitivity approach, is represented by three terms (instead of two), more distinguished signatures are generated and improved fault and mode change isolation abilities are achieved.

Trajectory Control of a 3-link Planar Manipulator using Virtual Link Based Controller

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A hyper-redundant manipulator has the advantage that they can be used in constraint space; however the control of hyper-redundant manipulator is difficult. This paper presents a concept of virtual link based two degrees of freedom (DOF) controller. With the proposed controller, manipulator of any number of links can be reduced to either a 2-link virtual manipulator or one real and one virtual link manipulator. To illustrate the methodology, a 3-link planar hyper-redundant manipulator has been considered. Simulations have been carried out to validate the efficacy of the controller. The developed control scheme can be used in trajectory control of manipulators used for surgical applications i.e., in- vivo robot.

A Stable Docking Operation by a Group of Space Robots

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This paper presents an attitude control strategy in the three planar space robots having two DOF for docking operation of a free flying hexagonal object using the bond graph technique for modeling and simulation. As the highly non linearity, strongly coupled and non-holonomic characteristics of a free flying space robot, the position and posture of the base body changes when the free floating space robot is moving its manipulator to the position to capture a target. As the base of space robot is not fixed, it gets disturbed while docking operation in the absence of attitude controller. Therefore, it is a great challenge to control the base disturbance. To minimize this problem, dynamic model of three space robots is proposed. The simulation results show that the attitude disturbance is minimized by using the three space robots in place of the two space robots keeping all parameters same.

PAPERS ABSTRACT: DESIGN

Damage Detection on Structures using Transfer Matrix with Lumped Crack Properties

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A novel lumped crack transfer matrix (LCTM) and state vector based method is proposed in this paper for identification of damage in the beam like structures. Transfer matrix (TM) is a square matrix which contains all structural and crack parameters such as crack depth and its location. State vector at a node is the sum of internal and external contributions of displacements, forces and moment at that node on the structural element, when it is multiplied with TM the state vector at the adjacent point can be obtained. A cracked beam element is assumed as two intact beam elements are connected by a hinge or torsional spring. The crack is modelled as an element of zero length and mass but has elastic properties. Hence the LCTM for the cracked beam element is obtained by series multiplication of LCTMs for the intact beam elements and that for the crack element. State vector is formed at one node known as initial state vector from which state vectors at other nodes are predicted by multiplying with TM for the predicted values of crack parameters. Displacement responses are measured at a few nodes in the structure. The mean square error between measured and predicted responses is minimized using a heuristic optimization algorithm with crack depth and location as the optimization variables. Two numerical examples a cantilever and sub-structure of a frame with nine members are solved with multiple cracks in an element. The TM algorithm is also validated experimentally. The main advantage in this method is one or more cracks in the single element can be identified.

Design and Prototyping of a Low-Cost Manually Operatedbamboo-Cored Incense-Stick Making Machine

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The design and prototyping of a low cost hand-operated incense-stick making machine to alleviate the labor intensive work associated with the production of bamboo-cored incense sticks is outlined in this paper. The machine is based on the mechanism of extruding the incense stick paste over the bamboo stick. The main components of this machine include a hand-crank, a compound gear-train system, rack and pinion system and an extruder. As the paste used is of a semi-solid nature and a high force was needed for extrusion, a confined compression test using Universal Testing Machine was carried out to obtain rough estimates of the force required for the extrusion. During this experiment a known force was applied, varied and exerted on the rack until the paste was extruded out of the die. Using this force estimate, a suitable two-stage compound gear-train system with mechanical advantage of 9:1 and a hand-crank was designed. The lever and gear-train system was designed ergonomically so that the applied force results in a minimal arm-muscle fatigue for the operator.

Estimation of Strain Controlled Fatigue Properties of Steels Using Tensile Test Data

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Aim of this study is to estimate various strain life fatigue parameters using tension test data. Monotonic tensile test properties, hardness and modulus of elasticity of various steel grades are extrapolated to predict various parameters of strain based fatigue approach. Artificial Neural Network (ANN) tool is used for prediction purpose. A neural network program is developed in MAT-LAB-2012 software. Four separate networks are developed to estimate four strain-life fatigue properties. These are stress at fracture in one stress cycle, true strain corresponding to fracture in one stress cycle, fatigue strength and ductility exponents. Tensile test results data, material hardness and modulus of elasticity is used as input for networks. The experimental fatigue test data available in literature for different grades of steel is used for training and test purpose. The results of neural network modeling indicated the close agreement with the real time values. The accuracy of predicted result is found to be approximately 87-98%. Finally, it is concluded that ANN is prominent tool to predict various properties of strain based fatigue approach which eliminates the need of actual experimentation.

Comparative Finite Element Analysis of Reconstructed New and Worn Tooth of Spur Gear

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Spur gear wears either due to rubbing action between the meshed gears or by the occurrence of unwanted elements like dust particles, metal fragments, etc. which reduces its efficiency and service life. It is always a challenging task to determine the remaining life of a component or the strength of a component once wear has occurred on teeth surface. This paper presents an application of reverse engineering approach for reconstruct the spur gear 3D CAD model using scanned data. A gear has been scanned using PICZA 3D laser scanner (Roland LPX60). The digitized data of spur gear was collect in the form of .stl data and point cloud data file formats. The scanned spur gear has been reconstructed in 3D CAD model before and after wear using SolidWorks modeling software. The finite element analysis has been carried out for tooth strength assessment between original and worn out gear teeth. These results were obtained on ANSYS Workbench. The results will allow for a better understanding of existing limitations for power transmitting with worn out gear tooth and also may be helpful to determine remaining life cycle of gear under loading conditions.

Study on Mesh Power Losses in High Contact Ratio (HCR) Gear Drives

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Continuous demands for higher efficiency gear drives need an understanding on the role of power loss that depends on the frictional forces. The load dependent tooth mesh power losses (i.e., sliding and rolling power losses) are the dominant power loss components at heavy loads with low or moderate pitch line velocities. Hence, these two power losses are given more importance in this study to evaluate the performance of the HCR gear drive. The calculation of sliding power loss is carried out based on the Elastohydrodynamic lubrication (EHL) model proposed by Xu et al.[1], but with the consideration of load sharing ratio(LSR). Higher contact ratio is achieved through addendum enlargement in this work.The comparative study of normal and high contact ratio gears is discussed for better understanding on gear mesh losses on HCR gear drive.

Determination of Stress Intensity Factor and Interaction Behaviour of Opposite Surface Cracks in a Rectangular Bar

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Multiple cracks emanating from fasteners and rectangular plates represent one of the most common fracture sources in aircraft structures and automobiles. Due to complexities in analysis of multiple cracks, many researchers have studied the damage tolerance analysis of single crack in rectangular plate, notched and un-notched round bar and thus the effect of crack interaction has been neglected. This paper present the SIF and interaction behavior of multiple cracks which are located in opposite direction in a rectangular bar subjected to far filed tension loading. Two surface cracks of same dimensions were introduced in the opposite sides of a rectangular bar. The crack depth ratio (a/t) ranging between 0.1 and 0.4 was considered with two different crack aspect ratios (a/c = 0.6 and 1.0). The crack tip was meshed with iso-parametric singular elements to determine the SIF values. The SIF values of single and multiple cracks are compared to determine the interaction behaviour of opposite cracks on SIF. Higher SIF values are observed at the crack surface region for a circular crack (a/c=1.0) at lower crack depths ((a/t) < 0.2 whereas the SIF values are higher at the crack middle region for an elliptic crack (a/c = 0.6) irrespective of the crack depth ratios. It is observed that, SIF values are not symmetric with crack middle region at higher depths due to additional effect of mode II and mode III fracture. It is also noted that the interaction effect of the growing cracks is more significant at higher crack depths. The effect is more significant at the crack middle region compared to crack surface region. The SIF values at the middle region of an elliptic crack are higher than circular crack irrespective of crack depth ratios considered in the present study.

Integrated Approach of Ergonomics and FEM into Truck Drivers Seat Comfort

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Seats are one of the most significant components of vehicles where truck driver spend most of their time and hence call for comfort. The present research work is focusing on the ergonomics approach for driver's seat comfort. Driving a truck in Indian condition cannot be compared with driving in developed countries because of the external factors such as road conditions, maintenance of vehicle, drivers habits etc. Driving throughout the day in such conditions leads to various health problems for the drivers which may even lead to accidents. So it is important to design the comfortable seat for truck drivers keeping in view the ergonomic factors such as anthropometry, physiological workload, psychological stress etc. Since from last few decades, it is observed that the truck drivers are facing various muscle-skeletal injuries due to lengthy driving hours. The foremost cause for all the injuries are the improper design of driver's seat. Present research is divided in two parts. First, to conduct survey amongst the truck drivers, examine the travel time factor, and seat discomfort. Second is to design and recommend best possible alternatives of driver's seat with the aid of ergonomics and advanced design tools like CAD CAE.

An Experimental Driven Approach of Braille Embosser Print Head Design Using Analytical and Computational Techniques

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This paper presents an experiment driven approach for the design of a braille embosser print head characterised by impact generated by electromagnetic force. The developmental work presented here is an experimental driven approach for design of a braille embosser which is essentially an impact printer, that convert text as braille output. The problem with bad quality printing of the braille dots including waviness and vibration, which limit the operating speed of the printer, is specially addressed. In this research study variation in printing quality are caused by non linear dynamics coupled with other factors such as proper material, vibration, specific electro-mechanical design issue and many more. This approach clearly shows that even a successful product design at laboratory level requires continuous experimentation to achieve the desired goal. The experiments results show that some mechanical parameters are critical in order to get satisfactory quality on the braille text print. Altogether, this approach contributes to better knowledge and understanding about various aspects that needs to be considered while designing similar types of products.

Formulation of Field Data Based Model for Productivity Improvement of an Enterprise Manufacturing Tractor Axle Assembly: An Ergonomic Approach

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The paper describes an approach for formulation of generalized field data based model for the process of tractor axle assembly of an enterprise. The theory of experimentation as suggested by Hilbert Schenck Jr. is applied. It suggests an approach of representing the response of any phenomenon in terms of proper interaction of various inputs of the phenomenon. The Tractor axle assembly process is considered for study which is a complex phenomenon. The aim of field data based modeling for axle assembly process is to improve the performance of system by correcting or modifying the inputs for improving output. The reduction of human energy expenditure while performing axle assembly is main objective behind study. Reduced human energy consumption will increase overall productivity of assembly process. The work identifies major ergonomics parameters and other workstation related parameters which will affect the productivity of axle assembly process. The identified parameters are raw material dimensions, workstation dimensions, energy expenditure of workers, anthropometric data of the workers and working conditions. Working conditions include humidity of air, atmospheric temperature, noise level, intensity of light etc. at workstation which influence the productivity of assembly operation. Out of all the variables identified, dependant and independent variables of the axle manufacturing system are identified. The no of variables involved were large so they are reduced using dimensional analysis into few dimensionless pi terms. Buckingham pi theorem is used to establish dimensional equations to exhibit relationships between dependent terms and independent terms. A mathematical relationship is established between output parameters and input. The mathematical relationship exhibit that which input variables is to be maximized or minimized to optimize output variables. Once model is formulated it can be optimized using the optimization technique. Sensitivity analysis is a tool which can be used to find out the effect of input variables on output variables. Simultaneously it would be interesting to know influence of one parameter over the other. The model will be useful for an entrepreneur of an industry to select optimized inputs so as to get targeted responses.

The Influence of Friction Force on Modified Gear Teeth and its Effect on Bearing Forces

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Theoretical analysis of vibration of a geared system becomes quite complicated because of the presence of several factors contributing to generation of the excited motions. Some examples are static transmission error (STE), gear tooth flexibility, backlash, friction forces present at the contact surfaces, torsional and flexural rigidity of the shafts on which gears are mounted etc. Considerations of all these factors make a model too complicated to be treated analytically. STE is believed to be chiefly responsible for gear vibration and noise. Consequently, tooth profile modification is employed to minimize dynamic transmission error (DTE) variation and dynamic load. However, high performance gears are still noisy in many applications. One possible explanation is the presence of friction as a noise source. A six degree-of-freedom torsional-translational model is considered to study the effect of friction in the line-of-action (LOA) and off-line-of-action (OLOA) direction under gear tooth modification. An attempt is made to find optimum profile modification for minimum bearing force along LOA and OLOA direction.

Performance Analysis of Oil Dashpot in Control and Safety Rod Drive Mechanism of Prototype Fast Breeder Reactor

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In Prototype Fast Breeder Reactor, there are two independent, fast acting, diverse shutdown systems each comprising of sensors, logic, circuit, Drive Mechanisms and neutron absorber rods having B4C pellets. The absorber rod of the first system is known as Control &Safety Rod (CSR) and its drive mechanism is known as Control & Safety Rod Drive Mechanism (CSRDM). The functions of CSRDM are to facilitate start-up, reactor control, controlled shutdown and emergency shutdown by scram (Safety Control Rod Accelerated Movement) action. During normal operation of the reactor the CSRs are all partially inserted in the core. During emergency shutdown the scram release electromagnet gets de-energised and the Mobile Assembly (MA) of CSRDM along with CSR drops under gravity into the active core. The maximum drop height is 1085 mm. At the end of free fall there is an oil dashpot which acts as a damper to absorb the kinetic energy of the falling mass. Proper functioning and performance of the oil dashpot is critical for the healthiness of the shutdown system. In the present study, Characterisation of flow parameters in the oil dashpot using a commercial Computational Fluid Dynamics (CFD) code to obtain a relation between velocity and pressure drop in the dashpot and implementation of the flow characteristics in the performance analysis code to obtain the performance characteristics of the dashpot has been done. The performance analysis is performed by mathematical modeling of the dashpot system as spring-mass-damper two degree of freedom system. This paper gives a brief description of Control and Safety Rod Drive Mechanism and oil dashpot, the methodology of modeling, flow characterisation in dashpot and presents the results of performance analysis of oil dashpot.

Ductile Crack Growth Simulations under Mode-I Loading using CTOA Criterion

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In the present work, extended finite element method (XFEM) has been extended to simulate the large deformation stable crack growth problems using finite strain plasticity. In XFEM, special enrichment functions are employed in the portion of domain where discontinuity and singularity are found whereas the rest of domain is modeled using finite element method. The modeling of large deformation is performed using updated Lagrangian approach. The nonlinear equations obtained as a result of large deformation and nonlinear material behavior, are solved by Newton-Raphson approach. Von-Mises yield criterion has been employed along with isotropic hardening to model finite strain plasticity. The elastic-predictor and plastic-corrector algorithm is employed for stress computation. To verify the proposed CTOA criterion, the results are compared with J-R criterion. Two problems i.e. crack growth in compact tension specimen and crack growth in triple point bend specimen are solved under plane stress condition to demonstrate the accuracy and capability of the proposed crack growth criterion.

Numerical Simulation of Static Cracks using Extended Isogeometric Analysis

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In last decade, isogeometric analysis (IGA) has gained a lot of interest among the scientific community in solving various engineering problems. Nowadays, IGA has been extended to many scientific and engineering areas including fracture mechanics. This paper presents the simulation of stationary plane crack problems using extended isogeometric analysis (XIGA). In XIGA, both geometry and solution are approximated using NURBS basis functions. Heaviside function is used to model the crack face, while crack tip singularity is modeled using asymptotic crack tip enrichment functions. The various crack problems i.e. left edge crack, centre crack and double edge crack are solved using XIGA. The value of stress intensity factor (SIFs) is computed using domain based interaction integral approach. These simulations showed that SIF obtained using XIGA with higher order NURBS basis functions provide more accurate results as compared to those obtained by XFEM.

Design and Analysis of Picking Cam for High Speed Shuttle Loom

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Shuttle Loom is widely used in Indian Power loom industry due to its versatility to weave nearly all kind of fabrics. The only problem with this machine is that the speed is low compared to the other weaving machines. It can be enhanced by improving the speed of shuttle loom .This needs to increase the speed of picking mechanism which plays the main role in weaving of fabric. Detailed study was done on the working of the picking mechanism of present loom. Experiments have been carried out to study the motion of a shuttle in the present machine. Kinematic and Dynamic analysis are done for the present loom. Cam profile has been generated and Kinematic and Dynamic Analysis are carried out for the designed cam. A prototype is manufactured and from the practical experiment it has been observed that the accuracy, speed and force of picking mechanism have been increased.

Study of Subjective Responses on Ride Comfort in Public Transport Uttarakhand State Buses

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Today, ride comfort has developed facets that are as significant as safety and speed in assessing the physical characteristics of transportation. The road roughness and vehicle vibration play a predominant role in the subjective evaluation of the ride comfort and activity comfort. The quality of life on board road vehicles is influenced by the level of ride comfort which is basically related to vibration levels and the perception of fatigue. The present study encompasses a questionnaire based study conducted on public transport buses in India, in different routes between Roorkee to Hardwar, Hardwar to Roorkee, and Saharanpur to Roorkee together with vibration measurements on the seat and floor with vertical (z) and lateral (y) directions. The subjective study involved reading of a national Hindi newspaper, to obtain a subjective opinion and to quantify the difficulty in reading and also from the vibration measurements the seat accelerations were measured for suggesting the proper design of seats in public transportation buses. The Preference technique method was adopted and the level of discomfort analyzed in 7- point Semantic scale. The conclusions from the seat location, postures adapted for reading and the vibration measurements served as useful guidelines for conducting experimental work in the laboratory.

