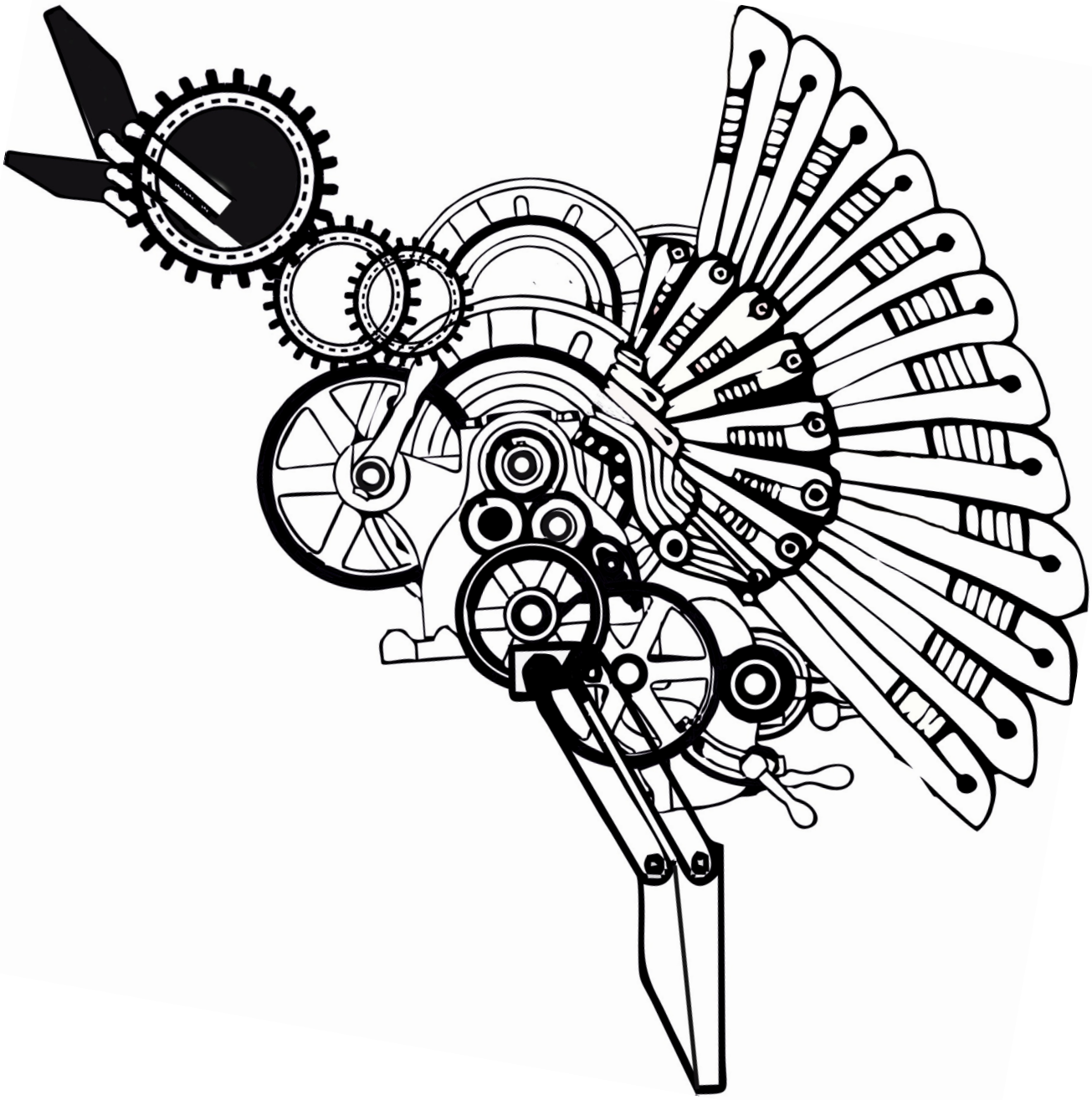

Indian Institute of Technology Kanpur

iNaCoMM 2015

2nd International and 17th National Conference on Machines and Mechanisms

Compendium
On Keynotes, Talks,
Oral and Poster Sessions

Cover and last page designed by Dr. Koumudi Patil

2nd International & 17th National Conference on Machines and Mechanisms, IIT Kanpur, India, 16th – 19th December, 2015

PROGRAMME AT A GLANCE

Date	8:00 AM- 9:00 AM	9:00 AM – 10:30 AM	10:30 AM - 11:15 AM	11:30 AM - 12:30 PM	12:30 PM –2.00 PM	2:00 PM – 4:00 PM	4:00 PM – 4:30PM	4:30 PM – 5:30 PM	5:30 PM – 6:30 PM	6:30 PM – 7:30 PM	8:00 PM –
16-12-15	Registration (Outreach Audi)	Inauguration of iNaCoMM 2015 Keynote I (Outreach Audi)	High Tea (Outreach Lawns)	Talk by Prof. J. S. Rao (Outreach Audi)	Lunch (PECBC Lawns)	Workshop W1 (PECBC I)	Tea/Coffee Break (PECBC Foyer)	Talk by Dr. Madhusudhan Raghavan (Outreach Audi)	AMM GBM (PECBC I/ Meeting Room)	Cultural Programme (Outreach Audi)	Dinner (Outreach Lawns)

Date	9:00 AM – 9:45 AM	10:00 AM- 11:00 AM	11:00 AM- 11:30 AM	11:30 AM- 12:30 PM	12:30 PM- 1:45 PM	2.00 PM – 3:00 PM	3:00 PM- 3:30 PM	3:30 PM – 4:30 PM	4:30 PM – 5:30 PM	5:30 PM– 6:30 PM	7:30 PM -
17-12-2015	Keynote II (Outreach Audi)	Session S1 (PECBC I) Session S3 (PECBC II)	Tea Break	Session S2 (PECBC I) Session S4 (PECBC II)	Lunch	Session S6 (PECBC I) Session S8 (PECBC II)	Tea Break	Session S7 (PECBC I) Session S9 (PECBC II)	Session S10 (PECBC I) Session S15 (PECBC II)	Poster I (PECBC Foyer)	Dinner (Outreach Lawns)
18-12-2015	Session S11 (PECBC I) Session S16 (PECBC II)	Session S12 (PECBC I) Session S5 (PECBC II)		Student Mechanism Design Contest (PECBC Foyer)		Session S13 (PECBC I) Session S14 (PECBC II)		Session S17 (PECBC I) Session S18 (PECBC II)	Poster II (PECBC Foyer)	Valedictory Function (Outreach Audi)	Dinner (Outreach Lawns)

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16 December, 2015 11:30 AM -12:30 AM	Outreach Auditorium	Talk I
Evolution of Machines for Fusion Reactors JS Rao, President-Academics, Kumaraguru College of Technology, Chinnavedampatti, Coimbatore, Tamil Nadu 641049		

16 December, 2015 2:00 PM -4:00 PM	PECBC I	Workshop
Workshop on Haptics M.Manivannan, Professor, Touch Lab, Biomedical Engineering Group, Department of Applied Mechanics, IIT Madras - Chennai-36		

16 December, 2015 4:30 PM -5:30 PM	Outreach Auditorium	Talk II
Novel Mechanisms for Advanced Propulsion Systems Madhusudhan Raghavan, Group Manager, Global Energy Systems & Hybrid Systems, GM R&D Center, 30500 Mound Road, Warren, Michigan 48090-9055, USA, madhu.raghavan@gm.com, T 586.986.2579 | C 248.930.5248		

17 December, 2015 9:00 AM -9:45 AM	Outreach Auditorium	Keynote II
The Lakshminarayana Lecture S.K. Saha, Mechanical Engineering, IIT Delhi, Hauz Khas, New Delhi 110 016, INDIA Tel: (011)2659 1135; Fax: (011)2658 2053		

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KEY NOTES

The Belgaumkar Memorial Lecture

Views From A Vibration Laboratory Of Pre-Labview Era

A. K. Mallik

Abstract

For research work in the field of mechanical vibrations, both design of experimental set-up and procedures for collecting and analysis of data undergo changes with passage of time. These changes are due to available equipments, software and nature of problems investigated. Experiments conducted over three decades in the same laboratory will be reviewed to highlight such changes. The areas covered will include material damping, nonlinear systems, vibration isolators and self-excited oscillations.

A. K. Mallik
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The Lakshminarayana Lecture

Innovative Teaching and Research[1] in Robotics and Mechanisms

S. K. Saha

Abstract

In this presentation, innovative ways of teaching and research in the area of Robotics and Mechanisms are proposed. They have emerged, mainly, due to the reasons of unemployable graduates from a large number of engineering colleges in the country, and the apathy of the leading researchers in various well-reputed institutes/organizations for not taking up the grass-root researches seriously. In order to address the above two issues, the speaker preaches two approaches which he refers as Innovation Teaching (IT) and Innovative Research (IR). While IT has been pursued by Prof.Saha through a concept what he calls Robotic Competition Knowledge Based Education in Engineering or RoCK-BEE, the IR was carried out by him using the concept of Multibody Dynamics for Rural Applications or MuDRA.

Since the word "robot" attracts the young students, its design, fabrication, programming, testing, etc. to perform certain tasks as per the rules of a game specified by the organizer of a competition exposes the students to a variety of subjects. It forces them to assimilate the knowledge to successfully developa robot (or in general any product), which is actually the objective of any technical education. This kind of education makes the students industry-ready. Prof.Sahacampaigns the ITthrough a lecture series called RoCK-BEE. He has delivered the lecture more than 60 times in last seven years in India, Japan, Poland, Mexico and the USA. On the other hand, the speaker converts associated rural problems into research topics of his area, i.e., multibody dynamics. Such an approach solved many rural challenges which led to journal publications and monographs by reputed publishers. During his presentation, Prof.Saha will illustrate several developments of machines and mechanisms used by carpet industries and energy sector. Such attempts actually allow researchers to fulfil their social responsibility or RSR. Prof.Sahashares these thoughts through another lecture series called MuDRA, which he delivered more than 40 times in India and abroad since 2007.

[1]These concepts appeared in an article published in the AMM News Bulletin, October 2011 issue.

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TALKS

Evolution of Machines for Fusion Reactors

J. S. Rao

Abstract

With the discovery of modern atomic theory and that the matter and energy are convertible mankind began looking for producing this energy in place of fossil fuels and renewable energies as the source. Of the two routes to produce atomic energy by Fission and Fusion, the later one has been found to be uneconomical until Superconductivity was discovered. Then the problem was on withstanding solar temperatures on the earth on one side and near absolute zero temperatures of cryogenic liquids. Thus began the development of multi-physics design processes involving Solid Mechanics, Electromagnetic Fluid Mechanics subjected to very high vacuum levels in toroidal chamber to high atmospheric pressures in heat exchangers. By the end of this decade we may have the first operating 500 MW fusion reactor in France under a consortium of seven countries including India. Because of radiation concerns the fission reactors will be phased out. Since the world needs huge amounts of power, we have to be prepared in the design of such reactors and the design aspects incorporated in the undergraduate curriculum. We have to bring Science to Engineering Approach using Simulation Based Design with High Performance into our class rooms. A brief description of a Fusion Reactor and the underlying scientific aspects of engineering are first given. A typical example of design of a unit that produces Tritium fuel is next given.

