

MMT Symposium

Celebrating 60 years since the journal's foundation

June 26-28, 2024 | Guimarães, Portugal

Book of Abstracts

Editors

Paulo Flores

Filipe Marques

Mariana Rodrigues da Silva

MMT Symposium

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PROGRAM INCLUDED

Edited by

Paulo Flores ▪ Filipe Marques ▪ Mariana Rodrigues da Silva

June 26-28, 2024 | Guimarães, Portugal

Title:

BOOK OF ABSTRACTS
Mechanism and Machine Theory Symposium

Edited by:

Paulo Flores, CMEMS, Universidade do Minho, Portugal
Filipe Marques, CMEMS, Universidade do Minho, Portugal
Mariana Rodrigues da Silva, CMEMS, Universidade do Minho, Portugal

First Edition, June 2024

Welcome Message

On behalf of the Organizing Committee of the Mechanism and Machine Theory Symposium, I am delighted to welcome all participants.

In the autumn of 1964, Professor Erskine Crossley was invited by Professor William Johnson to deliver a course on mechanisms at the School of Mechanical Engineering at the Manchester Institute of Science and Technology in England. At that time, Professor Johnson was managing the International Journal of Mechanical Sciences, published by Pergamon Press. On that occasion, he introduced Professor Crossley to Robert Maxwell, the chairperson of Pergamon Press. This introduction led to the birth of the Journal of Mechanisms, which later changed its name to Mechanism and Machine Theory when it was adopted as the official voice of IFToMM. Thus, in 2024, we are celebrating 60 years since the foundation of our journal. Mechanism and Machine Theory was conceived in 1964, but the first issue was published in the spring of 1966. During this long journey, hundreds of volumes have been published uninterruptedly, featuring innumerable articles from thousands of authors within leading research groups in the vast field of mechanism and machine science from all over the world. Over the decades, the journal has evolved to become one of the most renowned international journals in the field, publishing many of the historically groundbreaking contributions in mechanism and machine science.

This is the motto for organizing the MMT Symposium, which has two primary aims: first, to bring together researchers in the field of mechanism and machine science to exchange their results; and second, to celebrate the 60th anniversary of the foundation of the Mechanism and Machine Theory journal. This symposium serves as a meeting point for the international mechanisms and machines community and provides an opportunity to exchange high-level, current information on the theory and applications within this vast scientific domain. The MMT Symposium gathers more than 250 submissions from over 30 countries, representing most of the active research groups worldwide. The topics of the meeting include, but are not limited to, biomechanical engineering, cable-driven mechanisms, computational kinematics, dynamics of rotating machinery, gears and transmissions, mechanics of robots and manipulators, mechanism design, mechatronics, micro-mechanisms, multibody dynamics, reconfigurable mechanisms, and theoretical kinematics. Thematic sessions have been organized around these topics to better promote discussion and foster cooperation among participants. Due to the excellence of the research presented in these technical sessions and the state-of-the-art findings discussed, a Special Issue of the Mechanism and Machine Theory journal is being organized. This issue will include selected works that will undergo review, revision, and thorough scrutiny for acceptance.

I would like to express our appreciation to all members of the Scientific Committees and session organizers who were instrumental in promoting the symposium and ensuring that all relevant topics associated with mechanism and machine science are addressed. To all staff members, colleagues, and students who were fundamental in organizing the MMT Symposium, I thank you for your dedicated work, without which this event would not be possible. I also want to thank all the authors and presenters for sharing their ideas and results, as well as to all participants for making this event possible. I invite all of you to be an active part of our symposium throughout this three-day journey. Finally, I extend my gratitude to all attending the MMT Symposium. I wish each of you not only a pleasant stay in Guimarães but also, above all, that we can provide a schedule of unquestionable practical interest and scientific quality.

Guimarães, June 2024
Paulo Flores
Symposium Chair

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Symposium Organization

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Symposium Chair

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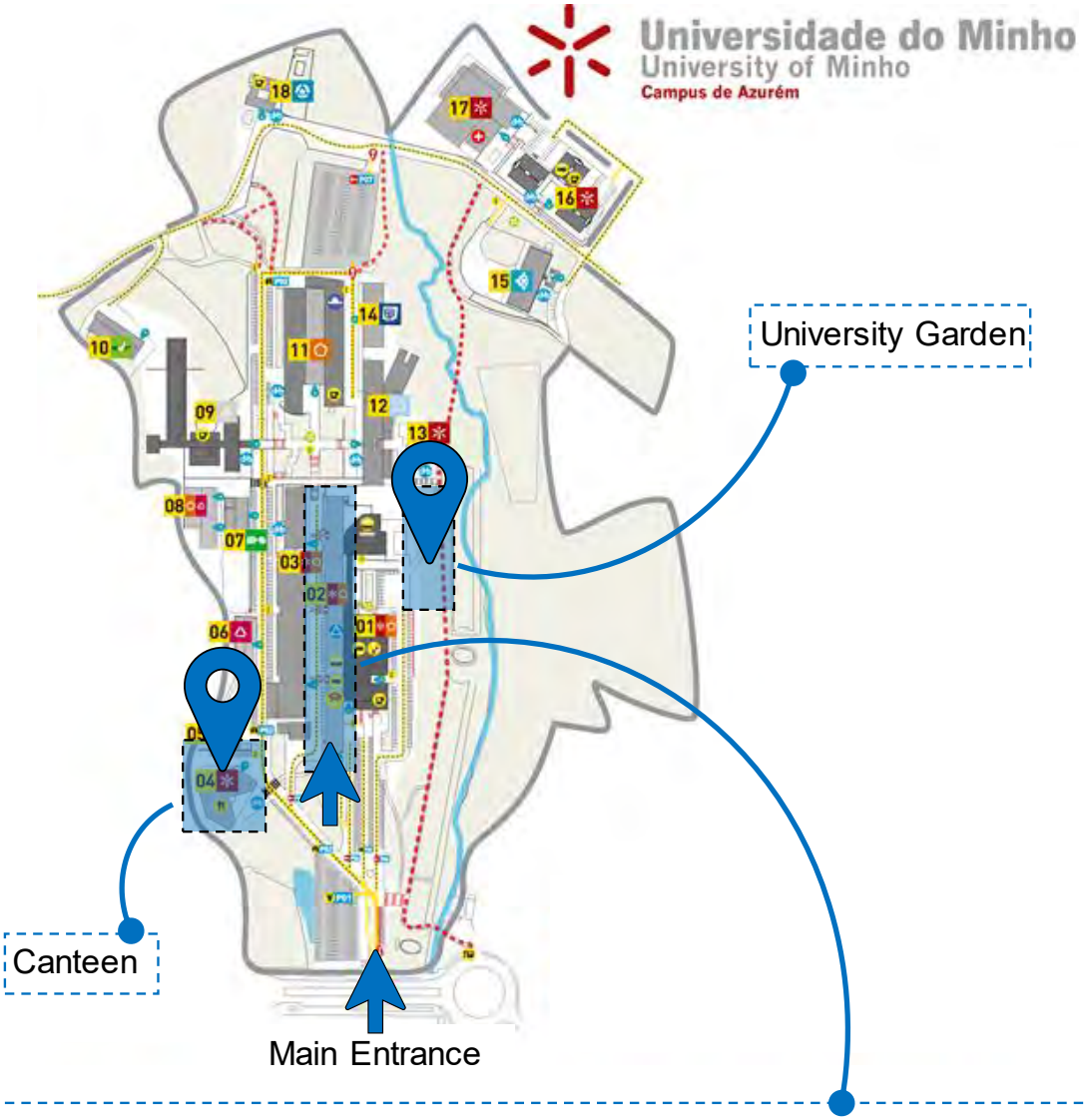
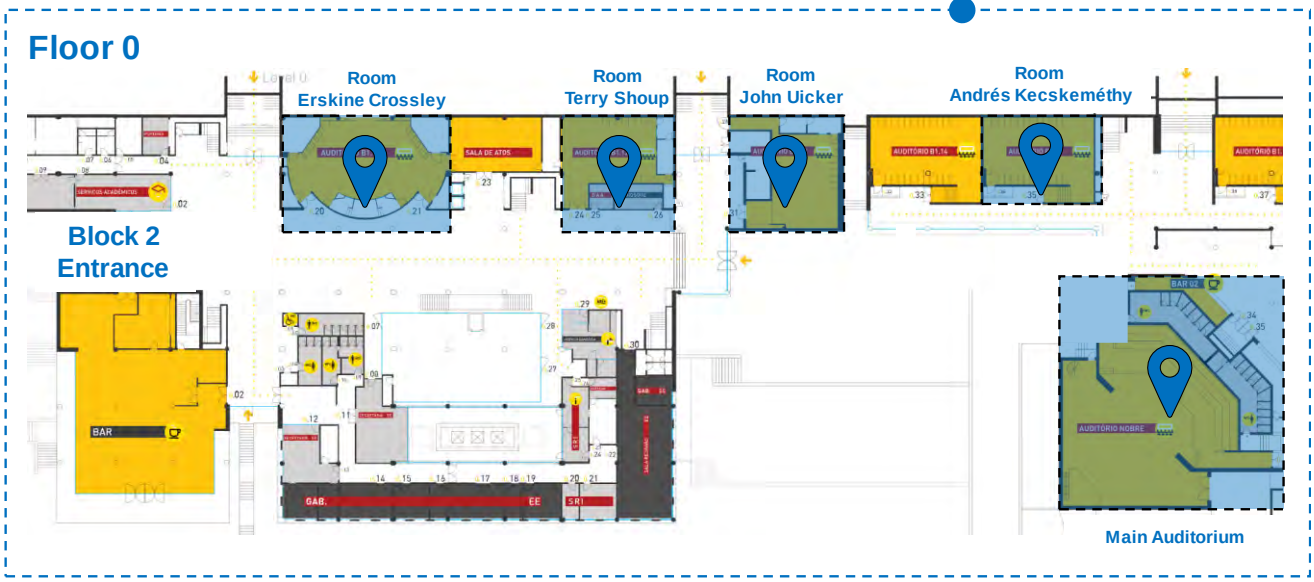
Symposium Information

Symposium Venue

The MMT Symposium takes place at Building 2 of the University of Minho, Azurém Campus, Guimarães, Portugal.



