Program & Abstracts

16-18 December 2009

Orchard Hotel

Singapore

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Welcome Message

After the success of the inaugural conference, the purpose of the Second International Conference on Intelligent Robotics and Applications was to provide a venue where researchers, scientists, engineers and practitioners throughout the world come together to present and discuss the latest achievement, future challenges and exciting applications of intelligent and autonomous robots. In particular, the emphasis of this year's conference was on "**robot intelligence for achieving digital manufacturing and intelligent automations.**"

We would like to thank all the contributors and authors for their continuous support of ICIRA conference series. Also, we would like to thank the international Program Committee for their generous efforts and critical reviews. Thanks also go to the keynote speakers, Sadayuki Tsugawa, Meijo University, Japan, Zhengyou Zhang, Microsoft Research, USA, and Yongkiang Koh, ST Kinetics Ltd, Singapore, for providing very insightful talks. Finally, we would like to thank those who have devoted their time and effort to make ICIRA2009 a successful scientific meeting.

Ming Xie

Youlun Xiong

Caihua Xiong

Honghai Liu

Zhencheng Hu

Conference Committees

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Zhijun Yang, UK
Zhouping Yin, China
Changjiu Zhou, Singapore
Limin Zhu, China

Keynote Speeches

Plenary Talk 1:

Intelligent Vehicles for Intelligent Transport Systems: Current Status and Future Expectation

Sadayuki Tsugawa, Dr. Eng.
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E-mail: tsugawa@ccmfs.meijo-u.ac.jp

Abstract

The Intelligent Transport Systems (ITS), the objectives of which are safety, efficiency, environment protection, and comfort of automobile traffic and road transportation, include various systems and the main systems are traffic signal control systems, route guidance systems, driver assistance systems, and automated driving systems,. The Intelligent Vehicles, which the talk is focusing on, are closely related to the driver assistance systems and the automated driving systems. Some driver assistance systems like adaptive cruise control and lane keep assistance have already in the market, but the dissemination rates are not high at present and it will take some time to be accepted by every driver like ABS and air bags. Although there is a long history of research and development on automated driving systems, there are little systems for practical use. Currently, the projects on automated driving systems have just started in Europe and Japan: HAVE-it (Highly Automated Vehicles for Intelligent Transport) in Europe, and Energy ITS aiming at an automated platoon of heavy trucks in Japan. The introduction of automation to automobile traffic is an inevitable trend for the compatibility of the safety and efficiency, which can be already seen in air traffic and railway traffic. In the future automobiles will be not only more intelligent but also more diversified for the global warming prevention as well as safety, and there will appear automated platoons of heavy trucks along expressways and intelligent, single-seated, ultra-small vehicles along urban streets, which will be the synergy of automobiles and robots.

Biography of Speaker

Dr. Tsugawa got his Bachelor, Master, and Doctor of Engineering degrees in 1968, 1970, and 1973 respectively, all from the University of Tokyo, in the field of control engineering. In 1973, he joined Mechanical Engineering Laboratory under Japanese Ministry of International Trade and Industry, where he worked in the area of ITS and intelligent vehicles for 30 years. In 2003, he moved to Meijo University. He got the best paper award on a vision-based intelligent vehicle from Japanese Society of Instrumentation and Control Engineers in 1992. The Minister of Science and Technology awarded him for his research on intelligent vehicles in 1999. He has been serving as a BOG (Board of Governors) member of IEEE ITS Society since 2008.

Plenary Talk 2:

Computer Vision and Auditory Perception

Zhengyou Zhang, Dr. Eng

Microsoft Research

USA

http://research.microsoft.com/~zhang/.

Abstract

Endowing machine with human-like seeing and hearing capabilities has long been an endeavor for generations of scientists. Although seeing and hearing are granted to a human, human vision and auditory perception are still poorly understood. I will show a number of interesting examples illustrating both robustness and illusiveness of human vision and auditory systems. Despite limited understanding of human vision and auditory systems, we have seen tremendously progress in computer vision and auditory perception in the last two decades. I will show some of our recent research projects in vision (e.g., face modeling/detection/tracking/verification, visual echo cancellation in a projector-camera system, human event detection and recognition), in audio (e.g., sound source localization, multichannel acoustical echo

cancellation, audio event detection and recognition, speaker verification), in multimodal analysis (e.g., audio-visual active speaker detection). I will finally demonstrate the application of some of those technologies in mediated human-human interaction and human-computer interaction.

Biography of Speaker

Zhengyou Zhang received the B.S. degree in electronic engineering from the University of Zhejiang, Hangzhou, China, in 1985, the M.S. degree in computer science from the University of Nancy, Nancy, France, in 1987, and the Ph.D. degree in computer science and the Doctor of Science (*Habilitation à diriger des recherches*) diploma from the University of Paris XI, Paris, France, in 1990 and 1994, respectively.

He is a Principal Researcher with Microsoft Research, Redmond, WA, USA, and manages the multimodal collaboration research team. Before joining Microsoft Research in March 1998, he was with INRIA (French National Institute for Research in Computer Science and Control), France, for 11 years and was a Senior Research Scientist from 1991. In 1996-1997, he spent a one-year sabbatical as an Invited Researcher with the Advanced Telecommunications Research Institute International (ATR), Kyoto, Japan. He has published over 200 papers in refereed international journals and conferences, and has coauthored the following books: *3-D Dynamic Scene Analysis: A Stereo Based Approach* (Springer-Verlag, 1992); *Epipolar Geometry in Stereo, Motion and Object Recognition* (Kluwer, 1996); and *Computer Vision* (Science Publisher, 1998, 2003, in Chinese). He has given a number of keynotes in international conferences.

Dr. Zhang is an IEEE Fellow, the Founding Editor-in-Chief of the *IEEE Transactions on Autonomous Mental Development*, an Associate Editor of the *International Journal of Computer Vision*, an Associate Editor of the *International Journal of Pattern Recognition and Artificial Intelligence*, and an Associate Editor of *Machine Vision and Applications*. He served as an Associate Editor of the *IEEE Transactions on Pattern Analysis and Machine Intelligence* from 2000 to 2004, an Associate Editor of the *IEEE Transactions on Multimedia* from 2004 to 2009, among others. He has organized or participated in organizing numerous international conferences. More details are available at http://research.microsoft.com/~zhang/.

Plenary Talk 3:

Development of Autonomous Vehicles

KOH Yong Khiang, Dr. Eng

Vice-President, Engineering

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Abstract

The ultimate goal of an autonomous vehicle is a driverless car that can drive itself from one point to another without the assistance from a driver. It seems to be a scientist's dream or a futuristic movie flick. However with the advances in technology, both in sensors' technologies and artificial intelligence research, and the ever increasing computing power, this dream seems to be reality in times to come. In order for a car to drive without a driver, one would need a sensor suite and perception algorithms to understand its immediate environment in order to create the "world map" as if it is seen by the driver; to know where it is and where it wants to go via the navigation module; to find its way in the traffic, i.e. to be able to calculate path planning and lastly to give commands to the vehicle to perform the desired actuation, such as steering, braking, accelerating, moving forward or reversing via the interaction of the vehicle control module and the drive-by-wire system of the vehicle.

The DARPA Urban Challenge held on 3 November 2007 at a former US Air Force base near Victorville, CA. had raised the autonomous driving technology to a new height. Over the 60 miles of simulated urban driving, the driverless vehicles, needed to negotiate in this urban setting, recognize if they were approaching cross-roads and deciding when to move off as there were human-driven cars which incorporating traffic density and traffic rules for the competition.

This presentation briefly explains how these scenarios can take place with the explanation of the basic building blocks for an autonomous vehicle. It also discusses the likely outcomes of current technologies, especially those demonstrated during DUC 2007 for driver assistance systems development and the additional technologies or vehicle systems needed in order to make the vehicle entirely driverless in an urban setting. Researchers have begun to believe that the future for autonomous vehicles is very promising, as several key enablers, the basic technologies, are already in place. They envisage that with the utilization of autonomous vehicles, we could dramatically reduce accidents, and there is potential for congestion management and improved time and fuel efficiency.

Biography of Speaker

Dr KOH Yong Khiang received the Bachelor of Engineering in Mechanical Engineering from the National University of Singapore in 1981; the MSc in Sound and Vibration Studies and the PhD degree specializing in Structural Vibration and Control from the Institute of Sound and Vibration Research, University of Southampton in September 1989 and February 1993 respectively. He joined Singapore Technologies Kinetics Ltd in March 1994 as a Principal Engineer responsible for structural analysis, noise & vibration studies of tracked vehicles, Human Factors Engineering, instrumentation and field measurement. He is currently the Head of Unmanned Systems Centre overseeing the development of Unmanned Ground Vehicle projects. The Centre also provides test & evaluation, instrumentation & field measurement services to support in-house development projects.

Plenary Talk 4

Automation and Key Technologies on Shield Tunneling Machine

Huayong YANG, Dr. Eng

State Key Laboratory of Fluid Power Transmission and Control,

Zhejiang University,

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Abstract

Shield tunneling machine is a large and complex machine which is widely used in underground constructions, such as underground rail lines, water conservancy, urban pipelines, etc. The shield machine is mostly a mechanism at the very beginning. With developments of computer science and automation, modern technologies are applied on the shield machine. Nowadays, shield machine is a functional machine with automatic navigation, proportional electro-hydraulic control, monitoring and field-bus technology. The speech is going to talk about key technologies on the shield machine, two different energy conservation methods using in cutter head driving, and the automatic system on the test rig of shield machine.

Biography

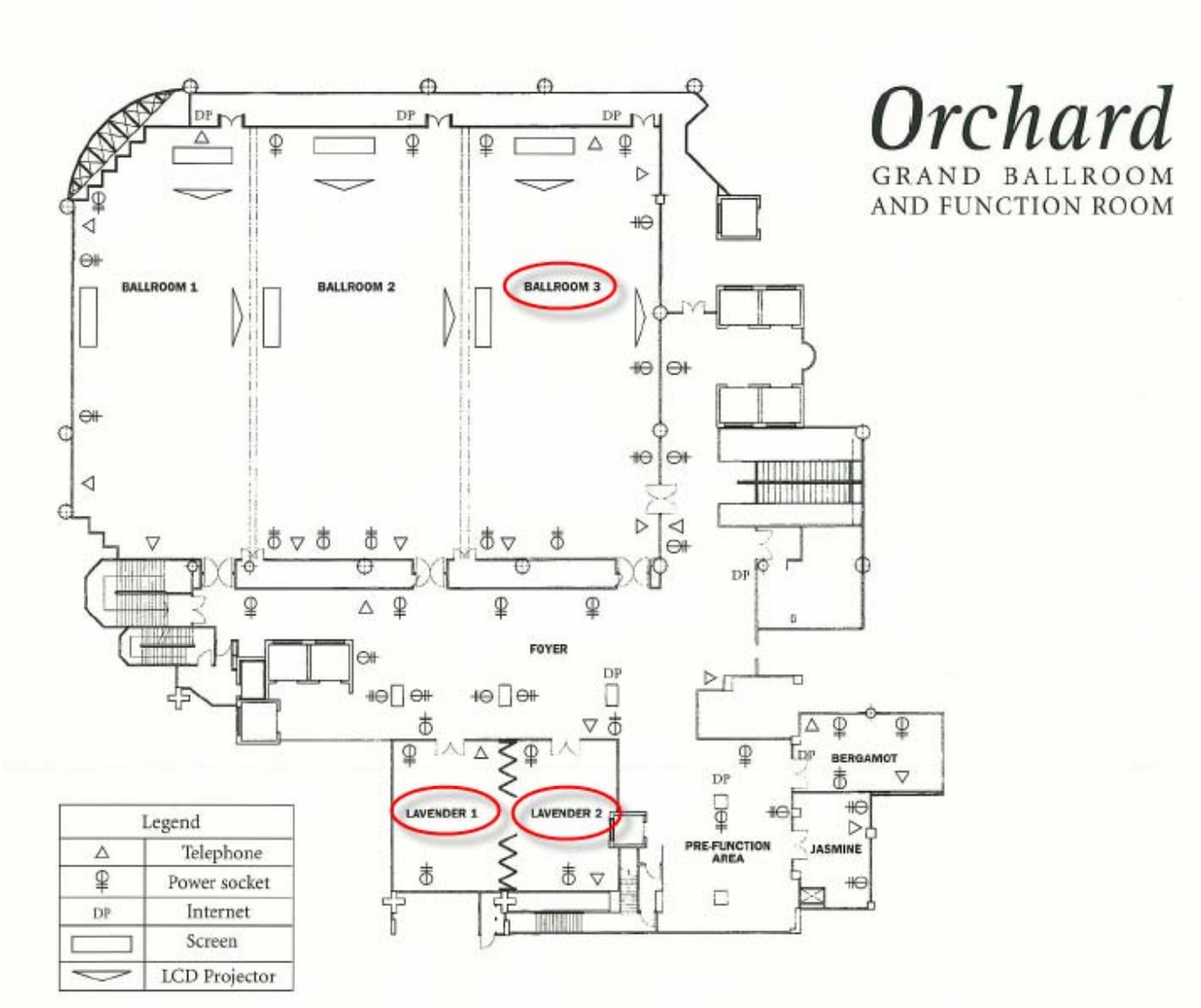
Huayong Yang received the Ph.D degree in mechanical engineering from Bath University, U.K., in 1988. He is a professor of Zhejiang University, Yangtze Fund Scholar of China, the scholar of the National Science Foundation for Distinguished Young Scholars of China, the chief scientist of the National Basic Research Program (973 Program) of China. Currently, he is studying control technologies and energy conservation of mechatronics system, electro-hydraulic elements and electro-hydraulic system integration of major equipments. He has published over 160 papers in Chinese journals, international journals and conferences.

Conference Rooms

Assignment of Seminar Rooms

Seminar Room for Track 1	Seminar Room for Track 2	Seminar Room for Track 3
Lavender 1	Lavender 2	Grand Ballroom 3

Floor Layout



Timetable of Technical Sessions

Technical Sessions on 16 December 2009

9:00 – 10:00	Ballroom 3 Plenary Talk "Intelligent Vehicles for Intelligent Transport Systems: Current Status and Future Expectation" **Chair**: Zhencheng Hu		
10:00 – 10:30	Tea Break		
10:30 – 12:30	Session D1-T1A (Track 1)	Session D1-T2A (Track 2)	Session D1-T3A (Track 3)
	Ubiquitous and Collaborative Robots in Smart Space (1) **Session Chair**: Honghai Liu	Advanced Control on Autonomous Vehicles **Session Chair**: Abdel AITOUCHE	Robot and Automation in Tunneling (973) (1) **Session Chair**: Huayong Yang, Guoli Zhu, and Yongan Huang
12:30 – 13:30	Lunch		
13:30 – 14:00	Ballroom 3 Plenary Talk "Automation and Key Technologies on Shield Tunneling Machine" **Chair**: Caihua Xiong		
14:00 – 15:40	Session D1-T1B (Track 1)	Session D1-T2B (track 2)	Session D1-T3B (track 3)
	Ubiquitous and Collaborative Robots in Smart Space (2) **Session Chair**: Honghai Liu and Zhouping Yin	Visual Perception by Robots (1) **Session Chair**: Luca Brayda	Robot and Automation in Tunneling (973) (2) **Session Chair**: Huayong Yang, Guoli Zhu, and Yongan Huang
15:40 – 16:00	Tea Break		
16:00 – 17:20	Session D1-T1C (track 1)	Session D1-T2C (track 2)	Session D1-T3C (track3)
	Robot Simulation **Session Chair** Haoyong Yu	Intelligent Vehicles: Perception for Safe Navigation **Session Chair**: Zhencheng Hu	Robot and Automation in Tunneling (973) (3) **Session Chair**: Huayong Yang, Guoli Zhu, and Yongan Huang
18:30 21:00	Welcome Reception		

Session D1-T1A

Ubiquitous and Collaborative Robots in Smart Space (1)

Session Chair:
Dr. Honghai Liu, University of Portsmouth
United Kingdom
honghai.liu@port.ac.uk

Time	ID	Paper Title
10:30 – 10:50	D1-T1A-1	A Ubiquitous and Cooperative Service Framework for Network Robot System
10:50 – 11:10	D1-T1A-2	The Hand-bot, a Robot Design for Simultaneous Climbing and Manipulation
11:10 – 11:30	D1-T1A-3	Human multi-robots interaction with high Virtual Reality abstraction level
11:30 – 11:50	D1-T1A-4	Laser based people following behaviour in an emergency environment
11:50 – 12:10	D1-T1A-5	RENS -- Enabling A Robot to Identify A Person
12:10 – 12:30	D1-T1A-6	Classifying 3D Human Motions by Mixing Fuzzy Gaussian Inference With Genetic Programming
End of Session		

Session D1-T2A

Advanced Control on Autonomous Vehicles

Session Chair:
Prof. Abdel AITOUCHE, LAGIS UMR CNRS 8146, France
Abdel.AITOUCHE@hei.fr

Time	ID	Paper Title
10:30 – 10:50	D1-T2A-1	Mono landmark localization for an autonomous navigation of a cooperative mobile robot formation
10:50 – 11:10	D1-T2A-2	Challenges of the multi-robot team in the GUARDIANS project
11:10 – 11:30	D1-T2A-3	Modelling and Control of a Train of Autonomous Electric Vehicles
11:30 – 11:50	D1-T2A-4	Organization and Operation of Electronically Coupled Truck Platoons on German Motorways
11:50 – 12:10	D1-T2A-5	Navigation method selector for an autonomous rover
12:10 – 12:30	D1-T2A-6	SLAM Estimation in dynamic outdoor environments: A Review
End of Session		

Session D1-T3A

Robot and Automation in Tunneling (973)

Session Chairs:
Prof. Huayong Yang, Prof. Guoli Zhu, and Dr. Yongan Huang
yhy@zju.edu.cn

