RiTA2013

The 2nd International Conference on
Robot Intelligence Technology and Applications 2013

December 18 - 20, 2013

Colorado Convention Center
Denver, Colorado, USA

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Conference Digest

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Contents

Welcome Message

We are delightful to welcome to the 2nd International Conference on Robot Intelligence Technology and Applications (RiTA2013) at the Colorado Convention Center, Denver, USA on December 18 - 20, 2013. Following the RiTA 2012 in Gwangju, Korea, RiTA has been held annually in conjunction with the International Robot Olympiad (IRO). A key objective of this conference is to share information, advance robot intelligence technology, and search for its possible applications. We will discuss how to make artificial creatures smarter using the intelligence technology (iT).

By increasing the use of robots and their role around societies, robots have grown up with agility and acuity. In order to carry out missions in dangerous environments, manufacturing processes, educating academics, nursing disabled people, etc., robots have required human-like intelligence or thought mechanism to use the data and information by manipulating their knowledge. In recognition of robot intelligence technology, we are very pleased to invite robot experts for plenary talks; Prof. Alan Mackworth, Prof. Tetsuya Iwasaki and Prof. Jong-Hwan Kim. Also, special talks are made by Prof. Victor Raskin, Prof. Jacky Baltes, Prof. Hyun Myung, and Prof. Henrik Hautop Lund. Their talks will lead us to better understanding of robot intelligence technology and applications. Additionally, Prof. Robert G. Reynolds's tutorial will provide us with an in-depth lecture on this field.

Technical program will consist of 3 plenary sessions, 1 special talk session, 15 oral sessions and 1 interactive session. All of the 88 presented papers have already been accepted through peer-reviews. Speakers will show up their recent achievements, research results and theories.

We would convey thankful message to all of the contributed authors, special session organizers, plenary speakers, special talk speakers, organizing committee, program committee, and IRO committee. We hope all of the attendees can have a wonderful time with season's greetings. Thank you.

Jong-Hwan Kim
General Chair
KAIST, Korea

Eric T. Matson
General Co-Chair
Purdue University, USA

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Program at a Glance

	Wednesday, 18 Dec
15:30-17:30	Tutorial @ Rm#602
18:00-19:30	Welcome Reception @ Rm#601

	Thursday, 19 Dec			Friday, 20 Dec		
Rm#	602	604	606	602	604	606
08:50-10:50	T1A Intelligent Agents & Medicine	T1B Navigation/ SLAM/ Localization	T1C-SS1 Soft Robotics	F1A Humanoid/ Micro/ Nano Robotics	F1B Emerging Application	F1C Signal Processing
10:50-11:10	Break			Break		
11:10-11:30	Opening Ceremony @ Rm#601			F2PS-III: Plenary Session III @ Rm#601 Prof. Jong-Hwan Kim		
11:30-12:00	T2PS-I: Plenary Session I @ Rm#601 Prof. Tetsuya Iwasaki					
12:00-12:20				Lunch		
12:20-13:30	Lunch					
13:30-14:20	T3PS-II: Plenary Session II @ Rm#601 Prof. Alan Mackworth			F3IS: Special Talks Session @ Rm#601 Prof. Hyun Myung Prof. Jacky Baltes Prof. Victor Raskin		
14:20-14:40	Break					
14:40-15:00	T4A Human-robot Interaction	T4B-SS3 Underwater Robots & Applications	T4C Kinematics/ Dynamics/ Control			
15:00-15:10				Break		
15:10-16:00				F4A-SS4 Flapping-Wing Air Vehicles	F4B Ambient / Collective Intelligence	F4C Computer Vision
16:00-16:20	Break					
16:20-16:50	T5A-SS2 Knowledge Representation for Robotics & Automation	T5B Cognitive Intelligence	T5C Genetic/ Behavioral Intelligence			
16:50-18:00				F5P @ Lobby Interactive Session		
18:30-20:30				Conference Banquet @ Rm#601		

Conference Information

Registration

The Registration desk will be open at 600 corridor of the Meeting Room Level during the following times:

Wednesday, 18 December	02:30pm - 7:30pm
Thursday, 19 December	08:30am - 6:00pm
Friday, 20 December	08:30am - 6:00pm

Registrants will be provided with a registration kit. The kit includes a small bag, conference digest, USB proceedings, receipt and name badge. All attendees must wear their name badges at all times to gain admission to all conference sessions, reception and banquet. The information and message board will be located near the registration desk. Messages or promotional leaflets will be posted in this area throughout the conference.

Conference Proceedings

A full manuscript of each paper presented at the conference is published in the conference proceedings on digital media and in the series Advances in Intelligent Systems and Computing of Springer as a printed book. The registration fee includes a digital copy of the conference proceedings. The printed copy may be purchased for $50 per each including shipping. Ordered books will be delivered after the conference.

Social Events

Welcome Reception

Wednesday, 18 December at 6:00 pm -7:30 pm
At room #601 on Meeting Room Level

A light buffet meal and drinks will be offered to all participants and accompanying persons as a relaxing welcome. Attendees will be able to explore the conference venue.

Conference Banquet

Friday, 20 December at 6:30 pm -8:30 pm
At room #601 on Meeting Room Level

The banquet features celebrating Christmas, ending up the year and wrapping up the conference. Best paper award ceremony will be held as part of the banquet.

Venue & Floor Map

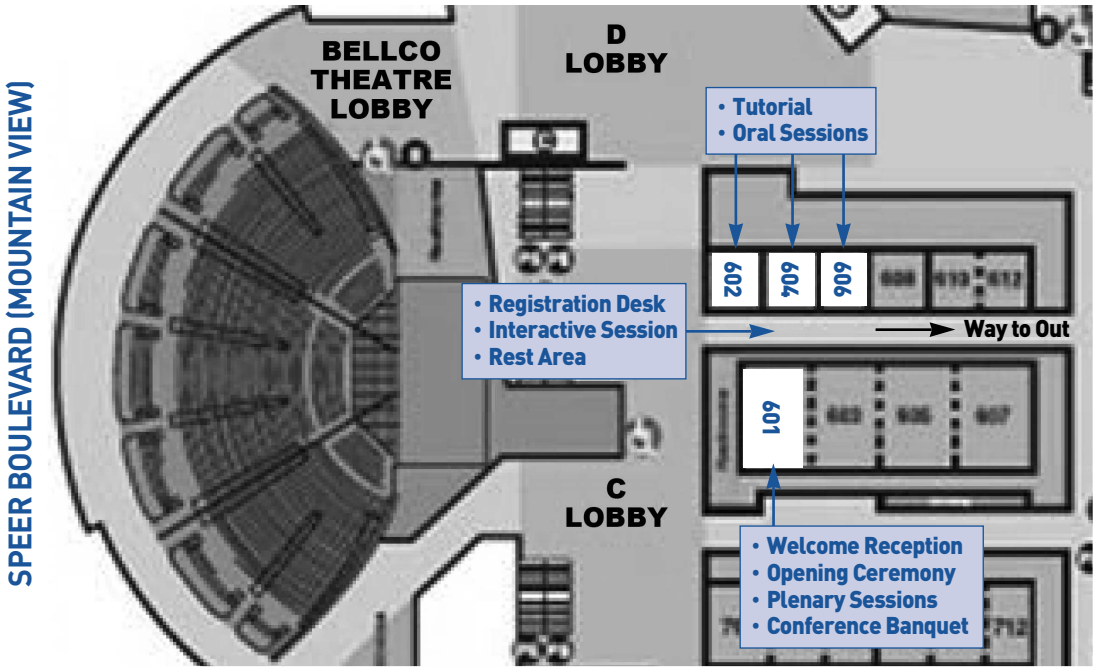
Conference Venue

All sessions and social events will be held at 600 meeting room level of Colorado Convention Center.

Colorado Convention Center and Bellco Theatre
700 14th St.
Denver, CO 80202
(303) 228-8000

Floor Map

- **Meeting Room Level**



Plenary Talks

Plenary Session I, T2PS-I, Rm#601, 11:30-12:20 Thursday, 19 December

"Dynamics and Control of Oscillatory Movements in Animal Locomotion"

Professor Tetsuya Iwasaki, University of California, Los Angeles, USA

Oscillations are often observed in nature at multiple levels, and form a basis for sustained operation of various functionalities. This talk introduces biological principles for coordinated oscillations and provides an overview of some recent developments on the analysis and design of dynamical mechanisms for oscillations, inspired by neuronal control systems. A particular focus will be placed on rhythmic body movements observed in animal locomotion, controlled by neuronal circuits called central pattern generators (CPGs).

Biological mechanisms for locomotion will be mathematically formalized by viewing rhythmic movements as a limit cycle resulting from dynamic interactions of a CPG, body, and environment. We then discuss a neuronal pattern formation problem, where it is examined how the neural interconnection structure within a CPG relates to the profile of oscillation. It is shown that the frequency and amplitude are encoded in the maximal eigenvalue of the interconnection matrix, and the phase pattern is encoded in the corresponding eigenvector. A biomechanical pattern formation problem is also discussed, where an optimal periodic body motion (or gait) is sought to minimize a quadratic cost function such as mechanical power consumption, while maintaining a prescribed locomotion velocity. The analysis and design methods are illustrated by undulatory swimming of slender fish and flapping propulsion of batoids.

The results form a basis for a fundamental theory of feedback control for coordinated oscillations, which has broad areas of potential applications, including periodic movements of robotic manipulators, autonomous vehicles inspired by animal locomotion, multi-vehicle motion coordination, phase synchronization of power systems, treatments for neurological disorders, and neuromechanical prosthetic devices.

His biography

Tetsuya Iwasaki received B.S. and M.S. degrees in electrical and electronic engineering from the Tokyo Institute of Technology (Tokyo Tech), Tokyo, Japan, and a Ph.D. degree in aeronautics and astronautics from Purdue University, West Lafayette, IN, in 1987, 1990, and 1993, respectively. He was a Post-Doctoral Research Associate with Purdue University from 1994 to 1995 and a Faculty Member with Tokyo Tech from 1995 to 2000 and the University of Virginia, Charlottesville, from 2000 to 2009. He is a Professor of mechanical and aerospace engineering with the University of California, Los Angeles since 2009.

His current research interests include biological control mechanisms underlying animal locomotion, nonlinear oscillators, global pattern formation via local dynamic interactions, and robust/optimal control theories and their applications to engineering systems. He is a coauthor of A Unified Algebraic Approach to Linear Control Design, Taylor & Francis, 1998, and a coeditor of Developments in Control Theory Towards Glocal Control, the IET, 2012. He has published 2 books, 7 book chapters, and more than 180 technical articles, 62 of which are in archival journals (~5000 citations, Google Scholar).

Dr. Iwasaki was a recipient of the CAREER Award from the National Science Foundation, the Pioneer Prize from the Society of Instrument and Control Engineers (SICE), the George S. Axelby Outstanding Paper Award from the Institute of Electrical and Electronics Engineers (IEEE), the Rudolf Kalman Best Paper Award from the American Society of Mechanical Engineers (ASME), and the Steve Hsia Biomedical Paper Award at the 8th World Congress on Intelligent Control and Automation. He has served as an Associate Editor of the IEEE Transactions on Automatic Control, Systems and Control Letters, the IFAC Automatica, the International Journal of Robust and Nonlinear Control, and the SIAM Journal on Control and Optimization. He is a Fellow of IEEE.

Plenary Session II, T3PS-II, Rm#601, 13:30-14:20 Thursday, 19 December

"Designing Constraint-Based Robots"

Professor Alan Mackworth, University of British Columbia, Canada

In order to thrive, a robot must satisfy dynamic constraints deriving from four sources: its internal structure, its goals and preferences, its external environment and the coupling between its internal and external worlds. The life of any robotic agent who acts without respecting those constraints will be out of balance. Based on this framework, I shall give four perspectives on the theme of designing constraint-based agents. The first is a discussion of the evolution of the concept of constraints in intelligent systems, from static to dynamic constraints. Second, I shall present our theory of constraint-based agent design and a corresponding experiment in robot architecture. Third, I shall sketch our work on the design and testing of a semi-autonomous wheelchair for people with physical and mental disabilities, who are living with significant additional constraints. Finally, our collective failure to recognize and satisfy various constraints explains why many of the multiple worlds we live in are so out of kilter. This approach suggests ways of restoring the balance.

His biography

Alan Mackworth is a Professor of Computer Science and Canada Research Chair in Artificial Intelligence at the University of British Columbia. He was educated at Toronto (B.A.Sc.), Harvard (A.M.) and Sussex (D.Phil.). He works on constraint-based artificial intelligence with applications in vision, robotics, situated agents, assistive technology and sustainability. He is known as a pioneer in the areas of constraint satisfaction, robot soccer, hybrid systems and constraint-based agents. He has authored over 100 papers and co-authored two books: Computational Intelligence: A Logical Approach (1998) and Artificial Intelligence: Foundations of Computational Agents (2010). He was President and Trustee of International Joint Conferences on AI (IJCAI) Inc.; he is on the IJCAI Executive Committee. He was President of the Canadian Society for Computational Studies of Intelligence (CSCSI) and President of the Association for the Advancement of Artificial Intelligence (AAAI). He has received the ITAC/NSERC Award for Academic Excellence, the Killam Research Prize, the CSCSI Distinguished Service Award, the AAAI Distinguished Service Award, the Association for Constraint Programming Award for Research Excellence and the Lifetime Achievement Award of the Canadian AI Association (CAIAC). He served as the founding Director of the UBC Laboratory for Computational Intelligence. He is a Fellow of AAAI, the Canadian Institute for Advanced Research and the Royal Society of Canada.

Plenary Talks

Plenary Session III, F2PS-III, Rm#601, 11:10-12:00 Friday, 20 December

"The Next Technological Wave: Intelligence Technology ("IT") for Intelligence Super-Agent"

Professor Jong-Hwan Kim, KAIST, Korea

Information technology (IT), first coined in 1958 and booming since the early 1990s, is the application of computers and telecommunication equipments to store, retrieve, transmit and manipulate data. In 1990s, the concept of Information Superhighway was developed to realize the goals of IT across the globe. In a business context, it has been defined as "the study, design, development, application, implementation, support or management of computer-based information systems" by the Information Technology Association of America. It has generated several associated industries, such as computer HW, SW, electronics, semiconductors, internet, telecom equipment, e-commerce and computer services.

Now we are facing a new technological challenge on how to store and retrieve knowledge and manipulate intelligence, in addition to the management of information and data, for autonomous services by intelligent systems. In this regard, the speaker has proposed "intelligence technology ("IT") for robots that think" in his recent paper in IEEE Computational Intelligence Magazine (August 2013). "IT" is the application of computers and machines to perceive and process data and information for knowledge-based reasoning and utilize their own reasoning to execute an appropriate action. "IT" covers all aspects of intelligence from perception at sensor level and reasoning at cognitive level to behavior planning at execution level for each low level segment of the machine. It is equipped with technologies for cognitive reasoning, social interaction with humans, behavior planning, ability to cooperate with other robots, ambience awareness, and an artificial genome that can be passed on to other robots. Based on these six aspects of intelligence technology, "IT" can be employed to build "Intelligence Super-Agent (iSA)." A virtual example for such an agent is VIKI (Virtual Interactive Kinetic Intelligence), an intelligent virtual super-agent from a science-fiction action film, I-Robot, released in 2004. iSA aims to augment human capabilities in perception, reasoning and actions as well as to provide intelligent supervision to lesser intelligent robots and devices within its domain

This talk presents the concept of iSA and Intelligence Operating Architecture (iOA) for realizing iSA using "IT." iOA, inspired by human brain functions, is a modular framework that can be used as a whole or in modules to generate intelligent functions for iSA. It can be used to implement different kinds of intelligence, such as cognitive intelligence, social intelligence, behavioural intelligence, ambient intelligence, collective intelligence and genetic intelligence. To emphasize the functionality of each category of intelligence, this talk also introduces the related research outcomes for building thinking robots, i.e. "Robots That Think," carried out at the Robot Intelligence Technology Lab., KAIST in recent years. These research outcomes include mechanisms of thought for robots, humanoid robot's ability to choose the gaze direction, evolutionary multi-objective optimization for humanoid robot navigation, etc. Moreover, DREAM (Development of Robots Enacted through user-level Agent-based Modularization) for realising iSA and other intelligent robots through iOA are also presented. These outcomes shall pave the way to the development of iSA.

