CLAWAR

August 26-28, 2019 KUALA LUMPUR, MY

The 22nd International Conference on Climbing and Walking Robots and Support Technologies for Mobile Machines, August 26 –28,2019

PROGRAM BOOK

Supported By:

WELCOME MESSAGE FROM CHAIRMAN

السلام عليكم ورحمة الله

First of all, I would like to welcome all participants to the 22nd. edition of the International Conference series on "Climbing and Walking Robots and the Support Technologies for Mobile Machines" 2019, organized by CLAWAR Association (UK) in collaboration with the Malaysian Society for Automatic Control Engineers (MACE).

I would like to thank and congratulate the team at Universiti Teknologi MARA (UiTM), Malaysia, MACE, CLAWAR and all those who have been working tirelessly to make this event a success. Congratulations.

The conference has attracted significant paper submissions from countries, such as Italy, Panama, United States, United Kingdom, Japan, Russia, China, Thailand and Singapore. This international participation is definitely promoting global intellectual interactions and exchanges.

In line with the dynamically evolving global scenarios, I strongly believe this conference will explore novel development and research findings to adapt to the new technological challenges in societies. As a consequence, the theme of this current conference is aptly chosen to be 'Synergy of Automation, IoT & AI'. The engineers in the related fields must use their knowledge to adapt and adopt so that they can offer better solutions.

Finally, I hope this conference will continue to stir the desire for academicians, technologists and researchers to work towards the progress of mankind as a whole. Once again, congratulations to all of you.

Thank you.

Prof Ir Dr Mohd Rizal Arshad
General Co-Chair, CLAWAR2019

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ORGANIZING COMMITTEE

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PLENARY PRESENTATIONS

SPEAKER 1

Dr. Hanafiah Yussof

Universiti Teknologi MARA (UiTM), Malaysia

PIONEERING SERVICE ROBOTICS INDUSTRY IN MALAYSIA: DEVELOPMENT OF HUMANOID ROBOT ADAM

Service Robots is defined as robot that performs useful tasks for humans or equipment excluding industrial automation applications. The service robotics industry is emerging, categorized into personal/domestic use and professional use, a high growth is expected in service robotics segment due to technological advancements and growing adoption in diverse industries. The total market size of service robotics in global robotics technology market is expected to reach USD82.7Billion by year 2020. The service robotics annual growth is also expected to reach up to 25% compared to 15% for industrial robotics. With the positive growth in global robotics business together with the growing numbers of service robots employing AI and Machine Learning solutions, we will soon be seeing robots of all shapes and sizes making their first forays into our everyday lives. Robopreneur Sdn Bhd is a local Malaysian robotics company focusing on service robotics industry. Established in 2015 as a spin-off company of UiTM, Robopreneur is creating values in Malaysia robotic business ecosystem providing service robotics development and solutions for professional use, healthcare applications and business services. In 2018, the company is taking a bold step by pioneering the development of first Malaysian made humanoid robot ADAM (Advanced Development Autonomous Machine). Funded by the Ministry of Finance Malaysia, the first stage of ADAM project is focusing on the development of upper trunk humanoid with full body motion, vision and speech capabilities. ADAM is consists of 12 DOFs at the arm, shoulder and neck, with additional 10 DOFs from 10 fingers on both arms connected to 10 micro motors to move the fingers. ADAM is embedded with dual-stereo camera which connected to vision system with face detection algorithm. For speech recognition, the robot is using Mary-speech Engine

with autonomous dialog using AIML Chatbot Engine (similar with Sophia robot system). The speech database was programmed on-board at the robot processor. By completing the development objective in the first stage of the project, Robopreneur has started commercializing ADAM as prototype humanoid robot platform for research purpose. Moving forward, further development on ADAM project is aiming on a fully functional biped humanoid robot for commercial use by year 2023.

BIOGRAPHY

Dr. Hanafiah Yussof is the Founder, Board of Director and Group Chief Executive Officer of Robopreneur Sdn Bhd. Dr. Hanafiah holds PhD in Information Science from Nagoya University Japan specializing in humanoid robot. Dr. Hanafiah extended his research in humanoid robotics by developing tele-rehabilitation system employing humanoid robot in Autism rehabilitation. Holding permanent position as Associate Professor at the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Dr. Hanafiah venture into business by establishing Robopreneur Sdn Bhd in 2015 to commercialize his research products and explore service robotics business. Recognized as the pioneer in Service Robotics Industry in Malaysia by the Malaysia Investment Development Authority (MIDA), Robopreneur features a solid foundation in industrial R&D specializing in developing service robots and Artificial Intelligent (AI) solutions, with team of local talents at the new office setup in Cyberjaya. The company is currently undergoing several projects including development of first Malaysian made Humanoid Robot; a project funded by the Ministry of Finance Malaysia. The company is also venturing into AI solutions, Additive Manufacturing and Smart Manufacturing as technology solutions provider for Malaysia 4th Industry Revolution Policy (Industry 4Ward). With strong business corporate management, leadership and deep technical knowledge in robotics, Dr. Hanafiah believes that Robopreneur will become a world-class robotics company and making Malaysia as one of the producer and exporter of service robots to the world. Dr. Hanafiah also holds prominent position in robotics professional community. He was the Chairman of IEEE Robotics and Automation Society (RAS) Malaysia Chapter from 2013 until 2015, Editors in several high-impact journals and well known among robotics scientists and researchers. He also serves as Visiting Professors at University of Toyama Japan, and Visiting Researcher at Nagoya University and Hosei University Japan. Dr. Hanafiah have received several national and international awards such as ASME Best Mechatronics Paper Award and Nagoya University Award for Contribution to International Exchange between Japan and Malaysia.

SPEAKER 2

Prof. Massimiliano Zecca

Loughborough University, UK

SPORT IS MEDICINE

Physical exercises have been prescribed for good health since 600BC, and there is plenty of scientific evidence that exercise is effective to improve health outcomes. The healthcare scenario, however, is changing at an increasingly rapid pace: on one hand, the population is becoming older, with more than 16% of the world population expected to become over 65yo by 2050, due to a contemporary decrease of birth rate and increase of life expectancy (megatrend #1); on the other hand, more and more technology is entering our healthcare system and our daily lives (megatrend #2). Current healthcare systems are not sustainable, as both megatrends call for a more personalised and objective healthcare, to allow people to live longer, healthier lives, as well as to allow health professionals to be more efficient and proficient in their jobs, while at the same time reducing the costs for the society. To achieve this, there is the clear need for a contextual understanding of the activities (what is being done? when? where? how?) to be used to inform any subsequent plan. Our research is focused in particular on the observation and the analysis of the human being, which can be seen as an extreme and exquisite example of a robotic system, and on the development of the necessary tools to inform this understanding. Specifically, we aim at the objective quantification of the capabilities and skills in different situations, such as surgical training or rehabilitation, just to mention a few, and the application of these findings for developing more advanced healthcare systems. The healthcare sector, however, is highly regulated with very high barriers to entry, and as such it is always difficult to test innovative solutions. Sport can be considered the Petri Dish for technological innovation, allowing the exploration of several different ideas and solutions to identify the most promising ones which can be progressed further. This presentation will show a few current examples of these activities.