Time	ID	Paper Title
10:30 – 10:50	D1-T3A-1	On the Analysis of Force Transmission Performance for the Thrust Systems of Shield Tunneling Machines
10:50 – 11:10	D1-T3A-2	Passive Ultrasonic RFID Localization for Pipeline Pigs
11:10 – 11:30	D1-T3A-3	Allocation of Measurement Error of Shield's Pose
11:30 – 11:50	D1-T3A-4	The Compliance Design on Thrust System of Shields Excavating in Various Geologic Conditions
11:50 – 12:10	D1-T3A-5	Analysis for Dynamic Load Behavior of Shield Thrust System Considering Variable Boundary Constraints
12:10 – 12:30	D1-T3A-6	Evaluation and Optimization Method of High Speed Cutting Parameters Based on Cutting Process Simulation
End of Session		

Session D1-T1B

Ubiquitous and Collaborative Robots in Smart Space

Session Chairs:
Dr. Honghai Liu, University of Portsmouth, United Kingdom
honghai.liu@port.ac.uk
Dr. Zhouping Yin
Huazhong University of Science and Technology, China
yinzhp@mail.hust.edu.cn

Time	ID	Paper Title
14:00 – 14:20	D1-T1B-1	Pointing Gestures for a Robot Mediated Communication Interface
14:20 – 14:40	D1-T1B-2	Symbricator3D - A Distributed Simulation Environment for Modular Robots
14:40 – 15:00	D1-T1B-3	View-invariant Human Action recognition using Exemplar-based Hidden Markov Models
15:00 – 15:20	D1-T1B-4	A Local Interaction Based Multi-robot Hunting Approach with Sensing and Modest Communication
15:20 – 15:40	D1-T1B-5	Robot Formations for Area Coverage
End of Session		

Session D1-T2B

Visual Perception by Robots

Session Chair:
Dr. Luca Brayda
Team Leader, Researcher, TeleRobotics and Applications dept, Istituto Italiano di Tecnologia, Italy
luca.brayda@iit.it

Time	ID	Paper Title
14:00 – 14:20	D1-T2B-1	Quantitative and qualitative evaluation of vision-based teleoperation of a mobile robot
14:20 – 14:40	D1-T2B-2	Stereo Vision Based Floor Plane Extraction and Camera Pose Estimation
14:40 – 15:00	D1-T2B-3	What Visual Cues Do We Use to Perceive Depth in Virtual Environments?
15:00 – 15:20	D1-T2B-4	An Embedded Vision System for A Power Transmission Line Inspection Robot
15:20 – 15:40	D1-T2B-5	Binocular based Moving Target Tracking for Mobile Robot
End of Session		

Session D1-T3B

Robot and Automation in Tunneling (973)

Session Chairs:
Prof. Huayong Yang, Prof. Guoli Zhu, and Dr. Yongan Huang
yhy@zju.edu.cn

Time	ID	Paper Title
14:00 – 14:20	D1-T3B-1	The Reconfiguration Design of Redundant Thrust of Shields Excavating in Various Geologic Conditions
14:20 – 14:40	D1-T3B-2	Research of an electric laser system based on the non-diffracting beam
14:40 – 15:00	D1-T3B-3	Research on Multi-Motor Synchronization Control for Cutter Head of Shield Machine Based on the Ring Coupled Strategy
15:00 – 15:20	D1-T3B-4	Position and Attitude Precision Analysis of Segment Erector of Shield Tunneling Machine
15:20 – 15:40	D1-T3B-5	An Improved Model of Loads Acting on Shield
End of Session		

Session D1-T1C

Robot Simulation

Session Chair:
Dr. Haoyong Yu
DSO National Laboratories., Singapore

Time	ID	Paper Title
16:00 – 16:20	D1-T1C-1	Real-time Simulation System of Virtual Picking Manipulator Based on Parametric Design
16:20 – 16:40	D1-T1C-2	Study of modeling and simulating for Picking Manipulator Based on Modelica
16:40 – 17:00	D1-T1C-3	Development of a Single Manipulator System Applied to "Accompany & Nursing" Robot
17:00 – 17:20	D1-T1C-4	
End of Session		

Session D1-T2C

Intelligent Vehicles: Perception for Safe Navigation

Session Chair:

Dr. Zhencheng Hu

Associate Professor., Kumamoto Univ., Japan

Time	ID	Paper Title
16:00 – 16:20	D1-T2C-1	An Improved Road Network Modeling and Map Matching for Precise Vehicle Localization
16:20 – 16:40	D1-T2C-2	A VISION SYSTEM of HAZARD CAMERAS for LUNAR ROVER BH2
16:40 – 17:00	D1-T2C-3	Stereovision-based Algorithm for Obstacle Avoidance
17:00 – 17:20	D1-T2C-4	Improved Techniques for the Rao-Blackwellized Particle Filters SLAM
End of Session		

Session D1-T3C

Robot and Automation in Tunneling (973)

Session Chairs:
Prof. Huayong Yang, Prof. Guoli Zhu, and Dr. Yongan Huang
yhy@zju.edu.cn

Time	ID	Paper Title
16:00 – 16:20	D1-T3C-1	Establishment of TBM disc cutter Dynamic Model for the Vertical Vibration
16:20 – 16:40	D1-T3C-2	Soft Rock Cutting Mechanics Model of TBM Cutter and Experimental Research
16:40 – 17:00	D1-T3C-3	Neural Network Strata Identification Based on Tunneling Parameters of Shield Machine
17:00 – 17:20	D1-T3C-4	Analysis of Chamber Pressure for Earth Pressure Balance Shield Machine by Discrete Numerical Model
End of Session		

Technical Session on 17 December 2009

9:00 – 10:00	Ballroom 3 Plenary Talk "Computer Vision and Auditory Perception" **Chair**: Ming Xie		
10:00 – 10:30	Tea Break		
10:30 – 12:30	Session D2-T1A (track 1)	Session D2-T2A (track 2)	Session D2-T3A (track 3)
	Robot Motion Analysis (1) **Session Chair**: Limin Zhu	Novel Techniques for Collaborative Driver Support **Session Chair**: Makoto Itoh	Robot Mechanism and Design (1) **Session Chair**: Taro Nakamura
12:30 – 13:30	Lunch		
13:30 – 14:00	Ballroom 3 Industrial Talk "NAO: Autonomous and Programmable Humanoid Robots" **Chair**: Honghai Liu		
14:00 – 15:40	Session D2-T1B (track 1)	Session D2-T2B (track 2)	D2-T3B (track 3)
	Robot Motion Analysis (2) **Session Chair**: Hui Chen	Visual Perception by Robots (2) **Session Chair**: Zhencheng Hu	Robot and Automation in Tunneling (973) (4) **Session Chair**: Huayong Yang, Guoli Zhu, and Yongan Huang
15:40 – 16:00	Tea Break		
16:00 – 17:20	Session D2-T1C (track 1)	Session D2-T2C (track 2)	Session D2-T3C (track 3)
	Computational Intelligence by Robots (1) **Session Chair**: Jean-Daniel Dessimoz	Visual Perception by Robots (3) **Session Chair**: Ryad CHELLALI	Robot and Automation in Tunneling (973) (5) **Session Chair**: Huayong Yang, Guoli Zhu, and Yongan Huang
18:30 - 21:00	Conference Award and Banquet		

Session D2-T1A

Robot Motion Analysis

Session Chair:
Dr. Limin Zhu
Prof., Shanghai Jiaotong University, China
zhulm@sjtu.edu.cn

Time	ID	Paper Title
10:30 – 10:50	D2-T1A-1	A Method of Stiffness Analysis of Parallel Mechanisms
10:50 – 11:10	D2-T1A-2	Numerical Methods for Frictional Contact of Multi-rigid-body with Redundant Constraints
11:10 – 11:30	D2-T1A-3	Inverse dynamic modeling of two unsymmetrical 3UPU parallel manipulators
11:30 – 11:50	D2-T1A-4	Kinematic Analysis of the SPKM165, a 5-Axis Serial-Parallel Kinematic Milling Machine
11:50 – 12:10	D2-T1A-5	Dynamic Simulation of Passive Walker Based on Virtual Gravity Theory
12:10 – 12:30	D2-T1A-6	Kinematic Model of Bionic Wheel-legged Lunar Rover and its Simulation Analysis
End of Session		

Session D2-T2A

Novel Techniques for Collaborative Driver Support

Session Chair:
Dr. Makoto Itoh
Associate Professor., Tsukuba Univ., Japan
itoh@risk.tsukuba.ac.jp

Time	ID	Paper Title
10:30 – 10:50	D2-T2A-1	A Deceleration Assistance Control for Collision Avoidance based on Driver's Perceptual Risk
10:50 – 11:10	D2-T2A-2	Toward Preventive ACC Systems against Crashes due to Another Vehicle's Cut-in
11:10 – 11:30	D2-T2A-3	How Do Cognitive Distractions Affect Driver Intent in Lane Changing Behavior?
11:30 – 11:50	D2-T2A-4	Effects of missed alarms on driver's response to a collision warning system according to alarm timings
11:50 – 12:10	D2-T2A-5	Emergent Behavior Control Patterns in Robotic Environments
12:10 – 12:30	D2-T2A-6	A Simulation Model to Evaluate and Verify Functions of Autonomous Vehicle based on Simulink®
End of Session		

Session D2-T3A

Robot Mechanism and Design

Session Chair:
Dr. Taro Nakamura
Associate Professor, Chuo Univ., Japan
nakamura@mech.chuo-u.ac.jp

Time	ID	Paper Title
10:30 – 10:50	D2-T3A-1	Spike: A Six Legged Cube Style Robot
10:50 – 11:10	D2-T3A-2	From morphologies of six-, four- and two-legged animals to the HexaQuaBip robot's reconfigurable kinematics
11:10 – 11:30	D2-T3A-3	A Dexterous and Self-adaptive Humanoid Robot Hand: Gesture-changeable Under-actuated Hand
11:30 – 11:50	D2-T3A-4	Variable rheological joints using an artificial muscle soft actuator and magneto-rheological fluids brake
11:50 – 12:10	D2-T3A-5	The Similarity Design of the Heavy Forging Robot Gripper
12:10 – 12:30	D2-T3A-6	Design of the Upper limb Rehabilitation Support Device Using a Pneumatic Cylinder
End of Session		

Session D2-T1B

Robot Motion Analysis

Session Chair:
Dr. Hui Chen
Prof., Tongji Univ., China
hui-chen@mail.tongji.edu.cn

Time	ID	Paper Title
14:00 – 14:20	D2-T1B-1	Dynamics and GA-Based Optimization of Rectilinear Snake Robot
14:20 – 14:40	D2-T1B-2	Optimum Dynamic Modeling of a Wall Climbing Robot for Ship Rust Removal
14:40 – 15:00	D2-T1B-3	Stiffness and singularity analysis of 2SPS+2RPS parallel manipulator by using different methods
15:00 – 15:20	D2-T1B-4	Experimental Evaluation on Dynamic Characteristics of Coaxial Magnetic Couplings for Vacuum Robot
15:20 – 15:40	D2-T1B-5	Complex surface machining: Flexible thermo-mechanical model for error prediction of low-rigidity work-piece
End of Session		

Session D2-T2B

Visual Perception by Robots

Session Chair:
Dr. Zhencheng Hu
Associate Professor, Kumamoto Univ., Japan
hu@cs.kumamoto-u.ac.jp

Time	ID	Paper Title
14:00 – 14:20	D2-T2B-1	Simultaneous Visual Object Recognition and Position Estimation Using SIFT
14:20 – 14:40	D2-T2B-2	The Vision System of the ACROBOTER Project
14:40 – 15:00	D2-T2B-3	Autonomous Update of Novelty Detection Map
15:00 – 15:20	D2-T2B-4	Active Contour Method with Separate Global Translation and Local Deformation
15:20 – 15:40	D2-T2B-5	PLG-based Visual Tracing for Eye-in-Hand Puma 560 Robot
End of Session		

Session D2-T3B

Robot and Automation in Tunneling

Session Chair:
Prof. Huayong Yang, Prof. Guoli Zhu, and Dr. Yongan Huang
yhy@zju.edu.cn

Time	ID	Paper Title
14:00 – 14:20	D2-T3B-1	Dynamic Mechanism and Key Rectification Techniques of Shield Machine in the Vertical Plane
14:20 – 14:40	D2-T3B-2	A precise measurement method of azimuth angle for TBM
14:40 – 15:00	D2-T3B-3	Identification of Abnormal Operating Condition and Intelligent Decision System for Earth Pressure Balance Shield
15:00 – 15:20	D2-T3B-4	Optimal Disc cutters plane Layout Design of the Full-Face Rock Tunnel Boring Machine (TBM) using an ant colony optimization algorithm
15:20 – 15:40	D2-T3B-5	Rotational Moment Analysis and Posture Rectification Strategy of Shield Machine
End of Session		

Session D2-T1C

Computational Intelligence by Robots

Session Chair:
Prof. Dr. Jean-Daniel Dessimoz
Western Switzerland University of Applied Sciences
Jean-Daniel.Dessimoz@heig-vd.ch

Time	ID	Paper Title
16:00 – 16:20	D2-T1C-1	Cognition Dynamics; Time and Change Aspects in Quantitative Cognitics
16:20 – 16:40	D2-T1C-2	Acquisition of Movement Pattern by Q-learning in Peristaltic Crawling Robot
16:40 – 17:00	D2-T1C-3	Study on a Location Method for Bio-objects in Virtual Environment Based on Neural Network and Fuzzy Reasoning
17:00 – 17:20	D2-T1C-4	Adaptive Cellular Automata Traffic System Model Based on Hybrid System Theory
End of Session		

Session D2-T2C

Visual Perception by Robots

Session Chair:
Prof. Dr. Ryad CHELLALI
Senior Scientist,
Istituto Italiano di Tecnologia, Italy
ryad.chellali@iit.it

Time	ID	Paper Title
16:00 – 16:20	D2-T2C-1	Obtaining Reliable Depth Maps for Robotic Applications from a Quad-camera System
16:20 – 16:40	D2-T2C-2	Research on Automatic Reconstruction of Unknown 3D Objects based on the Limit Visual Surface and Trend Surface
16:40 – 17:00	D2-T2C-3	Surface Reconstruction of Engine Intake Ports with Mixed Constraints
17:00 – 17:20	D2-T2C-4	A Fast Connected-Component Labeling Algorithm for Robot Vision Based on Prior Knowledge
End of Session		

Session D2-T3C

Robot and Automation in Tunneling

Session Chair:
Prof. Huayong Yang, Prof. Guoli Zhu, and Dr. Yongan Huang
yhy@zju.edu.cn

Time	ID	Paper Title
16:00 – 16:20	D2-T3C-1	Compensation of Measurement Error for Inclinometer Based on Neural Network
16:20 – 16:40	D2-T3C-2	Redundantly Actuated PRPRP Radial Mechanism in Segment Erector of Shield Machine for Synchronization Control
16:40 – 17:00	D2-T3C-3	Electrohydraulic Control of Thrust Hydraulic System for Shield Tunneling Machine
17:00 – 17:20	D2-T3C-4	Simulation Analysis of Pressure Regulation of Hydraulic Thrust System on a Shield Tunnling Machine
End of Session		

Technical Sessions on 18 December 2009

9:00 – 10:00	Ballroom 3 Plenary Talk "Development of Autonomous Vehicles" **Chair**: Zhencheng Hu		
10:00 – 10:30	Tea Break		
10:30 – 12:30	Session D3-T1A (track 1)	Session D3-T2A (track 2)	Session D3-T3A (track 3)
	Robot Motion Analysis (3) **Session Chair**: Minghui ZHANG	Robot Experimentation (1) **Session Chair**: Yong-an Huang	Robot Mechanism and Design (2) **Session Chair**: Caihua Xiong
12:30 – 14:00	Lunch		
14:00 – 15:40	Session D3-T1B (track 1)	Session D3-T2B (track 2)	Session D3-T3B (track 3)
	Computational Intelligence by Robots (2) **Session Chair**: Jean-Daniel Dessimoz	Visual Perception by Robots (4) **Session Chair**: Ryad CHELLALI	Robot Motion Control (1) **Session Chair**: Grigory Panovko
15:40 – 16:00	Tea Break		
16:00 – 17:20	Session D3-T1C (track 1)	Session D3-T2C (track 2)	Session D3-T3C (track 3)
		Robot Experimentation (2) **Session Chair**: Zhencheng Hu	Robot Motion Control (2) **Session Chair**: Honghai Liu
18:30 - 21:00	Farewell Cocktail		

Session D3-T1A

Robot Motion Analysis

Session Chair:
Prof. Dr. Minghui ZHANG
College of Mechanical and Electronic Engineering
Shandong University of Science and Technology, China
zmh1999238@163.com

Time	ID	Paper Title
10:30 – 10:50	D3-T1A-1	Modeling and Optimization of Contact Forces for Heavy Duty Grippers
10:50 – 11:10	D3-T1A-2	Performance of Inertia Force Analysis for Spherical Bearing Test Stand Mechanism
11:10 – 11:30	D3-T1A-3	Reordering and Partitioning Jacobian Matrices Using Graph-Spectral Method
11:30 – 11:50	D3-T1A-4	Workspace Analysis and Parameter Optimization of a Six DOF
11:50 – 12:10	D3-T1A-5	Obstacle-climbing Capability Analysis of Six-wheeled Rocker-bogie Lunar Rover on Loose Soil
12:10 – 12:30	D3-T1A-6	Hyper-chaotic Newton-downhill Method and its Application to Mechanism Forward Kinematics Analysis of Parallel Robot
End of Session		

Session D3-T2A

Robot Experimentation

Session Chair:
Dr. Yong-an Huang
Huazhong University of Science & Technology, China
yahuang@hust.edu.cn

Time	ID	Paper Title
10:30 – 10:50	D3-T2A-1	Experimental Study on Alpine Skiing Turn Using Passive Skiing Robot
10:50 – 11:10	D3-T2A-2	Study on Mine Rescue Robot System
11:10 – 11:30	D3-T2A-3	A Hybrid FES Rehabilitation System based on CPG and BCI Technology
11:30 – 11:50	D3-T2A-4	A Study On the key technology of AUV's self-rescue beaconing system
11:50 – 12:10	D3-T2A-5	(shifted to T1-D1C-3 on 16 December 2009)
12:10 – 12:30	D3-T2A-6	A Study on Wafer-handling Robot with Coaxial Twin-shaft magnetic fluid seals
End of Session		