J. S. Rao, President Academics Kumaraguru College of Technology, Coimbatore Chief Science Officer (Consulting) Altair Engineering, Bangalore

Novel Mechanisms for Advanced Propulsion Systems

Madhusudhan Raghavan

Abstract

This paper presents two interesting mechanisms-related problems in the area of advanced propulsion systems, one in power generation and the other in power transmission. The first is an opposed-piston variable compression ratio engine mechanism for possible use in advanced powertrains. The concept is a two-stroke engine equipped with a Roots supercharger to facilitate the scavenging process. The engine has been numerically evaluated using 1-D and 3-D simulation tools. We present the kinematic details of the mechanism arrangement that serves to couple the two cranks which may be selectively phased relative to each other to achieve a variable compression ratio. Secondly, the paper describes a high-speed flywheel system and its use as an alternative energy storage system for recapturing vehicle kinetic energy as a low-cost hybrid architecture. Such a system has the potential to improve fuel economy by 15-20% on the certification drive-cycle when coupled to the driveline via a three-speed clutched transmission system in a representative mid-size vehicle. The fuel economy gain is shown to be due to idle stop/start, recuperation of vehicle kinetic energy during deceleration events, launching of the vehicle with the flywheel, and driveline torque boosting to offset fuel use. We present simulation results on drive cycle fuel consumption as well as the kinematic details of the geared arrangement to get energy into and out of the flywheel system.

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SESSION 1

Modeling and Simulation of a Three-Joint Prosthetic Finger Actuated by Remaining Functional Natural Fingers: A Bond Graph

Arvind Kumar Pathak, Neeraj Mishra, Anand Vaz

Abstract

This paper addresses issues pertaining to hand prostheses with functional finger joints actuated by remaining natural fingers. These offer improved options for rehabilitation of hand impairments with partial disabilities. A prosthetic finger mechanism with three joints, offering greater dexterity and based on the like-unlike configuration presented earlier is used to realize the implementation of the abstract concept of Opposition Space. A methodology for modeling and simulating the dynamics of a three-joint prosthetic finger actuated by remaining natural finger joints based on the string-tube mechanism using multibond graph is presented here. The numerical simulation of the Bond graph model is performed using MATLAB and SCILAB. 3D animation of the simulated results performed in the open source VRML environment has been used to obtain a better understanding through visualization.

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Image based Data Preparation for Neuronavigation

Abhishek Kaushik, Gaurav Bhutani, Venkata P P K, T A Dwarakanath,
Aliasgar Moiyadi

Abstract

In neuronavigation (also known as image guided surgery), the re-constructed CT/MRI image of the patient super-imposed with the moving surgical tool is available on the computer screen in real time to the surgeon. This paper presents the methodology for CT/MRI image based data preparation used for image guided neurosurgery. Patient preparation procedures for neuro-registration based on the surgeon's qualitative assessment are presented. The imaging data acquired from the scan is in Digital Imaging and Communications in Medicine (DICOM) format. The paper discusses layers of information of DICOM and provides an insight into its information architecture. The methodology for DICOM data preparation for neuronavigation is presented. The different Unique Identifiers (UID's) for DICOM are studied and all slices of various views are identified and placed in their appropriate location. Given the DICOM data of a patient, a module is developed to display the three orthographic views, an oblique view of choice and a 3D model of the patient's brain. An algorithm and the corresponding GUI for neuro-registration are prepared, which helps to determine the coordinates of the tumor point with respect to the surgical tool. For registration, the fiducials that appear in the image are marked in the DICOM data and the corresponding fiducials in the physical space are marked using a Surgical Coordinate Measuring Mechanism (SCMM). The implementation of the SCMM based neuro-registration and neuronavigation are demonstrated. The above methodology is demonstrated on various phantoms and a human skull to validate the data preparation for neuronavigation. The test procedures are found to be in accordance with the neurosurgical standards.

Keywords: Neuro-registration, Neuronavigation, Neurosurgery, DICOM, Medical imaging, Image guided surgery.

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Shape Estimation and Prediction of Locations of the Force on a Flexible Tube using Strains at a Few Points

Ananya, Shanthanu Chakravarthy, Kumar Saurabh and G. K. Ananthasuresh

Abstract

In this work, we address two problems concerning flexible tubes such as the ones used in endoscopy. In the first problem, we use a shape estimation algorithm to simulate the shape of the entire endoscope during endoscopy. In the second problem, we explore a method to predict the location of point forces acting on the tube during endoscopy. Strain measurements made at a few discrete locations on the tube are used as input for both shape estimation and force-location prediction.

A suitable strain interpolation method is explored to capture all the necessary information for the aforementioned two problems. For the first problem, we implemented in both 2D and 3D a shape estimation algorithm based on differential geometry methods. Through experiments we show that the developed shape estimation method can reconstruct the shape with errors no more than 20%. For the second problem, we look at the nature of the derivatives of the interpolated strain values. As the derivative of the strain is proportional to the shear force, we identify the locations of the applied point forces by looking for discontinuities in the strain derivative. Furthermore, we develop graphical visualisation method using OpenGL libraries to render the shape of the endoscope in real time. Implementation and error analysis of the shape estimation algorithm, validation of the force-location predicting method, and the visualisation module comprise the paper.

Keywords: Endoscopy, Endoscopic simulator, Strain interpolation.

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SESSION 2

Innovative Flexible Bracket Design and Simulation for Aircraft Mechanical Systems

M.L Shankar, Vinay C. A and Sandhya R

Abstract

Support brackets are extensively used for holding the ducts, cable bundles and high pressure and temperature fluid lines in aircraft mechanical systems such as in Environmental Control System (ECS) and electrical systems. Typically, the air conditioning system operates using engines bleed air and supplies controlled conditioned air to the passenger and the crew compartments. Refrigeration is produced by an air cycle system. Bleed air needs to be tapped from engine would experience a varying pressure load (up to 350 psi) and varying temperature (up to 600°C) at different operating conditions. This would obviously produce the expansion/contraction of pipes which will result in axial moment and angular displacement from their nominal positions. These movements should be compensated by means of providing suitable expansion joints/thermal compensators to avoid undesirable loads at the support points which may affect the overall functioning of the system. It is found that several methods such as braided flexible hoses with rigid support brackets are used in skewed pipe routing layouts. In this paper it is proposed to use flexible support brackets instead of rigid brackets. This methodology allows us to introduce plain bellows (low cost & weight) with flexible brackets which allows the pipe assemblies for expansions/contractions. Modular construction of the bracket allows movements either in linear or lateral directions with minor modification to the bracket, thus making it suitable for any pipe assembly lines carrying high pressure and temperature fluid. Simulation is carried out using CATIA V5 R20 kinematics for a typical ECS-engine bleed air pipe routing of a transport aircraft where lateral/linear movement of the pipe is simulated in the model for different directions.

Keywords: Flexible, Bracket, Engine, Bleed Air, Kinematics, Simulation.

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Study of various flexible joints as the thermal compensator elements in a typical light transport aircraft engine bleed system

Prashanth Banakara, H.T. Akshatha, M.L. Shankar and A. Rinku

Abstract

Engine bleed system helps in pressurisation and ventilation of aircraft cabin. Air tapped from the engine will be supplied to the bleed system, whose operating temperature and pressure will be of 340^{0}C and 140psi (differential) respectively. Due to the variation of temperature and pressure, the extension of pipes will produce high loads at the bends and supports, which should not exceed the limits specified by the engine manufacturer. Hence, it is necessary to choose a suitable thermal compensator to account for thermal expansion in the system and to reduce support reactions. The present work deals with study of various standard flexible joints like gimbals, bellows-braided and un-braided for engine bleed system of a typical light transport aircraft. For the simulation and analysis, commercially available finite element software like Altair Hypermesh and MSC Nastran were used. Initially, these flexible joint mechanisms were studied in isolation at element level and the results were compared with the guidelines of Expansion Joints Manufactures Association handbook. Once the study was found satisfactory, the compensators were introduced in the pipe system and a global analysis was carried out. During the study various parameters such as compensator location, their number, stiffness and optimal pipe routings were considered. Based on extensive study, braided bellows were found to be most effective thermal compensators for the present aircraft configuration. The braided bellow was designed and developed as per the analysis results and was successfully realised on the aircraft and found to function satisfactorily.

Keywords: Engine bleed system, Bellows, Gimbals, thermal compensator, flexible joints.

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A Generalized Method to Investigate the Bistability of Curved Beams using Buckling Analysis

Safvan P, Darshan S, Anirudh N Katti, G.K.Ananthasuresh

Abstract

In this paper, an initially straight beam with torsional springs at its two hinged ends is subjected to an axial force and its buckling mode shapes are found. Any shape which is a linear combination of the modes is taken as the as-fabricated stress-free form and then subjected to a transverse actuating force. Post-buckling analysis is used to compute the force-displacement characteristic of such a beam and thereby check if bistability exists. Two special cases of the torsion spring constants being very large and zero are presented. The former is a known result where a cosine curve is the fundamental buckling mode that does not give bistability unless its asymmetric second mode shape is avoided by a physical constraint. When the spring constant is zero, a single sine curve profile, which is the fundamental mode, can be made bistable without having to physically constrain the asymmetric buckling modes. This is realized when pinned-pinned boundary condition is used, which further allows the element to have enhanced range of travel between its two stable states, reduced switching force, and provision for secondary lateral actuation. To realise a monolithic compliant bistable element without any kinematic joints, torsion springs are substituted with equivalent revolute flexures. Physical embodiments three types of bistable curved beams, namely, fixed-fixed, pinned-pinned, and revolute flexure-based, are presented.

Keywords: Fully-compliant mechanisms, revolute flexures, buckling modes

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SESSION 3

Teaching mechanism dynamics using a haptic device – II

Majid Koul, Subir Saha, M Manivannan

Abstract

Haptics feedback has interested several researchers in using the technology for teaching dynamics associated with many physical systems. Mechanism dynamics is one such area in which the effects of changes in kinematic and dynamic parameters of a virtual mechanism can be realized physically with a haptic device. In this work, an in-house developed inverse dynamics algorithm for closedloop systems is utilized in order to compute the forces/torques associated with the complex mechanisms in motion. The proposed work is a generalization to the concept of 'teaching mechanism dynamics using haptics' demonstrated in our previous work [1]. In this part, the protocol to integrate virtual mechanisms, generalized dynamics algorithm, the control causality and the haptic device are discussed. The development of such technologies is contemporary and is expected to greatly transform the pedagogy of teaching dynamics.

Keywords: Haptics, Dynamics, Education, Higher-DOF mechanisms

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PID-like Fuzzy Logic Control Scheme for Control of a Planar Parallel (3PPR U-base) Manipulator

Yogesh Singh, M. Santhakumar

Abstract

The paper investigates the control of a three prismatic-prismatic-revolute joints (3 PPR) U-base planar parallel manipulator in the presence of parameter uncertainties and unknown disturbances. The 3PPR U-base planar parallel manipulator is a motion platform with singularity free workspace (bounded orientation angle $\theta_x \leq \pm 90$) and has manipulator legs located on the plane in association with a moving platform. Each leg has a prismatic-prismatic-revolute joint configuration in which one prismatic joint is active in each leg. To control the end-effector's mobility of the 3PPR U-base motion platform a proportional-integral-derivative (PID)-like fuzzy logic control scheme is introduced. Purpose of the proposed control scheme is to follow the given task-space trajectory in spite of external disturbances, system uncertainties and internal noises associated with the proposed planar parallel manipulator system. To demonstrate the effectiveness of the proposed controller, experiments (on a in-house fabricated prototype of the proposed manipulator) with a desired characteristic trajectory are performed and its control performance is compared with an existing conventional PID controller. The results confirmed that the proposed controller has the capability to track the desired task space trajectory and gives a better robust control performance.

