ICMT 2021

BOOK OF ABSTRACTS

December 18th - 22nd, 2021

24th INTERNATIONAL CONFERENCE ON MECHATRONICS TECHNOLOGY – ICMT 2021

Edited by JJ Chong and Truong Quang Dinh

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24th INTERNATIONAL CONFERENCE ON MECHATRONICS TECHNOLOGY – ICMT 2021

December 18th – 22nd, 2021 at Newcastle University in Singapore (Virtual Conference)

www.icmt2021.org

Organised by:

Newcastle University in Singapore and University of Warwick

Edited by JJ Chong and Truong Quang Dinh

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General Introduction

24th INTERNATIONAL CONFERENCE ON MECHATRONICS TECHNOLOGY – ICMT 2021

December 18th – 22nd, 2021 at Newcastle University in Singapore (Virtual Conference)

Scope of the Conference

ICMT 2021 – The aim of this conference is to allow participants an opportunity to discuss, exchange recent developments, new ideas and share their research experiences in the field of Mechatronics technology. The conference will be featuring invited speakers as well as consisting of oral presentations and contributed posters covered a wide range of topics and issues on specific themes. The 24th edition of ICMT conference is jointly organized by Newcastle University in Singapore and University of Warwick. ICMT 2021 will be held virtually at Newcastle University in Singapore, on December 18th – 22nd 2021.

ICMT History

The ICMT is an annual international conference on mechatronics technology successfully held for over 20 years. ICMT offers a forum to discuss state-of-the-art technologies and emerging application trends, and provides great opportunities for professional interactions and networking in a friendly and hospitable setting. The first ICMT was convened in Santa Clara, USA, in 1996, and subsequently in Yokohama, Hsinchu, Pusan, Singapore, Kitakyushu, Taiwan, Hanoi, Kuala Lumpur, Mexico City, Ulsan, Sudbury, Cebu City, Osaka Melbourne, Tianjin, and Jeju Island, Taipei, Tokyo, Dalian, Ho Chi Minh City, Jeju Island and Salerno. The objective of ICMT is to facilitate close dialogues, networking and collaborations among experts on issues related to research and technological development in mechatronics, as well as in human resource development and education.

ICMT 2019 – Salerno, Italy (23th)
ICMT 2018 – Seogwipo, South Korea (22nd)
ICMT 2017 – Ho Chi Minh City, Vietnam (21st)
ICMT 2016 – Dalian, China (20th)
ICMT 2015 – Tokyo, Japan (19th)
ICMT 2014 – Taipei, Taiwan (18th)
ICMT 2013 – Jeju, South Korea (17th)
ICMT 2012 – Tainjin, China (16th)
ICMT 2011 – Melbourne, Australia (15th)
ICMT 2010 – Osaka, Japan (14th)
ICMT 2009 – Cebu City, Philippines (13rd)
ICMT 2008 – Sudbury, Canada (12nd)
ICMT 2007 – Ulsan, South Korea (11st)
ICMT 2006 – Mexico City, Mexico (10th)
ICMT 2005 – Kuala Lumpur, Malaysia (9th)
ICMT 2004 – Hanoi, Vietnam (8th)
ICMT 2003 – Taiwan (7th)
ICMT 2002 – Kitakyushu, Japan (6th)
ICMT 2001 – Singapore (5th)
ICMT 2000 – Pusan, South Korea (4th)
ICMT 1999 – Hsinchu, China (3rd)
ICMT 1998 – Yokohama, Japan (2nd)
ICMT 1996 – Santa Clara, USA (1st)

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Sponsors

ICMT 2021 Programme

Technical Tracks

The topics of interest include (but are not limited to) the followings:

Advanced Mechatronics Devices, Sensing and Control (TT-01)
Robotics, Robot factory, Mobile Robots, Motion control, Intelligent Mechanism, Parallel Mechanisms in Machine Tools, Man-Machine Interfaces, Sensors, Computer Vision and Recognition, Automated Navigation, Modeling, Tele-operation, Intelligent and Advanced Control, Adaptive Control, Artificial Intelligence, Precision Control.

Smart Actuators and Materials (TT-02)
Actuators using Functional Fluid, SMA Actuators, Piezo-Electric Actuators, Electro-Static Actuators, Magneto-Strictive Actuators, Smart Materials and Structures: Ionic Polymer–Metal Composites, Dielectric ElectroActive Polymer.

MEMS/NEMS and Micro/Nano-Manufacturing (TT-03)
Precision Mechatronics, Micro/Nano-Electro Mechanical Systems, Opto-Mechatronics, Ultra-High Precision Machining, Focus Ion Beam Manufacturing.

Production Systems (TT-05)
Automation Science and Technology, Intelligent Machine Tools, Flexible Manufacturing Systems, Agile Manufacturing, Production Planning and Control, Fault Monitoring & Diagnosis, e-Maintenance, e-Manufacturing, Rapid Prototyping, Remote Manufacturing with Internet, Free Form Surface Machining.

Sustainable Transport and Energy Systems (TT-06)
Automotive Hybridization and Electrification, Vehicle Lightweight Materials and Structures, High Power Energy Storage Systems and Integration, Advanced Propulsion Technologies and Energy Saving Options, System Modelling and Real-Time Estimation, Energy Management Strategies and Optimization

Mechatronics as an Enabler for Innovative and Intelligent Transportation Systems (TT-07)
Telematics, Big Data Mining, Deep Leaning, Smart, Autonomous and Connected Vehicles

Renewable Energy and Smart Grid (TT-08)
Sustainable Energy Resources, Energy Conversion Devices, Control Technologies, Energy Generation.

Bioengineering and Mechatronics Applications in Life Sciences (TT-09)
Biosensors, Biochip Manipulation, Medical equipment, Human-Friendly Mechatronics, Human Adaptive Mechatronics, Life Cycle Design, Recycle Technology, Ecological Design and Production.

Information and Networking (TT-10)
Network-Based Control Systems, Real-Time Systems, Embedded Systems, Self-Configuring Wireless Sensor Networks.

Human Resource Development and Education on Mechatronics Technology (TT-11)
Strategy on Mechatronics Technology, Mechatronics Education, Computer-Aided Instruction, Virtual reality Applications on Education, Policy and Strategy Studies.

Internet in Industry 4.0 (TT-12)
Internet of Things, Internet based Manufacturing, AI, Super Smart Society

Composite and Polymer Materials (TT-13)
Advanced Composite for smart devices, polymer for light structures in mechatronic and automation systems, smart integration of polymers in actuators, sensors and manufacturing technologies

Conference Schedule

Dates	Times	Events and Links
Now – 22 December 20201	**Open**	**Virtual Reception – ICMT2021 Registration Form**
18 December 2021 (Day 0)	10:00 – 23:59 10:30 – 12:00	Greetings message Online Tour Singapore Maritime – Singapore River
19 December 2021 (Day 1)	17:00 – 17:45	Online Tour Downtown Singapore Virtual Tour
20 December 2021 (Day 2)	14:30 – 14:50 14:50 – 15:00 15:00 – 17:45 17:45 – 18:30	Welcome and Reception (Main Virtual Hall) Opening Ceremony (Breakout Room) Industry Workshops and Networking (Breakout Room) International Steering Committee Meeting (Breakout Room)
21 December 2021 (Day 3)	11:45 – 18:00 12:00 – 18:00	Main conference day 1 (Main Virtual Hall) Keynote Speeches and Technical Sessions (Breakout Rooms)
22 December 2021 (Day 4)	11:45 – 18:20 12:00 – 18:00 18:00 – 18:45	Main conference day 2 (Main Virtual Hall) Keynote Speeches and Technical Sessions (Breakout Rooms) Closing Ceremony

Notes:

Conference will be held Singapore Standard Time (GMT+8 hours)

Passwords will be required for all meetings from Day 2 to Day 4. The passwords will be sent on to the authors by email.

Please join the webinar at least **10 minutes before** the scheduled starting time so you won't miss valuable information.

Industrial Talks

[Schneider Electric, Qiu Ting Qian] – Schneider Electric Innovation Experience Live (Virtual Tour)

15:00 – 15:45, 20th December 2021

Qiu Ting QIAN - Talent Acquisition Specialist, Singapore & Malaysia

Abstract: Situated on the ground floor of Schneider Electric East Asia & Japan Headquarters, the hub features our products and Ecostruxure solutions so you can discover the latest innovations and learn about our story, values and commitments. This hub is a co-innovation platform with world-class facilities, enabling Schneider Electric to develop tailored solutions to optimize energy efficiencies for various segments, such as commercial and industrial building, healthcare, hotel, manufacturing, pol and gas, cloud and service providers, banking and finance, utilities.

[Siemens, David Morand and Djiby Touré] – Complex Mechatronics Systems: electric drive component integration and verification by means of simulation

15:50 – 16:30, 20th December 2021

David Morand - is a part of the aerospace and defense business development team for Simcenter systems simulation solutions. His current role comprises go to market strategy and delivery, direct customer engagement and business project proactive support. He has been holding several positions related to presales activity and business development for system simulation software in various area such as automotive, aerospace, marine and heavy industry. He received a Mechanical engineer diploma from National Institute of Applied sciences in Lyon with a specialization in automation and control. He also holds an MBA from IAE Lyon School of Management.

Djiby Touré - is product manager for systems simulation solutions related to Aerospace and Defense. In his current job he contributes to product roadmap definition to address the aerospace market simulation needs. He is involved in applications related to electric propulsion, gas turbines, rocket/liquid propulsion and flight performance among others. Prior to that, he was a software developer for A&D electric component on Simcenter Amesim simulation platform. He graduated from the French Higher Institute of Mechanical Engineering (SUPMECA) and majored in mechatronics.

Abstract – Sizing of electric propulsion for hybrid aircraft requires precision of component design as well as its complete integration within the plane to assess global behavior for representative flight missions. Complexity of mechatronics systems and the need to early design and validation of technology choices is today achievable thanks to a greater use of computer simulation. In an approach of the problem from a system point of view, top level requirements for a dual three-phase machine are defined with a system simulation model of a hybrid aircraft. Based on these requirements, a detail FEM simulation model of the motor is used to size the machine. Electric motor performance is then integrated in the system simulation model of the aircraft and several flight conditions are evaluated: nominal and failure cases.
Use of various simulations tools is critical to get benefits of each special capability. But simulation design process should be kept simple and continuous. The example presented demonstrates use of Simcenter system simulation Amesim software as an integration platform for aircraft predesign analysis, completing system simulation model with FEM Simcenter MAGNET software performance model of a motor.

[dSPACE, Dr. Philip Clarke] – The challenges of HiL simulation for electric drives and inverters
16:35 – 17:15, 20th December 2021

Dr. Philip Clarke – dSPACE Business Manager, United Kingdom

Keynote Speeches

Keynote Speaker

Professor Huijun Gao
School of Astronautics
Harbin Institute of Technology, China

Keynote Talk 01: Networked Control Systems with Industrial Applications

Recently, the analysis and synthesis of networked control systems (NCSs) have received increasing attention from both academic and industrial perspectives. Compared with traditional point-to-point control systems, the main advantages of NCSs are the low cost, flexibility, easy re-configurability, and their adaptation capability. Consequently, NCSs can be found in various areas such as power grids, water distribution networks, transportation networks, haptics collaboration over the Internet, mobile sensor networks. However, the introduction of communication channels in the control loop also brings network-induced critical issues or constraints such as variable transmission delays, data packet dropouts, packet disorder, quantization errors, which would significantly degrade the system performance or even destabilize the system in certain conditions.