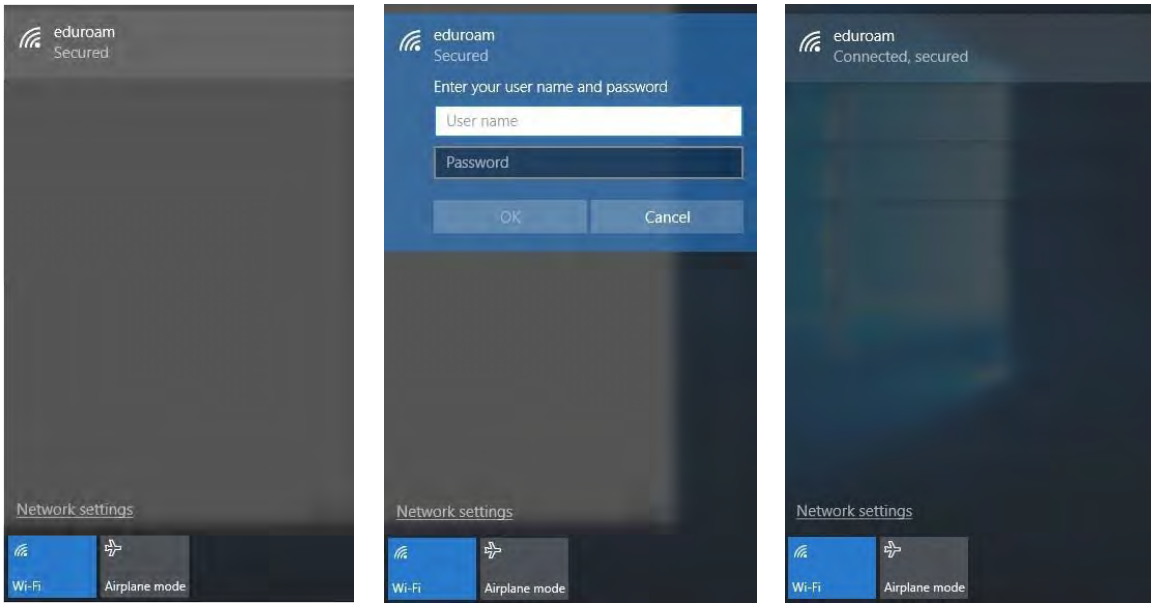


Instructions for Presenters

- Each oral presentation will take 15 minutes, including a 3-minute discussion. The chairperson of each session will manage the time for presentation and discussion.
- Presenters will be informed as the presentation time limit approaches (i.e. 2-minute warning).
- The files required for presentation (PowerPoint, PDF or other) should be uploaded and tested during the coffee or lunch breaks before the beginning of the session.
- The symposium rooms contain a Windows PC, with Office and Acrobat PDF Reader, connected to a data projector. The use of personal computers is not recommended.
- Technical support will be provided on-site by the MMT Symposium staff (yellow badges).
- Posters should be placed in the assigned location by the symposium organization.

Wireless Internet Access

In order to have wireless connectivity to the Internet you must follow the steps below.



Step 1: Browse available wireless networks and select **eduroam**.

Step 2: Insert the following credentials and click OK.

Username: mmt@guest

Password: 2024!!mmt

Step 3: The wireless network connection will be successful.

Secretariat Open Hours

The secretariat will be located in the Main Hall next to the symposium rooms.

- Tuesday, June 25, 16:00 – 19:00
- Wednesday, June 26, 8:00 – 16:00
- Thursday, June 27, 8:30 – 12:00
- Friday, June 28, 8:30 – 16:00

Name Badges

Please use your name badge at all times, including technical sessions, coffee-breaks, lunches and social events.

Coffee-Breaks

The coffee-breaks will take place in the Main Hall next to the symposium rooms and will be open to all participants. Kindly wear your name badge.

Lunches

Lunches will take place at the Canteen (Building 4) of the University of Minho (see map of the symposium venue) and will be open to all participants. Kindly wear your name badge and bring your lunch ticket.

Social Program

Welcome Reception – Wednesday, 26th June ■ 16:30

The Welcome Reception will take place at the Garden of the University of Minho.

Please don't forget to bring your name badge.

Symposium Tour – Thursday, 27th June ■ 13:30

The bus will depart from the Main Entrance of the University of Minho (see page 8) at 13:30. Please be there 10 minutes prior to departure and do not forget to bring your name badge. The use of comfortable shoes is recommended.

The symposium tour will begin at *Citânia de Briteiros*, which is one of the most significant protohistoric settlements of the Iberian Peninsula, both in terms of its size and the monumentality of its walls, urbanism and architecture.

From this point, the tour will continue to the Sanctuary of *Bom Jesus do Monte* in Braga, considered as a World Heritage Site by UNESCO.

Afterwards, some time will be given to explore the Braga city center, where *Arco da Porta Nova, Sé de Braga* or *Jardins de Santa Bárbara* can be visited.

Symposium Banquet – Thursday, 27th June ■ 19:30

The Symposium Banquet will take place at *Quinta del Rei*. Located in the heart of the green Minho region, in the municipality of Vizela, close to Guimarães. *Quinta del Rei* is the place where King Sancho II, great-grandson of King Afonso Henriques, spent his childhood.

MMT Symposium

Celebrating 60 years since the journal's foundation

Scientific Program

June 26-28, 2024 | Guimarães, Portugal



Program at a Glance

Tuesday, June 25	
16:00-19:00	PRE-REGISTRATION

Time	Wednesday, June 26			
08:00	REGISTRATION			
08:30	**OPENING CEREMONY** – Main Auditorium			
09:00	**TECHNICAL SESSIONS I**			
	Computational Kinematics Room Erskine Crossley	**Gears and Transmissions** Room Terry Shoup	**Multibody Dynamics** Room John Uicker	**Mechanism and Machine Design** Main Auditorium
10:45	Coffee-Break and Poster Session			
11:15	**TECHNICAL SESSIONS II**			
	Robots and Manipulators Room Erskine Crossley	**Gears and Transmissions** Room Terry Shoup	**Rotating Machinery** Room John Uicker	**Mechanism and Machine Design** Main Auditorium
13:00	Lunch			
14:00	**KEYNOTE LECTURE I** – EDWARD HAUG – Main Auditorium			
14:45	**TECHNICAL SESSIONS III**			
	Robots and Manipulators Room Erskine Crossley	**Nonlinear Systems and Vibration** Room Terry Shoup	**Biomechanics** Room John Uicker	**Dynamics of Machinery** Main Auditorium
16:15	**MMT & IFToMM** – PAULO FLORES and ANDRÉS KECSKEMÉTHY – Main Auditorium			
16:30	**WELCOME RECEPTION** – University Garden			

Time	Thursday, June 27			
08:30	REGISTRATION			
09:00	**KEYNOTE LECTURE II** – FENG GAO – Room Erskine Crossley			
09:45	**TECHNICAL SESSIONS IV**			
	Control and Mechatronics Room Erskine Crossley	**Numerical Methods** Room Terry Shoup	**Mechanism and Machine Design** Room John Uicker	**Robots and Manipulators** Room Andrés Kecskeméthy
10:45	Coffee-Break and Poster Session			
11:05	**TECHNICAL SESSIONS V**			
	Multibody Dynamics Room Erskine Crossley	**Gears and Transmissions** Room Terry Shoup	**Mechanism and Machine Design** Room John Uicker	**Robots and Manipulators** Room Andrés Kecskeméthy
12:20	Lunch			
13:30	**SYMPOSIUM TOUR**			
19:30	**BANQUET** – Quinta del Rey			

Time	Friday, June 28			
08:30	REGISTRATION			
09:00	**TECHNICAL SESSIONS VI**			
	Multibody Dynamics Room Erskine Crossley	**Gears and Transmissions** Room Terry Shoup	**Control and Mechatronics** Room John Uicker	**Nonlinear Systems and Vibration** Room Andrés Kecskeméthy
10:45	Coffee-Break and Poster Session			
11:15	**TECHNICAL SESSIONS VII**			
	Multibody Dynamics Room Erskine Crossley	**Mechanism and Machine Design** Room Terry Shoup	**Gears and Transmissions** Room John Uicker	**Biomechanics** Room Andrés Kecskeméthy
13:00	Lunch			
14:00	**TECHNICAL SESSIONS VIII**			
	Compliant Mechanisms Room Erskine Crossley	**Mechanism and Machine Design** Room Terry Shoup	**Robots and Manipulators** Room John Uicker	**Rotating Machinery and Tribology** Room Andrés Kecskeméthy
15:35	**KEYNOTE LECTURE III** – PIER PAOLO VALENTINI – Room Erskine Crossley			
16:15	**AWARDS AND CLOSING CEREMONY** – Main Hall			

Wednesday, June 26

08:00	REGISTRATION
08:30–09:00	**OPENING CEREMONY** – Main Auditorium

TECHNICAL SESSIONS I – A — Wednesday, June 26 • 09:00 – 10:45

COMPUTATIONAL KINEMATICS

Room Erskine Crossley — CHAIR **Martin Pfurner**

Time	ID	Presenting Author	Title
09:00	2	Huiping Shen	**Topological design and analysis of a new 4-DOF kinematic decoupled 3T1R parallel mechanism** Huiping Shen
09:15	21	Raffaele Di Gregorio	**Dynamic model of single-DOF spherical mechanisms based on instantaneous pole axes and Eksergian's equation** Raffaele Di Gregorio
09:30	25	Basilio Lenzo	**Gravity balancing of spatial serial manipulators without auxiliary bodies** Basilio Lenzo
09:45	31	Paul Zsombor-Murray	**Algebraic Kinematic Geometry with Pictures** Paul Zsombor-Murray
10:00	50	Vimalesh Muralidharan	**Influence of geometry on the nature of stiffness modulation in antagonistically actuated 1-DoF joints** Vimalesh Muralidharan; Christine Chevallereau; Philippe Wenger
10:15	63	Huijuan Feng	**Bifurcation design of single loop linkages based on double points of kinematic curves** Weihao Wang; Xuesi Ma; Huijuan Feng; Jian S. Dai; Ruirui Zhang
10:30	105	Ziyue Li	**A complete approach for error modeling based on failure of geometrical constraint and kinematic error node (KEN)** Ziyue Li; Weizhong Guo

TECHNICAL SESSIONS I - B	Wednesday, June 26 ▪ 09:00 – 10:45

GEARS AND TRANSMISSIONS

Room Terry Shoup	CHAIR **Fernando Viadero**

Time	ID	Presenting Author	Title
09:00	198	Yi-Cheng Chen	**Design and analysis of a novel ZI-type double-enveloping worm drive** Yi-Cheng Chen; Jun-Ting Liu
09:15	22	Konstantin Ivanov	**Theorem on the definability of motion of a two-movable kinematic chain with a single input** Konstantin Ivanov
09:30	26	Miroslav Václavík	**Model of a device for reducing the driving torque of mechanisms with a non-constant transmission** Jan Bělík; Miroslav Václavík; Jiří Ondrášek
09:45	84	Marina Baldissera de Souza	**Efficiency Formulae for Automotive Differential Bevel Gearbox** Marina Baldissera de Souza; Gustavo Queiroz Fernandes; Andrea Piga Carboni; Luís Paulo Laus; Daniel Martins
10:00	91	Yuichiro Seo	**Eigenvalue analysis of graph Laplacian representing helix deviation network** Yuichiro Seo; Daisuke Iba; Daisuke Yamazaki; Jing C. Low; Kunitoshi Kawano
10:15	215	Aurea Iñurritegui Marroquin	**Influence of the crowning ratio in spherical gear couplings working in misaligned conditions** Aurea Iñurritegui; Jon Larrañaga; Aitor Arana; Ibai Ulacia
10:30	75	Javier Sanchez-Espiga	**On the behaviour of n-planets planetary gearsets influenced by geometrical factors** Javier Sanchez-Espiga; Marius Fuerst; Alfonso Fernandez-del-Rincon; Michael Otto; Fernando Viadero; Karsten Stahl