Session D3-T3A

Robot Mechanism and Design

Session Chair:
Prof. Dr. Caihua Xiong
Huazhong University of Science and Technology
chxiong@mail.hust.edu.cn

Time	ID	Paper Title
10:30 – 10:50	D3-T3A-1	The Research of Mechanism Synthesis Based on Mechanical System Chaos Anti-control Methods
10:50 – 11:10	D3-T3A-2	Design and Application of High-Sensitivity Hexapod Robot
11:10 – 11:30	D3-T3A-3	On the design of exoskeleton rehabilitation robot with ergonomic shoulder actuation mechanism
11:30 – 11:50	D3-T3A-4	Novel Five Wheeled Rover for All Terrain Navigation
11:50 – 12:10	D3-T3A-5	The Mechanism, Kinematics and Experiment Research on 220kv Double-Circuit Transmission Line Inspection Robot
12:10 – 12:30	D3-T3A-6	The design of the GPS-based surveying robot automatic monitoring system for underground mining safety
End of Session		

Session D3-T1B

Computational Intelligence by Robots

Session Chair:
Prof. Dr. Jean-Daniel Dessimoz
Western Switzerland University of Applied Sciences
Jean-Daniel.Dessimoz@heig-vd.ch

Time	ID	Paper Title
14:00 – 14:20	D3-T1B-1	Planner9, a HTN planner distributed on groups of miniature mobile robots
14:20 – 14:40	D3-T1B-2	A New Strategy of the Robot Assembly Motion Planning
14:40 – 15:00	D3-T1B-3	An adaptive Rolling Path Planning Method for Planet Rover in Uncertain Environment
15:00 – 15:20	D3-T1B-4	Planning and Control of Biped Walking along Curved Paths on Unknown and Uneven terrains
15:20 – 15:40	D3-T1B-5	The Study on Optimal Gait for Five-Legged Robot with Reinforcement Learning
End of Session		

Session D3-T2B

Visual Perception by Robots

Session Chair:
Prof. Dr. Ryad CHELLALI
Senior Scientist,
Istituto Italiano di Tecnologia, Italy
ryad.chellali@iit.it

Time	ID	Paper Title
14:00 – 14:20	D3-T2B-1	Robust Calibration of a Color Structured Light System Using Color Correction
14:20 – 14:40	D3-T2B-2	Close Range Inspection using Novelty Detection Results
14:40 – 15:00	D3-T2B-3	Prediction Surface Texture in Flank Milling
15:00 – 15:20	D3-T2B-4	Combination of annealing particle filter and belief propagation for 3D upper body tracking
15:20 – 15:40	D3-T2B-5	Automatic Soldering System Based on Computer Vision
End of Session		

Session D3-T3B

Robot Motion Control

Session Chair:
Prof. Dr. Grigory Panovko
Chief of vibromechanics Department of Blagonravov Mechanical,
Engineering Research Institute of Russian
gpanovko@yandex.ru

Time	ID	Paper Title
14:00 – 14:20	D3-T3B-1	Keeping a Stable Position of Walking Robot with Vibration
14:20 – 14:40	D3-T3B-2	An algebraic approach for accurate motion control of humanoid robot joints
14:40 – 15:00	D3-T3B-3	Modeling and Impedance Control of a Chewing Robot with a 6RSS Parallel Mechanism
15:00 – 15:20	D3-T3B-4	Decentralized Control for Swarm Flocking in 3D Space
15:20 – 15:40	D3-T3B-5	Nonlinear analysis and application of servo control system based on relay feedback
End of Session		

Session D3-T2C

Robot Experimentation

Session Chair:
Dr. Zhencheng Hu
Associate Professor, Kumamoto Univ., Japan
hu@cs.kumamoto-u.ac.jp

Time	ID	Paper Title
16:00 – 16:20	D3-T2C-1	The Flexible Two-wheeled Self-balancing Robot Based on Hopfield
16:20 – 16:40	D3-T2C-2	(shifted to D1-T1C-1 on 16 December 2009)
16:40 – 17:00	D3-T2C-3	(shifted to D1-T1C-2 on 16 December 2009)
17:00 – 17:20	D3-T2C-4	Optimal design on cutterhead supporting structure of tunnel boring machine based on continuum topology optimization method
17:20 – 17:40	D3-T2C-5	Study on External Load Domain of Cutterhead
End of Session		

Session D3-T3C

Robot Motion Control

Session Chair:
Dr. Honghai Liu, University of Portsmouth, United Kingdom
honghai.liu@port.ac.uk

Time	ID	Paper Title
16:00 – 16:20	D3-T3C-1	Kalman estimator-based state-feedback high-precision positioning control for a micro-scale air-bearing stage
16:20 – 16:40	D3-T3C-2	Adaptive Sliding Mode Control of an Autonomous Underwater Vehicle
16:40 – 17:00	D3-T3C-3	Dynamic Control and Analysis of the Nonholonomic Mobile Modular Robot
17:00 – 17:20	D3-T3C-4	Inverted Pendulum System Control by Using Modified Iterative Learning Control
End of Session		

Abstracts and Author Index

Abstracts

Wednesday, December 16, 9:00-10:00

Wed. 9:00-10:00

Plenary Talk
Intelligent Vehicles for Intelligent Transport Systems: Current Status and Future Expectation
Chair: Zhencheng Hu, Kumamoto University

Wednesday, December 16, 10:30-12:30

Wed. 10:30-12:30 **Lavender 1**

Session D1-T1A
Ubiquitous and Collaborative Robots in Smart Space(1)
Chair: Honghai Liu, University of Portsmouth

D1-T1A-1 10:30-10:50
A Ubiquitous and Cooperative Service Framework for Network Robot System
Yabo Liu and Jianhua Yang

Network robot system (NRS) is a new concept that integrates physical autonomous robots, environmental sensors and human-robot interactions through network-based cooperation. The aim of this paper is to provide a ubiquitous and cooperative service framework for NRS. We first present foundational concepts of semantic map and service abstraction for the framework. Then, in order to generate feasible service configurations to fulfill tasks, we propose service configuration and reconfiguration algorithms, which dynamically search the appropriate service configurations for each task. Additionally, we put forward a service reasoning an enabling process to tackle service unavailable problems. The service configuration's cost evaluation function is also proposed to facilitate the choosing against different service configurations. In implementation, we have developed a prototype system comprised of two robots and other various devices. Experiments indicate that the versatile service framework provides self-adaptive capabilities and utilizes available resources efficiently under a range of different scenarios.

D1-T1A-2 10:50-11:10
The Hand-bot, a Robot Design for Simultaneous Climbing and Manipulation
Michael Bonani,Stephane Magnenat,Philippe Retornaz and Francesco Mondada

We present a novel approach to mobile object manipulation for service in indoor environments. Current research in service robotics focus on single robots able to move, manipulate objects, and transport them to various locations. Our approach differs by taking a collective robotics perspective: different types of small robots perform different tasks and exploit complementarity by collaborating together. We propose a robot design to solve one of these tasks: climbing vertical structures and manipulating objects. Our robot embeds two manipulators that can grasp both objects or structures. To help climbing, it uses a rope to compensate for the gravity force. This allows it to free one of its manipulators to interact with an object while the other grasps a part of a structure for stabilization. Our robot can launch and retrieve the rope autonomously, allowing multiple ascents. We show the design and the implementation of our robot and demonstrate the successful autonomous retrieval of a book from a shelf.

D1-T1A-3 11:10-11:30
Human multi-robots interaction with high Virtual Reality abstraction level
Khelifa Baizid, Zhao Li, Nicolas Mollet and Ryad Chellali

Tele-operating robots' team is a way to increase tasks type and complexity, the working space size and to improve the remote interactions robustness. These interesting potentialities have a counterpart in terms of human robots interface. Indeed, we increase the complexity of the system and users must handle heterogeneous entities with different intrinsic mobility and sensing capabilities: tele-operators make integration and prediction efforts, firstly to built the remote world status and secondly to generate the right commands to be sent to the robots.
In this paper, we present the platform we are developing to allow multi-robots tele-operation based tasks. The main aim of this platform is to support investigations about Human Multi-robots interfaces. Namely, to conduct studies concerning the integration of virtual and augmented reality technologies to reduce operators mental efforts. A description of this system is given. We present preliminary results in executing a simple scenario allowing to a single operator to supervise a given area.

D1-T1A-4 11:30-11:50
Laser based people following behaviour in an emergency enviroment
Jose Maria Martínez-Otzeta, Aitor Ibarguren, Ander Ansuategi and Loreto Susperregi

Rescue robots have a large application potential in rescue tasks, minimizing risks and improving the human action in this kind of situations. Given the characteristics of the environment in which a rescue robot has to work, sensors may suffer damage and severe malfunctioning. This paper presents a backup system able to follow a person when

camera readings are not available, but the laser sensor is still working correctly. A probabilistic model of a leg shape is implemented, along with a Kalman filter for robust tracking. This system can be useful when the robot has suffered some damage that requires it to be returned to the base for repairing.

D1-T1A-5 11:50-12:10
RENS – Enabling A Robot to Identify A Person
Xin Yan , Sabina Jeschke , Amit Dubey , Marc Wilke and Hinrich Schütze

We outline a web personal information mining system that enables robots or devices like mobile phones which possess a visual perception system to discover a person's identity and his personal information (such as phone number, email, address, etc.) by using NLP methods based on the result of the visual perception. At the core of the system lies a rule based personal information extraction algorithm that does not require any supervision or manual annotation, and can easily be applied to other domains such as travel or books. This first implementation was used as a proof of concept and experimental results showed that our annotation-free method is promising and compares favorably to supervised approaches.

D1-T1A-6 12:10-12:30
Classifying 3D Human Motions by Mixing Fuzzy Gaussian Inference With Genetic Programming
Mehdi Khoury and Honghai Liu

This paper combines the novel concept of Fuzzy Gaussian Inference(FGI) with Genetic Programming (GP) in order to accurately classify real natural 3d human Motion Capture data. FGI builds Fuzzy Membership Functions that map to hidden Probability Distributions underlying human motions, providing a suitable modelling paradigm for such noisy data. Genetic Programming (GP) is used to make a time dependent and context aware filter that improves the qualitative output of the classifier. Results show that FGI outperforms a GMM-based classifier when recognizing seven different boxing stances simultaneously, and that the addition of the GP based filter improves the accuracy of the FGI classifier significantly.

Wed. 10:30-12:30 **Lavender 2**

Session D1-T2A
Advanced Control on Autonomous Vehicles
Chair: Abdel Aitouche, LAGIS UMR CNRS 8146, France

D1-T2A-1 10:30-10:50
Mono landmark localization for an autonomous navigation of a cooperative mobile robot formation
Hugues Sert, Annemarie Kökösy , Jorge Palos and Wilfrid Perruquetti

In this paper the problem of the autonomous navigation of a cooperative robot formation is studied. Robots navigate in an unknown environment, encumbered by obstacles which have a circular shape or which can be modeled by polygons. Robots must move between an initial known position and a final known position. While going ahead robots discover the obstacles which block their passage and must avoid the collision and go to their final destination. This paper tackles two problems:

1) path planning, which is described as an optimal control problem under constraints (robot physical limits, collision avoidance).
2) localization, in order to plan its trajectory, the robot has to know its localization in the environment : a mono-landmark algorithm of localization in 2D is proposed. This mono-landmark algorithm tracks a landmark during the navigation and uses it to localize the robot in an algebraic framework.

In this paper the problem of path planning is described like an optimal control problem under constraints (robot physical limits, collision avoidance). To plan its trajectory, the robot has to know its localization in the environment. This paper proposes a mono-landmark algorithm of localization in 2D. This mono-landmark algorithm tracks a landmark during the navigation and uses it to localize the robot in an algebraic framework.

D1-T2A-2 10:50-11:10
Challenges of the multi-robot team in the GUARDIANS project
Lyuba Alboul, Joan Saez-Pons, Jacques Penders and Leo Nomdedeu

The GUARDIANS multi-robot team is being designed to be deployed in a large warehouse to assist firefighters in the event or danger of a fire. The large size of the environment together with development of dense smoke that drastically reduces visibility, represent major challenges in search and rescue operations. The GUARDIANS robots act alongside a firefighter and should provide, among others, the following tasks: to guide or accompany the firefighters on the site while indicating possible obstacles and locations of danger and maintaining communications links. In order to fulfill the aforementioned tasks the robots need to be able to exert certain behaviours. Among the basic behaviours are capabilities to unite in a group - generate a formation - and navigate on the site while keeping this formation. The basic control model used to generate these behaviours is based on the so-called social potential field framework, which we adapt to fulfill specific tasks of the GUARDIANS scenario. All of the tasks can be achieved without central control, and some of the tasks can be performed even without explicit communication among the robots. We discuss advantages and shortcomings of our model and present samples of implementation on ERA-MOBI robots, commonly referred to as Erratics.

D1-T2A-3 11:10-11:30
Modelling and Control of a Train of Autonomous Electric Vehicles

Kamel Bouibed, Abdel Aitouche and Mireille Bayart

While driving, the position and velocity of the vehicles in front of one greatly influence the way he/she drives the car. The purpose of this paper is to design a stable train of vehicles using longitudinal control, with a constant spacing between each vehicle. The method proposed here makes use of relative spacing and velocities between the vehicles to determine any changes (if any) that are required in the condition of the following vehicle to ensure a safe and comfortable journey. We will use a second order sliding mode control to maintain the platoon stable and the inter-vehicular spacing to the safe distance. Simulation results will be given to show the effectiveness of the method.

D1-T2A-4 11:30-11:50
Organization and Operation of Electronically Coupled Truck Platoons on German Motorways
Ralph Kunze, Richard Ramakers, Klaus Henning and Sabina Jeschke

One opportunity to manage the increase of freight transportation and to optimize utilization of motorway capacities is the concept of truck platoons. With the aid of Advanced Driver Assistance Systems, trucks are electronically coupled keeping very short gaps (approx. 10 meters) to form truck platoons on motorways. This contributes to optimisation of traffic flow and reduction of fuel consumption advantaged by slipstream driving. In this paper, a brief introduction into these truck platoons is given as well as a short overview about the elements of the automation-, information- and automotive-technology of the experimental trucks. The paper focuses on the Driver Information System which helps truck drivers to organize and operate these platoons. A generic software architecture for the Driver Information System of the platoon system is presented, which guarantees the development of a modern, flexible, extensible and easily configurable system, especially for Human Machine Interfaces of Advanced Driver Assistance Systems.

D1-T2A-5 11:50-12:10
Navigation method selector for an autonomous explorer rover with a Markov Decision Process
Simon Le Gloannec and Abdel-Illah Mouaddib

Many high level navigation methods exists for autonomous rovers. Usually, fixed methods is choosen for the rover to follow its trajectory. In some cases, a rover can have several embedded navigation methods, but there is currently no automatic approach to select the best method. In this paper, we propose an automatic navigation method selector using Markov Decision Process (MDP) framework. Navigation method are modelized in the MDP transitions functions. Results we achieved were promissing.

D1-T2A-6 12:10-12:30
SLAM Estimation in Dynamic Outdoor Environments: A Review
Zheyuan Lu, Zhencheng Hu and Keiichi Uchimura

This paper gives a review of the literature on Simultaneous Localization and Mapping (SLAM). SLAM has been intensively researched in recent years in the field of robotics and intelligent vehicles, many approaches have been proposed including occupancy grid mapping method (Bayesian, Dempster-Shafer and Fuzzy Logic), Localization estimation method (edge or point features based direct scan matching techniques, probabilistic likelihood, particle filter). In this paper, we classify SLAM approaches into three main categories: visual SLAM, Lidar SLAM and sensor fusion SLAM, while visual and lidar can also contain many types and levels, such as monocular camera, stereovision, laser scanner, radar and fusion of these sensors. A number of promising approaches and recent developments in this literature have been reviewed in this paper. To give a better understanding of performance difference, an implementation of Lidar SLAM is presented with comparative analysis result.

Wed. 10:30-12:30 **Grand Ballroom 3**

Session D1-T3A

Robot and Automation in Tunneling(973)(1)

Chair: Huayong Yang, Zhejiang University
Guoli Zhu, Huazhong University of Sci. & Tech.
Yongan Huang, Huazhong University of Sci. & Tech.

D1-T3A-1 10:30-10:50
On the Analysis of Force Transmission Performance for the Thrust Systems of Shield Tunneling Machines
Kongshu Deng, Xiaoqiang Tang, Liping Wang, Pingfa Feng and Xu Chen

Earth pressure balance is normally used in excavating tunneling due to high automation, quick construction, environmental friendliness, etc. Based on minimum mean square error, optimized mechanical models for non-group and group thrust systems of the earth pressure balance have been constructed. Through the offset load, the force transmission performances for the two thrust systems were studied, respectively. By applying force ellipse to the thrust system of a shield machine, the difference between the two configurations was analyzed. It provides an important theoretical foundation for the development and design of thrust systems.

D1-T3A-2 10:50-11:10
Passive Ultrasonic RFID Localization for Pipeline Pigs
Xubing Chen, Hanxin Chen and Youlun Xiong

For locating pipeline pigs, passive ultrasonic RFID tags are proposed to indicate pipeline segments in the paper. Ultrasonic transmitters and receivers are carried on the pig robot, and RFID tags are placed on the outside wall of long-distance pipelines. The built ultrasonic RFID localization model shows that ultrasonic transmitters and receivers work in their radiating near-field regions, while RFID tags work

in their reactive near-field regions. These tags can also be discovered by hand-held readers when the maintenance required. Therefore, both requirements of inner localization and outer localization are satisfied simultaneously. What is more, system structures and operation steps of pig launching and pig receiving are provided. In discussion, three RFID tags are placed around the outside wall of each pipeline segment to improve the identification rate and in case of any potential malfunction. The methodology also provides a feasible solution to determine orientations of pipeline pigs and potential defects.