This talk will first introduce some elegant approaches to network-based control and estimation problems. Then, a novel two-layer network-based architecture and the overall tracking performance for operational control of industrial processes will be discussed.

Keynote Speaker

Professor Nobuyuki Iwatsuki
Vice President for Global Communication
Tokyo Institute of Technology, Japan

Keynote Talk 02: A Flexibly Grasping and Manipulating Mechanism Composed of Many Elastic Cords and A Linkages

Aiming to realize to grasp and manipulate objects with a non-uniform shape or fragile structure using a simple mechanism, a novel mechanism composed of many elastic cords connecting two circular rings is proposed. By giving a relative rotation between the circular rings, the elastic cords wind around an object and the mechanism can grasp the object softly. By giving a relative translation, the mechanism can change the posture of the object.

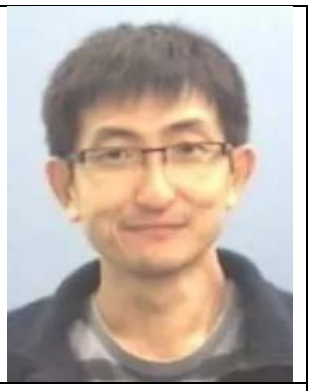
Euler's belt theory is extended to calculate the pressing and friction forces to a three dimensional object by an elastic cord. Motion of elastic cords on an arbitrary object modelled as a polyhedron and grasping force and moment acting on the object can then be theoretically calculated. Actual algorithm to judge contact, slippage, passing beyond vertex and taking off between an elastic cord and an object is established and coded by using optimization. The translational and angular motions of a grasped object due to relative displacements between the rings can then be calculated with an iterative calculation based on the equilibrium of the force and moment applied by elastic cords taking account of inertial forces. The performance to grasp objects with various shape is theoretically evaluated and is experimentally validated with a simple prototype.

The second prototype with a planar parallel mechanism with 2 DOF to give a pure relative translation between the rings is built and experimentally examined. The prototype mounted on a spatial serial robot arm can grasp a cylinder and insert it into a circular hole in inclined surface by utilizing posture control with translation between the rings and the flexibility due to the elastic cords which plays a role of the remote center compliance.

The third prototype in which the lower circular ring is replaced to the two-dimensional Hoberman link mechanism so as to magnify the diameter of the lower ring is designed and built. A new simple control system which can easily detect a longitudinal direction of an object with two cameras and pattern matching with ellipsoidal approximation and makes the mechanism approach to the detected longitudinal direction is developed. A robot arm equipped with the prototype can pick and place objects with various shapes, sizes and locations without any complicated control system.

Keynote Speaker

Dr Kheng-Lim Goh
Department of Mechanical Engineering
Newcastle University, Singapore



Keynote Talk 03: Towards Precision Repair of Damaged Fiber-reinforced Polymer Composites

The intent of this talk is to discuss some recent important developments and insights in repairing damaged fiber-reinforced composites. Aerostructures (such as the fuselage of B787 which are made from fiber-reinforced composite material) are prone to damage. Apart from the economic consideration of aircraft-on-ground, the decision to repair or replace the structure by an undamaged one depends on the cost. In some cases, one could question if this is a sustainable approach from an environmental perspective. The composite structure may not be reused for safety reasons, although the composite material may be recycled. But more importantly, how can one make the option of repairing attractive so that the service life of the composite structure may be extended?

In this talk I am delighted to share with you the recent studies conducted at my lab on impact damage-repair studies in fiber-reinforced composites, healants and in situ repair systems, namely the resin-injection repair system, that could provide for a way for developing an effective strategy for repairing the damaged composite structure.

Keynote Speaker

Professor Josep M. Guerrero
Department of Energy Technology
Aalborg University, Denmark

Keynote Talk 04: Space Microgrids

Space Microgrids – Satellites, Lunar Bases and Closed Bio-Ecosystems
This talk will begin by introducing the control of microgrids, the parallelisms with the human brain and the research for possible sources of inspiration in last frontiers of neuroscience. Then, control in electric power systems of satellites and space platforms will be presented, showing approaches that are extended from terrestrial microgrids and explaining the differences and challenges when it comes to apply them out in the space. Further, multi-microgrid systems will be discussed for moon craters in future lunar and mars manmade bases. Finally, the extension from the hierarchical control of microgrids to bioastronautics in the control of closed ecological systems to support with oxygen, water, and food to the astronauts and creating thus creating new ecosystems for the moon and future mars bases.

Paper Abstracts

Tuesday, 21 December 2021 (Day 3)

12:00 – 13:00	*Day 3 – Main Virtual Hall*
	Keynote Talk 01: Professor Huijun Gao Chairs: Kyoung Kwan Ahn / JJ Chong
13:00 – 15:00	*Day 3 – Breakout Room 01*
	Technical Session: Sustainable Transportation and Energy Systems (1) Chairs: Xuan Phu Do / Anurag Sharma
13:00 – 13:20	SF-000027: Nguyen Minh Huy, Dang Van Hai, Nguyen Minh Phu **Energy, Exergy and Economic (3E) Analysis and Optimization of a Combined Heat and Power (CHP) Plant**
13:20 – 13:40	SF-000639: Manami Tono, Yutaka Tanaka, Chiaki Tanuma **Additive Printing System by Rotational Type of Tripod Parallel Mechanism**
13:40 – 14:00	SF-000612: Thanh Ha Nguyen, Tri Cuong Do, Kyoung Kwan Ahn **A study on Independent metering valve system for boom excavator system**
14:00 – 14:20	SF-000744: Hoai-An Trinh, Hoai-Vu-Anh Truong, Kyoung-Kwan Ahn **Energy management strategy for fuel cell hybrid power system using fuzzy logic and frequency decoupling methods**
14:20 – 14:40	SF-000582: Tieu Binh Tran, Cong Bang Pham **Study and Implementation of a Robot Soccer System based on the CDIO approach**
14:40 – 15:00	*Break*

Conference will be held Singapore Standard Time (GMT+8 hours)

SF-000027 - Energy, Exergy and Economic (3E) Analysis and Optimization of a Combined Heat and Power (CHP) Plant

Nguyen Minh Huy, Dang Van Hai, Nguyen Minh Phu*
*Ho Chi Minh City, Viet Nam

Abstract: In this paper, a combined gas–steam power plant using exhaust heat to produce hot water is estimated in terms of energy, exergy and economics (3E). The examined parameters included the pressure ratio of the air compressor (r_p), the gas turbine inlet temperature, the steam turbine inlet pressure and the condenser pressure to evaluate thermal performance, exergy performance, and total annual cost (TAC). The mathematical model was established and solved in the environment of Engineering Equation Solver (EES) with comparison of results from the Aspen HYSYS simulator. The calculation results show that the exergy efficiency is maximum at rp = 11. TAC is strongly influenced by gas cycle operating parameters. The minimum TAC can obtain at the steam turbine inlet pressure of 5,300 kPa. Overall optimization reveals maximum efficiencies and minimum cost at pressure ratio of 8.65, gas turbine inlet temperature of 1460 K, the smallest condenser pressure, and the highest steam turbine inlet pressure.

Keywords: 3E analysis, CHP, Weighted sum method, EES, HYSYS

SF-000639 - Additive Printing System by Rotational Type of Tripod Parallel Mechanism

Manami Tono*, Yutaka Tanaka, Chiaki Tanuma
*Hosei University, Japan

Abstract: The use of the rotational type of tripod parallel kinematic mechanism to move the motion stage has been proposed as a new additive printing method for a surface of three-dimensional objects. For the rotational type of tripod parallel mechanism, the inverse kinematic formulation has been derived. For the target dish surface, MATLAB/Simulink was used to simulate the motion path of each actuator in the tripod parallel mechanism for additive printing. The prototype system was developed to test the proposed additive printing method's validity. The additive printing was performed on the surface of the ceramic dish. The performance of the prototype system has been tested in the field. When the additive printing was performed multiple times under the same conditions, decorated printing circles ware repeatedly drawn on the dishes' edge.

Keywords: additive printing, inverse kinematics, linear actuator, parallel kinematic mechanism, rotary actuator, 3D object

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SF-000612 - A study on Independent metering valve system for boom excavator system

Thanh Ha Nguyen, Tri Cuong Do, Kyoung Kwan Ahn*
*University of Ulsan, Korea

Abstract: In this paper, a new design of independent metering valve system is proposed for saving energy in boom excavator. The proposed system uses three Electro-Hydraulic Poppet valve (EHPV) and one directional control valve which reduce one EHPV compared to conventional independent metering valve (CIMV). Besides, an energy management strategy is designed to operate the system. To verify the effectiveness of the proposed system, some simulations are carried out based on an AMESim/Matlab co-simulation model. The results demonstrate that the energy saving achieve up to 25%. Consequently, the proposed system can not only reduce the installation cost but also improve fuel economy.

Keywords: Hydraulic excavator, Electro-Hydraulic Poppet valve, boom system

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SF-000744 - Energy management strategy for fuel cell hybrid power system using fuzzy logic and frequency decoupling methods

Hoai-An Trinh, Hoai-Vu-Anh Truong, Kyoung-Kwan Ahn*
*University of Ulsan, Korea

Abstract: Proton-exchange membrane fuel cell (PEMFC) has become a potential renewable energy source to replace fossil fuels and reduce greenhouse gas emissions. However, slow power density and slow power response are drawbacks of the PEMFC. In order to overcome these shortcomings and improve the fuel economy, this paper presents an innovative energy management strategy (EMS) using a fuzzy logic control (FLC) and frequency decoupling (FD) for a hybrid power system (HPS) with PEMFC,

Keywords: Energy management strategy, PEMFC, hybrid power source, frequency decoupling, fuzzy logic control

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SF-000582 - Study and Implementation of a Robot Soccer System based on the CDIO approach

Tieu Binh Tran*, Cong Bang Pham
*Ho Chi Minh City University of Technology, Vietnam

Abstract: Proton-exchange membrane fuel cell (PEMFC) has become a potential renewable energy source to replace fossil fuels and reduce greenhouse gas emissions. However, slow power density and slow power response are drawbacks of the PEMFC. In order to overcome these shortcomings and improve the fuel economy, this paper presents an innovative energy management strategy (EMS) using a fuzzy logic control (FLC) and frequency decoupling (FD) for a hybrid power system (HPS) with PEMFC, battery (BAT), and supercapacitor (SC). Based on the power response of energy sources, the combination of FLC and FD is applied to determine the appropriate power distribution for load power demand. Besides, a DC bus control loop was designed by using the BAT to guarantee a stable DC output voltage. Comparisons between the proposed strategy with a conventional approach are conducted to verify the strategy's effectiveness through MATLAB/Simulink environment. Simulation results show that the proposed EMS can be guaranteed to not only sufficiently coordinate powers even when the abrupt changes of load or high peak power, but also enhance the efficiency of the PEMFC in comparison with the conventional EMS.

