CIRA 2009

2009 IEEE International Symposium on
Computational Intelligence in Robotics and Automation

Program & Abstracts

December 15-18, 2009
Daejeon, Korea

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Welcome to CIRA 2009

I would like to thank you all who come from all around the globe to take part in IEEE CIRA 2009 Korea. It is my great honor to be General Chair of its 8th conference this year.

CIRA has been providing an opportunity for prominent researchers, engineers and practitioners to present the latest research results, innovations, and potential future directions in computational intelligence in robotics and automation.

Its special emphasis on innovative usage of computational intelligence in robotics, manufacturing systems, medical instruments and systems, health care, and automation covers wide range of practical applications for industry development and improvement of quality of life as well.

It is significant that CIRA is held in Korea, since Korea is putting so much emphasis on robotic industry and research field and believes that robotics industry will lead the country in the near future.

Also, I hope that all the participants of CIRA 2009 could have wonderful time here in Daejeon, the city of science and technology.

Last but not least, I would like to thank many of my colleagues who have helped me preparing this conference.

Thank you!

Jong-Hwan Kim
General Chair
CIRA 2009

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Timetable

Tuesday, December 15, 2009	
Room #	**101**
09:00-12:30	**T1: Sensors and Robots for Humanitarian Demining: Needs, Present and Future** Maki K. Habib (The American University in Cairo, Egypt)
12:30-14:00	Lunch Break
14:00-17:30	**T2: Linking Cognitive Robotics and Brain Research** **#1: What's so special about the brain?** Dae-Shik Kim (KAIST, Korea) **#2: Methods in computational neuroscience** Myoung Won Cho (Korea Institute for Advanced Study, Korea) **#3: From single neurons to large-scale modeling** Chang-Woo Shin (Asia Pacific Center for Theoretical Physics, Korea) **#4: Brain Connectivity Analysis** Tae-Wook Ko (National Institute for Mathematical Sciences, Korea) **#5: Application of retina-on-chip to the development of visual neural prosthesis** Kyung Hwan Kim (Yonsei University, Korea)
18:00~19:30	**Welcoming Reception** (Grace Hall, Hotel Riviera)

Wednesday, December 16, 2009			
Room #	**101**	**102**	**103**
08:30-09:30	**Opening Ceremony & Plenary #1** (Room #101) **Using Evidence and Theory to Design More Effective Evolutionary Algorithms** David B. Fogel (President, the IEEE Computational Intelligence Society)		
09:30-09:50	Coffee Break		
09:50-11:30	**WA1** **Multi Co-operative Robotics**	**WB1** **Neural Networks**	**WC1** **Social Intelligence**
11:30-13:00	Lunch Break		
13:00-14:40	**WA2** **Computer Vision 1**	**WB2** **Machine Learning**	**WC2** **Swarm Intelligence**
14:40-15:00	Coffee Break		
15:00-17:00	**WA3** **Adaptive and Learning System 1**	**WB3** **Evolutionary Computation 1**	**WC3** **Intelligent Systems 1**

Thursday, December 17, 2009			
Room #	**101**	**102**	**103**
08:30-09:30	**Plenary #2** (Room #101) **Cognitive Robotics: State of the Art and Challenges** Fakhri Karray (University of Waterloo, Canada)		
09:30-09:50	Coffee Break		
09:50-11:30	**TA1** **Computer Vision 2**	**TB1** **Evolutionary Robotics**	**TC1** **Intelligent Systems 2**
11:30-13:00	Lunch Break		
13:00-14:40	**TA2** **Computer Vision 3**	**TB2** **Sensor Fusion 1**	**TC2** **Behavioral Intelligence**
14:40-15:00	Coffee Break		
15:00-17:00	**TA3** **Adaptive and Learning System 2**	**TB3** **Evolutionary Computation 2**	**TC3** **Fuzzy Logic**
18:00~	**Banquet** (Torch Hall, Hotel Riviera)		

Friday, December 18, 2009			
Room #	**101**	**102**	**103**
08:30-09:30	**Plenary #3** (Room #101) **Intelligent Robot Software Framework for Real Robotic Service to Human** Munsang Kim (Director, Center for Intelligent Robotics, KIST, Korea)		
09:30-09:50	Coffee Break		
09:50-11:30	**FA1** **Computer Vision 4**	**FB1** **Sensor Fusion 2**	**FC1** **Personal Robotics**

Floor Map

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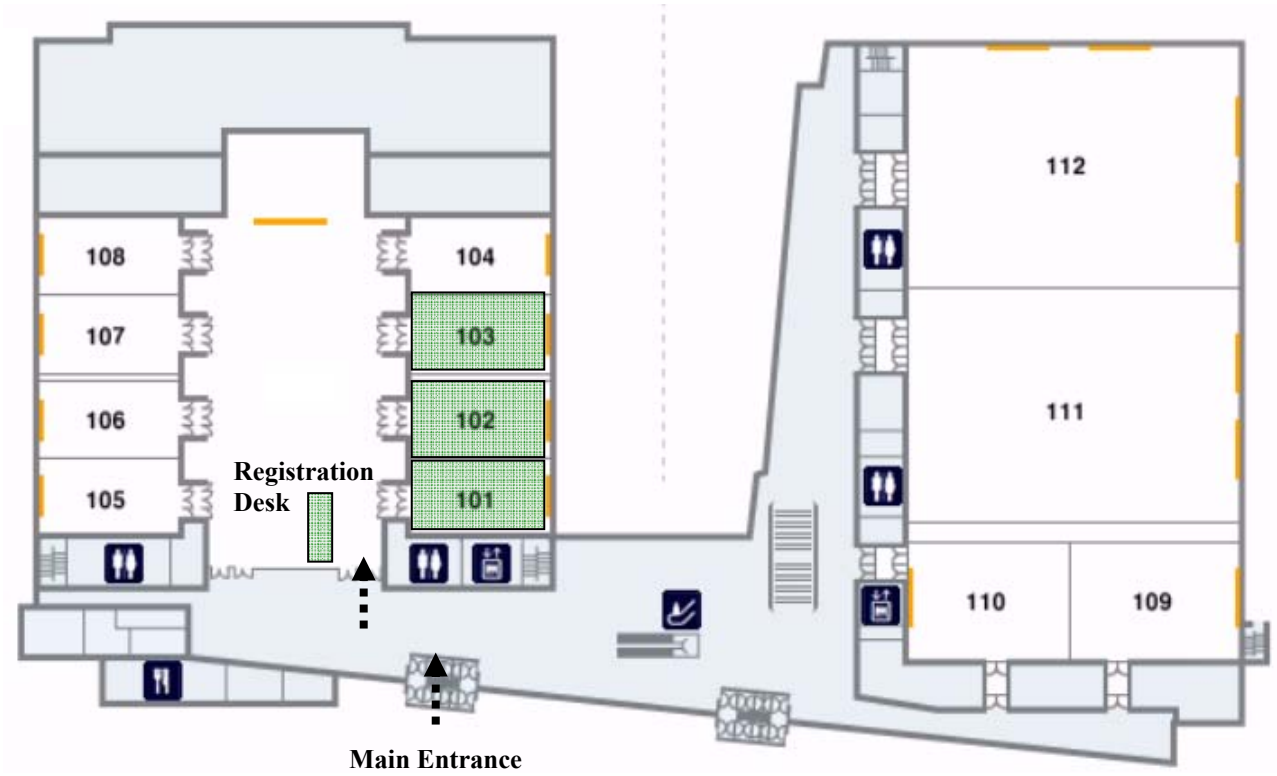

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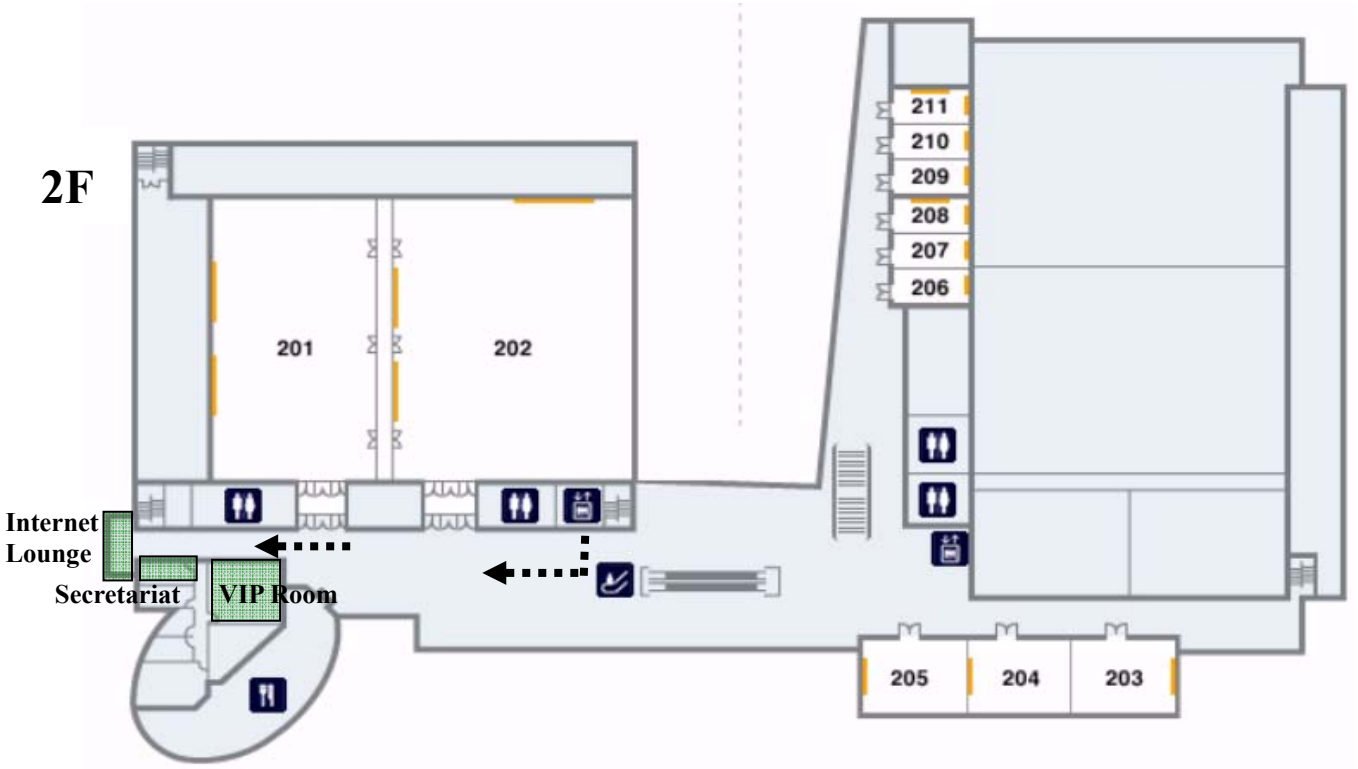

General Information

Official Language
The official language of the conference is English.

Registration Desk
The registration desk on the main lobby (1st Floor) in the venue will be open as follow:

Tuesday, December 15, 2009	08:30-18:00
Wednesday, December 16, 2009	08:00-17:00
Thursday, December 17, 2009	08:00-18:00
Friday, December 18, 2009	08:00-11:30

Oral Presentation
Every room is equipped with LCD projector and Windows Laptop, with PowerPoint and Acrobat PDF reader. Please make your best to use the room laptop and upload your presentation file on it before the beginning of the session. If you really need to use your laptop (only in the case you need special software for your presentation or in case of major compatibility problems), check the connection with the projector before the session starts. Notice: time lost in setting up your laptop during the session cannot be recovered: this will end up in a shorter time available for yours presentation. Greet/meet the session chair before the session starts. Please arrive early enough, to find out the session chair and to tell him/her your name, affiliation and the title of your paper. The presentation time is 20 minutes. This includes speaker transition, the setting of your computer (if needed), and question & answers. So each speaker should finish his/her talk within 15 or 16 minutes to have a time for question & answers.

Internet Lounge
Internet lounge will be operated on the 2nd floor in the venue without charge during Conference dates.

Social Program

Welcome Reception
Time: 18:00-19:30
Date: Tuesday, December 15, 2009
Place: Grace Hall (2nd Floor), Hotel Riviera

The welcome reception will be held at the Grace Hall (2nd Floor) in the Hotel Riviera. An invitation to the welcome reception is extended to all participants including registered students.

Banquet
Time: 18:00 ~
Date: Thursday, December 17, 2009
Place: Torch Hall (1st Floor), Hotel Riviera

We hope this banquet will offer you a good opportunity to promote friendship with participants. Delicious food, and fusion Korean traditional music performance will be offered at the banquet. A banquet ticket is included in the Regular Registration (R1~R2). Student Registration (R3) does not include the banquet.