D1-T3A-3 11:10-11:30
Allocation of Measurement Error of Shield's Pose
Minghua Pan, Bin Zhao and Guoli Zhu

To improve the measurement precision of the shield's pose, the factors which influence the measurement results are studied in this paper. Coordinate transformation formula is applied to calculate the shield's pose by transforming the relative coordinate of the shield's cutter head center in the laser target coordinate system to the world coordinate. The relative coordinate of the cutter head center is calibrated by transforming the formula inversely. The calibration error of the relative coordinate caused by the measurement error of the attitude angle is analyzed detailedly. The position measurement error of the cutter head center is deduced based on the principle of error transfer. Finally, the impact of each attitude angle's measurement error on the cutter head center is obtained by traversal algorithm in the variation range of attitude angle. According to the different influence degree, the measurement error of each attitude angle is proportionally allocated.

D1-T3A-4 11:30-11:50
The Compliance Design on Thrust System of Shields Excavating in Various Geologic Conditions
Zhongpo Liu, Genliang Chen, Haidong Yu and Xinmin Lai

The redundant actuating thrust system is usually employed to comply with the complex load on the excavating face. The control strategy of these hydraulic cylinders is critical to the load transmission. The forces transmission model of the redundant actuating thrust system of shield machines was established based on the screw theory. The force transmission behavior was studied when the shields excavate in the heterogeneous geologic structures containing the hard rock and soft soil. The correlation between the group strategy of the thrust hydraulic cylinder and the load behavior on the cutterhead was discussed. A flexible group strategy on the redundant actuating hydraulic cylinders was proposed in terms of the various loads. It may improve the compliance ability of the thrust system excavating in the heterogeneous geologic structures.

D1-T3A-5 11:50-12:10
Analysis for Dynamic Load Behavior of Shield Thrust System Considering Variable Boundary Constraints
Kaizhi Zhang, Haidong Yu, Zhongpo Liu and Xinmin Lai

In this paper, the load transmission model of the shield thrust system is established taking into account the variable boundary constraints between the shield skin and the surrounding strata, which is obtained based on the finite element methods. The results show that the resisting moment on the shield skin from the geologic layer has a nonlinear relationship with the bending moment loads on the cutterhead when the material behavior of the strata is modeled by an elasto-plastic Mohr-Coulomb model. The dynamic load behavior of the shield thrust system is significantly influenced by the variable shield-strata boundary constraints, which may cause incorrect load predictions of the hydraulic thrust system and consequent snake-like motions of the shield machine.

D1-T3A-6 12:10-12:30
Evaluation and Optimization Method of High Speed Cutting Parameters Based on Cutting Process Simulation
Zhijun Wu, Daochun Xu, Pingfa Feng, Dingwen Yu and Chenglong Zhang

The choice of reasonable cutting parameters is very important for the application of high speed cutting technology. Cutting parameters optimization is a contradiction optimization problem of multi-objectives including cutting efficiency, tool wear and machining quality etc. In order to simplify the complicated problem, a new dimensionless comprehensive evaluation method of cutting parameters based on cutting multi-dimension characteristics including cutting force, temperature, feed rate and cutting depth is put forward in the paper. Then multi-level weight decomposition method is applied to determine the evaluation factors. The relations between multi-objectives and cutting force and temperature are emphatically analyzed. In combination with cutting process physical FEA (finite element analysis) simulation, the effect laws of cutting parameters to cutting force and temperature is researched. Furthermore cutting parameters are evaluated and optimized through the established comprehensive evaluation method. As shown the results: The results obtained by comprehensive evaluation method are match with the results by plenty of cutting experiments. The comprehensive evaluation method is suitable for actual production application because of its simple, effective and extensive characteristics.

Wednesday, December 16, 13:30-14:00

Wed. 13:30-14:00

Plenary Talk

Automation and Key Technologies on Shield Tunneling Machine

Chair: Caihua Xiong, Huazhong University of Sci. & Tech.

Wednesday, December 16, 14:00-15:40

Wed. 14:00-15:40 **Lavender 1**

Session D1-T1B
Ubiquitous and Collaborative Robots in Smart Space(2)
Chair: Honghai Liu, University of Portsmouth
Zhouping Yin, Huazhong University of Sci. & Tech.

D1-T1B-1 14:00-14:20
Pointing Gestures for a Robot Mediated Communication Interface
John-John Cabibihan, Wing Chee So, Medi Nazar and Shuzhi Sam Ge

This paper asked whether the pointing gesture accompanying with speech would facilitate comprehension of spatial information in the videoconference communication. Ten adults participated in our study and communicated with the experimenter over Skype (Skype Technologies, Luxembourg). The experimenter described the spatial layout of items in a room to the participants in two conditions - dynamic and static. In the static condition, the notebook was not moving; in the dynamic condition, the notebook moved around with the arms pointing to abstract spatial locations that represented the locations of items in the room. The movement was done by putting the notebook on the three-wheeled Wi-Fi enabled device that was equipped with two artificial arms and was controlled by the experimenter over the Internet. At the end of each description, the participants were asked to lay out the items properly. Reaction times and accuracy rate were recorded. The findings showed that the accuracy rate was higher in the dynamic condition than in the static condition. In addition, the response time was faster in the dynamic condition than in the static condition. It turned out that pointing gestures facilitated the speech comprehension of spatial information.

D1-T1B-2 14:20-14:40
Symbricator3D - A Distributed Simulation Environment for Modular Robots
Lutz Winkler Heinz Wörn

A distributed simulation environment is introduced in this paper that allows to simulate robot swarms as well as modular robots. This simulator is in use within the European projects 'SYMBRION' and 'REPLICATOR'. The project's main goal is to build robots that can aggregate to multi-robot organisms. These robots will be able to act individually, as a swarm or within an organism. The simulator needs to be able to simulate all of these behaviors. As the number of robots can be large, both in the swarm as well as in the organism, the simulator needs to be distributed on several computers. As the demand varies between the different behaviors –swarm and organism behavior– the behavior of the simulator needs to vary as well, e.g. for a swarm, a dynamic simulation is not necessary, whereas for an organism, a fast dynamic simulation is obligatory. We are therefore developing the Symbricator3D simulation environment, that will fulfill all the described requirements.

D1-T1B-3 14:40-15:00
View-invariant Human Action Recognition Using Exemplar-based Hidden Markov Models
Xiaofei Ji and Honghai Liu

An exemplar-based Hidden Markov Model is proposed for human action recognition from any arbitrary viewpoint image sequence. In this framework, human action is modelled as a sequence of body poses (i.e., exemplars) which are represented by a collection of silhouette images. The human actions are recognized by matching the observation image sequence to predefined exemplars, in which the temporal constraints were imposed in the exemplar-based Hidden Markov Model. The proposed method is evaluated in a public dataset and the result shows that it not only reduces computational complexity, but it also is able to accurately recognize human actions using single cameras.

D1-T1B-4 15:00-15:20
A Local Interaction Based Multi-robot Hunting Approach with Sensing and Modest Communication
Wenwen Zhang, Jing Wang, Zhiqiang Cao, Yuan Yuan and Chao Zhou

A local interaction based hunting approach for multi-robot system in unstructured environments is proposed in this paper. The hunting task is modeled as three modes: initial leader-fixed following&search mode, leader-changeable following&search mode and hunting mode. The conditions for modes switching are given. In order to reduce the dependence on communication, an event-trigger communication scheme based on the evader's observation state is designed. For individual robot, it integrates local information from vision system, sonar sensors and encoders in its local coordinate frame as well as modest communication data to acquire situation-suited task mode, and then makes decisions based on behaviors with appropriate local coordination rules. The experiments with physical mobile robots verify the effectiveness of the proposed approach.

D1-T1B-5 15:20-15:40
Robot Formations for Area Coverage
Jürgen Leitner

Two algorithms for area coverage (for use in space applications) were evaluated using a simulator and then tested on a multi-robot society consisting of LEGO Mindstorms robots. The two algorithms are (i) a vector force based implementation and (ii) a machine learning approach. The second is based on an organizational-learning oriented classifier system (OCS) introduced by Takadama in 1998.

Wed. 14:00-15:40 **Lavender 2**

Session D1-T2B
Visual Perception by Robots(1)
Chair: Luca Brayda, Istituto Italiano di Tecnologia

D1-T2B-1 14:00-14:20
Quantitative and qualitative evaluation of vision-based teleoperation of a mobile robot
Luca Brayda, Jesús Ortiz, Nicolas Mollet, Ryad Chellali and Jean-Guy Fontaine

This paper analyzes how performance of a basic teleoperation task are influenced by the viewpoint of the video feedback, using a remote mobile robot. Specifically, the viewpoint is varied in terms of height and tilt and the influence on a basic task, such as following some pre-defined paths, is analyzed. The operators are able to control one motor degree of freedom and up to two perceptive degrees of freedom. It is shown that performance vary depending both on the viewpoint and on the amount of perceptive freedom; in particular, the chosen metrics give better results when more perspective and, surprisingly, a more constrained perception is deployed. Furthermore, the contrast between the actual performance and the performance perceived by the operators is shown, which allows to discuss about the need of quantitative approaches in measuring the efficiency of a teleoperation task.

D1-T2B-2 14:20-14:40
Stereo Vision Based Floor Plane Extraction and Camera Pose Estimation
Lei Chen, Zhongli Wang and Yunde Jia

In this paper, we present a unified approach for floor plane extraction and camera pose estimation. A histogram based method is performed on the reconstructed 3-D points obtained by an onboard video-rate stereo vision system to extract candidate points of the floor plane and determine the pose of vision system simultaneously. The obstacle area is easily localized given the floor plane region. In order to improve reliability and accuracy of camera pose estimation results, the Least Median of Squares (LMedS) based fitting method is applied to estimate the floor plane parameters with the extracted candidate points. The precise pose of the onboard stereo vision system is directly acquired related to the floor plane parameters. Experimental results in real indoor environments are discussed and show the good performance.

D1-T2B-3 14:40-15:00
What Visual Cues Do We Use to Perceive Depth in Virtual Environments?
Abdeldjallil Naceri, Ryad Chellali, Simone Toma and Fabien Dionnet

The main objective of this work is to investigate human depth perception in virtual reality (VR). Specifically, we attempt to give a first step that towards finding the relationship between size-distance in depth perception in virtual environment. Depth perception has been shown to be key element and a major factor either for simple navigation tasks or for complex and dexterous manipulation tasks. However, in the history of psychology of perception few matters have been of more continuous interest than the issue of the relationship between perceived size and perceived distance. Most studies focused on such questions have converged upon a hypothesis named Size-Distance Invariance. This hypothesis is often stated in the following terms: “A retinal projection or visual angle of given size determines a unique ratio of apparent size to apparent distance” . The relationship between distance and size perception remains unclear in a virtual environment. The effectiveness of virtual environments has often been linked to the sense of presence that users feel in the virtual world. Moreover, Depth perception is one major factor among many believed to underlie presence for teleoperation and virtual environments. Our findings suggest that the strategy based on imagination of motor tasks could have a major effect on users’ accurate depth perception in virtual reality.

D1-T2B-4 15:00-15:20
An Embedded Vision System for a Power Transmission Line Inspection Robot
Weiyang Lei, En Li, Guodong Yang,Changchun Fan, Fengshui Jing and Zize Liang

Surrounding environment information is significant for an inspection robot to plan its behavior to stride over obstacles. This paper describes a compact embedded monocular vision system for a power transmission line inspection robot. This system involving a DSP processor has superior hardware design and excellent performance on image processing. Emphasis of the image processing software design is the algorithm of image segmentation and straight line extraction. Base on the structure of the transmission lines, an algorithm for obstacle distance estimation is proposed. Experimental results show that good capability on recognition and location can be achieved with this proposed vision system.

D1-T2B-5 15:20-15:40
Binocular based Moving Target Tracking for Mobile Robot
Yingkui Du, Baojie Fan, Jianda Han and Yandong Tang

Moving target tracking is an important application of computer vision. A binocular based method is presented for mobile robot to track target reliably under the effect of occlusion, transform and rotation in unstructured environment. Point features are extracted for representing the target and environment background under middle distortion, and then are matched and tracked through consecutive stereo frames by our improved MNCC algorithm. The point features are reconstructed and utilized to estimate the relative motion by Least-Square algorithm. Because the relative motion between the point features of target and robot is inconsistent to that of environment background and robot, the point features of environment background and the errors in feature tracking are removed by RANSAC algorithm. Experiment results validate the efficiency of our method.

Wed. 14:00-15:40 **Grand Ballroom 3**

Session D1-T3B

Robot and Automation in Tunneling(973)(2)

Chair: Huayong Yang, Zhejiang University
Guoli Zhu, Huazhong University of Sci. & Tech.
Yongan Huang, Huazhong University of Sci. & Tech.

D1-T3B-1 14:00-14:20

The Reconfiguration Design of Redundant Thrust of Shields Excavating in Various Geologic Conditions

Haidong Yu, Zhongpo Liu, Kaizhi Zhang and Xinmin Lai

The loads on the cutterhead will vary with the mechanical properties and the compositions of geologic structures on the excavation face. It is necessary that the reconfiguration design of the redundant thrust system for various geologic formations is conducted to improve the load compliance ability effectively, which is beneficial to decrease the excessive wear and the other accidents. In this paper, a 4-bar parallel manipulator is established in terms of the control characteristic of the redundant thrust system of the shield machines. The location parameters of legs on the platform and the base are used as the variables to obtain the force transmission matrix between the limbs and the platform. The force transmission behavior is studied when the shields excavate in the alignment direction. Based on the cutting principle, the total bending moment model exerted on the cutterhead is proposed. The behavior of bending moments during excavating in the various geologic formations is studied. The correlation between the bending moments and the configuration is discussed. The results show that the configurations of the thrust manipulator may be selected in terms of the geologic structures. It is useful for the compliance design of the thrust system of shields.

D1-T3B-2 14:20-14:40

Research of an electric laser system based on the non-diffracting beam

Hui Chen and Bin Zhao

A novel electronic laser system is proposed. Based on the principle of the non-diffracting beam, a new method for measuring attitude angle has been developed in this paper, in combination with image processing technology. The system constitution and the measuring principle of the electronic laser system are introduced. As the non-diffracting beam is composed of Bessel fringe ring, the anti-interference ability and the measurement sensitivity is greatly improved by center location of the non-diffracting beam in digital image processing technology, compared with barycenter method. The electronic laser system is applicable to attitude angle measurement of the tunnel boring machine in tunnel construction and other similar occasions.

D1-T3B-3 14:40-15:00

Research on Multi-Motor Synchronization Control for Cutter Head of Shield Machine Based on the Ring Coupled Control Strategy

Jianzhong Sun, Ran Liu, Yaqin Luo and Wei Sun

Multi-motor synchronization control for cutter head of shield machine is studied in this paper. Firstly, a ring coupled control strategy for multi-motor synchronization control based on the idea of parallel control with compensation is proposed, and sliding mode variable structure control algorithm is used in the design of the controllers to ensure high robustness of the control system. Furthermore, synchronization control of a four-motor driving system with the proposed control strategy is simulated with MATLAB, and its effectiveness is verified by comparing its control performance with that of the traditional master-slave strategy. Finally, the ring coupled control strategy is applied to the cutter head driving of a prototype shield machine. The simulation results show that the proposed ring coupled control strategy has good dynamic performance and synchronization performance.

D1-T3B-4 15:00-15:20

Position and Attitude Precision Analysis of Segment Erector of Shield Tunneling Machine

Hu Shi, Guofang Gong, Huayong Yang and Rulin Zhou

Focusing on a segment erector of a shield tunneling machine developed with 6 degrees of freedom and controlled by electro-hydraulic proportional systems, kinematics for the segment erection process is presented. The perturbation method in error analysis is introduced to establish the position and attitude error model, considering a number of factors such as hydraulic drive and control accuracy, tolerance in manufacturing and assembly. Dynamic simulations are carried out to obtain the controlling precision of the electro-hydraulic drive systems. Formulas for calculating the position and attitude error of the grip hand of the segment erector are derived. The calculation results verify the practicality and effectiveness of error analysis, providing a foundation for practical designing, manufacturing and assembling of the segment erecting mechanism.

D1-T3B-5 15:20-15:40

An Improved Model of Loads Acting on Shield

Xiangtao Hu Zhouping Yin and Yongan Huang

Shield tunneling technologies have been developed for constructing tunnels in soft ground especially with groundwater. However, the automatic deviation correction systems are based on empirical relationships or theoretical model including a great deal of unknown parameters. In this paper, the shield-segment system is considered as underground parallel manipulators, so the shield behavior can be represented by the rotation of motion platform around the static platform. Consequently, load model acting on the shield is developed based on the proposed relationship between the shield behavior and the ground displacement. The examples of straight alignment and curve alignment were studied, comparing the results with the others model,

and the results validate the load model studied here.

Wednesday, December 16, 16:00-17:20

Wed. 16:00-17:20 **Lavender 2**

Session D1-T2C
Intelligent Vehicles: Perception for Safe Navigation
Chair: Zhencheng Hu, Kumamoto University

D1-T2C-1 16:00-16:20
An Improved Road Network Modeling and Map Matching for Precise Vehicle Localization
Chenhao Wang, Zhencheng Hu, Naoko Hamada and Keiichi Uchimura

This paper presents a precise and robust road model for Map Matching (MM). Map matching approach is generally used to move vehicle localization output to the nearest road segment in order to improve the accuracy of vehicle lateral localization. Most of the MM approaches adopted piece-wise line segment road network model, which will generate large bias at curve segment or turning point on the intersection. In this paper, a two-dimensional parabola road network model is employed in order to correctly represent vehicle's real state (position and orientation). Furthermore, an advanced longitudinal MM approach is also proposed here by comparing current road geometry model with visual lane detection results to improve longitudinal accuracy. Simulation and real road tests verified the proposed approaches.