Keywords: Energy management strategy, PEMFC, hybrid power source, frequency decoupling, fuzzy logic control

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13:00 – 15:00	*Day 3 – Breakout Room 02*
	Technical Session: Advanced Mechatronics Devices, Sensing and Control (1) Chairs: Duc Thien Tran / Somnath Sengupta
13:00 – 13:20	SF-000213: Junmo Yang, Minsong Kim, Donghyun Kim, Dongwon Yun **Protrusion Type Slip Detection Soft Sensor and Application to Anthropomorphic Robot Hand**
13:20 – 13:40	SF-000264: Vinh Nguyen Hoang, Luan Bui Thanh, Quang Tran Phan Minh **The Control of the Metering Valve for the Petroleum Depot Based on the Trapezoidal Flow Rate Algorithm**
13:40 – 14:00	SF-000299: Manh Hung Nguyen, Hoang Vu Dao, Kyoung Kwan Ahn **Nonlinear robust control for electro-hydraulic servo systems with largely unknown model dynamics and disturbances**
14:00 – 14:20	SF-001473: Thanh Quoc Truong, Thien Duc Tran, Phuc Hong Nguyen, Minh Cong Ho **Command filter backstepping control of a 2-DOF cable-driven manipulator**
14:20 – 14:40	SF-000868: Huu-Cuong Nguyen, Quang-Hieu Ngo, Van-Cuong Nguyen **A Self-Calibration Method for 2D Vision-based Reverse Engineering**
14:40 – 15:00	Break

Conference will be held Singapore Standard Time (GMT+8 hours)

SF-000213 - Protrusion Type Slip Detection Soft Sensor and Application to Anthropomorphic Robot Hand

Junmo Yang, Minsong Kim, Donghyun Kim, Dongwon Yun*
*Daegu, Republic of Korea

Abstract: In this study, a soft protrusion type sensor that can detect slip was designed. In general, gripper or robot hand receives additional information using vision system, force sensor, and tactile sensor to stably grip an object. These sensors require a lot of cost to manufacture, and the grippers that can be applied are limited. Therefore, in order to overcome this limitation, a soft sensor that has low manufacturing cost and can be applied to various grippers was manufactured using strain gauges and silicon. The performance of the proposed two types of soft sensors was confirmed through slip detection experiments. In addition, it was confirmed whether grasping could be performed after inserting a soft sensor into the distal phalanges by fabricating a four-finger anthropomorphic robot hand. As a result, the soft sensor proposed in this paper shows the advantage of being small in size and can be manufactured at low cost, and the possibility of manufacturing a sensor using soft material was confirmed.

Keywords: friction sensor, soft material, anthropomorphic gripper, robot hand

SF-000264 - The Control of the Metering Valve for the Petroleum Depot Based on the Trapezoidal Flow Rate Algorithm

Vinh Nguyen Hoang*, Luan Bui Thanh, Quang Tran Phan Minh
*Southern Branch of Petrolimex Information Technology and Telecommunication JSC, Vietnam

Abstract: Automating the control of petrol depots for tank trucks is a requirement today. The automation system will reduce manual operations, improve productivity and avoid operator errors. In this paper, an algorithm to control the metering valve for petroleum depots outputting tank trucks based on the trapezoidal flow rate algorithm is introduced. To implement the control algorithm, the paper also proposes a solution to automatically control the pump, control the valve, receive feedback on temperature and the actual number of liters output. This control algorithm has been tested and applied in practice at the western petroleum depot at Tra Noc Industrial Park, Can Tho city, Vietnam. This algorithm has worked well and helped the petrol depot for tank trucks to be more flexible, convenient, and accurate.

Keywords: petrol, control the metering valve, trapezoidal flow rate, tank trucks, petroleum depots

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SF-000299 - Nonlinear robust control for electro-hydraulic servo systems with largely unknown model dynamics and disturbances

Manh Hung Nguyen, Hoang Vu Dao, Kyoung Kwan Ahn*
*University of Ulsan, Korea

Abstract: In this paper, an adaptive sliding mode controller based on disturbance observers and neural network (NN)-based function approximators is introduced to improve the tracking performance of electro-hydraulic servo systems with largely unknown model dynamics. The RBF-based function approximators are employed to deal with unstructured uncertainties, whereas UDE-based disturbance observers are designed to estimate not only lumped mismatched disturbance but also matched disturbance. The derivatives of system states are obtained by using high-order Levant's exact differentiators. Finally, the adaptive robust control law is synthesized to attenuate the imperfections in disturbance estimation and NN-based approximation performances and guarantee high-accuracy tracking performance. The stability of the closed-loop system is analyzed by using Lyapunov theory. Comparative simulations based on an electro-hydraulic rotary are conducted using MATLAB/Simulink to verify the effectiveness of the proposed control approach.

Keywords: hydraulic servo system, sliding mode control, Levant's differentiator, RBF neural network, disturbance observer

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SF-001473 - Command filter backstepping control of a 2-DOF cable-driven manipulator

Thanh Quoc Truong*, Thien Duc Tran, Phuc Hong Nguyen, Minh Cong Ho
*Ho Chi Minh City University of
Technology, Vietnam

Abstract: This paper focuses on addressing the tracking problem of a 2-DOF cable-driven manipulator by employing a command filter backstepping control. In the 2-DOF cable-driven manipulator, both the manipulator dynamics and cable transmission dynamics are described in the manuscript. As a result, the manipulator becomes a fourth-order system, and the problem of "explosion of complexity" will arise when conventional backstepping control is applied to manage the system. To overcome this issue, a command filter backstepping control is proposed. A Lyapunov approach is investigated to demonstrate the stability and robustness of the whole system with the backstepping technique. Finally, some simulations are conducted on a 2-DOF cable-driven manipulator to verify the effectiveness of the proposed control.

Keywords: command filter; backstepping control; cable driven manipulator; Lyapunov approach; cable transmission

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SF-000868 - A Self-Calibration Method for 2D Vision-based Reverse Engineering

Huu-Cuong Nguyen*, Quang-Hieu Ngo, Van-Cuong Nguyen
*Can Tho University, Vietnam

Abstract: Fast copying of the profile of sample object is a requirement of vision-based reverse engineering system. However, there is a problem that the size of sample object is limited to a certain range. In this study, this obstacle is solved by a novel self-calibration method. Based on inverse perspective transformation approach, using a flat marked plane, the 2D profile of a sample object can be obtained with a freely moving camera, such as the camera of smart phone. This allows quickly collecting of the 2D shape of an object with any size. Experimental results show that the proposed method achieves high accuracy. This helps to improve the 2D vision-based reverse engineering system more efficient and flexible.

Keywords: self-calibration, reverse engineering, machine vision, perspective transformation, CNC machining

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15:00 – 16:00	*Day 3 – Main Virtual Hall*
	Keynote Talk 02: Professor Nobuyuki Iwatsuki Chairs: Adolfo Senatore / Dinh Truong
16:00 – 18:00	*Day 3 – Breakout Room 03*
	Technical Session: Sustainable Transportation and Energy Systems (2) Chairs: JJ Chong / Adolfo Senatore
16:00 – 16:20	SF-001139: Mona Faraji Niri, Truong Quang Dinh, James Marco **Riding Pattern Identification by Machine Learning for Electric Motorcycles**
16:20 – 16:40	SF-001414: Krishna kumar Ramakrishna Pandian **Modelling and Brake Blending Control for Multi-Drive Mode Electric Two-wheelers**
16:40 – 17:00	SF-000949: Mehmet Çağın Kırca, Aman Surana, Andrew McGordon, Truong Quang Dinh **Rapid Decision-Making Tool for Powertrain Sizing**
17:00 – 17:20	SF-000981: Christoph Holtmann, Christoph Köhler **Eddy Current and Friction Brake Fusion by a Disc-Spring to a Hybrid-Brake**
17:20 – 17:40	SF-001589: Imran Mohammad Sofi, Truong Quang Dinh, Araan Mohanadass, James Jeffs, Truong Bui Ngoc Minh, Truong Quoc Thanh **Advanced Simulation Tool to Develop Efficient Thermal Management Systems for Electric Vehicles**
17:40 – 18:00	SF-001457: Syed Abu Nahian, Imran Mohammad Sofi, Truong Dinh Quang, Andrew McGordon, Thomas Clapton, Jim Sibson **A Modified-Optimal Energy Management Strategy of Fuel Cell- Battery hybrid Energy Storage System for Marine Application**

Conference will be held Singapore Standard Time (GMT+8 hours)

SF-001139 - Riding Pattern Identification by Machine Learning for Electric Motorcycles

Mona Faraji Niri*, Truong Quang Dinh, James Marco
*WMG, University of Warwick, United Kingdom

Abstract: Identification of riding patterns is one of the key enablers to update energy consumption strategy, optimise the energy management system and increase the range of electric motorcycles despite their weight and space limits. Considering the varying driving conditions in real applications, improving accuracy of the riding pattern recognition without significant complexity is the main challenge. In this paper a simple and efficient online classification method is introduced based on features extracted only from the motorcycle speed. The recognition mechanism is firstly developed using support vector machine technique. The effect of validation method for removing the optimism in classification and the contribution of features to the accuracy of model is then investigated. Evaluation of the method on the real riding conditions in simulation environment shows the effectiveness of the approach.

Keywords: Ride Cycle Classification, Electric Motorcycles, Machine Learning

SF-001414 - Modelling and Brake Blending Control for Multi-Drive Mode Electric Two-wheelers

Krishna kumar Ramakrishna Pandian*, Truong Quang Dinh, James Marco
*WMG, University of Warwick, United Kingdom

Abstract: In electric two-wheelers, high riding performance in terms of energy consumption, ride comfort and rapid acceleration is known as a key enable for the sustainable development. The key performance indicators are dependent upon factors like length of the trip, state of charge of the battery, current traffic conditions and rider behaviors. This leads to the need to develop a highly efficient and convenient motorcycle with multiple drive modes, to enhance customer satisfaction. It is therefore critical to design a brake blending control strategy capable of working effectively with different drive modes to maximize the braking energy recoverability without impacting ride comfort. In order to address this challenge, a simple but efficient brake blending strategy based on serial braking concept, has been developed in this paper, for a two-wheeler electric vehicle with multiple drive modes.

Keywords: Two-wheeler Dynamics, Multiple Drive Modes, Brake Control, Regenerative Braking, Brake Blending Strategy

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SF-000949 - Rapid Decision-Making Tool for Powertrain Sizing

Mehmet Çağın Kırca*, Aman Surana, Andrew McGordon, Truong Quang Dinh
*WMG, University of Warwick, United Kingdom

Abstract: In the early stages of electric vehicle design, the decision-making process concerns the component sizing and trade-offs between various configurations to achieve or update initial target specifications. Motorcycle performance and range are more sensitive to added mass due to configuration selection. Hence, there is a need to quantify the high-level implications of different powertrain configurations and component selection, affecting the total vehicle mass, vehicle range, vehicle acceleration performance. An Excel spreadsheet-based model is described in this paper to aid decision-makers at the early stages of vehicle design. The tool is capable of sizing battery pack, inverter, traction, motor and gearbox, and making performance estimations of a powertrain configuration and component selection. The tool is validated against the listed ranges of two motorcycles and predicts energy usage with an error of 5% for low-speed drive cycles.