Related publications are available at http://rit.kaist.ac.kr/home/International_Journal.

His biography

Jong-Hwan Kim received his B.S., M.S. and Ph.D. degrees in Electronics Engineering from Seoul National University, Korea, in 1981, 1983 and 1987, respectively. Since 1988, he has been with the Department of Electrical Engineering at KAIST and is currently KT Chair Professor. He was Head of Robotics Program, KAIST for 2004-2006. He is Adjunct Professor of Griffith University, Australia and Honorary Professor of De La Salle University, the Philippines. Dr. Kim is Director for the National Robotics Research Center for Robot Intelligence Technology. His research interests include computational intelligence and ubiquitous and genetic robotics. Dr. Kim has authored 5 books and 3 edited books, 2 journal special issues and around 300 refereed papers in technical journals and conference proceedings. He currently serves as an Associate Editor of the IEEE T. on Evolutionary Computation and the IEEE Computational Intelligence Magazine. Dr. Kim is one of the co-founders of the Int'l Conf. on Simulated Evolution and Learning in 1996, FIRA Robot Wold Congress in 2002 and Int'l Conf. on Robot Intelligence Technology and Applications (RiTA) in 2012. He was General Chair for the IEEE Congress on Evolutionary Computation, Korea, 2001, the IEEE Int'l Symp. on Computational Intelligence in Robotics and Automation, Korea, 2009, and RiTA 2012 and 2013. He has been on the program committees and advisory boards of more than 100 int'l conferences. Dr. Kim has delivered over 180 invited talks, keynote speeches and tutorials on computational intelligence and robotics in 24 countries. His name was included in the Barons 500 Leaders for the New Century in 2,000 as the Father of Robot Football. He is the Founder of FIRA and IROC and is currently serving them as President. Dr. Kim was the recipient of the science and technology award from the President of Republic of Korea in 1997 and has been elevated to 2009 IEEE Fellow.

T4A-2, Human-robot Interaction, Rm#602, 15:00-15:40 Thursday, 19 December

"Playware from Distributed Robotics"

Professor Henrik Hautop Lund, Technical University of Denmark, Denmark

Playware is defined as intelligent hardware and software that creates play and playful experiences for users of all ages. With recent technology development, we become able We conceptualized the approach of modular playware in the form of building blocks to exploit distributed robotics, modern artificial intelligence and embodied artificial life to create playware which acts as a play force that inspires and motivates users to enter into a play dynamics. Building blocks should allow easy and fast expert-driven or user-driven development of playware applications for a given application field, and the find their inspiration from distributed robotics.

Distributed robotics takes many forms, for instance as multi-robots, modular robots and self-reconfigurable robots. The understanding and development of such advanced robotic systems demands extensive knowledge in engineering and computer science. We introduce a method that allows a change of representation of the problems, related to multi-robot control and human-robot interaction control from a virtual to a physical representation focusing on interactive parallel and distributed processing programming as the foundation for distributed robotics and human-robot interaction development. Further, the proposed method provides a system for bringing into education a vast number of issues (such as parallel programming, distribution, communication protocols, master dependency, connectivity, topology, island modeling software behavioral models, adaptive interactivity, feedback, user interaction, etc.). We illustrate how the proposed system can be considered a tool for easy, fast, and flexible hands-on exploration of these distributed robotic issues, and show how to implement interactive parallel and distributed processing in robotics with different software models such as open loop, randomness based, rule based, user interaction based, AI and ALife based, and morphology based.

Further, the talk will present the design principles for creating such modular playware technology with focus on the embodied AI principles that forms the foundation for the design principles of modular playware technology. I will exemplify the design principles with practical applications from the fields of play, sports, music, performance art, and health.

His biography

Henrik Hautop Lund is head of the Center for Playware at Technical University of Denmark (DTU Elektro). Professor Henrik Hautop Lund is known world-wide for his work in bringing robotics to use in novel ways. His approach is to combine modular robotics and modern artificial intelligence to create novel solutions to problems that occupy the citizens of the World, e.g. obesity, rehabilitation, and 3rd World development. He has recently founded the Center for Playware to focus even further on how playful aspects of robotics may provide motivation for any citizen to perform different kinds of interaction with the robots of our future daily life. He chaired the Robots at Play festivals in the open city areas where researchers, artists, entertainers, and citizens meet through playful hands-on experience with robotics in the daily life of the citizens. In all cases, Lund has shown how the combination of a modern artificial intelligence, modular robotics and entertainment may provide novel opportunities in play, rehabilitation, sport, music, teaching, third World development, etc., by trying to allow non-expert users easy access to the technology in a playful and motivating way.

Professor Henrik Hautop Lund has published more than 150 scientific articles in the field of robotics, he has been a member of the Danish Research Council, and he has been invited to present his robotic work in numerous occasions, for instance for the Emperor of Japan at Akasaka Palace in Tokyo. He founded and headed the LEGO Lab in 1997-2000. He invented the RoboCup Junior robot football game for children, and his Adaptronics group won the RoboCup Humanoids Free Style World Championship 2002 in front of 120.000 spectators. Further, he developed the RoboMusic in collaboration with World Music Award winner, remix musician Funkstar De Luxe and later with Peter Gabriel. Professor Lund's work has received world-wide interest from news media, and he was nominated for the award for the best entertainment robots and systems research over the last 20 years at the IEEE International Conference on Intelligent Robots and Systems (IROS). He is nominated for the European Innovative Games Award.

F3IS-1, Special Talks Session, Rm#601, 13:30-14:00 Friday, 20 December

"Robot Navigation and Monitoring Technologies for U-City"

Professor Hyun Myung, KAIST, Korea

In this talk, the core technologies to provide various services in ubiquitous city (U-City) will be introduced, mainly focusing on localization, autonomous navigation, and monitoring technologies.

- Robot navigation
  - Wireless and Vision-based SLAM (Simultaneous Localization And Mapping)
  - Swarm robot formation control
  - JEROS (Jellyfish removal robot)
- Structural Health Monitoring (SHM)
  - Vision-based SHM
  - Flying and wall-climbing robot for SHM

His biography

Hyun Myung received his Ph.D. degree in electrical engineering from KAIST (Korea Advanced Institute of Science and Technology), Daejeon, South Korea in 1998. He is currently an associate professor in the Dept. of Civil and Environmental Engineering, and also an adjunct professor of the Robotics Program at KAIST. He was a principal researcher in SAIT (Samsung Advanced Institute of Technology, Samsung Electronics Co., Ltd.), Yongin, South Korea (2003.7-2008.2). He was a director in Emersys Corp. (2002.3-2003.6) and a senior researcher in ETRI (Electronics and Telecommunications Research Institute) (1998.9-2002.2), South Korea. His research interests are in the areas of robotic SHM (Structural Health Monitoring), mobile robot navigation, autonomous underwater vehicle, autonomous surface vehicle, SLAM (Simultaneous Localization And Mapping), evolutionary computation, numerical and combinatorial optimization, and intelligent control based on soft computing techniques.
He recently developed JEROS (Jellyfish Elimination RObotic Swarm) which is the world first surface vehicle that can remove jellyfish autonomously in the ocean environment.

F3IS-2, Special Talks Session, Rm#601, 14:00-14:30 Friday, 20 December

"Recent Advances in Humanoid Robotics"

Professor Jacky Baltes, University of Manitoba, Canada

The talk describes recent advances in humanoid robotics research in the areas of active balancing and push recovery. The first part of the talk will describe Jennifer, the first ice hockey playing humanoid robot. As most beginning skaters will realize very quickly, ice skating is a more difficult than walking. The talk will analyze ice skating from the perspective of humanoid robotics control and will highlight the differences between skating and walking. This leads to a discussion of why typical approaches to humanoid robotics control such as zero moment point (ZMP) control do not work well on skating robots.

In the second part, a highly dynamic challenge task - balancing on a bongo board (also called balance board) - is introduced. A bongo board is a flat board that is put on top of a small barrel. This task is often performed by acrobats in the circuit, since it is difficult and people need to practice for a long time before they can balance on the board. Not surprisingly, this task is also very difficult for robots. The bongo board or related rod and cart system have often been analysed as an inverted pendulum and is a classical problem in control. Many control systems have been proposed including traditional control and more modern approaches such as neural networks, fuzzy logic, and reinforcement learning. However, implementing these approaches in practice is hard because of limits in the accuracy and update speed of sensors and actuators. We describe a predictive control approach that allows us to overcome these limitations and is able to balance the robot in a dynamically stable configuration.

His biography

Dr. Jacky Baltes is a Full Professor in the department of computer science at the University of Manitoba in Winnipeg, Canada. Dr. Baltes was born and grew up in Munich, Germany. He is a three time national champion in speed skating and participated at the 1984 and 1988 Olympic games. Dr. Baltes received his Ph.D. in 1996 from the University of Calgary, Canada in the area of artificial intelligence and machine learning. For his Ph.D., Dr. Baltes developed a learning multi-strategy planning system called DoLittle. From 1996 to 2002, Dr. Baltes worked as a senior lecturer in the department of computer science at the University of Auckland, New Zealand. In 2002, Dr. Baltes moved to the University of Manitoba in Winnipeg, Canada.

Dr. Baltes and his students have participated at international robotics competitions for robotic soccer and urban search and rescue since 1998. His teams won honours in the FIRA HuroCup humanoid robot competition (HuroCup 2002, 2003,and 2004), RoboCup E-League (1st Place 2004), RoboCup humanoid league (2002, 2003), and ICRA DARwIn OP Application Challenge (1st Place 2012). Dr. Baltes has published over 100 peer reviewed articles and was on the program committee for several international conferences. He is a vice president of the Federation International of Robotic Soccer (FIRA), chair of the International HuroCup competition. He is an executive committee member of the International RoboCup Federation and co-chair of the RoboCup humanoid league competition. He is also a a member of the steering committee of the International Robot Olympiad (IRO).

Dr. Baltes is the founder of White Magic Robotics, a successful start-up company founded in 2006, that develops robotic simulation software. His recent enterprise is Taibotics, a company that develops educational robotic kits.

F3IS-3, Special Talks Session, Rm#601, 14:30-15:00 Friday, 20 December

"Robotic Intelligence-a Specific Form of Artificial Intelligence"

Professor Victor Raskin, Purdue University, USA

Much success has been achieved in robotic hardware: today's robots can perform physical activities that were not achievable only a few years ago: they are more stable, faster, carry more sensors, are more versatile. At the same time, progress, not so dramatic perhaps but stable, has been achieved in artificial intelligence (AI) and its applications. This paper focuses on bringing these two types of parallel achievements together, thus rendering the robots more autonomous, smarter, and usable in more applications as well as rendering AI theory testable and verifiable in practical applications. One reasonably mature approach to such a synthesis is the onthologization of the robotic world and aligning this ontology with the general property-rich multi-domain ontology, such as the one developed in Ontological Semantic Technology (OST) (cf. Raskin 2012, the Best Paper Award presentation at RITA 2012). This approach underlies the HARMS hybrid natural-language-based (NL-based) system of communication within a team of humans, robots, agents, etc. (see Matson et al. 2011, an ICARA presentation).

The specificity of AI in robotic intelligence is that the world of each individual robot is limited to its capabilities and functionalities, even though it is not as "primitive" as one might think (see Raskin 2012, again). As a result, any general command, whether in NL, such as English or Korean, or in any other ontologized form, that orders the robot to go somewhere and do something must be transposed into the very specific modes of activity for each robot. The paper will show that, seemingly an endless nuisance, this is not a unique situation but rather a domain-shift that is characteristic of purely human use of NL and has been proven to be computationally feasible in OST.

A special role in the development of the theoretical base and in computational implementation of this ontological process of specification/robotization is played by the crucial notion of scripts as goal-oriented strongly standardized sequences of actions. Thus, the typical "go and do something" command for a human will typically involve getting dressed, collecting all the necessary items, getting into the car, driving to a familiar place and, say, depositing a check in an ATM. For the robot, a command to determine and report what the outside temperature is, will mean to activate and read the temperature sensor and then to determine the best way to communicate it to the ordering human and/or another robot. If this operation requires a physical contact or proximity, the determination of its own and the other party's location and figuring out the shortest and safest route, with obstacle-avoidance becomes part of the script. The detection and determination of the scripts is essential for any information processing system but, for the robots, the problem seems both simpler because of the limited world of the robot, and more complex because every seemingly trivial process must be explicated without any possibility of glossing over it.

The last point of the paper is that extending the robotic intelligence will also extend the robotic applications as well as their marketability. A fire-fighting robot, for instance, that is capable a significant number of chips, may take over its own navigation, thus dispensing with human tele-guidance, carry a large number of sensors, analyze an image on its camera on its own, thus differentiating between a sack of sand or an unconscious human, communicate with other fire-fighting and different-specialization robots, such as those in charge of medical evacuation from an environment that is harmful to a human, and perform other well-defined human tasks in HARMS-type team environment. Notably, many such capabilities will extend beyond fire-fighting, thus making the robots usable and marketable for a wider spectrum of applications.

The author would like to acknowledge his indebtedness to Profs. Julia M. Taylor and Eric T. Matson of Purdue's M2M Lab as well as their and his own graduate students/research assistants, current and former, for their valuable contributions to his conceptualizing the ideas and methods of this research. He is fully responsible, however, for the statements in this paper without implying that his colleagues fully share all of them.

His biography

Having earned all of his degrees from Moscow State University in Moscow, then USSR, currently Moscow Lomonosov University of Russia (B.A. in Linguistics/B.S. in Discrete Mathematics, 1964; M.A. in Formal and Computational Linguistics/M.S. in Algorithms, Automata, and Computer Science, 1966; Ph.D. in Mathematical, Structural, and Computational Linguistics, 1970), Victor Raskin advanced from Lecturer to Acting Associate Professor at his alma mater

(1966-73), was a Senior Associate Professor at the Hebrew University of Jerusalem (Philosophy of Science and General Linguistics, full time) and Tel Aviv University (Linguistics, half-time) in 1973-78. He was hired by Purdue University to found the Program in Linguistics as an Associate Professor of English in 1978, promoted to Full Professor in 1980 and was made Distinguished Professor of English and Linguistics in 2007. With Professors E. H. Spafford and M. J. Atallah in 1998, he co-founded CERIAS, the Center for Education and Research in Information Assurance and Security at Purdue University, where he has served as an Associate Director, becoming its Charter Fellow in 2009. He also co-founded and has run the Interdisciplinary Graduate Program in Information Security since 2000. Raskin's research has focused on the formal semantic theory of natural language and its theoretical extensions and computational applications to half a dozen adjacent areas. He founded the rigorous scientific study of the linguistics of humor in 1979-85 and has since raised a couple of generations of humor researchers all over the world, leading to the development of computational humor as an important component of social computing. With his former Ph.D. advisee, Prof. Dr. Sergei Nirenburg, he developed Ontological Semantics, a theory and methodology of meaning-based natural language processing in the 1990s, and with his collaborators, Prof. Julia M. Taylor and C. F. Hempelmann, he has revised and improved that theory into the Ontological Semantic Technology, which has been applied to robotic intelligence in collaboration with Prof. E. T. Matson. In 1999-2001, with M. J. Atallah, he founded natural language information assurance and security (NL-IAS) that developed a number of pioneer applications, such as NL watermarking and tamperproofing and, later, semantic forensics that detects contradictions and flags possible deception. Raskin has published 17 books and over 250 papers on semantic theory, philosophy of language, humor theory, computational humor, computational semantics, and robotic intelligence. He has supervised over 200 Ph.D. dissertations at Purdue and elsewhere. He has been a visiting professor and scholar at several US and foreign universities and delivered a large number of invited lectures, keynote and plenary addresses. He has also served as a chief scientific advisor for several companies implementing ontological semantic applications

Special Sessions

Special Session 1, T1C, Rm#606, 08:50-10:50 Thursday, 19 December

Soft Robotics

Organizer: Professor Peter Xu, the University of Auckland, New Zealand

This session will present some recent advance in soft robotics including design, modeling, fabrication, sensing, actuation and control. A number of unique applications will also be demonstrated.