D1-T2C-2 16:20-16:40
A Vision System of Hazard Cameras for Lunar Rover BH2
Guicai Wang, Hehua Ju and Hongpeng Feng

According to analyze vision system of hazard cameras for lunar rover BH2 and characteristics of working environment, firstly, intrinsic and extrinsic parameters of camera are accurate calibrated and image distortion is corrected in this paper; Secondly, images are processed according to Bayer filter, image rectification, LoG filter, pyramid delaminating, photometric consistency dense matching; Finally, the paper can obtain high precision and dense disparity map. Furthermore, the paper uses three sets of experiment results on obstacle avoidance cameras vision system of lunar rover BH2 to validate the scheme. the experimental results show that the system possesses the features with less calculation amount, high reliability, robustness of illumination change and environmental noise, which can quickly and reliably achieve dense disparity map and meet the real-time avoid obstacle requirement of BH2.

D1-T2C-3 16:40-17:00
Stereovision-based Algorithm for Obstacle Avoidance
Lazaros Nalpantidis, Ioannis Kostavelis and Antonios Gasteratos

This work presents a vision-based obstacle avoidance algorithm for autonomous mobile robots. It provides an efficient solution that uses a minimum of sensors and avoids, as much as possible, computationally complex processes. The only sensor required is a stereo camera. The proposed algorithm consists of two building blocks. The first one is a stereo algorithm, able to provide reliable depth maps of the scenery in frame rates suitable for a robot to move autonomously. The second building block is a decision making algorithm that analyzes the depth maps and deduces the most appropriate direction for the robot to avoid any existing obstacles. The proposed methodology has been tested on sequences of self-captured outdoor images and its results have been evaluated. The performance of the algorithm is presented and discussed.

D1-T2C-4 17:00-17:20
Improved Techniques for the Rao-Blackwellized Particle Filters SLAM
Huan Wang, Hongyun Liu, Hehua Ju and Xiuzhi Li

Rao-Blackwellized particle filters simultaneous localization and mapping can yield effective results but it has the tendency to become inconsistent. To ensure consistency, a methodology of an unscented Kalman filter and Markov Chain Monte Carlo resampling are incorporated. More accurate nonlinear mean and variance of the proposal distribution are obtained without the linearization procedure in extended Kalman filter. Furthermore, the particle impoverishment induced by resampling is averted after the resample move step. Thus particles are less susceptible to degeneracies. The algorithms are evaluated on accuracy and consistency using computer simulation. Experimental results illustrate the advantages of our methods over previous approaches.

Wed. 16:00-17:20 **Grand Ballroom 3**

Session D1-T3C
Robot and Automation in Tunneling(973)(3)
Chair: Huayong Yang, Zhejiang University
Guoli Zhu, Huazhong University of Sci. & Tech.
Yongan Huang, Huazhong University of Sci. & Tech.

D1-T3C-1 16:00-16:20
Establishment of TBM Disc Cutter Dynamic Model for Vertical Vibration
Kui ZHANG, Yimin XIA, Qing TAN, Kai WANG and Nian-en YI

On the basis of reasonably simplifying the interaction process of TBM disc cutters and rock on tunneling surface, the shape of effective breaking pit is used as the lower boundary condition of vibration system and based on the equivalent stiffness method, two general differential equations of TBM disc cutter for vertical vibration are established, which are respectively suitable for hard rock, soft rock and soil. Taking an experimental disc cutter rolling granite as the example, through dynamic simulation, results show that

vibration acceleration increases linearly with increased depth of the effective breaking pit and linear velocity of disc cutter and Nonlinearly decrease with increased width of the effective breaking pit; Besides satisfying the strength requirement, the selection of bearings and the design of cutter shaft should give dual attention to dynamics performance.

D1-T3C-2 16:20-16:40
Soft Rock Cutting Mechanics Model of TBM Cutter and Experimental Research
Jing Xue, Yimin Xia, Zhiyong Ji and Xiwen Zhou

On the basis of brittle tensile fracture theory, assuming the destruction of rock was due to tensile failure, a cutting-tool loading calculation model was established, considering the compact core impact in front of cutting-tool, then the mechanism of cutter-rock, as well as the process of brittle fracture of rock were analyzed and the expressions of horizontal cutting force and vertical propulsive force for the shield cutter were obtained. At the same time, three kinds of cutters with different rake angle were designed, and the cutting experiments on a linear cutting performance testing station were carried out. By comparing, the results of experiments were basically in accordance with those of mechanical model, error rate of horizontal cutting force was below 7% and that of vertical propulsive force was in the scope of 9%. At last, the experiments proved that the force of cutter would increase along with the increasing depth, or decreasing rake angle.

D1-T3C-3 16:40-17:00
Neural Network Strata Identification Based on Tunneling Parameters of Shield Machine
Xiwen Zhou, Yimin Xia and Jing Xue

A database of tunneling parameters and strata was established considering the shield tunneling practice of Guangzhou Rail Transit. Based on the data, a method of strata identification was studied by using neural network pattern recognition technology. Based on the analysis of the features of strata in shield tunneling and the data, a one-to-many mapping relation between strata and data was proposed, as well, the strata identification not only to contrast between the parameters, but also to contrast between the combined effects of each parameter mapping was pointed out. On the basis of what was mentioned above, a three-layer BP neural network model was built. What is more, some typical tunneling process parameters were input as training data, and the test results had a good agreement with practical situation. The test result could be used as strata identification. This method will enhance the scientificalness of shield tunneling control, and the timeliness and speediness of it are helpful to automatic driving for shield machine.

D1-T3C-4 17:00-17:20
Analysis of Chamber Pressure for Earth Pressure Balance Shield Machine by Discrete Numerical Model
Fuzheng Qu, Li Wu and Wei Sun

Taking the shield machine tunneling in a railway section as the research object, the discrete element numerical model for analyzing the chamber pressure is established. Comparing the numerical simulation results of the observed pressure on the chamber board with the field construction data, the validity and the feasibility of the simulation method is testified. Then the pressure distribution rules on the chamber board in different opening ratios of the cutting wheel and tunnel axis depth are studied, and the mathematical model of the pressure distribution is proposed. The mapping relation between the excavation face pressure and the chamber board pressure is advanced. The results provide basis for the design and control of the earth pressure balance shield machine.

Wednesday, December 16, 18:00-21:00

Wed. 18:00-21:00

Welcome Reception

Thursday, December 17, 9:00-10:00

Thur. 9:00-10:00

Plenary Talk
Computer Vision and Auditory Perception
Chair: Ming Xie, Nanyang Technological University

Thursday, December 17, 10:30-12:30

Thur. 10:30-12:30 **Lavender 1**

Session D2-T1A
Robot Motion Analysis(1)
Chair: Limin Zhu, Shanghai Jiaotong University

D2-T1A-1 10:30-10:50
A Method of Stiffness Analysis of Parallel Mechanisms
Boqiang Xu, Tiemin Li and Jun Wu

This paper presents a method, called Parameter-Separation Method, for stiffness analysis of parallel mechanisms. By treating the effect of different parameters (i.e. external force and torque, translational and rotational displacement) separately, the method produces 4 criteria of stiffness analysis. A further method based on the first method is proposed when we conduct stiffness analysis on some parallel mechanisms whose inputs are of the same unit. It applies a special way to formulate dimensionally homogeneous Jacobian matrix with consideration of the input need, and comes up with 2 criteria to judge the stiffness of parallel mechanisms. These two methods are explained in detail, and their effects and relationship are demonstrated by stiffness analysis of a 4RRR redundantly actuated parallel mechanism.

D2-T1A-2 10:50-11:10
Numerical Methods for Frictional Contact of Multi-rigid-body with Redundant Constraints
Haitao Gao, Zhisheng Zhang, Jun Liu, Guang Lu and Jinfei Shi,

To tackle the frictional contact problem of multi-rigid-body with redundant constraints, efficient numerical resolution methods and stabilization algorithm are proposed. Firstly, based on time-stepping method and linear programming theories, a mixed nonlinear complementary model describing frictional contact problem is built. In order to solve the model effectively, the least square method for solving redundant constraints and linearization method are used to change the mixed nonlinear complementary problem into a linear complementary problem that can be easily solved. And then, a direct stabilization algorithm is given to stabilize resolution process of contact forces in advance, which effectively eliminates the drift problem for both equality and inequality constraints. At last, the validity of the numerical resolution methods and stabilization algorithm are verified through a numerical example.

D2-T1A-3 11:10-11:30
Inverse dynamic modeling of two unsymmetrical 3UPU parallel manipulators
Bo Hu, Yi Lu and Haixia Mao

The inverse dynamic of two 3UPU parallel manipulators (PM) are analyzed in this paper. The first 3UPU PM has three translational degree of freedom (DOF) and the second 3UPU PM has two translational and one rotational DOF. First, the mobility of the two UPU PMs is analyzed. Second, the constrained forces/torques in UPU-type legs are determined, and the 66 Jacobian matrices of the two 3UPU PMs are derived by considering the constrained forces/torques. Third, based on the principle of virtual work, the dynamic is solved with the active forces and the constrained forces/torques derived. Finally, an analytic solved example for the 3UPU PM is given.

D2-T1A-4 11:30-11:50
Kinematic Analysis of the SPKM165, a 5-axis Serial-Parallel Kinematic Milling Machine
Fugui Xie, Xinjun Liu, Jinsong Wang and Liping Wang

This paper analyzes the kinematics of a 5-axis serial-parallel kinematic milling machine, i.e., the SPKM 165, which consists of a three-DOF (degree of freedom) parallel module and a two-DOF serial table. In order to achieve 5-axis control, the inverse kinematic equations are derived and corresponding coordinate system is established. The relationship between the NC-code and the operating attitude of the machine is shown and the numerical results are presented.

D2-T1A-5 11:50-12:10
Dynamic Simulation of Passive Walker Based on Virtual Gravity Theory
Heng Cao, Yu Wang, Jun Zhu and Zhengyang Ling

Passive dynamic walking is a high efficiency way for bipedal robots to reduce energy cost. To study the nature of passive dynamic walking, we propose a new dynamic simulation method and build a virtual passive walker prototype based on virtual gravity theory using ADAMS. The results of the simulation are believable by comparing with the former research results, and the influences on gait stability of three critical physical parameters are obtained by using the parameterization analysis tools. These simulation results show that the suitable initial parameter is a critical factor for a simplest passive walker's stability on slope ground and the dynamic simulation is an available way to study the bipedal robot's walking.

D2-T1A-6 12:10-12:30
Kinematics Model of Bionic Wheel-legged Lunar Rover and its Simulation Analysis
Yongming Wang, Xiaoliu Yu and Wencheng Tang

Based on the principle of double-half-revolution mechanism, a new-style bionic wheel-legged lunar rover was designed in this paper. Its mobile mechanism is comprised of four identical wheel-legged mechanisms, rover body bracket and steering brackets, etc. On the basis of establishing the coordinate transformation models of the bionic wheel-legged mechanisms, kinematics of its mobile mechanism was analyzed, and the forward kinematics models of the striking rods were established. Based on kinematics simulation in COSMOS Motion software, this paper obtained the trail curves of joints relative to the reference coordinate system. Simulation shows that the fluctuation of the bionic wheel-legged lunar rover is small and it can realize the striding movement smoothly.

Thur. 10:30-12:30 **Lavender 2**

Session D2-T2A

Novel Techniques for Collaborative Driver Support

Chair: Makoto Itoh, Tsukuba University

D2-T2A-1 10:30-10:50
A Deceleration Assistance Control for Collision Avoidance based on Driver's Perceptual Risk
Takahiro Wada, Shoji Hiraoka and Shun'ichi Doi

It is important to judge necessity of deceleration assistance as earlier as possible and initiate the assistance naturally in order to reduce rear-end crashes. On the other hand, we have derived a mathematical model of driver's perceptual risk of proximity in car following situation and successfully derived driver deceleration model to describe deceleration patterns and brake initiation timing of expert driver. In this research, an deceleration assistance control for collision avoidance will be proposed based on the formulated braking behavior models of expert drivers to realize smooth, secure

brake assistance. It will be shown that the proposed control method can generate smooth profile for various conditions. In addition, experimental results using a driving simulator will show validity of the proposed system based on subjective evaluation.

D2-T2A-2 10:50-11:10
Toward Preventive ACC Systems against Crashes due to Another Vehicle's Cut-in
Makoto Itoh

This paper discusses design of a driver support system for managing risks of crashes due to another vehicle's cut-in. In study 1, we investigate to what extent changing of the target can be automated when a vehicle is cutting in. Experimental results suggest that the autonomous target change may be acceptable for drivers. In study 2, we discuss about reducing driver annoyance with information given from the system if "providing information only" design is employed. The idea is that such information is inhibited when a driver is aware of the situation. A prototype method to detect driver's "preparedness" to hit the brake is shown.

D2-T2A-3 11:10-11:30
How Do Cognitive Distraction Affect Driver Intent of Changing Lanes?
Huiping Zhou, Makoto Itoh and Toshiyuki Inagaki

This paper revealed effects of cognitive distraction on driver intent of changing lanes. We conducted an experiment to collect data of driver's eye-movement on checking traffic conditions and driving behavior in lane changes in two conditions: driving only and performing a secondary task during driving. The result indicated that there were two types of changes in terms of the intent: (1) driver intent emerges lately and (2) the intent emerges without enough checking on traffic conditions. The investigation also showed that a driver made a decision of changing lanes in a relatively short time period due to driver distraction, which might increase risk in driving. Those findings implied necessity for an intent detection method adaptive to driver psychological state.

D2-T2A-4 11:30-11:50
Effects of missed alarms on driver's response to a collision warning system according to alarm timings
Genya Abe, Makoto Itoh and Tomohiro Yamamura

By using a driving simulator, two kinds of alarm timing were compared to investigate how drivers respond to missed alarms regarding different alarm timings: (1) an alarm was given based on ordinary braking behaviour for the individual; alarm timing T, (2) an alarm was given by using an particular alarm trigger logic (Stopping Distance Algorithm) as a common timing for all drivers; alarm timing S. Alarm timing S was earlier than alarm timing T in this study. The results showed that compared to alarm timing T, alarm timing S induced earlier braking behaviour independent of degree to which an imminent collision was critical. However, effects of a missed alarm on braking behaviour may be mitigated by alarm timing T, compared to alarm timing S. Moreover, it is possible that effect of missed alarm on driver's trust may vary according to alarm timings and the number of experience of missed alarms.

D2-T2A-5 11:50-12:10
Emergent Behavior Control Patterns in Robotic Collectives
Razvan-Dorel Cioarga, Mihai V. Micea, Vladimir Cretu and Daniel Racoceanu

This paper focuses on the implementation and evaluation of a set of integrated models for the representation of emergent behavior control patterns in robotic environments. The models have been validated on a custom developed emergent behavior simulator and tested using the CORE-TX (COllaborative Robotic Environment - the Timisoara eXperiment) prototype platform. Four metrics (pheromone intensity, path affinity, reachability and liveness) are introduced and used to evaluate the performance of the proposed control patterns. Experimental results for an environment which employs ant colony behavior patterns in obstacle avoidance applications show that the emergent behavior of the robotic collective is triggered by a number ranging from 9 to 11 entities. The results are also consistent with the theoretical model-based predictions. When doubling the number of entities, the performance of the system can be further increased by 19.3%. On the other hand, a high concentration of entities has been noted to affect the emergent behavior of the system and, thus, its performance, mainly due to the interaction overhead. An upper bound to the number of individuals has been computed, based on a set of parameters which model each particular application. The experimental validation of the proposed behavior control patterns endorses them as a good framework for the analysis and development of complex applications which require collaborative and distributed intelligence, perception and operation.

D2-T2A-6 12:10-12:30
A Simulation Model to Evaluate and Verify Functions of Autonomous Vehicle based on Simulink
Jie Zhou, Hui Chen and Caijing Xiu

The paper presents a simulation model of autonomous vehicle based on Matlab/Simulink?, which is simple and efficient. Concerning about the relationship among autonomous vehicle, road, and obstacle, it forms a 'Vehicle-Sensor-Controller' closed-loop control system. The model provides a platform to design and validate the control logic of Local Path Planning, and to design post-process of the raw data from sensors. The paper also presents the simulation results of a PID steering controller for lane following, Artificial Potential Field (APF) method for collision avoidance, and the dynamic planning for overtaking when the obstacle is moving. The simulation model is verified to be effective by a lane change experiment.

Thur. 10:30-12:30 **Grand Ballroom 3**

Session D2-T3A

Robot Mechanism and Design(1)
Chair: Taro Nakamura, Chuo University

D2-T3A-1 10:30-10:50
Spike: A Six Legged Cube Style Robot
Christopher Coyte, Mark Beckerleg and John Collins

This paper describes a six legged cube based robot named 'Spike', which uses three axes of symmetry with a collinear pair of legs mounted on each axis. Spike is designed to implement a novel form of locomotion which uses a tilting and falling motion as a result of leg movements to form its gait. Due to the triangular symmetry inherent in the robot's footprint, each step the robot takes is limited to one of three directions. At rest, the robot has three points of contact with the ground and all sides share equal length to form a tripedal stance. The gait is generated by directing a single leg toward the bisector of the opposing side, causing the robot to tumble, and fall into a new leg configuration. It was found that the robot was able to move along an angle of trajectory, where the accuracy of following the trajectory over time was dependant on the number of steps made.

D2-T3A-2 10:50-11:10
From morphologies of six-, four- and two-legged animals to the HexaQuaBip robot's reconfigurable kinematics
Alexandre Veinguertener, Thierry Hoinville,Olivier Bruneau and Jean-Guy Fontaine

How can we go beyond the locomotor versatility of current legged robots? We propose an approach, called HexaQuaBip, based on merging the most prevalent legged animal morphologies in a bioinspired polymorphic yet non-modular robot, intended to be able to reconfigure in either hexapodal, quadrupedal or bipedal modes. This paper focuses on reviewing main types of 6-, 4- and 2-legged animal kinematics and results in integrating all of them into a reconfigurable kinematic structure.