Design of Sprue Bush for a Plastic Injection Mould: A Machine Perspective

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Design methodology and criteria to configure sprue bush for enhancing functionality is systematically compiled from plastic injection moulding machine perspective. Sprue conduit's sensitivity to moulding objectives are quantitatively ghettoised as expansion ratio on the basis of ubiquitous empirical relationships. This generic, simple, inexpensive preventive criterion enables sprue bush conduit geometry design to exemplifying the melt injection specifically for a particular machine. Continuous Sensitivity Equation Method (CSEM) was adopted to sensitise sprue conduit expansion over infinite dimensional range exclusively for injection rate, maximum injection pressure and barrel size. Inferred results were exponential in nature with injection rate having direct proportionality, while maximum injection pressure and barrel size had inverse proportionality to conduit expansion off parting plane. Off them injection rate was found to be relatively more influential than injection pressure and barrel size.

An Approximate Analysis for Hertzian Elliptical Wheel-Rail Contact Problem

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The wheel-rail contact condition is modeled assuming two general quadratic surfaces. The formulation in this study aims primarily at determination of stresses by varying contact geometry arising from variation in profile geometry. A change in surface topology, may result from wear, brings in a change in contact geometry and stresses. To understand their influence profile radii are changed for six different values. Problem formulation is based on Timoshenko's approach. Correspondingly, variations in the results in terms of principal stresses with changes in wheel profile radii, wheel taper and rail profile radii are obtained. A comparison with available published results shows an error within two to three percent of models [1, 2]. Results obtained are expected to help understand the rail wheel topology dependence on the stress deformation pattern. This may allow a direct design application for railways in particular.

Gear Shift Schedule Optimization and Drive Line Modeling for Automatic Transmission

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Gear shifting strategy is the core of intelligent control of any automatic transmission used in modern vehicles. It directly influences the vehicle performance, drivers feel and fuel economy. This paper describes two different design methods of gear shift schedules for optimum dynamic performance and fuel economy separately. Mathematical model of vehicle driveline containing automatic transmission and other parts of vehicle is developed to evaluate the effectiveness of these methods. The developed model is simulated on European drive cycle to establish effectiveness of the derived gear shift schedule methods. Simulation results show that the designed methods are quite effective and can be used to generate gear shift schedules for automatic transmissions.

PAPERS ABSTRACT: DYNAMICS

Effect of Multiple Delamination on Composite Turbine Blade Subjected To Low Velocity Impact

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This paper investigates on transient impact response of pretwisted composite conical shell panel which could be idealized as turbine blades. In the formulation, an eight noded quadratic isoparametric plate bending element is employed. A multipoint constraint algorithm is used to model the delamination crack. The modified Hertzian contact law is used to portray the impact parameters and Newmark's time integration scheme is utilized to solve the time dependent equations. Comparative analyses are carried out with respect to triggering impact parameters considering a spherical mass with low velocity impacted normally at the centre.

Missile Launcher System Dynamic Design Criteria

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Missile Launcher system is an assembled store carried externally on the rotor craft (Helicopter). The main objective of present study is to design launcher system to the dynamic environment created due to the main rotor of the helicopter, and hence it is an apt case of design for dynamic environment. The mass of launcher should not exceed 20 kg. Launcher system designed as a modular construction, considering the ease of assembly, quick loading and unloading of the missile launch tubes and replacement requirement of accessories. The launcher frame is made up of members, having hollow box-type cross-sections. Box-section has been chosen after initial iterations of open I-section indicated low frequency torsion modes. The box-section has high torsion rigidity compared to the open I-section. Most important input which dictates the design of launcher system is the launcher system structural resonant frequencies, which should not match with helicopter main rotor frequencies. To ascertain this requirement modal analysis has been carried out on the initially designed configuration and iterated the design till it meets the design constraints. Sine-on-random vibration input was constructed by superimposing the broadband random excitation with sinusoidal excitation coming from the helicopter main rotor frequencies. Response analysis has been carried out using the modal analysis output data and sign-on-random excitation. Constant damping ratio is used for analysis. The maximum 1σ displacements, 1σ acceleration and 1σ stresses for the launcher are computed using finite element analysis and factor of safety are reported. The 1σ stress results shows that the launcher has a minimum required factor of safety. The response results shows that the amplifications in amplitudes for vibration input are within the permissible range. The separation has been maintained between launcher frequency and the rotor's critical frequencies. The study demonstrates the need for considering the dynamic design criteria for missile launcher system.

Estimation of States of Seeker System of a Missile using Sliding Mode Observer and Kalman Filter Approaches - A Comparative Study

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This paper presents a comprehensive comparison of estimation of states for seeker system of a missile using Sliding Mode Observer and Kalman filter approaches. This estimation accounts for the angular position and displacement rates of the seeker pitch and yaw gimbals. These seeker body rates are required to estimate the line of sight (LOS) rate to determine target position. Both estimation approaches are simulated and a comparative analysis is presented. The peculiar advantages of the two methodologies; i.e. parametric robustness of SMO and noise damping of Kalman filter, have been validated in simulation.

Deployment and Latching Simulation of Large Reflectors

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Large deployable reflectors are widely used in satellite communication. These are light weight and flexible. The reflectors are mounted with revolute joint hinges to deploy and cam and roller mechanism to latch. These reflectors are stowed during launch to accommodate within the launch envelope. In orbit, the reflector is deployed and latched at the end of deployment through cam and roller mechanism to the intended position. The reflector deployment is a mission critical activity hence it requires detailed modelling and analysis to ensure positive deployment and latching. This paper presents the dynamics of reflector from the stowed to deployed configuration and latching simulation which has been carried out in a single finite element software-ABAQUS. The reflector and reflector hinges are modelled as a flexible body during deployment. The contact between roller and cam is modelled as a surface to surface contact. The finite sliding approach is used to continuously update the contact connectivity during deployment. The time variation of loads induced in different components of hinge after latching is evaluated.

Mechanism of Nanoparticle Dispersion via Acoustic Cavitation in Highly Viscous Fluid

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Nanoparticles have a strong tendency to agglomerate when used as filler in composites, due to strong van der Waals forces and have adverse influence on property improvement. In this context breaking of agglomerated nanoparticles and their homogeneous dispersion in epoxy adhesive is imperative for enhancement of properties. The nanoparticles can either be dispersed mechanically, with a dissolver or with a bead mill, or by means of ultrasound waves. Present study is primarily concerned with the power required for generation of ultrasonic waves responsible for the dispersion of SiO2 nanoparticles into epoxy resin. The effect of amplitude is also considered in the present study as higher amplitude includes risk of degradation of the epoxy resin due to localized heat generation at the vicinity of ultrasonic horn. Also in view of the difficulties in the dispersion of nanoparticles in highly viscous fluid, mechanisms of dispersion was studied in the present work and modeled using the experimental results. Experimental results in terms of process parameters such as amplitude, pulsating time, dispersion time etc. were used to determine the mechanisms of Nanoparticle breaking and adequate mathematical expression and compared to Winkler's model. Design of mixing chamber was further studied with regard to the modelled value and experimental process parameters.

Control of Whirling of a Rotating Shaft Using HSLDS Mountings

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In rotating machineries vibration causes various problems. The moving parts get fatigued, greater wear and noise formation takes place, undue vibration is transmitted to the supporting frame or base foundation etc. The predominant cause of this vibration is unbalanced forces. To reduce the rotor's response, the machine is mounted on HSLDS (high-static-low dynamic-stiffness) mechanism as proposed in this paper. Like an equivalent linear support its static stiffness is same but at the same time, it offers a lower dynamic stiffness. So, it has the same capability of carrying the load but has a lower natural frequency compared to a linear counterpart. This is fulfilled by reducing the values of the critical speed and peak whirl amplitude of the rotor, being mounted on HSLDS springs. In this paper the advantages of HSLDS mounts are explained using a 2 DOF model of simple rotary machine. It consists of a rigid disk having a mass 'm' and a shaft, bearings, supports which are flexible but has negligible mass. To present the advantages of dynamic stiffness with low value, a linear analysis is done for small deflection of the rotor from its static equilibrium position; in case of large displacement, a nonlinear equation of motion is formed and solved using two terms harmonic balance method in MATLAB. The usefulness of the HSLDS supports is shown by plotting the responses of the rotor with linear and HSLDS mounts simultaneously. Last but not the least, the problems due to strong nonlinearity (hardening HSLDS mechanism) is depicted.

Spacecraft Motion Simulator and Associated Modeling for Realistic Hardware-In-Loop Simulation

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Hardware–In–loop simulation (HILS) is a realistic dynamic test environment for verification and validation of Attitude and Orbit Control System (AOCS) of a satellite. The tight attitude rate requirement of the order of +/- 5.0e-5 deg/sec of AOCS calls for high bandwidth high accuracy 3 degree of freedom spacecraft Angular Motion Simulator (AMS). The AMS along with dynamics model achieves the overall goal of assessing the performance of various control elements for all mission scenarios from satellite injection, transfer orbit acquisition, orbit raising, on-orbit, station-keeping & normal mode operations. The mechanism of AMS and associated modeling is successfully deployed in HILS testing of various satellite missions of Indian Space Program. This paper describes the closed loop system built around AMS for demonstrating the stringent pointing specification requirements of control system of a spacecraft.

Biodynamic Response to Random Whole Body Vibration in Standing Posture

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The bio-dynamic responses of the human body to whole body vibration have been studied in various studies to find out the causes of health and comfort deterioration of the human body. The transmissibility of whole body vibration (WBV) from the floor to the head and knee for standing posture has been studied in the present work. The six healthy male subjects were exposed to random whole-body vibration having 0.5m/s2 and 1m/s2 r.m.s vibration magnitude and frequency ranges from 1-20 Hz. Also the effect of two hand support (handle and handrail) on floor to head transmissibility as well as on floor to knee transmissibility was studied. The first peak has been observed in the 4 to 7 Hz frequency range for floor to head transmissibility in both the postures. The transmissibility of the floor to the head was found to be greater for holding the handrail than handle while little effect on floor to knee transmissibility.

Unbalance Detection in Flexible Rotor Using Bridge Configured Winding Based Induction Motor

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An eccentric rotor position produces unbalance in the field and generates a net radial force called unbalance magnetic pull (UMP). The magnitude and direction of this UMP mainly depends on the degree and type of the eccentricity. The electromechanical interaction in an induction machine is due to the coupling between magnetic fields and the eccentricity in the rotor motion and both radial and tangential electromagnetic forces are generated in the air gaps due to this interaction. This paper investigates a specialized winding scheme for a three-phase, four-pole induction machine called a bridge-configured winding (BCW) which can be used for generating a controllable transverse force and also can be used for monitoring the health of a machine. This paper addresses the latter one where unbalance can be detected in the system due to the currents generated in the bridges. These currents are called bridge currents. In this way the bridge current can be used as a measure of the unbalance present in the rotor. To develop the experimental setup the stator winding of a 37kW three phase four-pole induction machine was modified by incorporating a bridge-configured winding. Existing rotor of the motor has been replaced with a longer rotor and a perforated disc is inserted in the rotor to introduce different unbalance. Experiments were carried out to check the presence of bridge current which is an indication of an unbalance present in the system and it has been also shown that the bridge current changes with the unbalance present in the system.

PAPERS ABSTRACT: MACHINES

Analysis of Leakage Flow Characteristics in Bent Axis Motors

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This article presents a practical approach to determine the characteristics of the leakage flow of the bent axis hydro-motor. In this study, a mathematical model is developed by considering the flow through the clearances between the piston and the barrel-hole (i.e. annular section) and the gap between the ball and socket joint at the spherical head of the piston. To develop the mathematical model for the leakage flow of the hydro-motor, the expressions for the leakage through the clearances are obtained using Navier- Stokes equation, where the change in thickness of the clearances with the differential pressure across the leakage path is also taken into consideration. The co-efficients of the polynomial expression obtained through the modeling that varies with the operating pressure are identified through the experimental investigation. From the characteristics of the leakage flow of the hydro-motor, it is observed that the flow loss of the hydro-motors increases with the increase in operating pressure, speed and displacements of the motor.

High Speed Machining of Ti-alloys- A critical Review

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Titanium alloys are widely used in many applications such as Aerospace, Automotive, Biomedical, Marine, Mining and Oil Industries. Titanium elucidates many engineering challenges for its effective utilization. The tool wear, material removal rate, surface finish and overall cost in titanium machining are major challenges. In order to meet these challenges conventional high speed machining may be one of the solutions to produce more durable and quality products. The present paper discusses to find the most efficient combination of tool, machining parameters, milling strategy, workpiece materials, etc. for the particular application. The work carried out by various researchers is studied in the field of conventional machining of titanium alloys considering only turning and milling operation and important findings are narrated.

Effect of Various Parameters on Material Removal Rate in Flashing Operation of Precision Steel Ball Manufacturing Process

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Precision balls are used in critical aeronautical bearings, guidance system balls for space and military applications, precision valves, automotive bearings and other applications where higher precision is necessary. However, since the surface finishing process necessary for the balls to achieve the required surface quality and geometric accuracy is time consuming and expensive, it increases the manufacturing cost significantly and therefore confines their widespread application. Hence, the development of a more economical finishing method becomes a critical problem in the application of advanced Steel ball manufacturing. The major concern of the current study is to investigate the performance of the Flashing machine in the initial stage. In flashing of steel balls, the influence of the groove depth of plates on the Material Removal rate of balls is analyzed experimentally. Five flashing plates with different groove depth are used. A shallow round groove is equivalent to a V groove with a large angle. A deep round groove corresponds to a V groove with a small angle. From the experimental readings, regardless of the groove depth of the Gap plate, the one where the groove of the rotary plate is deep it is found that MRR is large. Best MRR is found at the combination of 0.1 D – 0.3 D. The experiment for Flashing was designed using a full factorial design with two levels for each input variable (2k factorial design). Since there are three factors, each at two levels, the design is 23 factorial design which requires 8 runs to complete all the possible combinations. Factors taken for the experiments are Pressure between two plates, No. of Grooves in plates & RPM of Ring Plate. From the main effect plots, to achieve higher Material removal rate pressure should be at its higher level, RPM should be also at higher level, No. of grooves should be at its lower level. Also from the experiments the percentage contribution of various parameters on Material removal rate are Pressure having 58.16% , RPM having 16.86%, No. Of grooves having 23.90%. Analyzing the various process parameters, their influence in the operation & experiments are conducted at NHB Bearings Company.

PAPERS ABSTRACT: MULTI BODY DYNAMICS

Development of Miniaturized Pneumatic Artificial Muscle for Surgical Device

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Robotic surgical tools used in minimally invasive surgeries (MIS) require reliable actuators for precise positioning and control. Miniature pneumatic artificial muscles (MPAM) appear most suited for actuating surgical devices because of their inert nature, high force to weight ratio and fast actuation. However, MPAMs are not readily available and pose considerable challenge in their design and control. In this regard, we develop a miniaturized air muscles with outer diameter of ~1.2 mm. The developed MPAMs have high contraction ratio of about 22% and can provide pull force in excess of 5N at a supply pressure of 0.83 MPa. In this paper, we present the details of the developed experimental set-up, experimental data on contraction and force as a function of applied pressure and characterization of the MPAM. Furthermore, the details of the design and experiments with novel endoscopic surgical tool that uses the developed MPAMs for improved dexterity and position control are presented.

Minimization of Shaking Force and Shaking Moment in Multiloop Planar Mechanisms

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This paper presents an optimization method to dynamically balance the complex multiloop planar mechanisms. The shaking force and shaking moment transmitted to the ground are balanced through optimization to improve the mechanism's dynamic performance. The pareto optimal conditions are proposed considering the shaking force and shaking moment as two objective functions. First, the force balancing of the mechanism is obtained numerically. The shaking moment was found increased for a force balanced mechanism. To reduce both the shaking force and shaking moment, a multi-objective optimization problem is formulated and solved using conventional and genetic algorithm (GA) techniques. The genetic algorithm produces several optimum solutions (pareto optimal points) and the best solution can be chosen from this set of optimum solutions. The optimization method presented in this paper is general and can be applied to any mechanism whereas the analytical solutions already available are for the specific mechanisms. The effectiveness of the proposed method is shown considering a Stephenson six-bar mechanism.

Forward Dynamics for Gait Analysis as an Intermediate Step to Motion Prediction

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Human motion prediction through computational simulation can serve as a tool to anticipate the result of surgery or to help in the design of prosthetic/orthotic devices. The latter is the motivation in a project being run by the authors, devoted to the design of an active stance-control knee-ankle-foot orthosis (SCKAFO) as an assistive device for the gait of incomplete spinal cord injured (SCI) subjects. Optimization is a well-suited technique to tackle the human motion prediction problem, and several approaches have been proposed in the literature. However, no matter which is the used approach, the implementation of these methods represents a great challenge in terms of both convergence and efficiency. Therefore, the authors intend to firstly address the analysis of a certain measured motion through forward dynamics, which can be considered as an intermediate step towards the prediction problem, since it requires dynamical consistency too, but does not suffer from the same high amount of uncertainty. Consequently, a systematic study of the different alternatives to obtain, through forward dynamics, the drive efforts at joint level that produce a certain known motion is started in this paper. Three model-based control methods have been implemented for the gait of a healthy subject, and their performances have been compared.