Special Session 2, T5A, Rm#602, 16:20-18:00 Thursday, 19 December

Knowledge Representation for Robotics and Automation

Organizer: Craig Schlenoff, National Institute of Standards and Technology, USA

One of the basic requirements for any type of robot communication (regardless if with other robots or humans) is the need for a common vocabulary with clear and concise definitions. With the growing complexity of behaviors that robots are expected to perform as well as the rise of multi-robot and human-robot collaboration, the need for a well-defined knowledge representation is becoming evident. The existence of such a standard knowledge representation would:

1) Precisely define concepts and relations in the robot's knowledge representation,
2) Ensure common understanding among members of the community and
3) Facilitate efficient data integration and transfer of information among robotic systems.

This special session will have papers and presentations from areas such as knowledge representations for industrial robots, service robots, unmanned aerial vehicles, autonomous underwater vehicles, and others. All of them are will address knowledge representation and reasoning challenges.

Part of the focus of this special session will be on the IEEE-RAS Working Group entitled "Ontologies for Robotics and Automation" (IEEE WG ORA). This group aims to develop a standard ontology and associated methodology for knowledge representation and reasoning in robotics and automation. This standard will provide a unified way for representing knowledge allowing for unambiguous knowledge transfer among any group of humans, robots, and other artificial systems. The working group has more than 150 members from different countries around the globe.

Topics of interest include:

- Standards for robotics and automation
- Ontology development for robotics and automation
- Knowledge representation for robotics and automation
- Reasoning techniques for robotics and automation ontologies
- Activity recognition
- Knowledge enabled control of robots
- Industrial automation using ontologies
- Robot-robot collaboration using ontologies
- Human-robot collaboration using ontologies
- Human-robot intention recognition
- Knowledge representation and reasoning in ubiquitous environments.

Special Session 3, T4B, Rm#604, 14:40-16:00 Thursday, 19 December

Underwater Robots & Applications

Organizer: Dr. Hyun-Taek Choi, Korea Institute of Ocean Science & Technology, Korea

Recently, an underwater robotic vehicle market known as conservative has been changed toward reducing operating cost. Since the major portion of operating cost is large supporting facilities and well-trained personnel's, robotic intelligence plays very important roles for highly demanding market-driven needs just like ground robots and aerial robots. Unfortunately, underwater environment is too tough to be able to make our expectation true, which could be barriers to people who want to get into new fused research area. Nevertheless, many researchers have been working for algorithms pursuing a real unmanned underwater robot, they have been announcing many results on various topics including robot vision, sound source localization, intelligent localization and navigation, probability based filtering, 3D path planning, middleware, optimal design & implementation and so on. In this session, we'd like to share common objectives regarding intelligent underwater robots and to try to give you new chances to pick up fresh idea from various background people.

Special Session 4, F4A, Rm#602, 15:10-16:30 Friday, 20 December

Flapping-Wing Air Vehicles - Construction, Control, and Validation

Organizer: Dr. Sanjay Boddhu, Wright State University, USA

Flapping-Wing Air Vehicles present significant challenges in construction, control, modeling, and validation. In this special session, we will address each of these topics via a combination of invited and submitted papers. Of special interest are papers that address construction and control of actual (not simulated) vehicles and papers that attempt to advance the art of controller adaptation and performance verification in actual operational environments while conducting normal missions.

Tutorial, Rm#602, 15:30-17:30 Wednesday, 18 December

"Using Cultural Algorithms to Design Controllers for Robot and Softbots"

Dr. Robert G. Reynolds, Wayne State University / University of Michigan-Ann Arbor, USA

A. Tutorial description:

Cultural Algorithms were developed by Reynolds as a computational framework in which to embed social learning in an evolutionary context [1979]. Unlike traditional learning approaches Cultural Algorithms derive their power from large collections of interacting agents. Within virtual worlds such as games or other interactive digital entertainment systems it is often the case that we wish to coordinate the behavior of large groups of intelligent agents in an efficient fashion. This tutorial focuses on the ability of Cultural Algorithms to perform large-scale group learning within these virtual worlds. They have been used to generate socially intelligent controllers and group social behavior in various gaming genres, both serious and fun. This tutorial describes Cultural Algorithms and how they can be used to incorporate social intelligence into a virtual world using examples form a variety of genres. A toolkit based upon the Cultural Algorithms paradigm will be presented and used as a basis for developing example applications.

B. Content Outline:

1. What are Cultural Algorithms:
   A basic description of the Cultural Algorithm Framework and its relationship to other socially motivated learning technologies will be described along with an introduction to the Cultural Algorithms Toolkit, CAT 3.1 that supports mutli-objective problem solving.
2. Why Cultural Algorithms work:
   Here we discuss the basic phases of the problem solving process in Cultural Algorithms and how those phases emerge from the interaction of the knowledge sources in the belief space, knowledge swarms, and the population of problem solvers in the population space. Convergence properties will be discussed.
3. When will Cultural Algorithms work?
   Since Cultural Algorithms derive their power from the emergence of knowledge and population swarms, what problems are suitable for solution with Cultural Algorithms and what problems will be hard or deceptive?
4. Virtual Worlds:
   Since Cultural Algorithms derive their power from the emergence of knowledge and population swarms, what problems are suitable for solution with Cultural Algorithms and what problems will be hard or deceptive?
   a. The Basic Components
   b. Opportunities for Socially Motivated Learning in Virtual Worlds.
      1. Avatar design.
      2. Collective movement.
      3. Group decision making.
      4. Level design.
      5. Application Examples:
   a. Game Worlds
      1. Platform Games: Super Mario
      2. 3D Racing Games
      3. Real Time Strategy Games: Starcraft
   b. Real Worlds
      1. Emergence of Urban Centers
      2. The Ancient Land Bridge (Prehistoric Hunter-Gatherers).
      3. Vanishing Societies
      4. Health Care Applications
      5. Sustainable Culture

His biography

Dr. Robert G. Reynolds received his Ph.D. degree in Computer Science, specializing in Artificial Intelligence, in 1979 from the University of Michigan, Ann Arbor. He is currently a professor of Computer Science and director of the Artificial Intelligence Laboratory at Wayne State University. He is a Visiting Associate Research Scientist with the Museum of Anthropology at the University of Michigan-Ann Arbor, a member of the Complex Systems Group at the University of Michigan-Ann Arbor, and is a participant in the University of Michigan ?Wayne State University NSF IGERT program on Incentive-Based Design. His interests are in the development of computational models of cultural evolution for use in the simulation of complex organizations and in computer gaming applications. Dr. Reynolds produced a framework, Cultural Algorithms, in which to express and computationally test various theories of social evolution using multi-agent simulation models. He has applied these techniques to problems concerning the design of controllers for softbot and robot controllers in both virtual and real world systems.

Dr. Reynolds AI group has won several prizes in controller design for IEEE Gaming Competitions including first place in the IEEE World Congress Super Mario Controller Design Competition, second place in the 2008 IEEE World Congress Racing Controller Competition, third place in the 2012 IEEE Turing Competition, and second place in the IEEE CEC 64 Bit World in a Word Competition. In addition his group has won several best paper awards including the Best Paper of 2008 in the International Journal of Intelligent Computing and Cybernetics and the best student paper at the 2010 IEEE World Congress on Computational Intelligence in Barcelona, Spain, and the Overall Best Paper at the 2013 IEEE Congress on Evolutionary Computation.

Technical Program Information

Each session in the technical program is assigned a unique number which clearly indicates when and where the paper is presented. A typical number is shown below:

Typical Session Number: T1A.2

The first letter (i.e. T) indicates the day of the conference.
T = Thursday
F = Friday

The second number (i.e. 1) indicates the time of the day.
1 = the first time
2 = the second time
3 = the third time
4 = the fourth time
5 = the fifth time

The third letter (i.e. A) shows the location of the presentation which is one of the session rooms.
A = Rm#602
B = Rm#604
C = Rm#606
P = Lobby
PS & IS = Rm#601

The fourth letter (i.e. 2) shows the presentation order in the session.
1 = the first presentation
2 = the second presentation
3 = the third presentation
4 = the fourth presentation
5 = the fifth presentation
6 = the sixth presentation

Technical Program Details

-Program and Abstracts: Thursday, 19 December

-Program and Abstracts: Friday, 20 December

Thursday, 19 December

T1A	Intelligent Agents & Medicine	602

08:50-10:50

Chairs : Riaan Stopforth, University of KwaZulu-Natal, South Africa
Qining Wang, Peking University, China

T1A-1

08:50-09:10

Dynamic Simulation of a Sagittal Biped System

Riaan Stopforth and Glen Bright
University of KwaZulu-Natal, South Africa

Controlling a system with chaotic nature provides the ability to control and maintain orbits of different periods which extends the functionality of the system to be flexible. A system with diverse dynamical behaviours can be achieved. Simulations of dynamic modelling of a sagittal biped system is investigated and results are obtained.

T1A-2

09:10-09:30

Axon: a Middleware for Robotic Platforms in an Experimental Environment

Michael Morckos and Fakhreddine Karray
University of Waterloo, Canada

Major strides have been achieved recently in developing frameworks for multi-robot systems. The need to integrate different heterogeneous robotic systems has led to the emergence of robotic middleware design. The aim of the work presented in this paper is to develop an easy-to-use middleware that is able to effectively handle multiple robots and clients within an experimental environment. Unlike previous work in robotic middleware which models a robot as a network of components and provide low-level control, our proposed approach provides a highlevel representation of robots. We also introduce the notion of efficient structured data exchange as an important aspect in robotic middleware research. We designed and developed our middleware using recent technologies. Moreover, two different robotic platforms, the PeopleBot mobile robot and the Cyton Alpha robotic arm, were used to test and evaluate the middleware's ability to integrate different types of robots. A series of performance measurement experiments were carried out to gauge the middleware's ability to handle multiple robots.

T1A-3

09:30-09:50

Coordination of UAV-UGVs Team with Vision-Based Mapping and Greedy Task Allocation

Keum-Seong Kim, Gun-Hee Moon, Jeong-Woon Kim, Ji-Won Jeong, Han-Lim Choi, David Hyunchul Shim and Min-Jea Tahk
Korea Advanced Institute of Science and Technology, Korea

This paper addresses architecture of a cooperative mission which is conducted by a team of heterogeneous mobile platforms. The concept of the mission is based on future battle field environment which is operated by a team of heterogeneous platforms. The mission demonstrated in this paper consists of a surveillance task conducted by an UAV and multiple target assignment of UGVs. Image processing was conducted for generating an environmental map which contains obstacles and targets information. As a ground mission, path planning and high level task assignment are employed. Path planning process employs Visibility graph and Dijkstra's algorithm. In task assignment step, sequential greedy task allocation algorithm is used. Indoor experiments demonstrate feasibility of the overall cooperative mission process.

T1A-4

09:50-10:10

Classifier Selection for Locomotion Mode Recognition Using Wearable Capacitive Sensing Systems

Yi Song[1,3], Yating Zhub, Enhao Zheng[1,3], Fei Tao[2] and Qining Wang[1,3]
[1]Peking University, China, [2]Beihang University, China, [3]Beijing Engineering Research Center of Intelligent Rehabilitation Engineering, China

Capacitive sensing has been proven valid for locomotion mode recognition as an alternative of popular electromyography based methods in the control of powered prostheses. In this paper, we analyze the characteristics of the capacitive signals and extract suitable feature sets to improve the recognition accuracy. Then the classification results of different classifiers are compared and one optimal classifier which can offer highest accuracy within a reasonable time limit is selected. Experimental results show that the recognition accuracy of the wearable capacitive sensing system has been improved by using the selected classifier.

T1A-5 10:10-10:30

Development of Jaw Exoskeleton for Rehabilitation of Temporomandibular Disorders

Xiaoyun Wang[1], Johan Potgieter[1], Peter Xu[2] and Olaf Diegel[1]
[1]Massey University, New Zealand, [2]University of Auckland, New Zealand

A jaw exoskeleton is proposed in this paper to assist the exercise for the purpose of practical rehabilitation of temporomandibular disorder (TMD). The jaw, attached to the skull by muscles and pivoted at the condyle via the temporomandibular joint (TMJ), can be simplified as moving in the two-dimensional sagittal plane. Based on the in-vivo recording the jaw movement from the healthy subject, the motion pattern is justified to be the primary specification to design the jaw exoskeleton. A planar four-bar linkage is synthesized to reproduce the specified normal jaw motion in terms of incisor and condyle trajectory on the coupler point to meet the kinematic specification. Adjustable lengths of the links are used to achieve a group of trajectories of any possibility.

T1A-6 10:30-10:50

Towards a Touchless Master Console for Natural Interactions in Sterilized and Cognitive Robotic Surgery Environments

Cai Lin Chua[1], Hongliang Ren[1] and Wei Zhang[2]
[1]National University of Singapore, Singapore, [2]Shandong University, China

With the increasing benefits of minimally invasive surgery (MIS), computer assisted surgical systems are widely used to handle the challenges of sterilization, augmented reality, intracorporeal accessibility, dexterity in confined space and precision demanded in MIS. In conventional surgical environments, the sterilized objects in the surgical space are manipulated either manually or by tele-operated master-and-slave system. One of the challenges faced in this kind of manipulation is the physical controls can present risks of non-sterile contact for surgeons in a highly sterilized operating room. Gesture recognition has been widely researched as a Natural User Interface (NUI) for human-computer and human-robot interactions. This paper focuses on assessing the feasibility of using skeletal tracking as a touchless control interface for the master consoles of master-and-slave surgical robotic systems. A demonstration system that uses one RGB-D sensor is set up for the purpose of the assessment.

T1B | Navigation / SLAM / Localization | 604

08:50-10:50

Chairs : Peter Sincak, Technical University of Kosice, Slovak Republic
Hyun Myung, KAIST, Korea

T1B-1 08:50-09:10

A Convex Fuzzy Range-Free Sensor Network Localization Method

Fatma Kiraz, Barış Fidan and Fakhri Karray
University of Waterloo, Canada

We propose a new fuzzy range-free sensor localization methodology, using certain Euclidean notions to build convex fuzzy sets and circumvent multiple stable local minima issues, encountered in some recent range-free localization approaches. A range-free localization algorithm is developed based on the proposed methodology. Performance of the developed algorithm is tested via a set of simulations, comparatively to some recent fuzzy range-free localization algorithms in the literature.

T1B-2

09:10-09:30

Multi-Directional Weighted Interpolation for Wi-Fi Localisation

Dale Bowie, Jolon Faichney and Michael Blumenstein
Grith University, Australia

The rise in popularity of unmanned autonomous vehicles(UAV) has created a need for accurate positioning systems. Due to the indoor limitations of the Global Positioning System (GPS), research has focused on other technologies which could be used in this landscape with Wi-Fi localisation emerging as a popular option. When implementing such a system, it is necessary to find an equilibrium between the desired level of final precision, and the time and money spent training the system. We propose Multi-Directional Weighted Interpolation (MDWI), a probabilistic-based weighting mechanism to predict unseen locations. Our results show that MDWI uses half the number of training points whilst increasing accuracy by up to 24%.