Keywords: Planar parallel manipulator, proportional-integral-derivative (PID) control, PID-like fuzzy logic control, task space trajectory control

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Simulation of impact and rolling contact dynamics between a rigid body and a soft material using multibond graph approach

Mohit Sachdeva, Anil Kumar Narwal, Anand Vaz

Abstract

Impact is a contact between two bodies for a short duration. Dynamics of impact is quite complex as it involves application of contact forces for a short period. Evaluation of impact and rolling contact dynamics is important to understand many contact problems in robotics, manipulation tasks, multibody dynamics, explosive loading, etc. In this paper, impact and rolling contact between a rigid sphere and a soft material is modeled using multibond graph. A specimen of silicon rubber, which is a soft material, is discretized into a number of eight nodes brick elements. Stiffness, mass and damping matrices of the soft material are calculated using finite element method, and used as **C**, **I** and **R** field respectively in the bond graph model. A contact algorithm is developed to detect dynamically contact location and contact area as contact interface changes during rolling and impact. Contact interface between the sphere and the soft material is assumed to be viscoelastic, and modeled using spring-damper subsystems along normal, tangential and binormal directions. Stick-slip friction between the two contacting surfaces is modeled using Kelvin-Voigt model. A rigid sphere is thrown on the soft material with some horizontal velocity, and it bounces many times and then rolls on the soft material before attaining a state of static equilibrium. The model determines contact area and spatiotemporal distribution of contact forces during impact and rolling contact. Dynamics of the soft material during compression and restitution along with the dynamics of the sphere is evaluated from the model.

Keywords: Impact, Contact dynamics, Bond graph, FEM, Viscoelastic

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SESSION 4

Link Shape Optimization for Input Torque Reduction

Vinay Gupta, Subir K. Saha, Himanshu Chaudhary

Abstract

The reduction of input torque in robots can be performed by optimal distribution of mass in the links. Conventionally, optimal distribution of the mass is carried by adding counter weights, etc. Addition of counterweights increases the overall mass of the system. As a result torque reduction at each joint is not trivial. This paper proposed a methodology for achieving optimal mass distribution in link by changing its shape rather than adding counterweights. The problem formulated here is a shape optimization of the links of robots for the desired mass inertia properties. These desired inertia properties are the outcome of the optimization routine run for the minimization of actuating torques at the joints of the robot. This approach for the shape optimization is based on the material distribution method, which is mainly used for the topology and shape optimization of structures.

Keywords: Shape optimization, torque minimization, manipulator

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Dynamic Identification of Manipulator: Comparison between CAD and Actual Parameters

Abdullah Aamir Hayat, Vishal Abhishek, Subir. K. Saha

Abstract

It is essential to know the dynamic parameters of the robot for its precise control and simulation. Philosophy of identification is based on finding the model using its input-output data. The identification equation of the manipulator is derived from Newton-Euler equations, using manipulator kinematic, i.e., geometric parameters and joint values as input and joint torque data as output. In this paper, the dynamic parameters are identified for the CAD model provided by the robot manufacturer in simulation. And experimentally for the installed seven degrees of freedom (DOF) robot KUKA-iiwaR800. The variation between the joint torques predicted from the estimated base parameters obtained using CAD model and actual robot are presented. The factors responsible for the variation are also highlighted.

Keywords: Dynamics, Identification, Base Parameters

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Hexahedron Point Mass Model and Teaching Learning Based Optimization for Balancing of Industrial Manipulators

Devi Singh Kumani, Himanshu Chaudhary

Abstract

Dynamic balancing of an industrial manipulator using hexahedron point mass model and teaching learning based optimization is presented in this paper. The minimization problem is formulated using concept of dynamically equivalent system of point-masses in hexahedron configuration for each link such that positive values for all point masses and link's inertias are ensured. To compute the shaking forces and moments the dynamic equations of motion for manipulator are systematically converted into the parameters of the equimomental point masses. The recently developed, 'Teaching Learning Based Optimization (TLBO)' is used to solve the optimization problem. The effectiveness of the methodology is demonstrated by applying it to a six-dof PUMA robot. shaking forces and moments at joints for the balanced and unbalanced PUMA manipulator are also provided to compare the result. The TLBO is a teaching-learning process inspired algorithm. It uses the mean value of the population and the best solution of the iteration to change the existing solution in the population, thereby improving the solution for the whole population and increasing the convergence rate. A MATLAB program is developed to find the design variables to minimize the shaking force and moment at the base of the robot. The objective function value obtained using TLBO is validated and compared with another population based solution i.e. GA. It is observed that TLBO is better than that of GA in terms of computational effort.

Keywords: Dynamic balancing, Teaching Learning Based Optimization (TLBO), Hexahedron point mass model, Shaking force and Shaking moment.

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SESSION 5

Fault Diagnosis of Gearbox Using Various Condition Monitoring Indicators for Non-Stationary Speed Conditions: A Comparative Analysis

Vikas Sharma, Anand Parey

Abstract

Fault diagnosis of gearbox at the initiation of crack is very important before it get turned into catastrophe. These condition monitoring indicators are applied to the signal acquired from the gearboxes via accelerometers. Every indicator has own capabilities to identify the fault and gives alarm during crack propagation. But, in the bunch of indicators which is most worthy and sensitive toward fault is still not clear? So this study shows a widespread comparison between RMS, Kurtosis, Crest Factor, FM0, FM4, M6, NB4, Energy ratio, NA4, Energy operator, performed for no crack, initial crack and advanced crack on pinion with different fluctuating input speeds. In real time situations, machines like gearboxes observe various types of fluctuations like sinusoidal speed fluctuation, quadratic speed fluctuations and random speed fluctuation. Experiments are performed on gearbox test rig; signals are acquired at different input speed profiles to test the performance of statistical indicators. This comparative analysis shows the responsiveness of indicators towards crack. Result suggests that statistical indicators are more prone to fluctuating speed, but not towards crack.

Keywords: Fault diagnosis, condition monitoring indicators, gear fault, fluctuating speed.

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Defect Detection Methods for Gears- A Review

S. Gautam, N. Tandon, S. Khanam

Abstract

The present review covers various types of defects in gears, how to detect and diagnose these defects, broad literature overview related to defects and condition monitoring (CM) techniques and finally, conclusions drawn from survey. Presence of defects in gears can alter the normal operating conditions leading to higher vibration and noise levels and decrease in the efficiency of the transmission. Many CM techniques are known for the defect detection and diagnosis of gears. Cepstrum analysis, vibration measurement, acoustic emission (AE) technique and noise monitoring etc. are the prominent CM techniques used in industries. Vibration signals carry dynamic information of the machine and hence these signals are very useful for fault identification. AE signals identify defects earlier than vibration signals. Application of vibration and AE monitoring techniques to spur, helical and worm gears have been identified and summarized through wide literature survey. Most of the work have been reported in detecting and diagnosing defects in spur gears. Few literatures are also available for defect detection in helical and worm gears.

Keywords: Gears, Defects, Diagnosis and Condition-monitoring

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Modelling of a Prognostics Observer for Automated Manual Transmission

Sivakumar Ramalingam, Sanjeev Ramakant Pimpale, Srinivasa Prakash Regalla

Abstract

Currently gear actuation control module of an Automated Manual Transmission (AMT) system does not receive the feedback on the actual condition of the gearbox hardware, particularly synchronizer which is critical for gear shift quality. This paper covers modelling of a Prognostics Observer for AMT system. The observer monitors real time position of the gear shift actuator, specifically during synchronization phase of the gear shift cycle. Based on the actuator travel measured at the gear actuator end, synchroniser wear limit is monitored and warning provided for replacement. Also, the synchronization time is monitored real time and warning for re-calibration of the AMT system is provided, when the synchronization time exceeds the allowable limits. Condition monitoring of gearbox hardware provides the prognostic functionality for AMT system which ensures consistent gear shift quality and warning for repair and/or re-calibration. Systematic analysis of the monitored data provides an accurate diagnosis of a developing fault. Thus, with the advanced control systems in place for AMT, it is possible to develop a closed loop feedback based condition monitoring system, for improved diagnostics and prognostics of AMT system.

Keywords: Automated Manual Transmission, AMT, Prognostics, Diagnostics, Observer, Condition Monitoring, Gear Shift Quality.

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SESSION 6

Single Actuator Shaker Design to Generate Infinite Spatial Signatures

K D Lagoo, T A Dwarakanath and D N Badodkar

Abstract

The PSS joint configurations based parallel mechanism is discussed. Kinematic design of a PSS based parallel mechanism is presented. The cam and the follower for a joint space prismatic displacement are proposed and the design is presented. The design of a single actuator shaker to operate in a six dimensional space based on a PSS joint configuration is designed. The various combinations of cam and the follower options for the design are tabulated. The kinematic design analysis for generating an infinite signature set is given. A virtual simulator validates the design and motion signatures in six dimensions employing a single actuator. This, also as a manipulator that follows a specific trajectory repeatedly is described.

Keywords: 6-PSS Parallel Mechanism, Cam and follower, Shaker tables, Displacement signature, Single Actuator Manipulator.

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Development of a Sun Tracking System using a 3-UPU Spherical Wrist Manipulator

Sudipta Pramanik, Ashitava Ghosal

Abstract

This paper presents the development of a sun tracking system using a 3-UPU parallel spherical "wrist" manipulator. The 3-UPU manipulator, consisting of a fixed base and an orient-able platform, is actuated by three linear motors at the prismatic (P) joints and has a special geometry which makes the 3-UPU manipulator equivalent to a spherical wrist with three rotational degrees of freedom. A flat mirror is mounted on the top of the platform and by actuating the prismatic joints, the platform can be made to track the sun and focus the incident energy at a distant receiver. The main advantage of the 3-UPU configuration is a result of the parallel nature – it can carry larger mirror (more loads) and has lower tracking error. The azimuth and the elevation angles of the sun change as the sun moves across the sky and are dependent on the date, time and location on the Earth"s surface. A set of kinematic equations is derived which can be solved numerically to obtain the translations at the prismatic joints as the azimuth and the elevation angles of the sun change. Though the 3-UPU spherical wrist manipulator has its inherent singularity, the singularity condition is avoided by suitable design of the system and by judicious use of the workspace. The theoretical and numerical simulation results are validated by simulating the sun-tracking system with a CAD model.

Keywords: Sun tracking system, 3-UPU spherical wrist manipulator, Kinematics equations, CAD model.

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Kinematic Analysis of a Passive Sitting/Lying type Lower Limb Rehabilitation Robot using a Planar Parallel Manipulator

Jayant Kumar Mohanta, Santhakumar Mohan , Chitransh Saxena, Gaurav Gupta

Abstract

This paper addresses the working of a sitting/lying type passive lower limb rehabilitation robot (LLRR) where patients legs connected with a passive serial manipulator which consists of three rotary joints serially connected in a plane (RRR), with an active feedback, driven by a three degrees of freedom (DOF) parallel manipulator looks like a symbol *"The Lambda"*. The kinematics of the proposed rehabilitation robot has been presented and discussed. Performance analysis of the proposed robot for basic therapeutic exercises has been analyzed on a virtual prototype with the help of multibody dynamic package (namely MSC ADAMSTM) and discussed.

Keywords: Lower limb rehabilitation; rehabilitation robot; parallel manipulator; sitting/lying type rehabilitation robot; robotherapy**.**

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SESSION 7

A study of Σ^2 singularities in the 3-RPS Parallel Manipulator

Rohit Kalla, Latifah Nurhami, Sandipan Bandyopadhyay, Stephane Caro, Philippe Wenger

Abstract

This paper presents some analytical results related to the determination of the singular poses of the 3-RPS parallel manipulator at which it gains two degrees of freedom. The forward kinematic univariate (FKU) of the manipulator acquires a special structure at such a pose. All such poses have been identified in the closed-form, using a St¨udy-parameter representation of SE(3), for both the operation modes of the 3-RPS. These results are novel, to the best of the knowledge of the authors, and these have been verified using the traditional method, using the criterion of loss of rank of certain Jacobian matrices. The theoretical results have been illustrated with numerical examples.

Keywords: Σ^2 singularity, 3-RPS manipulator, gain of degree-of-freedom, Study parameterisation, spatial parallel manipulators.