Design of an Endoscopic Haptic Display System using an Integrated Ring-actuator

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Existing virtual reality-based endoscopic simulators lack immersive haptic feedback. We address this need with a one degree-of-freedom haptic display module that can be retrofitted onto an endoscopic simulator. In this paper, we present the design of circumferentially actuated compact ring-mechanisms that provide radial motion for force-reflection on the tube of the endoscope. Both compliant and rigid-body embodiments of the ring-mechanisms are explored in this work. The multi-padded force-reflecting mechanism is designed to apply a maximum force of 5 N and to cover a range of endoscope tubes whose outer diameters range from 10 mm to 15 mm. Design, modeling, electronics, and fabrication of the ring-actuator endoscopic haptic display system are presented in this paper.

Wheel Torque Optimization for a Compliant Modular Robot

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This paper proposes a systematic method to optimize wheel torques in a compliant modular robot, which consists of 3 link-wheel modules connected by revolute joints. Conventionally, actuators are used at these joints for posture control while climbing. In this work, use of torsional springs at the joints is proposed for posture control. The compliance thus obtained is profitably used to manoeuvre on uneven terrains. It is also shown how the springs are designed to be stiff enough to restrict the link-wheel module from tipping over while climbing big step-like obstacles. The only actively controlled variables of the robot are wheel torques, which are optimized to minimize wheel slip. This helps in reducing odometric error and maximizing energy efficiency. The proposed optimization builds on the quasi-static analysis of the robot and forms one of the key novelties of this paper. The results show the advantages of modularity in climbing big steps without any slip. The proposed wheel-torque optimization lends utility in the design of an appropriate wheel velocity controller.

Vibration Suppression of a Cart-Flexible Pole System Using a Hybrid Controller

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A hybrid control strategy is used in this work to suppress the structural vibrations of a flexible system. The hybrid controller is based on the combination of inverse dynamics feedforward control, command shaping and linear state feedback control. The nonlinear feedforward control is derived using inverse dynamics, which is useful to linearize the system around the nominal trajectory. The feedback loop is designed with linear observer based optimal regulator which ensures stabilization and performance objectives. Finally, the command shaping is incorporated to obtain the desired nonoscillatory response. Command shaping is an effective way of improving the performance of systems with flexible dynamics, e.g. flexible manipulators, flexible structures, spacecraft with large appendages, ships, cranes and telescopes. The method is applied to the case of a flexible inverted pendulum on a moving cart. The simulation runs show the efficacy of the proposed controller in vibration suppression of a highly flexible system.

Energy Optimum Reactionless Path Planning for Capture of Tumbling Orbiting Objects using a Dual-Arm Robot

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This paper presents energy optimum capture of orbiting objects using a dual-arm robot mounted on a service satellite. An attempt has been made to formulate energy efficient trajectories for the dual-arm robot such that the reaction moments acting on the base satellite are minimum. To achieve this, first a local optimization problem is formulated exploiting redundancy associated with the constraints for reactionless manipulation. This method, however, fails to provide optimal trajectories. In order to overcome this disadvantage, an optimal control problem is formulated which not only helps in achieving energy efficient trajectories but also ensures zero reaction moments to the base satellite. The proposed method is validated using a 6-link planar dual-arm robot mounted on a service satellite.

Dynamic Analysis of Impact of Ball on Cricket Bat and Force Transfer to the Elbow

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A number of games like cricket, tennis, baseball, etc. have developed a lot due to the extensive research done in the sporting equipment. The main aim of this researchis the evaluation of stresses in the hands of a cricket batsman. Very less literature has been found to attempt such an analysis, although it can be of great use, like predicting the location of injury, predicting the performance of the safety wear being used by the batsman, etc. One of the aims of this work is also to study in detail the variation in the ball exit velocity with respect to the impact location on the blade. Finite Element Modeling is used as an approach to predict the exit velocity of the ball. Three situations with various velocities of bat and ball are considered and simulated. The results confirm the existence of sweet spot, and indicate the same location where minimum amplitude of vibration is expected. A study on the reaction forces on the hand due to both the bat swing as well as ball impact is done. It is seen that reaction forces are minimum for sweet spot impact. The load on the hand is observed to be a dynamic load, occurring for a period almost five times the impact period of ball. A study is also performed on the stress distribution in the hand of the batsman, due to these reaction forces.

Dynamics of a Spatial Multibody System using Equimomental System of Point-Masses

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This paper presents dynamic modelling of a spatial multibody system using the equimomental system of point-masses which has several advantages, e.g., one needs to write only the translational equations of motion without the necessity of writing the rotational equations as the point masses have no dimension. For this, a rigid body is represented as a set of rigidly connected seven point-masses. Accordingly, the velocities of the point-masses are derived as a linear transformation of the joint-rates resulting into a set of three decoupled matrices called the Decoupled Natural Orthogonal Complement (DeNOC) matrices for the point-masses. The matrices are then used to form a minimum set of constrained equations of motion from the uncoupled Newton's equations of linear motion. The methodology is illustrated using a spatial solid pendulum.

PAPERS ABSTRACT: MECHANISM

Steering Linkage Optimization of Articulated Construction Equipment

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Articulated vehicles of Earthmoving equipment are steered using hydraulic cylinders mounted between the front and rear frames. Mounting position and location of the cylinders play an important role in uniform stress distribution in frame/chassis, cylinder pressure and stroke Optimization, there by influencing on the power required to steer. By reducing the steering forces, stresses induced in the structures are reduced, facilitating the improved life of the structures. This paper reviews the literature in the subject area, total work done to steer the equipment is calculated, thereby finding the steering pressure and forces. Optimization of mounting points is discussed using the optimization tool available in CAD package and validated experimentally.

Method of Defining of Intervals of Joints' Initial Coordinates for Kinematic Synthesis of Planar Lever Mechanisms

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In this paper is considered the approach to solve the problem of defining of initial conditions intervals. Shown, that the choosing of intervals is the self-contained problem. The problem is solved by the optimization of a certain objective function. This function is formed on the basis of established properties of dyad's transfer functions. The proposed method permits to scan a multidimensional coordinate space of basis points and to define intervals there their initial values may be located. The method can do it in acceptable time span.

Evaluating Bulk Stiffness of MCF-7 Cells using Micro-scale Composite Compliant Mechanisms

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Biomechanical assays offer a good alternative to biochemical assays in diagnosing disease states and assessing the efficacy of drugs. In view of this, we have designed, fabricated and tested a miniature compliant tool to estimate the bulk stiffness of cells, particularly MCF-7 (Michigan Cancer Foundation) cells. The compliant tool comprises a gripper and a Displacement-amplifying Compliant Mechanism (DaCM), where the former helps in grasping the cell and the latter enables vision-based sensing of force. A DaCM is necessary because the field of view of a microscope at the required magnification is not large enough to simultaneously observe the cell and a point on the gripper that move sufficiently to estimate the force. Therefore, a DaCM is strategically embedded within an existing gripper design leading to a composite compliant mechanism. The DaCM is designed using the kinetoelastostatic map technique to achieve a resolution 42 nN. The gripper, microfabricated with SU-8 polymer using photolithography, is within the footprint of about 10 mm by 10 mm with the smallest feature size of about 5 microns. The gripper was tested in air and was found to be satisfactory in grasping and squeezing objects as small as 15 microns in size. However, testing in aqueous medium encountered an unanticipated problem due to buoyancy, which curled the jaws of the gripper up by as much as 40 microns and thus losing contact with the cell that is to be grasped. A design modification is suggested to fix this problem.

Balancing of Linkages under Constant Loads

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Minimizing the potential energy of statically balanced linkage eases the assembly of the balancing springs and reduces the loads experienced by the constituent members. Current techniques for statically balancing a linkage using only springs and no auxiliary bodies have free parameters to be chosen by the designer. We present a technique that utilizes these free parameters to impose additional conditions that make the potential energy not just constant in all configurations but also a minimum among all possible design alternatives. The conditions required for minimum potential energy for a statically balanced lever and a statically balanced planar 2-R linkage are derived in this paper. These results are then generalized for any planar linkage by noting that the lower bound for the balanced potential energy is equal to the maximum external work among all possible configurations. Two practical examples that use Peaucellier-Lipkin and scissors linkages are included to exemplify the method.

Test Rig Design for Bending Fatigue Performance Evaluation of Polymer Based Composite Gears

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Test rig for evaluating the bi directional bending fatigue performance of polymer composite gears simulating the actual gear meshing is designed. In the test rig linear motion of servo hydraulic fatigue testing machine is converted into the rotary motion and is used for loading the plastic test gear through steel driver gear. Provision to conduct the tests at different gear roll angle, loading torque and frequency is incorporated in the test rig. The test rig is configured with additional features of monitoring in line torque and angular motion of test gear. Kinematic and kinetic analyses authenticate the utility of the test rig designed.

Study of Kinematic Chains and Distinct Mechanisms

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A new method is proposed to identify the distinct mechanisms (DMs) of a given kinematic chain in this paper. The kinematic chains (KCs) and DMs are shown in the shape of a [JJ] matrix. Two constant numbers calculated with the help of polynomials of the [JJ] matrix are the sum of the absolute values of the polynomial coefficients (SCPC) and maximum absolute value of the polynomial coefficient (MCPC). These constant numbers have been used as the identification code of a KC and DMs and used to determine all DMs of KC of 1-DOF, 8-bar and 10-bars as well as 2-DOF, 9-bar simple kinematic paired KC. This study will facilitate and help the design engineer to choose the best DM to do a specified task in the conceptual stage of design. The suggested technique needs not any test for isomorphism separately.

Conjugate-Wheel Driven 'Staircase Climbing Wheelchair'

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Average human age is increasing, and a common problem that the elderly people are facing, is 'impaired mobility'. In densely populate areas of society; old buildings can't be re-developed just because they are without elevators. So 'Staircase Climbing Wheelchair' is a need of the day, at least in the developing countries. Available designs are not cost effective. This paper proposes a new, innovative, simple but 'Affordable' design of stair-climbing configuration. It uses wheels with their profile similar to a 'Pinion Gear', perfectly conjugate to the staircase profile, treating it as a 'Rack'. Due to the elimination of complicated parts and transmission elements, it is easily adoptable in the wheelchairs.

Loop Based Algorithm for Automatic Sketching of Planar Kinematic Chains

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Methods for systematic enumeration of kinematic chains essentially involves sketching of kinematic chains. Search for a simple and reliable procedure for automatic sketching of mechanisms is still on. In the present work a simple and reliable method, that identifies the joints and loops as the basic constituents of a kinematic chain, is presented. The development and application of the algorithm is demonstrated with the help of several examples.

A Study of Mechanical Advantage in Compliant Mechanisms

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Understanding mechanical advantage of a compliant mechanism is not straightforward for two reasons: (i) it uses a part of the input energy in elastic deformation and (ii) its kinetoelastic behavior depends on the stiffness of the workpiece. In this paper, we study mechanical advantage using non-dimensional analysis of compliant mechanisms. We use parameterized kinetoelastostatic maps that show mechanical advantage against a non-dimensional number that captures geometric and material properties as well as forces. The maps help compare different topologies of compliant mechanisms based on mechanical advantage. The maps also help delineate kinematic and elastic contributions to mechanical advantage. Case studies reveal that while mechanical advantage usually increases with increasing external stiffness and slenderness ratio, but it decreases with increasing gap between the output port and an elastic workpiece. A noteworthy observation in this work is that there can be exceptions to this general trend and that kinematic and elastic contributions can both be positive so that the mechanical advantage of a compliant mechanism can exceed that of a rigid-body counterpart. This work also revisits the fact that it is possible to design a compliant mechanism such that its mechanical advantage is not affected by the stiffness of the workpiece.

Synthesis of Adjustable Offset Slider-Crank Mechanism for Simultaneous Generation of Function and Path using Variable-Length Links

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This paper presents a new method to design an adjustable offset slider-crank mechanism to generate a function and a path simultaneously with the lengths of the input link and the link representing offset (henceforth called offset link) varying, without any limitation on the number of precision points. The mechanism comprises of the original offset slider crank mechanism along with a ternary link, a roller link and a guiding slot in the fixed link for each of the variable-length links. An n-degree polynomial is used to design the contours of the guiding slots, n being the number of precision points. A case study is provided to verify the feasibility of this new synthesis method.

Towards Synthesis of Tensegrity Structures of Desired Shapes

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In this paper, we formulate an optimization problem to synthesize tensegrity structures of desired shapes. In particular, we consider class 1 tensegrity where no two compression elements have a common vertex, by designating all members in the desired shape a priori as either a bar in compression or a cable in tension. We solve static equilibrium equations at the vertices in the desired configuration subject to constraints on force densities, which are the variables in the synthesis problem. The reason for using the force density, defined as the force per unit length in the desired configuration, is twofold: (i) to directly impose constraints of positive and negative force densities in tension and compression elements, respectively, and (ii) to obtain free lengths of all the members using the force densities. We use this method to synthesize a previously known semi-toroidaltensegrity arch with 24 bars and 102 cables and a hitherto unknown tensegrity of biconcave shape similar to that of a red blood cell comprising 24 bars and 112 cables. We also present static analysis of a tensegrity structure by minimizing of potential energy with unilateral constraints on the lengths of the cables, which cannot take compressive loads. We also extend the method to synthesize a tensegrity table of desired height and area with three bars and nine cables under a predefined load. The prototypes of all three synthesized tensegrities are made and tested.

Effect of Change of the Orientation of Dyad Links on Kinematics of Stephenson-III Six-Bar Linkage

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This paper investigates the kinematic analysis and synthesis of a Stephenson-III six-bar linkage. It is proposed here first as a dwell mechanism (Mechanism A) and later as a double reciprocation mechanism (Mechanism B). Out of the various synthesis techniques, use of coupler curves is adopted for the design of mechanism. Same technique also explains the motion of output link during a complete rotation of input crank. This paper presents the effect of change of dyad links orientation on the kinematic performance of the mechanism. Synthesis has been done assuming the oscillation angle of the crank to be 360°. However the angle, through which the output link oscillates, for each revolution of the input crank can be adjusted. This paper also includes a study of the geometry of the path traced by a coupler point. Use of MATLAB 7.10 and Working Model 2D has been incorporated for the purpose of simulation and analysis of the various orientations. Possible applications of the proposed mechanism are later discussed.

Coupler-Curve Synthesis via Multi-Objective Optimisation Using NSGA-II

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This paper presents a study of a classical mechanism synthesis problem in the framework of multi-objective optimisation. In addition to the primary kinematic objective of reducing the structural error, staying away from the singular configurations is considered as a secondary objective. Two wellstudied coupler-curve synthesis problems reported in existing literature are revisited for the purpose of application of the proposed formulations, and the results are obtained using the genetic algorithm-based optimiser, NSGA-II. Detailed analysis of the results show that the Pareto-optimal fronts obtained dominate the existing ones in terms of the secondary objective, while being comparable in the primary one.

Jacobian Based Kinematic and Static Analysis of Over-Constrained Mechanisms with Prismatic and Revolute Joints

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Over-constrained and deployable mechanisms are extensively used in space and in other applications. There is an existing approach which studies the mobility and static analysis of the over-constrained and deployable mechanisms. The main feature of this approach is that the natural co-ordinates are used to define all the constraints present in the mechanisms. The constraint Jacobian matrix is developed by taking the derivatives of all the constraint equations. The null space dimension of the constraint Jacobian matrix gives the degree of freedom of the over-constrained mechanism. A numerical algorithm is used to identify the number of redundant links and joints through the constraint equations. Closed-loop kinematic solutions are found out to ensure that the over-constrained mechanism can be made deployable by actuating only one joint and all other points can be expressed in terms of this actuated variable. In this paper, the existing approach has been extended by implementing the same in an over-constrained box mechanism, where the trajectory of the joints obtained by using the constraint equations has been compared with the trajectory obtained from ADAMS. We have also extended the same approach to static analysis for an overconstrained hexagonal mechanism. The result obtained has been cross checked with that of obtained in ANSYS. Above all the new contributions of this paper is that we have used the approach for studying kinematics and statics of a mechanism having both prismatic and revolute joints which has not been done before. Secondly, the validation of the proposed theory has been done by using the above mentioned commercial packages.

Detection of Fractionated DOF and its Varieties using Modular Kinematics

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Modular kinematics is a recursive scheme which is typically used for kinematic analysis of mechanisms. This paper extends the scope of modular kinematics for efficient structural analysis, namely for detecting if a given planar kinematic chains (KCs) has fractionated degrees of freedom (d.o.f.) or not. Detailed literature survey reveals the availability of the methods based on loops, graph theory, link-link distances etc. The method introduced is reliable in terms of robustness and completeness. Modular kinematics is based on the fact that any KC can be constructed as a sequence of the classes of modules for example dyad, input, floating link transformations and constraint. This construction procedure is termed as module sequence. This module sequence is used in detection of fractionation in KCs. From this module sequence single d.o.f., subchains are identified. The common link between adjacent single d.o.f. subchains gives way to potential separation link, depending on the connectivity data between the links of the adjacent subchains. The method implemented not only detects whether fractionation in a KC exists or not but also gives details about separation link as well as types in fractionation. A new terminology to define order of fractionation is also introduced depending on the number of type of fractionations in the KC. A number of illustrative examples have been shown to explain the method in an efficient manner.

Infinitesimal Mechanisms Analogy for Immobilization

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This paper presents an analogy between a planar immobilized object with point contacts and a platform type first-order infinitesimal planar mechanism. It is proposed that a smooth immobilized object has similar mobility characteristics with the immobilized platform in a first-order infinitesimal mechanism. It is shown that through the classical higher pair lower pair replacement, a first-order infinitesimal mechanism is generated from second-order form-closed pair. Procedure to synthesize immobilized objects from a first-order infinitesimal mechanism is detailed and implementation is shown for two examples. It is observed that for a given first-order infinitesimal mechanism, multiple families of second-order form-closed pairs can be synthesized. A geometrical technique based upon the first-order contact of workspace boundaries of sub-chains of the linkage is used for determining the first-order infinitesimal mechanism configurations .