T1B-3

09:30-09:50

Visual Loop-Closure Detection Method Using Average Feature Descriptors

Deok-Hwa Kim and Jong-Hwan Kim
KAIST, Korea

This paper proposes a novel visual loop-closure method using average feature descriptors. The average feature descriptors are computed by averaging the descriptors of feature points at each frame. Through GPGPU (General-Purpose computing on Graphics Processing Units) technique, the proposed method selects a frame having a minimum distance with the current average feature descriptor from the average feature descriptor history. After the minimum distance calculation, loop-closure is determined by matching feature points between the selected frame and current frame. Experiments results demonstrate that the proposed method successfully detects the visual loop-closure and is much faster than the conventional visual loop-closure method in detecting the visual loop-closure.

T1B-4

09:50-10:10

Mobile Robot Localization using Multiple Geomagnetic Field Sensors

Seung-Mok Lee, Jongdae Jung and Hyun Myung
KAIST, Korea

This paper proposes a novel approach to substantially improve the performance of the conventional vector field SLAM (simultaneous localization and mapping) by using multiple geomagnetic field sensors. The main problem of the conventional vector field SLAM is the assumption of known data association. If a robot has a high uncertainty of the pose estimate, the probability of data association failure increases when the robot's pose is located in a wrong cell. To deal with this problem, we propose a multi-sensor approach utilizing multiple geomagnetic field sensors. As the multi-sensor approach updates nodes of one or more cells simultaneously, the probability of data association failure significantly decreases. The proposed multi-sensor-based localization is implemented based on a Rao-Blackwellized particle filter (RBPF) with geomagnetic field sensors. Simulation results demonstrate that the proposed approach greatly improves the performance of the vector field SLAM compared to the conventional approach with a single sensor.

T1B-5

10:10-10:30

GA-based Optimal Waypoint Design for Improved Path Following of Mobile Robot

Jae-Seok Yoon[1], Byung-Cheol Min[2], Seong-Og Shin[1], Won-Se Jo[1] and Dong-Han Kim[1]
[1]Kyung-Hee University, Korea, [2]Purdue University, USA

Mobile robot can follow the planned path using a waypoint following guidance scheme. As this type of guidance scheme only uses the position of waypoints to navigate the path, the waypoint following is relatively simple and efficient to implement. However, it is non-trivial to determine the number and size of waypoints, which heavily affect the performance of robot. Thus, we tackle the problem of finding the optimal number and size of waypoints in this paper. For this optimization problem, we use genetic algorithm, where the effectiveness of the proposed method is verified in MATLAB simulation. The proposed method shows that mobile robot effectively navigates the planned path and successfully reaches the destination with the minimum path following error and travel time.

T1B-6

10:30-10:50

Indoor Mobile Robot Localization Using Ambient Magnetic Fields and Range Measurements

Jongdae Jung, Seungmok Lee and Hyun Myung
KAIST, Korea

In this paper we present a method for solving an indoor SLAM and relocation problem using ambient magnetic fields and radio sources. Specifically, we exploit the magnetic field anomalies and noisy radio ranges in indoor environments. A robot with two magnetometers and one active radio range sensor first explores the unknown environment based on the simultaneous localization and mapping (SLAM) technique, gathering its path and some useful multisensory observations. The gathered data are then applied to the Monte Carlo localization (MCL)-based relocation algorithms. The performance of the proposed methods is validated by simulation using the real-world data.

T1C	Soft Robotics	606

08:50-10:50

Chairs : Jian Zhu, National University of Singapore, Singapore
Weimin Yang, Beijing University of Chemical Technology, China

T1C-1

08:50-09:10

A New Kind of Soft Robotics Actuating by Electromagnetic Force

Zhi-Wei Jiao, Xiang-Cheng, Luo- Zhang and WeiMin-Yang
Beijing University of Chemical Technology, China

A soft robot is a new kind of robots, its actuator is the bottleneck problem in the design of soft robots. This paper presents a new actuation mechanism by the contraction and restoring force of the epidermal structure and generated mutual repulsion when the adjacent electromagnetic units are charged with electricity. The epidermal structure is formed by the polymer of the elastomeric material having the telescopic deformation capacity, in which four groups of actuators made of several flexible electromagnet units with symmetrically relative polarity in series. Generated mutual repulsion when the adjacent electromagnetic units are charged with electricity leads to the epidermis deformation, and the repulsive force disappears when power is off, but the elastomeric material of the epidermis will contract, which results in the motion of the soft robot. In accordance with a certain sequence, to control the current or voltage of electromagnets when charged can achieve the relevant control of the motion of the soft robot. The solution of the research problems of the project will provide new ideas for designs and researches of soft robots.

T1C-2

09:10-09:30

Soft-Robotic Peristaltic Pumping Inspired by Esophageal Swallowing in Man

Steven Dirven, Weiliang Xu, Leo K.Cheng and John Bronlund
University of Auckland, New Zealand

The demand for novel actuation and sensation technologies has seen the emergence of the biomimetic engineering field where inspiration is drawn from phenomena observed in nature. Soft robotic techniques are particularly suitable for physical modeling in this area as they can be designed to manifest features such as mechanical compliance and continuity. The process of peristalsis is common in many organisms for locomotion or pumping transport of fluid or semi-solid materials. This research initiative looks into how inspiration from the esophageal phase of swallowing can be communicated into the engineering domain such that a physical model of the esophagus can be developed. The resulting device is of a soft-robotic nature, asserted by pneumatic actuation on a silicone rubber conduit. The continuous nature of device output, and its perturbation throughout pumping transport present some interesting trajectory generation and control challenges. The inspiration for the mechanical design as well as the embodiment of device transport intelligence is described.

T1C-3

09:30-09:50

Design and Fabrication of a Soft Actuator for a Swallowing Robot

Fei-Jiao Chen[1,3], Steven Dirven[2], Wei-Liang Xu[2], Xiao-Ning Li[3], John Bronlund[1]

[1]Massey University, New Zealand, [2]University of Auckland, New Zealand, [3]Nanjing University of Science and Technology, New Zealand

Textured food is provided to dysphagia populations in clinical practice for assessment and management of swallowing disorders. A considerable amount of measurements showed that the textural properties of food can affect the performance of human swallow significantly. However, the selection of food for a specific subject is difficult, due to the complexity of the biological structures and the potential risks of in vivo testing. For the purpose of providing a safe environment for food flow study, a novel soft actuator capable of producing peristalsis movement was proposed. During the esophageal swallowing, which is the last stage of human swallow, food is transported through the muscular tube by peristalsis mechanism. The motion pattern is generated by the coordinated contractions of circular muscles of the esophagus. Inspired by human esophagus and the biological process, the actuator was designed to have a completely soft body without any hard components. Discrete chambers are embedded inside the body regularly and a cylindrical food passage locates at the center of the actuator. Finite element analysis (FEA) was used to determine the structure parameters of the actuator. The soft body was fabricated by casting silicon material in a custom mold. Preliminary experiments have been performed to characterize the actuator.

T1C-4

09:50-10:10

Development of a soft jellyfish robot based on dielectric elastomer actuators

Weiping Ng, Bo Li, Chongyan Chew and Jian Zhu

National University of Singapore, Singapore

Unmanned underwater vehicles (UUVs) are used for valuable functions such as the study of marine life, sea and seabed environmental conditions and exploration, oceanography, monitoring of ocean currents, detection of chemical agents, etc. It is significant to study and develop UUVs. We propose that biomimetic jellyfish would be a good choice for UUVs. Jellyfish are commonly found in the waters surrounding Singapore. Their biology suggests that they are good candidates for a biomimetic study as they are well adapted for ocean living. For example, natural jellyfish have several good attributes such as its ability to consume little energy owing to a lower metabolic rate compared to other marine species. In this seminar, I will talk about a prototype of a jellyfish-like robot, which we developed recently. This robot mainly consists of a bell, an air chamber, and a dielectric elastomer membrane. The air chamber is filled with air, which makes the dielectric elastomer membrane pre-stretched and bulged into a balloon. The balloon can provide a buoyancy to balance the gravity of the robot. The air chamber is fixed with the bell through connecting bars. When the voltage is off, the balloon has small volume. When the voltage is on, the dielectric elastomer membrane expands, and the balloon volume increases. As a result, the buoyancy can increase. Meanwhile the water can be ejected from the jet apertures to obtain jet propulsion. The preliminary studies show that dielectric elastomers can be potentially used in biomimetic underwater robots, due to large deformation, light weight, and low noise. This could be the first time that dielectric elastomer actuators are employed in underwater robots. At the next step, we will improve the mechanical designs of the robot to improve efficiency of jet propulsion. The bell will have a structure similar to a mechanical umbrella. By opening and closing the "umbrella", the robot can eject more water from the robot body to obtain a large jet propulsion. We will use the finite element method to simulate the robot's movement, so that we can determine how the whole robot body deforms, when a voltage is applied to the dielectric elastomer actuators. These findings will allow us to control the robot's movement effectively.

T1C-5

10:10-10:30

A P300 Model for Cerebot-a Mind-Controlled Humanoid Robot

Mengfan Li[1], Wei Li[1,2], Jing Zhao[1], Qinghao Meng[1], Ming Zeng[1] and Genshe Chen[3]

[1]Tianjin University, China, [2]California State University, USA, [3]Intelligent Fusion Technology, Inc, USA

In this paper, we present a P300 model for control of Cerebot-a mind-controlled humanoid robot, including a procedure of acquiring P300 signals, topographical distribution analysis of P300 signals, and a classification approach to identifying subjects' mental activities regarding robot-walking behavior. We design two groups of image contexts to visually stimulate subjects when acquiring neural signals that are used to control a simulated or real NAO robot. Our study shows that the group of contexts using images of robot behavior delivers better performance.

T1C-6

10:30-10:50

Preliminary Experiments on Soft Manipulating of Tendon-Sheath-Driven Compliant Joints

Wang Kai and Wang Xingsong

Southeast University, China

This paper introduced a kind of Tendon-Sheath-actuated compliant joints which fixed on some long and slender robot for searching and inspection interior of confined space safely. The actuator discussed in this paper is comprised of the three modules of the clamping pair, bending pair and rotational pair. Each joint is compliant structure and has embedded sensors as part of its structure. The validity of the design is evaluated by finite element analysis. The robot is actuated by Tendon-Sheath and utilizes strain gages to measure both the force and position. In order to realize soft and stable contact with human body, a position based impedance controller is adopted. The experimental results of the compliant gripper show that the position based impedance controller is capable to realize accurate force tracking.

T2PS-I | Plenary Session I | 601

Chair : Peter Xu, The University of Auckland, New Zealand

11:30-12:20

Dynamics and Control of Oscillatory Movements in Animal Locomotion

Tetsuya Iwasaki

University of California, Los Angeles, USA

T3PS-II | Plenary Session II | 601

Chair : Jacky Baltes, University of Manitoba, Canada

13:30-14:20

Designing Constraint-Based Robots

Alan Mackworth

University of British Columbia, Canada

T4A | Human-robot Interaction | 602

14:40-16:00

Chair : Luigi Pagliarini, Academy of Fine Arts of Macerata, Italy

T4A-1

14:40-15:00

Consideration about the Application of Dynamic Time Warping to Human Hands Behavior Recognition for Human-Robot Interaction

Ji-Hyeong Han and Jong-Hwan Kim

KAIST, Korea

To prepare the age when humans and robots live together, robots need to understand the meaning of human behaviors for the natural and rational human-robot interaction (HRI). The robot particularly needs to recognize the human hands behavior, since humans usually express their meanings and intentions by using two hands. In this paper, the robot recognizes the human hands behavior by simulating it based on robot's own hands behaviors set and finding the most similar one as human behavior using dynamic time warping (DTW) algorithm. To consider the effects of different variables, i.e. data normalization methods and local cost measures for DTW algorithm, this paper considers two different normalization methods and four different local cost measures and their effects are discussed. The robot successfully recognizes the eight different human hands behaviors by DTW algorithm with the chosen normalization methods and local cost measures.

T4A-2 SS1

15:00-15:40

Lessons Learned in Designing User-configurable Modular Robotics

Henrik Hautop Lund

Technical University of Denmark, Denmark

User-configurable robotics allows users to easily configure robotic systems to perform task-fulfilling behaviors as desired by the users. With a user configurable robotic system, the user can easily modify the physical and functional aspect in terms of hardware and software components of a robotic system, and by making such modifications the user becomes an integral part in the creation of an intelligence response to the challenges posed in a given environment. I.e. the overall intelligent response in the environment becomes the integration of the user's construction and creation with the semi-autonomous components of the user-configurable robotic system in interaction with the given environment. Components constituting such a user-configurable robotic system can be characterized as modules in a modular robotic system. Several factors in the definition and implementation of these modules have consequences for the user-configurability of the system. These factors include the modules' granularity, autonomy, connectivity, affordance, transparency, and interaction.

T4A-3 15:40-16:00

Playware Explorations in Robot Art

Luigi Pagliarini[1,2] and Henrik Hautop Lund[1]

[1]Technical University of Denmark, Denmark, [2]Academy of Fine Arts of Macerata, Italy

We describe the upcoming art field termed robot art. Describing our group contribution to the world of robot art, a brief excursion on the importance of the underlying principles, of the context, of the message and its semiotic is also provided, case by case, together with few hints on the recent history of such a discipline, under the light of an artistic perspective. Therefore, the aim of the paper is to try to summarize the main characteristics that might classify robot art as a unique and innovative discipline, and to track down some of the principles by which a robotic artifact can be considered - or not - an art piece, in terms of social, cultural and strictly artistic interest.

T4B Underwater Robots & Applications 604

14:40-16:00 **Chair : Hyun-Taek Choi, Korea Institute of Ocean Science and Technology, Korea**

T4B-1 14:40-15:00

Issues in Software Architectures for Intelligent Underwater Robots

Hyun-Taek Choi[1] and Joono Sur[2]

[1]Korea Insitute of Ocean Science and Technology, Korea, [2]Samsung Thasles, Korea

Recently, as increasing demands of taking care of complex missions, robot software architecture has been focused on the provision of an effective development environment. In this paper, we describe some issues regarding software architecture for an underwater robot, in particular, a middleware. It has been popular because it provides a well-structured, unified and proven environment for a development. First, we summarized concept and requirements for a robot middleware with some names of well-known service robot middleware. Then, additional requirements for an underwater robot are addressed and recent cases of underwater robot software architecture are presented. Actually, there are limited time and budget for a development of software architecture, unless it is a goal. Considering this, two practical approaches are proposed; (1) using an open source software platform like MOOS-IvP, (2) using a simple but effective software structure, proposed for implementing mid-level intelligent algorithms. Under this streatgy, yShark2, a test-bed underwater robot developed by KIOST, is operated for developing various algorithms such as sensing, decision making, and controlling, and ready to move to MOOS-IvP.

T4B-2 15:00-15:20

Estimation of Vehicle Pose Using Artificial Landmarks for Navigation of an Underwater Vehicle

Tae Gyun Kim[1], Hyun-Taek Choi[1] and Nak Yong Ko[2]

[1]Korea Institute of Ocean Science and Technology, Korea, [2]Chosun University, Korea

This paper describes a localization method to localize a mobile vehicle in underwater environment. Particle filter based localization method is implemented, which is based on Bayesian filter to deal with nonlinear system. This method comprises prediction step and correction step to estimate the pose of the vehicle. The prediction step is achieved by a motion model of the vehicle with inertial sensor data acquired from Doppler Velocity Log, inertia sensors, and electronic

compass. In the correction step, the pose of the vehicle is updated using range and bearing information of externally fixed landmarks in the vehicle work space. The performance of the proposed localization method is verified by experiment in a tank environment using four artificial landmarks. In the experiment, the motion information of the underwater vehicle is used as surge and yaw velocities obtained from DVL and AHRS sensors. The landmark information is acquired from the artificial landmarks using an image sensor. The experimental result shows that the proposed method successfully estimated the pose of the vehicle.