Keywords: modelling, component sizing, electric vehicles, range estimation

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SF-000981 - Eddy Current and Friction Brake Fusion by a Disc-Spring to a Hybrid-Brake

Christoph Holtmann, Christoph Köhler*
*German Aerospace Centre, Germany

Abstract: This paper shows the concept and design method of a hybrid brake. The magnetic attraction force between rotor and stator of an eddy current brake can be used to generate an additional mechanical friction torque. By using a disc spring between rotor and stator, the eddy current brake is extended to a so-called hybrid brake. In particular, the design method of the disc spring is the focus of this work. Using a system model that includes the electromagnetic and mechanical domains, the wear reduction compared to a conventional friction brake and the dynamic behavior depending on the spring parameters are investigated. Finally, a disc spring is designed in FEM with the desired force-displacement curve.

Keywords: brake, eddy current brake, friction brake, retarder, disc-spring, diaphragm-spring, membrane-spring

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SF-001589 - Advanced Simulation Tool to Develop Efficient Thermal Management Systems for Electric Vehicles

Imran Mohammad Sofi*, Truong Quang Dinh, Araan Mohanadass, James Jeffs, Truong Bui Ngoc Minh, Truong Quoc Thanh
*WMG, University of Warwick, United Kingdom

Abstract: The worldwide concerns on air pollution and oil depletion in resources have pushed more automotive industry attention toward electric vehicles (EVs) as a long-term solution. However, the driving range of EVs are still less than the traditional combustion engine vehicles. Development of an efficient thermal management system for EVs is of significant importance to improve the overall vehicle performance whilst prolonging the driving range. To accelerate this development target, this paper introduces an advanced simulation tool based on an internet-distributed hardware-in-the-loop simulation (IDHILS) concept. The ID-HILS platform therefore offer a high flexibility in configuring the simulation which combines both virtual and/or physical vehicle sub-systems distributed at different environment and/or locations. This helps to reduce the efforts and costs to build an entire vehicle simulation tool for the generation of thermal management systems.

Keywords: Electric vehicle, Thermal management strategy, Modelling, Internet-distributed hardware-in-the-loop simulation

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SF-001457 - A Modified-Optimal Energy Management Strategy of Fuel Cell- Battery hybrid Energy Storage System for Marine Application

Syed Abu Nahian*, Imran Mohammad Sofi, Truong Dinh Quang, Andrew McGordon, Thomas Clapton, Jim Sibson
*WMG, University of Warwick, United Kingdom

Abstract: Considering the present limitations of battery technology, a hybrid combination of fuel cells (FCs) and batteries can be considered as one of the environment friendly, reliable, and efficient energy solutions for marine ship applications. However, proper energy and power management are some of the critical issues for fuel cell-based energy storage system (ESS) because the degradation of a fuel cell lifetime is strongly affected by its operating condition. In this paper, a modified-optimal energy management strategy (MOEMS) is proposed which determines the power-split ratio between the FC and battery efficiently. By integrating the popular gradientdescent algorithm into a state machine control the proposed controller is realized. The performance of the MOEMS is compared with conventional EMS with simulation. Results suggest that the proposed EMS improve the fuel cell lifetime by 44% while reducing the fuel consumption by 7% compared to the basic EMSs.

Keywords: Fuel cell, Energy management strategy, Hybrid propulsion-architecture

16:00 – 18:00	*Day 3 – Breakout Room 04*
	Technical Session: Advanced Mechatronics Devices, Sensing and Control (2) Chairs: Aghil Jafari / Dongwon Yun
16:00 – 16:20	SF-000418: Hoang Vu Dao, Kyoung Kwan Ahn **Task coordinate frame-based contouring control of an excavator with sliding mode observer and prescribed performance**
16:20 – 16:40	SF-000515: Phan Van Du, Ahn Kyoung Kwan **Observer-based Fault-Tolerant Control of an Electro-Hydraulic Actuator with mismatched disturbance**
16:40 – 17:00	SF-000922: Adolfo Senatore, Alex De Simone, Martina Travaglino, Mario Pisaturo, Veronica D'Urso **Modeling of Onshore Wave Energy Converter: Inverse Dynamic Analysis and Thermal Prediction**
17:00 – 17:20	SF-000167: Aniruddha Gupta, Muhammad Sheikh, Yashraj Tripathy, W. Dhammika Widanage **Transfer learning LSTM model for battery useful capacity fade prediction**
17:20 – 17:40	SF-001406: Kartikey Chauhan, Aman Kumar, Krishna kumar Ramakrishna Pandian, Somnath Sengupta **Brake Control of a Two-wheeler using Optimal Slip Prediction based Sliding Mode Control**
17:40 – 18:00	SF-000272: Cinzia Amici, Federica Ragni, Monica Tiboni, Joel Pollet, Riccardo Buraschi **Quantitative Kinematic Assessment of the Sit-to-Stand Transition using an IMU Sensor**

SF-000418 - Task coordinate frame-based contouring control of an excavator with sliding mode observer and prescribed performance

Hoang Vu Dao, Kyoung Kwan Ahn*
*University of Ulsan, Korea

Abstract: In this paper, a contouring control algorithm is developed for surface flattening tasks of an excavator regardless of lumped disturbances/uncertainties and system nonlinearities. The task coordinate frame (TCF) is adopted to decouple the contouring error from the tracking error, which allows different treatments on each error component. Moreover, a sliding mode observer (SMO) is proposed to effectively estimate both unmeasurable joint velocities and lumped disturbances and uncertainties. To integrate these techniques into the main controller, backstepping control and the barrier Lyapunov function (BLF) are introduced to guarantee the system stability and prescribed contouring performance. Finally, simulations with different operating conditions are conducted to validate the effectiveness of the proposed contouring control method with a mini-excavator model.

Keywords: Task coordinate frame, sliding mode observer, barrier Lyapunov function, prescribed performance, excavator

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SF-000515 - Observer-based Fault-Tolerant Control of an Electro-Hydraulic Actuator with mismatched disturbance

Phan Van Du, Ahn Kyoung Kwan *
*University of Ulsan, Korea

Abstract: This article develops a novel fault-tolerant controller for an electro-hydraulic actuation system in the presence of mismatched disturbance and sensor malfunction. In detail, on the basic of the linear matrix inequality (LMI) approach, a nonlinear unknown input observer (NUIO) is designed to simultaneously estimate the sensor fault and output of position that is not impacted by the external disturbance. Next, a fault detection module is constructed to detect sensor fault and feedback the estimated position to the controller when the fault occurs. For the purpose of approximating and reducing the influence of the mismatched disturbance, a radial basis function neural network (RBFNN) is deployed. The combination of NUIO, RBFNN in a dynamic surface control (DSC) approach is introduced to not only achieve precision tracking control but also guarantee a stable system in the event of sensor fault. Furthermore, the Lyapunov function method is utilized to analyze the stability of the resulting closed-loop system. Finally, simulation results and comparison studies are presented to verify the effectiveness and feasibility of the theoretical claims.

Keywords: Sensor fault, neural network, nonlinear unknown input observer, dynamic surface control

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SF-000922 - Modeling of Onshore Wave Energy Converter: Inverse Dynamic Analysis and Thermal Prediction

Adolfo Senatore*, Alex De Simone, Martina Travaglino, Mario Pisaturo, Veronica D'Urso
*University of Salerno, Italy

Abstract: Sea wave energy is being increasingly regarded as one of the most promising sources of renewable energy. This paper deals with the modeling and simulation of an onshore Wave Energy Converter system designed by UMBRA GROUP SpA, world leader in the production of high-precision ball screws for aerospace, industrial and energy sectors. Several topics are addressed: starting from the multibody modeling strategy, this paper goes more deeply into the characterization of the most interesting forces acting on the structure, as well as the thermal behavior investigation of the power take-off module based on lumped-parameter and Finite Element Method models. Inverse Multibody Dynamic Analysis is performed and simulation results are collected to prove the effectiveness of the proposed approach. The indirect efficiency of the mechanism has been found quite high (80-85%) in comparison with other wave energy converter mechanisms, whereas the thermal level does not exceed 165 °C (electric machine), 140 °C (screw), 47 °C (nut).

Keywords: Wave Energy Converter (WEC), Multibody Modeling and Simulation, Recirculating Ball Screw, Thermal Models, Inverse Dynamic Analysis

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SF-000167 - Transfer learning LSTM model for battery useful capacity fade prediction

Aniruddha Gupta*, Muhammad Sheikh, Yashraj Tripathy, W. Dhammika Widanage
*WMG, University of Warwick, United Kingdom

Abstract: Lithium-ion (Li-ion) batteries have become increasingly useful within the automotive industry and modern life applications due to high energy and power densities. However, these batteries suffer capacity loss due to different ageing mechanisms in various applications. Despite several existing models, lack of accurate predictability of capacity degradation limits the advancement of Li-ion batteries. The present work focuses on prediction of battery useful capacity degradation using long-short term memory (LSTM) transfer learning neural network model. At first, a base model was developed and trained using all the (100%) degradation data available at 0°C and 10°C environmental temperatures. Thereafter, the training of the base model was fixed, and additional hidden layers were added on top of the base model to further fine tune it with only the initial 30% degradation data available at 25°C environmental temperature. The remaining (70%) data of the 25°C case was tested for model prediction. To decide the number of fixed hidden layers to be transferred from base model to transfer model and the number of additional hidden layers on top, an optimization for minimum cross validation error was performed. It was found that the resulting model was able to forecast the remaining battery degradation with 96% accuracy. The model prediction was also compared with LSTM deep learning architecture without using transfer learning. The LSTM with transfer learning model was found to be 17% higher in prediction accuracy than that without utilizing transfer learning.

Keywords: Battery degradation, LSTM, transfer learning, deep learning

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SF-001406- Brake Control of a Two-wheeler using Optimal Slip Prediction based Sliding Mode Control

Kartikey Chauhan, Aman Kumar, Krishna kumar Ramakrishna Pandian*, Somnath Sengupta
*WMG, University of Warwick, United Kingdom

Abstract: With the increase in average speed of two-wheelers, there is a compelling need to ensure safety by maintaining stability of the two-wheelers during braking by preventing wheel lock. In this paper, we develop a sliding mode controller based brake control strategy for a two-wheeler using its dynamic model which proportions the brake force to front and rear wheels through appropriate commands, so as to track the optimal wheel slip during braking. This is in response to the rider's brake force demand through the front and rear brake control levers, taken as inputs, which influence the braking torque in another wheel as well. Further, the optimal wheel slip is calculated during runtime to achieve the maximum coefficient of friction in the given road and vehicle. By implementing the control strategy in conjunction with a two-wheeler simulation model, the performance is analyzed in terms of stability, minimum stopping distance, optimal slip tracking and jerk.