Tutorials

Tuesday, December 15, 2009

Morning Session: 9:00 ~ 12:30
Room: #101

T1: Sensors and Robots for Humanitarian Demining: Needs, Present and Future
Maki K. Habib (The American University in Cairo, Egypt)

Afternoon Session: 14:00 ~ 17:30
Room: #101

T2: Linking Cognitive Robotics and Brain Research

#1: What's so special about the brain?
Dae-Shik Kim (KAIST, Korea)

#2: Methods in computational neuroscience
Myoung Won Cho (Korea Institute for Advanced Study, Korea)

#3: From single neurons to large-scale modeling
Chang-Woo Shin (Asia Pacific Center for Theoretical Physics, Korea)

#4: Brain Connectivity Analysis
Tae-Wook Ko (National Institute for Mathematical Sciences, Korea)

#5: Application of retina-on-chip to the development of visual neural prosthesis
Kyung Hwan Kim (Yonsei University, Korea)

Plenary Speakers

08:30-09:30, Wednesday, December 16, 2009
Room: #101

Using Evidence and Theory to Design More Effective Evolutionary Algorithms

David B. Fogel
President, the IEEE Computational Intelligence Society

Abstract
Evolutionary computation has been applied to real-world problem solving for over 50 years. The evolutionary approach requires considering a variety of design decisions involving problem representation, variation operators, selection, population size, objective functions, and others. In this lecture, Dr. Fogel addresses some of the aspects of problem solving that he employs when addressing a problem from an evolutionary computing perspective. Aspects of mathematical theory about exploration and exploitation in search, as well as convergence rates, will be discussed as they apply to certain mathematical functions. Tools for assessing the effectiveness of alternative search operators and selection methods will be detailed. Finally, visualization of adaptive landscapes will be offered to assist in identifying different representations. Recombining the results of these analyses into a comprehensive picture of the problem can result in marked improvements in the quality of solutions and the speed in which those solutions are discovered.

Biography
David B. Fogel is the managing director of the Lincoln Vale Adaptive Strategies Group, which was formed in early 2008. He also serves as chairman of the board of Natural Selection, Inc., a company that applies evolutionary computation methods to challenging problems in United States defense and homeland security as well as providing solutions for industry and medicine. Dr. Fogel has served as a systems analyst at Titan Systems, Inc. (1984-1988), a senior principal engineer at ORINCON Corporation (1988-1993), and as an officer of Natural Selection, Inc. (1993-2008). Dr. Fogel received his M.S. and Ph.D. in engineering sciences with an emphasis on systems science from the University of California at San Diego in 1990 and 1992, respectively. He earned his B.S. in mathematical sciences with an emphasis on probability and statistics from the University of California at Santa Barbara in 1985. Dr. Fogel has written more than 200 publications, including 6 books, about evolutionary computation, neural networks, and computational intelligence. Dr. Fogel is the current president of the IEEE Computational Intelligence Society, a Fellow of the IEEE, and has received several scientific awards including the 2004 IEEE Kiyo Tomisayu Technical Field Award and the 2008 IEEE Computational Intelligence Society Evolutionary Computation Pioneer Award. He received an honorary doctorate from the University of Pretoria in 2008.

Plenary Speakers (cont.)

08:30-09:30, Thursday, December 17, 2009
Room: #101

Cognitive Robotics: State of the Art and Challenges

Fakhri Karray
University of Waterloo, Canada

Abstract
Major advances made over the past years in the areas of computational Intelligence, sensor fusion, intelligent man machine interaction, bio-inspired systems and neuroscience have made it possible to design new generation of intelligent robotic systems known as cognitive robotics. The increased interest in this field is mainly driven by the need for designing machines (robots in this context) that are able to interact with human very naturally and as much socially as possible, thus the new connotation of Social Robots. These new type of robots could be used for assistive tasks, for entertainment purposes and could be deployed in potentially hazardous and remote environment. Recent advances made in the field of cognitive systems and computational intelligence has made it possible to impart robots with new perceptual and context aware capabilities (humanoid systems). This is mostly done by endowing a machine with autonomous knowledge acquisition capabilities and automated reasoning mechanism allowing it to make high level decisions and respond adequately to previously unseen situations while being aware of its own existence and abilities (self-awareness) in achieving a particular goal. In this talk, we retrace the major milestones that led to the development of this emerging field and outline recent advances in developmental cognitive robotics, multi-modal attention, perception, reflectivity and social interaction. The talk also tackles recent application of cognitive robotics in areas such as assistive robotics and highlights the challenges encountered in developing cognitive systems that are truly human-like in terms of perception, adaptability and versatility.

Biography
Fakhri Karray received the Ph.D. degree from the University of Illinois, Urbana-Champaign, USA (89) in the area of Systems and Control. He is a Professor of Electrical and Computer Engineering at the University of Waterloo, Canada and the Associate Director of the Pattern Analysis and Machine Intelligence Laboratory. Dr. Karray has authored extensively in journals and conferences proceedings and holds thirteen US patents in various areas of intelligent systems. He is the co-author of a textbook on soft computing: Soft Computing and Intelligent Systems Design, Addison Wesley Publishing, 2004. Dr. Karray serves as the Associate Editor of a number of journals in his filed: the IEEE Transactions on Mechatronics, the IEEE Transactions on Systems Man and Cybernetics (part B), the IEEE Computational Intelligence Magazine, the International Journal of Robotics and Automation, the Journal of Intelligent Systems and Control, and the International Journal on Smart Sensing and Intelligent Systems. He has served as Chair/ co-Chair for more than 12 International Conferences and Technical Programs and served most recently as the General Co-Chair of the IEEE Conference on Logistics and Automation, China, 2008 and is the General co Chair of the International Conference on Systems, Circuits and Signals, Tunisia, 2009. Dr. Karray is the Waterloo Chapter Chair of the IEEE Control Systems Society and the IEEE Computational Intelligence Society.

Plenary Speakers (cont.)

08:30-09:30, Friday, December 18, 2009
Room: #101

Intelligent Robot Software Framework for Real Robotic Service to Human

Munsang Kim
Director, Center for Intelligent Robotics, KIST, Korea

Abstract
In recent years service robots have received a lot of attention from both industry and academia. They are individually designed to perform tasks in an unstructured environment for working with or assisting humans. Such robots thus have to be able to actively interact with potential users in their surroundings and to appropriately offer their services. It is essential for service robots to have a very flexible and well organized software framework in order to handle this kind of enormous and diverse information flow. In this talk robot intelligence architecture and it's corresponding knowledge base framework will be introduced, which are being developed for realizing practical robot intelligence at KIST. And efforts to make the software available as the reusable components for integration and to achieve error and exception handling methodology due to environmental diversity and complexity will be discussed. The proposed intelligent robot architecture was successfully applied to the intelligent robot platforms called Silbot and Ciros. Some video clips through the real experimental tryout will be also given during the presentation.

Biography
Munsang Kim received the B.S. and M.S degree in Mechanical Engineering from the Seoul National University in 1980 and 1982 respectively and the Dr.-Ing. degree in Robotics from the Technical University of Berlin, Germany in 1987. Since 1987 he has been working as a research scientist at the Korea Institute of Science and Technology. He lead the Advanced Robotics Research Center since 2000 and became the director of the "Intelligent Robot – The Frontier 21 Program" since Oct. 2003, which is one of the most challenging research programs in Korea. He is an invited professor at the Waseda University and Korea University since the year 2008 and 2000 respectively. He is serving as the editor for the Journal "Intelligent Service Robot" and has served as Chair and co-Chairs for several international conferences. He is also serving as the Korean representative for the International Advanced Robotics Program since 2005. His current research interests are design and control of novel mobile manipulation systems, haptic device design and control, and sensor application to intelligent robots.

Tuesday, December 15, 09:00-12:30

Tutorial T1 (#101)
Sensors and Robots for Humanitarian Demining: Needs, Present and Future
Maki K. Habib, The American University in Cairo

Tuesday, December 15, 14:00-17:30

Tutorial T2 (#101)
Linking Cognitive Robotics and Brain Research
Dae-Shik Kim, KAIST
Myoung Won Cho, Korea Institute for Advanced Study
Chang-Woo Shin, Asia Pacific Center for Theoretical Physics
Tae-Wook Ko, National Institute for Mathematical Sciences
Kyung Hwan Kim, Yonsei University

Tuesday, December 15, 18:00-19:30

Welcome Reception (Hotel Riviera)

Wednesday, December 16, 08:30-09:30

Opening Ceremony (#101)

Plenary #1 (#101)
Using Evidence and Theory to Design More Effective Evolutionary Algorithms
David B. Fogel, President, the IEEE Computational Intelligence Society

Wednesday, December 16, 09:50-11:30

Wed. 09:50-11:30 **#101**

WA1: Multi Co-operative Robotics

Chair: Masakazu Suzukim, Tokai University

1. Grasp Motion Planning for Box Opening Task by Multi-fingered Hands and Arms
Tetsuyou Watanabe, Michael Beetz

The aim of our project is to develop a robot to manipulate an object in human environment. In this paper, as a first step, we focus on opening paper box such as tea box, and present a method to plan grasp motion by 2 arms with multi-fingered hands. We propose a task priority based scheme to plan grasping area consistent with whole steps of the given task procedure. Based on the grasping area and the concept of preshape, we derive desired fingertip positions and hand base position and orientation for preshape. Based on the vector field approach, we propose a motion planning method for the planned grasp by multi-fingered hands to avoid any undesired collisions. This method can be applied to regrasping and a motion in which collision is required.

2. Planning of Diverse Complex Cooperative Robot Actions using Multi-stage Genetic Algorithm
Masakazu Suzuki

This article is concerned with autonomous planning of diverse cooperative robot actions. In this work complex cooperative actions are realized based upon the Intelligent Composite Motion Control, which is a learning methodology for intelligent robots that gradually realize complex actions from fundamental motions. For efficient construction of action intelligence Multi-stage Genetic Algorithm, MGA, is used. The MGA solves a large scale optimization problem with complicated constraints as multi-stage but small scale combinatorial optimization problems with simple constraints, which are solved by GA to generate their suboptimal solution sets. In order to realize autonomous planning of diverse cooperation according to situation, Variable-chromosome-length Genetic Algorithm (VGA) is introduced and combined to MGA. The presented method is successfully applied to planning of diverse cooperative robot soccer actions according to situation.

3. Exploration and Mapping for Unstructured Robot Teams
Adrian Martin, M. Reza Emami

As the applications of mobile robot teams become more complex, the impracticality of designing custom solutions is becoming increasingly obvious. A new approach to control system design is required to facilitate the development of modular and scalable systems. Control ad libitum is an approach that decouples the software and hardware design of robot teams, allowing the system to adapt to changing hardware and simplifying the process of adding functionality to the control system. The “Host, Avatar, Agent” control architecture was developed utilizing this approach and preliminary experimental results from an exploration and mapping scenario are presented here. The experimental results demonstrate the viability of the architecture, specifically in the areas of modularity and scalability, and provide some insights into how such a system could work for real-world applications.

Wed. 09:50-11:30 **#102**

WB1: Neural Networks

Chair: Naoyuki Kubota, Tokyo Metropolitan University

1. Stable Trajectory Generator—Echo State Network Trained by Particle Swarm Optimization
Qingsong Song, Zuren Feng

Recurrent neural networks (RNNs) have good modeling capability for nonlinear dynamic systems, but due to the difficulties for training this superiority is discounted. Echo state network (ESN) is a new paradigm for using RNNs with a simpler training method, where an RNN is generated

randomly and only a readout is trained. ESN method has quickly become popular in robotics, such as for motor control, for navigation. However, the classical training method for ESNs can not ensure the dynamics asymptotic stability if the trained ESNs run in a closed-loop self-generative mode. The reason is analyzed at first. We then consider the ESN training problem as an optimization problem with a nonlinear constraint, and take a particle swarm optimization (PSO) algorithm solve it. In our simulation experiments, the ESNs are trained as "figure-eight" trajectory generators. The results show that the proposed PSO-based training method can effectively ensure the dynamics asymptotic stability as well as the precision of generating trajectories of the trained ESNs.

2. Modular Reservoir Computing Networks for Imitation Learning of Multiple Robot Behaviors
Tim Waegeman, Eric Antonelo, Francis wyffels, Benjamin Schrauwen

Autonomous mobile robots must accomplish tasks in unknown and noisy environments. In this context, learning robot behaviors in an imitation based approach would be desirable in the perspective of service robotics as well as of learning robots. In this work, we use Reservoir Computing (RC) for learning robot behaviors by demonstration. In RC, a randomly generated recurrent neural network, the reservoir, projects the input to a dynamic temporal space. The reservoir states are mapped into a readout output layer which is the solely part being trained using standard linear regression. In this paper, we use a two layered modular structure, where the first layer comprises two RC networks, each one for learning primitive behaviors, namely, obstacle avoidance and target seeking. The second layer is composed of one RC network for behavior combination and coordination. The hierarchical RC network learns by examples given by simple controllers which implement the primitive behaviors. We use a simulation model of the e-puck robot which has distance sensors and a camera that serves as input for our system. The experiments show that, after training, the robot learns to coordinate the Goal Seeking (GS) and the Object Avoidance (OA) behaviors in unknown environments, being able to capture targets and navigate efficiently.

3. Interactive Evolutionary Computation for Robot Design Support System
Wataru Sato, Naoyuki Kubota

Recently, human-friendly support systems for product design have been developed as demands of individual user to products become diversified. In the previous works, Interactive Evolutionary Computation has been applied to support product designs. An advantage of Interactive Evolutionary Computation is that it can perform the optimization based on human preference and feeling in addition to the evaluation by fitness functions. However, the main target of the application of Interactive Evolutionary Computation lies in the design of appearance, not functionality. The simultaneous optimization of appearance and functions of a target product is very important to shorten the cycle of product development. Therefore, in this study, the final aim is to develop a support system for simultaneous design of appearance, shape, and functionality. First of all, in this paper, we focus on the development of a design system based on the user's preference. We apply Interactive Evolutionary Computation to make designs based on the human preference and feeling. As an example, we apply a proposed method to design a partner robot because the systematic tools of developing robots for daily use have rarely been developed. This system aims not to make final design but to make "Relation between the user and the robot." Next, we focus on the development of a simulation system to confirm the results of the developed. We can see images of the robot and movements, etc. by using this system, even if we do not actually make robots. Finally, we discuss the effectiveness of the proposed methods and future works.