BIOGRAPHY

Professor Massimiliano Zecca is Chair of Healthcare Technology and leader of the Wearable BioRobotics research team in the Wolfson School of Mechanical, Electrical and Manufacturing Engineering of Loughborough University. He is based in STI, the Sports Technology Institute of Loughborough University, and is a key member of the NCSEM, the National Centre for Sport and Exercise Medicine, both located in Loughborough. Before joining Loughborough University Prof. Zecca worked in Waseda University, Tokyo, Japan, from 2003 to 2013, as Associate Professor of Robotics, and in Scuola Superiore Sant'Anna, Pisa, Italy, from 1999 to 2003. Prof. Zecca's main research interests focus on the development of wearable and portable, extremely small and very accurate bespoke sensors, together with the necessary data processing and analysis methodologies (artificial intelligence) to extract useful information from the raw data flow. The skilful combination of advanced hardware with advanced software makes it possible to make measurements in situations where it would otherwise be very difficult or impossible to measure. Current projects include the development of nearable measurement system for the objective assessment of exercise at home, the development of a real-time biomedical physiological sensing for first responders or exposed workers, and the development of a smart training system for surgeons.

SPEAKER 3

Prof. Fujimoto Yasutaka

Division of Intelligent Systems Engineering, Faculty of Engineering, Yokohama National University

HIGHLY BACKDRIVABLE ACTUATORS FOR HUMAN-MACHINE COLLABORATION

The talk will be on a new development of bilateral drive gears that can be easily driven by load side shaft. For safety purposes, cooperative robots are installed with an actuator composed of a low power servo motor, a reduction gearbox, and a torque sensor. When cooperative robots contact humans or the environment, they must detect the contact force with a force sensor, a touch sensor, or joint-torque sensors. Exoskeletons enclosing geared motors, hydraulic actuators, or pneumatic actuators are also developed for assistive applications. For detecting the torque from outside, some sensors are needed. Equipping these sensors increase the cost and size of the application, but can be avoided under sufficient backdrivability of the actuator. To this end, we propose a method that maximizes the power transmission efficiency of a compound planetary reduction gear and develop prototypes of the backdrivable reduction gearbox called the bilateral drive gear. The forward and backward driving efficiencies of the prototype gearbox are around 90% and the reversedrive starting torque is less than 0.05N.m. We also confirmed that prototype gearboxes with different gear ratios are easily backdrivable by hand.

BIOGRAPHY

Yasutaka Fujimoto (S'93-M'98-SM'11) received the B.E., M.E., and Ph.D. degrees in electrical engineering from Yokohama National University, Yokohama, Japan, in 1993, 1995, and 1998, respectively. In 1998 he joined Keio University, Yokohama, Japan as a research associate. Since 1999, he has been with the Department of Electrical and Computer Engineering, Yokohama National University, Japan, where he is currently a full professor. His research interests include motion control and actuators. In 1995, he published a work on three-dimensional robotic dynamic simulator and control considering a floating base link and physical interaction between robot and environment. He also contributed to development and control of helically-shaped direct-drive actuators with high-thrust force density and high-backdrivability. He received Inose Young Researcher's Award in 1994, IEE-Japan Excellent Presentation Award in 2001, 2003, and 2005, JEMA/NECA SCF2009 Executive Committee Chairman Award in 2009, IECON2010 First Prize Paper Award of the IEEE-IES Electrical Machines Technical Committee, and IEEE ECCE2016 Best Paper Award. He is an IEEE-IES AdCom Member, an Associate Editor of IEEE Transactions on Industrial Electronics, a Program Chair of IEEE AMC2014, IEEE AMC2018, and a General Co-chair of IEEE ICM2019.

SPEAKER 4

Dr. Pham Cuong

Nanyang Technological University, Singapore

MOTION PLANNING AND CONTROL WITH CONTACTS AND DYNAMICS

Robots climb and walk by making and breaking contacts with the environment. Efficient climbing and walking also make use of dynamics, as opposed to the quasi-static "robot-like" motions of old. Yet, planning and executing motions in presence of contacts and significant dynamics effects still constitute major challenges. In this talk, I will present our recent research in those topics. In particular, we developed a new algorithm to find time-optimal motions under kinodynamic constraints in milliseconds. We leveraged this algorithm to discover feasible (inherently dynamic) motions in situations where no quasi-static motion is possible. In terms of contacts, we developed robust, optimal, controllers to regulate the contacts between robots and environments whose physical properties (geometry, stiffness, friction) are unknown and diverse. Along the way, I will also present a number of complex tasks involving contacts and dynamics we have tackled in recent years: dynamic waiter, critically-fast pick-and-place with suction cups, automatic precision drilling (Airbus Shopfloor Challenge at ICRA 2016), autonomous assembly of an IKEA chair, large-scale 3D-printing by a team of mobile robots, etc. These complex tasks illustrate the need for building robust and scalable robotic systems that address multiple challenges, from precise localization, to motion planning, to control of contact forces.

BIOGRAPHY

Cường was born in Hanoi, Vietnam and grew up in Vietnam and then in France. He is an alumnus of École Normale Supérieure, rue d'Ulm (France) and holds a Ph.D. in Neuroscience from Université Pierre et Marie Curie (France). He was a visiting researcher at the University of São Paulo (Brazil) in 2010, and a JSPS Fellow at the University of Tokyo (Japan) in 2011-2013. He joined NTU (Singapore) as an Assistant Professor in 2013. He was a recipient of the Best Paper Award at the conference Robotics: Science and Systems, 2012. He was the leader of Team CRI Group which won the second prize at the Airbus Shopfloor Challenge at ICRA 2016. His research has been featured on major international media, including The New York Times, The Guardian, The Economist, CNN, Science, Nature, etc.

SPEAKER 5

Prof. Feng Gao

School of Mechanical Engineering, Shanghai Jiao Tong University

DESIGN AND CONTROL OF 6-LEGGED ROBOTS WITH PARALLEL OR HYBRID MECHANISMS FOR APPLICATIONS

Research on the walking robots has been one of key topics in robotics for a long time. In recent years, many legged robots were developed in the world, which of them achieved great progress and received much attention from the robotic field. The most important challenging issues are the design and human robot Interaction control of the legged robots. This speech will introduce our research on both mechanism design and real time control of the6-legged robots for applications, whichinclude the following issues: design process of type synthesis for legged robots with parallel or hybrid mechanisms ; design of the unit composed of motor, reducer, encoder and torque sensor for legged robots; real-time operating system for legged robots, walking based on force sensing, obstacle avoidance with both vision and F/T sensor, walking upstairs by vision, human-robot interactive assembly based on F/T sensor, locked door opening based on F/T sensor for legged robots, fire-fighting and so on.

BIOGRAPHY

Feng Gao is a Chair Professor at the Shanghai Jiao Tong University. He earned his Ph.D. in mechanical engineering at Beijing University of Aeronautics and Astronautics in 1991, and his Master in Mechanical Engineering at Northeast Heavy Machinery Institute in 1982. From 1995 to 1997, he was a postdoctoral research associate in the School of Engineering Science at Simon Fraser University. He was a full professor at Yanshan University from 1995 to 1999. He served first as Vice President and then as President of Hebei University of Technology from 2000 to 2004. He served as the director of the State Key Laboratory of Mechanical Systems and Vibration at Shanghai Jiao Tong University from 2008 to 2013. Since 2004, he has been a full professor at Shanghai Jiao Tong University. He has been serving as an Associate Editor of Mechanism and Machine Theory since 2008 and the ASME Journal of Mechanical Design since 2012, and theGeneral Memberof the ASME Mechanisms and Robotics Committee since 2012. He gave the Keynote Speeches on the conferences of the ASME 2012 and IFToMM 2015, respectively. He won the 2013 China National Natural Science Award because of his contributions in parallel mechanism designand the 8 items of awards from the provincial science and technology invention prizes in China.And he won the ASME Leonardo Da Vinci Award for his invention of parallel manipulators in USA in 2014. He has been granted 120 patents and has published 3 research books on mechanisms and robotics, as well as 120 papers in international journals.