TECHNICAL SESSIONS I – C	Wednesday, June 26 ▪ 09:00 – 10:45	
MULTIBODY DYNAMICS		
Room John Uicker		CHAIR **Pier Paolo Valentini**
Time	ID	Presenting Author	Title
09:00	5	Yongjun Pan	**Pitch Motion Suppression of Electric Vehicle Active Suspensions Based on Multibody Dynamics** Xiangping Wu; Yongjun Pan; Gengxiang Wang; Liang Hou
09:15	54	Manuel Alcázar Vargas	**Non-Ideal Joints and Friction: A Study on Motorcyle Front Suspension Dynamics** Manuel Alcázar Vargas; Javier Perez Fernandez; Agustin Escalera Zamudio; Juan Antonio Cabrera Carrillo; Juan Jesus Castillo Aguilar
09:30	83	Luciano Cianciotta	**Investigation on engagement dynamics of parklock mechanism using a multibody approach** Luciano Cianciotta; Enrico Segalini; Pier Paolo Valentini
09:45	95	Karol Zielonka	**Use of extended mechanical energy balance of vehicles' collision to determine pre-impact velocity in accident reconstruction** Leon Prochowski; Mateusz Ziubiński; Mirosław Gidlewski; Karol Zielonka
10:00	128	Alejandro Bustos	**Effect of the secondary suspension on the performance of a high-speed train** Alejandro Bustos; Higinio Rubio; Cristina Castejon; Juan Carlos Garcia-Prada
10:15	232	Jorge Ambrósio	**Digital twin for the condition monitoring of railway bogies based on multibody dynamics tools** Jorge Ambrósio; João Pagaimo; Pedro Millan; Joao Costa
10:30	219	Alessandro Cammarata	**A non-local interface impact model for planar flexible mechanisms with revolute joints** Alessandro Cammarata; Pietro Davide Maddio; Rosario Sinatra

TECHNICAL SESSIONS I - D	Wednesday, June 26 ▪ 09:00 – 10:45

MECHANISM AND MACHINE DESIGN

Main Auditorium			CHAIR **Ashitava Ghosal**
Time	ID	Presenting Author	Title
09:00	183	David Herrmann	**Theoretical considerations on 2D multistable tensegrity structures based on equilateral triangles** David Herrmann; Leon Schaeffer; Valter Böhm
09:15	229	Michael Valasek	**The death and birth of mechanisms on examples of PKM at CTU** Michael Valasek
09:30	93	Ketao Zhang	**Modelling of a variable-stiffness rotary joint with soft-rigid hybrid actuators** Zhujin Jiang; Ketao Zhang
09:45	119	Yu-Ren Wu	**Uniform-design-based Optimization for Screw Rotor Profiles Generated by the Sealing Line** Van-Quyet Tran; Yu-Ren Wu
10:00	130	Chaoyang Song	**The Design and Learning of Overconstrained Mechanisms towards Overconstrained Robotics** Chaoyang Song
10:15	174	Vinicius Noal Artmann	**Direct four-bar function generator synthesis for four precision positions by means of complex numbers** Vinicius Noal Artmann; Saint Clair Trisotto; Leonardo Mejia; Daniel Martins
10:30	53	Sonja Jozic	**Application of metal foams obtained by recycling aluminum chips to cork industry wastewater treatment** Sonja Jozic; Ana Sofia Fajardo; João Silva; Branimir Lela; Dražen Bajić; Luis M Castro; Cândida Malça

10:45 - 11:15	Coffee-Break and Poster Session

TECHNICAL SESSIONS II - A	Wednesday, June 26 ▪ 11:15 – 13:00

ROBOTS AND MANIPULATORS

Room Erskine Crossley	CHAIR **Basilio Lenzo**

Time	ID	Presenting Author	Title
11:15	48	Kuan Zhang	**An adaptable, intelligent, and robust inner wall gripper for tube-sheet crawling robot** Kuan Zhang; Jizhuang Fan; Tian Xu; Zhenming Xing; Jinghan Lin; Biying Xu; Jie Zhao
11:30	56	Dan Shachaf	**Wave robot locomotion in circular canals: modeling and experimentation** Dan Shachaf; Lee-Hee Drory; David Zarrouk
11:45	57	Alexandr Klimchik	**Stiffness modelling for robotic manipulators with cross-linkages using virtual joint modelling method** Alexandr Klimchik; Anatol Pashkevich
12:00	171	Adrián Peidró	**Motion analysis of a tree-climbing robot** Paula Mollá-Santamaría; Adrián Peidró; Marc Fabregat-Jaén; Luis M. Jiménez; Óscar Reinoso
12:15	99	Nadia Ramona Cretescu	**End-effector trajectory dynamic errors and optimal design of a Delta parallel robot with flexible links and joint clearances** Nadia Ramona Cretescu; Mircea Neagoe
12:30	47	Sajjad Keshtkar	**Novel Airborne Configuration for Gas Mapping in Open Areas** Juan Gabino Díaz Martínez; Irandi Gutierrez; Sajjad Keshtkar; Hirohisa Kojima; Finbar Maunsell
12:45	149	Zhumadil Baigunchekov	**Geometry, kinematics and workspace of the novel 3-PRRS type tripod** Zhumadil Baigunchekov; Giuseppe Carbone; Med Amine Laribi; Wang Xuelin; Li Qian; Rustem Kaiyrov; Zhadyra Zhumasheva

TECHNICAL SESSIONS II – B	Wednesday, June 26 ▪ 11:15 – 13:00

GEARS AND TRANSMISSIONS

Room Terry Shoup	CHAIR **Carlos Fernandes**

Time	ID	Presenting Author	Title
11:15	36	Yaping Zhao	**Meshing theory of face worm gear drive with torus enveloping cylindrical worm** Yaping Zhao
11:30	65	Stephane Portron	**A model to study the effect of micropitting on the dynamic behaviour of a geared system** Stephane Portron
11:45	68	Thijs Van der Veken	**Kalman filter-driven gear mesh stiffness estimation** Thijs Van der Veken; Jordi Jordan Marco; Bart Blockmans; Matteo Kirchner; Jan Croes; Frank Naets
12:00	134	Matteo Autiero	**Exploring the effect of gear Macro-geometric parameters on the optimization of Micro-geometry** Matteo Autiero; Luca D'Angelo; Giovanni Paoli; Marco Cirelli; Pier Paolo Valentini
12:15	111	Rodrigo Metzger da Silva	**Machine learning algorithms for gear contact fatigue detection** Rodrigo Metzger da Silva; Ronnie Rego; Robert Frazer; Brian Shaw
12:30	129	Maksat Temirkhan	**Enhancing Performance of Cycloidal Gear Drives: A Novel Tooth Contact Analysis Method with Pin Surface Modification for Improved Misalignment Tolerance** Maksat Temirkhan; Christos Spitas; Andas Amrin

TECHNICAL SESSIONS II – C	Wednesday, June 26 ▪ 11:15 – 13:00	
ROTATING MACHINERY		
Room John Uicker	CHAIR **Ibai Ulacia**	
Time	ID	Presenting Author	Title
11:15	39	Arthur Mereles	**Center manifold reduction applied to rotors with fluid bearings subjected to unbalance** Arthur Mereles; Diogo Stuani Alves; Katia Lucchesi Cavalca
11:30	59	Martin Eizmendi	**Hysteretical damping model for experimental correlation of the axial dynamic response in four-point contact slewing bearings** Martin Eizmendi; Josu Aguirrebeitia; Iker Heras; Mikel Abasolo
11:45	125	Iman Sabahi	**Framework for estimation of lumped bearing loads using accurate housing models** Iman Sabahi; Martijn Vermaut; Matteo Kirchner; Zhen Li; Konstantinos Gryllias; Frank Naets
12:00	8	Mattia Battarra	**Design potentials of elliptical vane tips in balanced vane pumps** Mattia Battarra; Caterina Natali; Emiliano Mucchi; Giorgio Dalpiaz
12:15	209	Pello Alberdi Quevedo	**Redefining Ball Screw Kinematics: Exposing the Limitations of Traditional Formulations for Orbital and Angular Speed** Pello Alberdi; Aitor Arana; Aitor Oyanguren; Jon Larrañaga; Ibai Ulacia
12:30	206	José Antonio Hernandez-Torres	**Highly efficient failure frequency detection on rotating machinery, analysis and discrimination through neuronal approximations** Javier Castilla-Gutierrez; Jose Antonio Hernandez-Torres; Juan Carlos Fortes; José Miguel Dávila

TECHNICAL SESSIONS II - D	Wednesday, June 26 ▪ 11:15 – 13:00

MECHANISM AND MACHINE DESIGN

Main Auditorium			CHAIR **Philippe Wenger**
Time	ID	Presenting Author	Title
11:15	197	Alejandro Arreola	**Novel Adjustable Landing Gear for Uneven Terrains** Alejandro Arreola; Eusebio Hernandez; Sajjad Keshtkar; Hirohisa Kojima; Crescensio Garcia
11:30	163	Ashitava Ghosal	**Design of pointing mechanism for satellite-based optical communication** Sachin Barthwal; Ashitava Ghosal
11:45	77	Álvaro Noriega	**A simple and efficient way to introduce bounded ranges in parameters and functional constraints in a dimensional synthesis problem** Álvaro Noriega; Igor Fernández de Bustos; Vanessa García-Marina
12:00	32	Juan A. Cabrera	**Design of mandibular advancement devices using an evolutionary algorithm** Juan A. Cabrera; Alex Bataller; Javier Perez; Manuel Alcazar
12:15	62	Marko Lubarda	**Analysis of a linear motion slider with two point contacts under variable loading** Marko Lubarda; Nina Abraham; Surejkrishna Melattinkara Sunil; Joseph Lee
12:30	103	Jiaji Ma	**A compact spherical-gear wrist mechanism with comparable movement to human wrists** Jiaji Ma; Caihua Xiong; Dai Chu; Baiyang Sun
12:45	24	Kanan Azimov	**Structural and constructive synthesis of hexagonal Euclidean parallel robot manipulator of spacecraft docking system** Rasim Alizade; Kanan Azimov; Javad Samadzade