Keywords: Two-wheeler dynamics, Brake control strategy, Wheel slip control, Optimal slip for varying road conditions, Sliding Mode Control

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SF-000272 - Quantitative Kinematic Assessment of the Sit-to-Stand Transition using an IMU Sensor

Cinzia Amici*, Federica Ragni, Monica Tiboni, Joel Pollet, Riccardo Buraschi
*University of Brescia, Italy

Abstract: Objective: The sit-to-stand transition is an important task for the evaluation of physical independence, especially in fragile subjects like elderly patients, to monitor and reduce the risk of falls or damage. This study aims at assessing the kinematic characteristics of the sit-to-stand transition from a quantitative perspective, using a wireless IMU sensor, and describes a set of parameters suitable for evaluating the movement performance in everyday practice. Methods: An acquisition campaign was designed and carried out on 20 healthy subjects and 13 patients to evaluate acceleration and angular velocity generated during a sit-to-stand task. For each subject, at least four acquisitions were performed, to create a final dataset of 173 acquisitions. The values of the proposed parameters were computed, and results were analyzed with descriptive statistics. Results: According to the proposed parameters definitions and the analyzed dataset, acceleration and angular velocity-related parameters present statistically significant differences between healthy and pathological data samples, unlike total time TT.

Keywords: sit-to-stand movement, IMU sensor, accelerometer

Wednesday, 24 December 2021 (Day 4)

12:00 – 13:00	*Day 4 – Main Virtual Hall*
	Keynote Talk 03: Dr Kheng Lim Goh Chairs: Anurag Sharma / Wei-Chin Chang
13:00 – 15:00	*Day 4 – Breakout Room 05*
	Technical Session: Sustainable Transportation and Energy Systems (3) Chairs: Kyoung Kwan Ahn / JJ Chong
13:00 – 13:20	SF-000019: Nguyen Minh Phu, Nguyen Van Hap, Phan Thanh Nhan, Huynh Phuoc Hien **A One-dimensional Analysis and Optimum Air Flow Rate of a Triple-Pass Solar Air Heater**
13:20 – 13:40	SF-000655: Duy Linh Vu, Kyoung Kwan Ahn **High-Performance Liquid-Solid Triboelectric Nanogenerator Based on Polyvinylidene Fluoride and Magnetic Nanoparticle Composites Film**
13:40 – 14:00	SF-000507: Cong Minh Ho, Kyoung Kwan Ahn **Adaptive Neural Networks Control for Half-Car Active Suspension Systems with Prescribed Performance and Actuator Fault**
14:00 – 14:20	SF-000884: Cong Hung Nguyen, Cong Minh Ho, Kyong Kwan Ahn **Numerical Analysis of Vibration Isolator using Negative Stiffness Mechanism for Vehicle Seats**
14:20 – 14:40	SF-001694: Ching-Hua Hung, Appolinaire Etoundi, Aghil Jafari, Jason Matthews, Wei-Chin Chang, Jun Jie Chong **Mimicking Condylar Knee to Design Bio-Inspired Robotic Knee Joint Based on Magnetic Resonance Imaging**
14:40 – 15:00	Break

Conference will be held Singapore Standard Time (GMT+8 hours)

SF-000019 - A One-dimensional Analysis and Optimum Air Flow Rate of a Triple-Pass Solar Air Heater

Nguyen Minh Phu*, Nguyen Van Hap, Phan Thanh Nhan, Huynh Phuoc Hien
*Industrial University of Ho Chi Minh City (IUH), Viet Nam

Abstract: Renewable energy conversion of solar energy to hot air is a feasible and sustainable solution in the trend of energy saving and environmental protection. In this work, a 1D mathematical model is reported and solved using the control volume method to investigate the distribution of seven temperatures in the triple pass flat plate solar air heater (SAH). A compact solver for predicting local temperatures of a multiple-pass SAH has been rarely found in the open literature. The collector parameters are fixed while the mass velocity of the air is varied from 0.0121 to 0.07246 kg/m^2 -s. The results of temperature distribution analysis show that the absorber plate temperature reaches a maximum in the center of the plate which is different from that of a double pass solar air collector. When the air flow rate is large, the upper glass is no longer able to transfer heat to the air, so the efficiency of the triple pass collector decreases. It is concluded the pertinent air flow rate of 0.04 kg/m^2 -s to obtain the highest effective efficiency of 64%. The present study is expected to develop multi-parametric study and apply finned, baffled or ribbed air channels.

Keywords: Energy conversion, 1D analysis, mass flow rate, multiple pass, local temperature, effective efficiency, renewable energy

SF-000655 - High-Performance Liquid-Solid Triboelectric Nanogenerator Based on Polyvinylidene Fluoride and Magnetic Nanoparticle Composites Film

Duy Linh Vu, Kyoung Kwan Ahn*
*University of Ulan, Korea

Abstract: Magnetorheological compounds, which are created by distributed magnetic particles in viscoelastic environments and employed as materials for energy collecting and conversion, significantly enhance wearable and skinmountable electrical devices. Considering the anisotropic properties through the magnetic fields have a significant impact on the surface polarization of the material, it is critical to examine the role of the magnetorheological compound as a triboelectric layer in triboelectric nanogenerator (TENG) output performance. Here, polyvinylidene fluoride (PVDF) and ferromagnetic cobalt ferrite ($CoFe_2O_4$) nanoparticles were used to fabricate a magnetic polymeric composite (MPC) film as a triboelectric layer to enhance the output performance of TENG. The polar crystalline phase content of PVDF was considerably enhanced with the addition of $CoFe_2O_4$ nanoparticles, going from 51.2% with pristine PVDF to 77.7% with 5 wt.% $CoFe_2O_4$ in MPC, demonstrating a rise in negative charge and dielectric constant of the MPC film. Therefore, the output performance of the MPC5-TENG was shown a significant increase with a peak current of 2.27 μA, a peak voltage of 17.2 V, and power density up to 90 mW/m^2, giving 2.4 times higher than pristine PVDF-TENG. Finally, with exceptional stability and durability, we anticipate that this MPC-TENG will bring additional views on hydrokinetic energy harvesting in the future.

Keywords: triboelectric nanogenerator, magnetic polymeric composite, magnetic fields, polar crystalline phase

SF-000507 - Adaptive Neural Networks Control for Half-Car Active Suspension Systems with Prescribed Performance and Actuator Fault

Cong Minh Ho, Kyoung Kwan Ahn*
*University of Ulsan, Korea

Abstract: This study proposes an adaptive neural backstepping control scheme for a half-car vehicle suspension system considering the displacement constraint of chassis and actuator failures. The unknown functions caused by the different passenger masses and uncertain factors are estimated by neural networks. To guarantee the chassis displacement within limited constraints, the prescribed performance function is used to describe the convergence rate of tracking error and ensure the maximum overshoot within the boundaries. The vertical displacement and pitch angle of the half-car model are considered simultaneously to improve the riding comfortability and handling stability of suspension performance. The comparative simulation examples will be realized to show the feasibility and effectiveness of the developed method.

Keywords: Active suspension system, neural networks (NNs), prescribed performance function (PPF), adaptive control

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SF-000884 - Numerical Analysis of Vibration Isolator using Negative Stiffness Mechanism for Vehicle Seats

Cong Hung Nguyen, Cong Minh Ho, Kyong Kwan Ahn*
*University of Ulsan, Korea

Abstract: Seats are the ultimate mechanisms that can isolate the operator from vehicle vibration. As a result, the vehicle seats should be effectively isolated from road disturbances to offer drivers comfort. This paper deals with the design of a negative stiffness structure (NSS) by using the two bellows-type air springs for a vehicle seat. The static characteristics of the negative stiffness elements as well as the nonlinear mathematical model are presented. Further, the dynamic characteristics are evaluated by adopting the harmonic balance method. In addition, the effect of the geometry parameter on the dynamic stiffness of the isolator at the static equilibrium position is also studied. Finally, the simulation results show that a significant improvement in vibration isolation of the proposed system with NSS, while the system performance without NSS is poor.

Keywords: bellows-type air spring, classical vibration isolator, negative stiffness structure, vehicle seat.

SF-001694 - Mimicking Condylar Knee to Design Bio-Inspired Robotic Knee Joint Based on Magnetic Resonance Imaging

Ching-Hua Hung*, Appolinaire Etoundi, Aghil Jafari, Jason Matthews, Wei-Chin Chang, Jun Jie Chong
*Southern Taiwan University of Science & Technology, Taiwan

Abstract: The process of designing bio-inspired knee joint has been a challenging issue due to the complicated kinematics and dynamics of the human knee joint. This paper addresses this issue by presenting a design methodology that has been used to model the human knee joint from Magnetic Resonance Imaging (MRI) scans, and curve fitting method to approximate the condylar profiles. The study was to extract the knee profiles from MRI scans and create a 3D model of a condylar knee joint for robotic applications. A medical imaging software was used to assist the process of converting these scans into a 3D model. This model was then imported into a 3D Computer Aided Design (CAD) software and various profiles from the model were extracted to derive the articular surfaces of the condylar knee. The condylar profiles that were extracted to create the bio-inspired knee model based on articular surfaces, were also analysed in MATLAB using polynomial equations. The results of the polynomial equation are a good fit of the condylar profile extracted from the 3D model, which can benefit the design of a prosthetic joint. The generated 3D model of the knee from the MRI scans can also be used to assist with the sizing and movement of a life-like knee implant.

Keywords: Bio-Inspired Robotic Knee Joint, Biomimicry, Curve Fitting, MRI Scan

13:00 – 15:00	*Day 4 – Breakout Room 06*
	Technical Session: Advanced Manufacturing and Production System Chairs: Wei-Chin Chang / Quoc Thanh Truong
13:00 – 13:20	SF-000914: Mohamed M.A. Ammar, Bijan Shirinzadeh **The Role of Compaction Roller in Defining the Layup Quality and Laminate Porosity in Robotic Fiber Placement**
13:20 – 13:40	SF-000892: Subham Agrawal, Jun Jie Chong, Ali A. Yacoub, Manuel Giuliani, Aghil Jafari, Appolinaire Etoundi **Physiological Data Measurement in Digital Manufacturing**
13:40 – 14:00	SF-001538: Zhenqi Chee, Zi Jie Choong, Wai Leong Eugene Wong **Digitization of Fused Deposited Methods (FDM) Printer for Smart Additive Manufacturing (AM)**
14:00 – 14:20	SF-000086: Kuiyuan Mu, Makoto Nikawa, Minoru Yamashita **Experimental Examination of Method for Estimating Solid Fraction at Flow Cessation from Flow Velocity of Molten Al–Si–Mg Alloy**
14:20 – 14:40	SF-000906: Tick Boon Loh, Michelle Shin Rong Chua, Siang Huat Goh, Kian Hau Kong, Kheng Lim Goh, Jun Jie Chong **Determination of Static and Dynamic Young's Modulus of A Cantilever Beam using Digital Image Correlation (DIC) Method**
14:40 – 15:00	Break

SF-000914 - The Role of Compaction Roller in Defining the Layup Quality and Laminate Porosity in Robotic Fiber Placement

Mohamed M.A. Ammar*, Bijan Shirinzadeh
*Monash University, Australia

Abstract: The automated fiber placement has been commonly used to fabricate composite structures with high performance. However, the automated manufacturing process is limited by the developed defects in the final composite components. The current study focuses on the effect of the compaction roller's configurations and stiffness on the manufactured thermoset composites. The robotic fiber placement process is applied to fabricate different composite specimens. Several unidirectional and multiaxes specimens have been manufactured using 4 different rollers. The attitude of the compaction roller is also adjusted to be normal and to ensure uniform distribution of the compaction pressure. The surface quality of the manufactured components has been evaluated through image processing and detecting the layup defects. The scanning electron microscopy is used to estimate the change in the material porosity. The samples manufactured using a compliant and perforated roller included defects such as blisters, wrinkles, overlaps, and distortions. Additionally, the material porosity has been significantly improved when using the solid steel roller.