T4B-3

15:20-15:40

A New Approach of Detection and Recognition for Artificial Landmarks from Noisy Acoustic Images

Yeongjun Lee, Tae Gyun Kim and Hyun Taek Choi
Korea Institute of Ocean Science and Technology, Korea

This paper presents a framework for underwater object detection and recognition using acoustic image from an imaging sonar. It is difficult to get a stable acoustic image from any type object because of characteristic of ultrasonic wave. To overcome the difficulties, the framework consists of the selection of candidate, the recognition, and tracking of identified object. In selection of candidate phase, we select candidate as possible objects using an initial image processing and get rid of noise or discontinuous object using a probability based method in series of images. The selected candidate is processed in adaptive local image processing and recognition using shape matrix recognition method. Identified object in previous phase is tracked without selection of candidate, and recognition phase. We perform two simple tests for the verification of each phase and whole framework operability.

T4B-4

15:40-16:00

Design, Implementation, and Experiment of an Underwater Robot for Effective Inspection of Underwater Structures

Seokyong Kim, Hyun-Taek Choi, Jung-Won Lee and Yeong jun Lee
Korea Institute Ocean Science and Technology, Korea

This paper describes development of a specialized underwater robot for effective inspection of underwater structures. Among various inspection methods of underwater structures, using underwater robots becomes popular. Unfortunately, most underwater robots are not specialized for the inspection purpose. The inspection using traditional method is more inefficient and more inconvenient than the inspection by divers. To overcome this problem, functions to be specialized in the underwater inspection is conceived and these functions are implemented in the developed robot. The type of the developed underwater robot is ROV which is possible to communicate large amount of data in real-time and to supply power efficiently. Moreover, the performance of visual sensor is improved, because most inspection methods rely on visual information. Operational algorithms of the robot developed for stable and convenient operations. The performance of the developed robot is verified in a tank.

T4C | Kinematics / Dynamics / Control | 606

14:40-16:00

Chairs : Hongliang Ren, NUS, Singapore
Julia Taylor, Purdue University, USA

T4C-1

14:40-15:00

An adaptive sliding mode control for trajectory tracking of a self-reconfigurable robotic system

R. Al Saidi and B. Minaker
Windsor University, Canada

This paper presents the development of the model, dynamics and an adaptive sliding mode control of new self-reconfigurable robotic systems. These robotic systems combine as many properties of different open kinematic structures as possible and can be used for a variety of applications. The kinematic design parameters, i.e., their Denavit-Hartenberg (D-H) parameters, can be modified to satisfy any configuration required to meet a specific task. By varying the joint twist angle parameter (configuration parameter), the presented model is reconfigurable to any desired open

kinematic structure, such as Fanuc, ABB and SCARA robotic systems. The joint angle and the offset distance of the D-H parameters are also modeled as variable parameters (reconfigurable joint). The resulting self-reconfigurable robotic system hence encompasses different kinematic structures and has a reconfigurable joint to accommodate any required application in medical, space, future manufacturing systems, etc. Automatic model generation of a 3-DOF reconfigurable robotic system is constructed and demonstrated as a case study which covers all possible open kinematic structures. An adaptive controller is developed based on the sliding mode approach for a 3-DOF self-reconfigurable robotic system to achieve high tracking performance. This research is intended to serve as a foundation for future studies in reconfigurable control systems.

T4C-2 15:00-15:20

Position-trajectory Control of Advanced Tracked Robots with Diesel-electric Powertrain

Denis Pogosov
Southern Federal University, Russia

Recently an interest about the control systems for ground robots has increased. The main papers are focused on improving the accuracy of motion of complex nonlinear and multilinked systems. This paper presents a control system of s highly maneuverable tracked robot based on algorithms of The Position-trajectory control. These algorithms have proved their effective in synthesis of control systems for aeronautic, aircraft and ground-based robots. This paper introduced a model of the advanced tracked robot taking into account the internal and external forces acting on it; a model of diesel engine with turbo-charger and model of electric powertrain based on inertial parts.

T4C-3 15:20-15:40

Stable Modifiable Walking Pattern Generator with Arm Swing Motion Using Evolutionary Optimized Central Pattern Generator

Chang-Soo Park and Jong-Hwan Kim
KAIST, Korea

In this paper, a stable modifiable walking pattern generator (MWPG) is proposed by a employing arm swing motion. The arm swing motion is generated by a central pattern generator (CPG) which is optimized by a constraint evolutionary algorithm. In this scheme, the MWPG generates a position trajectory of center of mass (COM) of humanoid robot and the CPG generates the arm swing motion. A sensory feedback in the CPG is designed, which uses a inertial measurement unit (IMU) signal. For the optimization of the CPG parameters, a two-phase evolutionary programming (TPEP) is employed. The effectiveness of the proposed scheme is demonstrated by simulations using a Webots dynamic simulator for a small sized humanoid robot, HSR-IX, developed in the Robot Intelligence Technology (RIT) Lab, KAIST.

T4C-4 15:40-16:00

Performance comparison between a PID SIMC and a PD fractional controller

L. Angel and J. Viola
Universidad Pontificia Bolivariana, Colombia

This paper presents the development and design of a fractional PD controller for a second order system with a pole at the origin, which approximates the dynamic behavior of a servomotor used in the field of robotics. FOPD is contrasted with a PID SIMC controller to analyze the system robustness. Four tests are performed to evaluate the robustness of the system which are: plant gain variation, variable setpoint, external perturbation and adding a random noise. Results show that fractional controller is more robust than PID SIMC controller.

T5A Knowledge Representation for Robotics & Automation 602

16:20-18:00

Chairs : Craig Schlenoff, NIST, USA
Stephen Balakirsky, Georgia Tech Research Institute, USA

T5A-1 16:20-16:40

An Ontology Based Approach to Action Verication for Agile Manufacturing

Stephen Balakirsky[1] and Zeid Kootbally[2]
[1]Georgia Tech Research Institute, USA, [2]University of Maryland, USA

Many of today's robotic work cells are unable to detect when an action failure has occurred. This results in faulty products being sent down the line, and/or downtime for the cell as failures are detected and corrected. This article examines a novel knowledge-driven system that provides added agility by detecting and correcting action failures. The system also provides for late binding of action parameters, thus providing flexibility by allowing plans to adapt to changing environmental conditions. The key feature of this system is its knowledge base that contains the necessary relationships and representations to allow for failure detection and correction. This article presents the ontology that stores this knowledge as well as the overall system architecture. The manufacturing domain of kit construction is examined as a sample test environment.

T5A-2

16:40-17:00

Evaluating State-Based Intention Recognition Algorithms Against Human Performance

Craig Schlenoff[1] and Sebti Foufou[1,2]

[1]University of Burgundy, France, [2]Qatar University, Qatar

In this paper, we describe a novel intention recognition approach based on the representation of state information in a cooperative human-robot environment. We compare the output of the intention recognition algorithms to those of an experiment involving humans attempting to recognize the same intentions in a manufacturing kitting domain. States are represented by a combination of spatial relationships in a Cartesian frame along with cardinal direction information. Based upon a set of predefined high-level states relationships that must be true for future actions to occur, a robot can use the approaches described in this paper to infer the likelihood of subsequent actions occurring. This would enable the robot to better help the human with the operation or, at a minimum, better stay out of his or her way.

T5A-3

17:00-17:20

Knowledge and Data Representation for Motion Planning in Dynamic Environments

Seyedshams Feyzabadi and Stefano Carpin

University of California, USA

In this paper we describe our initial efforts to develop a knowledge base for motion planning in dynamic environments. Our eventual goal is to smooth the design and integration of multiple heterogeneous robots working in shared environments, and to enable the creation of libraries of plans that can be shared and reused by different robots. We furthermore attempt to align our work with the ongoing activities of the IEEE Ontologies for Robotics and Automation working group.

T5A-4

17:20-17:40

A Simulated Sensor-based Approach for Kit Building Applications

Zeid Kootbally[1], Craig Schlenoff[2], Teddy Weisman[3], Stephen Balakirsky[4], Thomas Kramer[5] and Anthony Pietromartire[2]

[1]University of Maryland, USA, [2]National Institute of Standards and Technology, USA, [3]Yale University, USA, [4]Georgia Tech Research Institute, USA, [5]Catholic University of America, USA

Kit building or kitting is a process in which separate but related items are grouped, packaged, and supplied together as one unit (kit). This paper describes advances in the development of kitting simulation tools that incorporate sensing/control and parts detection capabilities. To pick and place parts and components during kitting, the kitting workcell relies on a simulated sensor system to retrieve the six-degree of freedom (6DOF) pose estimation of each of these objects. While the use of a sensor system allows objects' poses to be obtained, it also helps detecting failures during the execution of a kitting plan when some of these objects are missing or are not at the expected locations. A simulated kitting system is presented and the approach that is used to task a sensor system to retrieve 6DOF pose estimation of specific objects (objects of interest) is given.

T5A-5

17:40-18:00

A Survey on Biomedical Knowledge Representation for Robotic Orthopaedic Surgery

Paulo J. S. Goncalves[1,2] and Pedro M.B. Torres[1,2]

[1]Polytechnic Institute of Castelo Branco, Portugal, [2]Technical University of Lisbon, Portugal

The paper presents a survey of the efforts and methods presented by the research community to represent knowledge to be used, in a machine readable format, in the biomedical field. From the surveyed ontologies, the base ontologies for the conceptual model of the Ontology for Robotic Orthopaedic Surgery (OROSU), are dened. Methods for merging the base ontologies to obtain the OROSU, are discussed, while the under development framework is briefly presented.

T5B	Cognitive Intelligence	604

16:20-18:00 Chair : James A. Crowder, Raytheon Intelligence, USA

T5B-1 16:20-16:40

Combined Trajectory Generation and Path Planning for Mobile Robots Using Lattices with Hybrid Dimensionality

Janko Petereit, Thomas Emter, and Christian W. Frey
Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB, Germany

Safe navigation for mobile robots in unstructured and dynamic environments is still a challenging research topic. Most approaches use separate algorithms for global path planning and local obstacle avoidance. However, this generally results in globally sub-optimal navigation strategies. In this paper, we present an algorithm which combines these two navigation tasks in a single integrated approach. For this purpose, we introduce a novel search space, namely, a state ×time lattice with hybrid dimensionality. We describe a procedure for generating high-quality motion primitives for a mobile robot with four-wheel steering to define the motion in this lattice. Our algorithm computes a hybrid solution for the path planning problem consisting of a trajectory (i.e., a path with time component) in the imminent future, a dynamically feasible path in the near future, and a kinematically feasible path for the remaining time to the goal. Finally, we provide some results of our algorithm in action to prove its high solution quality and real-time capability.

T5B-2 16:40-17:00

Artificial Neural Diagnostics and Prognostics in Cognitive Systems

James Crowder
Raytheon Intelligence, USA

Self-diagnostics and prognostics in multi-agent processing systems are explored in the context of self-soothing concepts in Neuropsychology. The use of emotional memory and autonomic nervous state recall can be used to provide contextual cognition for system-level diagnostic and prognostics in large-scale systems. The use of an Artificial Cognitive Neural Framework with intelligent information software agents can be utilized to emulate emotional learning to facilitate self-soothing, which equates to self healing in artificial neural systems. This paper describes the architecture and specifications of software agents that are used to provide self-soothing and self-healing constructs for intelligent systems [1].

T5B-3 17:00-17:20

Organization and Selection Methods of Composite Behaviors for Artificial Creatures Using the Degree of Consideration-based Mechanism of Thought

Woo-Ri Ko and Jong-Hwan Kim
KAIST, Korea

This paper proposes organization and selection methods of composite behaviors for artificial creatures. Using the degree of consideration-based mechanism of thought (DoC-MoT), each pre-defined atom behavior is evaluated by the fuzzy integral of the partial evaluation values of atom behaviors over the artificial creature's wills and external contexts, with respect to the fuzzy measure values representing its degrees of consideration (DoCs). Based on these evaluation values of atom behaviors, a composite behavior is organized as a set of atom and composite behaviors which are connected by the relationships of 'parallel,' 'choice' and 'sequence.' However, in the organized composite behavior, the behaviors connected by 'choice' relationship can not be generated at the same time, and therefore, only one atom or composite behavior is randomly remained in each set of atom or composite behaviors connected by 'choice' relationship. The effectiveness of the proposed scheme is demonstrated by simulations carried out with an artificial creature, "DD" in the 3D virtual environment. The results show that the diversity of the generated behaviors is increased

fourfold compared to the behavior selection without the organization process of composite behaviors. Moreover, the generated composite behaviors satisfy the artificial creature's wills more and the logical connectivity of them is increased compared to the method without the process.

T5B-4 17:20-17:40

Brainwave Variability Identification in Robotic Arm Control Strategy

Chiemela Onunka, Glen Bright and Riaan Stopforth
University of KwaZulu-Natal, South Africa

Neuronal activity, the fundamental source for bio-electric signals expresses the variability of brainwaves in humans. Brainwave and specific EEG spectral analysis are important in bio-electric signal variability identification. Recent researches in neuro-robotics rely on the use of brain computer interface (BCI) technology in developing robotic commands. Brainwave variability identification provides different levels of robot control signal development and optimization. This paper presents the development of robotic arm control strategy using brainwave signal variability. The bio-electric signal identification was derived from physiological expressions. The physiological expressions are identified using spectral analysis and the paper presents possible future research options and applications towards using physiological and facial parameters in controlling robotic arm.

T5B-5 17:40-18:00

Acquisition of Context-based Active Word Recognition by Q-Learning Using a Recurrent Neural Network

Ahmad Af Mohd Faudzi[1,2] and Katsunari Shibata[3]
[1]*Kyushu University, Japan,* [2]*Universiti Malaysia Pahang, Malaysia,* [3]Oita University, Japan

In the real world, where there is a large amount of information, humans recognize an object efficiently by moving their sensors, and if it is supported by context information, a better result could be produced. In this paper, the emergence of sensor motion and a contextbased recognition function are expected. The sensor-equipped recognition learning system has a very simple and general architecture that is consisted of one recurrent neural network and trained by reinforcement learning. The proposed learning system learns to move a visual sensor intentionally and to classify a word from the series of partial information simultaneously only based on the reward and punishment generated from the recognition result. After learning, it was verified that the contextbased word recognition could be achieved. All words were correctly recognized at the appropriate timing by actively moving the sensors not depending on the initial sensor location.

T5C | Genetic / Behavioral Intelligence | 606

16:20-18:00 **Chair : Tiberiu Stefan Letia, Technical University of Cluj Napoca, Romania**

T5C-1 16:20-16:40

Adding adaptable stiffness joints to CPG-based dynamic bipedal walking generates human-like gaits

Yan Huang, Yue Gao, Baojun Chen, Qining Wang and Long Wang
Peking University, China

In this paper, we propose a seven-link passivity-based dynamic walking model, in order to further understand the principles of real human walking and provide guidance in building bipedal robots. The model includes an upper body, two thighs, two shanks, flat feet and compliant joints. A bio-inspired central pattern generator (CPG)-based control method is applied to the proposed model. In addition, we add adaptable joint stiffness to the motion control. To validate the effectiveness of the proposed bipedal walking model, we carried out simulations and human walking experiments. Experimental results indicate that human-like walking gaits with different speeds and walking pattern transitions can be realized in the proposed locomotor system.