13:00 - 14:00	Lunch

KEYNOTE LECTURE I	Wednesday, June 26 ▪ 14:00 – 14:40

Main Auditorium			CHAIR **Jorge Ambrósio**
Time	ID	Presenting Author	Title
14:00	7	Edward Haug	**Kinematics and dynamics of redundant robotic manipulators; an accurate differential geometric formulation** Edward Haug

TECHNICAL SESSIONS III - A	Wednesday, June 26 ▪ 14:45 – 16:15

ROBOTS AND MANIPULATORS

Room Erskine Crossley	CHAIR **Xianwen Kong**

Time	ID	Presenting Author	Title
14:45	196	Zijian Ma	**A model-based cutting stability prediction method for parallel machining robots** Zijian Ma; Fugui Xie; Xin-Jun Liu
15:00	76	Soumya Kanti Mahapatra	**Using neural networks for the kinematics of closed loop mechanisms and serial robots** Soumya Kanti Mahapatra; Naveen Kumar Maddu; Ashitava Ghosal
15:15	114	Isaac John	**Stiffness profile investigation of a variant of the 2-US-1-UU mechanism, with offsets at the proximal U joints** Isaac John; Santhakumar Mohan; Philippe Wenger
15:30	208	Eldho Paul	**Sensitivity Driven Kinematic Calibration of an Industrial Robot** Benny Paul I; Riby Abraham Boby; Eldho Paul; K Hariharan
15:45	180	Xiao Li	**Singularity analysis of a multiple-loop kinematically redundant parallel mechanism based on Grassmann line geometry** Xiao Li; Haibo Qu; Yili Kuang; Giuseppe Carbone; Sheng Guo
16:00	131	Bogdan Gherman	**Higher order kinematics for an innovative surgical parallel robot** Bogdan Gherman; Calin Vaida; Iosif Birlescu; Daniel Condurache; Pisla Doina

TECHNICAL SESSIONS III - B	Wednesday, June 26 ▪ 14:45 – 16:15

NONLINEAR SYSTEMS AND VIBRATION

Room Terry Shoup	CHAIR **Andrzej Urbaś**

Time	ID	Presenting Author	Title
14:45	150	Ociel Flores-Díaz	**The logistic function for predicting vibration frequency in low-power wind turbine blades** Ociel Flores-Díaz; Jesús O. Martínez-Cabañas
15:00	86	Marco Carricato	**Eliminating Vibrations in Nonlinear Systems with Input Shaping: a Novel Approach** Andrea Lucarini; Michele Angelini; Edoardo Idà; Marco Carricato
15:15	207	Xinxin Yu	**Comparisons between moving mode and beam models for modelling wheel-rail impact at a singular rail surface defect** Xinxin Yu; Chen Shen; Jose Escalona; Aki Mikkola; Zili Li
15:30	214	Sanjin Braut	**Transient vibration analysis and fatigue assessment of the ship propulsion shaft FE model** Sanjin Braut; Alen Marijančević; Roberto Žigulić; Goranka Štimac Rončević
15:45	71	Maksymilian Bednarek	**Properties of the electromagnetic softening and hardening spring: experiment and simulation** Maksymilian Bednarek; Jan Awrejcewicz

TECHNICAL SESSIONS III - C	Wednesday, June 26 ▪ 14:45 – 16:15

BIOMECHANICS

Room John Uicker	CHAIR **Miguel Tavares da Silva**

Time	ID	Presenting Author	Title
14:45	96	Francisco Geu Flores	**Using RFID tags for lower-limb clinical gait assessment: Concept, virtual simulation, and prototype validation** Francisco Geu Flores; Katharina Müller; Andrés Kecskeméthy
15:00	166	Nicola Sancisi	**A two-DOF parallel mechanism to model the ankle complex** Nicola Sancisi; Raphael Dumas; Vincenzo Parenti-Castelli; Michele Conconi
15:15	1	Mariana Rodrigues da Silva	**Modeling and analysis of the ankle joint complex with muscles** Mariana Rodrigues da Silva; Maria Francisca Sousa; Filipe Marques; Sérgio B. Gonçalves; Miguel Tavares da Silva; Paulo Flores
15:30	230	Sérgio B. Gonçalves	**On the Modeling of Musculotendon Units with Fully Cartesian Coordinates and a Generic Rigid Body** Sérgio B. Gonçalves; Paulo Flores; Miguel Tavares da Silva
15:45	225	Gonçalo Marta	**Kinematic and kinetic differences between two running shoes at 3 selected running speeds** Gonçalo Marta; Carlos Quental; Pedro Fonseca; Francisco Guerra-Pinto; João Vilas-Boas; João Folgado
16:00	167	Raphael Dumas	**Parallel mechanisms for the TLEM2 musculoskeletal model** Raphael Dumas; Michele Conconi; Nicola Sancisi

TECHNICAL SESSIONS III - D	Wednesday, June 26 ▪ 14:45 – 16:15
DYNAMICS OF MACHINERY	
Main Auditorium	CHAIR **Mircea Neagoe**

Time	ID	Presenting Author	Title
14:45	43	Karl Scholl	**Efficient and Robust Control for Active Magnetic Bearings of an Outer-rotor Flywheel for a Broad Speed Range** Karl Scholl; Stephan Rinderknecht
15:00	81	Elias Rechreche	**Experimental and numerical analyses of grid couplings in quasi-static and dynamic conditions** Elias Rechreche; Philippe Velex; Jérôme Bruyère; Quentin Le Guennec
15:15	38	Zharilkassin Iskakov	**Dynamic modeling of the mixing device when the drive link moves in a rotational mode** Zharilkassin Iskakov; Kuatbay Bissembayev; Assylbek Jomartov
15:30	69	Montserrat Simarro	**Dynamic characterization of pantograph and validation of simplified mathematical models** Montserrat Simarro; Pedro Reyes; Rafael Jesus Luque; Antonio Gerra; Juan J. Castillo; Sergio Postigo
15:45	205	José Antonio Hernandez-Torres	**Analysis of turbine morphology for tidal low-speed flow energy extraction** José Antonio Hernandez-Torres; Reyes Sanchez-Herrera; Juan P. Torreglosa; Jesus Clavijo-Camacho; Ángel Mena-Nieto
16:00	15	Binbin Peng	**A novel multi-link high speed precision punching machine mechanism and its dynamic balance design** Binbin Peng; Aoning Ren; Hongzhen Liu

MAIN AUDITORIUM	Wednesday, June 26 ▪ 16:15 – 16:30
Paulo Flores and Andrés Kecskeméthy	**MMT & IFToMM: A road from 1960s until yesterday**

16:30 – 17:30	**WELCOME RECEPTION** – University Garden

Thursday, June 27

08:30	REGISTRATION

KEYNOTE LECTURE II			Thursday, June 27 • 09:00 – 09:40
Room Erskine Crossley			CHAIR **Andrés Kecskeméthy**
Time	ID	Presenting Author	Title
09:00	179	Feng Gao	**Beijing Winter Olympics journey of the Curling and Skiing Robots** Feng Gao

TECHNICAL SESSIONS IV - A			Thursday, June 27 • 09:45 – 10:45
CONTROL AND MECHATRONICS			
Room Erskine Crossley			CHAIR **Benjamin Boudon**
Time	ID	Presenting Author	Title
09:45	6	Hossein Habibi	**Wave-based control of vibration in an active suspension system with a quarter-car model** Hossein Habibi
10:00	78	Fernando Viadero-Monasterio	**Robust semi-active suspension control using magnetorheological dampers** Fernando Viadero-Monasterio, Miguel Meléndez-Useros, Manuel Jiménez-Salas, Beatriz Lopez Boada and María Jesús L. Boada
10:15	210	Jason Bettega	**Path following and tension distribution on overactuated cable suspended parallel robots through nonlinear model predictive control with exponential cost function** Jason Bettega, Dario Richiedei; Alberto Trevisani
10:30	55	Hyunjun Bae	**Analysis of model accuracy impact on model-based control performances under high dynamic conditions: mechatronic approach and experimental validation on the dextar robot** Hyunjun Bae; Benjamin Boudon; Thu Thuy Dang; Belhassen Chedli Bouzgarrou; Quang Hoang Nguyen

TECHNICAL SESSIONS IV - B	Thursday, June 27 • 09:45 – 10:45

NUMERICAL METHODS

Room Terry Shoup			CHAIR **Iker Heras**
Time	ID	Presenting Author	Title
09:45	41	Domenico Mundo	**Performance and accuracy analysis of higher-order Finite Element formulations for dynamic digital twins** Anna Karpik; Francesco Cosco; Domenico Mundo
10:00	181	Jon Larrañaga	**Efficient multiblock approach for automated and refined 3D hexahedral mesh generation: applied to machine elements** Jon Larrañaga; Aurea Iñurritegui; Aitor Arana; Aitor Oyanguren; Ibai Ulacia
10:15	73	Jaroslav Cibulka	**NURBS teaching methods focused on practical applications** Ivana Linkeová; Marta Hlavová; Jaroslav Cibulka
10:30	115	Carlos Rodriguez-Donate	**A new methodology for improving kinematic profiles using oversampling, fir filter, and decimation** Carlos Rodriguez-Donate; Jacob Gonzalez-Villagomez; Esau Gonzalez-Villagomez; Ruth Ivonne Mata-Chavez; Omar Palillero-Sandoval

TECHNICAL SESSIONS IV - C	Thursday, June 27 • 09:45 – 10:45

MECHANISM AND MACHINE DESIGN

Room John Uicker			CHAIR **Bogdan Gherman**
Time	ID	Presenting Author	Title
09:45	156	Siyuan Ye	**Nonlinear modelling of a novel general single-translation constraint and centre drift analysis of the resulting spherical joint** Jiaxiang Zhu; Guangbo Hao; Siyuan Ye
10:00	212	David Herrmann	**Illuminating the morphological diversity of 2D tensegrity grids** John Rieffel; David Herrmann; Lukas Lehmann; Leon Schaeffer; Valter Böhm
10:15	164	Qianqian Zhang	**Design of a polygonal mobile mechanism with cam mechanism based on dynamic rolling** Qianqian Zhang; Yezhuo Li; Shaoze Yan; Yan-An Yao
10:30	104	Sajjad Keshtkar	**Experimental Study of Novel Reaction Wheel Systems with Variable Moment of Inertia** Sajjad Keshtkar; Rintaro Itakura; Hirohisa Kojima