Booster Attachment Mechanism for Pilotless Target Aircraft

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Pilotless Target Aircraft (PTA) is an unmanned aerial vehicle, which is used as a target for weapon systems like radar guided and heat seeking Surface to Air missiles, Air to Air missiles, shoulder launched missiles, land and ship based anti aircraft guns. PTA is launched from a zero length launcher with the help of a booster. The booster carries high energy explosive, which is highly inflammable. Attaching booster to the PTA is cumbersome and risky job. Three crew were necessary to attach the booster to the PTA, manually. It was quite dangerous for life of the crew to work with such high energy explosive for approximately 10 minutes in not so easily accessible position. The job has become more risky as it is to be carried out at a height of approximately 2.5m from the ground level. To minimise human interference and to provide safety of the crew, a mechanism has been provided. The booster is attached to the inclined PTA using three pins, as before. In this paper, a mechanism is presented which has been successfully designed, developed and presently being used. The straight line mechanism, which is a modified four bar mechanism has been used. In this mechanism, one zero force link has been attached at the midpoint of the crank, to achieve perfect vertical motion. Two more degrees of freedoms has been introduced in the mechanism to obtain the motions of tilting and sliding. The motion is achieved using three hydraulic actuators operated from a distance of 7 m, which is quite safe. The booster is attached using the combined motion of these three actuators. The attachment of booster has thus become very easy and safe by the use of this mechanism.

A Novel Approach for Detection of Isomorphism of Kinematic Chains

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Countless methods are reported to check isomorphism amongst kinematic chains. A novel method for detection of isomorphism and inversions based on theoretic approach, simple to work out and reliable is recommended in this paper. The work offered here is focused on recognition of isomorphic chains with their inversions.

Optimization of Design Parameters for Rotary Tiller's Blade

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Tillage is an operation performed to obtain a desirable soil structure for a seedbed. A granular structure is desirable to allow rapid infiltration and good retention of rainfall, to provide adequate air capacity and exchange within the soil and to minimize resistance to root penetration. Rotary tiller or rotavator (derived from rotary cultivator) is a tillage machine designed for preparing land by breaking the soil with the help of rotating blades suitable for sowing seeds (without overturning of the soil). Nowadays, utilization of rotary tillers has been increased in agricultural applications because of simple structure and high efficiency for this type of tillage implements. By taking advantage of rotary tillers, the primary and secondary tillage applications could be conjugated in one stage. This results in a decrease in the number of machinery passes, causes a decrease overall costs for land preparation. However in a rotary tiller, blades are the main critical parts which engaged with soil to prepare the land. These blades interact with soil in a different way than normal plows which are subjected to impact and high friction which ultimately creates unbalancing and non uniform forces on the rotary tiller which results wearing of the blades as a whole. The continuous fluctuating impact of soil crust / clods / stone develops high stress areas on blade tip or blade critical edges. Therefore, it is necessary to optimize the design of blade so that these blades experience less stress thereby reduces the wear. Thus an "L" type blade for tractor drawn Rotary tiller or Rotavator was designed and developed. Computer Aided Design package for designing of the blade and ANSYS programming was used for the simulation and optimization of the blade. Based on the simulation results optimized design of blade through was suggested

Design and Analysis of an Orthotic Device with Torque Reducing Mechanism for Knee Joint during Normal Walking

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An orthotic device is used to assist movements of the patients having physical disabilities. The objectives of this study are to develop an analytical model of kinematics and dynamics of human walking, and to design an external orthotic device for assisting patients with impairment at knee joint. A mechanism is incorporated with this device, which will reduce the knee joint torque during walking. The values of knee joint torque and power consumption are determined for two cases, with and without the torque reducing mechanism. Results have been verified using solid-works. For maintaining the stability of the human body while walking, loci of Zero Moment Point and Dynamic Balance Margin are also obatined. For the orthotic device with mechanism, a reduction of 92% in maximum torque is obtained in comparison to the device without any such mechnaism. Thus, a novel design of an optimized orthotic device has been obtained with the above torque reducing mechanism.

Dimensional Synthesis of Three-point Hitch Linkage System of Tractor – An Approach Based on Maximizing Mechanical Advantage

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Non-dominated Sorting Genetic Algorithm (NSGA-II) was applied to identify the improved design solutions to three-point hitch linkage system of a tractor by formulating the optimal dimensional synthesis as a constrained multi-objective optimization problem. Objective functions were developed to maximize the mechanical advantage of the driving mechanism of the linkage system, minimize the deviation of mechanical advantage from its mean value throughout the movement range and obtain the transport pitch in the vicinity of 8º. Length of lift arm and lower link, spatial location of pivot point of lower link, and distance of lift rod connection point on the lower link from the pivot point of lower link were taken as the design variables. The values of all the design variables were initialized and constrained within the range of values existing in the commercially available tractors. The constraints imposed by the governing standards were applied. The algorithm was implemented in MATLAB with path generation program for the hitch points as the sub-function. Ten best design solutions were identified, of which 8 solutions were found to be superior to the existing design of hitch. The optimal dimensional synthesis of three-point hitch linkage system by NSGA-II was found to be fast, flexible, efficient and better than manual search of optimal solutions.

Link Invariant Functions and Detection of Isomorphism and Inversions of Kinematic Chains

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Detection of isomorphism and inversions are two closely associated problems encountered during structural synthesis and analysis of kinematic chains. Most of the solutions presented in the literature are based on adjacency matrices or their modification. Studies incorporating other aspects such as distance matrix and loops are limited. Present work defines link invariant functions based on distance matrix and loops of a kinematic chain. The functions generate a set of structural invariants capable of detecting distinct links of a kinematic chain and isomorphism between kinematic chains simultaneously. Proposed heuristic takes into account all aspects of kinematic chain at once, satisfying necessary and sufficient conditions. The method is simple, reliable and can easily be implemented on a computer. It has been tested successfully on known cases of kinematic chains up to 10 links and having 1, 2 and 3 degrees of freedom. An exampleof chains with higher number of links is also presented to demonstrate the effectiveness of the method.

Kinematic Analysis of the Double Wishbone Suspension System

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The double wishbone suspension is used commonly in high performance vehicles due to its superior kinematic response. However, its kinematics is very complicated, and to the best of the authors' knowledge, no reported analysis of the same for the full spatial model of the suspension exists in literature. This paper presents such a solution, building upon two key elements in the formulation and solution stages, respectively: the use of Rodrigue's parameters to develop an algebraic set of equations representing the kinematics of the mechanism, and the computation of Groebner basis as a method of solving the resulting set of equations. It is found that the final univariate equation representing all the kinematic solutions for a given pair of steering and road profile inputs is of 64 degrees – which explains the complexity observed in the kinematics of the mechanism. The real roots of this polynomial are extracted, and the solutions to the kinematic problem are computed for a particular set of inputs for the sake of illustration of the proposed formulation. The numerical accuracy of the solutions is verified by computing the residuals of the original set of kinematic constraints. The configurations of the mechanism for the real solutions are shown graphically.

On Embedded Recursive Boundary Smoothing in Topology Optimization With Polygonal Mesh and Negative Masks

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Topology optimization with polygonal meshes is promising since checkerboards, point-flexures, layering and islanding like singularities get circumvented by the natural imposition of the geometric, 'edge-connectivity' constraint. However, numerous notches get retained on the boundaries of optimal topologies obtained from polygonal tessellations. Previous efforts on Material Mask Overlay Strategy (MMOS) that used hexagonal cells and negative masks have either ignored boundary smoothing, have used it as a post processing step, or have implemented it between the gradient and stochastic searches. Here, we embed boundary smoothing within each iteration of gradient search permitting true evaluation of the objective and the associated sensitivities for all intermediate topologies. Smoothing is performed in a number of steps (represented by parameter β) by systematically shifting the nodes at the boundaries of the continuum. Consequently, some hexagonal cells get degenerated which necessitates their remodeling into Wachspress pentagonal or quadrilateral finite elements to avoid singularity of the stiffness matrix. Material assignment to each cell is accomplished using the logistic function with high values of the material parameter, α approximating the Heaviside function to yield close to binary solutions. However, initial use of high material parameter destabilizes the MMOS since the design sensitivities approach to zero. For stability, α is increased gradually from 1 to an a priori specified value α_s. Compared to its predecessors, the modified algorithm shows promise in terms of quality of solutions obtained in least possible number of function evaluations.

On the Novel Compliant Remote Center Mechanism

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Remote center motion (RCM) mechanisms provide manipulation over a circular arc about a distant center point. Different techniques to achieve such RCM can be classified as those providingeither a virtual RCM or a real mechanical RCM. The mechanical RCM mechanisms are being used for minimally invasive surgery that imposes constraints on the end effector or surgical tool motion. In this paper, we propose a novel design (Patent file no.: 187/MUM/2013) which uses compliant links to generate the desired real RCM. Challenge involves generation of real RCM in such a way that the cross axis stiffness is very high as compared to the desired rotation stiffness with high accuracy in maintaining the RCM. The proposed compliant remote center motion mechanism (CRCMM) is conceived with angular arrangement of twocompliant links connected to a motion stage. Under the applied force, this arrangement makes the links undergo simultaneous bending and twisting which results in the desired RCM. Extensive non-linear FE analysis is carried out to demonstrateaccuracy of the RCM for the case under consideration. Further the mechanism is fabricated and preliminary experiments are carried out.

A Comparative Study of Various Methods for Identification of Isomorphism in Kinematic Chains

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Study of isomorphism of kinematic chains has found a lot of attention on the part of kinematicians during last couple of decades. Isomorphism identification is very important with a view point in saving time and doing correct synthesis and analysis of mechanisms. A lot of methods are available in literature for the identification of isomorphism among chains and inversions but each method has its own shortcomings. Some of the existing methods for identification of isomorphism among kinematic chains and among inversions of given kinematic chain have been critically studied and applied for identification of various structural properties. These methods have been compared with the illustrations of Watt and Stephenson Chain and rating factor from 0 to 5 has been given from the point of view of various attributes, in order to select the best method for identification of isomorphism among chains and inversions of a chain. The final rating for different methods is presented graphically and from this rating, it has been concluded that the method with the highest total rating may be considered as the best method for isomorphism identification. Also, the inner relationship between different methods compared has also been established.

Comparative Evaluation of Particle Swarm Optimization Algorithms for the Optimal Dimensional Synthesis of Planar Four-bar Mechanism

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This paper presents the application of Particle Swarm Optimization (PSO) and its variants to the dimensional synthesis of 5 coupler paths described by 11 to 25 precision points. Minimization of the structural error and degree of constraint violation were taken as the objective functions. In addition to basic PSO, stretched PSO (S-PSO), near neighborhood information based PSO (NNI-PSO), gregarious PSO (G-PSO) and hybrid PSO with differential evolution operator (DE-PSO) were also applied. The results revealed that the performance of DE-PSO is superior to basic PSO and all other variants for the dimensional synthesis. Comparison of the results with other soft computing technique for the dimensional synthesis indicated that the DE-PSO can be effectively used for the dimensional synthesis of four-bar mechanism.

PAPERS ABSTRACT: MECHATRONICS

Design and Development of Automatic Stirrup Bending Mechanism

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In the construction of any structure major work is done by labour. In column or beam there are many horizontal and vertical rods to support the concrete, they are required to be tied together so that they give enough strength to the structure. Square or any trapezoidal shape stirrups are used to tie rod together by means of tight wires. In small construction sites workers bend stirrup using traditional way. There is no other way to make stirrup with less human effort. And for this reason automation is required which is the objective of the project presented. It is possible to decrease construction lead time with increase of the stirrup bending rate by automation only. Here an attempt is made to design and develop an "Automated Stirrup Bending Mechanism" (ASBM) using the principles of hydraulics and electronics. Its use reduces a lot of labour cost, effort and construction lead time and production of various sizes of stirrup and accuracy increases.

Modeling of Electro-Hydraulic Servo Valve and Robust Position Control Using Sliding Mode Technique

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Electro-hydraulic servo valve plays vital role in control of systems which are controlled hydraulically. A detailed mathematical model of a hydro-actuation system is developed using first principle approach. Dynamics of electro-hydraulic systems is highly non-linear. Moreover it is subjected to parametric perturbations which hamper the performance of controller. PID controllers do not ensure robust performance in presence of these complexities. A sliding mode control is investigated to ensure robustness. A new sliding surface is proposed. Controller is developed using Gao's reaching law. The method is validated in simulations.

Q Learning Based Reinforcement Learning Approach to Bipedal Walking Control

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Reinforcement learning has been active research area not only in machine learning but also in control engineering, operation research and robotics in recent years. It is a model free learning control method that can solve Markov decision problems. Q-learning is an incremental dynamic programming procedure that determines the optimal policy in a step-by-step manner. It is an online procedure for learning the optimal policy through experience gained solely on the basis of samples. A Q learning based reinforcement learning of a double inverted pendulum has been shown in this paper which reaches a limit cycle at the end of several learning cycles. The double inverted pendulum becomes stable, since the pole angle and pole angular velocity become zero. Stabilization of an equivalent double inverted pendulum representing a bipedal robot has been successfully implemented for balancing the pole angles in the required range using Q learning in Reinforcement Learning.

Performance Analysis of Different Controller for a 2 DOF Electro-Hydraulic Motion Simulator

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In the present work a two degree of freedom (2-DOF) electrohydraulic motion simulator platform has been developed. The heave motion of the platform has been controlled by a real time controller. Three different types of controller, namely proportional integral derivative (PID) controller, Hybrid Fuzzy-PID Controller and self-tuning Fuzzy-PID controller have been designed. The real time control performance of the controllers has been studied for 0.05m, 0.1m and 0.15m step demand. In order to achieve the required performance of the controller, suitable values for the control parameters are tuned by different method for different controller. The self-tuned Fuzzy-PID controller shows best control response compare to PID and hybrid Fuzzy PID controller.

Color Guided Vehicle – An Intelligent Material Handling Mechatronic System

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Industries established earlier were using material handling systems which were time consuming, less efficient, demanded more manpower, which ultimately increases the manufacturing lead time. As a result of that, productivity reduces. To overcome these demerits, industries need an efficient system, which can be automatically controlled. Such concept has been demonstrated in this paper. Vehicle has been developed by using concepts of electric drives, ElectroPneumatics, machine vision, microcontroller (Arduino) and Zigbee wireless module. For human machine interface, Matlab GUI toolbox is used (windows 8 touch screen) in this paper. The color guided vehicle (CGV) will convey the object to the desired destination according to its color. Moreover the undesired object will be rejected instantly by pneumatic system. Such a vehicle or a system works as a color detector automated guided vehicle. Therefore here developed CGV can be considered as an intelligent material handling Mechatronic system.

Optimization of Size Parameters for Interconnected Pneumatic Cylinders Positioning System

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Servo pneumatics is a mechatronic approach that enables accurate position control of pneumatic drives with high speed. In this paper, a new method of position manipulator with two interconnected pneumatic cylinders is presented. Nonlinear mathematical model of the system comprising of mass flow rate, pressure dynamics, frictional forces and motion dynamics has been formulated. Using Matlab-Simulink software the system is simulated. The size parameters are optimized using Taguchi method for minimization of settling time. It is found that the area of the cylinders have more significance in efficient positioning of the system than length of the cylinders.

Simulation of Haptics Force Law using SimMechanics and Simulink

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Haptic devices are special robotic devices that convey interaction forces from the virtual reality environment to the human operator. Since the human operator holds the device for interaction, ensuring the stability of these systems is very important. In this paper we present our work in analyzing and identifying the stability bounds of these haptics systems, namely the Z-width, specifically for multi-DOF (Degrees of Freedom) systems. Multi-DOF systems are usually modelled with complex dynamic equations. We utilized the features of SimMechanics and Simulink toolboxes of MATLAB for generating the dynamic model of these systems. In addition to the basic stick modelling feature in SimMechanics, CAD model of a real 2-DOF haptic device was imported to SimMechanics environment. A virtual wall interaction with the 2-DOF haptic device was modeled using the basic modules available in Simulink. The complete haptics environment including components like quantization of encoders, sampling rate of the controller, device friction, velocity estimation and filtering was realized for a realistic haptics force law simulation. The proposed implementation enabled us to study the effect of various components like virtual damping, encoder resolution, sampling rate etc. on the performance and stability of a haptics control loop.

Teaching Mechanism Dynamics using a Haptic Device

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Haptic devices play a significant role in conveying physical feeling of real objects through their computer simulation with force feedback. Apart from their standard applications in medical surgery, gaming, entertainment etc., teaching dynamics and control with haptic devices has been gaining popularity. Educational haptics has been recognized as an effective method to improve the understanding of a learner about the physics of a system, say, a mechanism, which does not exist in reality or is difficult to realize physically. The effect of change in inertial and kinematic properties of the mechanism is reflected and conveyed to the learner in the form of torque at the actuated joints. In this work, we demonstrate how a simple low cost 1-DOF (Degree of Freedom) haptic device can be utilized in teaching a typical course on dynamics of mechanisms. The methodology can be extended to higher-DOF systems as well, to understand the effect of kinematic and inertial properties of actual mechanisms, even though they do not physically exist.