4. CMAC Neural Networks Structures
Kamran Mohajeri, Ghasem Pishehvar, Mohammad Seifi

Cerebellar Model Articulation Controller (CMAC) NN is a computational model of cerebellum introduced as an alternative to backpropagated multilayer networks to control robot arms. From then it has seen many improvements and has been applied in many other areas as a general NN. These improvements have been in the context of generalization, learning techniques, differentiability, memory size, fuzzification and hardware implementation. This paper is a systematic review of CMAC's different structures and applications.

Wed. 09:50-11:30 **#103**

WC1: Social Intelligence

Chair: Kiju Lee, Case Western Reserve University

1. Robot Deception: Recognizing when a Robot Should Deceive
Alan R. Wagner, Ronald C. Arkin

This article explores the possibility of developing robot control software capable of discerning when and if a robot should deceive. Exploration of this problem is critical for developing robots with deception capabilities and may lend valuable insight into the phenomena of deception itself. In this paper we explore deception from an interdependence/game theoretic perspective. Further, we develop and experimentally investigate an algorithm capable of indicating whether or not a particular social situation warrants deception on the part of the robot. Our qualitative and quantitative results provide evidence that, indeed, our algorithm recognizes situations which justify deception and that a robot capable of discerning these situations is better suited to act than one that does not.

2. A Small World Algorithm for High-Dimensional Function Optimization
Xiaohu Li, Jinhua Zhang, Sunan Wang, Maolin Li, Kunpeng Li

In this paper, we describe a new small world optimization algorithm for obtaining satisfactory solution for high-dimensional function. Based on the small world phenomenon which is revealed in Milgram's sociological

experiment, some operators with decimal-coding strategy are proposed, and then an "imitated society" decimal-coding small world optimization algorithm (DSWOA) is designed to solve high-dimensional function optimization. Compared with the corresponding evolution algorithms, such as orthogonal genetic algorithm with quantization (OGA/Q), the simulation results of several benchmark functions with high dimension show that DSWOA can acquire satisfied solution, has also a better stability, and a fast convergence rate. Therefore, it is feasible to solve high-dimensional optimization problems.

3. Towards Social-Therapeutic Robots: How to Strategically Implement a Robot for Social Group Therapy?
Kiju Lee, Georgios Kaloutsakis, Jeremy Couch

One of the most innovative applications of robotics is creating artificial social relationships between humans and robots in order to promote healthier and more active lifestyles as a means of long-term, sustainable healthcare solutions. This paper describes a theoretical framework to strategically and effectively implement a sociable robot in a healthcare or elderly care facility. Based on the innovation diffusion theory and the agent-based modeling (ABM) technique, a diffusion model of social interactions between a robot and multiple individuals is proposed. This model links the diffusion of human-robot social interactions (HRSI) to the social characteristics of the first adopters and their subsequent influence on the rest of the social network. Therefore, in our view, determination of innovators in a social group can play an important role in planning robot-assisted social therapy. To identify the innovators in a given social group, an information-theoretic approach based on entropy computation is presented. In addition, a postexperimental analysis method for assessing the effect of the robot in promoting social interactions among group members is proposed based on the entropy reduction due to the social network changes.

4. Stochastic Approach on a Simplified OCC Model for Uncertainty and Believability
Won Hwa Kim, Jeong Woo Park, Won Hyong Lee, Woo Hyun Kim, Myung Jin Chung

As robots step into the human's daily lives, interaction and communication between human and robot is becoming essential. For this social interaction with humans, we propose an emotion generation model considering simplicity, believability and uncertainty. First, OCC model is simplified and then stochastic approach on emotion decision algorithm for believability and uncertainty is applied. The proposed model is implemented on a 3D robot expression simulator that can express emotions through its facial expression, gesture, led and so on. A demo of the model is provided as a result.

Wednesday, December 16, 13:00-14:40

Wed. 13:00-14:40 **#101**

WA2: Computer Vision 1

Chair: Erdinc Altug, Istanbul Technical University

1. Examining Robotic Systems with Shape-Adjustable Manipulators under Dynamic Environments: from Simulation to Verification
Chih-Hong Cheng, Alois Knoll, Christian Buckl, Javier Esparza, Yang Chen

In this paper, we present our preliminary report in applying formal verification to the design process of robotic systems under dynamic environments; the goal is to complement existing testing or simulation techniques by experimenting an adaptable framework, where verification models with tamable complexity are generated from the simulation model. Our targets are robotic systems with shape-adjustable manipulators (e.g., robot arms), which in essence bring different challenges compared to existing research. By investigating the problem structure, we propose ingredients for successful verification of such systems, conduct experiments, and outline future studies.

2. SILT: Scale-Invariant Line Transform
Bahador Khaleghi, Malek Baklouti, Fakhreddin O. Karray

Line matching is useful in many computer vision tasks such as object recognition, image registration, and 3D reconstruction. The literature on line matching has advanced in recent years, nevertheless, compared to other features (such as point and region matching approaches) it has made little progress. Especially, very few algorithms address the prob-lem of image scaling. In this paper, we present new line detection and matching algorithm that is invariant to image scale variation (SILT). The algorithm detects line segments as local extrema in the scale-space. Each detected line segment is represented in a distinctive manner using Haar-like features. PCA is further deployed to improve upon the compactness and robustness of representation. Experimental results demonstrate the effectiveness of the proposed approach to deal with image scale variations.

3. Vision-based Servo Control of a Quadrotor Air Vehicle
Zehra Ceren, Erdinc Altug

Unmanned aerial vehicles (UAVs) are seeing more widespread use in military, scientific, and civilian sectors in recent years. This study presents algorithms for the visualservo control of an UAV. The helicopter has been stabilized with visual information through the control loop. Unlike previous study that use pose estimation approach which is time consuming and subject to various errors, the visual-servo control is more reliable and fast. The model involves the camera speed and visual sensor blocks. Visual sensor block consists of the camera model and feature extraction blocks. Various simulations are developed on MATLAB, in which the quadrotor aerial vehicle has been visual-servo controlled. In order to show the effectiveness of the algorithms, experiments were performed on a model UAV which suggest successful performance.

Wed. 13:00-14:40 **#102**

WB2: Machine Learning

Chair: Kentarou Kurashige, Muroran Institute of Technology

1. Information-based Exploration Strategy for Mobile Robot in Dynamic Environment
Satoshi Hirashita, Takehisa Yairi

To meet the necessity of handling environmental uncertainties of mobile robots, we proposed an efficient exploration strategy to gather information, called Entropy Sweeper. To do so, we utilized the entropy distribution and the utility function to determine which positions have more uncertainties. Proposed strategy is divided into two phases: the learning phase and the action phase. In general, uncertainties increase unevenly and never disappear in dynamic environments. So in the learning phase, robots move wall to wall to learn which positions are likely to increase uncertainties actively. In the action phase, robots explore the environment efficiently and continue lifelong learning to handle environmental uncertainties. This strategy is an optimization not only for paths but also for sequences of exploration points using information about uncertainties of dynamic environments. We demonstrated its effectiveness with several simulations.

2. A Boltzmann Theory Based Dynamic Agglomerative Hierarchical Clustering
Gang Li, Jian Zhuang, Hongning Hou, Dehong Yu

In this study, a novel dynamic agglomerative hierarchical clustering algorithm which combines Boltzmann theory of thermodynamics and a graph-theoretic representation of data objects is put forward for data with non-sphere shape clusters. The new algorithm employs neighbors searching operator and vertices spanning operator to construct the linkage paths between vertices. Additionally, in order to obtain the ideal clusters the temperature coefficient is used to completely adjust the linkage paths between vertices. Experimental results on nine benchmark synthetic datasets with different manifold structure demonstrate the effectiveness of the algorithm as a clustering technique. Compared with the K-means algorithm, a genetic algorithm-based clustering algorithm (GAC) and minimum spanning tree clustering algorithm (MST) for clustering task, the presented algorithm has the ability to identify the number and location of the clusters jointly and its clustering performance is clearly better than that of the aforementioned algorithms for complex manifold structures dataset.

3. Q-learning using Fuzzified States and Weighted Actions and Its Application to Omni-direnctional Mobile Robot Control
Dong-Hyun Lee, In-Won Park, Jong-Hwan Kim

The conventional Q-learning algorithm is described by a finite number of discretized states and discretized actions. When the system is represented in continuous domain, this may cause an abrupt transition of action as the state rapidly changes. To avoid this abrupt transition of action, the learning system requires fine-tuned states. However, the learning time significantly increases and the system becomes computationally expensive as the number of states increases. To solve this problem, this paper proposes a novel Q-learning algorithm, which uses fuzzified states and weighted actions to update its state-action value. By applying the concept of fuzzy set to the states of Q-learning and using the weighted actions, the agent efficiently responds to the rapid changes of the states. The proposed algorithm is applied to omni-directional mobile robot and the results demonstrate the effectiveness of the proposed approach.

4. A Cognitive Approach for a Robotic Welding System That Can Learn How to Weld from Acoustic Data
Ingo Stork genannt Wersborg, Thibault Bautze, Frederik Born, Klaus Diepold

Laser beam welding is the method of choice for the high-quality joining of materials. However, for industrial production these systems have to be set up and calibrated manually with much effort. Our objective is to apply intelligent data processing that results in a cognitive technical system that can learn how to weld, speed up the configuring process, and reduce costs. While monitoring laser welding with cameras and optical sensors has already been demonstrated elsewhere, this paper emphasizes the benefits of monitoring with acoustic sensors and feature extraction. Using acoustic sensors, the cognitive system is more sensitive to strong optical radiation. Several combined methods such as wavelet analysis, fast Fourier transformation, and linear dimensionality reduction are evaluated with sensor data from real experiments. Finally, as machine learning, the results are classified with learned reference data to obtain reliable information for monitoring and possibly using closedloop control.

5. Use of the Knowledge which is Independence on Reward in Reinforcement Learning
Yoshiki Miyazaki, Kentarou Kurashige

Now, there are some techniques called machine learning, and reinforcement learning is one of the machine learning which often used for actual machine. In this study, we pay attention to the knowledge that does not depend on a reward in reinforcement learning, and we will improve learning efficiency by using it. Furthermore, we aim at letting agent coping with various tasks under environment where agent is put. In this paper, we propose the knowledge that does not depend on a reward, and we show utility by applying it to the problem that a task turns into under same environment.

Wed. 13:00-14:40 **#103**

WC2: Swarm Intelligence

Chair: Eiji Hayashi, Kyusyu Institute of Technology

1. DEM: A Discrete Electromagnetism-like Mechanism for Solving Discrete Problems
Omid AghaLatifi, Mohammad Reza Bonyadi

In this paper a novel model based on Electromagnetism-Like Mechanism (EM) is proposed which is highly compatible

with discrete space problems. The proposed method utilizes the EM operators to move particles towards an optimal or near optimal solutions. In fact, the proposed algorithm exploits the crossover operator to calculate forces on particles and move them according to these forces. To keep the algorithm from getting sock on local maxima a mutation approach is used. To show the performance of the proposed method it is applied on a discrete space problem called Multidimensional Knapsack Problem (MKP). To compare our results, some standard test benches of the MKP are used and the results are compared with other methods. Experimental results showed that the proposed method outperforms some new methods in terms of the number of needed iterations to find best known solutions (about 73% in average) and CPU time (about 77%). Furthermore, the DEM is applied on some bigger MKPs and the experiments showed that the algorithm works very well and had very small error from best known optimums (0.17% error in average).

2. Autonomous Behavior System Combing Motivation with Consciousness Using Dopamine
Eiji Hayashi, Takahiro Yamasaki, Koichiro Kuroki

To enhance the affinity between humans and robots, we have attempted to give a robot "consciousness" and “emotion” such as that identified in humans and animals. A hierarchical structure model has been developed to connect the robot’s consciousness with the robot’s behavior. However, it is difficult to autonomously control the timing that changes the consciousness and behavior of the robot. Therefore, in order to induce and autonomously change consciousness and behavior, a motivation model has been developed, and was combined with the hierarchical structure model. Then, the action of dopamine in neurotransmitters was incorporated in the motivation model to add activity to the robot in conjunction with the incentive to perform an behavior. In this paper the expression of emotion by a Conscious Behavior Robot (Conbe-I) that incorporated this motivation model, and the autonomous behaviors performed to take an object from human’s hand were studied.