TECHNICAL SESSIONS IV - D	Thursday, June 27 • 09:45 – 10:45

ROBOTS AND MANIPULATORS

Room Andrés Kecskeméthy			CHAIR **Daniel Condurache**
Time	ID	Presenting Author	Title
09:45	135	Zhi Wang	**A 2-DOF remote center-of-motion mechanism based on zipper-inspired compact arc joint** Zhi Wang; Yixin Shao; Fei Liu; Shengnan Lyu; Xilun Ding; Wuxiang Zhang
10:00	20	Philippe Wenger	**A new class of planar 3-DOF cable-driven parallel robots with decoupled workspace** Philippe Wenger; Christine Chevallereau; Stéphane Caro
10:15	102	Avi Cohen	**Minimally Actuated Serial Robot - Design and Kinematics** Avi Cohen; David Zarrouk
10:30	195	Eldho Paul	**Stiffness modeling and calibration of coordinated robots: Application to incremental forming** Eldho Paul; Alexandr Klimchik; Hariharan Krishnaswamy; Riby Abraham Boby; Sahil Bharti

10:45 - 11:05	Coffee-Break and Poster Session

TECHNICAL SESSIONS V - A	Thursday, June 27 • 11:05 – 12:20

MULTIBODY DYNAMICS

Room Erskine Crossley			CHAIR **Eduardo Corral**
Time	ID	Presenting Author	Title
11:05	161	Antonio J. Rodríguez	**Development of Kalman Filter Approaches for the Monitoring of Mechanical Clearances** Antonio J. Rodríguez; Emilio Sanjurjo; Mario Cabello; Mario López-Lombardero; Pablo Díaz; Francisco González; Miguel Ángel Naya
11:20	170	José Ferreira	**Real-time simulation of multibody systems with hydraulic actuators** José Ferreira; Filipe Marques; Paulo Flores
11:35	176	Pablo Riera	**Ball bearing multibody simulations with ball contact damping** Pablo Riera; Luis Maria Macareno; Josu Aguirrebeitia; Igor Fernandez de Bustos
11:50	193	Raúl Gismeros Moreno	**A General Formulation of the Contact Interaction Between a Circle Surface and a Convex-Concave-Convex Surface** Raúl Gismeros Moreno; Filipe Marques; Eduardo Corral Abad; María Jesús Gómez García; Jesús Meneses Alonso; Paulo Flores
12:05	118	Orazio Sorgonà	**Functional design of compliant multibody systems** Orazio Sorgonà; Matteo Verotti; Oliviero Giannini

TECHNICAL SESSIONS V – B	Thursday, June 27 • 11:05 – 12:20

GEARS AND TRANSMISSIONS

Room Terry Shoup	CHAIR **Alessio Artoni**

Time	ID	Presenting Author	Title
11:05	58	Fernando Viadero	**Simulation and validation of the transmission error, meshing stiffness, and load sharing of planetary spur gear transmissions** Jose Pedrero; Javier Sánchez-Espiga; Miryam Sánchez; Miguel Pleguezuelos; Alfonso Fernández-del-Rincón; Fernando Viadero
11:20	143	Carlos Fernandes	**A semi-analytical thermal model for polymer gears** João Marafona; Jorge Seabra; Pedro Marques; Pedro Romio; Stephane Portron; Carlos Fernandes
11:35	17	Mircea Neagoe	**Dynamic Modeling and Simulation of a Counter-rotating Wind System with Reconfigurable Monomobile Planetary Speed Increaser** Mircea Neagoe; Saulescu Radu
11:50	74	Pedro Marques	**Crowned helical gears for constant mesh stiffness** Pedro Marques
12:05	42	Domenico Mundo	**Performance study of spiral bevel gears under misaligned conditions for different load levels using a 3D gear contact force model** Sebastiano Parrinello; Mathijs Vivet; Rocco Adduci; Francesco Cosco; Domenico Mundo

TECHNICAL SESSIONS V – C	Thursday, June 27 • 11:05 – 12:20

MECHANISM AND MACHINE DESIGN

Room John Uicker	CHAIR **Marco Carricato**

Time	ID	Presenting Author	Title
11:05	79	Huijuan Feng	**A novel metamorphic mechanism with multi-motion branches** Xi Kang; Qia Lin; Huijuan Feng; Bing Li
11:20	97	Yuanqing Gu	**Overconstraint reduction for three- symmetric Bricard assembly** Yuanqing Gu; Xiao Zhang; Yan Chen
11:35	90	Xianwen Kong	**Single-DOF multi-mode mechanisms constructed by plane-symmetric four-bar spherical linkage and orthogonal Bricard linkage** Jieyu Wang; Weiwei Hu; Yingzhong Tian; Yinjun Zhao; Xianwen Kong
11:50	116	Enrique Pujada Gamarra	**Displacements analysis of the double-hinge technique for origami thickness accommodation** Enrique Pujada Gamarra; Lena Zentner; Daniel Lavayen Farfan; Jorge Antonio Rodriguez Hernandez

TECHNICAL SESSIONS V - D	Thursday, June 27 • 11:05 – 12:20

ROBOTS AND MANIPULATORS

Room Andrés Kecskeméthy			CHAIR **Damien Chablat**
Time	ID	Presenting Author	Title
11:05	190	Zhenming Xing	**A tendon-driven wheeled gripper capable of flexible movement outside variable-diameter pipelines** Zhenming Xing; Jizhuang Fan; Tian Xu; Ke Yao; Kuan Zhang; Jie Zhao
11:20	202	Anya Forestell	**Physics-Motivated Reinforcement Learning for Robotic Contact Interactions** Anya Forestell; Siamak Arbatani; Chen Chen; Charles Sirois; József Kövecses
11:35	35	Jialiang Sun	**Optimization design and dynamics of cable-driven flexible robotics** Jialiang Sun
11:50	217	Brandon-Dariel Salazar-Bravo	**Gait Planning for Humanoid Robots Optimizing the Stability Margin by Applying Genetic Algorithms** Brandon-Dariel Salazar-Bravo; J. Alfonso Pamanes; Jesus-Eduardo Fierro-Proa
12:05	201	Eldho Paul	**Calibration of Coordinated Industrial Robots** Riby Abraham Boby; Eldho Paul; K Hariharan

12:20 - 13:30	Lunch
13:30 – 19:30	**SYMPOSIUM TOUR**
19:30 – 22:30	**BANQUET** - Quinta del Rey

Friday, June 28

08:30	REGISTRATION

TECHNICAL SESSIONS VI - A — Friday, June 28 • 09:00 – 10:45

MULTIBODY DYNAMICS

Room Erskine Crossley — CHAIR **Daniel García-Vallejo**

Time	ID	Presenting Author	Title
09:00	72	Jorge González Navarro	**Comparative Analysis of Friction Force Models in Multibody Systems** Jorge González Navarro; Raúl Gismeros Moreno; Eduardo Corral Abad; Cristina Castejon
09:15	11	Tomasz Piatkowski	**Model and analysis of the objects' positioning process by system of rectilinear barrier and oblique friction force field** Tomasz Piatkowski
09:30	108	Jia Ma	**A Novel Continuous Contact Force Model Based On Variable Restitution Coefficient Model** Menghao Bai; Jia Ma; Can Luo; Jing Peng
09:45	153	Gengxiang Wang	**Analysis of nonphysical attraction force from the nonlinear viscoelastic contact model in the cohesionless granular system** Gengxiang Wang; Wanxun Jia; Fuan Cheng; Yongjun Pan
10:00	165	Simone Serafino	**Mode Based Multibody Modelling of Spur Gear Dynamics** Simone Serafino; Luca Bruzzone; Matteo Verotti; Pietro Fanghella
10:15	106	Roberto Guida	**Introducing a novel multibody model for harmonic drives with individual teeth dynamics** Roberto Guida; Antonio Carlo Bertolino; Andrea De Martin; Andrea Raviola; Massimo Sorli
10:30	168	Pedro Millan	**Dynamics of road vehicles with structures made of new materials and structural joints** Pedro Millan; Jorge Ambrósio

TECHNICAL SESSIONS VI - B	Friday, June 28 • 09:00 – 10:45

COMPUTATIONAL KINEMATICS

Room Terry Shoup			CHAIR **Raffaele Di Gregorio**
Time	ID	Presenting Author	Title
09:00	169	Gustavo Queiroz Fernandes	**Grasping capability analyses for optimal grasp synthesis** Gustavo Queiroz Fernandes; Marina Baldissera de Souza; Leonardo Mejia Rincon; Daniel Martins
09:15	140	Ravi Tripathi	**Motion space analysis of smooth objects in circular curved contact** Ravi Tripathi; Rama Krishna K
09:30	142	Fei Liu	**Harvesting bistable energy to release dynamic performance in metamorphic mechanisms for automated fibre placement heads** Fei Liu; Shenru Wang; Junfan Shang; Zhen Sun; Zhi Wang; Yixin Shao; Wuxiang Zhang; Xilun Ding
09:45	172	Alexis Boulay	**Ruling guidance an adaptative and dynamic haptic guide model** Alexis Boulay; David Daney; Margot Vulliez
10:00	159	Fernando Vinicius Morlin	**Determining the connectivity matrix using matroid theory** Fernando Vinicius Morlin; Andrea Piga Carboni; Daniel Martins
10:15	151	Giorgio Figliolini	**Kinematic analysis of a higher-pair mechanism for the generation of involute tooth profiles** Giorgio Figliolini; Hellmuth Stachel; Jorge Angeles
10:30	141	Zhao Tang	**Computation of Kinematic Paths and Bifurcation Points for Multi-Degree-Of-Freedom Mechanisms with Singular Value Decomposition** Zhao Tang; Huijuan Feng; Jian S. Dai

TECHNICAL SESSIONS VI – C	Friday, June 28 • 09:00 – 10:45

CONTROL AND MECHATRONICS

Room John Uicker			CHAIR **Hossein Habibi**
Time	ID	Presenting Author	Title
09:00	145	Manuel Jiménez-Salas	**Combined lateral and longitudinal energy efficient MPC control for vehicle path tracking** Manuel Jiménez-Salas; Basilio Lenzo; Miguel Meléndez-Useros; Fernando Viadero-Monasterio; María Jesús López-Boada; Beatriz López-Boada
09:15	175	Ahmed-Manaf Dahmani	**Parametric Trajectories and Measurement Error in Inverse Optimal Control** Ahmed-Manaf Dahmani; David Daney; François Charpillet
09:30	107	Krzysztof Jankowski	**Synthesis and simulation tests of the control algorithm of the car steering system during a sudden change of the lane** Dariusz Żardecki; Mirosław Gidlewski; Krzysztof Jankowski; Leszek Jemioł; Karol Zielonka
09:45	160	Pedro Neto	**Robust Learning Interaction Control of Serially-Linked Robotic Manipulators in Unknown Environments** Reza Nazmara; Pedro Neto; A. Pedro Aguiar
10:00	189	Bálint Bodor	**Iterative approaches for the control of underactuated mechanical systems** Bálint Bodor
10:15	100	Alexandre Lê	**Certified Kinematic Tools for the Design and Control of Parallel Robots** Alexandre Lê; Fabrice Rouillier; Guillaume Rance; Damien Chablat
10:30	80	Miguel Meléndez-Useros	**Robust Active Suspension Control Tolerant to Sensor Faults** Miguel Meléndez-Useros; Manuel Jiménez-Salas; Fernando Viadero-Monasterio; Beatriz López Boada; María Jesús López Boada