Development of Monocular Vision based Targeting System for an Autonomous Defence Vehicle

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The present work deals with development of a Target tracking system based on Monocular Vision for an Autonomous Defence Vehicle without a global satellite view. The vehicle is also equipped with ultrasonic sensors to gauge distance from the target at any point of time. In this work, theoretical expressions have been arrived at for control of motors for accurate capture of target without image capture of the targeting pointer itself. This can greatly reduce the costs as the high resolution cameras required for capture of targeting pointer (generally a LASER pointer) are very costly. Theoretical expressions have also been determined for the approach distance in dependence only on camera, motor specifications and the target size. A prototype system was developed along with the necessary real time embedded controller and image processing algorithms for identifying the target and to control targeting system LASER pointer. Experiments were conducted to find out efficacy of developed system. The system is able to detect the target on different approach distances and camera cone angles. It should be noted that the target size will also be calculated on the fly by the robot itself. This makes it possible for deployment of this targeting module without much change to the existing system.

PAPERS ABSTRACT: ROBOTICS

Neuro-Registration and Navigation Unit for Surgical Manipulation

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The paper deals with the synthesis, development and implementation of a neuro-surgical registration unit for neuro-surgical procedures. The neuro-surgical registration unit consists of a portable Surgical Co-ordinate Measuring Mechanism (SCMM), a 3 DOF spatial parallel robot and the related imaging and graphic components. A portable SCMM is developed and demonstrated for registration of the anatomical spatial points and for carrying out neuro-navigation procedures. The fiducial based registration and surface based registration procedures using SCMM are described. The accuracy of the SCMM unit is analyzed. Further the advantage of the SCMM over current practices in navigation is discussed. Also, a 3 DOF spatial parallel robot developed in the author's laboratory is used to perform a robot based neuro-navigation. Imaging and graphic modeling components for SCMM based neuro-navigation and robot based neuro-navigation are developed.

Kinematic Analysis and 3D Workspace Development of 3DOF Parallel Manipulator with a Rotary Base

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This paper presents the systematic methods to deal with kinematic analysis of 3-PRS configuration parallel manipulator involving non-linear simultaneous equations. Using the loop closure constraints, three coupled equations are formulated using configuration of the manipulator. Bezout's resultant and Sylvester method are used to determine roots of three non-linear equations. The tilt of the moving platform is measured with respect to fixed base for single prismatic joint actuation or any combination of these three joints actuations. The maximum tilt of moving platform for the proposed configuration is also computed for limited range of joints. Tool tip coordinates are determined using vector approach with reference to established coordinate system on the base platform. Jacobian matrices are derived for active and passive variables for singularity determination. Using tool tip coordinates for various combinations of linear actuations as point cloud, workspace for 3 – DOF parallel manipulator is developed.

Realizing Positive Gait Stability of a Quadruped Robot Walking on Sloping Surface

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A fault-tolerant gait planning of a quadruped robot is presented. The considered robot has static walking and suffers from a locked joint failure. Especially, the quadruped robot is equipped with the moving appendage onto the body. By controlling the moving appendage, the robot can adjust the effective position of the center of gravity. Incorporating the adjustment of the moving appendage along the leg and body sequence, the fault-tolerant gait can have positive stability margin. Based on gait study, we address theoretical analyses on the proposed fault-tolerant gait planning for the quadruped robot to walk over a slope. We also conduct 3D simulation studies on a synthetic quadruped robot to show the applicability of the proposed scheme.

Virtual Robot Simulation in RoboAnalyzer

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Robotics is an important area not only in research and development but also from the perspective of industrial automation. As a result, increasing number of fundamental and advanced level robotics courses are being introduced in the undergraduate and postgraduate curricula, particularly in Mechanical and Electrical engineering streams. Robot kinematics is the cornerstone of such courses and it is equally challenging for teachers to teach as well as students to learn, as the concepts such as Denavit-Hartenberg (DH) parameters, robot kinematic and dynamic analyses, trajectory planning, etc. are difficult to understand. Various robotics learning software and tools have been developed by researchers around the world. One such attempt is made here to develop software called RoboAnalyzer. It can show animated DH parameters and performs forward and inverse kinematics, and dynamic analyses on serial robots. In this paper, a new module named "Virtual Robot Module" is reported which consists of 17 CAD models of commercially available industrial robots. Joint-level and Cartesian-level jogging can be performed on these robots. Relative and absolute motion of the end-effector can be achieved in the Cartesian space by controlling the position as well as the orientation of the end-effector. RoboAnalyzer software is freely available for academic purposes from http://www.roboanalyzer.com, and can be used by teachers and students almost instantly. It has a very easy to use interface and lets the user start learning the robotics concepts directly rather than learning CAD modeling, assembly modeling and then simulate a robot, as done using any commercial CAD software such as ADAMS, RecurDyn, Autodesk Inventor, etc.

Design and Synthesis of a Four Fingered Articulated Dexterous Robot Hand

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The human hand with more than twenty seven Degrees of Freedom (DoFs) has a unique musco-skeletal structure with neuro-sensory attributes under control of CNS, is a quintessence to construct a robotic hand. The fingers are connected to the palm with metacarpophalangeal (MCP) joints. These joints have two DoFs i.e. flexion-extension and abduction-adduction whereas the remaining two joints of the digits have only one DoF. Literature survey divulges that, while constructing a robotic hand, mostly the abduction-adduction at MCP joint is discarded for simplicity. This paper is aimed at development of a mechanism that encompasses both flexion-extension and abduction-adduction for all the three fingers located on the palm opposite to the thumb, whereas the thumb has been separately designed to impart both the radial and palmer movements with respect to the palm as well as flexion and extension, thereby imparting greater compliance to the system, to cope up with wide variety of tasks.

Second Order Sliding Mode Control for Single Link Flexible Manipulator

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This paper presents a second order sliding mode control (SOSMC) for a single link flexible manipulator, which represents a class of under actuated systems. A second order super twisting algorithm (STA) is used to provide better positional accuracy and robustness against parametric variation and external disturbances with alleviation in chattering. A smooth control is synthesized using STA to exploit the robustness properties of sliding-mode controllers to ensure finite time convergence of the states. The flexible manipulator is actuated by a DC motor and the flexibility of the link is modeled as a linear torsional spring with stiffness. Comprehensive comparison between sliding mode control (SMC) and SOSMC is done in this study to show the effectiveness of the proposed strategy.

Dynamic Gaits and Control in Flexible Body Quadruped Robot

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Legged robots are highly attractive for military purposes such as carrying heavy loads on uneven terrain for long durations because of the higher mobility they give on rough terrain compared to wheeled vehicles/robots. Existing state-of-the-art quadruped robots developed by Boston Dynamics such as LittleDog and BigDog do not have flexible bodies. It can be easily seen that the agility of quadruped animals such as dogs, cats, and deer etc. depend to a large extent on their ability to flex their bodies. However, simulation study on step climbing in 3D terrain quadruped robot locomotion with flexible body has not been reported in literature. This paper aims to study the effect of body flexibility on stability and energy efficiency in walking mode, trot mode and running (bounding) mode on step climbing.

Reconfigurable Mechanism for Mobile Robotic Platform

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Future planetary exploration missions will require mobile robots which are able to carry out highperformance locomotion tasks. The robotic platform should be able to move between areas of interest quickly and safely. Improvement of robotics and or robotic movement is a continuing pursuit. Wheeled transportation can be characterized by greater efficiency or speed, while articulated leg transportation can be characterized by greater flexibility for movement over complex terrain. Wheels can rotate quickly, but can have difficulty on uneven terrain, while articulated legs can negotiate the uneven terrain, but can have difficulty with speed. Such wheeled transport can have limited mobility and behavior due to complex environment and lack of adaptability to unpredictable terrain. There exists now an interest for a new type of vehicle which inherits both advantages of legged and wheeled vehicles, namely the high adaptive capabilities of legs and the high velocity and payload of the wheels. In order to deal with the rough terrains of planetary surfaces, researchers put most of the efforts in designing new structure of rover body, but give less attention to new types of reconfigurable mechanism for wheels and trailing link (utilized in two wheeled robots). In this paper, “Singrauli 1.0”, a novel reconfigurable mechanism for “Elan Robot”, is proposed. This reconfigurable mechanism combines two elementary mechanisms. One is responsible for expanding the wheel and the other one for ensuring sufficient elongation of trailing link to maintain the stability of the robotic platform while encountering uneven terrains and negotiating stairs. This proposed reconfigurable mechanism “Singrauli 1.0”, is a single degree of freedom mechanism. Reconfigurability enhances mobility capability in different terrains. “Elan Robot”, utilizes perfect circular form as wheel with conventional width for travelling over even surfaces and also utilizes expandable wheel form for travelling over uneven surfaces. Proposed Elan Robot can move steadily and turn around agilely. Thanks to its novel reconfigurable mechanism which enhances the locomotion performance and enable robot to climb steps or hurdles whose height is almost four times higher than the radius of the robot’s wheel. And, there is no resistance in between wheel tracks while expanding the wheel diameter.

A Novel Modular Strategy for the Fabrication of Robotic Manipulators Based Upon Task-Based Designs

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A modular fabrication strategy for the development of customized robotic arms is proposed in this paper. With increasing variety in robotic applications, the concept of task-based customized design is expected to play a big role in deployment of robotic arms for the required jobs. Many manipulator design strategies have been presented. However, there remains a challenge of fabricating the manipulators – possessing the configurations and the parameters resulting out of the design process. This paper presents a strategy for modular development of arms. The novelty of the strategy lies in the aspect that the modules possess adaptable robotic parameters – to adjust the size and connecting angles of the modules according to the requirement. Given the degrees of freedom of the manipulator and the link and the joint parameters (D-H parameters in this paper), the modules are configured and assembled to develop the required manipulator. Assemblies of the modules for two standard configurations are presented in this paper to demonstrate the proposed strategy.

Delay Handling for an Adaptive Control of a Remotely Operated Robotic Manipulator

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This paper presents a time delay analysis of an adaptively controlled two link rigid Revolute-Revolute joint type manipulator when the device is remotely triggered or controlled. Such a manipulator could be connected to the internet and is controlled by a remote user through an internet server. However a delay is produced when the feedback signals reach the controller at the user's end. This delay is often found to severely pull down the accuracy of the manipulator in terms of its ability to execute a trajectory. The deviation from the desired to the drawn trajectory in this paper is calculated using the Hausdorff metric. Analysis with several values of delay clearly depicts an increase in inaccuracy of the output with increasing delay. The variation of the Hausdorff error with changes in control parameters of the system is also described. It is found that there exists a critical delay value above which the system practically fails to complete the objective. The dynamic equations of motion of the system have been formulated using the Lagrange-Euler method. A PD feedback controller is used for control. This analysis and determination of the critical delay is crucial for remotely triggered devices and will find application in the control of tele-robots.

Design and Development of a Spherical Robot (SpheRobot)

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The research on mobile robots has been started in the last century and still advancements in different domains, such as locomotion principles, mechanism, control, sensing etc. are going on. Mobile robots use rolling, walking, flying, hopping, swimming, as means of locomotion. To implement these locomotions, apart from the actuators (i.e. motors, thrusters), limbs (wheels, legs, fins) have to be associated to generate the motion. Only in case of rolling, limbless locomotion is being used. Rolling can only be generated by rotation of a sphere. This has been used for the development of Spherical Mobile Robots. Obviously the other control and sensing accessories, power supply are to be confined within the sphere. Spherical Mobile Robots have the strong advantage of their shape offering rigidity, robustness, non-invertible, travel over rough surfaces and ease of locomotion. This paper deals with the design and development of a spherical robot (termed as 'SpheRobot') using the principle of inverted pendulum. The work has been supported by approximate mathematical modeling, analysis and experimentation. A wireless camera has been mounted on a Gimbal system inside the SpheRobot. The images are transmitted to the command station for monitoring. Presently the robot is being controlled remotely. Work is in progress to introduce autonomous mode with the help of non-contact type sensors.

Kinematic-Chain of an Industrial Robot and its Torque Identification for Gravity Compensation

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In this paper, an experimental method is proposed to identify the relationship between the actuator space and joint space of an industrial robot, KUKA KR5. The mathematical model in the form of matrix relating the actuator and joint space is termed as "structure matrix". This matrix is useful in identifying the robot's architecture for the transfer of motion. Further, the torques required to balance the robot against gravity was identified through Fourier series fit. For that, only the joints that are orthogonal to the gravity direction were considered as they influence the most. The identified joint torques were validated by considering different trajectories than those used to identify the necessary coefficients of the Fourier series.

Variable Impedance Actuator with Exponential Elasticity for Flexible-Joint-Robot and Estimation of the Joint Impedance

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New generation robots, meant for physical human robot interactions, are no longer rigid; it has become soft in terms of introduction of considerable flexibility at the actuated joints, flexibility of the links and in terms of compliant coverings. Safety requirement becomes primary in situations where physical interactions occur, calling for compliance; but accuracy and control bandwidth get compromised. While it has been established in literature that flexible-link-robots are difficult to control, it is found feasible to recover some of the lost bandwidth by varying stiffness in flexible-joint-robots, maintaining safety of human during interaction. This article addresses development of such a flexible robot joint actuation system with stiffness/impedance variability. This variability of stiffness is achieved passively by the flexible transmission interposed between the prime mover and the actuated link, and in doing so, nonlinearity in the elastic transmission characteristic becomes essential. The Variable Stiffness Actuation (VSA) system of this article employs an elastic element having an exponential force-displacement characteristic, which has the property of stiffness varying linearly with transmission force. This property is favourably utilized in the estimation of stiffness, and in turn can be used in control of stiffness. The variable stiffness actuation is realized here by assembling two transmissions in agonist-anatagonistic arrangement in order to achieve simultaneous control of both joint-motion and stiffness, resembling biological musculo-skeletal system. By adding nonlinear damping elements in parallel to the elastic transmission, variability in mechanical impedance has been achieved. Joint stiffness is computed with the estimated stiffness of individual transmissions, which are obtained experimentally. Extended Kalman Filter is employed for the estimation of stiffness and other impedance components. Results are reported in support of the effectiveness of the joint actuator in achieving variability in stiffness and impedance and their estimation.

A Simple Design Approach for an Electro-Hydraulic Stewart Platform through MATLAB Simulation

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A Stewart platform has been designed by selecting commercially available components. Each of its six legs has spherical and universal joints respectively at the bottom and top ends of a piston-cylinder arrangement with the piston rod protruding out of the cylinder top. By a universal joint at the cap end at the bottom of each cylinder, the legs are mounted on a fixed horizontal frame. By electrical actuation of the valve for each cylinder, a six-DOF motion could be imparted to a cylindrical payload fixed on a circular disc. The motion is transferred through a spherical joint fitted between each piston rod and the disc. Corresponding to the specified payload pose range from its horizontal neutral, the inverse kinematic model has been used for simultaneously searching the piston stroke, the distance between the frame and the disc along with the locations of the joints, assuming each type arranged in a semi-regular hexagonal pattern. The discharge and pressure of a power pack feeding all the cylinders have been estimated by Matlab simulation of the inverse dynamic model for different velocity, acceleration and weight of the payload.

A Strategy for Finding a 2D Stable Grasp and Learning

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The paper aims at providing a strategy for a stable planar grasp of an object and using an evolutionary algorithm to learn grasping of the same object of different dimension by a three finger robotic hand. Stability in robotic grasping of an object is a big issue. Lot of research has been done in the field of stability of a robotic grasp, both theoretical and experimental. This paper theorizes the stability parameters that can be applied in practice with ease. The stability parameters are basically a subset of the parameters proposed by earlier researchers. A computer program has been written in MATLAB to implement the algorithm developed for grasp stability. The output of this program is the coordinates of the stable grasp in 2D around the periphery of the object. Further, two more programs have been written to help the three finger manipulator to learn how to reach the stable grasp points from its current position. Among the two programs the first one generates data within the work envelop of the robot in the Cartesian space and joint space. These data is used to train the neural network. The final output of the combination of these two programs is the coordinates in the joint space. If the size of the object is changed keeping the shape same we have to scale up or down the relative position of the grasping points keeping the finger orientation same.

An Integrated Computer Vision Based Approach for Driving Assistance to Enhance Visibility in All Weather Conditions

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One of the key element to increase road safety for surface transport operation is to provide new technological aids to improve the visibility condition across rail and road network. As such both the environmental and human factors are to be considered to achieve higher safety. This paper primarily focuses on a computer vision based solutions which can improve operational capability of road and rail transport under all weather conditions. This paper, therefore presents a new physics-based model in the form of transfer function for predicting the environmental degradation to the captured image, as light travels from a source to an observer. This model can essentially compute the variations in environmental irradiance and airlight model used for study of atmospheric scattering in the form of a transfer function. The model is valid for various weather conditions including fog, haze, mist and rain. This model has capability to recover from a single image source the area of maximum attenuation and restoring the contrast of the scene. In addition, the weather condition and the visibility level can be predicted using this approach.

Force-Torque Interpretation in Intermediary Telepresence for Remote Manipulation

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The paper presents force-torque interpretations in intermediary telepresence for remote manipulation. Methods of reconstruction of force-torque data and algorithms to depict contact forces are presented in this paper. Real time force trajectory, the accuracy of the force trajectory and the state of the remote site in terms of wrench state are also described. In addition, options to take corrective steps in case of remote manipulator malfunction or unforeseen forces acting on the environment are discussed. Experiments are conducted to demonstrate the contact perception of remote manipulation tasks.