TECHNICAL PROGRAM

Monday 26 August 2019		
Time	Program session	
08:00-09:00	Registration	IBE FOYER (LEVEL 4)
09:00-09:35	**Opening Ceremony**	IBE Auditorium 1
09:40-10:30	Plenary 1 – Hanafiah Yussof **Pioneering Service Robotics Industry in Malaysia: Development of Humanoid Robot ADAM** Session Chair: Prof Mohd Rizal Arshad	IBE Auditorium 1
10:30-10:50	**Coffee- break**	(VIP Room)
10:50-12:30	**SESSION: LEGGED LOCOMOTION** Chair: Dr. Mohd Khair Hassan IBE Auditorium 1	
10:50-11:10	A COMBINED CYCLOID FOOT TRAJECTORY AND VIRTUAL MODEL CONTROL FOR QUADRUPED ROBOTS *Jingyuan Sun*	
11:10-11:30	A SIMPLE AND FLEXIBLE MOVEMENT CONTROL METHOD FOR OF A HEXAPOD WALKING ROBOT *Yaguang Zhu, Liang Zhang, Wanjin Guo and Zhengcang Chen*	
11:30-11:50	DYNAMIC LOCOMOTION OF QUADRUPED WITH LATERALLY PARALLEL LEAF SPRING SPINE *Haruki Cho, Satoshi Nishikawa, Ryuma Niiyama and Yasuo Kuniyoshi*	
11:50-12:10	ON THE DETECTION AND LOCALIZATION OF SHIN COLLISIONS AND REACTIVE ACTIONS IN QUADRUPED ROBOTS *Victor Barasuol, Geoff Fink, Michele Focchi and Claudio Semini*	
12:10-12:30	REACTION TO TOUCH: EVASION AND PHYSICAL GUIDANCE WITH THE LIGHTWEIGHT QUADRUPED ROBOT SERVAL *Boxing Wang, Peter Eckert, Chunlin Zhou, Jun Wu and Auke Ijspeert*	
12:30-12:50	MOTION PLANNING OF A WALKING ROBOT WITH ROTARY MOVERS *Nikolay Sharonov, Eugene Briskin, Alexander Maloletov and Yaroslav Kalinin*	
12:50-14:00	**Lunch**	IBE Chempaka

14:00-14:50	Plenary 2 – Massimiliano Zecca **Sport is Medicine** Session Chair: Prof Osman Tokhi	IBE Auditorium 1
	SESSION: INNOVATIVE ACTUATORS AND POWER SUPPLIES	
14:50-15:50	Chair: Dr. Asnor Juraiza Ishak	
	IBE Auditorium 1	
14:50-15:10	MINIATURIZATION OF ULTRASONIC MOTOR AND ROTOR BLADE FOR ROTARY-WING MICRO AERIAL VEHICLE *Eric Tan Kai Chiang and Tomoaki Mashimo*	
15:10-15:30	DEVELOPMENT OF MOVEMENT SYSTEM USING MICRO GEAR MOTOR *Yoga Hutama Rudolf and Tomoaki Mashimo*	
15:30-15:50	EXPLORING STRUCTURAL CONTROL OF STIFFNESS IN SYNTHETIC TENDON *Caitrin Eaton, Trisha Ramdhoni and Riley Karp*	
15:50-16:00	**Coffee- break**	IBE Chempaka
	SESSION: REHABILITATION AND FUNCTION RESTORATION	
16:00-17:40	Chair: Dr Siti Khadijah Ali	
	IBE Auditorium 1	
16:00-16:20	CONCEPTUAL DESIGN OF 3D-PRINTED ACTIVE PROSTHETIC ARM WITH SOFT GRIPPERS FOR TODDLERS *Daniel De Barrie and Khaled Goher*	
16:20-16:40	USER-CENTRED CONCEPTUAL DESIGN OF A LOWER-BODY EXOSKELETON FOR STANDING IN ELDERLY *Ben Mound and Khaled Goher*	
16:40-17:00	THE EFFECTS OF AN ORTHOTIC DEVICE ON THE WALKING OF A HUMANOID ROBOT *Chokchai Pengyasa, Thavida Maneewarn and Suriya Natsupakpong*	
17:00-17:20	STANDING ASSISTANCE WITH INSTINCTIVE ASSISTANCE MOVEMENT WHICH INSTRUCTS SUITABLE STANDING WAY *Masahiro Yokota, Shohei Kawazoe, Daisuke Chugo, Satoshi Muramatsu, Sho Yokota, Hiroshi Hashimoto, Takahiro Katayama, Yasuhide Mizuta and Atsushi Koujina*	

Tuesday 27 August 2019		
Time	Programme session	
08:00-09:00	Registration	IBE FOYER (LEVEL 4)
09:00-09:50	Plenary 3 - Fujimoto Yasutaka **Highly Backdrivable Actuators for Human-Machine Collaboration** Session Chair: Prof Massimiliano Zecca	IBE Auditorium 1
09:50-10:20	CLAWAR Association & CLAWAR2020	IBE MEETING ROOM
10:20-10:40	**Coffee- break**	IBE Chempaka
10:40-12:00	**SESSION: INNOVATIVE DESIGN OF CLAWAR** Chair: Dr. Chong Shin Horng IBE Auditorium 1	
10:40-11:00	PROPOSAL OF BELLOWS-INTEGRATED ROBOT FOR IMPROVING FLEXIBILITY AND SEALABILITY OF PERISTALTIC MOTION ROBOT *Fumio Ito, Takahiko Kawaguchi, Yasuyuki Yamada and Taro Nakamura*	
11:00-11:20	DEVELOPMENT OF JOINT ATTACHMENT FOR CURVED PIPE PASSAGE OF PERISTALTIC MOTION ROBOT FOR IN-PIPE INSPECTION *Takumi Yasui, Yuki Mano, Fumio Ito and Taro Nakamura*	
11:20-11:40	DESIGN OF A SNAKE ROBOT BASED ON MODULAR JOINT *Yongjun Sun*	
11:40-12:00	DEVELOPMENT OF A REMOTO CONTROL TYPE WEEDING MACHINE WITH STIRRING CHAINS FOR A PDDY FIELD *Hiroaki Uchida, Tomotaka Funaki and Teruhiro Yamano*	
12:00-12:40	**SESSION: UNDERWATER AND SEA ROBOTICS** Chair: Dr Muhamad Sukri Hadi IBE Auditorium 1	
12:00-12:20	SOIL DISCHARGING MECHANISM FOR SEAFLOOR DRILLING ROBOT *Keita Isaka, Naoaki Tadami, Ami Fujiwara, Tomoki Watanabe, Manabu Okui, Taro Nakamura, Makoto Sugesawa and Hiroshi Yoshida*	
12:20-12:40	HIGHLY RESPONSIVE HEADING CONTROL OF UNDERACTUATED MODIFIED BLUEROV USING SLIDING-MODE CONTROLLER *Mohd Faid Yahya and Mohd Rizal Arshad*	
12:40-14:00	**Lunch**	IBE Chempaka
14:00-14:50	Plenary 4 - Quang-Cuong Pham **Motion planning and control with contacts and dynamics** Session Chair: Prof Feng Gao	IBE Auditorium 1