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Data-Driven Kinematics: Unifying Synthesis of Planar Four-Bar Linkages via Motion Analysis

Anurag Purwar, Q. Jeffrey Ge

Abstract

This paper presents a novel data-driven approach for kinematic synthesis of planar four-bar linkages consisting of revolute (R-) or prismatic (P-) joints by extracting the geometric constraints of a motion. The approach unifies the often elusive type synthesis problem with dimensional synthesis and for a given motion determines the best combinations of R- and P-joints in a four-bar linkage and their dimensions by analyzing a given motion. The underlying formulation is based on concepts of planar quaternions, kinematic mapping, data-fitting, and reverse-engineering of shapes. By formulating the kinematic constraints of planar four-bar linkages in a unified form and then fitting the constraints with the given motion data in the image space of planar displacements, we obtain the best type and the dimensions of the linkages. The results will be demonstrated via *MotionGen*, an intuitive iOS and Android app that implements this approach and allows designers to synthesize linkages for the motion generation problem.

Keywords: Planar-Four Bar Linkage Synthesis and Analysis, Planar Quaternions, Kinematic Mapping, Data Fitting, Reverse Engineering

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Design of lobe pair profile of an external rotary lobe pump

Tanuja P. Mishra[1], Yashavant D. Patel[2], Unnati A. Joshi[3]

Abstract

Noncircular lobe rotor pair profile generation is complex and new form of external rotary lobe pump used in industry. Rotors used in lobe pumps are conjugate generated pair, generated from their respective pitch pairs. The pumping ratio of a lobe pump is also a function of pure geometry of the lobe and thus it is mainly governed by the pitch and deviation function. In present work, non-circularity of the pitch was considered as a main parameter. Direct Profile Design (DPD) method was used to develop identical noncircular pitch pair. The noncircular pitch pair was modified to get generated pair by applying envelope theory and deviation function method. Lobe pair with different noncircular pitch functions was obtained for a given deviation function. The zero interference of the generated conjugate lobe pair at different orientations was also verified using high end software. Specific flowrate formula in the form of pitch function and deviation function was used to compare performance of the lobe profiles developed using different noncircular pitch functions.

Keywords: Noncircular pitch, Envelope theory, Deviation function, Direct profile design.

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SESSION 8

A method for controlling the bimorph piezoelectric actuator using fuzzy logic controller towards robotic assembly

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Abstract

Piezoelectric actuator is one of the most versatile types of smart actuators which is extensively used in different industrial applications like robotics, MEMS, micro assembly, biological cell handling, self-assembly and optical component handling in photonics. By applying potential to a piezoelectric actuator, it can produce micro level deflection with large force generation, very fast response and long term actuation as compared to other actuators. The design and analysis of the bimorph piezoelectric cantilever using novel fuzzy logic controller (FLC) tuned proportional-integral-derivative (PID) system are carried out where the bimorph piezoelectric actuator is used as an active actuator for providing the dexterous behaviour during robotic assembly. Fuzzy is introduced for fast tuning of PID and provides the steady state characteristics. Experimentally, it is verified that the actuator produces steady state behaviour of deflection for handling of the object. A prototype is also developed which shows the potential of handling the small light weight objects for robotic assembly.

Keywords: Piezoelectric actuator, fuzzy tuned PID, gripping system, robotic assembly

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Finite element analysis and design of an asymptotically correct patch-actuator model

Shreya Banerjee, Sitikantha Roy

Abstract

The main aim of the present study is to develop a mathematical model of a patch actuator using variational asymptotic method. Patch actuators are based on inverse piezoelectric effect where an electrical voltage is used as an input to induce internal stresses or mechanical deformations.Variational asymptotic method is a mathematical approach which can be applied to any problem defined by an energy functional having one or more small parameters. In this work for analyzing a patch actuator model we have taken variation of electromechanical enthalpy functional. Starting with the three dimensional electromechanical enthalpy functional which is then approximated asymptotically using the slenderness of the structure as the small parameter to find out an equivalent one dimensional electromechanical enthalpy functional. The three dimensional components of the field variables has been recovered to get a good insight of both electrical and mechanical variables of the patch actuator model. There are wide range of applications of a patch actuator, starting from cantilever tip of an Atomic force microscopy to miniature robotics, damage detection, excitation and control of beam, energy harvesters to aircraft and aviation industry. We have validated our results with the simulation results obtained from ABAQUS and shows a very good agreement.

Keywords: Variational asymptotic method Patch actuator Piezoelectrics.

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Experimental acoustic analysis of Sarasvati Veena

Samarth Mathur, Ayush Raizada, Pravin M. Singru, Radhika Vathsan

Abstract

This paper presents a complete and thorough experimental study of the acoustic characteristics of the Sarasvati Veena of South India. The variation of timbre with tension, string length and string mass has been studied using the acoustic FFT. The results showed a scientific explanation for the special quality of the sound of this seven-string fretted instrument. The timbre is characterized by the FFT, and it shows up features that are not expected in the plucked string fixed at two ends. These peculiar features are partly due to the boundary conditions imposed by the curvature of the kudirai (the main bridge) on one end of the string and themeru (upper bridge). The amplification and suppression of certain harmonics are explained through the phase change. This is the first scientific analysis of this ancient and most important South Indian musical instrument.

Keywords: Indian string instrument, acoustic analysis, timbre, plucked string, veena.

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SESSION 9

A Compact Bidirectional Bistable Electrothermal Switch

Pavan Kumar Challa, Abhishek Meena, A. Narayana Reddy

Abstract

In this paper, a novel design of electrothermally actuated microelectromechanical systems (MEMS) switch is presented. The MEMS switches have application in power relays, optical circuits, radio frequency devices, and biomedical devices. The electrothemal actuation is chosen for actuating compliant switch as it can generate large forces compare to other actuations. In our design, a curved beam is provided between two in-plane bidirectional electrothermal actuators. Applying appropriate polarity of voltage to the terminals, the bidirectional actuator can move in two opposite directions. There are two states for the switch as the curved beam exhibits two stable configurations; let them be ON and OFF states. Since both the electrothermal actuators can move in opposite direction, they can push the curved beam from ON state to OFF state and vice versa. It can be noted that it does not need any power supply whether it is in either ON or OFF. Novelty in the present design is that actuators along with curved beam is a single piece compliant mechanism. The proposed design can fit in the space of 650 μm × 100 μm.

Keywords: Electrothermal actuation, MEMS switch, Bistable beam, Bidirectional actuator, Snap-through

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An Experimental Method to Estimate the Growth-rate of a Leaf using Image Processing and solving an Inverse-Growth-Problem

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G.K. Ananthasuresh

Abstract

Plant leaves provide a convenient model system to study growth in living organisms and to investigate controlled growth for achieving a design objective. In this work, we describe geometric and kinematic aspects of estimating the growth-rate in a leaf. We use an image-processing technique in conjunction with time-lapse imaging of a spotted leaf and solving an inverse problem in growth. Geometry and kinematics are inherent in this problem.

We describe a leaf-growth experimental setup in which the leaves under consideration are first marked with dots and the evolution of their form is tracked by photographing the leaves. We then subject these images to image-processing operations namely image-perspective alignment followed by suitable scaling. The locations of markers in these images are then extracted with an accuracy of 100 microns, from which the intermediate growth-displacements are computed. These displacements are specified as input to the inverse problem, wherein the nodal coordinates of the initial and grown configurations are specified and the growth-rate required to effect the growth is estimated. The results of the experiments run in-house and the key insights are presented.

Keywords: Inverse problem, growth, image processing

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Development of Radioactive liquid dispensing mechanism for exclusive applications in Radio-pharmaceutical production laboratories

Chetan Kothalkar, A.C. Dey, Prabhakar Naskar, S.S. Sachdev

Abstract

Radio-isotopes (Mo-99, I-131, P-32, Cr-51,etc) in liquid form are popular in diagnosis and treatment of various Ailments.Radiopharmaceuticals (RPhs) are stored for transportation in 10 and 15ml capacity hermetically sealed vials. RPhs are transferred to the vial inside the lead shielded tong box to comply with the regulatory requirements. Around a decade back, when the RPhs application began in small scale, dispensing of the RPh preparation in liquid form was done using the pipette mounted arrangement on the pantograph mechanism and maneuvered using the tong manipulator. This 10ml capacity pipette was connected to the 20ml capacity syringe and using the suction generated by the syringe, the RPh from the pooling vessel use to get loaded in the pipette and then dispensed into the open top vial by pushing the plunger of the syringe. To hermetically seal the vial, rubber stopper and an aluminium cap was used and further sealed using the hand operated sealing machine. This operation was causing avoidable gamma radiation dose to the operator and therefore this unsafe operation necessitate discontinuation of the traditional method by developing new method of transfer of the liquid into the sealed vial directly by using remotely operated machines. With the modern dispensing mechanisms working on the principle of vacuum transfer, various machines have been designed and deployed for transfer of the liquid to either the pooling vessel from the vial or vice versa. In one of the cases where liquid I-131 is handled, peristaltic pump is used to transfer the RPh to eliminate the associated hazard due to it's volatile nature. Proposed paper discusses the chronological stages of development of the radioactive liquid transfer machines with the objective of making the operation more accurate, radiologically safe. Figures below show some ofthe liquid dispensing machines developed and deployed in the laboratory.

Keywords: Radiopharmaceuticals, pipette, syringe, vial, lead shielded tong box, peristaltic pump, negativepressure, pantograph, liquid transfer machine.

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SESSION 10

Development of Reconfigurable Outdoor Mobile Robot-a Design Optimisation Approach

Riddhi Das, D.N. Ray, S. Majumder

Abstract

A number of outdoor mobile robots have been designed to achieve specific operational characteristics. It is obvious such robots can offer excellent operational capabilities within a narrow and constrained domain. However with change of mission parameters and operating environment such superiority can no longer be exhibited by many systems. For example tracked mobile robot shows exceptional operating behaviour in outdoor marshland, sand and similar types of soil conditions whereas its operating behaviour is much inferior compared to a wheeled robot for paved robot environments. The main dichotomy faced by a designer is to select which one is the most suitable under given conditions, tracked, wheeled or legged. This paper tries to find a solution to this dilemma through design optimisation using reconfiguration capabilities as the unique deterministic feature. This research is being carried out using Autodesk Inventor as a provider of 3D modelling tools together with multibody simulation software ADAMS of MSC Software Corporation.The parameters taken into consideration include kinematic and geometric description, drive transmission including length of links, pitch length of belt, approach angle ground clearance and many more. This study clearly shows that the selection of a specific geometry of a drive mechanism alone is not suitable for design of an outdoor mobile robot.

Keywords: Outdoor, Tracked, Mobile Robot, Reconfiguration and Analysis

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Design, analysis and development of pipeline robot

Bijo Sebastian, Dip Narayan Ray, S. Majumder

Abstract

Pipe line inspection is an important task where robotics could be applied extensively. Robotic pipeline inspection devices reported in literature are primarily of internal type, requiring special preparation of pipelines for their deployment and retrieval. In this context, robotic systems which can traverse along the external surface of the pipeline structure have the advantage of being able to do inspection without blocking the pipeline. In this paper we have done the design, analysis and development of an external pipeline inspection robo. The proposed system consists of a base with two arms on both sides. It has four wheels, two large hollow ones enclosing the complete base structure and two smaller ones at the end of each arm. For inspection, the system hugs the pipe along its outer periphery such that, only the wheels are in contact with the surface and then drives along the length of the pipeline. Approximate mathematical modelling of the system has been performed and its working has been analysed through an ADAMSMatlab Co-simulation. Based on the results, a prototype has been manufactured, consisting of multiple digital servos for arm joints and dc motors for the wheels, along with on-board controllers and wireless camera. The system can be controlled throughWiFi from a remote station. Field trials have shown that the robot is capable of inspecting pipelines with an outer diameter of about of 200 mm. The application potential of the system includes surface and exposed large diameter pipeline inspection in outdoor and industry.