Self-Calibration of a Camera Equipped SCORBOT ER-4u Robot

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This paper introduces an experimental selfcalibration method for a SCORBOT ER-4u robot manipulator using stereo vision. Here, we make use of a ground-truth scale in the reference frame to achieve self calibration instead of external expensive calibration apparatus. A set of stereo images captured by a camera which is attached to the robot endeffector is used as input of the algorithm. These images contain the pose of the robot end effector (with all joints) when it is moving on a predefined trajectory. A each measurement, these poses are estimated up to a scale factor with Hartley's factorization method to improve the robustness of the system. Simulations results are obtained by using the proposed model for a number of trajectories. For simulation purpose, a program MATLAB 7.12.0 is used for the given set of parameters. Moreover, experimental studies by ViewFlex software for the calibration of a SCORBOT ER-4u robot (a vertical articulated robot, with five revolute joints, stationary base, shoulder, elbow, tool pitch and tool roll) are carried out. Finally, experimental and simulation results are compared to check the validity of the proposed algorithm.

Adult-Human Learning on a Robotic Wheelchair Using a Force Feedback Joystick

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Individuals with mobility impairments often find it challenging to use powered wheelchairs even after being given training. The motivation of this research was to study the effects of robotic wheelchair with force feedback joystick on adult-human learning behavior. In this study, healthy adult subjects were asked to follow a training path while driving a robotic wheelchair using a force feedback joystick. 'Assist as needed' paradigm was used to calculate the feedback force in order to train the user necessary driving skills for a particular trajectory. Two trajectory tracking algorithms, the line following and the point following, were implemented to drive the robot. The training protocol included pre-training, training and post-training sessions for each controller group. Driving skill improvements were observed using the line following trajectory tracking controller.

Input Shaper Design for Planar Parallel Manipulators

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The ever increasing demands on accuracy and faster response pose control challenges that are difficult to realize. Though advanced robust controllers can help address such demands to some extent, in reality actuator saturations and control limits can cause stabilized or sustained oscillations. In such scenarios, feed-forward methods and in particular input shaping (IS) seem to offer a valuable and cost-effective way for suppressing the residual vibrations [1] without major modifications to an existing system. Such schemes are found to be successful for a variety of (simple to complex) applications in flexible manipulators, gantry cranes etc [2], [3]. In this work, our focus is on the extending the traditional IS methods to constrained articulated multi-body systems (AMBS), specifically, for parallel manipulators (PMs) having revolute actuators. We present analytical formulation of linearized dynamic equations for a 5 bar (or 2-RR) and numerical computation of dominant mode frequency and eigenvalues of these systems. Dynamic simulation and IS control of the planar PM were subsequently carried out for simple point-to-point trajectory tracking problems. The corresponding results for shaped and unshaped inputs indicate considerable improvement in suppression of residual vibrations and were evaluated using reduction of maximum overshoot in position and torque inputs, settling time and percent residual energy as performance measures.

Robonwire: Design and Development of a Power Line Inspection Robot

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This paper presents a design of a low-cost, lightweight powerline inspection robot:Robonwire. Though commercial and research robots for inspecting and monitoring powerline are available, the weight of the robot is high and it requires a lot of human effort during set-up and operation. We focus on developing a laboratory scale robot for power line inspection. The robot has three arms and a base frame which houses the electrical and electronic elements to control the locomotion and avoiding obstacles. It uses three powered motors with wheels one for each arm providing the mobility of the robot on the wires. Each arm has two joints. The upper joint connects the arm body to the wheel assembly while the lower one connects the arm body to the base frame. The obstacle avoidance is achieved by lateral rotation of arms in sequence. This paper presents the initial phase of the development in which a robot is built for travelling on wire. The motion planning for obstacle avoidance and simulations for torque requirement analysis of joint motors are also presented.

Potential Function Based Formation Control of Mobile Multiple-Agent Systems

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In recent years, a great deal of interest has been focused on the control of mobile multi-robot systems. The primary reason for this interest in mobile multi-robot systems within the robotics research community is that such systems hold several advantages over single-robot systems. For example, these systems have the capability to quickly explore a large area, and for transporting heavy objects which may exceed the capacity of a single robot. One method of accomplishing these and other tasks is by controlling the formation of the system. In the research reported in this paper, the formation of a group of differential drive robots was controlled using a potential field strategy. Control methods were designed incorporating potential functions, and the results were validated in a physical arena. A group of three Khepera-II mobile robots was deployed using an OptiTrack motion tracking system, and experiments were successfully conducted to transport a box along the length of an arena, and to change the formation to avoid obstacles while maintaining group cohesiveness.

PAPERS ABSTRACT: TRIBOLOGY

A Review on the Excavator Tool Bits Wear

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In recent years, application of road-headers, continuous miners and shearer has increased tremendously for the excavation purposes. The performance of these machines depends on the cutting performance and tool life of the picks used for cutting purpose, which may be conical, chisel or button shaped. The tool life of these bits is limited by its wear rate. Wear rate of individual bits depend on its design, its position and orientation on cutting drum, tool material and rock material. Wear is destruction to a surface as a result of comparative motion with respect to another object. Wear may be occurred by adhesion, abrasion, fatigue and oxidation depending on the cutting condition and environmental factors. As a general rule, it is not possible to nullify the tool wear but it could be reduced to a certain level by controlling the different factors responsible for the wear. A lot of research work, mostly experimental, pertaining to the tool bit shape and its wear has been reported in the literature since last four decades. Now a day's lot of research is going on to reduce the tool bit wear in order to enhance the excavation machine performance. In this paper, an attempt has been made to systematically organize the research work carried out on the cutting performance and tool wear during excavation process. Several aspects related to the performance and tool wear like tool geometry, tool material, tool installation, depth of cut and spacing, cutting forces and speed, and specific energy has been focused. The effect of water spraying on tool wear reduction and improvement on cutting performance is also included.

Slurry Erosion Performance of Detonation Gun Sprayed Stellite-6 on 13Cr4Ni Hydroturbine Steel at two Different Angles under Hydro-Accelerated Conditions

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In the current study, slurry erosion behavior of Detonation Gun (D-gun) Stellite-6 coated and uncoated 13Cr4Ni steels was observed at two different angles (30° and 90°) under a slurry concentration of 5000 ppm with erodent particle size 600 µm and rotation speed of 3800 rpm. Commercially available silica sand was used as an abrasive media. High Speed Erosion Test rig was used for experimentation. Stellite-6 coating performed better than the uncoated 13Cr4Ni steel at 30°. On the other hand, at 90°, better performance of uncoated 13Cr4Ni steel in comparison toStellite-6 coating was observed. SEM of the eroded specimens showed mixed (brittle and ductile) mode of erosion mechanism.

Dynamic Analysis Including Stability of Flexibly Supported Narrow Hydrodynamic Journal Bearings with Micropolar Lubricant

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The present paper deals with the static and dynamic characteristics including the stability of flexibly supported narrow hydrodynamic journal bearings lubricated under the micropolar lubricants. From the basic equations i.e. the equation of continuity of mass, the equations for the balance of linear momentum and the balance of angular momentum, which are coupled together due to the existence of two kinematic vector fields of the microstructures and characterizing the micropolar fluid, the derivation of Reynolds equation has been modified. The theoretical prediction of hydrodynamic pressures in the bearing is obtained by the solution of modified Reynolds equation satisfying the appropriate boundary conditions. The steady state pressure profile is obtained easily by an analytical method. The steady state parameters like load carrying capacity and attitude angle can be easily obtained once the pressure profile over the entire bearing surface has been found. First order perturbations of eccentricity ratio and attitude angle are used to calculate the dynamic pressure and the resulting equations are solved by analytical method. Dynamic characteristics are obtained in terms of stiffness and damping coefficients by the help of perturbed pressures. Stiffness and damping coefficients aside, the dynamic characteristics also include the threshold stability and the whirl ratio.

Tribological Behaviour of Al-Si Alloy with Rare Earth and Manganese

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The effect of rare earth Cerium oxide and Manganese on the tribological properties of hypereutectic Aluminium-Silicon alloy has been reported in this paper. Wear studies were carried out on as cast samples of alloy modified with rare earth Cerium oxide (CeO2) and Manganese (Mn). Results obtained out of wear studies of rare earth Cerium oxide and Manganese modified alloy were compared with authors previous work on rare earth Cerium oxide modified hypereutectic Aluminium-Silicon alloy and hypereutectic Aluminium Silicon base alloy. It was observed that Cerium oxide and Manganese modified alloy reduced the wear rates as compared to Cerium oxide modified alloy and base alloy. An enhancement in mechanical properties was also observed. A comparison showed that Cerium oxide and Manganese modified alloy had least wear rates. Wear rates for Cerium oxide and Manganese modified alloy was 2.78 times lesser than wear rate of base alloy and was 1.68 times lesser than Cerium oxide modified alloy. Wear rates were calculated at loads ranging from 15N to 90N with an interval of 15N and at a constant velocity and sliding distance of 0.4m/s and 500m respectively. It was observed that minimum wear occurred at 15N load and maximum at 90N load. Further, scanning electron micrographs (SEM) of worn surfaces and wear debris of Cerium oxide and Manganese modified alloy showed mild wear.

Influence of Texture Orientation on the Hydrodynamic Lubrication

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Surface texturing is a prominent method to improve the hydrodynamic lubrication performance. The numerical work is carried out to study the effect of orientation of textures on the performance characteristics like load support, end flow and friction parameter of parallel sliding contacts. The parameters used in the analysis to investigate the effect of orientation are size and height of surface texture. The governing pressure equation is solved using Finite difference method with Gauss-Seidel iterative relaxation scheme. The result shows that orientation of texture shows significant effect on the performance characteristics. Moreover, texture size and its height also play a vital role on the performance of parallel sliding contacts.

Study of Surface Roughness Effects in Elastohydrodynamic Lubrication of a Finite Line Contact Using Probabilistic Model

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A numerical solution is obtained for fully flooded isothermal elastohydrodynamically lubricated finite line contact including surface roughness effect (Patir-Cheng flow model). It is observed that the maximum pressure and minimum film thickness appears along the edges of the ylindrical roller, which cannot be predicted by infinite line contact analysis (1D). A significant difference in the film thickness results of finite and infinite contact are reported, particularly for lower values of hydrodynamic roughness parameter Λ . Based on the numerically evaluated data, curve fitted relations for central and central minimum film thicknesses are developed by using a non-linear least square technique.

POSTERS ABSTRACT: DESIGN

Implementation of Central Bar Bending Yard A Case Study 6x660 MW Sasan UMPP

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Central Bar Bending Yard (CBBY) is implemented for the first time in India in power plant construction by Reliance at Sasan Ultra Mega Power Project (SUMPP) by use of fully automatic CNC based machines for improved project quality, automated precise rebar processing, low wastage of material and less labor dependency. Salient features, financial benefits and other associated benefits were discussed briefly in this case study.

A Study of Anti-Loosening Ability of 5/8 BSW Fasteners under Vibration with High Tension Steel and Stainless Steel Bolts

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Threaded fasteners have been popularly utilized for temporary joining of machine elements due to the feature that they provide high clamping force and torque using a simple tool. However, they have the problem of loosening under vibrating conditions which leads to loss of clamping force, and finally failure of the system. In the present experimental work, anti-loosening ability of various fastening elements, such as conventional nut, nylock nut, flat washer, spring washer, inside and outside serrated washer, are tested with conventional 5/8″ BSW High Tension Steel (HTS) and Stainless Steel (SS) bolts. The concept of hybrid double nut using a conventional nut and one nylock nut at the outside, and adhesive bonded nut with conventional 5/8″ BSW (both HTS and SS) bolt is also tested to obtain enough resistance to loosening. On the basis of the experimental results, hybrid double nut and adhesive bonded nut can be recommended for both HTS and SS 5/8″ BSW bolts to apply under vibration conditions, as they resist loss of clamping force effectively.

Concept Design and Feasibility Study of a Grid Free Solar Power Source for Small Scale Industries in Remote Areas Using Flywheel Batteries

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This paper presents a concept design of grid free solar power source. This design aims at creating a power source which can be utilized as a regular power source by remote rural industries. This paper attempts to present economically viable solution. The design proposed here is expected to be simple and will utilize technology which is appropriate for rural areas and rugged. The steady fall in the price of solar panels over the last decade has made it possible to adopt this as an alternative to paying extra cost of laying electric lines for use in remote areas. The use of flywheel batteries will drastically reduce the recurring cost of replacing chemical batteries. The technical feasibility of the proposed power source has been established by various applications of flywheel batteries and standby power sources already in use on commercial basis. An economically feasible solution utilizing appropriate technology for rural areas is urgently needed in India. The use of flywheel batteries will enable this. This design proposes to use the power source only during daytime which will eliminate the need of expensive energy storage arrangements for the night hours. The mechanical characteristics of this source are expected to be similar to the 5 Hp Genset since this design proposes to use a flywheel which is even larger than the one used on these Gensets. A prototype of the solar power source is being fabricated in the laboratory. It will be tested for its performance on actual loads.The paper gives detailed discussion about the use of a flywheel battery for grid free solution. It appears that this is one of the best solutions for the present state of the technology appropriate for rural areas. In the near future the use of flywheel batteries will increase and replace the chemical ones. The flywheel batteries will not only be used for providing backup power for critical power requirements (which is a regular practice at present) but also for creating motive power source.

Development of Strength Testing Machine for Artificial Ligaments

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Ligament injury occurs due to repetitive loading on the tissues which causes damage to the musculoskeletal. It affects the natural performance of the bio-system. The properties of soft tissues like ligaments, tendons, cartilages etc and hard tissues like bones get changed. It changes the natural function of the system. Normally, wounded ligaments is treated by using conservative method of treatment or surgically or by completely replacing it by artificial ligaments. In the present work, mechanism is proposed. It is use for measuring the different properties of the artificial ligaments. The major emphasis is given on how to perform the testing to know the strength of the artificial ligaments for the cyclic loading. The developed mechanism of lower limb includes structures of the bones, joints, artificial ligaments and various links. The mechanism demonstrates the way of feasibility to implant artificial ligaments in upper and lower extremities region. It is beneficial to know the implant status prior to the surgery. Thus, it helps the surgeons to proper maintain the integrity without losing the skeletal damage and structural stability. It aids to know the desirable characteristic of artificial ligament such as mechanical properties and joint forces.

Fabrication of Accurate Bone Implant Geometry using Puzzle Solving Technqiue

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In the cases related to comminuted fractures, a part of bone is damaged/ crushed (comminuted) to the point of being missing altogether. As an example this type of trauma could occur from military injuries like gunshot wounds, explosives, motor vehicle accidents, or falling from excessive heights; all where, substantially high energy is involved. To enable accurate reconstruction of the comminuted fracture surgeon has to believe in his expertise and intuition to arrange the broken parts of bone and carry out the surgery. A puzzle solving technique will definitely help surgeons to practice reconstruction of the broken bone fragments prior to surgery in order to avoid errors in reconstruction. This paper presents a genetic algorithm based approach to obtain optimal sequence of bone reconstruction. In order to compare the performance of proposed approach, a well-known Iterative closest point algorithm is also implemented. The comparison is done based on computational time, mean deviation and number of iterations.

Force Evaluation of Integrated Bamboo Processing Machine and Performance of Dies

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Bamboos are a unique group of giant arborescent grasses in which the woody culms arise from underground rhizomes. They are shrubs and have tree-like habit. Their culms are erect and sometimes climbing. It is the fastest growing plant on this planet. Bamboos are characterized by woody, mostly hollow culms with internodes and branches at the culms nodes. India is the second richest country in terms of Bamboo genetic diversity with a total of 136 species under 75 genera. It encompasses about 8.96 million hectares of forest area, which is equivalent to 12.8 per cent of the total forest cover of the country. Generally different types of machines are use in different industries like bamboo cross cutting machine, bamboo splitting machine, knot removing machine, bamboo slicing machine, bamboo stick making machine, bamboo stick sizing machine, bamboo stick policing machine. Initial treatment to raw bamboo before ready for actual work is called bamboo processing which includes Cross-Cutting, Splitting, External and Internal Knot Removing, stick length setting etc. Presently for all processing of bamboo, individual machines are available. The main theme involved in this work is to Design & Fabricate a machine with specialty of multiple operations of bamboo processing in a single unit. Hence, integrated bamboo processing machine is fabricated and tested for all successful runs. The design evolves a new concept of bamboo processing machine with multiple operations with help of multipurpose die, which eliminated the disadvantages offered by the present processing machines, which are for single operation only. The main objective of this work shows the development of experimental set up of integrated bamboo processing machine and force evaluation with a capability of doing two operations in a single unit.

Field Data Based Mathematical Model for Stirrup Making Activity in Civil Construction

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Stirrup or lateral tie is one of the essential element of reinforce cement concrete in civil construction. These stirrups are used for strengthening columns and beams, avoiding buckling of long slender column and avoiding sagging of horizontal beam. The detailed study of present manual stirrup making activity indicates that the process suffers from various draw back like lack of accuracy, low production rate and resulting in to severe fatigue in the operator. The construction operator not only subjects his hands to hours of repetitive motion but also some times suffers internal injury to his body organ that is disorder carpel tunnel syndrome. In order to remove above draw backs authors have determine an appropriate sample size for the activity and formulated various field data based mathematical models (FDBM) such as multivariable linear model, polynomial model, exponential model, logarithmic model, on the basis of gathered field data by applying theories of experimentation. The formulated model can use to optimize the human energy of worker, production rates and inaccuracy of stirrups.