TECHNICAL SESSIONS VI - D	Friday, June 28 • 09:00 – 10:45

NONLINEAR SYSTEMS AND VIBRATION

Room Andrés Kecskeméthy			CHAIR **Shane Johnson**
Time	ID	Presenting Author	Title
09:00	155	Alfonso García-Agúndez Blanco	**Gyroscopic stability of the hoop-rod system with nonholonomic constraints** Alfonso García-Agúndez Blanco; Daniel García Vallejo; Emilio Freire Macías
09:15	227	Devavrit Maharshi	**Higher Order Modal analysis of an axially loaded conical disk-shaft system under large deformation** Devavrit Maharshi; Barun Pratiher
09:30	194	Davide Grillo	**An experimental setup to characterize the influence of a tensile preload on the vibrational behaviour of a viscoelastic beam** Elena Pierro; Davide Grillo; Giuseppe Carbone
09:45	112	Damian Gąska	**Comparison of different bluff-body shapes for a flag configuration energy harvesting system** Damian Gąska; Jerzy Margielewicz; Sławomir Bucki; Grzegorz Litak
10:00	120	Cui Chao	**Parameter identification of nonlinear frictional systems using SINDy-PI** Cui Chao; David T. Branson; Jian Yang
10:15	186	Nitin Gupta	**Experimental investigation of endpoint vibration under fluid medium of moving base flexible robotic manipulator** Nitin Gupta; Barun Pratiher
10:30	224	Mayank Ahirwar	**Size-dependent Dynamics of micro rotating system based on modified couple stress theory** Mayank Ahirwar; Barun Pratiher

10:45 - 11:15	Coffee-Break and Poster Session

TECHNICAL SESSIONS VII – A	Friday, June 28 • 11:15 – 13:00	
MULTIBODY DYNAMICS		
Room Erskine Crossley	CHAIR **Alessandro Cammarata**	
Time	ID	Presenting Author	Title
11:15	154	Igor Fernández de Bustos	**On the use of an alternative null space formulation for the resolution of multibody simulation problems** Igor Fernández de Bustos; Alvaro Noriega; Haritz Uriarte; Gorka Urkullu
11:30	137	Daniel Condurache	**An overview of higher-order kinematics of rigid body and multibody systems with nilpotent algebra** Daniel Condurache
11:45	177	Márton Kuslits	**Velocity Projection of State Transition Matrices in Extended Kalman Filters of Multibody Systems** Márton Kuslits
12:00	218	João Pagaimo	**A floating frame of reference approach to study fracture in multibody systems using peridynamics** João Pagaimo; Francisco Vieira; Aurélio Araújo; Jorge Ambrósio
12:15	33	Andrzej Urbaś	**Applications of an eccentric crank-slider mechanism metamodels to examine their dynamics** Andrzej Urbaś; Jacek Stadnicki
12:30	231	Miguel Tavares da Silva	**On the use of Mixed Coordinates for the Simultaneous Determination of Joint Angles and Kinematically Consistent Positions** Sérgio B. Gonçalves; Paulo Flores; Miguel Tavares da Silva
12:45	211	Anya Forestell	**Alternative Formulation for Modelling Rigid Bodies in Unilateral Interaction Problems** David M. Solanillas Francés; József Kövecses

TECHNICAL SESSIONS VII - B	Friday, June 28 • 11:15 – 13:00

MECHANISM AND MACHINE DESIGN

Room Terry Shoup			CHAIR **Huijuan Feng**
Time	ID	Presenting Author	Title
11:15	10	Yu-Xin Wang	**A clustering-based generative functional synthesis for realizing ingenious combination of mechanisms** Yu-Xin Wang; Yu-Tong Li
11:30	3	Mathias Wallin	**Optimization and experimental verification of buckling-induced deployable structures** Mathias Wallin; Hoo Min Lee; Gil Ho Yoon; Jonas Engqvist; Matti Ristinmaa
11:45	19	Dongtian Wu	**Design and analysis of a missile-borne low-disturbance deployable mechanism** Dongtian Wu; Hui Yang; Yan Wang; Jian Feng; Rongqiang Liu
12:00	92	Yixin Shao	**Design of a novel adjustable passive constant-force mechanism based on magnetically modulated beam mechanisms** Yixin Shao; Zhi Wang; Shiwei Liu; Fei Liu; Xilun Ding; Wuxiang Zhang
12:15	127	Siyuan Ye	**Let joints based over-constrained origami structure design** Siyuan Ye; Fatemeh Kavousi; Guangbo Hao
12:30	110	Andrzej Pazur	**Determination of a total and partial operational readiness for a complex technical system on the example of a mobile medical module** Andrzej Pazur; Andrzej Szelmanowski; Slawomir Michalak
12:45	188	Gil Ribeiro	**A Methodology for project design parametrization** Bruno Pereira; Gil Ribeiro; Jorge Ortega; Hélder Puga; Paulo Flores

TECHNICAL SESSIONS VII – C	Friday, June 28 ▪ 11:15 – 13:00

GEARS AND TRANSMISSIONS

Room John Uicker			CHAIR **Domenico Mundo**
Time	ID	Presenting Author	Title
11:15	199	Alessio Artoni	**A Manufacturable Higher-Degree Flank Modification for Contact Enhancement in Bevel Gears** Alessio Artoni; Eugeniu Grabovic; Marco Gabiccini; Massimo Guiggiani
11:30	138	Giuseppe Sciarra	**Pitting resistance determination for beveloid gears** Giuseppe Sciarra; Giovanni Mottola; Luca Pezzuolo; Gustavo Casamenti; Marco Carricato
11:45	49	Jose Pedrero	**Analysis of the tooth-root stress of external spur gears with high effective contact ratio** Jose Pedrero; Miryam Sánchez; Miguel Pleguezuelos; Alfonso Fuentes-Aznar
12:00	157	João Marafona	**Influence of dynamics on gear meshing power loss** João Marafona; Pedro Marques
12:15	221	Zhenglong Fang	**Local cutting feature considered universal modelling for optimizing kinematic set of cylindrical cutters in gear skiving** Jia Sun; Qian Zhang; Zongwei Ren; Zhenglong Fang
12:30	200	Ibai Ulacia	**Influence of mesh stiffness in rack and pinion positioning** Ibai Ulacia; Ibon Irazustabarrena; Andrew Katz; Oier Franco; Aurea Iñurritegui; Kaan Erkorkmaz
12:45	44	Mircea Neagoe	**Conceptual design of a counter-rotating vertical-axis wind system with reconfigurable planetary speed increaser** Mircea Neagoe; Radu Gabriel Saulescu

TECHNICAL SESSIONS VII - D	Friday, June 28 • 11:15 – 13:00

BIOMECHANICS

Room Andrés Kecskeméthy	CHAIR **Raphael Dumas**

Time	ID	Presenting Author	Title
11:15	152	Daniel García-Vallejo	**Transverse deformation of the trajectory of biomechanical markers as an indicator of neurological injury in post-stroke patients** Daniel García-Vallejo; J Ojeda; J Mayo; P Ferrand-Ferri; A.G. Agúndez; E Martín-Sosa; M.J. Zarco-Periñán
11:30	46	Alberto Borboni	**EWA 3: A Single Size Self-Adapting Assistive Exoskeleton for Lifting** Alberto Borboni, Antonio Arbore; Irraivan Elamvazuthi
11:45	222	Claudiu Zaleschi	**Human forearm model for medical recovery and functional monitoring system** Adriana Comanescu; Claudiu Zaleschi; Doru Boblea; Andreea Neagoe
12:00	191	Jan Krivošej	**Eigenmotion Concept of Exoskeleton of Upper Limb** Jan Krivošej; Jakub Švadlena; Júlia Bodnárová; Matej Daniel; Zbyněk Šika
12:15	109	Tayyab Ahmad Ansari	**Conceptual design of a novel wearable knee exoskeleton using parallel mechanism** Tayyab Ahmad Ansari; Ketao Zhang
12:30	139	Dhruva Rajesh Khanzode	**A novel method for 3D workspace estimation of robotic surgical instruments in minimally invasive surgery using medical imaging data** Dhruva Rajesh Khanzode; Ranjan Jha; Damien Chablat; Alexandra Thomieres; Emilie Duchalais
12:45	223	Mehdi Ghiassi	**An efficient method for drift-free IMU orientation estimation during running: application to shank and foot** Mehdi Ghiassi; Andrés Kecskémethy

13:00 - 14:00	Lunch

TECHNICAL SESSIONS VIII – A	Friday, June 28 • 14:00 – 15:30

COMPLIANT MECHANISMS

Room Erskine Crossley			CHAIR **Matteo Verotti**
Time	ID	Presenting Author	Title
14:00	89	Siyuan Ye	**Type Synthesis of Morphing Mechanisms Consisting of Multi-Stable Compliant Mechanisms and Multi-DOF Linkages Generated from Baranov Trusses** Yinjun Zhao; Jieyu Wang; Yingzhong Tian; Jiacheng Li; Guangbo Hao; Siyuan Ye; Fengfeng Xi
14:15	12	Nicola Bailey	**Prediction of the shape deflection of nonlinear mulitisction compliant mechanisms** Jianhang Ding; Patrick Keogh; Nicola Bailey
14:30	27	Christian Iandiorio	**Kinematics analysis of flexure hinges under large displacements: experimental testing and comparative evaluation of analytical, numerical and pseudorigid models** Christian Iandiorio; Luca Farotto; Marco Cirelli; Pietro Salvini; Pier Paolo Valentini
14:45	187	Shane Johnson	**Design of a semi actively controlled adjustable quasi zero stiffness mechanism** Tanzeel Ur Rehman; Shane Johnson
15:00	158	Ruiyu Bai	**Achieving high-quality and large-stroke constant torque by axial force release** Ruiyu Bai; Nan Yang; Zhiwei Qiu; Bo Li; Shane Johnson; Guimin Chen
15:15	136	Sajjad Keshtkar	**Design and assessment of novel soft fingers with variable stiffness for gripping tumbling objects in space** Alfredo Puente-Flores; Hirohisa Kojima; Sajjad Keshtkar