3. Comparative Study of Genetic Algorithm and Ant Colony Optimization Algorithm Performances for Robot Path Planning in Global Static Environments of Different Complexities
Nohaidda Binti Sariff, Norlida Buniyamin

This paper presents the application of Genetic Algorithm (GA) and Ant Colony Optimization (ACO) Algorithm for robot path planning (RPP) in global static environment. Both algorithms were applied within global maps that consist of different number of free space nodes. These nodes generally represent the free space extracted from the robot map. Performances between both algorithms were compared and evaluated in terms of speed and number of iterations that each algorithm takes to find an optimal path within several selected environments. The effectiveness and efficiency of both algorithms were tested using a simulation approach. Comparison of the performances and parameter settings, advantages and limitations of both algorithms presented herewith can be used to further expand the optimization algorithm in RPP research area.

4. Bio-insect and Artificial Robots Interaction: A Dragging Mechanism and Experimental Results
Ji-Hwan Son, Hyo-Sung Ahn

In this paper, we introduce the experimental test platform for bio-insect and artificial robot interaction based on distributed systems (BRIDS). The main architecture of the BRIDS was reported in [1] and simulation results were introduced in [2, 3]. One of the most challenging problems of BRIDS is that a bio-insect does not usually react to actuation. When we try to stimulate the bio-insect for our purpose, its reaction is not that straightforward. From various trials-and-errors, we finally found actuation mechanism for an interaction between the bio-insect and the artificial robot. This paper reports what we have done to actuate a bio-insect and experimental test results.

Wednesday, December 16, 15:00-17:00

Wed. 15:00-17:00 **#101**

WA3: Adaptive and Learning System 1

Chair: Masahiro Oya, Kyushu Institute of Technology

1. A Combined Skin Model and Feature Approach For Tracking of Human Faces
Jamil Abou Saleh, Malek Baklouti, Fakhreddine Karray

In this paper, we propose a face detection framework that combines both feature, and skin pixel approaches, while making the framework self adaptive which is important for non controlled environmental conditions. The framework uses skin color information to reduce the search space for faces by localizing the probable skin regions using a mixture of multivariate Gaussians whose parameters are first estimated using the Estimation Maximization (EM) algorithm. Then, feature based classification differentiates face related pixels from other skin regions and objects with close intensity values. A novel approach for classifying faces using a structure of cooperating neural networks, for which learning parameters are generated using Adaboost learning method is proposed. In addition, a new approach is also proposed for training the neural network with reduced space Haar-like features instead of working with image pixels themselves. Principle component analysis was used to find the aspects of features that are crucial for detection. The features dimensionality was reduced by nearly 90 percent, hence improving radically the training time. When adequate parameters are chosen, the system yields face detection characteristics that outperform the best existing algorithms (such as the one proposed by Viola and Jones) in terms of accuracy. Finally, the parameters of the mixture of Gaussians model are updated based on the results of the classification testing results to increase its robustness against illuminations and other external environmental changes, as well as reducing even more the search space.

2. Adaptive Sliding Mode Trajectory Tracking Control of Mobile Robot with Parameter Uncertainties
Kunpeng Li, Xuewen Wang, Mingxin Yuan, Xiaohu Li, Sunan Wang

The trajectory tracking control problem of nonholonomic mobile robots with parameter uncertainties has been analyzed. The kinematics and dynamical models of mobile robots are taken into account, the control rule based on the kinematics model is taken as desired virtual control, and the adaptive sliding mode controller is designed, as the controller take into account both kinematics and dynamical model, the robot can not only track trajectory smoothly, but also be robust to parameter uncertainties. Based on Lyapunov theory, the system is stable. Finally, simulations are performed on the system with parameter uncertainties, and the results show that the proposed controller can track desired trajectory effectively.

3. Active Suspension Control Scheme for Vehicles without Measurements of Tire Deflection
Katsuhiro Okumura, Masahiro Oya, Masashi Nagae, Hidetaka Ota, Hideki Wada

In this paper, a new active suspension control scheme is proposed in which the tire deflections are not required. The controller has good property that we can specify a location where the ride comfort becomes best. To achieve this end, a combined ideal vehicle is designed. In the ideal vehicle, the location where ride comfort becomes best can be moved by setting only one design parameter. Next, to force the real vehicle track the motion of the combined ideal vehicle, a robust tracking controller is proposed.

4. Haptic Tele-Driving of Non-autonomous Mobile Robot Using a Force-Feedback Interface
Reza Haghighi Osgouei

Haptic interfaces allow the operator to feel reaction forces reflected from an environment during a bilateral driving or teleoperation task and provide the operator with increased awareness based on motion restrictions. In this paper effect of using haptic interface as guidance in driving of a non-autonomous wheeled mobile robot while performing a real-time obstacle avoidance is discussed. We consider driving of a robot when control commands are given by human operator through a haptic master device. Based on our proposed algorithms, a virtual interaction force is computed on the basis of obstacles surrounding the mobile robot and its state in order to prevent contacts, so that driving tasks can be done with generally better performances. In this study, we present a method for computing reflective force as haptic guidance which will be sensed by operator's hand during the driving process. A simulation was conducted to investigate the effectiveness of usage the haptic interface. The results show that the added haptic feedback as guidance significantly improves operator performance in several ways and reduced number of collisions and increased minimum distance between the robot and obstacle.

5. Topological Environment Reconstruction in Informationally Structured Space for Pocket Robot Partners
Naoyuki Kubota, Akihiro Yorita

This paper deals with environment reconstruction in informationally structured space used for pocket robot partners. The environmental information is measured through the sensor network, and is stored in the remote host computer. The pocket robot partner accesses the environment information through wireless LAN, and receives a 3D model of the environment including people and other robots. Therefore, we propose a topological environment reconstruction method to extract the state of the environment. Finally, we show several experimental results of the proposed method, and discuss the effectiveness of the proposed method.

Wed. 15:00-17:00 **#102**

WB3: Evolutionary Computation 1

Chair: Tetsuyou Watanabe, Kanazawa University

1. A Meta-Heuristic Paradigm for solving the Forward Kinematics of 6-6 General Parallel Manipulator
Rohitash Chandra, Marcus Frean, Luc Rolland

The forward kinematics of the general Gough platform, namely the 6-6 parallel manipulator is solved using hybrid meta-heuristic techniques in which the simulated annealing algorithm replaces the mutation operator in a genetic algorithm. The results are compared with the standard simulated annealing and genetic algorithm. It shows that the standard simulated annealing algorithm outperforms standard genetic algorithm in terms of computation time and overall accuracy of the solution on this problem. However, the hybrid meta-heuristic paradigm shows the best performance in terms of accuracy and success rate.

2. Solving the Forward Kinematics of the 3RPR Planar Parallel Manipulator Using a Hybrid Meta-Heuristic Paradigm
Rohitash Chandra, Mengjie Zhang, Luc Rolland

The forward kinematic of the 3-RPR parallel manipulator is solved using a hybrid meta-heuristic technique where the simulated annealing algorithm replaces the mutation operator in a genetic algorithm. The results from the hybrid meta-heuristic approach is compared with the standard simulated annealing and genetic algorithm. The results show that the simulated annealing algorithm outperforms genetic algorithm in terms of computation time and overall accuracy of the solution. The hybrid meta-heuristic search algorithm shows better performance than the standard genetic algorithm.

3. Feature Generation in Fault Diagnosis Based on Immune Programming
Maolin Li, Lin Liang, Sunan Wang, Xiaohu Li

In the symptom feature discovery, genetic programming has the shortage of premature convergence. So a new feature generation method based on immune programming is put forward. The new features are constructed by polynomial expressions of the original features. And then, with the immune operators such as antibody representation and mutation of tree-like structure, affinity function defined by classification performance of every individual, the clonal selection optimal algorithm is adopted to search the best feature that has excellent classification performance. The experiments of sound signal for gasoline engine show that, due to the diversity of antibodies is maintained by clonal selection principle, the best compound feature founded by immune programming has better classification ability than feature optimized by genetic programming.

4. A Hybrid Cultural Algorithm with Local Search for Traveling Salesman Problem
Yongjun Kim, Sung-Bae Cho

A new Hybrid Cultural Algorithm with Local Search (HCALS) is introduced to solve Traveling Salesman Problem (TSP). The algorithm integrates the local search method into the cultural algorithm which uses social intelligence to guide and lead individuals in the population. Better solutions can be attained by controlling individuals which are locally optimized by the local search methods. The combination of these two methods can be a promising method for solving the combinatorial problems like TSP. The experimental results show that the proposed algorithm can find better solutions than other methods for TSP in most cases.

5. A Master-Slave Algorithm for Control of Micro-Macro Manipulators along Unknown Path
Mohammad J. Sadigh, Ali Salehi

Micro-Macro manipulators are considered as a solution for applications which needs precise manipulation within a large work space. Such systems consists of two parts i.e. a flexible large manipulator – Macro – and a rigid short manipulator – Micro. There are many cases in which the mathematical description of desired path is unknown. In such cases one of the best solutions would be to use a master-slave algorithm to control the end-effector along the path. However, due to complicated configuration of the arm one need to employe a joystick type master to command the system. A method based on artificial constraint motion is presented which can semi-manually control the system. To this end, operator controls the macro manipulator by a macro-like master close to the desired path while generating tracking error signal by a joystick. A close loop computed-torque like controller which is designed based on constrained motion tries to eliminate the error and track the desired trajectory precisely.

Wed. 15:00-17:00 **#103**

WC3: Intelligent Systems 1

Chair: Maki K. Habib, The American University in Cairo

1. Force Control in Multi-degree-of-freedom Flexible Systems – Sensorless Technique
Islam S. M. Khalil, A. T. Naskali, Asif Sabanovic

This paper presents a novel sensorless force control algorithm for Multi-degree-of-freedom flexible systems which enables controlling the interaction forces with the environment without using force sensors. The coupled nature of flexible system dynamics makes it possible to estimate externally applied forces or torques that arise due to system's interaction with the environment. Disturbance and flexibility are simultaneously utilized to estimate system parameters, dynamics and externally applied forces or torques. The interaction torque estimate is then used to accomplish sensorless torque control assignment. This paper attempts to keep the flexible plant free from any measurement while performing a torque control assignment. However, actuator's parameters and variables are assumed to be available.

2. Virtual and Intelligent Traffic signs In Rescue Simulation System: Imitation of Human Society in Agent Society
Mostafa Asghari, Behrooz Masoumi, Mohammad Reza Meybodi

Robocup Rescue Simulation System is a suitable test-bed for test and evaluation of multi-agent system's related ideas and techniques. Hence, the world robocup competitions are held each year and the used ideas and techniques are evaluated in the form of different teams. In rescue simulation system, at the start of simulation, police agents should search and explore the earthquake area and open the blocked roads. In this paper, which is the first application of distributed learning automata in rescue simulation system, the agents imitate the ways which real people use for solving traffic problems in their societies. Like the real peoples' solutions for traffic problem, the agents use virtual police and street signs in their virtual environment junctions. The results indicate the fact that the proposed method gives more exploration power to rescue agents.

3. Decompose the Operational Space of FG Vision System into Parallel Virtual Planes to Support Autonomous Navigation in Dynamic Environment
Maki K. Habib

This article introduces the development of a fast 3D active vision system, and a new concept based on space decomposition into virtual planes to support 3D real time obstacle detection during the navigation mission of autonomous mobile robots. This system uses the richness and the strength of the vision while reducing the data load, and computational cost by encoding coarsely the working space using limited number of spatially interrelated 2D laser spots. The presence of a target within the projection view of the sensor disturbs the projected laser spots' pattern. A

disturbed spot gives information about the depth and position of the target part at that point. Efficient approach has been developed, to decompose spatially the space along the detectable depth in front of the sensor into a number of parallel virtual planes that are perpendicular to the line of robot's trajectory. The footprint size of the vision increases with the depth, and so the size of the virtual planes. To facilitate real time detection and tracking of dynamic objects/obstacles, each virtual plane is divided into five zones and the laser spots projected within each plane with its associated zones are used as a base for the tracking. The distance between the virtual planes represents the spatial decomposition of spot's movement space described by the number of pixels on the image plane in specific direction. The detection of a disturbed spot at a certain virtual plane indicates the availability of an obstacle or an object at the range of that plane with respect the robot. The longer a spot moves along its path the closer virtual plane to the robot is activated. Accordingly, the virtual plane closer to the robot has a higher priority in the detection and tracking process than the others do. This approach has the advantage of reducing significantly the computation time of 3D information that is required for real time detecting, and tracking objects in dynamic environment. The paper discusses and illustrates the developed concept.

4. Applying a Neuro-Fuzzy Classifier for Gesture-Based Control Using a Single Wrist-Mounted Accelerometer
Nona Helmi, Mohammad Helmi

Gestures, due to their natural modality, can be normally used in human-computer interaction (HCI) domains such as robotics, design environments and handheld devices. In this paper, a single wrist-mounted triaxial accelerometer is used to collect the acceleration data generated by hand movements forming 36 different gestures. This study intends to find the gestures which are capable of controlling an appliance with a maximum accuracy. A neuro-fuzzy classifier is devised for gestures detection to improve the classification rate in relative terms. The neuro-fuzzy system also selects the best features which yield the highest rate of classification. It reduces the dimensionality of feature set in two phases; the first phase is before carrying out the classification and the second phase is after selecting the most suitable gestures. The feature selection process finally reduces the number of features from 120 to 19. Our neuro-fuzzy system detects 25 gestures that can be classified with an accuracy of 100%, which is the highest rate among other classifiers. So, since the gesture-based control is accurately performed, it can be a proper method for HCI applications.