T5C-2 **16:40-17:00**

Hand-Eye Calibration and Inverse Kinematics of Robot Arm using Neural Network

Haiyan Wu, Walter Tizzano, Thomas Timm Andersen, Nils Axel Andersen and Ole Ravn
Technical University of Denmark, Denmark

Traditional technologies for solving hand-eye calibration and inverse kinematics are cumbersome and time consuming due to the high nonlinearity in the models. An alternative to the traditional approaches is the artificial neural network inspired by the remarkable abilities of the animals in different tasks. This paper describes the theory and implementation of neural networks for hand-eye calibration and inverse kinematics of a six degrees of freedom robot arm equipped with a stereo vision system. The feedforward neural network and the network training with error propagation algorithm are applied. The proposed approaches are validated in experiments. The results indicate that the hand-eye calibration with simple neural network outperforms the conventional method. Meanwhile, the neural network exhibits a promising performance in solving inverse kinematics.

T5C-3 **17:00-17:20**

An Evolutionary Feature Selection Algorithm for Classication of Human Activities

Si-Jung Ryu and Jong-Hwan Kim
KAIST, Korea

This paper proposes an evolutionary feature selection algorithm to classify human activities. Feature selection is one of the key issues in machine learning, along with classification when some parts of features are not available or have redundant information. It enhances learning accuracy by selecting essential features and eliminating nonessential features. In the proposed algorithm, a feature selection algorithm integrated with an evolutionary algorithm (EA) is developed. We use the wrapper approach, which repeatedly calls the learning algorithm to evaluate the effectiveness of the selected features. Quantum-inspired evolutionary algorithm (QEA) is utilized as an evolutionary algorithm and multi-layer perceptron (MLP) is used as a classifier. The proposed algorithm is applied to classification of the human activities using smartphone sensors.

T5C-4 **17:20-17:40**

Automatic Linear Robot Control Synthesis using Genetic Programming

Tiberiu S. Letia and Octavian Cuibus
Technical University of Cluj Napoca, Romania

An automatic controller synthesis method for a single axe linear robot is considered. The robot motions are modeled by a Delay Time Petri Net (DTPN). The search refers to automatically finding a controller modeled by a Time Petri Net (TPN) that fulfills some specified requirements. The controller model is synthesized using a Genetic Programming (GP) method. The mapping between TPN model and the tree representation of individual genotypes is performed using a formal language named here TPNL (Time Petri Net based Language). This language is suited for formal description of the controller behavior traits like sequential, concurrent, selection, loop or input/output. The use of control traits guaranties the construction of individuals that are capable and useful to control the robot moves. To diminish the search durations, besides the usual genetic operators like mutation, permutation and crossover, a new atrophy operator was introduced.

T5C-5 **17:40-18:00**

Estimation of Stimuli Timing to Evaluate Chemical Plume Tracing Behavior of the Silk Moth

Jouh Yeong Chew, Kotaro Kishi, Yohei Kinowaki and Daisuke Kurabayashi
Tokyo Institute of Technology, Japan

Insects serve as ideal models for replicating the adaptability of biological systems in Chemical Plume Tracing (CPT) because they perform efficient olfactory tracking. In this paper, we propose to evaluate the CPT behavior of the silk moth (Bombyx Mori) from the perspective of machine learning. We use a classification approach consisting of the Gaussian Mixture Model with Expectation Maximization (GMMEM) and the Echo State Networks (ESN) to identify the initial motion phases upon stimulation. The former method classifies the locomotion observation consisting of the linear and angular velocity into Gaussian density components which represent different elemental motions. Then, these motions are used

as training data for the ESN to estimate the initial motion phases upon stimulation which represents the stimuli timing. The same procedure is implemented on different moths and cross-evaluation is done among the moths in the sample to evaluate their behavior singularity. This method achieves decent estimation accuracy and serves as a feasible approach to complement the conventional neurophysiology analysis of insects' behavior. The results also suggest the presence of CPT behavior singularity for silk moths.

Friday, 20 December

F1A | Humanoid / Micro / Nano Robotics | 602

08:50-10:30

Chairs : John Gallagher, Wright State University, USA
Gourab Sen Gupta, Massey University, New Zealand

F1A-1

08:50-09:10

Towards Honeycomb PneuNets Robots

Hao Sun and Xiao-Ping Chen
University of Science and Technology of China, China

In recent years, Soft Robotics becomes a research hotspot. A soft robot is usually made of elastic materials, and thus has better adaptability and safety to the environment than a rigid robot. These advantages offer us a new opportunity to attack some fundamental challenges faced by traditional robots. Most of previous studies about soft robots focus on clarifying the deformation characteristics of the flexible materials used. In order to pursue a large expansion rate, the stiffness of the soft materials is usually very low, which brings a consequence that these soft robots are too soft to maintain its shape or to resist external forces. Inspired by the honeycomb structure, this paper proposes a honeycomb pneumatic network (HPN) robot, which consists of several pneumatic units. We put forward a force analysis model of a pneumatic unit and a kinematics model of honeycomb pneumatic network. Based on these models, we study the relationships between the air pressure, external force and geometrical shape through simulation. The experimental results showed that the excellent expansion rate and flexibility can be achieved in the HPN robot.

F1A-2

09:10-09:30

Progress of Research on A New Asteroid Exploration Rover Considering Thermal Control

Yosuke Miyata[1], Tetsuo Yoshimitsu[2] and Takashi Kubota[2]
[1]University of Tokyo, Japan, [2]Japan Aerospace Exploration Agency, Japan

Asteroids have some clues about the origin of the solar system. In recent years, asteroid exploration by surface explorers has been studied actively. Conventional rovers can move under microgravity environment, but the rovers have not considered thermal control. This paper proposes a novel mobility mechanism for a rover under microgravity environment along with temperature control. The effectiveness of the proposed rover is investigated by simulations and microgravity experiments.

F1A-3

09:30-09:50

A Proposal of Exploration Robot with Wire for Vertical Holes in the Moon or Planet

Shuhei Shigeto[1], Masatsugu Otsuki[2] and Takashi Kubota[2]
[1]University of Tokyo, Japan, [2]Japan Aerospace Exploration Agency, Japan

Moon holes were first discovered by JAXA in 2009. It is believed that moon holes are useful for learning about the formation of the moon because the bedding plane is exposed. In addition, because the inner holes are sealed from solar wind, moon holes are also considered important candidate sites for base camp in the future. However, exploration of vertical hole is difficult with the conventional robots. A new type of robot is required to go down and explore a moon hole. In this study, a vertical hole exploration system with a small robot with wire is proposed. This paper describes a modeling and attitude control scheme in a state where the robot is hanging by a wire, and evaluates the effectiveness of the proposed system.

F1A-4 09:50-10:10

Scanpaths Analysis with Fixation Maps to Provide Factors for Natural Gaze Control

Bum-Soo Yoo and Jong-Hwan Kim
KAIST, Korea

Human-like gaze control is needed for robots to be companions of humans. For human-like gaze control, much research has been progressing to identify factors that affect human gaze. The conventional approaches to discover factors that affect human gaze is based on their hypotheses. They presented gaze control algorithm based on hypotheses and verified through experiments. However, since the algorithms were originated from the hypotheses, they were prone to be biased to the hypotheses. This paper derives the factors that affect human gaze based on observation of real human's scanpaths, not hypothesis. From the recorded scanpaths, fixation maps are produced using the Gaussian distribution. The earth mover's distance (EMD) is used to measure similarity among fixation maps, and the fixation map with minimal difference is selected in each test image. The selected fixation maps are used to derive the factors that affect human gaze. The derived factors are center, salient regions, human, depth, objects, scene schema information, and they are shown with examples.

F1A-5 10:10-10:30

Design of a Bipedal Walker with a Passive Knee and Parted Foot

Honggu Lee and Sungho Jo
KAIST, Korea

The design of a bipedal walker that enables a human-like, compliant walking motions with simple control commands is presented. The design includes a passive knee bending/stretching mechanism with a latch hinge and a parted foot structure with compliant spring-based actuation. In addition, the leg posture, asymmetric lateral spring placement, round ankles, active hip sway, pelvic tilt actuation, and provisions for simple control were designed to implement the desired walking motion. The prototype bipedal walker was built with a combination of passive and actuated joints, utilizing springs around the joints for further compliancy. Experiments were conducted using the prototype bipedal walker in order to evaluate the design.

F1B | Emerging Application | 604

08:50-10:50

Chairs : Genshe Chen, Intelligent Fusion Technology, Inc, USA
Young J. Ryoo, Mokpo National University, Korea

F1B-1 08:50-09:10

One-way ViSP (Visually Servoed Paired structured light) for 6-DOF structural displacement measurement

Haemin Jeon, Wancheol Myeong, Youngjai Kim and Hyun Myung
KAIST, Korea

Structural health monitoring (SHM) of civil infrastructures has gained great attention since it is directly related to public safety. To estimate structural displacement, which is considered as one of important categories of SHM, a oneway type vision and laser-based 6-DOF displacement measurement system (oneway ViSP) is proposed. The system is composed of a transmitter with two laser pointers, a 1-D laser range finder (LRF), and a 2-DOF manipulator; and a receiver with a camera and a screen. The lasers and LRF project their parallel beams to the screen and the camera attached to the screen captures the image of the screen. The manipulator controls poses of the lasers and LRF for projected laser beams to be always inside the screen. By calculating positions of the laser beams and obtaining the distance from LRF, the relative displacement between two places can be estimated. The performance of the system has been verified from simulations.

F1B-2 09:10-09:30

SOLAR ENERGY AS AN ALTERNATIVE ENERGY SOURCE TO POWER MOBILE ROBOTS

Abdusalam Sulaiman, Freddie Inambao and Glen Bright
University of KwaZulu-Natal, South Africa

Solar energy can provide a viable alternative energy source to meet the special energy demands that are typically required to operate mobile robots. Conventional energy sources cannot fulfil these demands as satisfactorily as solar energy can, given the disfavour that conventional energy sources find in an eco-conscious world, and also given the practical limitations associated with conventional energy sources which cannot conveniently be accessed in places where mobile robots are normally put to use which are often inaccessible and beyond human reach. This study seeks to demonstrate that solar energy can be harnessed and stored using hydrogen as a medium to store an otherwise intermittent supply of energy that is characteristic of solar energy. In this study, an Industrial Mobile Robot Platform (IMRP) was designed to run on fuel cells using a low-pressure metal hydride hydrogen storage system which would store more energy on board than a rechargeable battery could.

F1B-3 09:30-09:50

Design of Child-sized Humanoid Robot for Performance Show

Kinam Lee, Hyunjin Kwak and Young-Jae Ryoo
Mokpo National University, Korea

In this paper, we describe a design procedure of a child-sized humanoid robot for a performance show. First, we formulated a concept for the design of the humanoid robot and designed a mechanism of the lightweight robot of 1.10 meters tall using 3D CAD tools. By considering the lightweight for the performance show, the hardware of the robot was designed. The robots' frame and links were designed by 3D CAD tools and was manufactured by precision machining with aluminum and plastics that are easy to fabricate and light to handle but have a good strength. The developed child-sized humanoid robot was experimented with dance performance, and inverse kinematics and motion control were applied.

F1B-4 09:50-10:10

Bowling with the DARwIn-Op Humanoid Robot

Saltanat B. Tazhibayeva, Mukhtar Kuanyshbaiuly, Aibek Aladabergenov, Ji Hyeon Hong and Eric T. Matson
Purdue University, USA

In this paper, we will describe our approach in building an application, which empowers the DARwIn-OP Humanoid robot to play a bowling game. The main difficulties of bowling, in both humans and robots, is steady walking control, vision processing to detect the pins and ball, precise localization of the ball and decision-making of angles to throw. The aim of this project is to contribute to better and more enjoyable robot and human interaction as well as to humanoid robot research area.

F1B-5 10:10-10:30

Analysis of Kinematics and Dynamics of 4-dof Delta parallel robot

Tuong Phuoc Tho and Nguyen Truong Thinh
HCMC University of Technical Education, Viet Nam

This paper will describe the kinematics and dynamics of parallel robot named Delta with 4 degree of freedom (dof). In this study, the model of Delta parallel kinematic robot 3 dofs combined with a mechanism, which is a kinematic chain with one dof of its links identified angle between the base and moving platform as the end-effector. The use of dynamics coupled with kinematics for the control of parallel robot has been gaining increasing popularity in recent years. Relationship between generalized and articular velocities is established, hence jacobian and inverse jacobian analyses are determines. The inverse formulas are generally shown simply and the direct formulas are also described. Besides, this paper deal with the direct and inverse dynamics to determine the relations between the generalized accelerations, velocities, coordinates of the end-effector and the articular forces based on simulation and control. Parallel robots have become the important machines to manufacturing using for various purposes in industry and life. The dynamic model of

parallel robot with 4 dof is presented, and an adaptive control strategy based kinematic and dynamic models for this robot is described. Experiments were implemented to evaluate the responding of controlling system based on dynamics and kinematics controlling method for tracking desired trajectories. The results show that the use of the suitable control system based on kiematic and dynamic model can provide the high performance of the robot.

F1B-6 10:30-10:50

Implementation of Split-Cycle Control for Micro Aerial Vehicles

Isaac E. Weintraub, David O. Sigthorsson, Michael W. Oppenheimer and David B. Doman
Air Force Research Laboratory, WPAFB, OH, USA

Flapping wing micro air vehicles have been of significant research interest in recent years due to the flight capabilities of their biological counterparts and their ability to hide in plain sight, inspiring applications for military and civilian surveillance. This work introduces the design, implementation, and fabrication of the circuitry used for split-cycle constant-period wingbeat capable flapping wing micro air vehicle platforms. Split-cycle constant-period modulation involves independent control of the upstroke and downstroke wing velocity profiles to provide the theoretical capability of manipulating five degrees of vehicle motion freedom using only two actuators, namely, a brushless direct current motor for each wing. The control circuitry mainly consists of a control circuit board, a wireless receiver, three micro-controllers, and drivers. The circuitry design is tested using a prototype vehicle mounted on an air-table platform. A human operated transmitter relays split-cycle constant-period commands to the vehicle to produce the desired vehicle motion.

F1C Signal Processing 606

08:50-10:10 **Chair : Seul Jung, Chungnam National University, Korea**

F1C-1 08:50-09:10

Adaptive Neuro-Fuzzy Control for Ionic Polymer Metal Composite Actuators

Nguyen Truong Thinh and Dang Tri Dung
Ho Chi Minh City University of Technical Education, Viet Nam

Electroactive polymers (EAPs) have many attractive characteristics for applications, especially for biomimetics robots and bio-medical devices. Among the electroactive polymers, the ionic polymer metal composite (IPMC) is the commonly used EAPs. The IPMC is new generation of smart materials with significant potential in producing biomimetic robots and smart structures, and for medical applications. Ionic polymer metal composites (IPMC) have attracted great attention in the past years due to its large strain. IPMC materials have quite an unpredictable behavior due to several critical aspects that produce a change in their dynamic response. For modeling of controlling the IPMC, it is required to find suitable algorithm. In order to avoid difficult problems in control, a controller based Adaptive Neuro-Fuzzy Inference System (ANFIS), which combines the merits of fuzzy logic and neural network, is used for tracking position of IPMC actuator. This paper describes the using of controller based on Neuro and Fuzzy for controlling an IPMC actuator under water to improve tracking ability for an IPMC actuator like as biomimetics and bio-medical devices. The results showed that ANFIS algorithm is reliable in controlling IPMC actuator. In addition, experimental results show that the ANFIS performed better than the pure fuzzy controller (PFC). Present results show that the current adaptive neuro-fuzzy controller can be successfully applied to the real-time control of the ionic polymer metal composite actuator for which the performance degrades under long-term actuation.