Keywords: Automated fiber placement, SEM, layup defects, Porosity

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SF-000892 - Physiological Data Measurement in Digital Manufacturing

Subham Agrawal*, Jun Jie Chong, Ali A. Yacoub, Manuel Giuliani, Aghil Jafari, Appolinaire Etoundi
*University of the West of England, Great Britain

Abstract: As industry is moving towards a new digital revolution, identifying workers' mental and physical status is key to improved productivity in a digital manufacturing scenario. The main objective here is to provide an overview of sensing technologies in digital manufacturing and discuss suitability for taking physiological measurements of workers collaborating with robots. A method for rating physiological sensors in digital manufacturing application areas has been discussed which takes into account expert reviews. Selected commercially-available sensors are rated based on 9 evaluation keys (wearability, form-factor, mobility, pre-training, data-exchange capability, onboard filtering, ease-of-use, cost, and calibration) for digital manufacturing. The result is a scorecard of available sensors with feasibility to be used in digital manufacturing. In a given category, this data allows the selection of the best available sensors for certain use cases. The method to score the sensors has been explicitly explained to allow readers to expand on and contribute towards the data.

Keywords: Industry 4.0, physiological sensors, manufacturing, collaborative manufacturing

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SF-001538 - Digitization of Fused Deposited Methods (FDM) Printer for Smart Additive Manufacturing (AM)

Zhenqi Chee, Zi Jie Choong*, Wai Leong Eugene Wong
*Newcastle University, Singapore

Abstract: The panic buying during Covid-19 caused farmers to amped-up production. However, farm equipment is costly to purchase. Therefore, some farmers utilized Additive Manufacturing (AM) to manufacture farming tools at low cost. However, the lack of in-situ monitoring in AM to stop printing failed parts can waste materials and time. Thus, this research aims to deploy a low-cost smart remote monitoring system using OctoPrint and Node-red to integrate a 3D printer and Teachable Machine and train a model to pre-emptively detect print errors. The result was satisfactory as the 3D printer stopped when the camera detected a defect with 75% accuracy. Furthermore, the user can easily customize the model to enhance the system versatility via the developed code-free platform.

Keywords: Smart Additive Manufacturing, Node-Red, Google Teachable Machine, Fused Deposit Modelling, Remote Monitoring System

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SF-000086 - Experimental Examination of Method for Estimating Solid Fraction at Flow Cessation from Flow Velocity of Molten Al–Si–Mg Alloy

Kuiyuan Mu, Makoto Nikawa*, Minoru Yamashita
*Gifu University, Japan

Abstract: The purpose of this study was to experimentally estimate the solid fraction at which the cessation of the flow of a molten Al–Si–Mg alloy (JIS-AC4C) occurs in casting. The flow cessation mechanism of JIS-AC4C is known as the “mushy” formation type, which means that the flow ceases when the solid fraction at the molten metal tip reaches a certain critical value. Therefore, the flow velocity at the molten metal tip is assumed to decrease gradually. Thus, a new method for calculating the solid fraction at flow cessation based on computer simulations was examined using experimental measurements of the flow velocity and flow length. As a result of the experiment, the flow length became longer as the mold temperature and molten metal temperature increased. The flow velocity gradually decreased from the initial stage, but there was a region where the velocity was almost constant after the initial stage. The molten metal temperature became lower from the root side to the tip side, and the solid fraction at the time of flow cessation was calculated from the measurement results, and it was approximately 0.35- 0.4 near the tip. Computer simulations were performed by tuning the heat transfer coefficients so that the flow length and flow velocity would match the experimental results and could simulate the changes in flow velocity obtained from the experiments. The solid fraction at the tip of the molten metal was almost the same as the experimental results. These results showed that it is possible to estimate the solidus fraction at the flow cessation from the flow velocity at the tip. It is easier and more accurate to calculate the flow ceased solid fraction by measuring the flow velocity of the molten metal tip. As a reference value, we were able to improve the calculation accuracy by comparing and verifying the flow ceased solid fraction calculated by the conventional calculation method from temperature.

Keywords: Casting, Flow cessation, Solid fraction, Mushy formation, Computer simulation

SF-000906 - Determination of Static and Dynamic Young's Modulus of A Cantilever Beam using Digital Image Correlation (DIC) Method

Tick Boon Loh*, Michelle Shin Rong Chua, Siang Huat Goh, Kian Hau Kong, Kheng Lim Goh, Jun Jie Chong
*Newcastle University, Singapore

Abstract: The Young's modulus is a fundamental mechanical property that measures the stiffness of a solid material. Destructive material testing is the common method to determine Young's modulus. This paper presents the vibration measurement technique using Digital Image Correlation (DIC) as an alternative method to determine the Young's modulus of materials. The principle is based on the linear transverse vibrations of a Euler-Bernoulli cantilever beam with clamped–free boundary conditions. The dynamic responses of three materials (steel, aluminium and brass) were discussed. For each material, the beam was subjected to an initial static transverse displacement at its free end and then allowed to vibrate freely. The vibrations at the free end were captured using DIC measurements, and the results processed and presented in the form of displacement versus time, following which the natural frequencies of the beam can be obtained using the method of Fast Fourier Transform (FFT). The Young's modulus can then be derived using the first natural frequency and the geometry of the beam. The calculated Young's modulus values obtained using the DIC measurements of the free vibrations are compared with the modulus obtained using the static deflection approach, which shows highly favorable agreement. The use of the vibration method to determine Young's modulus using DIC method can help in the non-contact assessment of the existing structural integrity without subjecting test specimens to destructive testing.

Keywords: Digital Image Correlation, Static and Dynamic Young's modulus, Cantilever beam, Natural frequency

15:00 – 16:00	*Day 4 – Main Virtual Hall*
	Keynote Talk 04: Professor Josep M. Guerrero Chairs: Dinh Truong / Yung-Tien Liu
16:00 – 18:00	*Day 4 – Breakout Room 07*
	Technical Session: AI Technologies for Mechatronic Systems Chairs: Huu Cuong Nguyen / Yung-Tien Liu
16:00 – 16:20	SF-000752: Riccardo Adamini, Nicholas Antonini, Alberto Borboni, Simone Medici, Cristina Nuzzi, Roberto Pagani, Alberto Pezzaioli, Cesare Tonola **User-friendly human-robot interaction based on voice commands and visual systems**
16:20 – 16:40	SF-000663: Zhicong Deng, Luke Holibar, Eric Wester **A Smart Grasping System for Handling Irregular, Naturally Varying Objects**
16:40 – 17:00	SF-001392: Faranak Pordanesh, Truong Quang Dinh, Fulvio Tagliabo **Failure Safety Analysis of Artificial Intelligence Systems for Smart/Autonomous Vehicles**
17:00 – 17:20	SF-000736: Alberto Borboni, Rodolfo Faglia, Paolo Marinoni, Cristina Nuzzi, Roberto Pagani, Simone Panada **Towards safe collaborative interaction empowered by face recognition**
17:20 – 17:40	SF-001155: Wei Teng Lee, Jun Jie Chong, Wei-Chin Chang **Reconstruction of Ancient Machinery Using Virtual Reality Technology for Game-Based Learning**
17:40 – 18:00	SF-000051: Yung-Tien Liu, Ping-Nan Chang **Comparison of Motion Behaviors of a Machine Tool Examined by Position Acquisition Device (PAD) and Laser Interferometry System (LIS)**

SF-000752 - User-friendly human-robot interaction based on voice commands and visual systems

Riccardo Adamini, Nicholas Antonini, Alberto Borboni*, Simone Medici, Cristina Nuzzi, Roberto Pagani, Alberto Pezzaioli, Cesare Tonola
*University of Brescia, Italy

Abstract: This paper describes the embryonal development stage of a ROS-based application with the aim of simplify human-robot interaction of collaborative workstations. The idea is to command the robot with voice commands detected by speech recognition algorithms and empower the robot's understanding of its surroundings to perform the tasks using a visual system capable of recognizing simple objects. In this first version the application has been developed virtually using Gazebo simulation software. Some qualitative tests regarding the vocal control and the visual detection have been performed to understand the system's issues and drawbacks that will be solved in future developments.

Keywords: Speech recognition, human-robot interaction, collaborative robots, object detection, industry 4.0, ROS

SF-000663 - A Smart Grasping System for Handling Irregular, Naturally Varying Objects

Zhicong Deng*, Luke Holibar, Eric Wester
* Callaghan Innovation, New Zealand

Abstract: This paper presents the design, integration, and validation of a smart grasping system for handling irregular, naturally varying objects. The system consists of a 6-axis robot, a soft robotic gripper, a vision sensor and a computer. A grasping algorithm utilizing reinforcement learning is implemented to provide the flexibility and adaptiveness required to handle object variations. Benchmark testing were conducted on simple objects and the system achieved a 68% grasp success rate after 1500 training iterations. Improvements to the system were then implemented including the repositioning of the vision sensor, a reset mechanism and a collision avoidance algorithm. A grasp success rate of 80% was achieved with the improved system. Kumara (sweet potato) was selected in this case as an example of irregular, naturally varying objects. Initial training and testing with kumara proved to be challenging and a pretraining approach with annotated images were proposed and implemented. Human grasping experience was incorporated into the grasping system via the pre-training and a 71% grasp success rate was achieved after 1500 iterations.

Keywords: robotic grasping, food handling

SF-001392 - Failure Safety Analysis of Artificial Intelligence Systems for Smart/Autonomous Vehicle

Faranak Pordanesh*, Truong Quang Dinh, Fulvio Tagliabo
*WMG, University of Warwick, United Kingdom

Abstract: Up to now failures in artificial intelligence systems, specifically machine learning algorithms which are their software components, are considered as systematic failures. The goal of this paper is to introduce a new concept of quantitative failure analysis for machine learning algorithms which can be used in smart/autonomous vehicles to guarantee sufficiently low risk of residual errors in this application. Firstly, a coincidence in evaluating impacts of unpredictable behaviours of machine learning algorithms and hardware components is introduced in order to statistically estimate failure rate based on a given number of data points. Next, a metric utilising this randomic failure rate is proposed to assess functional safety of smart and/or autonomous vehicles and evaluate their safeness according to ISO 26262:2018 , and ISO/PAS 21448.