5. Gain-Scheduled Takagi-Sugeno Fuzzy PI Control Methodology for LPV Systems
Joabe Silva, Ginalber Serra

This work proposes a theoretical approach of gainscheduled fuzzy PI control design based on gain and phase margins specifications for LPV (Linear and Parameters Varying) systems, in the continuous time domain. A mathematical formulation from the Takagi-Sugeno fuzzy model structure as well as the PDC (Parallel Distributed Compensation) strategy is developed. Analytical formulas are deduced for the PI subcontrollers parameters, in the robust fuzzy controller rules base, according to the fuzzy model parameters of the LPV plant to be controlled. Results of the necessary and sufficient conditions for the fuzzy controller design, from the proposed robust methodology, with one Axiom and two Theorems are also presented.

6. An Action Pool Architecture for Multi-tasking Service Robots with Interdependent Resources
Tapio Taipalus, Aarne Halme

We present a novel control architecture for execution of multiple tasks simultaneously. Traditionally, the task control architecture of a service robot has been focused on executing one task at a time. This has mainly been due to the history of mobility being the only function and tasks being so simple that just one or two abstract commands have been sufficient. During the last decade, these requirements have changed drastically and a more versatile operation is clearly required. Service robots commonly have physical subsystems such as manipulators and directable perception sensors that are not in use all the time. These task execution resources are dependent on the pose of the platform to which they are attached. Our architecture manages the concurrent use of these resources in order to achieve parallel task execution. We verify the architecture with experiments on two different robot platforms while performing concurrent tasks such as finding object, greeting people and taking pictures of a designated object. The proposed architecture can receive an arbitrary number of tasks to be executed at any time instant within limitations of computing resources.

Thursday, December 17, 08:30-09:30

Plenary #2 (#101)
Cognitive Robotics: State of the Art and Challenges
Fakhri Karray, University of Waterloo

Thursday, December 17, 09:50-11:30

Thu. 09:50-11:30 **#101**

TA1: Computer Vision 2

Chair: Yonghuai Liu, Aberystwyth University

1. Super-Resolution Using Regularized Orthogonal Matching Pursuit Based on Compressed Sensing Theory in the Wavelet Domain
Tingting Li

We proposed a compressed sensing Super Resolution algorithm based on wavelet. The proposed algorithm performs well with a smaller quantity of training image patches and outputs images with satisfactory subjective quality. It is tested on classical images commonly adopted by Super Resolution researchers with both generic and specialized training sets for comparison with other popular commercial software and state-of-the-art methods. Experiments demonstrate that, the proposed algorithm is competitive among contemporary Super Resolution methods.

2. JSEG-based Image Segmentation in Computer Vision for Agricultural Mobile Robot Navigation
Luciano C. Lulio, Mario L. Tronco, Arthur J. V. Porto

This project aims to apply image processing techniques in computer vision featuring an omnidirectional vision system to agricultural mobile robots (AMR) used for trajectory navigation problems, as well as localization matters. To carry through this task, computational methods based on the JSEG algorithm were used to provide the classification and the characterization of such problems, together with Artificial Neural Networks (ANN) for pattern recognition. Therefore, it was possible to run simulations and carry out analyses of the performance of JSEG image segmentation technique through Matlab/Octave platforms, along with the application of customized Back-propagation algorithm and statistical methods in a Simulink environment. Having the aforementioned procedures been done, it was practicable to classify and also characterize the HSV space color segments, not to mention allow the recognition of patterns in which reasonably accurate results were obtained.

3. Particle Filter Based Self-Localization Using Visual Landmarks and Image Database
Wardah Inam

This paper presents an approach to vision-based self-localization using the combination of particle filter and preprocessed image database. The robot uses particle filter with odometery data and landmark pose for position tracking. Furthermore, it uses the image database to globally localize itself when it has been kidnapped or when no landmark is visible.

4. Trajectories Tracing for a Pitching Robot based on Human Recognition
Osamu Yuuki, Kunihiro Yamada, Naoyuki Kubota

In this study, we discussed human recognition method for the trajectory tracking. Visual perception is very important to realize the feature extraction from the time series of images, but it is very difficult to perform the object tracking. We classified errors occurring in the throwing; errors caused by internal factors and errors caused by external factors. At first, we propose a theoretical method of calculating the trajectory of a ball from the set-values. Second, we propose the method of calculating the trajectory from parts positions. These positions are recognized from the image captured by CCD camera. In this calculation, the pattern recognition were used to find parts positions. These positions are the released position of a ball and the position of the fulcrum. By this way, e.g., we can find the released position error of a ball and the speed error of a ball caused by internal factors. We used parabola equations in these calculations of trajectories. Third, we propose the method of extracting the trajectory from the time series of images captured by CCD camera. The specifications of camera are "480 by 360 pixels", "RGB color" and "29 frames per second". We propose the method of recognizing a position of the flying ball from images of the movie, directly. The robot plots the trajectory of a flying ball. By using this method, we can find the errors caused by external factors, e.g., we can suppose the influence of the air resistance working to the ball. Finally, we performed the experiment of the trajectories tracing for a pitching robot based on human recognition.

Thu. 09:50-11:30 **#102**

TB1: Evolutionary Robotics

Chair: Se-Young Oh, Pohang University of Science and Technology

1. Evolving Multirobot Excavation Controllers and Choice of Platforms Using an Artificial Neural Tissue Paradigm
Jekanthan Thangavelautham, Nader Abu El Samid, Paul Grouchy, Ernest Earon, Terence Fu, Nagina Nagrani, Gabriele M. T. D'Eleuterio

Autonomous robotic excavation has often been limited to a single robotic platform using a specified excavation vehicle. This paper presents a novel method for developing scalable controllers for use in multirobot scenarios and that do not require human defined operations scripts nor extensive modeling of the kinematics and dynamics of the excavation vehicles. Furthermore, the control system does not require specifying an excavation vehicle type such as a bulldozer, frontloader or bucket-wheel and it can evolve to select for an appropriate choice of excavation vehicles to successfully complete a task. The "Artificial Neural Tissue" (ANT) architecture is used as a control system for autonomous multirobot excavation and clearing tasks. This control architecture combines a variable-topology neural-network structure with a coarsecoding strategy that permits specialized areas to develop in the tissue. Training is done in a low-fidelity grid world simulation environment and where a single global fitness function and a set of allowable basis behaviors need be specified. This approach is found to provide improved training performance over fixedtopology neural networks and can be easily ported onto different robot platforms. Aspects of the controller functionality have been tested using high fidelity dynamics simulation and in hardware. An evolutionary training process discovers novel decentralized methods of cooperation employing aggregation behaviors (via synchronized movements). These aggregation behaviors are found to improve controller scalability (with increasing robot density) and better handle robot interference (antagonism) that reduces the overall efficiency of the group.

2. Evolutionary Optimized Footstep Planning for Humanoid Robot
Young-Dae Hong, Ye-Hoon Kim, Jong-Hwan Kim

This paper proposes a novel evolutionary optimized footstep planner for humanoid robot. Firstly, a footstep planner using univector field navigation method is proposed to provide a command state (CS) which is to be the input of modifiable walking pattern generator (MWPG) at each footstep. Then the MWPG generates the associated trajectories of every leg joint of humanoid robot at each footstep to follow the inputted CS. Secondly, the step length modification method which makes the humanoid robot step over low obstacles with minimum step length is proposed. Lastly, evolutionary

optimization for the univector fields is presented. The univector fields are optimized by evolutionary algorithm (EA) considering objectives in navigation of humanoid robot for efficient navigation. The effectiveness of the proposed evolutionary optimized footstep planner is demonstrated through computer simulations for the simulation model of small-sized humanoid robot, HanSaRam-VIII (HSR-VIII).

3. Trajectory Planning Optimization with Dynamic Modeling of Four Wheeled Omni-Directional Mobile Robots
Ehsan Hashemi, Maani Ghaffari Jadidi, Omid Bakhshandeh Babarsad

Path planning together with the tuning and determination of controller parameters are major concerns in omnidirectional mobile robots. Defining appropriate controller parameters in acceleration and deceleration to reach far and near target points without slippage is one of critical issues since some troubles due to unregulated velocities may greatly affect the ability of robot for the specified path planning and attaining the mentioned targets. A robot accurate kinematic and dynamic modeling and simulation accompanied by velocity and acceleration filtering are mainly discussed in this paper. Major changes and improvements in motion analysis, simulation and accuracy for the newly presented model and its efficiency are discussed in comparison with the previous simple kinematic modeling. Employing the new approach for robot dynamic modeling, particularly acceleration filtering, results in to the more precise robot control and achieving appropriate results.

4. A New Approach to Simultaneous Localization and Map Building with Learning: NeoSLAM (Neuro-Evolutionary Optimizing)
Jeong-Gwan Kang, Su-Yong An, Sunhyo Kim, Se-Young Oh

This paper addresses a novel approach to the solution of the Simultaneous Localization and Mapping (SLAM) problem bared on a Neuro Evolutionary Optimization (NeoSLAM) method. The proposed algorithm first casts SLAM as a global optimization problem using the cost function which represents the quality of robot pose trajectory and the feature positions in world coordinate frame. In our algorithm, the neural network trained to estimate the pose difference of the two consecutive positions accurately from the corresponding sensor data and the previous pose difference. The cost function is formulated as the importance of the full SLAM assumptions of EKF. Evolutionary Programming (EP) is used to evolve the neural model that is most consistent with the actual data measurement. Prediction and correction is simultaneously performed in our neural model that combines both the motion model and sensor model. By way of learning and evolution, our algorithm does not need prior assumption on the motion and sensor models, and therefore shows a robust performance regardless of the actual noise type. Further, our method can generate an accurate map even without the data association step, paving the way to deal with practical applications. Both the simulation and real experimental results conducted made various environments and noise/sensor types demonstrate that NeoSLAM ensures a consistently robust and accurate performance.

5. Evolution of Co-operative Communication Signals in Artificial Societies
Zack Z. Zhu

Experimental issues arise when scientists attempt to directly study emergent behaviour brought on by the evolutionary process. Recently, algorithms that simulate artificial evolution in robotic societies have been used to circumvent such issues. This study attempts to investigate and interpret emergent signals used by artificial agents when evolved through a simple genetic algorithm setup. A multiagent simulation environment is used to model foraging behaviour of artificial agents. Results identify the importance of communication in facilitating co-operative behaviour and reveal interesting convergence in the use of communication signals. Future work is suggested to amend some of the model's drastic simplifications.

Thu. 09:50-11:30 **#103**

TC1: Intelligent Systems 2

Chair: Eric Matson, Purdue University

1. An Artificial Neural Network Approach for Creating an Ethical Artificial Agent
Ali Reza Honarvar, Nasser Ghasem-Aghaee

Autonomous robotic systems and intelligent artificial agents' capability have advanced dramatically. Since the intelligent artificial agents have been developing more autonomous and human-like, the capability of them to make moral decisions becomes an important issue. In this work we developed an artificial neutral network which considered various effective factors for ethical assessment of an action to determine that if a behavior or an action is ethically permissible or not. We integrated this net to the BDI-Agent model as a part of its reasoning process to behave ethically in various environments.

2. Path Planning Algorithm for VTOL Type UAVs Based on the Methods of Ray Tracing and Limit Cycle
Byung Cheol Min, Hee Yeul Kwon, Donghan Kim

In this paper, the new path planning algorithm for vertical take-off and landing (VTOL) type unmanned aerial vehicles (UAVs), which is widely used in various practical applications, is introduced. The essence of the algorithm comes from the existing limit cycle navigation method for works in 2D and 3D, respectively. In addition, the ray tracing method is applied in order to enhance the work in 3D. The combined method of ray tracing and limit cycle is the core of the proposed path planning algorithm, and it is verified through a set of simulations. And then, the results show that the algorithm can generate the ideal path among the possible paths to reach the destination.

3. A Study on Hierarchical Modular Reinforcement Learning for Multi-Agent Pursuit Problem Based on Relative Coordinate States
Tatsuya Wada, Takuya Okawa, Toshihiko Watanabe

In order to realize intelligent agent such as autonomous mobile robots, Reinforcement Learning is one of the necessary techniques in behavior control system. However, applying the reinforcement learning to actual sized problem, the "curse of dimensionality" problem in partition of sensory states should be avoided maintaining computational efficiency. In multi-agent reinforcement learning, the problem is emerged owing to the high dimensionality of each agent states. We apply the hierarchical modular reinforcement learning in order to deal with the dimensional problem and task decomposition. In this study, we focus on investigation of the learning performance of agent that represents the input states in relative coordinate system. We show effectiveness of proposed learning algorithm based on relative expressions with limited view through numerical experiments of the pursuit problem.

4. Embedding Intelligent Agents to Enable Physical Robotic and Sensor Organizations
Eric T. Matson

The integration of multiagent systems (MAS) with organizations creates a platform to solve a number of real world problems. Extending the use of multiagent organizations to work with physical sensors and robotic systems synergizes the control ability of agents with the ability to monitor and affect physical phenomena. This research effort examines the use of agents, which are embedded into microprocessor boards, to control sensor and robotic systems. The concept introduced is the Agent-on-a-Chip(AOC) which integrates the capabilities of agents, MAS, and physical systems to create a real, fieldable application to attack a great number of real world domain problems.