14:50-15:10	**Coffee- break**	IBE Chempaka
15:10-16:50	**SESSION: PLANNING AND CONTROL (I)**	
	Chair: Dr Normaniha Ghani	
	IBE Auditorium 1	
15:10-15:30	MOTION JUDGMENT ALGORITHM BASED ON JOINT ANGULAR VELOCITY WITH VARIABLE VISCOELASTIC ASSISTIVE SUIT *Ryuji Suzuki, Manabu Okui, Seigo Kimura, Rie Nishihama and Taro Nakamura*	
15:30-15:50	CONTROL OF PNEUMATIC CYLINDERS USING ITERATIVE LINEAR QUADRATIC REGULATOR WITH DEEP LOCAL LINEAR DYNAMICS FOR EXPLOSIVE MOTIONS *Yuki Nakamura, Izumi Karino, Shotaro Mori, Kazutoshi Tanaka, Satoshi Nishikawa, Ryuma Niiyama and Yasuo Kuniyoshi*	
15:50-16:10	SEARCH SPACE EXPLORATION USING LEVY FLIGHT WITH TURNING ANGLE CONSTRAINT AND BOUNDARY REFLECTION *Mad Helmi Ab. Majid and Mohd Rizal Arshad*	
16:10-16:30	CONTROL OF A TWO-WHEELED LEGO EV3 ROBOT USING INTERVAL TYPE-2 FUZZY LOGIC WITH PARTICLE SWARM OPTIMIZATION *W.S.Kin, N.M.A Ghani, M.F.Masrom, N.F. Jamin and N.A.A Razali*	
16:30-16:50	INTERVAL TYPE-2 FUZZY LOGIC WITH PARTICLE SWARM OPTIMIZATION FOR DC MOTOR POSITION CONTROL *M.S.C Kii, N.M.A Ghani, M.F.masrom, N.F. Jamin, N.A.A Razali and H. Ishak*	
19:00 - 22:00	**Banquet**	
Conference banquet Grand BlueWave Hotel Shah Alam		

Wednesday 28 August 2019		
Time	Programme session	
08:00-09:00	Registration	IBE FOYER (LEVEL 4)
09:00-09:50	Plenary 5 - Feng Gao **Design and Control of 6-Legged Robots with Parallel or Hybrid Mechanisms for Applications** Session Chair: Prof Fujimoto Yasutaka	IBE Auditorium 1
09:50-10:10	**Coffee- break**	IBE Chempaka
10:10-12:40	**SPECIAL SESSION MACE (CONTROL SYSTEM ENGINEERING IN ACTION)** Chair: Prof Mohd Rizal Arshad IBE Auditorium 1	
10:10-12:40	**COMEL – A Mobile Robot to Promote STEM Education** Dr Muralindran Mariappan **Control System Development for FGK** Dr Hazlina Selamat	
12:20-14:00	**Lunch**	IBE Chempaka
14:00-15:00	**SESSION: PLANNING AND CONTROL (II)** Chair: Dr. Intan Zaurah Mat Darus IBE Auditorium 1	
14:00-14:20	FUZZY-PID BASED CONTROLER FOR ACTIVE VIBRATION CONTROL OF NONLINEAR DYNAMIC SYSTEM *Muhamad Sukri Hadi, Hanim Mohd Yatim, Mat Hussin Ab Talib, Annisa Jamali and Intan Zaurah Mat Darus*	
14:20-14:40	IMPROVEMENTS IN DIRECT LYAPUNOV STABILIZATION OF UNDERACTUATED, MECHANICAL SYSTEMS BY MEAN OF THE SOLVABILITY OF THE FIRST MATCHING CONDITION. *Deyka Garcia, Marcelo Coronado and Antony Garcia*	
14:40-15:00	OPTIMIZATION OF PID CONTROLLER FOR DOUBLE-LINK FLEXIBLE ROBOTIC MANIPULATOR USING METAHEURISTIC ALGORITHMS *Annisa Jamali, Intan Zaurah Mat Darus, Muhamad Sukri Hadi, Hanim Mohd. Yatim and Mat Hussin Ab. Talib*	
15:00-15:20	**Coffee- break**	IBE Chempaka
15:20-15:40	**Closing Ceremony**	IBE Auditorium 1
15:20-15:40	Closing Ceremony: - Invitation to CLAWAR 2020 - Photo Session - CLAWAR & MACE membership drive	

TECHNICAL PROGRAM SCHEDULE

Day 1: Monday, Monday 26 August 2019

Session: Legged locomotion

Time: 10:50-12:30 Room: IBE Auditorium 1

Chairperson: Dr. Mohd Khair Hassan

Paper ID	Title & Authors
2	**A COMBINED CYCLOID FOOT TRAJECTORY AND VIRTUAL MODEL CONTROL FOR QUADRUPED ROBOTS** *Jingyuan Sun*
6	**A SIMPLE AND FLEXIBLE MOVEMENT CONTROL METHOD FOR OF A HEXAPOD WALKING ROBOT** *Yaguang Zhu, Liang Zhang, Wanjin Guo and Zhengcang Chen*
12	**DYNAMIC LOCOMOTION OF QUADRUPED WITH LATERALLY PARALLEL LEAF SPRING SPINE** *Haruki Cho, Satoshi Nishikawa, Ryuma Niiyama and Yasuo Kuniyoshi*
14	**ON THE DETECTION AND LOCALIZATION OF SHIN COLLISIONS AND REACTIVE ACTIONS IN QUADRUPED ROBOTS** *Victor Barasuol, Geoff Fink, Michele Focchi and Claudio Semini*
15	**REACTION TO TOUCH: EVASION AND PHYSICAL GUIDANCE WITH THE LIGHTWEIGHT QUADRUPED ROBOT SERVAL** *Boxing Wang, Peter Eckert, Chunlin Zhou, Jun Wu and Auke Ijspeert*
11	**MOTION PLANNING OF A WALKING ROBOT WITH ROTARY MOVERS** *Nikolay Sharonov, Eugene Briskin, Alexander Maloletov and Yaroslav Kalinin*

Session: Innovative Actuators and Power Supplies

Time: 14:50-15:50 Room: IBE Auditorium 1

Chairperson: Dr. Asnor Juraiza Ishak

Paper ID	Title & Authors
9	**MINIATURIZATION OF ULTRASONIC MOTOR AND ROTOR BLADE FOR ROTARY-WING MICRO AERIAL VEHICLE** *Eric Tan Kai Chiang and Tomoaki Mashimo*
10	**DEVELOPMENT OF MOVEMENT SYSTEM USING MICRO GEAR MOTOR** *Yoga Hutama Rudolf and Tomoaki Mashimo*
17	**EXPLORING STRUCTURAL CONTROL OF STIFFNESS IN SYNTHETIC TENDON** *Caitrin Eaton, Trisha Ramdhoni and Riley Karp*