TECHNICAL SESSIONS VIII – B	Friday, June 28 ▪ 14:00 – 15:30

MECHANISM AND MACHINE DESIGN

Room Terry Shoup			CHAIR **Hélder Puga**
Time	ID	Presenting Author	Title
14:00	88	Hao Chen	**Expanding the family of bundle folding deployable network mechanisms using plane-symmetric 6R deployable polygon mechanisms and generalized scissor-like elements** Hao Chen; Jiayu Chen; Weizhong Guo; Mingxuan Wang; Caizhi Zhou
14:15	34	Binbin Peng	**Dynamic design of a novel 4-DOF high-speed parallel mechanism with dual drive chain** Binbin Peng; Qingzhan Ma; Diansheng Shi
14:30	82	Swathi Saravanan	**Thickness accommodation for mountain valley switching in morph origami** Swathi Saravanan; Phanisri Pradeep Pratapa
14:45	98	Hui Yang	**Design and analysis of modular architecture deployable antenna mechanism based on two-high positioning nodes tetrahedral basic unit mechanism** Enbo Liu; Yongsheng Zhao; Tengfei Cao; Yundou Xu; Jiantao Yao; Xinlu Wei
15:00	101	Huijuan Feng	**Origami-inspired Design Methodology of Meta-chiral Mechanisms and Their Screw-based Reconfiguration Evolution** Mi Li; Huijuan Feng; Jian S. Dai
15:15	121	Xianwen Kong	**Construction of variable-DOF single-loop spatial mechanisms using Bennett mechanisms** Xianwen Kong

TECHNICAL SESSIONS VIII – C	Friday, June 28 • 14:00 – 15:30

ROBOTS AND MANIPULATORS

Room John Uicker			CHAIR **Huiping Shen**
Time	ID	Presenting Author	Title
14:00	117	Abbas Fattah	**Optimized flapping wing mechanism** Tim Armstrong; Matt Buckley; Nick Lambert; Carson Reuter; Dean Shaub; Aidan Weitzel; Abbas Fattah
14:15	178	Juan Pablo Mora Garota	**Natural motion design for energy-efficient parallel robots in pick-and-place tasks** Juan Pablo Mora Garota; Carlos Francisco Rodriguez; Burkhard Corves
14:30	147	Yue Zhang	**Kinematics analysis and performance optimization of a novel asymmetric parallel biped robot** Yue Zhang; Xizhe Zang; Boyang Chen; Chao Song; Liang Gao; Jie Zhao
14:45	132	Jisen Li	**Design and optimization of a transformable underwater robot** Jisen Li; Qiujun Huang; Jian Zhu
15:00	228	Pietro Davide Maddio	**Configuration Optimization to Enhance Stiffness of a Modular Snake-Like Robot** Pietro Davide Maddio; Alessandro Cammarata; Rosario Sinatra; Yingzhong Tian; Yinjun Zhao; Fengfeng Xi
15:15	220	Brandon-Dariel Salazar-Bravo	**Optimization of walking humanoid robots by applying a global energy criterion** Daniel-Roberto Soto-Delgado; Brandon-Dariel Salazar-Bravo; J. Alfonso Pamanes; J. Jesus Pamanes

TECHNICAL SESSIONS VIII - D	Friday, June 28 • 14:00 – 15:30

ROTATING MACHINERY AND TRIBOLOGY

Room Andrés Kecskeméthy			CHAIR **Josu Aguirrebeitia**
Time	ID	Presenting Author	Title
14:00	113	Jerzy Margielewicz	**System for harvesting energy from continuously rotating machine elements** Jerzy Margielewicz; Damian Gąska; Sławomir Bucki; Grzegorz Litak
14:15	216	Ali Tatar	**Experimental modal analysis of a planetary geared rotor system and its numerical model validation** Ali Tatar; Christoph Schwingshackl; Michael Friswell
14:30	64	Anqi Huang	**Design and verification of a contact state self-monitoring mechanical seal based on triboelectric effect** Anqi Huang; Jia Cheng; Ying Liu
14:45	213	Vishal Singh	**Impact of wear on the performance parameters of PVP fluid operated 4-pocket conical hybrid journal bearing** Vishal Singh; Arvind K. Rajput
15:00	70	Haoran Liao	**The scale identification interval method for solving fractal characteristic length scale** Haoran Liao; Ying Liu; Hongju Li
15:15	85	Vlad Carlesco	**Static and kinetic friction coefficients in stick-slip processes** Dumitru Olaru; Cezara-Mariuca Oprisan; Bogdan Chiriac; Ana Tufescu; Vlad Carlescu

KEYNOTE LECTURE III	Friday, June 28 • 15:35 – 16:15

Room Erskine Crossley			CHAIR **Filipe Marques**
Time	ID	Presenting Author	Title
15:35	30	Pier Paolo Valentini	**Present and future trends in the integration between enabling technologies and mechanism and machine design** Pier Paolo Valentini; Marco Cirelli

16:15-16:45	**AWARDS AND CLOSING CEREMONY** – Main Hall

Poster Session		Permanent Exhibition
ID	Presenting Author	Title
13	Marco Ceccarelli	**IFToMM Permanent Commission of History of MMS: A Poster on the activites** Marco Ceccarelli; Teun Koetsier; Alessandro Gasparetto
18	Hongye Wu	**Comparison study on motion/force transmissibility of a new 6-dof parallel mechanism and Gough-Stewart platform** Hongye Wu; Haitao Liu; Wei Yue; Shaofei Meng; Qingpo Xu; Tian Huang
45	Francisco Novais	**Dynamic modeling and analysis of a Formula Student car with focus on the friction behavior of the vehicle suspension subsystem** Francisco Novais; Filipe Marques; Paulo Flores
51	Maria Francisca Sousa	**Experimental and computational analysis of the human gait with crutches** Maria Francisca Sousa; Mariana Rodrigues da Silva; Filipe Marques; Sérgio B. Gonçalves; Miguel Tavares da Silva; Paulo Flores
60	Joana Coelho	**On the hexapod robot's gait optimization: A dynamic perspective on the limbs actuation** Joana Coelho; Filipe Marques; Bruno Dias; Gil Lopes; Paulo Flores
67	Jiale Han	**A novel multi-pulse friction compensation strategy for hybrid robots** Jiale Han; Haitao Liu; Xianlei Shan; Juliang Xiao; Tian Huang
87	Fernando Gonçalves	**Development of a multibody simulator to study the CHARMIE robot** Fernando Gonçalves; Tiago Ribeiro; A. Fernando Ribeiro; Gil Lopes; Paulo Flores
122	Yonghong Chen	**Generalized Model of a Local Conjugate Meshing Hourglass Worm Drive Based on Medium Gear** Zhongtao Li; Yonghong Chen; Chenyang Dou; Fei Liu; Zhenglin Yang; Wenjun Luo; Bingkui Chen
123	Yonghong Chen	**Research on Meshing Characteristics of a Novel Internal Whirling Toroidal Worm Drive** Zhenglin Yang; Yonghong Chen; Fei Liu; Chenyang Dou; Zhongtao Li; Wenjun Luo; Bingkui Chen
124	Yonghong Chen	**Study on Meshing Stiffness and Load Distribution of TI Worm Drive** Fei Liu; Yonghong Chen; Zhongtao Li; Chenyang Dou; Zhenglin Yang; Wenjun Luo; Bingkui Chen
126	Ehsan Askari	**An evolutionary hybrid approach to identify multibody systems with partially known physics** Ehsan Askari; Guillaume Crevecoeur; Paulo Flores
144	Yachao Sun	**Evaluation of meshing stiffness for spur gears supported by cantilever rotors based on extended coefficient matrix method** Yachao Sun; Jianghai Shi; Yang Yang; Minggang Du; Hongrui Cao
148	Hamid Lankarani	**Precision Tracking of Shoulder Joint Center for Bioinspired Exoskeleton Development** Yimesker Yihun, Pablo Delgado and Hamid Lankarani
182	Inês Gomes	**A simple and comprehensive approach to formulate and solve dynamics problems in a non-traditional engineering course** Francisco Novais; Mariana Rodrigues da Silva; Inês Gomes; Hélder Puga; Paulo Flores
184	Mariana Rodrigues da Silva	**On the modeling of crutch-assisted locomotion: examining the interfaces with the ground and with the human body** Maria Francisca Sousa; Mariana Rodrigues da Silva; Filipe Marques; Miguel Tavares da Silva; Paulo Flores

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Book of Abstracts

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MOTION ANALYSIS OF A TREE-CLIMBING ROBOT

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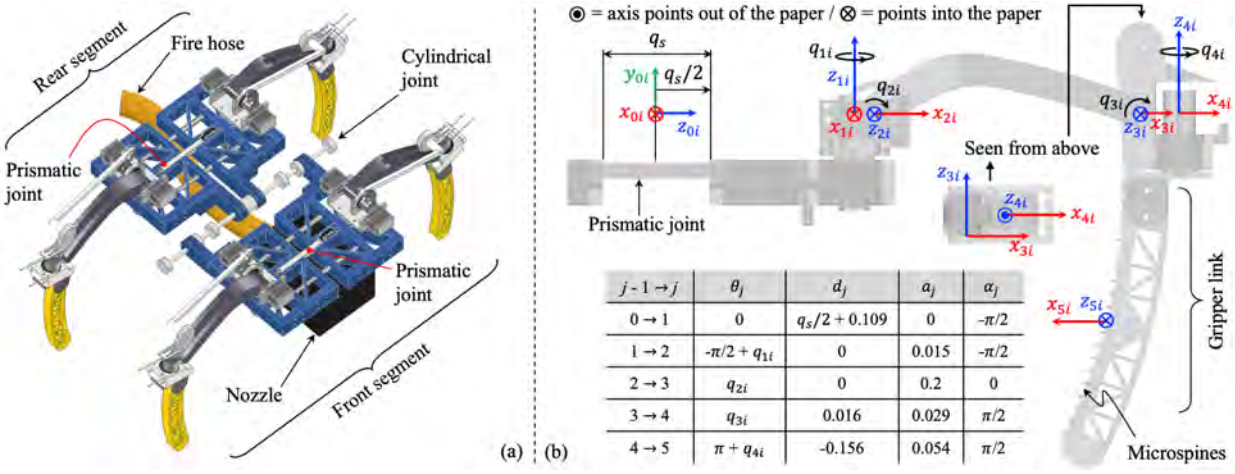
1. INTRODUCTION

Field robots that carry a fire hose and spray water to fight wildfires are mainly wheeled/tracked tank-like robots [1] or flying drones [2]. Tank-like robots are robust but bulky and may find it hard to traverse terrains with obstacles; besides, they cannot climb trees to reach high positions from which to spray water on far flames. Drones have larger freedom and scope but may not access some areas due to dense canopies, and their flight control is perturbed by large waterjet recoil forces. In this abstract, we analyze the motion of a new legged robot for fighting wildfires. Its legged locomotion eases obstacle negotiation, and it can climb trees to reach high positions from which to spray water. Moreover, the robot resists waterjet reactions by gripping to trees.