Keywords: Pipeline inspection, mobile robot, modelling, simulation

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Development of reconfigurable serial manipulators using parameters based modules

Satwinder Singh, Atul Aggarwal, Yogesh Singhal, Ekta Singla

Abstract

The aim of this paper is to present a modular architecture for the design and realization of reconfigurable serial manipulators. Based on the actuator specifications – size, weight and load carrying capacity – three divisions of the modules are proposed, possessing same architectural design but different sizes. The novelty of the approach lies in the adaptability of the modules in adjusting the link lengths and the twist angles, according to a given set of design parameters. A brief description of the task-based design is included in the paper. The primary objective of this work is the architectural design of the proposed modules which can cater to the designed values of the robotic parameters. The modules are analyzed under given static load conditions. Stress analysis is performed on the components for the worst case static loading and the simulation results for one division are discussed in the work. An optimal assembly planning, including the number and the type synthesis of modules, is briefed. To demonstrate the utility of the modules in realistic work cells, design and assembly of a 6-links manipulator suitable to work in the given environment is included in the paper.

Keywords: Re-configurable, modular design, task-based, assembly planning

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SESSION 11

Design for Additive Manufacturing of Products Containing Articulated Mechanisms

Sreeram Nurani Ramasubramanian, Ramakrishna K., Dibakar Sen

Abstract

This paper explores the issues and challenges involved in designing products containing articulated mechanisms for Additive Manufacturing (AM). Clearances in the kinematic pairs are governed by the requirement of precise kinematic functionality and concerns of the AM process. The necessary clearances in a product containing various kinematic pairs in the design for no-assembly (DNA) and design for assembly (DFA), in the context of AM, are discussed through various test cases. This paper, for the first time in literature, presents the issue of making helical joints by AM. It is observed that the joint level design decisions for AM do not guarantee functionality at the product level due to tolerance and body-space interactions with the support material. Geometric features are introduced into the design of the parts to facilitate post fabrication removal of the obtrusive support material and ensure smooth motion. The ideas are presented using AM of a kinematically over-constrained, pulse sensor device.

Keywords: Additive manufacturing, 3D printing, Product prototyping, Design for manufacturing, Joint clearance, Hole features, and Support material

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Decentralized Cooperation between a Terrain Aided Mobile Robot and Rotary-Wing Aerial Robot for Exploration: An Approach

S. Datta, D.N. Ray, U.S. Patkar, S. Majumder, M. Majumder

Abstract

This paper presents an approach towards developing decentralized cooperation among different classes of robots for efficient exploration where each class is uniquely equipped with a sensory suite with a set perception range thereby building a system where each class merges the acquired information in a global map of the environment increasing final accuracy, quality of localization and reducing the occurrence of spatial conflicts. The present work attempts at decentralized cooperation between a Terrain Aided Mobile Robot (TAMR) and a Rotary Wing Aerial Robot (RWAR) to provide enhanced capability for security and surveillance in various areas such as border patrolling and mine detection. TAMR is used for terrain exploration and surveillance whereas RWAR encompasses the area which cannot be covered by TAMR on the ground. Each robot's activity encompasses a certain domain of operation which complements other robot's activities. The sensory system for TAMR and RWAR differ in nature thus cooperation between TAMR and RWAR merges the acquired information to generate composite information thus increasing final map accuracy, quality of localization and reducing the occurrence of spatial conflicts for providing with enhanced capability for navigating through difficult, hazardous and remote environment with suitable domain based robot.

Keywords: Terrain Aided Mobile Robot, Rotary Wing Aerial Robot, Decentralized Cooperation

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Analytical Approach for Force Stability Analysis of Stair Climber

S. Jain, D. K. Munda, S. Majumder, D. N. Ray, S. K. Char, N. Gulgulia

Abstract

To design and develop a robot for climbing up the stairs as well as for urban search and rescue missions in buildings and cities, it is often necessary to place flipper or swing arms to get better grip of stairs. Stair climber robot should be quick and agile at the same time be able to deal with rough terrain. This paper presents the mechanical structure of stair climber robot with hardware composition and force analysis using classical mechanics method. To find out the effectiveness of the dynamical model the results from the model is compared with simulation and experiments.

Keywords: Stair climbing, Variable configuration, Flipper robot, Force analysis

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SESSION 12

Constrained Inverse Dynamics and Feet-Terrain Interaction Modelling of a Staircase Climbing Hexapod Robot

Abhijit Mahapatra, ShibenduShekhar Roy, Dilip Kumar Pratiha

Abstract

In the present study, the constrained inverse dynamics model using Newton-Euler approach has been developed for a realistic hexapod robot. For a more realistic locomotion analysis, oblique impact of feet-tip with the terrain is considered, which is governed by a compliant impact force model. It is assumed that the prescribed motion of the model is fully known and consistent with the kinematic constraints of the realistic model. The kinematic motion parameters (displacement, velocity and acceleration) obtained from the inverse kinematic analysis with specified path and gait planning for straight-forward motion in varying terrains are substituted in the inverse dynamic model to determine the dynamic motion parameters that are responsible to generate the prescribed motion trajectories. The solution is not unique due to the redundant set of forces/ moments and/or constraints used. Therefore, the contact force distribution in the feet during interaction with the terrain is considered to be a constrained optimization problem, where minimizing the sum of the squares of joint torques of the system has been considered as the objective function along with some linear equality and inequality constraints. The paper also investigates the optimal feet forces' distributions under body forces, joint torques, total power consumption etc. without any external disturbance during the robot's locomotion on a staircase.

Keywords: Hexapod Robot, Straight-Forward Motion, Staircase Climbing, Inverse Dynamics, Feet-Terrain Interaction, Optimization, and Power Consumption

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Modelling of mobile robot with on board redundant manipulator arm

R.V.Ram, P.M.Pathak, and S.J.Junco

Abstract

Manipulators with mobile base are gaining momentum in the industry due to improved workspace and flexible adaptability to changes in the product designs. Although there has been research in this field or considerable time, many issues are still to be resolved viz. obstacle avoidance, redundancy resolution for singularity avoidance, dynamic analysis of combined manipulator and a mobile robot, base disturbances and optimized motion planning for limited power sources. Meticulous motion planning is a very essential for a mobile robot, particularly when it is carrying an on board manipulator.

In this work a three wheeled mobile robot (Robotino) with on board redundant manipulator (MRBM) of eight degrees of freedom is considered for the analysis. Kinematic model of MRBM is developed first afterwards the Bond graph model of the mobile robot combined with manipulator is developed. Dynamic analysis is performed using the system equations generated from the bond graph model and simulation results are presented for different cases.

Keywords: mobile manipulator (MM), bond graph modeling, dynamic analysis

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Design of a static balancing mechanism for coordinated motion of an external load

Aravind Baskar, Gurunathan Saravana Kumar, Sandipan Bandyopadhyay

Abstract

This paper presents the design of a mechanism that allows for the staticbalancing of an external load, moving in coordination with the actuator of themechanism. The load is balanced with the help of linear springs mounted on thelinks of the mechanism. The springs are allowed to be of non-zero initial length,thus making the physical implementation of them easier, while requiring someanalytical approximations in their modelling. The two requirements of the design,namely, kinematic coordination, and static balancing, are achieved via threepositionclosed-form synthesis, and numerical optimisation using a software tool,respectively. A complete case-study is presented as an illustration of the proposedmethod.

Keywords: Static balancing, kinematic synthesis, mechanism design

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SESSION 13

Path-based Optimal Design Strategy for Customized Redundant Manipulators

Ekta Singla, Satwinder Singh, Rohit Paul Kuruvilla

Abstract

The rapidly growing range of robotic applications has resulted into the increased adoption of customized manipulators. This paper addresses the need for an optimization strategy that handles both the design and the path-planning of a robot, simultaneously, to fulfil the requirements of given tasks for a robotic application. The strategy will involve treating the path-planning and the robot design as coupled problems, as they are in reality, rather than treating them as separate stages in the robot development process for an application. This can be looked at as a superior approach to path planning that involves modifications in the underlying robot's design to optimize the output.This can also be looked at as a smarter robot design process in which the final path is not rigid, and can be altered to optimize given criteria. The work is focused at the robotic applications that involve cluttered environments and possesses the need of highly redundant manipulators. The proposed performance criteria is related to robot safety while maneuvering an optimal path. For non-redundant manipulators, focus is more on singularity avoidance and kinematic conditioning. Similarly, for a non-cluttered environment, a performance criterion related to robot safety would not be ideal. A novel performance index - *RoboGin* is proposed in this paper that relates to collision avoidance and fits as basis for redundant manipulator design in cluttered environments. A case study have been presented to illustrate the significance and application of the proposed strategy, resulting into an optimal set of robotic parameters along with the optimal path.

Keywords: Robot Safety, Task-based design, Performance indices, Redundant manipulators

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Population generation and validation for the task-based morphology evolution of robotic manipulators

Sameer Gupta, Ekta Singla, Bhaskar Dasgupta

Abstract

An algorithmic platform is proposed in this paper to randomly generate and validate a set of basic morphologies of planar robotic manipulators, with combinations of serially connected links and loops. To design a robot for specified tasks of following a trajectory and possessing a prescribed stiffness, there are possibilities of working with several hybrid morphologies. Normally, one such basic morphology is selected with experience and the robot is designed for the given tasks. In the present work, basic structures of planar robotic manipulators are generated randomly, while varying the number of links and number of degrees of freedom (dof), within a stipulated number of links. This set will serve as an initial population for the evolution of an optimal mechanism for given tasks, using evolutionary algorithms. A novel concept of Mechanism Assembly Matrix has been introduced to *randomly* generate planar hybrid manipulators. The proposed algorithm is executed for various number of links and dof. The resultant structures are successfully matching to the possible solutions for the given number of links and the dof. The second phase involves the scrutiny of generated morphologies for validity and retain only the viable structures in the database. A brief discussion is included on the morphology selection during the process of task-based design of a robot.

Keywords: Hybrid manipulators, Initial population generation, Morphology synthesis, Evolutionary robotics

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Gravity Balancing of a 7-DOF Hybrid Manipulator Containing Spatial Links

Amanpreet Singh, Ashish Singla*, Sanjeev Soni

Abstract

The main focus of this work is to perform the gravity balancing of a 7-DOF hybrid manipulator. A hybrid manipulator is a combination of open- and closed-loop chains and contains planar and spatial links. Gravity Balancing is an important aspect for robotic manipulators, especially for serial manipulators, where with increase in number of links, the gravitational effect of succeeding links increases on preceding joints. This leads to reduced positional accuracy, low payload carrying capacity, and high power requirement of the serial manipulator. In such situations, gravity compensation needs to be provided in order to improve the performance. In this paper, the concept of gravity balancing is used and extended for a hybrid manipulator. The gravity balancing for hybrid manipulators has been demonstrated on the case study of a hybrid manipulator, which is to be used for medical surgery. The prototype of a 7-DOF hybrid manipulator is developed to validate the efficacy of the proposed concept of gravity balancing experimentally.

Keywords: Hybrid manipulator, gravity balancing, zero-free-length spring, spatial link.