F1C-2 09:10-09:30

Enhancing Wi-Fi Signal Strength of a Dynamic Heterogeneous System Using a Mobile Robot Provider

Esther Rolf[1], Matt Whitlock[2], Byung-Cheol Min[3] and Eric Matson[3]
[1]Princeton University, USA, [2]The University of Alabama, USA, [3]Purdue University, USA

Heterogeneous networks of humans, robots, and agents are becoming increasingly common. Clients of wireless networks have continuously changing requirements for providers. In this project, a system to provide a sufficient signal for clients of a network as conditions change is proposed and validated. The system is comprised of hardware features such as a mobile access point and three heterogeneous client devices, and a movement algorithm. The mobile

provider's autonomy is verified by the independence of initial position or orientation from success of the system. The system is designed for ease of reconfiguration; modularity in system design allows for advancements to be implemented simply and effectively.

F1C-3 09:30-09:50

Application of the Chaos Theory in the Analysis of EMG on Patients with Facial Paralysis

Anbin Xiong[1,2], Xingang Zhao[1], Jianda Han[1] and Guangjun Liu[1,3]

[1]Chinese Academy of Sciences (CAS), China, [2]University of Chinese Academy of Sciences (CAS), China, [3]Ryerson University, Canada

Surface electromyography (sEMG) has been widely applied to disease diagnosis, pathologic analysis and rehabilitation evaluation. It is the nonlinear summation of the electrical activity of the motor units in a muscle and can reflect the state of neuromuscular function. Traditional linear and statistical analysis methods have some significant limitations due to the short-term stationary and lower signal-noise ratio of sEMG. In this paper, we introduce chaotic analysis into the field of sEMG process to investigate the hidden nonlinear characteristics of sEMG of patients with facial paralysis. sEMG on the bilateral masseter, levator labii superioris and frontalis of the 21 patients is recorded. Chaotic analysis is employed to extract new features, including correlation dimension, Lyapunov exponent, approximate entropy and so on. We discover the maximum Lyapunov exponents are all greater than 0, indicating that sEMG is a chaotic signal; correlation dimensions of sEMG on healthy sides are all smaller than that of diseased sides; and inversely, the approximate entropies of healthy sides are all greater than that of diseased sides. Consequently, chaotic analysis can provide a new insight into the complexity of the EMG and may be a vital indicator of diagnosis and recovery assessment of facial paralysis.

F1C-4 09:50-10:10

Neural Network Control for the Balancing Performance of a Single-wheel Transportation Vehicle: Gyrocycle

Minsoo Ha and Seul Jung

Chungnam National University, Korea

A single-wheel mobile robot has been developed for carrying a driver. Since a single-wheel mobile robot carries a human driver, the size and weight are larger compared with other sing-wheel mobile robots. To maximize the gyroscopic effects, Gyrocycle is designed to have two flywheels that need to be synchronized. In addition to the synchronization of two flywheels, Gyrocycle is tested for the robust balancing perfromance by unknown payloads. A neural network control method is used to control the balance. Experimental studies are conducted to verify the perfromance by the neural network controller.

F2PS-III | Plenary Session III | 601

Chair : Junmo Kim, KAIST, Korea

11:10-12:00 **The Next Technological Wave: Intelligence Technology ("IT") for Intelligence Super-Agent**

Jong-Hwan Kim

KAIST, Korea

F3IS | Special Talks Session | 601

13:30-15:00 Chair : Eric Matson, Purdue University, USA

F3IS-1 SS2 13:30-14:00

Robot Navigation and Monitoring Technologies for U-City

Hyun Myung

KAIST, Korea

As civil infrastructures get larger and more complex, the development of robot technologies that help to construct, monitor, inspect, and manage civil infrastructures is in need. In this paper, we introduce two major robot technologies for construction and monitoring of ubiquitous city (U-City). The first one is the localization technology for the robust localization of the robot and human. A novel geomagnetic field-based SLAM (Simultaneous Localization And Mapping) and 3D SLAM are introduced for robust localization. The second one is the modular robot system for structural health monitoring (SHM) of large structures. To develop an SHM system that directly measures the deformation of the structure using low-cost sensor, a visually servoed paired structured light (ViSP)-based modular robot system is introduced. The developed module which uses one or two actuated lasers and a camera in pair is inexpensive to implement and it can directly measure the accurate relative deformation between any two locations on the structure.

F3IS-2 SS3

14:00-14:30

Recent Advances in Humanoid Robotics

Jacky Baltes

University of Manitoba, Canada

The talk describes recent advances in humanoid robotics research in the areas of active balancing and push recovery. The first part of the talk will describe Jennifer, the first ice hockey playing humanoid robot. As most beginning skaters will realize very quickly, ice skating is a more difficult than walking. The talk will analyze ice skating from the perspective of humanoid robotics control and will highlight the differences between skating and walking. This leads to a discussion of why typical approaches to humanoid robotics control such as zero moment point (ZMP) control do not work well on skating robots.

F3IS-3 SS4

14:30-15:00

Robotic Intelligence-a Specific Form of Artificial Intelligence

Victor RASKIN

Purdue University, USA

Much success has been achieved in robotic hardware: today,s robots can perform physical activities that were not achievable only a few years ago: they are more stable, faster, carry more sensors, are more versatile. At the same time, progress, not so dramatic perhaps but stable, has been achieved in artificial intelligence (AI) and its applications. This paper focuses on bringing these two types of parallel achievements together, thus rendering the robots more autonomous, smarter, and usable in more applications as well as rendering AI theory testable and verifiable in practical applications. One reasonably mature approach to such a synthesis is the onthologization of the robotic world and aligning this ontology with the general property-rich multi-domain ontology, such as the one developed in Ontological Semantic Technology (OST) (cf. Raskin 2012, the Best Paper Award presentation at RITA 2012). This approach underlies the HARMS hybrid natural-language-based (NL-based) system of communication within a team of humans, robots, agents, etc. (see Matson et al. 2011, an ICARA presentation).

F4A Flapping-Wing Air Vehicles 602

15:10-16:30 **Chair : Sanjay Kumar Boddhu, Wright State University, USA**

F4A-1

15:10-15:30

Maintaining Model Consistency During In-Flight Adaptation in a Flapping-Wing Micro Air Vehicle

John C. Gallagher[1], Laura R. Humphrey[2] and Eric Matson[3]

[1]Wright State University, USA, [2]Air Force Research Laboratory, WPAFB, OH, USA, [3]Purdue University, USA

Machine-learning and soft computation methods are often used to adapt and modify control systems for robotic, aerospace, and other electromechanical systems. Most often, those who use such methods of self-adaptation focus on issues related to efficacy of the solutions produced and efficiency of the computational methods harnessed to create them. Considered far less often are the effects self-adaptation on Verification and Validation (V&V) of the systems in which they are used. Simply observing that a broken robotic or aerospace system seems to have been repaired is often

not enough. Since self-adaptation can severely distort the relationships among system components, many V&V methods can quickly become useless. This paper will focus on a method by which one can interleave machine-learning and model consistency checks to not only improve system performance, but also to identify how those improvements modify the relationship between the system and its underlying model. Armed with such knowledge, it becomes possible to update the underlying model to maintain consistency between the real and modeled systems. We will focus on a specific application of this idea to maintaining model consistency for a simulated Flapping-Wing Micro Air Vehicle that uses machine learning to compensate for wing damage incurred while in flight. We will demonstrate that our method can detect the nature of the wing damage and update the underlying vehicle model to better reflect the operation of the system after learning. The paper will conclude with a discussion of potential future applications, including generalizing the technique to other vehicles and automating the generation of model consistency-testing hypotheses.

F4A-2

15:30-15:50

Model Checking of a Flapping-Wing Mirco-Air-Vehicle Trajectory Tracking Controller Subject to Disturbances

James Goppert[1], John C. Gallagher[2], Inseok Hwang[1] and Eric Matson[1]

[1]Purdue University, USA, [2]Wright State University, USA

This paper proposes a model checking method for a trajectory tracking controller for a flapping wing micro-air-vehicle (MAV) under disturbance. Due to the coupling of the continuous vehicle dynamics and the discrete guidance laws, the system is a hybrid system. Existing hybrid model checkers approximate the model by partitioning the continuous state space into invariant regions (flow pipes) through the use of reachable set computations. There are currently no efficient methods for accounting for unknown disturbances to the system. Neglecting disturbances for the trajectory tracking problem underestimates the reachable set and can fail to detect when the system would reach an unsafe condition. For linear systems, we propose the use of the H-infinity norm to augment the flow pipes and account for disturbances. We show that dynamic inversion can be coupled with our method to address the nonlinearities in the flapping-wing control system.

F4A-3

15:50-16:10

Design Constraints of a Minimally Actuated Four Bar Linkage Flapping-Wing Micro Air Vehicle

Benjamin M. Perseghetti[1], Jesse A. Roll[2] and John C. Gallagher[1]

[1]Wright State University, USA, [2]Purdue University, USA

This paper documents and discusses the design of a low-cost Flapping-Wing Micro Air Vehicle (FW-MAV) designed to be easy to fabricate using readily available materials and equipment. Basic theory of operation as well as the rationale underlying various design decisions will be provided. Using this paper, it should be possible for readers to construct their own devices quickly and at little expense.

F4A-4

16:10-16:30

Improved Control System for Analyzing and Validating Motion Controllers for Flapping Wing Vehicles

Sanjay K. Boddhu, Hermanus V. Botha, Ben M. Perseghetti and John C. Gallagher

Wright State University, USA

In previous work, the viability of split-cycle constant-period frequency modulation for controlling two degrees of freedom of flapping wing micro air vehicle has been demonstrated. Though the proposed wing control system was made compact and self-sufficient to be deployed on the vehicle, it was not built for on-the-fly configurability of all the split-cycle control's parameters. Further the system had limited external communication capabilities that rendered it inappropriate for its integration into a higher level research framework to analyze and validate motion controllers in flapping vehicles. In this paper, an improved control system has been proposed that could addresses the on-the-fly configurability issue and provide an improved external communication capabilities, hence the wing control system could be seamlessly integrated in a research framework for analyzing and validating motion controllers for flapping wing vehicles.

F4B | Ambient / Collective Intelligence | 604

15:10-16:50

Chairs : Jin-Woo Jung, Dongguk University, Korea
Victor Raskin, Purdue University, USA

F4B-1

15:10-15:30

A method to localize transparent glass obstacle using laser range finder in mobile robot indoor navigation

Jungsoo Park[1], Eric T. Matson[2] and Jin-Woo Jung[1]
[1]Dongguk University, Korea, [2]Purdue University, USA

The problem to localize transparent glass obstacles using laser range finder is very difficult and still open problem. Most of applications use additional sensor device such as sonar sensor to cope with the transparent glass obstacle environment. This paper deals with that problem only using laser range finder. By the insight from human sensing mechanism which uses the fusion of more data with different view directions or different measurement locations, a novel method to localize transparent glass obstacles is addressed. And the effectiveness of the proposed algorithm is evaluated by the real robot experiments with three case studies.

F4B-2

15:30-15:50

Robotic Follower System using Bearing-only Tracking with Directional Antennas

Byung-Cheol Min[1] and Eric T. Matson[1,2]
[1]Purdue University, USA, [2]Dongguk University, Korea

This paper presents the development of a robotic follower system with the eventual goal of autonomous convoying to create end-to-end communication. The core of the system is a bearing-only tracking with directional antennas and an obstacle avoidance algorithm with sonar sensors. For bearing estimation with directional antennas, we employ a Weighted Centroid Algorithm (WCA), which is a method for active antenna tracking and Direction Of Arrival (DOA) estimation. We also discuss the use of sonar sensors that can detect objects, which could improve our robotic follower system in mobile robot navigation. Through extensive field experiments in different environments, we show feasibilities of our proposed system, allowing a follower robot to track a leader robot effectively in convoying fashion. We expect that our system can be applied in a variety of applications that need autonomous convoying.

F4B-3

15:50-16:10

Oscillator aggregation in redundant robotic systems for emergence of homeostasis

Sho Yamauchi, Hidenori Kawamura and Keiji Suzuki
Hokkaido University, Japan

The main feature that keeps states and structures stable can be seen in living organisms. This adjusting and adaptive feature is called homeostasis. This integrated adaptive feature is achieved by the cooperation of organs in living organisms. Living organisms in nature act dynamically due to this feature. Highly adaptive behavior caused by this feature is also observed in simple living organisms that have no neural circuits such as amoebas. Based on these facts, a method of control to generate homeostasis in robotic systems is proposed by assuming a robot system is an aggregation of oscillators in this paper and each parameter in a robot system is allocated to an oscillator. Such oscillators interact so that the whole system can adapt to the environment. Also, a redundant robot arm is made to confirm the effect of this control method to generate homeostatic behaviors in robotic systems.

F4B-4

16:10-16:30

The ChIRP Robot: a Versatile Swarm Robot Platform

Christian Skjetne, Pauline C Haddow, Anders Rye, Håvard Schei and Jean-Marc Montanier
The Norwegian University of Science and Technology (NTNU), Norway

Swarm Robotic experiments are ideally performed on real robots. However, a cost versus versatility trade-off exists between simpler and more advanced swarm robots. The simpler swarm robots provide limited features and thus, although suitable for simpler swarm tasks, lack versatility in the types of tasks that may be approached. On the other

hand, advanced swarm robots provide a broader range of features, enabling a wide range of tasks to be approached, from simple to advanced. To address this trade-off, an available and versatile robotic platform is proposed: the Cheap, Interchangeable Robotic Platform -the ChIRP robot. The basic platform implements mandatory features required for most swarm experiments, providing a cheap simple and extendible platform. Further, extensions (including both electronic and mechanical features) enable an advanced specialised swarm robot tailored to the needs of a given research agenda. The design considerations and implementation details are presented herein. Further, an example swarm task for the basic ChIRP robot is presented together with an example task illustrating an extension of the ChIRP robot.

F4B-5

16:30-16:50

Aeroponic Greenhouse as an Autonomous System using Intelligent Space for Agriculture Robotics

Martin PALA[1], Ladislav MIZENKO[1], Marian MACH[1] and Tyler REED[2]
[1]Technical University of Košice, Slovakia, [2]Independent Consultant, USA

This paper describes a novel approach to aeroponic and hydroponic system monitoring, fault detection and automation. The first part of this paper is dedicated to brief literature preview about hydroponics and aeroponics, its common and distinctive features and the description of the needs for its automation. The second part of this paper deals with aeroponic greenhouse control scheme proposal. We consider a greenhouse covered by a sensor network, actuators and hydroponic or aeroponic platforms to be a robotic system in so called intelligent space. The aeroponic platform design is described besides the conclusions and future work ideas in the last part of this paper.

F4C | Computer Vision | 606

15:10-16:30 Chair : Sergey M. Sokolov, KIAM RAS, Russian Federation

F4C-1

15:10-15:30

Computer vision system as part of bio-mechatronic rehabilitation simulator

Sergey M. Sokolov, Alexander K. Platonov, Andrey A. Boguslavskiy and Oleg V. Triphonov
Keldysh Institute for Applied Mathematics RAS, Russia

There is a description of the first stage of researches aimed at equipping with the vision system ("VS") for the rehabilitation simulator being developed for the rehabilitation of spinal patients who suffer paraplegia. Based on the VS information it is supposed to develop some software tools to solve the issue of mechatronics of the bio-training simulator in order to create artificial motions of the paralyzed legs imitating natural legged movement. There's discussed a hardware- and software of the system, methods of data-acquisition concerning the leg movements of a healthy person. There're given results of the first experiments aimed at acquiring data needed for the analysis of the geometrical parameters of the leg movement. There've been received some accuracy assessments to define angles and angular velocities in the hip, knee joint, and ankle joint. This research has been performed with the support of RFBR grants No. 11-01-12060-ofi-m-2011, No 12-08-12030-ofi-m-2012.