D2-T3A-3 11:10-11:30
A Dexterous and Self-adaptive Humanoid Robot Hand: Gesture-changeable Under-actuated Hand
Wenzeng Zhang, Demeng Che, Qiang Chen and Dong Du

A novel concept called gesture-changeable under-actuated (GCUA) function is proposed to improve the dexterities of traditional under-actuated hands and reduce the control difficulties of dexterous hands. Based on the GCUA function, a new humanoid robot hand, GCUA Hand is designed and manufactured. The GCUA Hand can grasp different objects self-adaptively and change its initial gesture dexterously before contacting objects. The hand has 5 fingers and 15 DOFs, each finger is based on screw-nut transmission, flexible drawstring constraint and belt-pulley under-actuated mechanism to realize GCUA function. The analyses on grasping static forces and grasping stabilities are put forward. The analyses and Experimental results show that the GCUA function is very nice and valid. The hands with the GCUA function can meet the requirements of grasping and operating with lower control and cost, which is the middle road between traditional under-actuated hands and dexterous hands.

D2-T3A-4 11:30-11:50
Variable rheological joints using an artificial muscle soft actuator and magneto-rheological fluids brake
Yuichiro Midorikawa and Taro Nakamura

In recent times, the chances of robot-human contact have increased; hence, safety is necessitated with regard to such contact. Thus, manipulators using a pneumatic rubber artificial muscle, which is lightweight and flexible, are studied. However, this artificial muscle manipulator has faults such as slow response and limited instantaneous power due to operation by air pressure. Because of these faults, uncontrollable vibrations can occur, leading to instability in the arm when an object is held and lifted. In this study, an artificial muscle manipulator with 1 DOF and a variable rheological joint mechanism using MR fluid is developed. Vibration control of the arm using MR fluid is realized when an object is held and lifted, confirming the reduction in vibration due to the MR effect.

D2-T3A-5 11:50-12:10
The Similarity Design of Heavy Forging Robot Grippers
Qunming Li, Yonghong Wu and Hua Deng

In order to design and study the gripping mechanism of heavy forging robots and to save money and delivery-time, it is necessary to optimize the structural dimensions of the gripper, and design a downsizing model gripper based on similarity theory, which can be had experiments to test the physical features and performances of the prototype of heavy grippers. This paper has studied the methods of similarity design and dimension optimization of the gripper mechanisms of heavy forging robots. Firstly, by using similarity theory, the similar criterion and similar indicators of the gripping system are presented, and the relationship between the geometry similarity ratio and other parameters' similarity ratio is defined. Secondly, based on the design requirement of the gripping design, the non-dimensional objective function is established. By using multi-objective optimization genetic algorithm, the optimization of the push-bar gripper is carried out. Finally, based on the simulation of a model and a prototype and the relationship of parameters of the gripping systems, the similarity of the experimental models is analyzed, demonstrating the feasibility of the similarity design for heavy forging robot grippers.

D2-T3A-6 12:10-12:30
Design of the Upper limb Rehabilitation Support Device Using a Pneumatic Cylinder
Koichi Kirihara, Norihiko Saga and Naoki Saito

This paper describes a device to support rehabilitation of a patient's upper limb motion. For safety, light weight, and flexibility, it uses a pneumatic cylinder, for which

the optimum arrangement is presented. The rehabilitation support device has two rehabilitation modes corresponding to different rehabilitation contents. A compliance control system and a position control system are applied for those modes. We evaluate the effectiveness of the rehabilitation support mode through some experimentation.

Wednesday, December 17, 13:30-14:00

Wed. 13:30-14:00

Plenary Talk
Industrial Talk "NAO Humanoid Robot and Its Application to RoboCup"
Chair: Honghai Liu, University of Portsmouth

Thursday, December 17, 14:00-15:40

Thur. 14:00-15:40 **Lavender 1**

Session D2-T1B
Robot Motion Analysis(2)
Chair: Hui Chen, Tongji University

D2-T1B-1 14:00-14:20
Dynamics and GA-Based Optimization of Rectilinear Snake Robot
Ahmad Ghanbari, Mir Masoud Seyyed Fakhrabadi and Ali Rostami

The goal of this study is analysis and optimization of rectilinear locomotion gait as one of the snake robot motion modes. An overview of kinematics and detailed dynamics and optimization of torque values are presented in this study. Well-known genetic algorithm scheme will be used in this paper.

D2-T1B-2 14:20-14:40
Optimum Dynamic Modeling of a Wall Climbing Robot for Ship Rust Removal
Xingru Wang , Zhengyao Yi, Yongjun Gong and Zuwen Wang

This paper presents the optimum dynamic model method for wall climbing robot for ship rust removal. The robot includes a frame, two servomotors and reducers, and two crawlers with permanent magnets for walking and absorbing. Its main function is loading the cleaner which can remove the rust on ship surface by water jetting. Because of the water jetting and vacuum recycle rust, the wall climbing robot need load heavy pipelines. The dynamic models of the robot climbing and turning on the ship wall are established and optimized. The climbing driving torque equation is obtained by considering the change of the weight of pipelines load and the center of gravity position. Finally, the simulation analysis shows that the optimum dynamic model and the optimum method are reliable, and the parameters which have main effect on the robot dynamic characteristic are obtained.

D2-T1B-3 14:40-15:00
Stiffness and singularity analysis of 2SPS+2RPS parallel manipulator by using different methods
Bo Hu, Yi Lu and Jiayin Xu

The Stiffness and singularity of a 2SPS+2RPS parallel manipulator is analyzed from different viewpoints in this paper. First, a new method for solving statics is presented, and the generalized force is derived. The 44 stiffness matrix which shows the relation of generalized force and generalized coordinates is derived. Second, base on observing the constrained forces in RPS legs, the 66 Jacobian matrix is derived and the statics is solved by another method. By using the principle of virtual work, a 66 stiffness matrix is derived with the constrained forces considered in stiffness analysis. Third, by locking the four actuators, the singularity is analyzed from different point of view.

D2-T1B-4 15:00-15:20
Experimental Evaluation on Dynamic Characteristics of Coaxial Magnetic Couplings for Vacuum Robot
Jun Wu, Pinkuan Liu, and Yulin Wang

Permanent magnetic couplings have the ability of transmitting torque from a primary driver to a follower without mechanical contact. In this paper, a pair of coaxial couplings are applied to vacuum robot design and fabrication. The tracking performance at different velocities without misalignment is presented first . Then the effects of radial offset and axial shift on the tracking errors are investigated. And, the cross coupling effects of two sets of couplings are simulated by 3D FEA, based on which a new method to minimize the cross coupling is proposed. Finally, experiments are carried out and results prove that magnetic couplings are feasible and reliable for further application.

D2-T1B-5 15:20-15:40
Complex surface machining: Thermo-mechanical analysis for error prediction of low-rigidity workpiece
Yongan Huang, Huimin Liu, Zhouping Yin and YouLun Xiong

A thermo-mechanical analysis is presented to predict the cutting force- and temperature-induced deflection in machining low-rigidity workpieces. Firstly, the cutting forces in ball-end milling are discussed. The theoretical flexible force model is considered to model the cutting force due to the coupling effect between force and deflection. Meanwhile, the thermal deformation is studied by including the dynamic temperature load, and it is to be combined into the flexible force model. The cutting force is given by geometric parameter method, the temperature at interface by empirical formula, and the dynamic temperature distribution by physical model. To take into account the deflection-force-temperature-deflection dependency, the workpiece geometry needs to be iteratively updated in computation. Last, the finite element analysis (FEA) is adopted to calculate the deformation.

Thur. 14:00-15:40 **Lavender 2**

Session D2-T2B

Visual Perception by Robots(2)

Chair: Zhencheng Hu, Kumomoto University

D2-T2B-1 14:00-14:20

Simultaneous Visual Object Recognition and Position Estimation Using SIFTm

Rigas Kouskouridas ,Efthimios Badekas and Antonios Gasteratos

In the last decade, pattern recognition tasks have flourished and become one of the most popular tasks in computer vision. A wealth of research focused on building vision systems capable of recognizing objects in cluttered environments. Moreover industries address all their efforts to developing new frameworks for assisting people in everyday life. The need of robots working closely to human beings in domestic workplaces, makes a necessity the usage of intelligent sensorial systems that are able to find patterns and provide their location in the working space. In this paper a novel method able to recognize objects in a scene and provide their spatial information is presented. Furthermore, we investigate how SIFT could expand for the purposes of location assignment of an object in a scene.

D2-T2B-2 14:20-14:40

The Vision System of the ACROBOTER Project

Rigas Kouskouridas, Nikolaos Kyriakoulis, Dimitrios Chrysostomou, Vasileios Belagiannis, Spyridon G. Mouroutsos and Antonios Gasteratos

The ACROBOTER project aims to develop a radically new locomotion technology that can effectively be used in a home and/or in a workplace environment for manipulating small objects autonomously. It extends the workspace of existing indoor service robots in the vertical direction, whilst its novel structure allows covering the whole volume of a room. For the adequate accomplishment of demanding manipulating tasks, its vision system must provide vital visual information concerning the position of the robot in the 3D working space and the topology of possible objects/obstacles in robot's trajectory. Thus, the proposed system is capable of: estimating robot's pose in the room; reconstruct the 3D working space and; recognize objects with remarkable efficiency. In this work, initially, we present the basic structure of ACROBOTER and its vision system and, we also evaluate the aforementioned functions.

D2-T2B-3 14:40-15:00

Autonomous Mapping using a Flexible Region Map for Novelty Detection

Muhammad Fahmi Miskon and Andrew R. Russell

This paper presents an autonomous method for a robot to map the normal condition of its environment using a flexible region map. The map is used as a reference to allow a mobile robot to perform novelty detection. The map has a flexible structure which could accommodate to the distribution of different types of entity in the environment. However, updating information in the map for autonomous mapping is not a trivial task since it requires changing the structure of the map. The contribution of this paper is twofold. First, the method for reshaping a flexible region map is discussed. Then, an algorithm that is inspired by the habituation principal for performing autonomous update is presented. Experimental results show that autonomous update was achieved by using the habituation principal and by allowing the flexible region to reshape itself to accommodate to changes in the environment.

D2-T2B-4 15:00-15:20

Active Contour Method with Separate Global Translation and Local Deformation

Linlin Zhu, Baojie Fan and Yandong Tang

Active Contour can describe targets accurately and has been widely used in image segmentation and target tracking. Its main drawback is huge computation that is still not well resolved. In this paper, by analyzing curve gradient flow, the evolution of active contour is divided into two steps: global translation and local deformation. When the curve is far away from the object, the curve just does the translation motion. This method can optimize the curve evolving path and efficiency, and then the computation cost is largely reduced. Our experiments show that our method can segment and track object effectively

D2-T2B-5 15:20-15:40

PLG-based Visual Tracing for Eye-in-Hand Puma 560 Robot

Wenqiang Hu, Kai Tian and Ronglei Sun

In this paper, one algorithm used to control eye-in-hand robot motion is studied and simulated. First, the fundament matrix of visual system is computed based on epipolar geometry; then the matrix is segmented to get the instantaneous poses and moving trajectories of end-effector based on IBVS. Finally one simulating experiment is completed and the experimental results demonstrate the efficiency of the proposed mothod.

Thur. 14:00-15:40 **Grand Ballroom 3**

Session D2-T3B

Robot and Automation in Tunneling(973)(4)

Chair: Huayong Yang, Zhejiang University
Guoli Zhu, Huazhong University of Sci. & Tech.
Yongan Huang, Huazhong University of Sci. & Tech.

D2-T3B-1 14:00-14:20

Dynamic Mechanism and Key Rectification Techniques of Shield Machine in the Vertical Plane

Ming Yue, Jian Wei, Wei Sun and Zhenggang Guo

With the development of the urban construction, the shield machine becomes more and more important as the main equipment to extend the underground space for the human being. In this paper, we investigate the dynamic mechanism of the shield machine in the vertical plane. Through this analysis, the basic requirement maintained balance of the shield machine while excavating is given. Meanwhile, the key rectification techniques about the deviation from the desired trajectory in vertical plane are discussed. This study is developed based on the engineering problems from which are frequently met in construction, and we hope to provide useful guidance to the actual excavating process.

D2-T3B-2 14:20-14:40

A precise measurement method of azimuth angle for TBM

Xinbao Zhang, Shuguang Liu and Bin Zhao

Based on the non-diffracting beam and the phase grating interferometer, a precise measurement method of azimuth angle for TBM has been developed in this paper. A high positioning precision is got on the image of the non-diffracting beam and its axis stability and a circular phase grating interferometer is used for angle measurement, so this measurement system can achieve that the measurement uncertainty of horizontal azimuth angle in absolute coordinates system is less than 0.507" and the measurement error of yaw angle, the angle between the non-diffracting beam and the axis of TBM, is less than 0.05mradial, when the distance between two conjoint work station positions is 200m. Therefore, this measurement system can be used as a guidance system of TBM in the shield tunneling and it can improve the orientation precision in the shield tunneling.

D2-T3B-3 14:40-15:00

Identification of Abnormal Operating Conditions and Intelligent Decision System for Earth Pressure Balance Shield Machine

Xiuliang Li, Junjie Jiang, Hongye Su and Jian Chu

In the Earth Pressure Balance shield construction, the soil dug in the capsule is difficult to form the "plastic flow state" and will cause three abnormal operating conditions including occlusion, caking in the capsule and spewing at the outlet of the dump device. These abnormal operating conditions will then trigger failure in tunneling, cutter-devices damage and even catastrophic incidents such as ground settlement. This paper effectively integrates mechanism of abnormal operating conditions and knowledge of soil conditioning and establishes a uniform model of identification of abnormal conditions and intelligent decision support system based on belief rule-base system. The model makes full use of knowledge of improving the soil, construction experience and data to optimize the model on-line. Finally, a numerical simulation with specific construction data is presented to illustrate the effectiveness of the algorithm.

D2-T3B-4 15:00-15:20

Optimal Disc Cutters Plane Layout Design of the Full-Face Rock Tunnel Boring Machine (TBM) Using an Ant Colony Optimization Algorithm

Junzhou Huo, Wei Sun, Pengcheng Su and Liying Deng

Cutter head is one of the most important components for the full-face rock tunnel boring machine (TBM), in which the layout design of the disc cutters is a key issue. Considering the complex engineering technical requirements, this paper studied an ant colony optimization (ACO) algorithm to solve the disc cutters plane layout problem. The searching space of the design variables (disc cutters' position) were dispersed by setting several different search steps, then an ACO algorithm was adopted to search the best searching step of each design variable dynamically during the whole optimization process. Finally, the disc cutters layout design instance was solved by the ACO method to demonstrate its feasibility and effectiveness. The computational results showed that that ACO method can provide various disc cutters layout schemes for engineers choosing from.

D2-T3B-5 15:20-15:40

Rotational Moment Analysis and Posture Rectification Strategy of Shield Machine

Zhenggang Guo, Wei Sun, Ming Yue and Jian Wei

The rolling phenomenon of the shield body occurs frequently in the process of practice construction, which could lead to the derivation of the shield machine and increase the difficulties of the excavation control. It is mainly caused by the rotation of the cutter head. Based on this practical problem, we investigate the forces around the shield body and the cutter head. Meanwhile, the positive and negative rotary controlling techniques are developed to regulate the deviated rolling angle. These studies would provide theoretical basis to the further research about the whole postures rectification of the shield machine.

Thursday, December 17, 16:00-17:20

Thur. 16:00-17:20 **Lavender 1**

Session D2-T1C

Computational Intelligence by Robots(1)

Chair: Jean-Daniel Dessimoz, Western Switzerland of Applied Sciences

D2-T1C-1 16:00-16:20

Cognition Dynamics: Time and Change Aspects in Quantitative Cognitics

Jean-Daniel Dessimoz

Cognition, and automated cognition i.e. cognitics, have recently been given a theoretical framework, whereby core concepts have been formally defined, along with metric units. Beyond intellectual exploration and cultural interest, this was also motivated by the goal to automate cognition, i. e. to

carry over some of the cognitive processes and tasks from humans to machine-based artifacts. First achievements have led to a number of interesting new results. One of them is to make explicit and more evident than in the past the critical role, in cognitics, of time and change quantities, as well as of the coercive level of control actions, along with perturbations and system properties. After a brief reminder of essential definitions, the paper reports on these topics, describing and discussing a number of complementary aspects summarized in title: 1. time and abstraction levels, which lead to various time properties and possibly specific orders of stationarity; 2. time based difference between knowledge and expertise; 3. critical role of time in estimation of information quantities, and thereby in particular in the estimation of complexity and knowledge quantities; 4. explanation, straightforward in this context, of the apparent so-called ”paradoxes of experts”, in learning and forecasting; 5. importance of time in automation as well, more specifically in loop control, where some time properties of control path (including perception, decision and action phases) relatively to those of system behavior (here the system is the entity to be controlled) are critical for success; 6. time and changes interrelations, with necessity, for quantitative estimation, of considering other factors as well; 7. possible changes of system time properties, in the context of closed loop control, whereby large differences may occur with respect to those in natural (open loop) status, depending on action and perturbation intensities, as well as on possible overall non-stationarities and non-linearities; 8. driving causes for changes, and classical analogies in the context of human psyche and cognition dynamics. The paper illustrates discussions with concrete examples relating to Robocup-at-Home competition tests and applications.

D2-T1C-2 16:20-16:40
Acquisition of Movement Pattern by Q-learning in Peristaltic Crawling Robot
Norihiko Saga and Atsumasa Ikeda

A peristaltic-crawling robot composed of many servo motors was developed. This robot can move equivalently to an earthworm using peristalsis, with expansion and contraction of segments, and also using contact sensors. The movement pattern was designed based on the peristaltic motion of an earthworm. The optimum movement pattern for a peristaltic-crawling robot was acquired through Q-learning. Its effectiveness was confirmed by mounting it onto a real robot.