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SESSION 14

Design and Development of a Robot Transformable between Biped Waking and Wheeled Modes

J. Singh, D.Gandhi, N. Reddy

Abstract

In this paper, a novel robot is designed such that it possesses walking as well as wheeled motion. Wheeled locomotion is most widely used mechanism for mobile robots on even terrain whereas walking mechanism is suitable for mobility of robots on uneven terrain. Unlike quadruped robots or hexapod robots, biped robots can serve as a replacement of humans for many hazardous tasks. To achieve advantages of wheeled as well as biped robot, we designed a robot with both mobility mechanisms. First, a 6-degree of freedom (DoF) biped robot has been constructed with 3 DoF on each leg. A gait pattern for walking mechanism is designed based on kinematic analysis of robot and simulations were done to visualize the walking gait. Furthermore, the actuation angles are provided based on foot trajectory and inverse kinematics of the robot. Every degree of freedom has been actuated by a motor with inbuilt PID controller. Two designs are proposed for the biped robot, one having springs between ankle and foot and the other entirely rigid. Next, the task is to transform from walking mode to wheeled mode. A setup was designed to bring four wheels in contact with the ground and lift the feet from the ground simultaneously. In the wheeled mode, rear wheels are active and front caster wheels are passive. Experiments were carried out in which the prototype is made to move with both mobility mechanisms.

Keywords: quadruped robots, hexapod robots, biped robots, degree of freedom, gait, PID

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Inch worm mechanism for solar panel cleaning robot

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Abstract

This paper describes a design of mechanism for robot of solar panel cleaning process. Cleaning process is requires the robot to be able to travel on the Solar panel module in specific area. The movement of the robot is due to Inch-worm mechanism with the help of two cables. Our proposed design having two body with two grippers placed at either end of its body, the inchworm's mode of locomotion is to decisively attach the rear portion of its body on a cable via its gripper, extending the remainder of its body forward, attaching it on the cable and bringing the rear part of its body to meet the forward part. This design has two servos. One servo is responsible for the closing and opening of first gripper as well as linear motion on the cable. Second one is responsible for closing and opening of the second gripper. Both grippers provides latching and unlatching of robot on the cable. In this way, the inchworm always has at least one portion of its body firmly latched on the cable. Robot has its own solar module. That converts solar energy to electrical energy and feed to robot. Robot has its own solar module. That converts solar energy to electrical energy. That mechanism will be very useful for surface cleaning robot.

Keywords: *Inch-worm mechanism, Solar panel, Cleaning robot, Latching, Cable*

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Designing compact remote centre of compliance devices for assembly robots

Jyotirmoy Ray, Vaibhav Gupta, Sudipto Mukherjee, Jitendra P. Khatait

Abstract

Remote centre of compliance is a critical passive device for successful robotic insertion operations. A variant of the classical device developed in this study is compact and has been manufactured through rapid prototyping and assembled by gluing. By characterizing the properties of remote compliance through a joint less elastic formulation, the centre location and maximum deflection of the device are derived as functions of geometric dimensions, Youngs modulus, ultimate tensile strength and Poissons ratio. A device is modelled for a round peg-in-hole insertion using a KUKA KR-5 robot. For specified maximum allowable deflection, the theoretical values for stiffness are compared with FE results. The device is then manufactured using rapid prototyping method and the design is validated by testing. The proposed design can be customized for a range of geometrical constraints, centre location and maximum deflection.

Keywords: centre of compliance, compliant mechanism, rapid prototyping

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SESSION 15

Effect of Surface Textures on the Performance Behaviours of Plain and Cycloidal Profiled Sector Shape Pad Thrust Bearings: A comparative Investigation

Shipra Aggarwal, R. K. Pandey

Abstract

Comparison of performance behaviours of fluid film thrust bearings having smooth and textured plain and cycloidal profiled sector shape pads have been presented in this paper. Surface textures on the sector shape pad have been simulated using the spherical dimples. Role of the depth, location and area density of dimples over the performance behaviours of bearing have also been investigated. Based on the analysis reported herein, it can observed that the textured cycloidal profiled pad surfaces yield significant improvement in the performance behaviours of bearing as compared to conventional smooth plain pad. It has also been established that the surface texture introduced at certain locations on the pad surface only produces significant improvement on the performance behaviours. Moreover, surface texture present on any surface profile (plain or cycloidal) of pad yields the improvement in the performance behaviours if the values of film thickness ratio (*h1/h2*) and dimple depth ratio (*dh/h2*) fall closer to unity.

Keywords: Thrust pad bearing, cycloidal and plain profiles, surface texture, dimple, friction coefficient, load carrying capacity

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On the Characterization of Surface Topography at Different Length Scales

Anand Panzade, Sandip Panda, Mihir Sarangi

Abstract

A concerted effort has been made to find an optimum way of characterizing roughness features of real engineering surfaces at different length scales with different instruments. Freshly prepared 316L stainless steel disc surfaces were measured for generating surface roughness profile by conventional contact stylus profilometer and non-contact optical profilometer. The roughness data obtained by two different instruments were analyzed to obtain various statistical roughness parameters such as c.l.a, r.m.s, skewness, kurtosis, average slope, correlation length etc. Different methodologies to estimate the correlation length from surface heights data were also included. The effects of measurement length scale (instrument's cut-off length) on roughness parameters have been investigated. The role of correlation distance and plasticity index to determine suitable cut-off length for contact profilometer has been discussed in some details. The study has been concluded with some remarks on the suitability of using any particular instrument to connect the measurement scales with roughness scale and nominal contact width.

Keywords: Surface roughness, Autocorrelation function, Cut-off length, Plasticity index

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Effect of Cavitation in Lubricated Sliding Textured Surfaces

Panigrahi D. K. and Sarangi M.

Abstract

Surface texturing has been recognized as one of the effective means to improve tribological performance of mechanical components. This technique can have a large variety of industrial applications, such as biomechanical components, solar cells, hydrodynamic bearings, mechanical seals, piston ring, cylinder-liner contacts and magnetic media disks, etc. Under full film lubrication condition, each micro dimple of the textured surface acts as a Rayleigh step, which could develop hydrodynamic pressure and thereby, will enhance the total load carrying capacity. In this situation, pressure in the lubricant may fall below gas saturation pressure or evaporation pressure at the divergent zone (i.e., trailing edge), leading to the occurrence of cavitation. It was found from literature that higher cavitation pressure significantly alters the hydrodynamic (positive) pressure development, so as the load carrying capacity and friction parameter. Therefore, an attempt has been made to investigate the cavitation phenomenon of positive textured surfaces under full film lubrication condition on parallel thrust bearings, where the cavitation zone profile, cavitation pressure, frictional force, load carrying capacity and oil film thickness are determined experimentally. It is found from the experimental results that with increasing speed, both (–ve) cavitation and (+ve) hydrodynamic pressure increases which can be correlated to the observed reduction in recess pressure and increment in film thickness. On the whole, higher cavitation at the trailing edge of the textures helps and/or enhances the (+ve) hydrodynamic pressure development.

Keywords: Surface Texture, Thrust Bearing, Cavitation and hydrodynamic pressure.

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SESSION 16

Study and prediction of micro-finish of recovered functional surfaces using a developed ECH machine

Harpreet Singh, P.K. Jain

Abstract

The aim of the study is to investigate the micro-finish and geometrical accuracy of the recovered functional surfaces made of EN52 material using a newly developed electrochemical honing (ECH) machine. ECH is a prominent hybrid machining process, which is widely used for precision finishing of intricate shapes and hard materials with an efficient and effective manner. In this work, discarded functional surface of the engine valve is recovered using high velocity oxy-fuel (HVOF) technique and its surface topography was studied using developed micro-finish machine. The results show that the ECH of recovered surfaces gives a glazed texture and produce an average surface roughness of 0.78 μm with a processing time of 3 minutes. The monitored outputs such as surface roughness (Ra and Rt), and processing time were also compared with the conventional micro-grinding process to compile the capabilities of the developed machine.

Keywords: Product recovery, HVOF, ECH machine, Micro-finish, Surface quality

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Studies for Friction and Temperature Parameters in Thrust Ball Bearing Lubricated with Grease Containing MoS_2 Particles

V. Bhardwaj, V. K. Agarwal, R. K. Pandey

Abstract

The objective of this paper is to report the experimental comparisons of friction and temperature variations in thrust ball bearing (SKF51308) lubricated with fresh lithium grease and lithium grease containing MoS_2 particles. The friction force and temperature have been measured for the speeds varying in the range 2 to 5 m/s at two loads characterised in terms of Hertzian pressures P_H = 0.4 and 0.6 GPa. Using infrared (IR) camera, the temperature contours of bottom race of the test bearing have also been captured and compared for few sets of operating parameters. Based on the experimental findings reported herein, it has been observed that with increase in the rolling speed the coefficient of friction (friction force) and temperature both increases irrespective of the magnitude of load in absence and presence of MoS_2 particles in the grease. Moreover, it is also recorded that with increase in the load on the test bearing at a constant value of rolling speed, the temperature rise enhances and friction coefficient decreases. It is worth noting here that both the friction coefficient and temperature substantially reduce in the bearing in presence of MoS_2 particles in the lubricating grease.

Keywords: Thrust ball bearing, MoS_2 particles, Friction coefficient, Temperature contour, and Lithium grease.

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Performance Behaviours of Flared Journal Bearings

P. Ganai, R. K. Pandey, J. K. Dutt, R. P. Singh

Abstract

A plain cylindrical bore journal bearing is designed for a particular operating condition by selecting suitable lubricating oil. If such bearing is operated with other lubricating oils having different viscosities, its performance behaviour is bound to off-set from the designed point, which is not a favourable situation. Thus, in order to keep the performance behaviour of the bearing at the designed point even with different lubricating oils, a journal bearing having flaredness has been conceived and analysed herein. Therefore, the objective of this study is to explore the role of flaredness on the performance characteristics of journal bearing supporting the aligned shaft using the thermohydrodynamic lubrication (THL) model. Based on the results reported herein, it is found that with a flaredness of 0.0688^0 in the bearing, about 25% increase in the load carrying capacity and approximately 15% reduction in friction coefficient have occurred in comparison to the conventional plain circular bore journal bearing. Moreover, substantial reduction in the lubricant's average temperature has also occurred.

Keywords: Flared journal bearing, THL analysis, load carrying capacity, friction coefficient, and temperature rise.

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SESSION 17

Synthesis and Analysis of Geared Five-Bar Mechanism for Ornithopter Applications

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Abstract

An "Ornithopter" is a device that imitates the flapping-wing motion of the birds. Hovering is a unique form of flapping wing flight, wherein birds float in the air without moving in any direction. It is exhibited by bees, dragonflies, hummingbirds, etc. Among these, Hummingbirds flight has a distinct characteristic that their wings can move in figure-of-eight (FO8) path. A Geared Five Bar Mechanism (GFBM) is one such potential mechanism which can generate FO8 path under certain link configuration. In this paper, a novel spatial mechanism based on a simple planar GFBM for generating spatial figure-of-eight path has been synthesized and analysed. This spatial mechanism is based on the Hummingbird morphology. Sensitivity studies have been carried out to determine the effect of various parameters of planar GFBM on the FO8 coupler curve. From the study, most sensitive parameters and conditions for generating singly symmetric FO8 coupler curve has been determined. A program has been developed to synthesise a GFBM for generating singly symmetric FO8 based on several design requirements. The most important requirements are the minimum transmission angle, bounding box requirements, symmetry of the coupler curve and rotatability criteria. The optimised planar GFBM from the program was modelled using MSC/ADAMS and validated analytically. The validated planar GFBM was further used for the synthesis of novel spatial mechanism, capable of generating spatial FO8 path. A wing flapping frequency up to 50 Hz has been considered for the study. Kinematic and dynamic analysis of the spatial mechanism has been carried out using MSC/ADAMS. The analysis has been carried out considering only the inertial loads on the linkages. The effect of aerodynamic loading is not taken into account.