Determination of Stress Intensity Factor and Interaction Behavior of Radial Cracks in an Un-notched Round Bar

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Cracks emanating from the surface of a bar, power transmission shafts, and pressure vessels when undergoing cyclic loading. Multiple radial cracks also originating from the inner surface of cylinders when undergoing cyclic internal pressure. In general, surface cracks in structural components are often approximated by elliptical, semi elliptical cracks, circular or semi circular cracks. Due to complexities in analysis of multiple cracks, many researchers have studied the damage tolerance analysis of single crack in rectangular plate, notched and un-notched round bar and thus the effect of crack interaction has been neglected. In order to predict safe-life of such cracked components, it is important to know the individual stress intensity factors (SIF) under mixed mode loading. This paper presents the SIF and interaction behavior of multiple radial cracks in an un notched round bar subjected to far filed tension loading. Three surface cracks of same dimensions (crack depth and aspect ratios) were introduced around the circumference of the cylindrical rod specimen. The crack depth ratio (a/d) ranging between 0.1 and 0.3 was considered for two different crack aspect ratios (a/c = 0.6 and 1.0). The crack tip region was meshed with iso-parametric singular elements to incorporate the singularity of stress and strain fields. The SIF values of single and multiple cracks are compared to determine the interaction behaviour of radial cracks on SIF. Comparison SIF of radial cracks with published SIF of single crack showed a good agreement at short crack depths ((a/d) <0.3). Beyond the crack depth ratio of 0.3 higher SIF is observed. This is due to interaction effect of radial cracks which increases with crack depth ratio. SIF are higher at the surface (S/S0 = ±1) of a semi-circular crack whereas SIF are higher at the crack middle region (S/S0 =0) for semi elliptic cracks independent of crack depth ratios.

Design and Development of Turmeric Polishing Machine Energized By Human Power Flywheel Motor-A Past Review

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In the present investigation, in the recent past human powered flywheel motor concept has been used for chaff cutter, bricks making, wood turning, cloth washing. The machine uses bicycle technology, with speed increasing gearing and a flywheel, which drive the process unit through a spiral jaw clutch and torque increasing gearing. Pedal power is used transmit this power to run the machine by the operator. Power can be transmitted through crank chain to free wheel to the working unit. This human powered flywheel motor concept (HPFM) provide new era in the human powered agriculture processing, harvesting, post harvested operations equipments. Considering social, cultural and environmental factor as well as in many rural operations utilizing unskilled worker and in Vidharbha rejoin there is more problem of electricity so this kind of HPFM concept is helpful in driving various rural machines. The machine is economically viable, can be adopted for human powered process units which could have intermitted operation without affecting the end product.

POSTERS ABSTRACT: DYNAMICS

Fuzzy Driver Command Interpreter for Parallel Hybrid Vehicle

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In order to exploit the advantages of parallel hybrid vehicles, it is necessary to develop a control strategy that typically implements a high-level control algorithm. This algorithm determines the appropriate power split between the electric motor and the engine to minimize fuel consumption and emissions, while staying within specified constraints on drivability, reliability, battery charge sustenance. Moreover, the control strategy should be adaptive to track the demand changes from the driver or drive cycle for optimization purposes. The energy in the system should be managed in such a way that: the driver inputs i.e. from brake and accelerating pedals are satisfied consistently. In order to fulfill these conditions, there is a need to develop an efficient control strategy, which can split power based on demands of the driver and driving conditions. Hence, for optimal energy management of PHEV, interpretation of driver command and driving situation is most important. In view of this, a fuzzy logic based strategy for interpretation of driver command is proposed in this paper.

Design & Analysis of Crankshaft Bending Test Rig for Actual Engine Condition

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The crankshaft is one of the most critically loaded components as it experiences cyclic loads in the form of bending and torsion during its service life. Its failure will cause serious damage to the engine so its reliability verification must be performed. This paper deals with fatigue strength assessment of crankshaft in automobile industry. The topic was chosen because of increasing interest in higher payloads, lower weight, higher efficiency and shorter load cycles in crankshaft equipment. The aim of this work is to design bending test fixture for crankshaft for load ratio R=-0.2 which is an actual engine condition. This paper consists of design of test fixture, 3-D model generation of test fixture and stress analysis of crankshaft & test fixture using CAE tool in order to minimize the time during physical test.

Profiled Shaft and Rotor Dynamics

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Shaft-rotor systems consisting of multi disks and profiled shafts are taken into consideration. The determination of deflection, slope, shear force and bending moment at the extremities of the shaft are done using conventional mathematical procedures. Transfer matrix method (TMM) is used for the computation of the resonance, critical speed or whirling frequency conditions. For particular profiles and rotational speeds and lengths, the response of the system is determined. A built-in profiled shaft-rotor system with two disks and an impulse load of 1N on the disk at the free end of the system is investigated for illustration purpose. The step response of the multi-disk profiled shaft-rotor system is also found.

Dynamic Analysis of Aero-engine Rotors Supported on Ball bearing system

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Present work deals with the numerical analysis of rotor carrying a central disk mounted over symmetrical ball-bearings, by considering the excitation forces using Muszynska's model along with linear unbalance force due to disk. Other nonlinearities considered in the model include: ball bearing contact forces and disk-stator rub-impact forces. Finite element model incorporating bending degrees of freedom is employed to mesh the system. Implicit Wilson-theta time-integration scheme is used to get the phase- plane, time-history plots and frequency spectra. Different periodic motions are studied by varying the different speeds.

Study of Vibration Dose Value and Discomfort Due to Whole Body Vibration Exposure for a Two Wheeler Drive

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All the vehicles are exposed to vibrations caused by the roughness of the road or soil profile, which affects the health as well as causes discomfort to the occupants (driver and passengers). In the present study, Vibration Dose Value (VDV) has been recorded for the driver as well as the pillion of two wheeler vehicle for the different road profile having speed breakers, at different speed. The methodology adopted from the International Organization for Standardization (ISO) guidelines for whole body vibration (WBV) exposure having frequency ranges from 0 to 100 Hz. VDV of six healthy male subjects was recorded through the Human Vibration meter via seat-pad triaxial accelerometers for two minutes drive and psychophysical response were measured with the help of Borg CR10 scale. The Time to reach 15 VDV and comfort decreases with the increase in vehicle speed and speed breaker's height, for both driver and pillion. Pillion feels more discomfort with the increase in vehicle speed and speed breaker's height when compared with driver.

POSTERS ABSTRACT: MACHINES

Accuracy Enhancement of 3 Axis Vertical Milling Machine Centre

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There are various ways which leads for enhanced performance of machine centre. Precision Machine tool must perform accurately in changing environment and working conditions. The factors which affect precision are static, kinematic, thermal and dynamics response. i.e. geometric alignment of slide ways, bed, thermal gradient in spindle, ball screw and wear of parts etc. This paper presents estimate and compensation of geometric error for 3 axis Vertical Milling Machine centre. Experiment test is carried out using ball bar test to check accuracy. The aspect of this is to predict and reduce errors. Validation of the same is done by experimental analysis.

Review on Dewatering Pumping Network for Underground Coal Mine

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Underground mine working changes hydraulic gradient which affect the underground surface water flow pattern. It induces slow inflow of water from, porous soil and rock mass towards the mining excavation. Mine dewatering is the removal of percolated or logged water from mines to ensure the safety of operating personnel and to safeguard the machineries involved in excavation. Usually pumps are employed for the purpose of removal of water because of their high economical value and reliability moreover pipeline network is also significant for the fast removal of logged water inside mine. Therefore, an optimize pipeline network is essential.

POSTERS ABSTRACT: MULTI BODY DYNAMICS

Mathematical Modeling and Simulation of Semi-Active Suspension System for An 8×8 Armoured Wheeled Vehicle with 11 DOF

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Stability and ride comfort in multi-wheeled military vehicles depend on a combination of vertical motion and angular motion of pitch and roll. Since multi-wheeled military vehicles are intended to deliver accurate firing attack, stability and ride comfort for the military vehicles is a must. This study focuses on modelling and predicting vehicle response under the source of road disturbance. A mathematical model has been developed and control algorithm has been verified with the purpose/objective of reducing the unwanted sprung mass motions such as heave, pitch and roll. Semi active suspension gives better ride comfort with consumption of fraction of power required for active suspension. In this paper, the comparative performance of passive suspension along with two semi-active suspension control logics namely, on-off skyhook and continuous skyhook has been demonstrated through simulations. The ride comfort is evaluated in terms of rms acceleration at CG in vertical direction (Z), which is the major contributor for ORV Measurement.

Analysis and Vibration Behavior of a Medium Voltage Spring Operated Switch Gear Mechanism used for Circuit Breaker

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In recent years, considerable attention has been given to the analysis of flexible mechanisms. For mechanisms which operate at high speeds, the inertial forces become so large and they cannot be ignored and the mechanism members undergo considerable deformation. Under these situations the rigid body assumption is no longer valid and hence the need arises for consideration of the flexibilities of the members of the mechanism. This paper investigates dynamic response of a spring operated mechanism of a 69-kilovolt SF6 (Sulphur hexa-Fluoride) circuit breaker during its opening operation. In the present work, a spring operated mechanism is analyzed using the multi body simulation. The kinematic synthesis of the mechanism considering its links to be rigid is derived. In kinematic analysis the velocity and acceleration of each link is calculated and their responses are plotted with the time during opening operation of the mechanism. This method is particularly important in analyzing the dynamics of complicated .mechanisms. The dynamic response of the circuit breaker with different spring constants was studied and its effect on the breaking time was also presented. The switchgear mechanism's link dimensions are verified by performing the mechanism motion simulation by using ADAMS software. The proto type model of the switch gear mechanism is fabricated and tested for studying the dynamic response of the links in the mechanism for its operation. The vibration characteristics by using LABVIEW software with the aid of FFT (Fast Fourier Transform) analyzer are presented.

Use of Six Bar Mechanism for Reduction in Force and Stroke Requirement as Against Four Bar Mechanism

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The advantage of six bar mechanism as against the existing four bar mechanism used in articulation of the missile launcher system and how self-replenishment of missile container from ground was made possible is brought out in this paper. The application has been designed, and development in this paper has a requirement of having a dual role of not only articulation from the 00 to 900 but also to act as self replenishment system for the missile container thus avoiding usage of external crane. Replenishment system means to place the missile container in horizontal condition from the ground on to the vehicle platform at a height of around 1500 mm (from ground). Articulation means to articulate the same missile container on the vehicle platform from 00 to 900 (Horizontal to Vertical). In this paper the comparison of the four bar mechanism and the six-bar mechanism has been evolved for such type of application. Here the main requirement is to quickly reload and articulate the missile container on the vehicle platform avoiding the usage of external crane. As there is no real reference material on this subject the first step has been the description of the kinematics of the articulation cum reloading mechanism of the mobile missile launcher system. The six bar mechanism has been manufactured and realized and also the functionality tests have been carried out.

Kinematic and Dynamic Analysis of a Surgical Tool Manipulator towards Robotic Surgery

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Robotic surgery reduces the amount of tissues that are damaged during a surgical procedure, thereby reducing the patient recovery time, discomfort and deleterious side effect such as infection. In this article, kinematic and dynamic analysis of a surgical tool manipulator is carried out to perform the desired range of motions for a typical minimal invasive surgical operation. The manipulator having 3 DOF is driven by D.C. servomotors and motion is transmitted through wires/cables pivoted to driving shaft at one end and to the gripper on the other end. Kinematics analysis is done by utilizing the D-H parameters as well as through ADAMS software. The position, orientation and workspace of gripper (end-effector) are calculated analytically using D-H parameters and transformation matrix.

Analysis and Control of a Six Link Serial Manipulator with Flexible Joints

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In this paper, a classical PID controller has been developed for a six-link, six-joint flexible robotic manipulator model. The flexibility has been given to the joint of the system model constructed in sim-mechanics environment. In the first stage, the simmechanics simulation results have been presented to ensure greater acceptability of the flexible model over the rigid joint-link manipulator. Finally, with the help of SISO design toolbox, a classical PID controller has been incorporated. Gains of the PID controller have been tuned using three methods and compared. Results corresponding to the optimized gains have been presented and discussed.

Semi-Active Vibration Isolation of a Quarter Car Model under Random Road Excitations using Magnetorheological Damper

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Semi active control systems are becoming increasingly popular because they offer reliability of passive systems combined with high performance and versatility of active control systems but with low power consumptions. As Magnetorheological (MR) fluids can produce good controllable damping force under application of magnetic field, MR damper can be used as effective element in semi-active vibration control. A phenomenological model of MR damper is considered in the present study. Out of various semi-active control strategies, the on-off sky-hook control strategy is used in this work. To check the performance of the proposed on-off controller with MR damper, a single degree of freedom system with MR damper under sinusoidal excitation is first studied. This control scheme is then applied to a two degree-of freedom quarter car model. The parameters of MR damper in the model are varied by changing the input voltage according to the control scheme. The vehicle is assumed to travel with a constant forward velocity and excitation from road irregularities is simulated considering suitable profile spectral density of road. Performances of this controller for two types of road profiles, namely, sinusoidal road profile, random road profile are studied. The control strategy is found to be effective for a quarter car model. To examine optimal damper force vehicle required to isolate the vibration several performance indices have been chosen which are functions of vehicle performance measures such as sprung mass acceleration, vehicle handling and working space.

POSTERS ABSTRACT: MECHANISMS

A New Method for Detection of Structural Properties of Planar Kinematic Chain

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Isomorphism had been keen area of research since long ago. Many methods are available to the kinematician to detect isomorphism among planar kinematic chains, but each has its own shortcomings. In this paper, an attempt is made to develop a technique to fulfill this need. A method is proposed for detection of isomorphism of the planar kinematic chains based on structural properties. In this approach, kinematic chains are represented by matrices, and the elements of matrices are used for detection of isomorphism. The kinematic chains of 1- D.O.F., 6- Links and 8- Links has been tested and the results are in complete agreement with the available literature. This method is simple, reliable and at the same time, it is capable to detect unique links of kinematic chains for identifying the different kinematic inversions.

POSTERS ABSTRACT: MECHATRONICS

Torque Ripple Minimization Techniques in Direct Torque Control Induction Motor Drive

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This paper considers direct torque control strategies in induction motor drive to minimize torque ripples. Spacevector modulation and modified space vector control concept is implemented to design the controller. Basic DTC method suffers from torque ripples problem and switching frequency variation.[1] Torque ripples are minimized using space vector modulation technique but execution time in three phases to two phase transformation and reference voltage calculations requires more, comparing with other method by determination of effective time vectors. Sector and angle determination and procedure of determination of reference vector is eliminated in modified Space vector modulation method. Simulation studies have been carried out for three methods. Basic DTC results in, change in flux, change in speed and change in load are simulated in Matlab and compared with other two strategies on the same platform.This paper mainlyhighlights performance of the drive in dynamic torque and flux response.

Proportional Actuator from on off Solenoid Valve using Sliding Modes

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Solenoid valve is a non-linear actuating device used as on-off control in many hydraulic industrial applications. This paper presents conversion of on-off solenoid valve into proportional actuator using sliding mode controller (SMC). A mathematical model of a solenoid valve is developed using first principle approach. As the model is nonlinear, design of proportional actuator becomes challenging. Initially force control strategy is used to ensure the desired plunger position using two PI controllers. Simulation results show deterioration of the performance in presence of parametric variations and disturbances even for the best tuned PI gains. Hence, a sliding mode controller is investigated for accommodating robustness. Gao's power rate and constant rate reaching law is used for SM control design.

Predicting the Dynamic Behaviour of Hybrid Stepper Motor

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Stepper motors drives with their simple position control and drive electronics are the most preferred alternative to the traditional spring based deployment systems of large spacecraft appendages. However for the proper use of the motor, there is need to understand and simulate its complex dynamic behavior in driving large inertia loads. The dynamic simulation model has to be developed with the limited data available in the data sheets of the motor. The validity of the motor constant supplied in the data sheet is verified by measuring the peak torque developed for different phase current. The damping coefficient (not provided in data sheet) needed for the dynamic model has been estimated using the simulation in comparison with the experimental single step response. The simulation model developed effectively predicts the multistep response of the stepper motors with large inertia. The model has been successfully validated against experimental data. The simulation paper also aims at improving the understanding of stepper motor for future use in deployment mechanism. An experimental test set up is realized for validating the simulation results.

Design of 25kW Redundant Linear Electro-Mechanical Actuator for Thrust Vector Control Applications

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Linear electro-mechanical actuators are finding increased use in the field of thrust vectoring of launch vehicles. Earlier, linear electro-hydraulic actuators were used especially in the lower stages of the launch vehicles where there is a requirement for large actuation forces. However, electro-mechanical actuators are being scrutinized for this purpose in an effort to provide lighter, cleaner and more reliant control actuators. The design philosophy, actuator configuration and selection of motor to meet the load dynamics, bearings, roller screw & sensor are discussed. Design verification of critical components like roller screw and rod end bearing assembly for their structural aspects is explained. Details of redundancy management scheme for the individual functional elements and the actuator qualification program are also covered.

Practical Phantom Studies with a Battery Based Electrical Impedance Tomography System

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Electrical impedance tomography (EIT) is a computed tomographic technique which has been applied for a number of medical investigations. Practical EIT systems need an electronic instrumentation system for current injection and voltage data collection from the patient's body. EIT instrumentation is generally fed by the ac main power supply which must be developed with a number of strictly specified design parameters and must be applied with certain cares for obtaining the better patient safety. To obtain a better patient safety a battery based EIT system developed and studied with practical phantoms. A battery based EIT system is developed with a LabVIEW based EIT instrumentation powered by a battery based power supply. A number of practical phantoms are developed and the resistivity images are studied with battery based EIT system. Signal to noise ratio is improved in battery based EIT system. Results demonstrated that the practical phantoms are successfully reconstructed with battery based EIT system. Results also show that all the phantom domains with different inhomogeneity configurations are successfully reconstructed from the boundary data measured.