F4C-2

15:30-15:50

FPGA Implementation of Global Vision for Robot Soccer as a Smart Camera

Miguel Contreras, Donald G Bailey and Gourab Sen Gupta
Massey University, New Zealand

An FPGA-based smart camera is being investigated to improve the processing speed and latency of image processing in a robot soccer environment. By moving the processing to a hardware environment, latency is reduced and the frame rate increased by processing the data as it is steamed from the camera. The algorithm used to track and recognise robots consists of a pipeline of separate processing blocks linked together by synchronisation signals. Processing of the robots location and orientation starts while the image is being captured so that all the robot data is available before the image has been fully captured. The latency of the current implementation is 4 rows, with the algorithm fitting onto a small FPGA.

F4C-3 15:50-16:10

Obstacle & Lane Detection and Local Path Planning for IGVC Robotic Vehicles using Stereo Vision

Christopher Kawatsu, Jiaxing Li and CJ Chung
Lawrence Technological University, USA

A robotic car, also known as a driverless or self-driving car, is an autonomous vehicle capable of sensing its environment and navigating itself without human input. Robotic cars exist mainly as prototypes and demonstration systems, but are likely to become more widespread in the near future. Usually, autonomous vehicles sense their surroundings for lane detection and obstacle avoidance with radar, 2D LIDAR, 3D LIDAR, and camera sensors. This article describes our approach in developing an affordable stereo vision system using two ordinary webcams and OpenCV (Open Source Computer Vision) library. We applied our stereo vision system to Vulture 2 and iWheels robotic platforms to enter IGVC (Intelligent Ground Vehicle Competition) 2012 and 2013. The results show that stereo vision based navigation is a promising and affordable mechanism to develop robot cars.

F4C-4 16:10-16:30

Adaptive regions of interest based on HSV histograms for lane marks detection

Vitor S. Bottazzi[1], Paulo V. K. Borges[2], Bela Stantic[1] and Jun Jo[1]
[1]Griffith University, Australia, [2]CSIRO ICT Centre, Australia

The lane detection is a vital component of autonomous vehicle systems. Although many different approaches have been proposed in the literature it is still a challenge to correctly identify road lane marks under abrupt light variations. In this work a vision-based ego-lane detection system is proposed with the capability of automatically adapting to abrupt lighting changes. The proposed method automatically adjusts the feature extraction and salient point tracking cues introduced by the GOLDIE (Geometric Overture for Lane Detection by Intersections Entirety) algorithm. The variance of the lighting conditions is measured using hue-saturation histogram and abrupt light changes on the road are detected based on the difference between histograms. Experimental comparison with previously proposed algorithms demonstrated that this method achieved efficient lane detection in the presence of shadows and headlights. In particular, the accuracy of the algorithm applied on the footage with highest light variation increased 12.5% on average. The overall detection rate increased 4%, which illustrated the applicability of the method.

F5P | Interactive Session | Lobby

16:50-18:00 **Chair : Peter Xu, The University of Auckland, New Zealand**

F5P-1 **Implementation of High Reduction Gear Ratio by Using Cable Drive Mechanism**

Bum-Joo Lee
Myongji University, Korea

In spite of advantages such as lightness, back drivability and zero backlashes, cable drive systems are slightly utilized in the robotic applications because it is hard to implement high reduction gear ratio in an acceptable size to install. Cable drive systems are commonly implemented by connecting several single-level systems to increase the reduction ratio. Since tension adjustment and fastening devices for wire cables are mounted in each level, however, the size of the system and the risk of fault are rather high. Proposed mechanical structure resolves these inherent difficulties by seamless winding technique. Consequently, this manner reduced the complexity significantly.

F5P-2 **Navigation Control of a Robot from a Remote Location via the Internet using Brain-Machine Interface**

Jorge Ierache[1,2], Gustavo Pereira[1] and Juan Iribarren[1]
[1]Universidad de Moron, Argentina, [2]Facultad da Ingeniería Universidad da Buenos Aires, Argentina

This article shows the experiences carried out in the context of Human Brain-Robot Control between Remote Places communication, on the basis of brain bio-electrical signals, with the application of the Brain-Machine Interface from Emotiv. There are available technologies and interfaces which have facilitated the reading of the bio-electrical signal

from the user's brain and their association to explicit commands that have allowed controlling mobile robots (NXT-Lego) by adapting communication devices. Our work presents an engineering solution, with the application of technological basis, the development of the local communication framework and remote control. Lastly, metrics and indicators from the realized tests are proposed.

F5P-3 **Cognitive Architectures for Prognostic Health Management**

James A. Crowder and John N. Carbone
Raytheon Intelligence, USA

In the real-time battlefield arena, situational awareness becomes critical to making the right decisions and achieving the overall goals for the system. The key to Situational Awareness is not simply collecting and disseminating data, but it is actually getting the right information to the right users at the right time. In ground processing systems, various sensors, spacecraft, and other data sources gather and generate data different relevant contexts. What is required is an Integrated System Health Management (ISHM) processing architecture that allows users to turn the data into meaningful information, and to reason about that information in a context relative to the user at that time, and to update the information real-time as the situation changes. In short, it is imperative that the information processing environment be efficient, timely, and accurate. Described will be an Intelligent Information Agent processing environment which allows data to be processed into relevant, actionable knowledge. Based on the technologies described above, situational management is one of the most innovative components of this processing system. Utilizing the Artificial Cognitive Neural Framework (ACNF) [5], it can provide real-time processing and display of dynamic, situational awareness information.

F5P-4 **Vibration Occurrence Estimation and Avoidance for Vision Inspection System**

Kap-Ho Seo, Yongsik Park, Sungjo Yun, Sungho Park and Jeong Woo Park
Korea Institute of Robot and Convergence, Korea

Disturbance / vibration reduction is critical in many applications using machine vision. The off-focusing or blurring error caused by vibration degrades its performance. Instead of going with the more familiar approach like vibration absorber, a real-time disturbance estimation and avoidance is proposed. Instantaneous motion due to the disturbance is sensed by an accelerometer inertial measurement unit (IMU). Modeling of periodic vibration is done to provide better performance. According to its modeling, the algorithm for vibration avoidance was described.

F5P-5 **Flexible and Wearable Hand Exoskeleton and Its Application to Computer Mouse**

Woo-Young Go and Jong-Hwan Kim
KAIST, Korea

This paper proposes a flexible and wearable hand exoskeleton which can be used as a computer mouse. The hand exoskeleton is developed based on a new concept of wearable mouse. The wearable mouse, which consists of flexible bend sensor, accelerometer and bluetooth, is designed for comfortable and supple usage. To demonstrate the effectiveness of the proposed wearable mouse, experiments are carried out for mouse operation consisting of click, cursor movement and wireless communication. The experimental results show that our wearable mouse is more accurate than a standard mouse.

F5P-6 **Formation Control Experiment of Autonomous Jellyfish Removal Robot System JEROS**

Donghoon Kim, Jae-Uk Shin, Hyongjin Kim, Hanguen Kim and Hyun Myung
KAIST, Korea

The proliferation of jellyfish is threatening marine ecosystem and has caused severe damage to marine-related industries. An autonomous jellyfish removal robot system, named JEROS (Jellyfish Elimination Robotic Swarm), has been developed to cope with this problem. This paper presents formation control of JEROS and related experimental results through field tests. The JEROS is extended to multi-agent robot system and employs the leaderfollower algorithm for formation control. The Theta* path planning algorithm is employed to generate an efficient path. Three prototypes of JEROS are implemented, and the feasibility of their formation control and the performance of jellyfish removal were demonstrated through field tests in Masan Bay located in the southern coast of South Korea.

F5P-7

Fall detection interface of remote excavator control system

Sun Lim, Han Youn Jin, Jae Soon Park and Bong-Seok Kim
Korea Electronics Technology Institute(KETI), Korea

This paper describes the fall detection algorithm for wireless excavator control system. During the using the it, user's unintentional fall cause the serious and sick problem such as overturned excavator and excavator failure. The distinguish of fall and fall-like activities is very difficult on practice environment. The adaptive band pass filter mechanism is very useful to determine the fall detection and to distinguish the state of excavator control system. Our algorithm reduce both false detection rate while improving fall detection accuracy. In addition, our solution features low computational cost and real time response. Thus most system will be equipped easy .

F5P-8

Target-driven Visual Words Representation via Conditional Random Field and Sparse Coding

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At any given moment, humans eye captures a large amount of information simultaneously. Among these information, human visual system is able to select specific information in which human is interested. In recent years, there have been trials for (system) experimental, computational and theoretical studies on imitating human visual system, which are commonly referred as sparse coding. When any visual stimuli are given, human visual system makes a minimal number of neurons activated efficiently. It increases the storage capacity in associative memories. A set of activated neurons and deactivated neurons are called sparse code and the process to make sparse code is called sparse coding. In this paper, the effectiveness of the proposed method is demonstrated for Graz-02 dataset. And visual words were visualized that were relevant to activated neurons as patch-level images and sparse coding. By displaying active neurons that are represented by visual words, sparse coding could be a solution to top-down visual object detection.

F5P-9

Feature-based 6-DoF Camera Localization using Prior Point Cloud and Images

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KAIST, Korea

In this paper, we present a new localization algorithm to estimate the localization of a robot based on prior data. Over the past decade, the emergence of numerous ways to utilize various prior data has opened up possibilities for their applications in robotics technologies. However, challenges still remain in estimating a robot's 6-DoF position by simply analyzing the limited information provided by images from a robot. This paper describes a method of overcoming this technical hurdle by calculating the robot's 6-DoF location. It only utilizes a current 2D image and prior data, which consists of its corresponding 3D point cloud and images, to calculate the 6-DoF position. Furthermore, we employed the SURF algorithm to find the robot's position by using the image's features and the 3D projection method. Experiments were conducted by the loop of 510m trajectory, which is included the prior data. It is expected that our method can be applied to broad areas by using enormous data such as point clouds and street views in the near future.

F5P-10

Trajectory Tracking Control Using Echo State Networks for the CoroBot's Arm

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Different neural network models have proven being useful for tracking purposes in robotic devices. However, some models have shown superior performances to others that generate a large computational cost. This is the case of recurrent neural networks, which due to the temporal relationship existing allows satisfactory answers. Furthermore, training used by traditional algorithms, require a relatively high convergence time for some applications, especially those that are on-line. Given this problematic, this paper suggests use Echo State Networks (ESN) to perform such tasks. Additionally, results are presented for two sets of predefined tests, which were used to validate control behavior of trajectories in a manipulator embedded in a mobile platform. The results presented are related to the planar control of the manipulator in a closed loop.

F5P-11 **An intelligent control system for mobile robot navigation tasks in surveillance**

Chi-Wen Lo, Kun-Lin Wu, Yue-Chen Lin and Jing-Sin Liu
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In recent years, the autonomous mobile robot has found diverse applications such as home/health care system, surveillance system in civil and military applications and exhibition robot. For surveillance tasks such as moving target pursuit or following and patrol in a region using mobile robot, this paper presents a fuzzy Q-learning, as an intelligent control for cost-based navigation, for autonomous learning of suitable behaviors without the supervision or external human command. The Q-learning is used to select the appropriate rule of interval type-2 fuzzy rule base. The initial testing of the intelligent control is demonstrated by simulation as well as experiment of a simple wall-following based patrolling task of autonomous mobile robot.

F5P-12 **Design and Control of a Humanoid Robot for Traffic Guidance**

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In this paper, a humanoid traffic guidance robot with 9 active degrees of freedom (DOF) is designed to relieve the traffic pressure and improve the working safety situation for the road traffic policemen and road maintenance workers. The proposed robot is able to perform the standard traffic command gestures such as turning left, turning right, slowing down and stopping according to the feedback signal of a radar sensor. Besides, there is a digital camera capturing the high resolution images of the vehicles having a speed higher than the preset limitation. The image information is recorded in a SD memory card and can be used to check the illegal driving history. The mechanical structure, the kinematics and the control system are described. On each robot joint a PID controller is implemented for trajectory tracking control. Several preliminary experiments have been implemented to verify the effectiveness of traffic conducting in the laboratory environment and realistic application.

F5P-13 **Programming an E-Puck Robot to Create Maps of Virtual and Physical Environments**

Pablo Tarquino and Kevin Nickels
Trinity University, USA

This project is a first step towards research on implementing Simultaneous Localization and Mapping (SLAM) techniques in robots. The paper provides theoretical background for SLAM and occupancy grids, which are used in the project to create maps. The paper also describes the software, Python and Player/Stage, and the hardware, the E-Puck robot, used in the project. This project successfully programmed an E-Puck robot to map an unknown virtual and physical environment. The virtual environment has perfect localization conditions, while the physical environment has error in its localization. A comparison of these maps shows that the map of the virtual environment is highly accurate, while the map of the physical environment is less accurate due to odometery errors.

F5P-14 **Cloud-based Object Recognition: A System Proposal**

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In this chapter, we will present a proposal for the cloud - based object recognition system. The system will extract the local features from the image and classify the object on the image using Membership Function ARTMAP (MF ARTMAP) or Gaussian Random Markov Field model. The feature extraction will be based on SIFT, SURF and ORB methods. Whole system will be built on the cloud architecture, to be readily available for the needs of the new emerging technological field of cloud robotics. Besides the system proposal, we specified research and technical goals for the following research.

F5P-15 **Design of Knowledge-based Communication between Human and Robot Using Ontological Semantic Technology in Firefighting Domain**

Ji Hyeon Hong, Eric T. Matson and Julia M. Taylor
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This paper discusses how to design robot-human communication using Ontological Semantic Technology (OST), which

is to address meanings of phrases or sentences in natural languages, in a firefighting domain. The OST is a system in an ontology-based structure to deal with different natural languages. In this study, English and Korean were selected to be implemented for the OST. The problem set is designed with Natural English, direct word-by-word translation from the natural English to Korean, natural Korean, and direct word-by-word translation from the natural Korean to English, which can be compared to examine the similarity of meanings with a language-independent ontology in processing English and Korean.

F5P-16 **Automatic Salient Object Detection Using Principal Component Analysis**

Hansang Lee, Jiwhan Kim and Junmo Kim
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In this paper, a novel method for salient object detection from natural images is proposed. In order to extract the object from an image which is visually attractive, non-redundancy is conceptually incorporated to define the saliency of image pixels by applying principal component analysis (PCA) to color components of an image. From the principal component images, seed pixels for object and background are extracted. Using these object and background seed pixels as training samples, linear discriminant analysis (LDA) is applied to image pixels so that the pixels are classified as object or background. Experiments on test images show that not only the performance of the proposed method is promising, but also it works competitively with state-of-the-art salient object detection methods.

F5P-17 **Human Inspired Control of a Small Humanoid Robot in Highly Dynamic Environments or Jimmy Darwin Rocks the Bongo Board**

Jacky Baltes, Chris Iverach-Brereton and John Anderson
University of Manitoba , Canada

This paper describes three human-inspired approaches to balancing in highly dynamic environments. In this particular work, we focus on balancing on a Bongo board - a common device used for human balance and coordination training - as an example of a highly dynamic environment. The three approaches were developed to overcome limitations in robot hardware. Starting with an approach based around a simple PD controller for the centre of gravity, we then move to a hybrid control mechanism that uses a predictive control scheme to overcome limitation in sensor sensitivity, noise, latency, and jitter. Our third control approach attempts to maintain a dynamically stable limit cycle rather than a static equilibrium point, in order to overcome limitations in the speed of the actuators. The humanoid robot Jimmy is now able to balance for several seconds and can compensate for external disturbances (e.g., the Bongo board hitting the table). A video of the robot Jimmy balancing on the Bongo board can be found at http://www.youtube.com/watch?v=ia2ZYqqF-lw.

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