2. DESCRIPTION AND KINEMATIC MODELING OF THE ROBOT

The proposed robot, shown in Fig. 1a, is a quadruped designed to walk over rough terrains and climb trees, where each leg has four degrees of freedom. Two legs joined by a prismatic joint form the front segment, and two more form the rear segment. Both segments are connected by a cylindrical joint that allows the robot to bend from ground to tree. The distal link of each leg ("gripper") has microspines to adhere to the tree. A fire hose ending at a nozzle is attached to the front segment to spray water on flames. The robot climbs by attaching the grippers of the rear segment to the tree, then the rear segment moves forward. Next, the front grippers are attached to the tree, the rear ones release, and the cycle repeats inverting the roles of the rear/front segments.



$j-1 \to j$	θ_j	d_j	a_j	α_j
$0 \to 1$	0	$q_s/2 + 0.109$	0	$-\pi/2$
$1 \to 2$	$-\pi/2 + q_{1i}$	0	0.015	$-\pi/2$
$2 \to 3$	q_{2i}	0	0.2	0
$3 \to 4$	q_{3i}	0.016	0.029	$\pi/2$
$4 \to 5$	$\pi + q_{4i}$	-0.156	0.054	$\pi/2$

Figure 1. (a) General view of the studied robot. (b) Denavit-Hartenberg reference frames and parameters of a leg (Y-axes are omitted).

Fig. 1b shows the Denavit-Hartenberg (DH) [3] frames of leg i ($i = 1,2$), where frame $x_{0i}y_{0i}z_{0i}$ is centered at the prismatic joint, and frame $x_{5i}y_{5i}z_{5i}$ is attached to the gripper. Let (p_x, p_y, p_z) denote the position and (α, β, γ) the orientation of frame $x_{01}y_{01}z_{01}$ with respect to a fixed world frame W, where (α, β, γ) are ZYX intrinsic Euler angles. The position and orientation of the gripper of leg i ($i = 1,2$) with respect to W is given by the following homogeneous transformation matrix $\mathbf{G}_i$:

$$\mathbf{G}_i = \begin{bmatrix} \mathbf{R}_z(\alpha)\mathbf{R}_y(\beta)\mathbf{R}_x(\gamma) \cdot \mathbf{K}_i & \begin{bmatrix} p_x & p_y & p_z \end{bmatrix}^T \\ [0\ 0\ 0] & 1 \end{bmatrix} {}^0\mathbf{T}_1(q_s)\ {}^1\mathbf{T}_2(q_{1i})\ {}^2\mathbf{T}_3(q_{2i})\ {}^3\mathbf{T}_4(q_{3i})\ {}^4\mathbf{T}_5(q_{4i}), \quad \text{with: } \begin{cases} \mathbf{K}_1 = 1 \\ \mathbf{K}_2 = \mathbf{R}_y(\pi) \end{cases} \tag{1}$$

where ${}^{j-1}\mathbf{T}_j$ is the DH matrix that gives the position and orientation of frame j relative to frame $j-1$ [3], and $\mathbf{R}_v(u)$ is a 3x3 rotation matrix of angle u about axis v. $\mathbf{K}_2$ simply means that the first frame $x_{02}y_{02}z_{02}$ of leg 2 is obtained by rotating the first frame $x_{01}y_{01}z_{01}$ of leg 1 by π rad about axis y_{01}. Unless otherwise specified, lengths in this abstract are in m, and angles in rad.

3. MOTION ANALYSIS

In this abstract we aim to analyze the motion of one segment when its grippers are attached to the tree, which constitutes a closed-chain mechanism. In order for the grippers to be attached to the tree, the following equations must hold:

$$g_{ix} - g_{ix}^d = 0,\ \ g_{iy} - g_{iy}^d = 0,\ \ g_{iz} - g_{iz}^d = 0,\ \ g_{i\alpha} - g_{i\alpha}^d = 0,\ \ g_{i\beta} - g_{i\beta}^d = 0,\ \ g_{i\gamma} - g_{i\gamma}^d = 0,\ \ \text{for } i = 1,2 \tag{2}$$

where (g_{ix}, g_{iy}, g_{iz}) are the position coordinates of gripper i, which are in the fourth column of $\mathbf{G}_i$, and $(g_{i\alpha}, g_{i\beta}, g_{i\gamma})$ are the intrinsic ZYX Euler angles that parameterize the orientation of gripper i, which can be reconstructed from the entries of the rotation submatrix of $\mathbf{G}_i$. The same symbols with a "d" superscript (e.g., g_{ix}^d) represent the desired values for these variables. We also consider bounds: $q_s^{min} \le q_s \le q_s^{max}$ and $p_z^{min} \le p_z$ (to avoid robot-tree collisions), which can be rewritten as equalities:

$$q_s - q_s^{min} - s_1^2 = 0,\ \ p_z - p_z^{min} - s_2^2 = 0,\ \ q_s - q_s^{max} + s_3^2 = 0 \quad (s_k \text{ are slack variables}) \tag{3}$$

Eqs. (2) and (3) form a nonlinear system $\mathbf{F}(\mathbf{q}) = \mathbf{0}$ of 15 equations in 18 unknowns: $\mathbf{q} = [p_x, p_y, p_z, \alpha, \beta, \gamma, q_s, q_{11}, q_{21}, q_{31}, q_{41}, q_{12}, q_{22}, q_{32}, q_{42}, s_1, s_2, s_3]^T$. For desired attachments $\{g_{ix}^d$=±0.016, g_{iy}^d=∓0.082, g_{iz}^d=-0.26, $g_{i\alpha}^d$=±π/2, $g_{i\beta}^d$=-0.5, $g_{i\gamma}^d$=π/2$\}$, limits $\{q_s^{min}$=p_z^{min}=0.03, q_s^{max}=0.07$\}$, and initial unattached configuration $\mathbf{q}_0^u$ =[0, 0, 0.05, 0, 0, π/2, 0.08, $\mathbf{0}_{1x8}$, 0.1, 0.3, 0.2]^T (shown in blue in Fig. 2a), we solve $\mathbf{F}(\mathbf{q}) = \mathbf{0}$ using Newton's method, using the minimum-norm pseudoinverse for inverting the 15x18 Jacobian matrix $\mathbf{J}$ (=$\partial\mathbf{F}/\partial\mathbf{q}$). After 3 iterations, this converges to the initial attached configuration $\mathbf{q}_0^a$ shown in gray in Fig. 2a.

3.1. Maximum Forward and Steering Motions

Starting from $\mathbf{q}_0^a$, we iterate the following steps to determine the maximum forward motion along the direction of the tree:

Step 1) Compute the Singular Value Decomposition of $\mathbf{J}(\mathbf{q}) = \mathbf{U}\,\mathbf{S}\,\mathbf{V}^T$. Let $\mathbf{N}$ denote last three columns of $\mathbf{V}$, then $\mathbf{N}$ spans the null space of $\mathbf{J}$, i.e., admissible small displacements can be written as: $\delta\mathbf{q} = \mathbf{N}\mathbf{c}$, for any small $\mathbf{c}_{3\times1}$.

Step 2) If $\mathbf{n}_1$ denotes the first row of $\mathbf{N}$, a small displacement in p_x can be written as: $\delta p_x = \mathbf{n}_1\mathbf{c}$. Solve $\mathbf{c}$ required to achieve a small increment $\delta p_x = 4 \cdot 10^{-4}$ m as follows: $\mathbf{c} = \mathbf{n}_1^+ \delta p_x$, where superscript $(\cdot)^+$ denotes the minimum-norm pseudoinverse.

Step 3) Update $\mathbf{q} \leftarrow \mathbf{q} + \mathbf{N}\mathbf{c}$. The new $\mathbf{q}$ will not exactly satisfy $\mathbf{F}(\mathbf{q}) = \mathbf{0}$, so Newton's method is used to refine $\mathbf{q}$ until $\mathbf{F}(\mathbf{q}) = \mathbf{0}$ is satisfied. If Newton's method converges, return to step 1. Otherwise, stop iterating: the maximum p_x has been reached.

Fig. 2b shows the resulting trajectory, which advances $\Delta x = 11.5$ cm along axis X until Newton's method fails to converge.

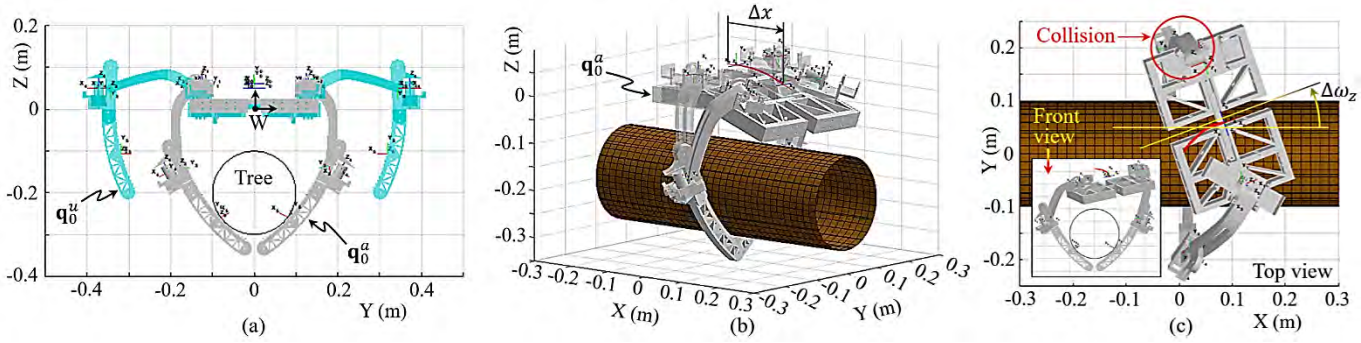


Figure 2. (a) Initial attachment of the robot. (b) Maximum forward motion along the tree. (c) Maximum steering motion.

These steps can also be used to find the maximum reachable rotation of the robot about world axis Z, to adapt to changes in the direction of the tree. To do this, $\mathbf{c}$ is computed in step 2 as follows: $\mathbf{c} = ([1,0,-\sin\beta]\mathbf{n}_{456})^+ \delta\omega_z$, where $\delta\omega_z = 0.0016$ rad and $\mathbf{n}_{456}$ denotes rows 4, 5 and 6 of $\mathbf{N}$, which account for small changes in Euler angles $(\delta\alpha, \delta\beta, \delta\gamma)$. The row $[1,0,-\sin\beta]$ maps small changes in Euler angles to small rotations $\delta\omega_z$ about world axis Z. Fig. 2c shows the maximum rotation $\Delta\omega_z = 20^o$. Both simulations of Figs. 2b and 2c stopped when $\mathrm{cond}(\mathbf{J})$ diverged. This coincided with both p_z and q_s reaching their lower limits.

4. CONCLUSIONS AND FUTURE WORK

When the proposed robot attaches two legs to a tree, its central body can advance up to 11.5 cm along the tree or rotate up to 20º to adapt to branches or to changes in the direction of the tree. In future analyses, we will consider self-collisions (Fig. 2c shows a collision between a leg and the central frame, which will require redesign of the shape of links), dynamics, and the whole robot.

ACKNOWLEDGMENTS

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