Keywords: Ornithopters, Hovering flight, Figure-of-eight (FO8), Geared Five Bar Mechanism (GFBM), Transmission angle, Rotatability criteria

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A Distributed Compliant Mechanism for a Piezo-actuated Flapping Wing

Nilanjan Chattaraj, G. K. Ananthasuresh, Ranjan Ganguli

Abstract

We present a distributed compliant mechanism, which acts like a transmission between a flapping wing of a micro air vehicle and a laminated piezoelectric actuator. The piezoelectric bimorph actuator is connected in the cantilever configuration with the compliant mechanism at its free tip. The mechanism takes translational deflection at its input from the piezoelectric actuator to provide angular displacement at its output, which causes flapping. We used topology optimization to obtain the design concept. The design of the mechanism is finalised using nonlinear elastic analysis. The final mechanism is a planar structure of 1 mm thickness and 40 mm × 24 mm in-plane footprint. The compliant mechanism exhibits 711 N/m input stiffness and 0.014 Nm/rad output torsional stiffness. The mechanism produces around 7^o angular displacement per 1 mm input stroke, and around 8^o angular displacement per 1 N force at its input. The mechanism has a fundamental frequency of 391 Hz, which is almost eight times greater than our assumed wing flapping frequency, which is 30 Hz. The final mechanism is prototyped with a 3D printer using VeroWhitePlus RGD835 material and tested with a piezoelectric bimorph actuator.

Keywords: Distributed compliant mechanism, Piezo-actuated flapping mechanism, flapping wing micro air vehicle

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Study of Spindle Rotational Accuracies versus Bore Accuracies on Machined Test Pieces on a CNC Machining Center

Ramesh H. Aralaguppi[1], T. Subramanian[2]

Abstract

Metal Cutting Machine tools are built to have certain geometrical accuracy interrelationships amongst its moving elements since they directly influence the geometrical relationships of machined surfaces on the components machined on them. Typically for a CNC Machining Center for example, the run out of main spindle and geometrical alignment with respect to the Work Table plane as well as movements in X Y Z axes directions are checked as per national and international Test Charts. Allowable Spindle Run Out values are routinely checked as part of standard Test protocols. However it is observed mere Run Out accuracies seen in the traditional method on the Test mandrel are insufficient to predict finish boring accuracies on the workpiece. Various factors like the dynamic running accuracies and spindle axis, stability during heating of the spindle bearings and housings, the dynamic unbalance of rotating parts etc finally influence the Bore Accuracies. In this paper, the effect of Dynamic running accuracies of the Main Spindle on the Circularity and Cylindricity of the finish machined bores are studied and interrelationship tried to be established.

Keywords: Machine tool spindle, Rotational Accuracy, and Bore Accuracy.

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SESSION 18

Texture Orientation Effect on the Performance of Parallel Sliding Contact in the Presence of Fluid-Solid Interfacial Slip

Syed Ismail, Sarangi M, Venkateswara Babu P

Abstract

In recent years, it is observed that introduction of specific textures on a sliding surface improves the tribological properties. A lot of research is carrying out on the specific features of surface textures like size, shape, distribution and orientation. The present paper aims to study the effect of triangular texture orientation on the performance parameters like load support, end flow and friction parameter of parallel sliding contact by varying critical threshold shear stress. The fluid-solid interfacial slip is provided on the stationary surface on which surface textures are produced. The two-component slip length model is used to include slip velocity terms in the pressure governing equations. The obtained modified Reynolds equation is solved by finite difference method using Gauss-Seidel iterative scheme. The results indicated that consideration of fluid-slip improves the performance parameters; however, texture orientation has small / negligible effect on load support and friction parameter when fluid / solid interfacial slip is considered.

Keywords: Fluid-solid interfacial slip, Orientation, Parallel sliding contact, Triangular texture.

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Design Development, Analysis and Fabrication of a Modified Three wheeled Vehicle.

Kiran Kumar.S, K.S Sridhar, G.S Ravi

Abstract

Three wheeled vehicles (TWV) particularly recognised as Auto Rickshaws are commonly preferred for public transportation in many developing countries such as India, Thailand and other places. It is also a form of novelty transportation in many eastern countries. These vehicles are usually built for economic reasons and being light in construction. In the present work an attempt is made to design a Tadpole type configuration TWV (2 wheels in the front and 1 wheel at rear) using CATIA V5. Finite Element model is developed using hypermesh software simulation system, and mode shapes are extracted to study the natural behaviour and response of the vehicle. The vehicle is fabricated as per the proposed design using an 8.65 kW engine to drive the vehicle. The other components, viz steering mechanism, brakes, stub axles, seats, foot rest, fuel tank, battery box, control pedals, cables, clamps, hinges, etc. are designed and fabricated for the vehicle. The maximum stress and deflection are determined by structural analysis method which also enables to recognise the critical regions in the design, under individual static loading conditions ranging from 1g force to 4g force. It is also noticed that the maximum stress values are well within the allowable limits. This modified design approach leads to producing a light weight vehicle along with new frame design and seating arrangements. This configuration type TWV with rear wheel drive and front wheel steering also overcomes the drawbacks of vehicle lateral instability in terms of vehicle rollover which otherwise is prevalent in Delta configuration type (1 wheel in front and 2 wheels at rear) TWV.

Keywords: Tadpole and Delta Configuration type Three Wheeled Vehicle, Design and Analysis (static and modal), Fabrication.

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POSTER I

Modelling and simulation of a bio-mimetic underwater robot inspired by feather sea star using smart actuators

Anitha Francis, V.K.Gupta, Sujoy Mukherjee

Abstract

Many kinds of underwater robots were developed in recent years. Modelling and simulation of a bio-mimetic underwater robot, which is inspired by Antedon Petasus (scientific name of Feather Sea Star) is introduced in this paper. This underwater robot finds its own application in small spaces and congested environment. The configuration and the propulsion nature of feather sea star are analyzed. The simple design which mimics the organism using smart actuators like Shape Memory Alloy (SMA) and Ionic Polymer Metallic Composite (IPMC) has been proposed. As robot should survive in underwater environment, consideration of hydrodynamic effects is very important, especially the drag force consideration. The design has been modelled in SOLIDWORKS and its effective analysis has been carried out in a sophisticated underwater environment provided by ANSYS-Fluent. The flapping module of IPMC is used for actuating and maneuvering. The shape memory alloy is used to achieve the proper propulsion. The calculated theoretical value and the simulated value of drag co-efficient are compared. The effects of hydrodynamics on the bot have also been calculated.

Keywords: Smart actuators, Shape memory alloy, Ionic polymer metallic composites, Biomimetic underwater robot, SOLIDWORKS model, ANSYS-Fluent.

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Design of a Snake Robot to exhibit Rectilinear Motion On Floor and Inside Pipes

Rajashekhar V.S, Swagat Kumar

Abstract

In this paper we present a novel 3 DOF joint mechanism for a snake robot which makes the segment to turn, lift and extend. Using these degrees of freedom, the robot is made to exhibit rectilinear motion on floor and inside pipes. A simple wall press mechanism is used at the center of each segment which helps it to climb pipes. The design of the snake robot using this joint mechanism is explained in detail. The experiments were conducted where the snake robot moved on a flat surface, horizontally inside a pipe and also vertically from top to bottom inside a pipe.

Keywords: Snake robot, disk cam link, spring joint, wall-press mechanism, pipe climbing robot

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MechAnalyzer: 3D Simulation Software to Teach Kinematics of Machines

Rakshith Lokesh, Rajeevlochana G. Chittawadigi andSubir K. Saha

Abstract

Mechanisms and linkages are vital components of a machine enabling desired motions and are taught in Theory of Machines course. Though, the course is an important part of Mechanical Engineering curriculum, it is often difficult for teachers to teach and students to learn the concepts related to mechanisms, by just following text-books. With physical prototypes or virtual mechanisms in a software environment, the course can be taught in a lucid and effective way. While several commericial and free software exist that can be used to compliment the teaching and learning, a significant amount of time is required to learn the software first and then use it.In this paper, version 3 of MechAnalyzer software is presented which has a very simple to use interface and an easy learning curve. An user can select from any of the available mechanism and change the input parameters. A 3D model of the selected mechanism with linkages and joints are generated and shown to the user in a 3D environment, whose motion can be animated and seen. Some of the mechanisms available are four-bar, slider-crank and double slider along with their inversions. It also has quick return, steering and pantograph mechanisms. Some of the higher pair mechanisms such as gears, cam-follower are also implemented in it.The main advantage of MechAnalyzer is that it has been developed as a framework with modules and adding new mechanism is easier by the developers. The authors would like to include as many mechanisms as possible to make it a digital library of mechanism and perform analyses on them. A screenshot of MechAnalyzer is shown in Fig (1).

Keywords:mechanisms simulation, animation, kinematic analysis, education

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Optimization of High Voltage Circuit Breaker Mechanism Design using Six Sigma Methodologies

Vishal Bagade

Abstract

The functions of circuit breaker spring operating mechanism are identified as: closing spring charging, closing operation and opening operation. Suitable mechanisms for these identified functions are discussed based on gear, linkage, cam, and intermittent motion elements. This paper presents the structural synthesis of opening mechanism considering the higher pair joints which results in several combinations of mechanisms. The focus of this work is on the design of opening mechanisms that open with high velocity using minimum opening spring energy. Two six bar linkages are selected for detailed evaluation, one based on Watt's mechanism and the other on toggle linkage. The toggle linkage is considered with link lengths, mass and inertia same as that of the Watt's mechanism. This enhanced the opening speed by 30% for the same amount of input i.e. opening spring energy. Effect of different parameters, such as spring stiffness, compression, stroke, rotation of lever, initial angle of lever, on opening speed are studied. The range of each parameter for optimization process is finalized. Plackett-Burman design in design of experiments (DOE) is used to eliminate the non-significant factors. Then a full factorial DOE is conducted on the vital factors to maximise the opening speed. 20% enhancement is achieved in the opening speed after optimization for the same opening spring energy. The optimized toggle mechanism exhibits 50% higher the opening speed than the Watt's mechanism for the same opening spring energy.

Keywords: Circuit breaker mechanism, Structural synthesis, Watt's mechanism, and DOE (design of experiments), Plackett-Burman design, full factorial DOE, Optimization

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A general purpose program for kinematic analysis of plane mechanisms

Suman Basak, Sumanta Neogy, Arghya Nandi

Abstract

Powerful packages based on multi body dynamics can solve virtually any dynamic system. But to the user they are black boxes. Kinematic analysis of plane mechanisms is vital to mechanical engineering. This analysis hardly requires such versatile tools. Further blind usage of these powerful tools does not permit the user to develop insight into the mechanisms. On the other hand packages based on simple but modular approach is ideally suited for the purpose. The present work has attempted to develop such a program for the purpose.

Keywords: Kinematic analysis of plane mechanism, Simple theory, General package, Modular approach, Four modules, Sequential calling, Building complex Mechanism

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Modelling of friction-stir welding of Aluminium alloy and design of a spherical redundant parallel manipulator

U. Sudhakar, Dr. J. Srinivas

Abstract

This paper presents the kinematic modelling of a robust parallel manipulator for friction-stir welding application of aluminium alloys and gives some stiffness considerations of the linkage. The mechanism can be used as an alternative platform for conventional friction-stir welding machines. Based on the work carried out on a vertical milling machine for welding the Al-alloy samples, it was found that minimum three degrees of freedom are necessary at the tool-tip for providing necessary huge axial force. A tool-head having three-degree of freedom in space is modelled based on a 3-UPS –PU redundant spherical parallel mechanism. It provides two rotations and one translation at the moving platform. Initially, the kinematics and Jacobian analysis of the mechanism is described. The forward and inverse kinematics are explained. The dexterity and stiffness indices of the mechanism are predicted and mechanism design strategy is presented. Tool-head capabilities in terms of orientation work-volume are also illustrated.

Keywords: Redundant parallel mechanism; Friction-stir welding tool head; Workspace and stiffness; Kinematic analysis.