Session: Rehabilitation and Function Restoration

Time: 16:00-17:40 Room: IBE Auditorium 1

Chairperson: Dr Siti Khadijah Ali

Paper ID	Title & Authors
21	**CONCEPTUAL DESIGN OF 3D-PRINTED ACTIVE PROSTHETIC ARM WITH SOFT GRIPPERS FOR TODDLERS** *Daniel De Barrie and Khaled Goher*
25	**USER-CENTRED CONCEPTUAL DESIGN OF A LOWER-BODY EXOSKELETON FOR STANDING IN ELDERLY** *Ben Mound and Khaled Goher*
29	**THE EFFECTS OF AN ORTHOTIC DEVICE ON THE WALKING OF A HUMANOID ROBOT** *Chokchai Pengyasa, Thavida Maneewarn and Suriya Natsupakpong*
32	**STANDING ASSISTANCE WITH INSTINCTIVE ASSISTANCE MOVEMENT WHICH INSTRUCTS SUITABLE STANDING WAY** *Masahiro Yokota, Shohei Kawazoe, Daisuke Chugo, Satoshi Muramatsu, Sho Yokota, Hiroshi Hashimoto, Takahiro Katayama, Yasuhide Mizuta and Atsushi Koujina*

Day 2: Tuesday 27 August 2019

Session: Innovative Design of CLAWAR

Time: 10:40-12:00 Room: IBE Auditorium 1

Chairperson: Dr. Chong Shin Horng

Paper ID	Title & Authors
7	**PROPOSAL OF BELLOWS-INTEGRATED ROBOT FOR IMPROVING FLEXIBILITY AND SEALABILITY OF PERISTALTIC MOTION ROBOT** *Fumio Ito, Takahiko Kawaguchi, Yasuyuki Yamada and Taro Nakamura*
8	**DEVELOPMENT OF JOINT ATTACHMENT FOR CURVED PIPE PASSAGE OF PERISTALTIC MOTION ROBOT FOR IN-PIPE INSPECTION** *Takumi Yasui, Yuki Mano, Fumio Ito and Taro Nakamura*
28	**DESIGN OF A SNAKE ROBOT BASED ON MODULAR JOINT** *Yongjun Sun*
30	**DEVELOPMENT OF A REMOTO CONTROL TYPE WEEDING MACHINE WITH STIRRING CHAINS FOR A PDDY FIELD** *Hiroaki Uchida, Tomotaka Funaki and Teruhiro Yamano*

Session: Underwater and Sea Robotics

Time: 12:00-12:40 Room: IBE Auditorium 1

Chairperson: Dr Muhamad Sukri Hadi

Paper ID	Title & Authors
5	**SOIL DISCHARGING MECHANISM FOR SEAFLOOR DRILLING ROBOT** *Keita Isaka, Naoaki Tadami, Ami Fujiwara, Tomoki Watanabe, Manabu Okui, Taro Nakamura, Makoto Sugesawa and Hiroshi Yoshida*
27	**HIGHLY RESPONSIVE HEADING CONTROL OF UNDERACTUATED MODIFIED BLUEROV USING SLIDING-MODE CONTROLLER** *Mohd Faid Yahya and Mohd Rizal Arshad*

Session: Planning and Control (I)

Time: 15:10-16:50 Room: IBE Auditorium 1

Chairperson: Dr Normaniha Ghani

Paper ID	Title & Authors
4	**MOTION JUDGMENT ALGORITHM BASED ON JOINT ANGULAR VELOCITY WITH VARIABLE VISCOELASTIC ASSISTIVE SUIT** *Ryuji Suzuki, Manabu Okui, Seigo Kimura, Rie Nishihama and Taro Nakamura*
13	**CONTROL OF PNEUMATIC CYLINDERS USING ITERATIVE LINEAR QUADRATIC REGULATOR WITH DEEP LOCAL LINEAR DYNAMICS FOR EXPLOSIVE MOTIONS** *Yuki Nakamura, Izumi Karino, Shotaro Mori, Kazutoshi Tanaka, Satoshi Nishikawa, Ryuma Niiyama and Yasuo Kuniyoshi*
18	**SEARCH SPACE EXPLORATION USING LEVY FLIGHT WITH TURNING ANGLE CONSTRAINT AND BOUNDARY REFLECTION** *Mad Helmi Ab. Majid and Mohd Rizal Arshad*
35	**CONTROL OF A TWO-WHEELED LEGO EV3 ROBOT USING INTERVAL TYPE-2 FUZZY LOGIC WITH PARTICLE SWARM OPTIMIZATION** *W.S.KIN, N.M.A GHANI, M.F.MASROM, N.F. JAMIN and N.A.A RAZALI*
34	**INTERVAL TYPE-2 FUZZY LOGIC WITH PARTICLE SWARM OPTIMIZATION FOR DC MOTOR POSITION CONTROL** *M.S.C KII, N.M.A GHANI, M.F.MASROM, N.F. JAMIN, N.A.A RAZALI and H. ISHAK*

Day 3: Wednesday 28 August 2019

Session: Planning and Control (II)

Time: 14:00-15:00 Room: IBE Auditorium 1

Chairperson: Dr. Intan Zaurah Mat Darus

Paper ID	Title & Authors
31	**FUZZY-PID BASED CONTROLER FOR ACTIVE VIBRATION CONTROL OF NONLINEAR DYNAMIC SYSTEM** *Muhamad Sukri Hadi, Hanim Mohd Yatim, Mat Hussin Ab Talib, Annisa Jamali and Intan Zaurah Mat Darus*
33	**IMPROVEMENTS IN DIRECT LYAPUNOV STABILIZATION OF UNDERACTUATED, MECHANICAL SYSTEMS BY MEAN OF THE SOLVABILITY OF THE FIRST MATCHING CONDITION.** *Deyka Garcia, Marcelo Coronado and Antony Garcia*
22	**OPTIMIZATION OF PID CONTROLLER FOR DOUBLE-LINK FLEXIBLE ROBOTIC MANIPULATOR USING METAHEURISTIC ALGORITHMS** *Annisa Jamali, Intan Zaurah Mat Darus, Muhamad Sukri Hadi, Hanim Mohd. Yatim and Mat Hussin Ab. Talib*

TECHNICAL PROGRAM ABSTRACT

PAPER ID: 2

A COMBINED CYCLOID FOOT TRAJECTORY AND VIRTUAL MODEL CONTROL FOR QUADRUPED ROBOTS

In order to plan the foot trajectory and provide compliant behavior for quadruped robots, a locomotion controller based on the trajectory planning method and the virtual model is presented. The trajectory planning model is generated during the swing phase by using inverse kinematics and coordination transition. One method to reduce the fluctuation of speed and acceleration jumps is proposed here, generating fluent motion and avoiding slipping. In this paper, a virtual model controller has been built for the stance legs, providing computational simplification and highly compliant behavior. A quadruped robot platform in the simulation is used to test the proposed controller, both on the flat terrain and uneven terrain by using the trot gait. The simulation results show the effectiveness of the control algorithm, where the robot has the ability to generate smooth movement and overcome uneven terrain.

PAPER ID: 4

MOTION JUDGMENT ALGORITHM BASED ON JOINT ANGULAR VELOCITY WITH VARIABLE VISCOELASTIC ASSISTIVE SUIT

In recent years, the burden for labor is increasing due to an aging society. To solve this issue, assistive suits are proposed as one of the solutions. In the previous study, an assistive suit has been developed that is based on variable viscoelasticity. However, the motion judgment interface for the variable viscoelastic based actuating device has not been studied. In this study, joint angle and joint angular velocity are used to judge the motion of the wearer, because variable viscoelastic based actuating device has a high backdrivability. In addition, with a suit of high backdrivability, the intention of a wearer can be shown as the joint angle. This study reports the motion judgment algorithm that is based on the wearer's joint angle, and joint angular velocity, and experiments have been conducted to evaluate the utility of the algorithm.