5. Path Planning Strategy Design under the Experience of Mobile Robot Navigation
Wen-Yo Lee, An-Doo Yang, Ta-Chih Hung, Jhu-Syuan Guo

This paper presents a path planning strategy for a mobile robot. The path planning strategy is according to the experience that the mobile robot has been experienced in target navigation. The mixed reality technique is implemented by both the Virtools tool and mobile robot. There are three basic interactive behaviors of human beings which have been implemented on this proposed mobile robot. They are targeting navigation behavior, face tracking behavior, and obstacle avoidance behavior; all of them are designed by the fuzzy rule methods, respectively. These behaviors make the proposed path planning strategy possible. The virtual reality environment is used to implement the arbitrator of the behaviors and to choose the behavior rules for dynamic environment changing. Experiments show that the proposed behaviors are well designed. The proposed robot system can optimize the path planning based on the previous navigation experience.

Thursday, December 17, 13:00-14:40

Thu. 13:00-14:40 **#101**

TA2: Computer Vision 3

Chair: Hyo-Sung Ahn, GIST

1. Head Orientation Estimation for Covert-tracking Robot
Wei Zou, Lixin Fang, Yuan Li, Kui Yuan

Covert-tracking robot refers to the mobile robot that not only can follow a human objective, but at the same time can control itself to keep away from the human's visual field. This paper proposes a head orientation estimation method based on probability model, which can help the robot to implement its covert behaviors. First, the elliptical head contour is tracked out by using a method based on quadrant arcs; then it is normalized into predefined size and is partitioned into 24 sub-areas. According to skin color model, an orientation probability model is built for each discrete angle. The final estimation is obtained by weighting each discrete angle, where the weight is calculated out by matching the current input with the model corresponding to the discrete angle. Experiment results confirm the method's good performance, strong robustness to different distance and high real time property.

2. Range Image Registration Using Hierarchical Segmentation and Clustering
Yonghuai Liu, Longzhuang Li, Xianghua Xie, Baogang Wei

An accurate, robust, and automatic registration of overlapping range images is usually a pre-requisite step for range image analysis and applications. While accurate depiction of object geometry requires the increase of the resolutions of images and thus, the amount of data to process, an efficient processing of such data then usually becomes an issue. In this paper, we first employ the efficient tensor analysis and k means clustering methods to hierarchically segment and cluster the original range images into a small number of planar patches represented as the closest points in the original images to their centroids. Then an advanced ICP variant is adopted to register such closest points. Finally, another ICP variant is used to refine the registration results obtained over all the points in the images. The experimental results based on real range images show that the proposed technique significantly outperforms the selected two state of the art ones for accurate and efficient registration of overlapping range images.

3. Accurate Camera Calibration Using the Collinearity Constraint
Yonghuai Liu, Ala Al-Obaidi, Anthony Jakas, Junjie Liu

In this paper, we apply the collinearity constraint for accurate camera calibration and correction. The novel method consists of two steps: the first is to estimate the relative parameters of interest with closed form solutions. The second employs the well known Levernburg-Marquardt (LM) algorithm for the global optimization of all the

parameters of interest: 4 intrinsic, 7 extrinsic and 4 distortion parameters. The LM algorithm is initialised either as the parameters estimated in the first step or as zero. The optimization is achieved through minimising the sum of the squared back projected errors. The distorted points are finally corrected using again the LM algorithm initialized by the distorted image points themselves, minimizing the squared difference between the distorted corrected point and the given distorted image point. A comparative study based on both synthetic data and real images show that the proposed algorithm produces promising camera calibration and correction results.

4. Formation Coordination for Self-mobile Localization: Framework
Hyo-Sung Ahn

In this paper we introduce a framework for self-mobile localization of a group of mobile agents via a novel formation coordination. The key idea of formation coordination is to make an agent move while fixing other agents as reference nodes. Since the mobile agent is connected to the fixed agents, it is localized during the movement. After the movement, the mobile agent is then fixed, and it is used as one of the reference nodes, while other agent is selected and switched to the next mobile agent. By repeating this process, all of the agents sequentially move being localized by aid from other agents. Simple simulation tests are conducted to illustrate the main idea of the formation coordination established in this paper.

Thu. 13:00-14:40 **#102**

TB2: Sensor Fusion 1

Chair: Ta-ming Shih, Chung Cheng Institute of Technology

1. Sensor Fusion for Differential Encoder Integrated with Light Intensity Sensors and Accelerometer
P. Surachai, T. Thiraporn, L. Chaiyaporn, T. Kittichai, S. Tayawat

This paper proposed mainly fusions between encoders and light intensity sensors and between encoders and accelerometer for distance increment with Kalman filter to estimate robot's position. A developed fusion algorithm between differential encoder system and light intensity sensor, and accelerometer is analyzed and experimental tested in square shape. Applying the Kalman filtering theory, we successfully fused differential encoders and external sensors to obtain improved position and heading angle estimation. Finally, the experimental result and simulation present the different trajectory generated by only differential encoders and differential encoders integrated with external sensors system.

2. A Multi-step Heart Rate Prediction Method Based on Physical Activity Using Adams-Bashforth Technique
Feng Xiao, Ming Yuchi, Ming-yue Ding, Jun Jo, Jong-Hwan Kim

Physical activity (PA) is commonly recognized to directly influence changes in heart rate (HR). HR prediction based on PA can be a useful tool in medical research and monitoring in a clinical setting. In our previous works, predictors with high accuracy were designed. However, the HR could only be predicted in single time steps. In this study, a multi-step HR prediction method is proposed. Firstly, the HR prediction problem was converted into an Initial-Value Problem for Ordinary Differential Equation (IVPODE). Then the Adams-Bashforth method was used to implement multi-step prediction. Only HR at the initial time step and PA signals are needed. Experiments were conducted based on the real-life signals from a healthy male. Predicted HR can approximately trace the actual HR in a long time step. The results show the potential of this proposed method.

3. Visual-Inertial Simultaneous Localization, Mapping and Sensor-to-Sensor Self-Calibration
Jonathan Kelly, Gaurav S. Sukhatme

Visual and inertial sensors, in combination, are well-suited for many robot navigation and mapping tasks. However, correct data fusion, and hence overall system performance, depends on accurate calibration of the 6-DOF transform between the sensors (one or more camera(s) and an inertial measurement unit). Obtaining this calibration information is typically difficult and time-consuming. In this paper, we describe an algorithm, based on the unscented Kalman filter (UKF), for camera-IMU simultaneous localization, mapping and sensor relative pose self-calibration. We show that the sensor-to-sensor transform, the IMU gyroscope and accelerometer biases, the local gravity vector, and the metric scene structure can all be recovered from camera and IMU measurements alone. This is possible without any prior knowledge about the environment in which the robot is operating. We present results from experiments with a monocular camera and a low-cost solid-state IMU, which demonstrate accurate estimation of the calibration parameters and the local scene structure.

4. Speeding up Top-Down Attention Control Learning by Using Full Observation Knowledge
N. Noori, M. Nili Ahmadabadi, M. S. Mirian, B.N. Araabi

We present a general mathematical description of the top-down attention control problem. Three important components are identified in the model: context extraction, attention focus and decision making. The context gives a coarse blurry representation of the whole input; the attention module models the focus of attention on a limited part of input, and the decision making component accounts the final decision of the agent for its motory actions. In order to achieve a faster convergence of attention learning in the online phase, an offline optimization step is performed in advance. To do so, we incorporate the knowledge of a full observer agent that has approximately learned the optimal decision making of the task. The simulation results show that by employing our algorithm, the learning speed is improved.

5. Registration of Fixed-and-Mobile- Based Terrestrial Laser Data Sets with DSM
Taha Ridene, Francois Goulette

This study tackles the production of 3D realistic map databases for outdoor environments. An approach based on the fusion of heterogeneous 3D representations was studied. We propose a variant of ICP (Iterative Closest Point) based on an adaptive dynamic threshold and a RANSAC removing outliers process. An application of our approach was tested on two scenarios: a registration of point clouds obtained by a fixed terrestrial 3D Laser on a 2.5D data Digital Model of Surface (DSM), and the registration of point clouds obtained by a Mobile Mapping System (MMS) on DSM. The objective is to obtain coherence of a homogeneous 3D representation, which will be the input of the following processing step: 3D modeling. We treat various scenarios of registration which were specified; the algorithm exploits specific pre-processing dedicated to the studied use-cases.

Thu. 13:00-14:40 **#103**

TC2: Behavioral Intelligence

Chair: Reza Emami, University of Toronto Institute for Aerospace Studies

1. An Ethical Adaptor: Behavioral Modification Derived from Moral Emotions
Ronald C. Arkin, Patrick Ulam

This paper presents the motivation, basis and a prototype implementation of an ethical adaptor capable of using a moral affective function, guilt, as a basis for altering a robot's ongoing behavior. While the research is illustrated in the context of the battlefield, the methods described are believed generalizable to other domains such as eldercare and are potentially extensible to a broader class of moral emotions, including compassion and empathy.

2. Bilateral Teleoperation Systems using Genetic Algorithms
Byeong-Yeon Kim, Hyo-Sung Ahn

This paper presents a synchronization scheme of bilateral teleoperation systems with time delay using genetic algorithms. In general, bilateral teleoperation systems have two main goals: stability and transparency. The system can be destabilized by time delay in the communication channel between the master and the slave. Also, transparency can be degraded by time delay. However, it is not easy to determine control gains to achieve these goals. In this work, we use genetic algorithms to choose optimal control gains for synchronization control law. Consequently, position and force tracking problem in free and contact motion is solved in a synchronized manner. Simulation results are presented to verify the effectiveness of proposed methods.

3. Harmonic Opponent Modeling and Behavior Structure for 3D Soccer Simulation Agent
B. Jozi, A. Fakharian, M. Nademi, M.Yousefi Azar Khanian

As the beginning of the 3D soccer simulation competitions the simulated humanoid robots were used to play soccer in simulated games, this event shifted the aim of the soccer simulation from the design of strategic behaviors into the low level skills like walking and kicking in soccer player itself at first, but by the improvement of these skills new challenge of how to play soccer has been engendered, so having a framework for agents that supports a hierarchy of behaviors is inevitable, in this paper we proposed a behavior structure for agents which consists of low level skills such as kicking and walking and high level skills like ball-handled and go to ball which uses a combination of low level skills, and also a simple method of opponent modeling called Harmonic opponent modeling which model the walking speed of opponent agent.

4. Appearance-based Action Recognition in the Tensor Framework
Behrouz Saghafi Khadem, Deepu Rajan

There are multiple contributory factors taking place in an action video, e.g., person, clothing, illumination, etc. When these factors change together, conventional 1-mode analysis like PCA in action space encounters difficulties. The Nmode analysis overcomes this problem. In this paper, we propose a novel framework for recognition of actions using silhouettes based on N-mode SVD. We use the silhouette ensembles to form a 3rd order tensor comprising three modes: pixels, actions and people. Using N-mode SVD, we find the bases as well as the coefficients for the action space. For a query sequence, the resulting action-mode coefficients are compared with the learned coefficients to find the action class. Through experiments on a common database, we compare the proposed method with 1-mode PCA in appearance-base recognition of human actions and show that our method outperforms 1-mode analysis.

5. A Study on an Ion Polymer Metal Composite Actuator as a Self-sensing System
K. K. Ahn, D. N. C. Nam, D. Q. Truong, J. I. Yoon, T. Q. Thanh

An ion polymer metal composite (IPMC) is an Electro-Active Polymer (EAP) that bends in response to a small electrical field as a result of mobility of cations in the polymer network and vice versa. A typical IPMC sheet is constructed with a thin ionic polymer membrane and two metal electrode layers outside. This paper proposes an idea to estimate the displacement of bending curvature of an IPMC actuator base on its self-sensing characteristic. A test rig is setup for an IPMC actuator type. Here, voltage signals are measured at two determined points on one side of the IPMC sheet in order to gather the deforming information. Consequently, that data set is combined with a representative vector to estimate the IPMC bending displacement. In addition, a CCD laser displacement sensor is installed to the test rig to measure accurately the displacement which is used to obtain the representative vector and also to verify the estimated bending shape by applied the suggested self-sensing technique.

Thursday, December 17, 15:00-17:00

Thu. 15:00-17:00 **#101**

TA3: Adaptive and Learning System 2

Chair: Kyoung Kwan Ahn, University of Ulsan

1. Adaptive Steering Controller to Improve Handling Stability for Driver-Combined-Vehicles System
Qiang Wang, Masahiro Oya, Natsuki Takagi, Yuichiro Taira, Hidetaka Ota

If the dynamics of combined vehicles such as tractor-semitrailer varies greatly, it may be very difficult for inexperienced drivers to achieve good handling stability. Moreover, once combined vehicles become unstable, it is very difficult for all drivers to stabilize vehicles. However, if the behavior of actual combined vehicles tracks a designed desired combined vehicle, the good handling property can be maintained even when the dynamics of actual combined vehicles varies large. In this paper, to achieve good handling property even for large variation of vehicle dynamics, a design method for a desired combined vehicle is shown, and then, an adaptive steering controller is developed so that the actual vehicle tracks the desired vehicle. The developed adaptive steering controller has strong robustness for the uncertainties of vehicle parameters. Moreover, a driver model is introduced to show the characteristics of driver. Carrying out numerical simulations, it is shown that the developed adaptive steering controller is very useful for the driver-combined-vehicles system.