D2-T1C-3 16:40-17:00
Study on a Location Method for Bio-objects in Virtual Environment Based on Neural Network and Fuzzy Reasoning
Hongjun Wang, Xiangjun Zou, Changyu Liu, Tianhu Liu and Jiaxin Chen

In picking manipulator location system, it is the actual challenge that the position of a bio-object is exactly determined in complex and uncertain environment. An accurate location method for a bio-object in virtual environment based on binocular stereo vision was studied. Firstly, an experiment platform for a bio-object and picking manipulator location based on binocular stereo vision was established, and the imaging of a bio-object and environment were gained by binocular stereo vision. Secondly, the causes of errors existing in the process of handling the bio-object and environment imaging were analyzed. An approach was point out that the vision errors were amended by means of building a neural network and a corresponding training system. Thirdly, considering there are many complex and uncertain factors existing in natural environment, fuzzy rule sets for ascertain the bio-object position were extracted and modeled. A fuzzy reasoning model which has multi-rules and multi-inputs is created based on experience of agricultural experts, which makes the location system more accurate and intelligent. Finally, a location simulation system was developed by VC++ and EON SDK, which can simulate a process of picking manipulator automatically locating to a bio-object.

D2-T1C-4 17:00-17:20
Adaptive Cellular Automata Traffic System Model Based on Hybrid System Theory
Yuge Xu , Fei Luo and Xiaodan Tian

Traffic system model with multiple lanes switch behaviors is very complex. In order to study the nonlinear and strongly relevant micro traffic system, this paper applied hybrid system theory into micro traffic system model. One novel cellular automata NaSch traffic model based on hybrid system is built up. The traffic flow made up of lots of cars is a hybrid system. The driving behaviors of cars are continuous but the events that affect the cars speed are certainly or randomly discrete events. This paper analyzes the effect of driver switch behaviors to the whole traffic flow. The proposed novel traffic model is simple and easy to expand. This model can simulate the traffic states in the different traffic conditions correctly especially in some complex multiple lanes conditions. Simulation results tell us the presented adaptive traffic system model is correct and effective.

Thur. 16:00-17:20 **Lavender 2**

Session D2-T2C
Visual Perception by Robots(3)
Chair: Ryad Chellali, Istituto Italiano di Tecnologia

D2-T2C-1 16:00-16:20
Obtaining Reliable Depth Maps for Robotic Applications from a Quad-camera System
Lazaros Nalpantidis, Dimitrios Chrysostomou and Antonios Gasteratos

Autonomous navigation behaviors in robotics often require reliable depth maps. The use of vision sensors is the most popular choice in such tasks. On the other hand, accurate vision-based depth computing methods suffer from long

execution times. This paper proposes a novel quad-camera based system able to calculate fast and accurately a single depth map of a scenery. The four cameras are placed on the corners of a square. Thus, three, differently oriented, stereo pairs result when considering a single reference image (namely an horizontal, a vertical and a diagonal pair). The proposed system utilizes a custom tailored, simple, rapidly executed stereo correspondence algorithm applied to each stereo pair. This way, the computational load is kept within reasonable limits. A reliability measure is used in order to validate each point of the resulting disparity maps. Finally, the three disparity maps are fused together according to their reliabilities. The maximum reliability is chosen for every pixel. The final output of the proposed system is a highly reliable depth map which can be used for higher level robotic behaviors.

D2-T2C-2 16:20-16:40
Automatic Reconstruction of Unknown 3D Objects based on the Limit Visual Surface and Trend Surface
Xiaolong Zhou, Bingwei He and Y.F. Li

This paper presents a new planning approach of generating unknown 3-D models automatically. The new algorithm incorporates the limit visual surfaces with the trend surfaces and selects the suitability of viewpoints as the NBV on scanning coverage. The limit visual surfaces and trend surfaces are modelled by means of the known boundary region data obtained from initial view. The optimal design method is used to obtain the maximal visible area of next viewpoint and correspondding pose parameters in left and right planning process respectively. And the position that can obtain the maximal visible area is defined as the next best view position. The reconstrcted result of real model showes that the method is effective in practical implementation.

D2-T2C-3 16:40-17:00
Surface Reconstruction of Engine Intake Ports with Mixed Constraints
Kun Mo and Zhouping Yin

This paper presents a novel algorithm called mixed constraints reconstruction (MCR) method for building the surface of engine intake ports from scanning point clouds. The key idea of MCR method is to incorporate the fluid flow as a global constraint to approximate the point clouds with implicit surface representation. By combining the distance field and the fluid velocity generated from point clouds as mixed constraints, a new minimal-like model and its variational level set equation are introduced. The fluid flow velocity is obtained by solving Navier-Stokes equation, where a method for confirming the boundary condition from an extended boundary is also proposed. This method can reconstruct the final surface more reasonably and smoothly, with good fluid flow testing results. It needs not any additional geometric information and mesh construction. In the end, an example from real case is given to demonstrate the effectiveness of this method.

D2-T2C-4 17:00-17:20
A Fast Connected-Component Labeling Algorithm for Robot Vision Based on Prior Knowledge
Jun Liu ,Guang Lu, Binbin Tao, Fang Chen, Haitao Gao and Zhisheng Zhang

Machine vision is now a major technique for intelligent robot system to sense the outside world. Connected-component labeling is a simple and efficient way to help robot identify a specific region of interest (ROI). In this paper, the improvement of a two-scan algorithm based on prior knowledge is presented: (1) the rule of label assignment in the mask is improved and ROI orientation is introduced; (2) two cases of label equivalence in the mask were extracted to optimize the strategy of scanning; (3) two fast-connect ways were proposed to reduce the times of scanning. After the algorithm was implemented, parameters of each connected component are calculated to identify the ROI. In addition, this algorithm was also implemented in DSP platform on a service robot to identify a water cup. The experiment results demonstrated the efficiency of the algorithm is enhanced using the above strategies.

Thur. 16:00-17:20 **Grand Ballroom 3**

Session D2-T3C

Robot and Automation in Tunneling(973)(5)

Chair: Huayong Yang, Zhejiang University
Guoli Zhu, Huazhong University of Sci. & Tech.
Yongan Huang, Huazhong University of Sci. & Tech.

D2-T3C-1 16:00-16:20
Compensation of Measurement Error for Inclinometer Based on Neural Network
Xiangwen Wen, Haiyang Cai, Minghua Pan and Guoli Zhu

In the shield tunneling construction, the inclinometer is usually utilized to measure the pitching angle and rolling angle of the shield machine in real-time. However, the nonlinearity and the temperature characteristic of the inclinometer always result in large measurement error. In order to improve its measurement accuracy, the research on compensating the nonlinear error and the temperature drift error based on BP neural network is presented in this paper. The characteristic of the inclinometer is studied by experiment at first and then its inverse model is built using BP neural network and trained with an amount of experimental data; finally the trained model is used to compensate the measurement error. The experimental results verify that the proposed compensation method can improve the measurement accuracy of the inclinometer greatly by correcting the nonlinearity and eliminating the influence of temperature.

D2-T3C-2 16:20-16:40
Redundantly Actuated PRPRP Radial Mechanism in Segment Erector of Shield Machine for Synchronization

Control
Wanghui Bu, Zhenyu Liu and Jianrong Tan

The shield machine is a heavy construction machine for tunnel excavation. The segment erector is an important subsystem of the shield machine. The 2DOF five-bar radial mechanism in the 6DOF erector is hard to implement the precise synchronization control. Hence, this paper proposes a redundantly actuated PRPRP radial mechanism for the segment erector. When the redundant actuator is locked or produces enough pretightening stretching force, the PRPRP mechanism can ensure the synchronization of the two driving hydraulic cylinders based on the mechanical structure. The redundant actuator can also make the two flexural torques applied at the hydraulic cylinders be the same, which avoids the overload of the single cylinder.

D2-T3C-3 16:40-17:00
Electrohydraulic Control of Thrust Hydraulic System for Shield Tunneling Machine
Beidou Zhu , Guofang Gong and Hu Shi

A thrust hydraulic system of shield tunneling machine with pressure and flow control is introduced. The electrohydraulic control model is presented. Based on conventional PID control, corresponding experimental analyses are carried out on the simulator test rig. Considering the uncertain and variable loads during shield tunneling, simulation study on fuzzy control of the thrust parameters is realized by applying fuzzy-PID compound control and fuzzy adaptive PID control strategies. Dynamic simulations are finished in AMESim and MATLAB/Simulink softwares. The simulation results show that the control with fuzzy logic algorithm can improve the performances of the thrust system evidently compared with pure PID control, and the fuzzy adaptive PID control system can achieve better performances.

D2-T3C-4 17:00-17:20
Simulation Analysis of Pressure Regulation of Hydraulic Thrust System on a Shield Tunneling Machine
Zhibin Liu, Haibo Xie and Huayong Yang

Hydraulic thrust system is an important system on a shield tunneling machine. Pressure regulation of thrust cylinders is the most important function of thrust system during tunnel excavation. In this article, a hydraulic thrust system is illuminated, and a corresponding simulation model is carried out in order to study the system characteristics. Pressure regulation of a certain group's cylinders has a little influence of the other groups' cylinders. The influence will not affect the process much during tunnel excavation. Pump displacement may have a great effect on the pressure regulation. Oil supply flow rate should be adaptive to the system demand. A tough situation is simulated to explain how the pressure regulation works during tunnel excavation.

Thursday, December 17, 18:00-21:00

Thur. 18:00-21:00

Conference Award and Banquet

Friday, December 18, 9:00-10:00

Fri. 9:00-10:00

Plenary Talk
Development of Autonomous Vehicles
Chair: Zhencheng Hu, Kumamoto University

Friday, December 18, 10:30-12:30

Fri. 10:30-12:30 **Lavender 1**

Session D3-T1A
Robot Motion Analysis(3)
Chair: Minghui Zhang, Shandong University of Sci. & Tech.

D3-T1A-1 10:30-10:50
Modeling and Optimization of Contact Forces for Heavy Duty Robot Grippers
Qunming LiDan Gao and Hua Deng

Different from dexterous robotic hands, the contact status of a two-finger heavy duty gripper between the two tongs and the object are much complex during forging operation, and the contact forces are difficult to be controlled in real-time, because the tong usually is designed to rotate freely around the arm to some extent, and the contact area is usually a surface or a line. Based on the force-closure condition to meet the force and the torque equilibrium equations, this paper presents a real-time calculation model considering the gripping contact areas as equivalent friction points for N robot fingers including four contact points for the heavy gripper gripping a cylinder object. Then the contact force optimization method for multi-fingered hand researches can be used for the gripping forces' calculation between gripper tongs and the forged object, and the task is formulated as an optimization problem on the smooth manifold of linearly constrained positive definite matrices, which has globally exponentially convergent solutions via gradient flows. This is a new approach to optimize the gripping forces in real-time for the gripper's design and control of heavy forging manipulators. Simulation and experimental results are analyzed.

D3-T1A-2 10:50-11:10
Performance of Inertia Force Analysis for Spherical Bearing Test Stand Mechanism
Yulin Yang, Xiong Du, Shaoshuai Fan and Xijuan Guo

According to inertia matrix, inertia force performance index

of mechanism is proposed, which used to analyze the effect of size and mass on inertia force of mechanism. As an example, 2-RUUS mechanism is analyzed. Without considering those secondary components that have little influence on inertia force, inertia moment of main components are got, the relationship between performance of inertia force, size and mass of mechanism is analyzed and atlas is got. From the atlas, the reasonable range of size was found out.

D3-T1A-3 11:10-11:30
Reordering and Partitioning Jacobian Matrices Using Graph-Spectral Method
Xuelin Wang and Yujin Hu

An efficient spectral method is developed for reducing the Jacobian matrix to its block-triangular form in order to solve the inverse kinematics problem. Based on the kinematic structure matrix, the problem of reducing the Jacobian matrix to block-triangular form is transformed into reducing the bandwidth of the matrix. The second Laplacian eigenvector, associated with the bigraph of the structure matrix of the inverse Jacobian, is used to renumber the rows and columns of the Jacobian. The rearranged Jacobian can be divided into subsystems immediately according to the entry value of the Fiedler vector. This algorithm is applied in detail to kinematic analysis for a PUMA robot and T3 robot. Because of the algebraic nature of spectral algorithm, the algorithm can be implemented in a fairly straightforward manner.

D3-T1A-4 11:30-11:50
Workspace Analysis and Parameter Optimization of a Six DOF 6-3-3 Parallel Link Machine Tool
Minghui Zhang and Baohai Zhuo

Taking the 6-3-3 parallel mechanism as the researching target and the inverse kinematics equation of the mechanism is built. Based on this, the relationships between the displacement of the slides and the full reachable workspace are deduced in the mathematic functions. Then boundary curves of the full reachable workspace are obtained by means of the algorithm of mathematical analysis under the traversed range of the slides, spherical joint fit corner and parallel bar interference constraints. And then the projection and section curve graphs of work space boundary surfaces are drawn. Finally, the relations between the full reachable workspace and the structure parameters are simulated, and the Genetic Algorithm is used to optimize the structural parameters in order to obtain the maximal workspace volume.

D3-T1A-5 11:50-12:10
Obstacle-climbing Capability Analysis of Six-wheeled Rocker-bogie Lunar Rover on Loose Soil
Xiaoliu Yu,Yongming Wang, Meiling Wang and Lifang Wang

Taking six-wheeled rocker-bogie lunar rover as an object, on the basis of force analysis between the wheels and lunar soil, its obstacle-climbing force model on loose soil was established in this paper, and the wheel sinkages were obtained. Based on the method of solving the wheel's driving torque solution space feasible regions, this paper analyzed the forward obstacle-climbing capability of six-wheeled rocker-bogie lunar rover on loose soil, including single-wheel obstacle-climbing and two wheels obstacle-climbing simultaneously. Simulations show that under the loose soil environment, the wheels have different obstacle-climbing capability, i.e. the rear wheel is the best, the middle one is the worst and the front one is moderate.

D3-T1A-6 12:10-12:30
Hyper-chaotic Newton-downhill Method and its Application to Mechanism Forward Kinematics Analysis of Parallel Robot
Youxin Luo

Aimed to the nonlinear equations-finding problem that only one solution is found with the Newton and quasi-Newton methods and sometime no solution is found when the iteration diverges, combining Newton-downhill method with hyper-chaotic system, hyper-chaotic Newton-downhill method based on utilizing hyper-chaotic discrete system to obtain locate initial points to find all real solutions of the nonlinear questions was proposed. Using cosine matrix method and link length constraint we establish nine variable equations of the general 6-SPS mechanism. The numerical example in forward kinematics analysis of the general 6-SPS parallel platform shows that all real solutions have been quickly obtained, and it proves the correctness and validity of the proposed method.

Fri. 10:30-12:30 **Lavender 2**

Session D3-T2A

Robot Experimentation(1)

Chair: Yongan Huang, Huazhong University of Sci. & Tech.

D3-T2A-1 10:30-10:50
Experimental Study on Alpine Skiing Turn Using Passive Skiing Robot
Norihiko Saga and Kengo Kono

In recently, study on skiing turn is researched from various viewpoints. And the mechanism of the skiing turn using the skiing robot is clarified now. However, those mechanical models derived by using the approximate expressions don't match to an alpine skiing turn. Therefore, to provide further details of theoretical consideration, the passive type skiing robot is developed. The influence on the skiing turn such as the position of gravitational center and the shape of skiing are examined by using this robot. In this paper, it reports on their experimental results.

D3-T2A-2 10:50-11:10
Study on Mine Rescue Robot System
Juan Wei and Hongwei Ma

Mine rescue robot system consists of the carrier robot and the exploration robot. After the incident, the rescue

robot system can instead of rescuers to enter the mine, collect environmental information of the scene of accident. This paper introduces the structure and components of the carrier robot and the exploration robot, and analyse separately their kinematics, find out the motion control parameters. Accordance rescue robot with the workplace, put forward the autonomous navigation method based on coal mine geographic information system, and finally to a simple example of the path searching process.

D3-T2A-3 11:10-11:30

A Hybrid FES Rehabilitation System based on CPG and BCI Technology for Locomotion: A Preliminary Study

Dingguo Zhang, Guangquan Liu, Gan Huan, Jianrong Liu, and Xiangyang Zhu

A hybrid functional electrical stimulation (FES) rehabilitation system for locomotion is proposed in this paper. It has a hierarchical structure. In upper level, brain-computer technology (BCI) is used to acquire the subject's intention. In middle level, central pattern generator (CPG) is designed to generate appropriate rhythmic motor patterns. CPG is triggered by BCI command, and send control patterns to lower level. In lower level, FES technique is used to activate the muscles, and drive the lower limbs to achieve the expected movements (i.e. locomotion). The whole system is developed according to the general nervous structure of human being. The hybrid system aims at developing a neuroprosthetic bridge for the impaired nervous system of paralyzed patients. Some preliminary results on BCI are given.

D3-T2A-4 11:30-11:50

A Study On the key technology of Autonomous Underwater vehicle- AUV's self rescue beaconing system

Guohua Xu , Kun Yu and Xiaoliang Chen

It is dangerous for Autonomous UnderwaterVehicle (AUV) to work in the deep sea. so varies of risk may be faced by an AUV when working in such environment. Thus, it costs a lot of humanbeing resource to develop an AUV while the data or the collection that attained by the working of an AUV in the deep sea is valuable. Especially for an AUV which carries person, the safety of itself is much more important. This Paper introduces an AUV underwater robot system based on MSP430 microcontroller. The technology of miniaturization, low power consumption, airproof and reliability are given in detailed. It will be disastrous if the AUV is lost in the sea and, at the mean time, an expense of oceanic research and development. So it is extremely significant to explore the self-rescue system for AUV.

D3-T2A-5 11:50-12:10

Introduction to the Development of a Robotic Manipulator for Nursing Robot

Guang Lu, Binbin Tao, Jun Liu, Fang Chen, Jinfei Shi and Zhisheng Zhang

The structure and function system of a practical robotic manipulator applied to nursing robot has been developed. According to the development requirements of practicality and low cost, a 4-DOF lightweight manipulator was firstly designed. Then its kinematics model was established to obtain the forward and inverse kinematics solutions. As to the manipulator control system, CAN-bus architecture was utilized to implement communication between the main control system of robot and the joint control unit of manipulator. Taking the terminal gripper controller as an example, the modular circuit design and the concrete communication rules were emphatically introduced. Furthermore, based on the service task of grasping water cup, a series of core technical schemes on camera calibration and object location were put forward under the measurement condition of monocular vision to achieve visual servo control. The experimental results show that the manipulator can preliminarily realize the predetermined service functions.