PAPER ID: 5

SOIL DISCHARGING MECHANISM FOR SEAFLOOR DRILLING ROBOT

This work introduces a soil discharging mechanism that involves water jetting to further the development of a seafloor robotic explorer that can excavate and collect samples of rare earth elements. The excavation depth of previously reported drilling robots has been limited to 430 mm; the discharging outlet became buried in the ground, making it difficult to discharge the drilled soil.

PAPER ID: 6

A SIMPLE AND FLEXIBLE MOVEMENT CONTROL METHOD FOR OF A HEXAPOD WALKING ROBOT

The movements of nature creature such as crawling, walking and running are so flexible and coordinate. Many reseachers turn to Central Pattern Generators (CPG) to make the legged robots be able to have the same behavior ability. In this paper, we combine the model control and bio-inspired contorl for the flexible locomotion control of legged robot to accomplish the omnidirectional movement of the hexapod robot through the Central Pattern based Backward Control method (CPBC). σ-Hopf oscillator is used as the control unit. Inspired by the compound motion of ants, which is made up of several simple movement forms, the movement trajectory is planned and then body kinematics is used to obtain expected body movement like ants. A hexapod robot named SmartHex is used to carry out the experiment of the omnidirectional movement. The experimental results show that the proposed algorithm can significantly improve the stability and flexibility of the robot, and various movement patterns can be achieved.

PAPER ID: 7

PROPOSAL OF BELLOWS-INTEGRATED ROBOT FOR IMPROVING FLEXIBILITY AND SEALABILITY OF PERISTALTIC MOTION ROBOT

Long-term use of pipes leads to increased cleaning and inspection demand. Conventional methods use longdistance inspection, which is difficult to implement due to friction along the pipe wall. Modern alternative methods, including the use of an in-pipe mobile robot, may address this issue. Nevertheless, it may be difficult for the robot to generate the necessary tractive force, especially in thin, long, and complicated pipelines. To counter such weakness, we developed a robot that mimics the peristaltic movement of an earthworm to generate a large traction force, even with small size. The robot is a bellows-integrated robot, which is characterized by high flexibility and an interior structure that does not permit the easy entrance of dust and moisture.

PAPER ID: 8

DEVELOPMENT OF JOINT ATTACHMENT FOR CURVED PIPE PASSAGE OF PERISTALTIC MOTION ROBOT FOR IN-PIPE INSPECTION

In the recent years, aged pipes are increasing, and many road collapse accidents occur. Therefore, it is necessary to inspect the condition of the pipe to efficiently determine whether a replacement or repair is necessary. However, pressure pipes that are capable of coping with complex terrains, the pipelines are complicated and are difficult to inspect with the existing inspection equipment. Therefore, based on the earthworm's peristaltic movement and artificial muscles, the authors developed a peristaltic robot in a previous research for inspecting the inside of a pressure-feeding pipe. However, owing to the unevenness its joint, the robot was unable to maneuver through the corners of a curved pipe. Therefore, in this study, we developed a joint attachment that enables the robot to pass through a curved pipe, and evaluated its effectiveness through traveling experiments by using a curved pipe.

PAPER ID: 9

Miniaturization of Ultrasonic Motor and Rotor Blade for Rotary-Wing Micro Aerial Vehicle

Micro actuator and micro rotor blade are important elements when developing a rotary-wing micro aerial vehicle (MAV). We propose a micro ultrasonic motor with a 1mm cube stator and design a micro rotor blade with 5mm wingspan. The trial production of both the micro ultrasonic motor and micro rotor blade is carried out. The prototype micro rotor blade is attached to the prototype micro ultrasonic motor and drive experiment is conducted to test the performance of the assembled device. A micro soldering equipment is also developed to produce stable solder results for the assembled device. Experimental result shows the transient response of rotational speed of the device

PAPER ID: 10

Development of Movement System Using Micro Gear Motor

We propose a micro mobile robot using the smallest set of micro ultrasonic motor and micro planetary gear. The size of the robot is 16 mm in length and 11 mm in width. Micro ultrasonic motor that we used has output torque power about 10 µNm. It is a powerful motor in onemillimeter size. And after attached to micro planetary gear, the motor reached about 6500rpm in 0.2s. Eventhough the micro geared ultrasonic motor that made is not stabil enough, we succeed to combined motor with gear system in millimeter scale.

PAPER ID: 11

MOTION PLANNING OF A WALKING ROBOT WITH ROTARY MOVERS

PAPER ID: 12

DYNAMIC LOCOMOTION OF QUADRUPED WITH LATERALLY PARALLEL LEAF SPRING SPINE

We focus on use of the movement of the spine in animal locomotion and propose a spinal mechanism to realize dynamic spine-source locomotion. The proposed mechanism is composed of two sets of a leaf spring with a dedicated motor used to bend the spring, with these sets being placed laterally in parallel. This mechanism can realize deformation of the spine including bending and twisting and can release large amounts of elastic energy instantaneously. We equipped a quadruped robot with the proposed spinal mechanism and examined how motion changes with the motion of the spinal mechanism and legs. The robot realized rapid running up to 1.0667 m/s. The difference of the actuation between the right side and left side of the spine derived a variety of rapid and spine-source locomotion modes that changed the running direction. In addition, the timing of the simple motion of the legs further expanded the diversity of the spine-source locomotion.

PAPER ID: 13

CONTROL OF PNEUMATIC CYLINDERS USING ITERATIVE LINEAR QUADRATIC REGULATOR WITH DEEP LOCAL LINEAR DYNAMICS FOR EXPLOSIVE MOTIONS

A pneumatic actuator is an attractive option for creating explosive robotic motions, such as jumping and running, because of its high power-to-weight ratio and compliance. However, control of pneumatic actuators suffers from the nonlinear dynamics of air and system identification problems. We propose a method combining deep-learning of local linear dynamics of the system and an iterative linear quadratic regulator (iLQR) for explosive motions by pneumatic robots. To verify the performance of the method, we performed a simple task to control the position and velocity of a one-degree-of-freedom slider driven by a push-pull pneumatic cylinder. The results show that the slider reached a target position with less than 1.4% error (3.5 mm against a 250 mm range of motion) with a task period of 0.5 s. The velocity was 1.09 m/s (starting from a negative position) and 0.551 m/s (starting from a positive position) against the target velocity of 1.00 m/s.

PAPER ID: 14

ON THE DETECTION AND LOCALIZATION OF SHIN COLLISIONS AND REACTIVE ACTIONS IN QUADRUPED ROBOTS

In this work, we investigate the impact of shin (distal limb) collisions on the performance of quadruped locomotion. In particular, we carry out a detailed study on the locomotion performance sensitivity to systematic errors and delays in the estimation of the shin contact location. We propose a sensor-less model based on kinematics to estimate the location of a single contact point at the shin level. In order to improve the robustness of robot locomotion, we use insights from our sensitivity study and our proposed model to develop a reactive strategy to detect and feedback information about the contact into the trunk controller. The effectiveness of the proposed approaches is experimentally demonstrated on the HyQ robot.