Keywords: Smart/Autonomous Vehicles, Machine Learning, Artificial Intelligent, Automotive Safety, ISO 26262, Systematic failure, Randomic failures, Metrics

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SF-000736 - Towards safe collaborative interaction empowered by face recognition

Alberto Borboni*, Rodolfo Faglia, Paolo Marinoni, Cristina Nuzzi, Roberto Pagani, Simone Panada
*University of Brescia, Italy

Abstract: This paper presents the implementation of a face recognition node for a Sawyer collaborative robot using Robot Operating System (ROS), and its preliminary experimental validation. The node acquires images through the head camera of a Sawyer cobot and elaborates it using OpenCV libraries, applying the Viola-Jones algorithm to detect faces. The aim is to use face recognition functionalities to make the robot start its operations only when it correctly recognizes an operator in its workspace, thus increasing the safety of the human-robot interaction. The developed ROS node recognizes multiple faces at the same time and publishes the information required on a dedicated topic. The validation performed analyzed the success rate of the procedure at different orientations of the user's face.

Keywords: face recognition, human-robot interaction, collaborative robots, industry 4.0, ROS

SF-001155 - Reconstruction of Ancient Machinery Using Virtual Reality Technology for Game-Based Learning

Wei Teng Lee, Jun Jie Chong, Wei-Chin Chang*
*Southern Taiwan University of Science
& Technology, Taiwan

Abstract: The purpose of this article is to undertake research on the reconstruction of ancient machinery and to highlight the critical nature of their preservation. The mechanism used to construct the ancient machine must be carefully preserved and passed on to future generations to instill ancient wisdom in them. The study's findings indicate that virtual reality technology has the potential to be a helpful educational tool for students, assisting them in acquiring knowledge about the ancient machinery historical background and its engineering design. In this paper, the methodology and framework used to reconstruct ancient machinery and develop the gamified learning environment will be documented. It will also showcase the successful result of interaction between player and ancient machine in the game following the methodology.

Keywords: Ancient Machine, Virtual Reality (VR), Virtual Environment, 3D, Assembly, Game-Based Learning

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SF-000051 - Comparison of Motion Behaviors of a Machine Tool Examined by Position Acquisition Device (PAD) and Laser Interferometry System (LIS)

Yung-Tien Liu*, Ping-Nan Chang
*National Kaohsiung University of Science and Technology, Taiwan

Abstract: With increasing needs of data acquisition for a legacy machine, the position acquisition device (PAD) developed was used to record the motion behaviors of a machining tool. The PAD has a real-time (RT) controller with field programmable gate array (FPGA) input/output modules, which can real-time record the motion behaviors of linear, rotary, and multi-axis simultaneous motions. In this study, to verify the PAD, a laser interferometry system (LIS) was employed to exam the linear motions of the machine tool and compared the results with the PAD. Both the measurements indicated that the feeding speed fluctuated in a certain range. In addition, the experiments for examining the repeatability of linear motions were performed to demonstrate the effectiveness of the PAD. Compared with the LIS, the PAD features cost-effectiveness and easy-to-use. It can be applied to the Industry 4.0 production for data collection and enable a legacy machine with position sensing function for developing a smart machine.

Keywords: industry 4.0, on-machine measurement, real-time measurement, laser interferometry system

16:00 – 18:00	*Day 4 – Breakout Room 08*
	Technical Session: Bioengineering and Humanoid Robot Chairs: Zi Jie Choong / JJ Chong
16:00 – 16:20	SF-000396: Chun-Yi Kuo, Dun-Yan Wu, Chi-Ying Lin **RNN Based Knee Joint Muscular Torque Estimation of a Knee Exoskeleton for Stair Climbing**
16:20 – 16:40	SF-001651: Truong MN Bui, Truong Q Dinh, James Marco **A Study on Electric Vehicle Battery Ageing Through Smart Charge and Vehicle-to-Grid Operation**
16:40 – 17:00	SF-000728: Xuan Phu Do, Minh Tri Bien **Adaptive Optimal Control for Upper Exoskeleton following Saturation Function**
17:00 – 17:20	SF-000221: Myeongjin Kim, Bongsub Song, Dongwon Yun **Study on Guinea Fowl Mimicking Jumping Robot with Momentum Wheel Mechanism**
17:20 – 17:40	SF-000779: Ayesha Jena, Junjie Chong, Aghil Jafari, Appolinaire Etoundi **TherapyEasy: A co-designed hand rehabilitation system using Leap motion controller**
17:40 – 18:00	SF-000248: Stephen Glanville, Jun Jie Chong, Aghil Jafari, Appolinaire Etoundi **Integration Of Computer Vision In A Testing Facility For Prosthetic Joint Inspection And Performance Assessment**

SF-000396 - RNN Based Knee Joint Muscular Torque Estimation of a Knee Exoskeleton for Stair Climbing

Chun-Yi Kuo, Dun-Yan Wu, Chi-Ying Lin*
*National Taiwan University of Science and Technology, Taiwan

Abstract: This study presents the use of a recurrent neural network to estimate knee joint muscular torques for the development of assistive control strategies of a knee exoskeleton in stair climbing applications. To identify the correct timing of giving assistive torques during the stair climbing process, integrating with a lower limb dynamic model with the foot-force measured data is a common way to derive the knee joint torque profile for gait analysis. However, this estimation method which requires the installation of pressure sensors on the sole of the feet has drawbacks including the inconvenience of exoskeleton wearing and increased moving difficulty. The fact that stair climbing is a sequential movement thus allows us to apply a recurrent neural network to obtain the relationship between the knee joint muscular torque and lower limb gait. Stair climbing experiments on a knee exoskeleton wearer reveal that the trained neural network is able to perform the desired knee joint torque estimation whose results can be applied to derive proper assistive torques in the presence of human-robot interaction.

Keywords: stair climbing, knee exoskeleton, knee joint muscular torque, recurrent neural network, assistive control strategy

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SF-001651 - A Study on Electric Vehicle Battery Ageing Through Smart Charge and Vehicle-to-Grid Operation

Truong MN Bui*, Truong Q Dinh, James Marco
*WMG, University of Warwick, United Kingdom

Abstract: Electrification of transportation means brings positive impacts to the environment because of reduced fossil fuel depletion and related carbon emissions. Critical obstacles remain in terms of battery costs and their expected life. Vehicle-to-grid technologies can deliver benefits to support electrical power grid and vehicle owner, while their practical implementation faces challenges due to the concerns over accelerated battery degradation. This study presents the evaluation of battery degradation through different smart charge strategies and vehicle-to-grid scenarios. The simulation results show that the developed smart charge schemes can mitigate the battery ageing up to 5% while lowering the charge cost from 30 – 60% as comparing to the conventional charge method within the first five days operation of the battery. In addition, the calendar ageing can be diminished upto 80% by participating in suitable V2G scenario.

Keywords: vehicle-to-grid, battery ageing, smart charge, calendar ageing, cycling ageing

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SF-000728 - Adaptive Optimal Control for Upper Exoskeleton following Saturation Function

Xuan Phu Do*, Minh Tri Bien
*Vietnamese-German University, Vietnam

Abstract: In this study, a new optimal control based on saturation function for the upper exoskeleton is presented. The saturation model is an advanced model including signum function property, which is symbolized by the sliding mode model. Input control of the system is then designed following the saturation model. The gain of the input control is obtained following adaptation law related to the dynamic parameter of the system. After formulating, the control is simulated for evaluation. The random movement of the upper exoskeleton is applied in the simulation, and the tracking performance is used for the proposed controller. The simulation results show that the proposed control is good performance and can be applied in the real system.

Keywords: Adaptive control, optimal control, upper exoskeleton, saturation model, upper mechanism

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SF-000221 - Study on Guinea Fowl Mimicking Jumping Robot with Momentum Wheel Mechanism

Myeongjin Kim, Bongsub Song, Dongwon Yun*
*DGIST, Korea (South)

Abstract: Jumping robots with a balance control mechanism using an inertial tail have been actively studied to overcome various obstacles. However, there have been no studies to increase the stability of the jumping robot's legs, which move rapidly during jumping, and to reduce the volume of the tail mechanism. In this paper, we focus on a prototype of guinea fowl jumping robot to improve the stability during the rapid jumping motion, and we introduce a momentum wheel mechanism to reduce the occupied volume of the tail mechanism. In addition, we suggest a basic study to make continuous jumping motion by using the momentum wheel mechanism to change the jumping angle, jumping height, and jumping distance. A theoretical analysis, simulation, prototype fabrication, and experiment of a guinea fowl jumping robot with a 1-axis momentum wheel mechanism were carried out. Besides, we confirmed that the passive hallux structure contributed to the jumping stability, and we verified that the prototype model could properly land on the ground by controlling the posture after vertical jumping using the momentum wheel mechanism.

Keywords: Guinea fowl, jumping robot, trigger mechanism, momentum wheel, hallux model, linkage model

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SF-000779 - TherapyEasy: A co-designed hand rehabilitation system using Leap motion controller

Ayesha Jena*, Junjie Chong, Aghil Jafari, Appolinaire Etoundi
*University of the West of England, Great Britain

Abstract: Disability affects over 1 billion people across the globe [1]. About 190 million people in this demographic aged 15 or older require healthcare services due to having significant difficulties in functioning [1]. Upper limb disability is one such issue that needs to be addressed as it leads to lower quality of living. Pandemic has been a major barrier towards accessible healthcare services. With the move towards a digitized world, it is necessary for the healthcare sector to adopt appropriate responses to the changing needs. Upper limb rehabilitation services are one such unit of the healthcare sector that can benefit from modern technologies and solutions. We have proposed a system called ”TherapyEasy” which is a flexible therapy system to carry out rehabilitation at the comfort of the user. The tasks in the system incorporate movements that are similar to those performed while carrying out activities of daily living (ADL). The system tracks the hand movements of the user using a Leap motion controller (LMC). Heuristic evaluation was conducted to test the system for usability issues.

Keywords: Upper limb, rehabilitation, activities of daily living, leap motion controller, unreal engine, heuristic evaluation

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SF-000248 - Integration Of Computer Vision In A Testing Facility For Prosthetic Joint Inspection And Performance Assessment

Stephen Glanville*, Jun Jie Chong, Aghil Jafari, Appolinaire Etoundi
*University of the West of England, Great Britain

Abstract: With increasing needs of data acquisition for a legacy machine, the position acquisition device (PAD) developed was used to record the motion behaviors of a machining tool. The PAD has a real-time (RT) controller with field programmable gate array (FPGA) input/output modules, which can real-time record the motion behaviors of linear, rotary, and multi-axis simultaneous motions. In this study, to verify the PAD, a laser interferometry system (LIS) was employed to exam the linear motions of the machine tool and compared the results with the PAD. Both the measurements indicated that the feeding speed fluctuated in a certain range. In addition, the experiments for examining the repeatability of linear motions were performed to demonstrate the effectiveness of the PAD. Compared with the LIS, the PAD features cost-effectiveness and easy-to-use. It can be applied to the Industry 4.0 production for data collection and enable a legacy machine with position sensing function for developing a smart machine.