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POSTER II

Aero Engine Vibration Measurement, Analysis and Trend Monitoring

Wilbur George Fernandes, Vinay C. A and Priyadarshini.L

Abstract

An engine is the most important functional entity in the aircraft. Vibration data is often an indicator of sudden changes in the state of an aircraft engine. Any faults developed in the engine, change its standard vibration signature thus making it one of the important parameters to judge its present condition, diagnose the problem and plan repairs and overhauls to optimize its availability. This paper describes the details of development of a system to measure vibration, acquire data, process it and monitor the vibration signal trend in order to analyze and ascertain if the vibration signals generated are within the acceptable limits. In the process, a transducer mounting bracket is designed using CATIA V5 and dynamic vibration analysis was carried out using commercial software ANSYS 13.0 and the results have indicated that the natural frequency of the mounting bracket is above the engine exciting frequency. Tests are conducted on the aircraft engine for different power settings to record the vibration at various locations. The signal processing of the raw vibration data to obtain the peak amplitude and corresponding frequency of interest is done using a custom code, developed using commercial software MATLAB and the code was validated using a 1g vibration calibrator. The in-house MATLAB code developed has been able to give satisfactory results in comparison with PROSIG DATS-lite analysis software which is industry standard software for vibration data analysis. A vibration trend curve has been plotted using the features extracted from the signal processing. Vibration levels measured are found to be within the limits specified by the Original Equipment Manufacturer (OEM) and a few exceptional cases of high vibration observed in the trend plot are also detailed with root cause analysis and appropriate corrective maintenance actions.

Keywords: Engine, Vibration, Data acquisition, Signal processing, Trend analysis

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Improving dimensional accuracy by error modelling and its compensation for 3-axis Vertical Machining Centre

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Abstract

In today's era, machining centres are very important units of manufacturing systems. Due to the structural characteristics, inaccuracy of the tool tip position is inherent. This could be a result of geometric error, thermal error, fixture dependant error and cutting force induced error. The geometric error contributes 70% of the total errors related to a machine tool. Present work focuses on improving dimensional accuracy of a 3-axis vertical machining centre (VMC). Accurate error estimation in machine tools is possible using kinematic error model. Initially, kinematic model for an error free VMC with TTT configuration was developed using D-H convention. Subsequently, a kinematic error model was developed by same technique considering 12 geometric error components. The actual error measurement along each axis was carried out using 3D microscope and vernier depth gauge. The concept of interpolation function was used to predict error distribution in a workspace enclosure. An error compensation algorithm using predicted error was developed and was also validated experimentally.

Keywords: Kinematic modelling of 3-axis VMC, Geometric error model, Prediction of error distribution and Compensation.

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System Identification: A Study of Various Methods for Continuous Systems

Ayush Raizada, Vishnuvardhan Krishnakumar, Dr. P. M. Singru

Abstract

This paper addresses and evaluates the methods of system identification of a continuous system. These methods help in finding out the system properties i.e. natural frequency and damping. The natural frequency and damping of a system provides the information about the resonance condition, which is of utmost importance in systems where failure can happen due to natural frequency excitation like road bumps exciting the car chassis, waves hitting an offshore.

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Modeling, Design and control of Planar parallel platform-based isolator mechanism

K V Varalakshmi, J Srinivas

Abstract

This paper proposes a motion isolation methodology by using a planar parallel linkage with two kinds of control schemes. Base excitations including the ground oscillations and resonance vibrations due to nearby equipment induce unexpected high end response at the instrument platforms. The concept of passive isolation is nowadays replaced by semi-active and active methods. This work proposes, the methodology of using a simple planar 3-RRR parallel mechanism having well known dynamic behaviour. Initially an excitation in the form of random base motion as translation is provided at the active joints and the corresponding transmitted displacements through the elastic links onto the mobile platform are reported. In the semi-active isolation approach an isolator having spring-damper element is considered and the effective isolation is obtained by tuning the spring and dashpot constants. In the active-isolation scheme, it is proposed to utilize the principle of active control, where the calculated motor torques are provided according to the instantaneous response obtained at the mobile platform. Effectiveness of the schemes is illustrated with a case study.

Keywords: Manipulator-dynamics, Isolation, Computed torque control, Planar mechanism, Base excitation.

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A computational static parametric study of a polystyrene sandwiched composite structural system

Arka Dey, Anubhav Roy, J.S.Ali

Abstract

Now-a-days sandwich composite materials play a significant role for energy efficient constructions. The reinforced concrete-polystyrene sandwich material prove to be an excellent composite in recent times. As static loads play an inevitable role in causing damage in structure, computational investigations of the proposed sandwich composite structures seems to be a primary necessity. However, the computational study of structural behaviour of the same is quite sparse in India. This proposed paper involves the computational investigation on the structural behaviour of the proposed composite panel on subjection of static loads. Finite Element Analysis are conducted by using ANSYS Workbench 15 simulations to compute the static parameters of the structural system under specific boundary conditions. In the second part of the proposed paper a sensitivity analysis of the nodes of a sandwich composite system is done on the basis of static structural property namely transverse deflection to find out the set of Sensitive Nodes (SN).Response of those nodes would guide and certainly assure about any damage occurred in the structure.

Keywords: Polystyrene, Sandwich Composite, Static loads, Transverse deflection, Sensitivity, Finite Element Analysis, Sensitive nodes

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Assessment of Free Vibration and Mode Shape Characteristics for Ti-SiC Functionally Graded Conical Shell

Apurba Das[*1], Subhrajyoti Sarkar[2], Amit Karmakar[3]

Abstract

This study evaluates the effect of rotation and pretwist angle on free vibration characteristics of functionally graded Ti-SiC conical shells. The dynamic equilibrium equation is derived from Lagrange's equation neglecting the Coriolis effect for moderate rotational speeds. The conical shell materials properties are supposed to vary with a power-law distribution of the volume fractions of their constituents through their thickness according to the Voigt rule. Convergence studies are performed in respect of mesh sizes, and comparisons of the present solutions and those reported in open literature are provided to verify the accuracy of the proposed method. Computer codes are developed based on finite element method to obtain the numerical results of the Eigen vectors. The natural frequencies are obtained by solving the standard Eigen value problem. The numerical results evaluated the non-dimensional frequencies and also captured the effects of twist angle and rotational speed on the natural frequencies of functionally graded conical shells. The mode shapes for each case are also illustrated.

Keywords: Free vibration; functionally graded; Voigt Rule; finite element; conical shell, twist angle

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Fatigue life enhancement of ratchet pawl charging mechanism through dynamic analysis

Vishal Bagade

Abstract

Ratchet pawl closing spring charging mechanism is an important building block of circuit breaker mechanism, seldom studied in past. It is utilized for transferring energy from motor and storing in the closing spring. The key challenges in designing ratchet pawl mechanism are avoiding failures such as burning of driving motor, wearing of pawl tips and ratchet teeth, wearing of pawl stoppers, breaking of eccentric shaft which drives the pawls. In order to combat these failures, this paper mainly considers minimization of driving torque required from motor by controlling friction, eccentricity and pressure angle. The ratchet pawl mechanism is designed for four important conditions: two load-handing over positions and two extreme conditions of pawls and mathematical relations are established for the same. This paper focuses on three aspects: a) effect of friction between pawl and eccentric shaft on driving torque, b) effect of friction between pawl tip and ratchet wheel, c) effect of eccentricity, backlash, and pressure angle on driving torque. Multibody dynamic analysis showed that the driving torque has exponential relationship with coefficient of friction between pawl and eccentric shaft. A similar analysis showed that the unequal backlash in pawls results in higher impact load by ratchet wheel on pawls than the equal backlash. In the third case study, the undesirable rubbing of pawl tips with ratchet wheel non teeth portion while closing operation is avoided by an innovative design of disengaging the pawls after charging operation. The enhanced designs showed 100-900 % improvement in fatigue life in experimental validation.

Keywords: Circuit breaker mechanism, Ratchet pawl, Closing spring, backlash, eccentricity, coefficient of friction

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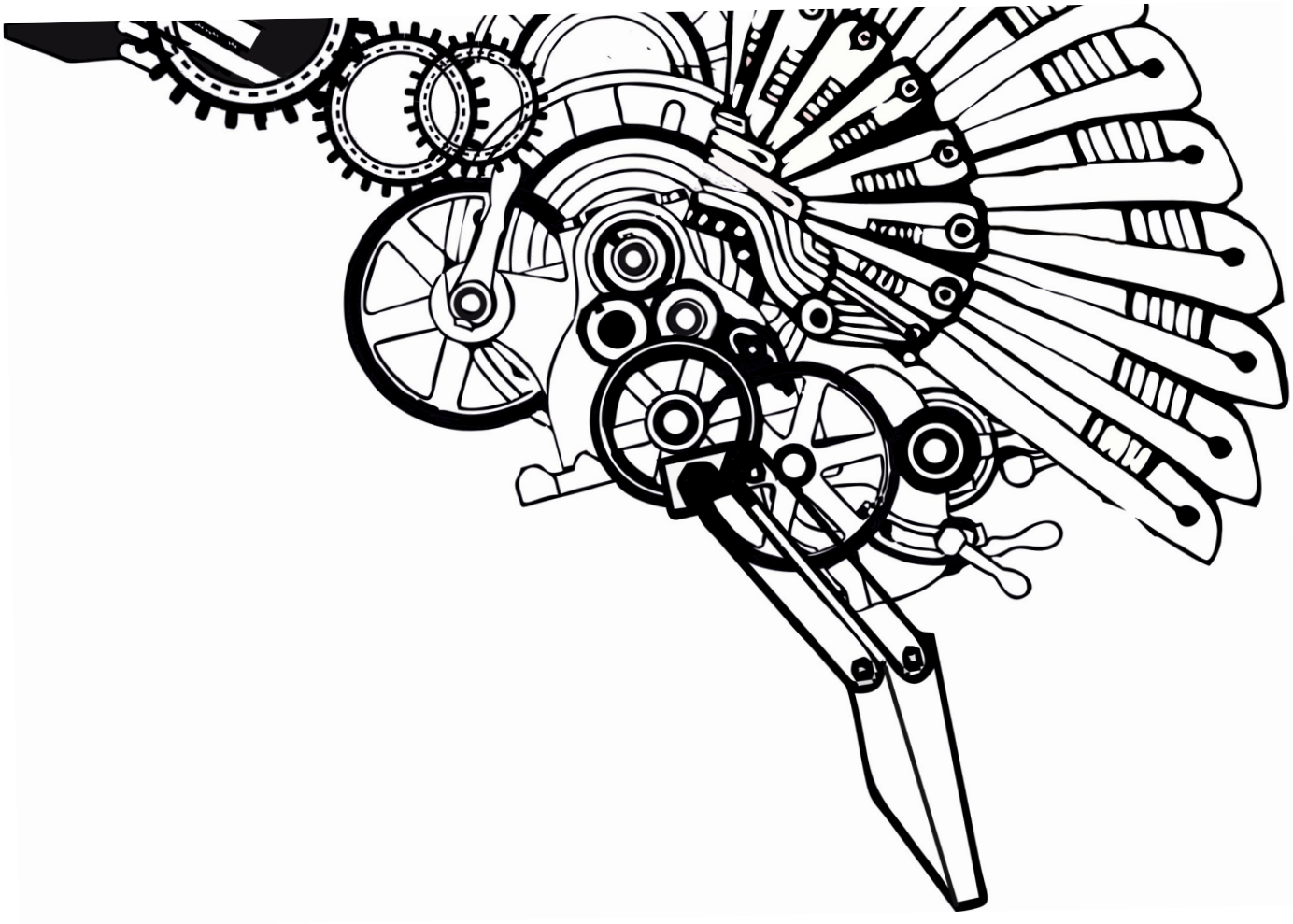

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