2. Adaptive Control of Systems with Input Saturation –A Scheme Using Output Derivatives of Order up to Relative Degree–
Natsuki Takagi, Masahiro Oya, Qiang Wang, Toshihiro Kobayashi

In this paper, the main attention is focused on transient property of control input signal, we propose a novel adaptive controller for time-continuous single-input singleoutput linear systems with an input saturation in which i-th derivatives of the output signal (i = 1, · · · , relative degree) are available. To improve the control performance, a novel estimator using an observer for the tracking error signals is proposed. Using the estimator, it is shown theoretically that the tracking error between the controlled object output and the reference model output can converge to zero when the initial value of the tracking error satisfies a condition.

3. Learning to Grasp Unknown Objects Based on 3D Edge Information
Leon Bodenhagen, Dirk Kraft, Mila Popovic, Emre Baseski, Peter Eggenberger Hotz, Norbert Kruger

In this work we refine an initial grasping behavior based on 3D edge information by learning. Based on a set of autonomously generated evaluated grasps and relations between the semi-global 3D edges, a prediction function is learned that computes a likelihood for the success of a grasp using either an offline or an online learning scheme. Both methods are implemented using a hybrid artificial neural network containing standard nodes with a sigmoid activation function and nodes with a radial basis function. We show that a significant performance improvement can be achieved.

4. Dynamic State Estimation Using Particle Filter and Adaptive Vector Quantizer
Takeshi Nishida, Wataru Kogushi, Natsuki Takagi, Shuichi Kurogi

Particle filter (PF) is a method for discrete approximation of dynamic and non-Gaussian probability distribution by using numerous particles, and its procedure can execute at high speed and is suitable for on-line applications. However, in conventional methods, a weighted average value or a maximum weighted value of particles is used as a filter output, and information on most particles is disregarded. On the other hand, an adaptive vector quantization (AVQ) algorithm called competitive reinitialization learning (CRL) that can achieve high-speed adaptation without depending on initial conditions has been proposed. Then, in this research, a method for extracting information on shape of probability density distributions by combining PF with CRL is proposed. Moreover, a rapid adaptation performance and the robustness of the proposed method are shown by the simulations.

5. Identification and Verification of a MR Damper Using a Nonlinear Black Box Model
D. Q Truong, K. K Ahn, J. I. Yoon, T. Q. Thanh

Nowadays, magneto-rheological (MR) fluid dampers (MRD) are widely used for the semi-active suspension control in vibration community. However, the inherent nonlinear nature of the MRD causes challenges for damping control of the suspension system using this device with high performance. Therefore, the development of an accurate modeling method for a MRD is necessary to take advantage of its unique characteristics. This paper focuses on the development of a nonlinear black box model to identify and verify behaviors of a MR damper. The model is built by using an online self tuning fuzzy (OSTF) method based on neural technique. The behavior of the MRD is directly estimated through the box. A series of experiments and modeling analysis had been done on test rigs to validate the effectiveness of the design nonlinear black box in predicting the damping force.

6. Acquisition of Shared Symbols in Multi-Agent Cooperative Tasks
Siavash Kayal, Abdol Hossein Aminaiee, Caro Lucas

In this paper a novel mechanism for acquiring shared symbols in multi-agent cooperative task is introduced. Inspired by human communication, a technique is suggested in which learning the behaviors and learning how to communicate are decomposed. Decomposing the shared symbol acquisition into two separate learning phases not only simplifies the learning algorithm but also it speeds up the process. Moreover, utilizing the gained information about the environment in the behavior learning phase, agent communication is learned easily. A couple of simulations are conducted to support the idea. Simulation results show

that agents could assign meaning to symbols and transfer information among themselves using the learned symbols. Roughly speaking, they could form a language.

Thu. 15:00-17:00 **#102**

TB3: Evolutionary Computation 2

Chair: Jing-Sin Liu, IIS, Academia Sinica

1. Bacterial Foraging Oriented by Particle Swarm Optimization Strategy for PID Tuning
Wael M. Korani, Hassen Taher Dorrah, Hassan M. Emara

Proportional integral derivative (PID) controller tuning is an area of interest for researchers in many disciplines of science and engineering. This paper presents a new algorithm for PID controller tuning based on a combination of the foraging behavior of E coli bacteria foraging and Particle Swarm Optimization (PSO). The E coli algorithm depends on random search directions which may lead to delay in reaching the global solution. The PSO algorithm may lead to possible entrapment in local minimum solutions. This paper proposed a new algorithm Bacteria Foraging oriented by PSO (BF-PSO). The new algorithm is proposed to combines both algorithms' advantages in order to get better optimization values. The proposed algorithm is applied to the problem of PID controller tuning and is compared with conveniently Bacterial Foraging algorithm and Particle swarm optimization.

2. A Hybrid PSO-DV Based Intelligent Method for Fault Diagnosis of Gear-box
Bo Liu, Hongxia Pan

The gear box fault occur can lead to the fatal breakdown of mechanical system. Back propagation neural network (BPNN) have been proved to be of widespread utility for identifying and classifying gear box faults to prevent serious damage in a mechanical system. Some researchers have used particle swarm optimization (PSO) to train BPNN. However, because the PSO algorithm has several parameters to be adjusted by empirical approach, if these parameters are not appropriately set, the search will become very slow near the global optimum and even trap into local minima. In this paper, a novel hybrid intelligent method for classifying gear box faults based on vibration signal using the particle swarm optimization (PSO) algorithm, differential evolution (DE) algorithm and BPNN named PSO-DV based BP is presented. The proposed PSO-DV includes both faster convergence of PSO and capability escape from local optima of DE. Experiments were performed on a gear-box fault simulator. The fault samples are obtained by simulating corresponding fault on experiment gear-box. In presented work, a classical PSO based BP neural network and PSO-DV based BP neural network are used for gear box fault classification, their relative effectiveness in fault diagnosis is compared. The experimental results verified that proposed hybrid PSO-DV intelligent method can escape from local minima, so has better convergence than BP neural network and classical PSO based BP neural network. Meanwhile, it achieves also very high accuracy rate of recognition and thus provides decision support in fault classification.

3. Finding Multiple First Order Saddle Points Using a Valley Adaptive Clearing Genetic Algorithm
Mostafa M. H. Ellabaan, Yew Soon Ong, Meng Hiot Lim, Kuo Jer-Lai

First order saddle points have important applications in different fields of science and engineering. Some of their interesting applications include estimation of chemical reaction rate, image segmentation, path-planning and robotics navigation. Finding such points using evolutionary algorithms is a field that remains yet to be well investigated. In this paper, we present an evolutionary algorithm that is designed for finding multiple saddle points. In contrast to earlier work [1], we propose a new fitness function that favors 1st order saddle points or transition states. In particular, a valley adaptive clearing multi-modal evolutionary optimization approach is proposed to locate and archive multiple solutions by directing the search towards unexplored regions of the search space [2]. Experimental results on benchmark functions and the Lennard Jones Potential are presented to demonstrate the efficacy of the proposed algorithm in locating multiple 1^{st} order saddle points.

4. Collision-free Curvature-bounded Smooth Path Planning Using Composite Bezier Curve based on Voronoi Diagram
Yi-Ju Ho, Jing-Sin Liu

In this paper, we present an obstacle avoiding smooth path planning method based on Voronoi diagram and composite Bezier curve algorithm which obtains the curvature bounded path with small length. In our algorithm, a Voronoi diagram is constructed according to the global environment. The piecewise linear rough path in the Voronoi diagram which keeps away from the obstacles is obtained by performing Dijkstra's shortest path algorithm. Dynamic programming is employed to subdivide the nodes on the piecewise linear path into control point subsequences to generate a collision free composite Bezier curve which satisfies the curvature constraint and approaches minimal path length.

5. Online Training for Single Hidden-layer Feedforward Neural Networks Using RLS-ELM
Hieu Trung Huynh, Yonggwan Won

Extreme learning machine (ELM) is one of the effective training algorithms for single hidden layer feedforward neural networks (SLFNs), but it often requires a large number of hidden units which makes the trained networks respond slowly to input patterns. Regularized least-squares extreme learning machine (RLS-ELM) is one of the improvements which can overcome this problem. It determines the input weights including hidden layer biases based on the regularized least squares scheme and the output weights based on the pseudo-inverse operation of hidden layer output matrix. In this paper, we develop the RLS-ELM for online sequential learning to due with large training datasets. It can learn the arriving data with one-by-one and chunk-by-chunk, blocks with different sizes. Experimental results show that the proposed approach can obtain good performance with compact network which results in high speed for both training and testing.

Thu. 15:00-17:00 **#103**

TC3: Fuzzy Logic

Chair Hyo-Sung Ahn, GIST

1. New Fuzzy-Based Anti-Swing Controller for Helicopter Slung-Load System near Hover
Hanafy M. Omar

In this paper, a new fuzzy based anti-swing controller for helicopter slung load system near hover flight is proposed. The output from this controller is additional displacements that are added to the helicopter trajectory in the longitudinal and lateral directions. Hence, its implementation is simple and it just needs small modification to the software of helicopter position controller. The rules of the anti-swing controller are derived based on the time-delayed feedback of the load swing angles. The simulation results show the effectiveness of the proposed controller in suppressing the swing of the suspended load and stabilizing the system.

2. Designing Integrated Guidance Law for Aerodynamic Missiles by Multi-Objectives Evolutionary Algorithm and Tabu Search
Hanafy M. Omar, M. A. Abido

In this paper, a Strength Pareto Evolutionary Algorithm (SPEA) based approach is proposed for designing an Integrated Fuzzy Guidance Law which consists of three fuzzy controllers. Each of these controllers is activated in a region of the interception. The distribution of the membership functions and the rules are obtained by solving a nonlinear constrained multiobjectives optimization problem where final time, energy consumption, and miss distance are treated as competing objectives. Tabu search is proposed to get the initial feasible solution for the multi-objective optimization algorithm. Then a hierarchical clustering technique is implemented to provide the decision maker with a representative and manageable Paretooptimal set without destroying the characteristics of the tradeoff front. Moreover, a fuzzy-based mechanism is employed to extract the best compromise solution over the trade-off curve. The simulation results show that the proposed design technique was able to generate a missile guidance law with satisfactory performance with the existence of noisy measurements.

3. An Intelligent Fuzzy Controller Based On Genetic Algorithms
M. Yousefi Azar Khanian, A. Fakharian, M. Godarzvand Chegini, B. Jozi

In view of many applications, in recent years, there has been increasing interest in robot's control. Two intelligent controllers based on fuzzy logic and neural network are developed to trace the desired trajectory for a robot. A variety of evolutionary algorithms, have been proposed to approximately solve problems of common engineering applications. Increasingly common applications involve automatic learning of nonlinear mappings that govern the behavior of control systems. In many cases where robot control is of primary concern, the systems used to demonstrate the effectiveness of evolutionary algorithms often do not represent practical robotic systems. In this paper, genetic algorithms (GA) are the evolutionary strategy of interest. This procedure and the manner in which fuzzy controllers are codified into chromosomes is described. It is applied to learn fuzzy control rules for a practical autonomous vehicle steering control problem, namely, path tracking. GA handles the simultaneous evolution of membership functions and rule bases for the fuzzy path tracker. Simulation results show that the proposed fuzzy controller whose all parameters have been tuned simultaneously using GAs, offers advantages over existing controllers and has improved performance.

4. Takagi-Sugeno Fuzzy Control Method for Nonlinear Systems
Ginalber L. O. Serra, Carlos Cesar T. Ferreira

This paper proposes a new methodology for analysis and design of robust fuzzy Takagi-Sugeno (TS) control, with PID structure, for nonlinear systems, based on gain and phase margins specifications. The nonlinear system to be controlled, is studied in the context of Linear Parameters Varying (LPV) systems, it is partitioned into several linear sub-models in terms of transfer function, forming a convex polytope. Once defined the linear sub-models of the plant, these are organized into fuzzy Takagi-Sugeno (TS) structure. From the Parallel Distributed Compensation (PDC) strategy, a mathematical formulation is defined in the frequency domain, based on the gain and phase margins specifications, to obtain robust PID sub-controllers in accordance to the Takagi-Sugeno fuzzy model of the plant. Results for the robust stability conditions with the proposal of one Axiom and two Theorems are also presented.

5. A New Design of Fuzzy Logic Controller Based on Generalized Orthogonality Principle
Nora Boumella, Karim Djouani, Sohail Iqbal

Improving Fuzzy Logic System (FLS) design is of main interest. Linguistic rules of a FLS can be converted into Fuzzy Basis Functions (FBFs). Moreover, numerical rules and their FBFs can be extracted from numerical training data. This combination of both linguistic and numerical information simultaneously makes the FBFs very useful. Since a specific FLS can be expressed as a linear combination of FBFs, we use generalized orthogonality principle on FBFs, that results in a better FLS. In this work, we consider each of these FBFs as a basis vector.We compute the optimal parameters of consequents that make the error vectors orthogonals to these FBFs, resulting in minimization of the magnitudes of these error vectors and consequently of the optimization of the FLS. This design method is used to tune the consequent parameters of a Fuzzy Logic Controller (FLC) for the non linear inverted pendulum on a cart. Simulation results show that a better control performance is achieved.