PAPER ID: 15

REACTION TO TOUCH: EVASION AND PHYSICAL GUIDANCE WITH THE LIGHTWEIGHT QUADRUPED ROBOT SERVAL

Physical human-robot interactions are commonly seen in many legged robot application scenarios. Although physical interactions could affect the stability of the robot, robots can be more versatile and adaptive by performing different reactions according to tactile input. In this paper, we propose an intuitive control framework that enables the trotting quadruped robot Serval to use the same, modular control framework, triggering different behaviors according to the perturbation experienced. In order to detect the tactile input, a force sensor is attached to the middle spine joint of Serval. For gentle taps, a central pattern generator model is used to perform open-loop control. As gentle taps induce few disturbances to the stability, the robot is open-loop controlled to move laterally as a reaction. For strong pushes, virtual model and stability margin control are added to bend the spine and adjust supporting legs to keep balance. As no sidesteps are required, the robot still keeps moving on its original route. Experiments are presented to validate the performance of the proposed control framework.

PAPER ID: 17

EXPLORING STRUCTURAL CONTROL OF STIFFNESS IN SYNTHETIC TENDON

Tendons shape the performance of biological actuators. The compliance of a tendon in series with a muscle influences that muscle's ability to transmit force, amplify power, or dissipate energy. Similar performance benefits have already been realized in robotic and prosthetic systems with compliant components. With low-cost, commercially available compliant filaments, it is now possible to fine-tune the structural properties of these compliant components during rapid prototyping. However, tailoring the compliance of these parts for diverse tasks such as force transmission, power amplification, or energy dissipation requires fine-grained control of a printed structure's stiffness.

Experimental data from printed synthetic tendons are used here to inform a computational model, mapping the space of achievable stiffnesses as a function of cross-sectional area and rest length. Results are verified by comparing the elastic modulus of a single layer of parallel fibers to the filament manufacturer's reported material properties. In multi-layer structures, the alternating orientation of printed fibers from layer to layer was found to significantly influence stiffness, precluding the derivation of this model from the filament's material properties alone. Drawing inspiration from biological tendon, future work will use this mapping to study the influence of custom synthetic tendons on force, displacement, energy, and power transmission pathways between actuators and end effectors in robotic limbs.

PAPER ID: 18

SEARCH SPACE EXPLORATION USING LEVY FLIGHT WITH TURNING ANGLE CONSTRAINT AND BOUNDARY REFLECTION

Source searching is an important task in many real world applications and it has been widely studied using various types of robotic systems. In this task, the robot has to first detect the presence of the source in the search space before it can continue to locate the source to its approximate location. In order to efficiently detect the source, the robot must optimize search space exploration. Lévy flight is one of the optimal algorithms for search space exploration. However, for a destructive type of source searching, Lévy flight is susceptible to two problems. Firstly, the possibility of immediate returns to the previously visited site is high. Secondly, robot tends to temporarily stuck at the boundary of the search space until a new angle that bring robot away from the boundary is generated. In this paper, the solutions to the two problems are proposed by imposing angle constraints to Lévy flight and by using boundary reflection, reflectively. The results show that the exploration capability of the Lévy flight with the proposed strategy is improved compared to the conventional Lévy flight model.

PAPER ID: 21

Conceptual Design of 3D-Printed Active Prosthetic Arm with Soft Grippers for Toddlers

The present paper introduces a novel concept design for a 3D-printed prosthetic arm for toddlers, being developed to showcase the viability of early active prosthetic fitting that in due course could reduce prosthetic rejection rates. Soft grippers have been designed to act as the end device, with the intent to improve grasp capability of the prosthetic. The grippers have been incorporated into a prototype hand in order to display the functionally of the system. A CAD model of a stump has been visualised in Fusion 360 using its mesh feature, presenting an alternative to the traditional casting technique. An outline for the control system is also presented, using the position detector in a linear actuator to determine when a grasp has occurred. The concepts presented will further be worked on, with the realisation of a working prototype being the final intent.

PAPER ID: 22

OPTIMIZATION OF PID CONTROLLER FOR DOUBLE-LINK FLEXIBLE ROBOTIC MANIPULATOR USING METAHEURISTIC ALGORITHMS

This paper investigates the optimization approach of PID controller for double-link flexible robotic manipulator using metaheuristic algorithm. This research focus on population-based metaheuristic that is particle swarm optimization (PSO) and artificial bees algorithm (ABC) to tune the PID control parameters of the system. In the tuning process, the number of iteration was set and the number of particles was varied. The tuning process was interrupted once the convergence value of Mean Square Error (MSE) was achieved. For PSO, it was found that when the number of iteration increased, or the number of particles were set to higher values, there were no significant improvement of MSE. Results showed that 25 iterations were required for MSE to converge for hub angle and 20 iterations were required for MSE to converge for endpoint acceleration. Meanwhile, it was discovered that ABC portrayed the same pattern with PSO whereby when the number of iteration increased or the number of colony sizes were set to higher values, there were no significant improvement of MSE. From the results, 15 iterations were required for MSE to converge for hub angle and 25 iterations were required for MSE to converge for end-point acceleration. The performance of the algorithm was validated by evaluating the performance of the controllers in comparison with the conventional controller that is Ziegler Nichols (ZN) in term of input tracking capability and vibration suppression for both links. The system managed to reach desired angle for both hub angle 1 and 2. Besides, vibration reduction shows great improvement for both link 1 and 2. This signifies that, the PSO and ABC algorithm are very effective in optimizing the PID parameters.

PAPER ID: 25

USER-CENTRED CONCEPTUAL DESIGN OF A LOWER-BODY EXOSKELETON FOR STANDING IN ELDERLY

Technology continues to extend the human life span with each new generation but fails to adequately support the daily challenges that come with old age. An increasing amount of elderly people experience difficulty performing daily tasks as simple as standing up from a chair causing a decrease in mental and physical wellbeing. Depending on users' perspectives, this paper designs an active lower limb exoskeleton (LLE) to support the sit to stand (STS) manoeuvre by employing multiple modelling techniques to determine the torque output required to provide 15% assistance to the wearer. The chassis of the exoskeleton is analysed using finite element analysis (FEA) software and is determined to experience acceptable amounts of stress and deformation.

PAPER ID: 27

HIGHLY RESPONSIVE HEADING CONTROL OF UNDERACTUATED MODIFIED BLUEROV USING SLIDING-MODE CONTROLLER

The control of Autonomous Underwater Vehicle (AUV) presents some challenging tasks such as dealing with the nonlinearity of AUV dynamics, coupling effects, and taking into consideration the hydrodynamics uncertainties and disturbances such as current. One of the more robust control method for controlling a nonlinear system is Sliding-Mode Control (SMC). In literature, SMC had been used to control the depth and yaw of an underactuated AUV. However, the switching term of the SMC had to be tuned to get a proper balance between performance and robustness and it has low responsiveness to track desired reference signal. This paper introduces the usage of smoothing filter to make the SMC more responsive to track desired heading motion. The methodology starts with deriving heading model of an AUV, then estimating the parameters in the AUV model, followed by designing the heading controller based on SMC, and finally optimizing the controller parameters. The design model is based on underactuated modified BlueROV. Results shown that when the reference heading signal is smoothed, the SMC is able to achieve 95.55% responsiveness compared to only just 78.05% responsiveness without smoothing. The thrusts produced by the AUV is also less strained when the smoothing filter is applied. Therefore, to get a highly responsive SMC and to preserve the longevity of the thrusters of an AUV, a smoothing filter had to be considered in controller design of an underactuated AUV.