12/27/2021 (Day 3)	12:00	13:00	1st Keynote including 5mins break at the end (Professor Gao), Chairs: Kyoung Kwan Ahn / JJ Chong	
			Technical Session: Sustainable Transportation and Energy Systems (1)	Technical Session: Advanced Mechatronics Devices, Sensing and Control (1)
	13:00	15:00	**Chairs: Xuan Phu Do / Anurag Sharma**	**Chairs: Duc Thien Tran / Somnath Sengupta**
	13:00	13:20	SF-000027: Nguyen Minh Huy, Dang Van Hai, Nguyen Minh Phu	SF-000213: Junmo Yang, Minsong Kim, Donghyun Kim, Dongwon Yun
			Energy, Exergy and Economic (3E) Analysis and Optimization of a Combined Heat and Power (CHP) Plant	**Protrusion Type Slip Detection Soft Sensor and Application to Anthropomorphic Robot Hand**
	13:20	13:40	SF-000639: Manami Tono, Yutaka Tanaka, Chiaki Tanuma	SF-000264: Vinh Nguyen Hoang, Luan Bui Thanh, Quang Tran Phan Minh
			Additive Printing System by Rotational Type of Tripod Parallel Mechanism	**The Control of the Metering Valve for the Petroleum Depot Based on the Trapezoidal Flow Rate Algorithm**
	13:40	14:00	SF-000612: Thanh Ha Nguyen, Tri Cuong Do, Kyoung Kwan Ahn	SF-000299: Manh Hung Nguyen, Hoang Vu Dao, Kyoung Kwan Ahn
			A study on Independent metering valve system for boom excavator system	**Nonlinear robust control for electro-hydraulic servo systems with largely unknown model dynamics and**
	14:00	14:20	SF-000744: Hoai-An Trinh, Hoai-Vu-Anh Truong, Kyoung-Kwan Ahn	SF-001473: Thanh Quoc Truong, Thien Duc Tran, Phuc Hong Nguyen, Minh Cong Ho
			Energy management strategy for fuel cell hybrid power system using fuzzy logic and frequency decoupling methods	**Command filter backstepping control of a 2-DOF cable-driven manipulator**
	14:20	14:40	SF-000582: Tieu Binh Tran, Cong Bang Pham	SF-000868: Huu-Cuong Nguyen, Quang-Hieu Ngo, Van-Cuong Nguyen
			Study and Implementation of a Robot Soccer System based on the CDIO approach	**A Self-Calibration Method for 2D Vision-based Reverse Engineering**
	14:40	15:00	Break	
	15:00	16:00	**2nd Keynote including 5mins break at the end (Professor Nobuyuki Iwatsuki), Chairs: Adolfo Senatore / Dinh Truong**	
			Technical Session: Sustainable Transportation and Energy Systems (2)	Technical Session: Advanced Mechatronics Devices, Sensing and Control (2)
	16:00	18:00	**Chairs: JJ Chong / Adolfo Senatore**	**Chairs: Aghil Jafari / Dongwon Yun**
	16:00	16:20	SF-001139: Mona Faraji Niri, Truong Quang Dinh, James Marco	SF-000418: Hoang Vu Dao, Kyoung Kwan Ahn
			Riding Pattern Identification by Machine Learning for Electric Motorcycles	**Task coordinate frame-based contouring control of an excavator with sliding mode observer and prescribed**
	16:20	16:40	SF-001414: Krishna kumar Ramakrishna Pandian	SF-000515: Phan Van Du, Ahn Kyoung Kwan
			Modelling and Brake Blending Control for Multi-Drive Mode Electric Two-wheelers	**Observer-based Fault-Tolerant Control of an Electro-Hydraulic Actuator with mismatched disturbance**
	16:40	17:00	SF-000949: Mehmet Çağın Kıroa, Aman Surana, Andrew McGordon, Truong Quang Dinh	SF-000922: Adolfo Senatore, Alex De Simone, Martina Travaglino, Mario Pisaturo, Veronica D'Urso
			Rapid Decision-Making Tool for Powertrain Sizing	**Modeling of Onshore Wave Energy Converter: Inverse Dynamic Analysis and Thermal Prediction**
	17:00	17:20	SF-000981: Christoph Holtmann, Christoph Köhler	SF-000167: Aniruddha Gupta, Muhammad Sheikh, Yashraj Tripathy, W. Dhammika Widanage
			Eddy Current and Friction Brake Fusion by a Disc-Spring to a Hybrid-Brake	**Transfer learning LSTM model for battery useful capacity fade prediction**
	17:20	17:40	SF-001589: Imran Mohammad Sofi, Truong Quang Dinh, Araan Mohanadass, James Jeffs, Truong Bui Ngoc Minh, Truong Quoc Thanh	SF-001406: Kartikey Chauhan, Aman Kumar, Krishna kumar Ramakrishna Pandian, Somnath Sengupta
			Advanced Simulation Tool to Develop Efficient Thermal Management Systems for Electric Vehicles	**Brake Control of a Two-wheeler using Optimal Slip Prediction based Sliding Mode Control**
	17:40	18:00	SF-001457: Syed Abu Nahian, Imran Mohammad Sofi, Truong Dinh Quang, Andrew McGordon, Thomas Clapton, Jim Sibson	SF-000272: Cinzia Amici, Federica Ragni, Monica Tiboni, Joel Pollet, Riccardo Buraschi
			A Modified-Optimal Energy Management Strategy of Fuel Cell- Battery hybrid Energy Storage System for Marine Application	**Quantitative Kinematic Assessment of the Sit-to-Stand Transition using an IMU Sensor**
12/27/2021 (Day 4)	12:00	13:00	**1st Keynote including 5mins break at the end (Dr Kheng Lim, Goh), Chairs: Anurag Sharma / Wei-Chin Chang**	
			Technical Session: Sustainable Transportation and Energy Systems (3)	Technical Session: Advanced Manufacturing and Production System
	13:00	15:00	**Chairs: Kyoung Kwan Ahn / JJ Chong**	**Chairs: Wei-Chin Chang / Quoc Thanh Truong**
	13:00	13:20	SF-000019: Nguyen Minh Phu, Nguyen Van Hap, Phan Thanh Nhan, Huynh Phuoc Hien	SF-000914: Mohamed M.A. Ammar, Bijan Shirinzadeh
			A One-dimensional Analysis and Optimum Air Flow Rate of a Triple-Pass Solar Air Heater	**The Role of Compaction Roller in Defining the Layup Quality and Laminate Porosity in Robotic Fiber**
	13:20	13:40	SF-000655: Duy Linh Vu, Kyoung Kwan Ahn	SF-000892: Subham Agrawal, Jun Jie Chong, Ali A. Yacoub, Manuel Giuliani, Aghil Jafari, Appolinaire Etoundi
			High-Performance Liquid-Solid Triboelectric Nanogenerator Based on Polyvinglidene Fluoride and Magnetic Nanoparticle	Physiological Data Measurement in Digital Manufacturing
	13:40	14:00	SF-000507: Cong Minh Ho, Kyoung Kwan Ahn	SF-001538: Zhenqi Chee, Zi Jie Choong, Wai Leong Eugene Wong
			Adaptive Neural Networks Control for Half-Car Active Suspension Systems with Prescribed Performance and Actuator	**Digitization of Fused Deposited Methods (FDM) Printer for Smart Additive Manufacturing (AM)**
	14:00	14:20	SF-000884: Cong Hung Nguyen, Cong Minh Ho, Kyong Kwan Ahn	SF-000086: Kuiyuan Mu, Makoto Nikawa, Minoru Yamashita
			Numerical Analysis of Vibration Isolator using Negative Stiffness Mechanism for Vehicle Seats	**Experimental Examination of Method for Estimating Solid Fraction at Flow Cessationfrom Flow Velocity of**
	14:20	14:40	SF-001694: Ching-Hua Hung, Appolinaire Etoundi, Aghil Jafari, Jason Matthews, Wei-Chin Chang, Jun Jie Chong	SF-000906: Tick Boon Loh, Michelle Shin Rong Chua, Siang Huat Goh, Kian Hau Kong, Kheng Lim Goh, Jun Jie Chong
			Mimicking Condylar Knee to Design Bio-Inspired Robotic Knee Joint Based on Magnetic Resonance Imaging	**Determination of Static and Dynamic Young's Modulus of A Cantilever Beam using Digital Image Correlation**
	14:40	15:00	Break	
	15:00	16:00	**2nd Keynote including 5mins break at the end (Professor Josep M. Guerrero), Chairs:Dinh Truong / Yung-Tien Liu**	
			Technical Session: AI Technologies for Mechatronic Systems	Technical Session: Bioengineering and Humanoid Robot
	16:00	18:00	**Chairs: Huu Cuong Nguyen / Yung-Tien Liu**	**Chairs: Zi Jie Choong / JJ Chong**
	16:00	16:20	SF-000752: Riccardo Adamini, Nicholas Antonini, Alberto Borboni, Simone Medici, Cristina Nuzzi, Roberto Pagani, Alberto Pezzaioli, Cesare Tonola	SF-000396: Chun-Yi Kuo, Dun-Yan Wu, Chi-Ying Lin
			User-friendly human-robot interaction based on voice commands and visual systems	**RNN Based Knee Joint Muscular Torque Estimation of a Knee Exoskeleton for Stair Climbing**
	16:20	16:40	SF-000663: Zhicong Deng, Luke Holibar, Eric Wester	SF-001651: Truong MN Bui, Truong Q Dinh, James Marco
			A Smart Grasping System for Handling Irregular, Naturally Varying Objects	**A Study on Electric Vehicle Battery Ageing Through Smart Charge and Vehicle-to-Grid Operation**
	16:40	17:00	SF-001392: Faranak Pordanesh, Truong Quang Dinh, Fulvio Tagliabo	SF-000728: Xuan Phu Do, Minh Tri Bien
			Failure Safety Analysis of Artificial Intelligence Systems for Smart/Autonomous Vehicles	**Adaptive Optimal Control for Upper Exoskeleton following Saturation Function**
	17:00	17:20	SF-000736: Alberto Borboni, Rodolfo Faglia, Paolo Marinoni, Cristina Nuzzi, Roberto Pagani, Simone Panada	SF-000221: Myeongjin Kim, Bongsub Song, Dongwon Yun
			Towards safe collaborative interaction empowered by face recognition	**Study on Guinea Fowl Mimicking Jumping Robot with Momentum Wheel Mechanism**
	17:20	17:40	SF-001155: Wei Teng Lee, Jun Jie Chong, Wei-Chin Chang	SF-000779: Ayesha Jena, Junjie Chong, Aghil Jafari, Appolinaire Etoundi
			Reconstruction of Ancient Machinery Using Virtual Reality Technology for Game-Based Learning	**TherapyEasy: A co-designed hand rehabilitation system using Leap motion controller**
	17:40	18:00	SF-000051: Yung-Tien Liu, Ping-Nan Chang	SF-000248:Stephen Glanville, Jun Jie Chong, Aghil Jafari, Appolinaire Etoundi
			Comparison of Motion Behaviors of a Machine Tool Examined by Position Acquisition Device (PAD) and Laser	**Integration Of Computer Vision In A Testing Facility For Prosthetic Joint Inspection And Performance**
	18:00	18:20	Closing Ceremony	