6. Rendering of Environmental Force Feedback in Mobile Robot Teleoperation Based on Fuzzy Logic
Ildar Farkhatdinov, Jee-Hwan Ryu, Jury Poduraev

In this paper a study on rendering of environmental force feedback in mobile robot teleoperation based on fuzzy logic is presented. To ensure safety of mobile robot teleoperation it is often necessary to provide environmental force feedback which is related to the distance between the obstacles and the mobile robot. In previous approaches force feedback was rendered based on the measured distance between the obstacles and the mobile robot. In this work, a novel method for force feedback rendering using fuzzy logic is presented. In proposed approach derivative of the distance to the obstacle is used for defining the amount of environmental force feedback which is displayed to human-operator. Fuzzy rules and controller are designed and simulation results are shown. Advantages of the proposed approach are discussed.

Friday, December 18, 08:30-09:30

Plenary #3 (#101)
Intelligent Robot Software Framework for Real Robotic Service to Human
Munsang Kim, Director, Center for Intelligent Robotics, KIST, Korea

Friday, December 18, 09:50-11:30

Fri. 09:50-11:30 **#101**

FA1: Computer Vision 4

Chair: Idaku Ishii, Hiroshima University

1. A Comparative Study of Different Corner Detection Methods
JunJie Liu, Anthony Jakas, Ala Al-Obaidi, Yonghuai Liu

Interest points are widely used in computer vision applications such as camera calibration, robot localization and object tracking that require fast and efficient feature matching. A large number of techniques have been proposed in the literature. This paper evaluates the state of art techniques for interest point detection including excution time and suitability for real time applications. Such comparative study is crucial for specific applications, since it is always necessary to understand the advantages and disadvantages of the existing techniques so that best possible ones can be selected. The comparative study shows that: (1) the CSS method performs best in corner extraction. It is the fast and the most reliable and has the lowest noise sensitivity with the highest true corner detection rate, even though it still detects some false corners; (2) SUSAN detector would be the second choice and is acceptable and useful in applications requiring a computationally efficient detector and working on a restricted set of images.

2. Real-time Feature Point Tracking at 1000 fps
Idaku Ishii, Ryo Sukenobe, Yuta Moriue, Kenkichi Yamamoto

Real-time feature point tracking at 1000 fps was performed by implementing a feature point tracking algorithm on a high-speed vision platform, which is improved for hardware integration and high-speed processing at real time. The high-speed vision platform on which the improved algorithm is hardware-implemented can be used to track feature points of 1024×1024 pixel images at 1000 fps. By considering fast-moving objects in the real world, we verified the performance of our developed real-time feature point tracking system.

3. A Statistical Image Retrieval Method Using Color Invariant
Cheng Jin

Content based image retrieval is an essential task in many image processing applications, among which, color based methods have been receiving constant attentions in past years, because color information is a discriminative descriptor for image retrieval, especially in case of large database. A limitation of previous color based methods is their unsuitability for retrieving similar scenes under varying lighting conditions as color is sensitive to illuminations. Besides image descriptors of some existing methods are with large dimensionality and thus computational expensive. As betterment, an adaptive method is proposed in this paper, which integrates the color invariant with some spatial information of images. Different from previous work, the number of states during the quantization of the color space is not manually determined. Instead, it depends on the context of the image itself, using an adaptive clustering technique: Firstly, feature map consisting of color invariants is established for images. Secondly, the Markov chain model is employed to capture the image both color and spatial information. Thirdly, an image descriptor is computed for each image, not under the frame of the entire fixed color space. To practice our method, similar images are retrieved with a similarity measure based on a two-stage weighted distance. Experiments show that, this method has improved simplicity and compactness without the lost of efficiency and robustness.

4. Composite Visual Servoing for Catching a 3-D Flying Object Using RLS Trajectory Estimation from a Monocular Image Sequence
R. Herrejon, S. Kagami, K. Hashimoto

Online coordination of visual information with slow speed manipulator control is studied in the specific task of three dimensional robotic catching using position based visual servoing. The problem involves the design and application of a recursive algorithm to extract and predict the position of an object in a 3D environment from one feature correspondence from a monocular image sequence. The measured data are the noisy image plane coordinates of object match taken from image in the sequence. Image plane noise levels are allowed and investigated. The target trajectory estimation is formulated as a tracking problem, which can use an arbitrary large number of images in a sequence and is done using Recursive Least Squares (RLS).

The feasibility of our methods for catching are demonstrated by both simulations and experiments using a a real-time vision system and a six-degree-of-freedom robotic arm with speed capabilities of up to 1.0 m/s.

5. Environment Adaptive 3D Object Recognition and Pose Estimation by Cognitive Perception Engine
Hyunjun Kim, Jangwon Lee, Sukhan Lee

In this paper, we propose novel evidence selection and collection method based on Bayesian theorem for object recognition and pose estimation in real environment. To recognize and estimate 3D object pose accurately, photometric and geometric evidences such as color blob, SIFT points and lines, can be utilized as single or multiple features in a sequence of images. However, to guarantee dependability in visual perception, the system have to cope with environmental variation that includes change of illumination, amount of texture, and distance to object. So, we made monitoring system to observe the change of environment. The main contribution of this paper is to develop and improve the recognition strategy by proper evidence selection and collection by using Bayesian rule that can be working robustly in various environmental conditions. The experimental results with a single stereo camera show the feasibility and effectiveness of the proposed method in an environment containing both textured and texture-less objects.

6. Fast Neighbor Cells Finding Method for Multiple Octree Representation
Jaewoong Kim, Sukhan Lee

A cell occupancy map has been used widely for efficiently representing obstacles in robotic navigation. Such a map can often be formed based on the multi-resolution octree representation (MOR) of 3D point clouds captured from objects and workspace. This elevated cell-based approach may offer the capability of understanding the geometric context of workspace, expanding its applicability to robotic manipulation in a cluttered workspace. Under this context, the main issue of MOR becomes how to represent and generate cell addresses in such a way as to find neighboring cells efficiently. This paper presents a novel method for efficiently searching for neighboring cells with the fast generation of all the neighboring cell addresses. The original contribution of this paper is that not only the direct neighbors defined by those cells the edges or corners of which are directly connected to the given cell, but also the indirect neighbors of distance r, defined by those cells being separated from the given cell by the distance r, are included. The proposed method have been implemented and applied to obstacle representation in the 3D workspace modeling.

Fri. 09:50-11:30 **#102**

FB1: Sensor Fusion 2

Chair: Shuichi Kurogi, Kyushu Institute of Technology

1. Range Image Registration Using Plane Extraction by the CAN2
Shuichi Kurogi, Hideaki Koya, Ryoji Nagashima, Daisuke Wakeyama, Takeshi Nishida

This paper describes range image registration to fuse three-dimensional surfaces of range images taken from around an object. By means of using the competitive associative net called CAN2 for plane extraction, we constructed two methods: one is for the case where the planes of the floor and the wall are available, and the other is for the case where the available planes are on the floor and the object. With experimental results using the real images obtained by the laser range finder (LRF), we examine the performance of the methods, and present several problems to be solved in future research studies.

2. FPGA Based Hardware in the Loop Test Platform of Small Size UAV
Ta-ming Shih, Ho-chung Chang

Recently, there has been a need of small size UAV for vast applications in military and civilian applications as local area surveillance reconnaissance in hostile condition, damage assessment in natural disaster and remote sensing of harmful materials. UAV can finish missions without risking human life. However, applying low-cost sensors for flight control is of extreme challenge due to less accuracy nature of sensors. Therefore a Hardware-in-the–Loop (HIL) is most necessary for test and evaluation purpose to reduce the risk of flight testing. In this paper, a HIL system is built up to test the autopilot hardware performance, control parameter tuning. By building the dynamic model of airplane and combining the microcontroller and FPGA(Field Programmable Gate Array) based hardware interfaces, a 3D visualize HIL platform is built to improve test efficiency and reducing time and cost.

3. Improving Generalization Performance of Bagging Ensemble Via Bayesian Approach
Shuichi Kurogi, Kenta Harashima

This paper describes a method for improving the generalization performance of bagging ensemble by means of using Bayesian approach. We examine the Bayesian prediction using bagging leaning machines for regression problems, and show a method to reduce the generalization loss defined by the square error of the prediction for test data. We examine and validate the effectiveness via numerical experiments using the CAN2s as learning machines, where the CAN2 is a neural net for learning efficient piecewise linear approximation of nonlinear functions.

4. Distributed Receding Horizon Filtering in Discrete-Time Dynamic Systems
Il Young Song, Vladimir Shin

A distributed receding horizon filtering for discrete-time dynamic systems is proposed. A distributed fusion with the weighted sum structure is applied to the set of local receding horizon Kalman filters (LRHKFs). All LRHKFs have the same receding horizon length. The distributed fusion algorithm represents the optimal linear fusion by weighting matrices under the minimum mean square criterion. In other to compute the optimal matrix weights, the recursive equations for error cross-covariances between the LRHKFs are derived. Simulation example for the tracking system with three sensors demonstrates effectiveness of the proposed filter.

5. Distributed Fusion of Local Probability Data Association Filters in Multi-Sensor Environment
Kyungmin Lee, Vladimir Shin

The problem of data association for target tracking in a multi-sensor cluttered environment is discussed. The probabilistic data association filter (PDAF) is useful to obtain proper estimate of state in this environment. We propose two distributed algorithms for PDAF to acquire high accuracy system and reduce computation burden caused by clutter. The distributed process and its modified fusion algorithm for the PDAF is introduced, such as the optimal fusion formula (OFF) and covariance intersection (CI). The OFF is optimal in view of each local sensor and it has the great accuracy among the distributed fusion algorithms. On the other hands, the CI has weighted convex combination without cross-covariance, so it has the advantage of fastness. Finally, the simulation results show that the proposed algorithms have advantages over robustness and lower computation burden.

Fri. 09:50-11:30 **#103**

FC1: Personal Robotics

Chair: Jangmyung Lee, Pusan National University

1. Hill Climbing Algorithm of an Inverted Pendulum
Howon Lee, Junseok Lee, Jangmyung Lee

This research aims at the control of the inverted pendulum attached on the top plate of a mobile robot. Especially, when the mobile robot is climbing up the hill, the stable control of the inverted pendulum is a challenging problem. Considering the gravity of the pendulum according to the inclined angle, the mobile robot motion is controlled to keep the inverted pendulum upright while the mobile robot is changing the location. For this purpose, the dynamics of the mobile robot and inverted pendulum have been derived and utilized with the PID control algorithm to keep the inverted pendulum upright. Through the real experiments, the range of disturbance which can be overcome by the controller has been shown. And also the effectiveness and validity the derived dynamics have been shown with various disturbances.

2. 3D Path Planning with Novel Multiple 2D Layered Approach for Complex Human-robot Interaction
Thomas A. Smith, Rui C. V. Loureiro, William S. Harwin

Navigating cluttered indoor environments is a difficult problem in indoor service robotics. The Acroboter concept, a novel approach to indoor locomotion, represents unique opportunity to avoid obstacles in indoor environments by navigating the ceiling plane. This mode of locomotion requires the ability to accurately detect obstacles, and plan 3D trajectories through the environment. This paper presents the development of a resilient object tracking system, as well as a novel approach to generating 3D paths suitable for such robot configurations. Distributed human-machine interfacing allowing simulation previewing of actions is also considered in the developed system architecture.

3. An Extensible Dialogue Script for Robot Based on Unification of State Transition Models
Yosuke Matsusaka, Hiroyuki Fujii, Isao Hara

In this paper, we propose an extension-byunification method to improve reusability and flexibility in the incremental development of state-transition models. The dialogue engine SEAT (Speech Event-Action Translator) has been developed to realize continuous development of statetransition models in order to give robots dialogue capability that can cope with various kinds of speech inputs in various tasks. SEAT has a flexible adaptor mechanism that can connect to many types of robotic interfaces, and the developer can accumulate the scripts by using the script management server, which has a function to propose existing reusable scripts to the developer. We have confirmed that the application of SEAT to the development of three robots has significantly improved development efficiency.

4. Gesture Based Dialogue Management Using Behavior Network for Flexibility of Human Robot Interaction
Sungsoo Lim, Jongwon Yoon, Keunhyun Oh, Sung-Bae Cho

The usage of robots becomes more sophisticated, direct communication by means of human language is required to increase the efficiency of their performance. However, the dialogue systems that reply to the user with a set of predefined answers tend to be static. In this paper, we propose a gesture based dialogue system using behavior network for flexibility of human robot interaction. Gestures take an important part of interactions. By using gestures in dialogues, it could support a flexible and realistic interaction with humans. We confirm the usability of gestures through several scenarios and SUS subject test.

5. Animal-Robot Interaction for Pet Caring
Jong-Hwan Kim, Seung-Hwan Choi, Duckhwan Kim, Joonwoo Kim, Minjoo Cho

Pet has been serving as an emotional companion to people. However, nowadays it is common that people are too busy to take care of their pet due to everyday work. This research is to see the possibility that robot can replace the role of taking care of pets on behalf of their owner and the conventional Human-Robot Interaction (HRI) can be extended to the interaction of robots and animals. In this paper, the concept of Animal-Robot Interaction (ARI) and its characteristics are presented along with basic experiments. The experiments are carried out with a cat and mobile robots. It clearly shows the possibility of implementation of ARI.

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