POSTERS ABSTRACT: ROBOTICS

Finite Element Analysis of a Stewart Platform using Flexible Joints

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The demand of high precision motion has been increasing in the recent years. Since performance of today's many mechanical systems requires high stiffness and accurate positioning capability, parallel manipulators gained popularity. Their superior architecture provides better load capacity and positioning accuracy over the serial ones. In this work, a popular parallel manipulator, Stewart Platform, has been studied. Stewart Platform is a positioning system that consists of top plate (moving platform), a bottom plate (fixed base), and six extensible legs connecting the top plate to the bottom plate. This work includes design and analysis of a complete positioning system. In order to achieve better accuracy over commonly used universal and spherical joints the flexible joints have been employed. Flexible joints would give better results than universal and spherical joints because they eliminate friction and backlash. Flexible joint has been developed in the FE software ANSYS for static and modal analysis and using this flexible joint Stewart Platform has been developed in the FE software for FE analysis. The static and modal analysis of the Stewart Platform using flexible joints will be evaluated.

Mobile Robots for Periodic Maintenance and Inspection of Civil Infrastructure: A Review

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Many studies and research interest for the development of various mobile robots have been taken up in the recent past. Mobile robots, capable of maneuvering on vertical/inclined wall surfaces or flying/gliding to reach higher sites, could replace humans in potential applications such as precise inspection and maintenance, considering human safety particularly while working along hard-to-reach locations of civil structures. To reach such locations Scansorial/Climbing mobile robots require adhesion as well as locomotion mechanisms. In this paper, several locomotion and adhesion mechanisms using either conventional or bio-inspired methods for developing Scansorial Robots (SRs) have been reviewed. The recent developments, performance evaluation and implementation of SRs mainly for concrete, brick masonry, glass, and steel structures have been considered for the review study. Comprehensive and quantitative analyses of various locomotion and adhesion mechanisms have also been made with illustrations.

Model Based Off-Line Method for Velocity Trajectory Compensation

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The velocity compensation method proposed in this paper computes the value of velocity compensation in the off-line mode to compensate the effects of non-linear dynamics of the robot. This paper explains a methodology that utilizes a priori knowledge of the robot dynamics to improve the path tracking accuracy by generating an additional velocity compensation based on robot dynamics. The strategy for off-line velocity compensation entails the determination of inverse dynamic model of the robot system. This model consists of inverse dynamic model of robot and the inverse model of the controller. The inverse dynamic model of robot is highly nonlinear where as controller model is linear. Both these models need to work in closed loop that demands for linear presentation of the robot inverse dynamics. In this work, a body oriented method for linear form of dynamics equation and PI controller model will be used. The proposed velocity compensation algorithm will be demonstrated for a spray painting robot using SIMULINK environment of the MATLAB. The results will be evaluated at joint as well as Cartesian level. Finally, the path tracking error with and with considering compensation will be determined for the case problems.

Neural Network Solutions of Forward Kinematics for 3RPS Parallel Manipulator

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This paper describes how neural networks are much capable to solve the forward kinematics of parallel manipulators. The solution to the forward kinematics involves highly nonlinear equations of motion, which can be solved by numerical methods with great accuracy but the time consuming calculations restrain it in implementing for real time kinematic control. Two types of neural networks namely multilayer perceptron (MLP) and radial basis function (RBF) are considered to solve the forward kinematics of 3RPS (revolute-prismatic-spherical) parallel manipulator. The performance and suitability of both the networks are evaluated for this specific application.

Workspace and Singularity Analysis of 3-RRR Planar Parallel Manipulator

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Nowadays, Planar Parallel Manipulators (PPMs) are widely used due to many inherent characteristics over the serial manipulator. In this paper, PPM with 3-RRR (revolute joints) configuration is simulated using Pro/mechanism and investigated analytically. Revolute joints are considered as joints with virtually no mechanical limits so that the workspace can be maximized. Loop closure equations are formulated for the 3-RRR manipulator and Jacobian matrices are developed for singularity analysis. For the proposed mechanism, singularity analysis is carried out using Instantaneous Center of Rotation (ICR) method. With regard to planar parallel manipulators, singularity can be classified into three groups based on properties of instantaneous center of rotation. This method is very fast and can easily be applied to the manipulators under study. The results of ICR are compared using analytical approach. Functional workspace of planar parallel manipulator is developed by actuating different combination of servomotors and is often limited because of interference among their mechanical components.

Kinematic Analysis of Biped Robot Forward Jump for Safe Locomotion

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In the present work kinematics of a four link biped robot is modeled using body coordinate formulation. The kinematic analysis of the biped robot is done for both stance and flight phases. Apart from joint constraints, constraint equations are introduced on the zero moment point (ZMP) and the centroidal angular momentum of the biped robot during stance phase. While the constraint on ZMP ensures stability during stance phase, constraint on angular momentum makes the biped robot non-holonomic even during the stance phase. During flight phase (during which angular momentum is conserved, and hence the system is non-holonomic by nature), the vertical distance between the foot and the center of mass is planned such that the velocity of the foot reaches zero at the time of landing to ensure a smooth landing without impact. Simulations are done in MATLAB using RK4 method. Simulation results have been presented for both the support and flight phases for various initial configurations of the robot, which resulted in variation of the horizontal distance and vertical height covered by the biped robot.

POSTERS ABSTRACT: TRIBOLOGY

Determining the Value of Archard's Co-Efficient on the Bottom Plate of Excavator Bucket: an Experimental Approach

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Heavy Earth Moving Machines (HEMM) is used mainly for opencast mining and construction works. These machines are used largely for mining to excavate the overburden and the raw materials e.g. coal, iron ore, copper etc. Most of the components of these machines are subjected to major abrasion impact and wear. In this paper, the value of Archard co-efficient has been determined for the abrasion phenomena in the bottom surface of the excavator bucket. One most necessary and important goal in engineering is to develop performance relationships between all the variables and parameters in a system, in mathematical form. Similarly, in tribological systems, it is necessary to establish a mathematical relationship between the different variables. Engineers and designers should have equations to predict wear rates. Unfortunately the available equations are not adequate to predict the product life with confidence. So, researchers normally use equations where the parameters are formed from data taken from experimental analysis or theoretical means. Wear of a material is influenced by many factors, including properties of the material, such as hardness, elasticity, yield strength, strain hardening and fracture strain etc. Wear rate on a surface can be normally determined by using Archard's equation, which states that the wear loss is linearly proportional to the sliding distance and the normal load, but inversely proportional to the hardness of the material. The objective of the present work is to observe the abrasion characteristic on the surface of excavator bucket and calculate the value of Archard coefficient from the data collected from the experimental analysis.

Development of a Split Bush Bearing System

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In the presented work a simple but effective bearing system is developed. It reduces the disadvantages of hydrodynamic and hydrostatic bearing systems. Like a taper roller bearing the developmental work includes the tapered and split collate fitted inside a matching tapered bush. The working clearances can be set to the desired closer limits. The split bush bearing system is developed, manufactured and run for sufficient period to see the performance. It is low cost, effective and easy to manufacture. The shaft rotates fairly concentric and therefore is a better suited bearing system.

Analysis of the Cuttability of Coal for Continuous Miner

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In this paper a practical approach is presented to analyse the coal cuttability of continuous miner due to cutting action of a tool bit. An experiment was performed on the shaper machine using conical tool bit to simulate the cutting action of the tool bit of the excavating machines. Cutting parameters like depth of cut and attack angle were varied and its effect on the amount of coal removal was observed for the efficient cuttability of the mechanical excavator.

POSTERS ABSTRACT: PRODUCT BRIEF

EPOS 2- A New Generation of The Successful Motion Controller

Atul Bhardwaj[1] and Urs Kafader[2]
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maxon's group of small, intelligent and compact EPOS positioning controllers has acquired a new member with even better performance and additional features. Complete drive solutions for accurate positioning and regulated rotary motions are now even easier to create when combined with maxon motors.

EPOS is a family of modular digital positioning controllers based on CAN open standard for DC and EC motors with an incremental encoder in the 1 – 700 watt power range. They can all be run in position, speed and current regulation mode, and configured to run with both DC and EC motors as per software commands. A number of operating modes means they can be used flexibly in a wide range of drive systems in automation technology and mechatronics.

Automatic Controller Setting For Electric Drives

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Perfect control of current, speed and position is a fundamental requirement for modern positioning control. However, optimum setting of all control parameters and feed-forward control values is by no means trivial. An intelligent, automated setting procedure handles this complex task.

Currently, servo amplifiers are expected to not only optimally perform the drive task and the fast, precise drive control, but also provide user-friendly functions for operation, configuration and diagnostics for the given application. To achieve this goal the maxon EPOS2 positioning controllers (EPOS; Easy to use Positioning System) offer a number of convenient functions for quick, easy setup of the drive. Focus is placed on electronic aids that relieve the user from the tedious and time-consuming setting of the controller.

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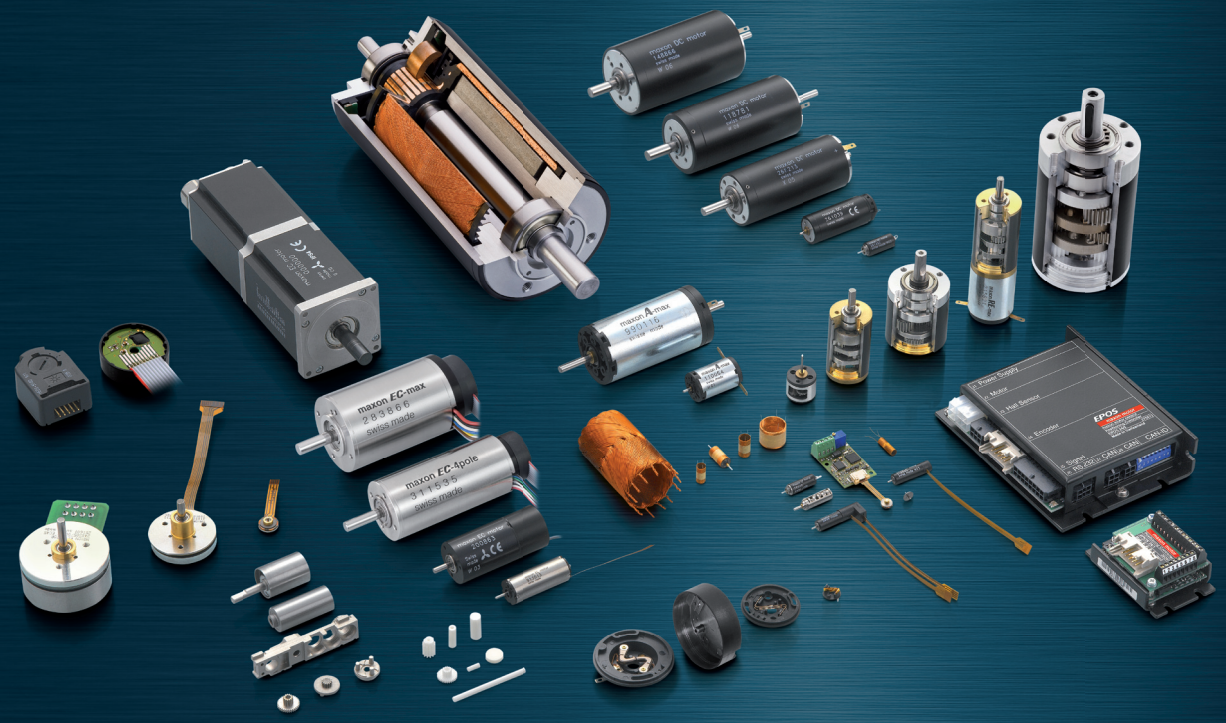

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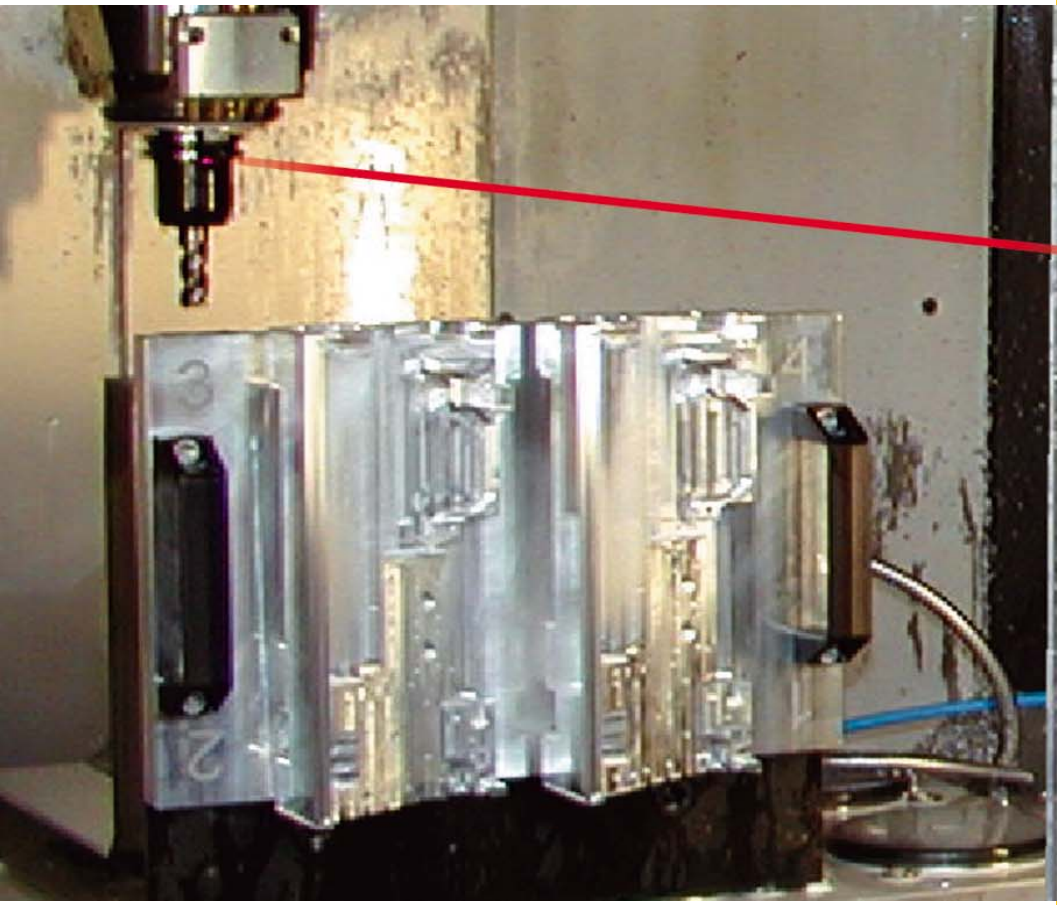

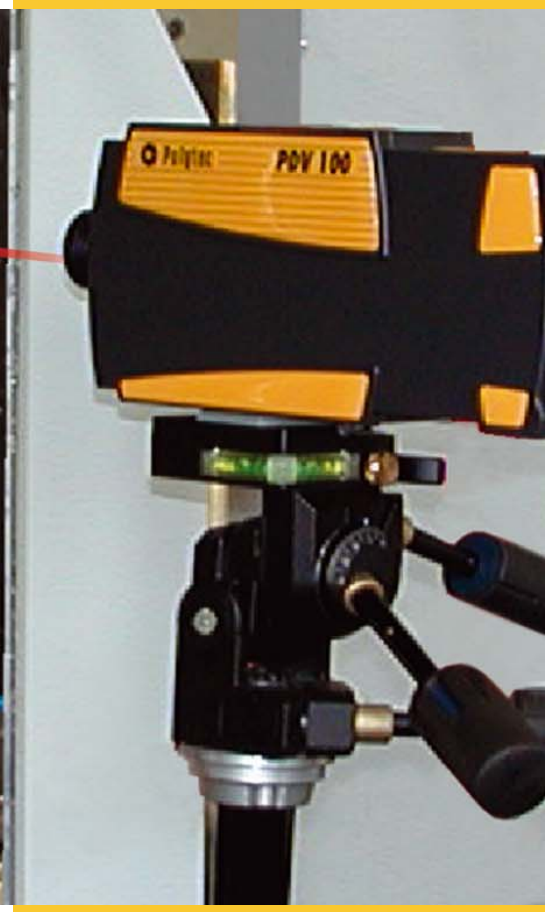

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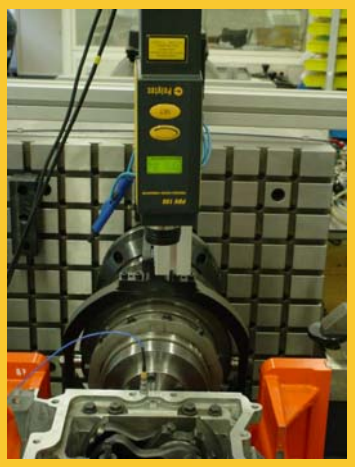

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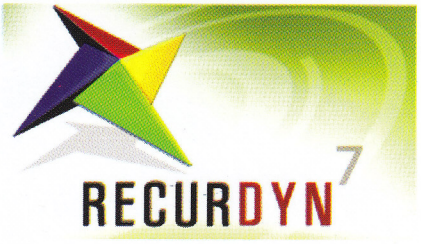

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