PAPER ID: 28

DESIGN OF A SNAKE ROBOT BASED ON MODULAR JOINT

This paper introduces a novel snake robot based on modular joints by harmonic reducer, which have position, torque, acceleration, angular motion, vision and temperature information sensing capabilities. The FPGA chip is used as the joint controller, and the computational powerful computing stick is used as the robot controller in the snake head. The communication between the joint controller and the robot controller is realized through the Point to Point High Speed Serial Communication System (PPSeCo). The prototype was developed and tested for joint output torque, joint desired trajectory and side motion.

PAPER ID: 29

THE EFFECTS OF AN ORTHOTIC DEVICE ON THE WALKING OF A HUMANOID ROBOT

An actuator or a support structure of a humanoid robot can be damaged in the same way that a human has musculoskeletal injuries. When an actuator is damaged or risked of being fatally damage, the robot may lack of some abilities to perform fundamental tasks such as walking. In this paper, we have applied an orthotic device which is a brace or a cast to support the damaged knee joint of a humanoid robot. By applying a brace to the knee joint, the walking parameters of the robot need to be adjusted to accommodate the motion constraint introduced by the brace. The limping gait was tested and compared with the normal walking gait. The experimental results showed that the limping gait resulted in slower walk and increased the energy consumption by 30% compared to the normal walking gait. However, a humanoid robot is able to walk despite of its damaged knee joint with the proposed orthotic device.

PAPER ID: 30

DEVELOPMENT OF A REMOTO CONTROL TYPE WEEDING MACHINE WITH STIRRING CHAINS FOR A PADDY FIELD

Pesticide-free farming methods are paid attention. There is a method that uses dabbling ducks as a pesticidefree farming method. This is a one of the method to remove of weeds. We release the chicks of a dabbling duck in paddy field. Then they swim and eat weeds. With this principle, weeds are removed. However this method is not easy. So it was considered to remove weeds with a machine. This idea imitates duck swimming. The developed machine floats on the surface of the water using a body board, and has a chain attached to the rear of the machine to stir the paddy field. In addition, the driving unit is an electric type in which the propeller is driven by a motor. The control system of the machine is composed by a raspberry pi, the acquisition of the sensor values are used Arduino. Weeding works were performed 5 times at a pace once a week. As a result, it was confirmed that Monochoria vaginalis of weed was reduced.

PAPER ID: 31

FUZZY-PID BASED CONTROLER FOR ACTIVE VIBRATION CONTROL OF NONLINEAR DYNAMIC SYSTEM

The light weight characteristic offered by flexible structures can be easily influenced to the excessive vibration and it also brings several problems including instability, fatigue, bending and low performance. Therefore, it is compulsory to suppress the undesired vibration of flexible structures due to sustain its performance. This paper presents the development of hybrid controller known as fuzzy-PID based controller for vibration suppression of the horizontal flexible plate structure. Initially, the experimental rig was designed and integrated with the instrumentation system for vibration data collection purpose. The vibration data obtained experimentally was used to model the dynamic system based on auto-regressive with exogenous input structure using evolutionary swarm algorithm. The model obtained in simulation environment was then used for the development of PID-Fuzzy based controller. The performance of proposed controller was validated by exerting two types of disturbances to the system for robustness verification. It was indicated that PID-fuzzy controller was achieved higher attenuation value at the first mode of vibration by achieving 32.14 dB attenuation in the system. The attenuation value has been reduced from 103.5 dB to 71.36 dB, equivalent to 31.05 % attenuation, after the introduction of vibration control. The mean squared error achieved by the controller is 0.0237, compared with 0.6655 before the activation of controller.

PAPER ID: 32

STANDING ASSISTANCE WITH INSTINCTIVE ASSISTANCE MOVEMENT WHICH INSTRUCTS SUITABLE STANDING WAY

This paper proposes a novel standing assistance scheme that guides a subject to adopt a suitable posture using intended movements. In many previous research, an assistive robot requires the patient to understand the standing reference beforehand and generally, the subject learns the standing motion used by the robot. However, for practical use, a patient should be able to use an assistive robot without special prior knowledge. Nursing specialists also guide their patients with an intended movement. For example, when they incline a patient's upper body before lifting it up, they guide the patient's body with a special moving pattern. Moving in this way is based on their experience and expertise and, in fact, the patient moves according to the motion intended by the nursing specialist. In this paper, we develop a standing assistance scheme that guides the patient to stand in the intended way. The effectiveness of the proposed method is verified by experiments with our prototype.

PAPER ID: 33

IMPROVEMENTS IN DIRECT LYAPUNOV STABILIZATION OF UNDERACTUATED MECHANICAL SYSTEMS BY MEANS OF THE SOLVABILITY OF THE FIRST MATCHING CONDITION.

A solvability of the direct Lyapunov first matching condition in terms of the generalized coordinates method is presented for the stabilization of underactuated, inverted pendulum cart. This work represents a continued development of previously published techniques for the exact controller design formulation without introducing control law terms or approximations. The use of the control law, instead of inverse dynamics to determine the coordinate histories for the unspecified axes, produced good performance results showing a faster response to stabilize both the actuated and non-actuated axes. The stability is achieved from the proper shape of the potential, the positive definiteness of the KD matrix, and the non-positive rate of change of the Lyapunov function.

PAPER ID: 34

INTERVAL TYPE-2 FUZZY LOGIC WITH PARTICLE SWARM OPTIMIZATION FOR DC MOTOR POSITION CONTROL

The main principle of this project is to control the position of the train door system by using Direct Current (DC) motor which has nonlinear behaviour. A Particle Swarm Optimization (PSO) optimized Interval Type 2 Fuzzy Logic Controller (IT2FLC-PSO) is proposed to control the position of DC motor with application to train door position control. The mechanism of the train door system is developed by using SimWise 4D and integrated with Matlab Simulink for control purpose. Then, the system identification tool is used to obtain the mathematical model of the system based on the input and output value in Simwise 4D motions. A comparative study is carried out using Type 1 Fuzzy Logic Controller (T1FLC) and a IT2FLC-PSO. Lastly, simulation results are presented in Matlab/Simulink and the performance of the proposed algorithms in controlling the position of the train doors is evaluated with various weights and sizes of the door

PAPER ID: 35

CONTROL OF A TWO-WHEELED LEGO EV3 ROBOT USING INTERVAL TYPE-2 FUZZY LOGIC WITH PARTICLE SWARM OPTIMIZATION

Two-wheeled robot self-balancing has gained much interest of researchers due to its nonlinear dynamics. This project is aimed to design an Interval Type-2 Fuzzy Logic Controller to control a two-wheeled LEGO EV3 robot self-balancing to keep it in the upright position. In this project, two-wheeled LEGO EV3 robot is modelled using SimWise 4D software and integrated with Simulink. The robot stability performance and output response are observed at the same time when the Simulink is executed. System identification is used to get the mathematical model of the system in state space based on input and output from SimWise 4D motion to compare both results. The state space is used during optimization of IT2FLS using Particle Swarm Optimization (PSO). The performances of Interval Type 2 Fuzzy Logic Controller (IT2FLC) and optimized IT2FLS are compared. The robustness of IT2FLS is observed during disturbance rejection by injecting different direction of 0.8N and 1.0N torque to the robot in first 15 seconds

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