D3-T2A-6 12:10-12:30

A Study on Wafer-handling Robot with Coaxial Twin-shaft Magnetic Fluid Seals

Ming Cong , Penglei Dai and Huili Shi

Wafer-handling robot is an important IC equipment in wafer manufacturing system. As such robot works in vacuum environment, there is a high requirement for the sealing device of it. Magnetic fluid rotary seal shows the effectiveness in machinery operating in a vacuum chamber, and the advantages of simple design, low friction and zero leakage at almost any rotation speed. This paper deduces the seal differential pressure formulas for magnetic fluid rotary seals. A coaxial twin-shaft magnetic fluid seals for wafer-handling robot is designed, of which the important structure parameters are optimized, the magnetic flux density distribution in the sealing gaps is analyzed and the pressure resistance of inner and outer shaft is calculated. Finally, a wafer-handling robot equipped with coaxial twin-shaft magnetic fluid rotary seals and bellows seal is devised. It is shown that this kind of robot can enhance the grade of vacuum and cleanliness in wafer processing system.

Fri. 10:30-12:30 **Grand Ballroom 3**

Session D3-T3A

Robot Mechanism and Design(2)

Chair: Caihua Xiong, Huazhong University of Sci. & Tech.

D3-T3A-1 10:30-10:50

The Research of Mechanism Synthesis Based on Mechanical System Chaos Anti-control Methods

Youxin Luo

Many questions in natural science and engineering are usually transformed into solving nonlinear equation. Newton iterative method is an important technique to one dimensional and multidimensional variables and iterative process exhibits sensitive dependence on initial guess points. For first

time, the nonlinear feedback chaos anti-control method of mechanism synthesis was put forward. The motion of mechanical centrifugal governor systems was transformed from periodic motion to chaotic motions by the addition of nonlinear feedback and all solutions of the nonlinear questions of mechanism synthesis were found by utilizing chaotic sequences of chaotic motions of mechanical system to obtain locate initial points. As an example the problem of function generation for planar four-linkage guide mechanism was considered. This makes that multi-projects selecting could be possible. This method is adaptive to planar multi-linkage and spatial mechanism. This provides a new simple realization method for mechanics design.

D3-T3A-2 10:50-11:10
Design and Application of High-Sensitivity Hexapod Robot
P.S. Pa and C.M. Wu

In recent years, with the advancement of electronic and control technologies, robots are being designed not only to perform dangerous or automated tasks, but also to serve in other fields such as education, entertainment, cleaning, security, tour guiding, and environmental exploration. Among the various types of robots, walking robots are less stable than wheeled ones. Moreover, it is also known that controllers, when required to multiplex and generate PWM signals for controlling servo actuation, may fail to handle multi-axis control and other external tasks simultaneously. Therefore, robots intended for both sensing and communication purposes are typically designed as wheeled robots rather than walking robots. This study aims to develop a low-cost walking robot that is capable of exploring the environment in a walking manner and transmitting environmental information to the computer end through a Bluetooth module. In this study, a hexapod robot is designed as a test carrier and is integrated with a single chip and a variety of sensing devices for environmental detection. The single chip is coupled with a CPLD, which controls the actuation of servos and thereby enables locomotion of the hexapod robot. More particularly, the single chip is coupled with ultrasonic sensors, infrared sensors, a biaxial accelerometer, an electronic compass, a temperature sensor, an infrared human-body sensor, and a Bluetooth module so as to realize a moving device capable of walking and high-sensitivity sensing. A digital man-machine interface is also designed in this study for transmitting information sensed by the single chip to the computer end, thus allowing a user to apply the information as needed.

D3-T3A-3 11:10-11:30
On the design of exoskeleton rehabilitation robot with ergonomic shoulder actuation mechanism
Wenbin Chen , Caihua Xiong, Ronglei Sun and Xiaolin Huang

Due to the advantages of more intensiveness, long duration, repeatability and task-orientation, robot-assistant training has become a promising technology in stroke rehabilitation. Comparing to the end-effector guided robots, exoskeleton robots provide better guidance on the posture of upper extremity, especially during movements with large ranges. Regarding the upper extremity, the natural coordination called shoulder rhythm is the most challenge to the ergonomic design of shoulder exoskeleton. Based on kinematic analysis of movement of shoulder complex, a nine degree-of-freedom exoskeleton rehabilitation with six degree-of-freedom shoulder actuation mechanism is proposed. In order to verify the manipulability of the proposed robot during assisting patient with performing activities of daily living (ADLs), the performance criteria, i.e., dexterity measure and manipulability ellipsoid, are used to evaluate and compare with human upper extremity. The evaluated result confirms the ergonomic design of shoulder mechanism of the rehabilitation robot on providing approximate dexterity matching that of human upper extremity in ADLs.

D3-T3A-4 11:30-11:50
A Novel Five Wheeled Rover for All Terrain Navigation
Arun Kumar Singh, Arun H Patil and Anup Kumar Saha

This paper presents a new concept for rough terrain navigation of rovers. The proposed design has reduced number of joints and links from existing suspension concepts. The suspension mechanism is derived from planar four bar mechanism and hence we present the singularity and trajectory analysis of the proposed mechanism. We derive the quasi-static equations of motion of the rover and a linear programming based approach is proposed for the optimum wheel motor torque control. Efficacy of the proposed mechanism is proved by simulations on undulating terrains as well as on terrains having discontinuity.

D3-T3A-5 11:50-12:10
The Research on Mechanism, Kinematics and Experiment of 220kv Double-Circuit Transmission Line Inspection Robot
Cheng Li, Gongping Wu and Heng Cao

Multi-circuit (extra) high-voltage transmission line places important role in China Power Grid. To ensure its running safety, it is better using inspection robots than helicopters or manual inspections. This paper first presents the mechanism of a kind of inspection robot for 220kv double-circuit transmission line, which has 7 degrees of freedom, designed into double anti-symmetrical retractable arms, interactive sliding and suspending structure. Then build up its kinematics equation using D-H method. In order to solve its reverse solution, apply Back Propagation (BP) neural network in MATLAB. The results have shown the method is effective. To verify the mechanism whether is feasible, build up the model in CATIA, translate it into ADAMS to be simulated. The tests of its prototype in lab shows the simulation is correct. Pictures of the robot overcoming the obstacle on the horizontal line and on the jumpers are shown in this paper.

D3-T3A-6 12:10-12:30
The Design of the GPS-based Surveying Robot Automatic

Monitoring System for Underground Mining Safety
Chenguang Jiang, Jianguo Peng, Chunqiao Yuan, Guohui Wang, Yong He , Shaohong Li and Bo Liu

Earth subsidence in underground mining is an unavoidable problem in mining production, and timely and scientific observation and early warning is one of the important factors in the security of mining production. Though the surveying robot (i.e. automatic electronic total station) can automatically (or semi-automatically) monitor ground deformation for underground mining, the stability of the station location (monitor base station) has great impact on the monitor precision and when the measurement vision is covered, the surveying robot fails to monitor the corresponding deformation point. In order to tackle the above problem, the author and the research team have integrated the technology of GPS Global Positioning System with surveying robot and developed the GPS-based surveying robot automatic monitoring system for underground mining safety, which completely solves the foresaid problem, simplifies the monitor program and reduces the fixed investment cost of monitor. The article introduces the structure and working principle of the GPS-based surveying robot automatic monitoring system for underground mining safety, presents examples of monitor.

Friday, December 18, 14:00-15:40

Fri. 14:00-15:40 **Lavender 1**

Session D3-T1B

Computational Intelligence by Robots(2)

Chair: Jean-Daniel Dessimoz, Western Switzerland University of Applied Sciences

D3-T1B-1 14:00-14:20
Planner9, a HTN planner distributed on groups of miniature mobile robots
Stephane Magnenat, Martin Voelkle and Francesco Mondada

Autonomous mobile robots are promising tools for operations in environments that are difficult to access for humans. When these environments are dynamic and non-deterministic, like in collapsed buildings, the robots must coordinate their actions and the use of resources using planning. This paper presents Planner9, a hierarchical task network (HTN) planner that runs on groups of miniature mobile robots. These robots have limited computational power and memory, but are well connected through Wi-Fi. Planner9 takes advantage of this connectivity to distribute the planning over different robots. We have adapted the HTN algorithm to perform parallel search using A* and to limit the number of search nodes through lifting. We show that Planner9 scales well with the number of robots, even on non-linear tasks that involve recursions in their decompositions. We show that contrary to JSHOP2, Planner9 finds optimal plans.

D3-T1B-2 14:20-14:40
A New Strategy of the Robot Assembly Motion Planning
Yanchun Xia, Yuehong Yin, Yuewei Bai and Yafei He

A motion planning strategy, a dissymmetrical T-shaped peg into a C-shaped slot, is proposed based on medial axis diagram knowledge and force control technology. It is very important to understand the assembly environment in the process of the active assembly operation. The assembly environment can be understood based on the analysis of the geometrical and force conditions. The medial axis diagram is used to analyze the geometric constraint relations of the parts during the robot assembly, and by which, the whole process of the complex assembly operation can be planned. As a result, the robot can understand the almost environment information based on the planning knowledge. Due to the uncertainties in the assembly process, the force sensing and force control are executed for apperceiving the precise physical relations. Combining the medial axis diagram knowledge-based with force sensing and force control strategy, the assembly task of T-shaped peg into C-shaped slot can be completed high efficiently, and it can be used for references to the study of the robot assembly.

D3-T1B-3 14:40-15:00
An adaptive Rolling Path Planning Method for Planet Rover in Uncertain Environment
Jinze Song, Bin Dai, Huihai Cui, Enzhong Shan and Hangen He

Though path planning methods based on rolling windows have been successfully applied to planet rover in uncertain environment, the efficiency still remains unsatisfactory due to the single-step advancement strategy. In this paper, a novel path planning approach called Rapidly-exploring Random Tree (RRT) is introduced to efficiently find local feasible paths in the region of rolling windows. The planning step-size in each rolling window can be adaptive adjusted according to the local environment it's moving in, which is recorded by historical information perceived by the sensors. Combined with the goal-oriented heuristic strategy, the global collision-free solution path can be generated by successively connecting the local feasible paths. A number of infield experiments demonstrate the effectiveness of the proposed method.

D3-T1B-4 15:00-15:20
Planning and Control of Biped Walking along Curved Paths on Unknown and Uneven Terrain
Guoqing Zhang, Ming Xie, Hang Yin, Lei Wang and Hejin Yang

This paper investigates the planning and control of biped walking along curved paths on unknown and uneven terrain. For widespread use of biped robots, the capability of walking on unknown and uneven terrain is essential. The description of uneven terrain, as the basis of discussion, is presented in terms of the spatial relationship between the world frame and the robot local frames. Then the principle and

implementation of walking pattern planning are given phase by phase. Feedback controllers, including the phase switching controller, the stabilizing controller and the foot landing controller, are also designed to guarantee stable and agile walking. The motion planning, path following, and controller design are discussed within the identical framework, such that various walking behaviors can be generated with few walking parameters modified. Some results of simulation and experiments performed on the LOCH robotic platform are given to show the effectiveness of the proposed approach.

D3-T1B-5 15:20-15:40
The Study on Optimal Gait for Five-Legged Robot with Reinforcement Learning
Adnan Rachmat Anom Besari, Ruzaidi Zamri, Anton Satria Prabuwono and Son Kuswadi

The research of legged robot was rapidly developed. It can be seen from recent ideas about new systems of robot movement that take ideas from nature, called biology inspired. This type of robot begins replacing wheeled robot with various functions and interesting maneuvers ability. However, designers should decide how many legs are required to realize the ideas. One of the ideas that are rarely developed is odd number of legs. This research focused on five legs robot that inspired from starfish. To realize the intelligent system in robot that does not depend on the model, this research used reinforcement learning algorithm to find the optimal gait when robot is walking. In order to achieve this goal, trial and error have been used to provide learning through an interaction between robot and environment based on a policy of reward and punishment. The algorithm is successfully implemented to get the optimal gait on a five-legged robot.

Fri. 14:00-15:40 **Lavender 2**

Session D3-T2B

Visual Perception by Robots(4)

Chair: Ryad Chellali, Istituto Italiano di Tecnologia

D3-T2B-1 14:00-14:20
Robust Calibration of a Color Structured Light System Using Color Correction
Xu Zhang and Limin Zhu

In this paper, a new method for calibration of the structured light system is presented. Three code words, i.e. red green and blue squares, are used to create the M-array pattern image. Then the color calibration is conducted to deal with the color crosstalk. The color correction can make the decoding process more robust. After that, the camera is calibrated and the 3D corresponding points are also computed using the calibrated camera. Finally, the projector calibration is carried out. The experiment results on our structured light system show that our method is correct and precise.

D3-T2B-2 14:20-14:40
Close Range Inspection using Novelty Detection Results
Muhammad Fahmi Miskon and Andrew R. Russell

This paper presents a close range inspection strategy which requires minimum information from mobile novelty detection results. We propose the use of the estimated position of the detected anomaly to assist path planning for close range inspection. This strategy allows the robot to have more inspection coverage of the surrounding perimeter of the object which in turn will increase the performance of detection using sensors with limited work range. A down sampled laser range finder measurements are used to show that the strategy is robust and work with any range sensors including one that is noisy, inaccurate and has low angular resolution. Experimental results show that the close range inspection brings the robot near the perimeter of the anomalous object and also achieved total close range inspection coverage.

D3-T2B-3 14:40-15:00
Prediction Surface Topography in Flank Milling
Wei Hao and XiaoJin Wan

Machined surface texture is very critical factor since it directly affects the surface quality and part mechanical behavior, especiallythe surface roughness. In this paper, a new model is presented to build kinematic relationship between the arbitrary point of the cutter edge and the arbitrary point of the machining feature, the ruled surface texture is first evaluated by means of calculating an deviation value along a normal direction of an arbitrary point on nominal part surface in terms of the proposed model, three dimension profile can also be simulated, two examples are used to verify the feasibility of the proposed model.

D3-T2B-4 15:00-15:20
Combination of annealing particle filter and belief propagation for 3D upper body tracking
Ilaria Renna, Catherine Achard and Ryad Chellali

3D upper body tracking and modeling is a topic greatly studied by the computer vision society because it is useful in a great number of applications such as human machine interface, companion robots animation or human activity analysis. However there is a challenging problem: the complexity of usual tracking algorithms, that exponentially increases with the dimension of the state vector, becomes too difficult to handle. To tackle this problem, we propose an approach that combines several annealing particle filters defined independently for each limb and belief propagation method to add geometrical constraints between individual filters. Experimental results on a real human gestures sequence will show that this combined approach leads to reliable results.

D3-T2B-5 15:20-15:40
Automatic Soldering System Based on Computer Vision
Zhenhua Xiong, Xinjue Zhou, Yulin Wang and Han Ding

Due to the fine pitch of today's micro-chips, accurate alignment is vital to acquire high quality joints with less

detrimental effects on other components. We developed an integrated soldering system which combines an X-Y stage, a computer vision and a laser head. Based on the analysis of experimental data, we find that lens distortions and assembly angular errors of the X-Y stage play a distinct role on the positioning errors. To improve the positioning accuracy of this system, we proposed an algorithm based on straight line method to reduce image distortions, and a compensation algorithm on the non-perpendicular X-Y positioning stage. Finally, experimental results and comparative data are presented to evaluate the performance of these algorithms.

Fri. 14:00-15:40 **Grand Ballroom 3**

Session D3-T3B

Robot Motion Control(1)

Chair: Grigory Panovko, Engineering Research Institute of Russian

D3-T3B-1 14:00-14:20

Keeping a Stable Position of Walking Robot with Vibration

Grigory Panovko, Evgeniya Myalo and Teodor Akinfiev

A walking robot is considered. For leg lightness it is suggested in some cases to miniaturize its cross section. At that buckling of the leg rectilinear form is possible under dead weight. To keep the rectilinear form it is proposed to place a vibroexciter for vertical oscillations in the bottom of the leg. It results in parametrical oscillations which make onset for effect of vibrational stabilization of the rectilinear form. This effect can be treated as an increase of flexural stiffness of the flexible rod. Scheme of the leg's model in the form of flexible rod with distributed mass and concentrated mass at its free end is developed. Taking into account finite rotations of its sections we derive the equation of oscillations for the rod. It is shown that the effect of rectilinear form stabilization occurs under certain magnitudes of vibration frequency and amplitude. Stability conditions for obtained solutions are analyzed.

D3-T3B-2 14:20-14:40

An algebraic approach for accurate motion control of humanoid robot joints

Jorge Villagra and Carlos Balaguer

Humanoid robots are extremely complex systems, where a multi-layer control architecture is necessary to guarantee a stable locomotion. In the lower layer, joint control has to track as finely as possible references provided by higher layers. A new approach to precisely control humanoid robot joints is presented in this paper. It is based on algebraic control techniques and on a model-free control philosophy. An online black-box identification permit to compensate neglected or uncertain dynamics, such as, on the one hand, transmission and compliance nonlinear effects, and on the other hand, network transmission delays.

D3-T3B-3 14:40-15:00

Modeling and Impedance Control of a Chewing Robot with a 6RSS Parallel Mechanism

L. Huang, W. L. Xu, J. Torrance and J.E. Bronlund

Chewing robots are designed to mimic human mastication process . Dynamic force and position control is needed for the robot to produce the chewing force and the trajectory typical for the foods being chewed. The controller design is challenging due to the complexity of the dynamic model of the robot which is normally in a parallel structure. In this paper, a simplified joint space based impedance control scheme is proposed for a 6RSS chewing robot. The special features of the kinematic, force and dynamic models of the robot are explored for the controller design. The effectiveness of the proposed approach is proved.

D3-T3B-4 15:00-15:20

Decentralized Control for Swarm Flocking in 3D Space

Xiang Li, M. Fikret Ercan and Yu Fai Fung

This paper presents a decentralized control strategy for a robot swarm where each robot tries to form a regular tetrahedron with its three neighbors. The proposed method is based on virtual spring. Robots can form regular tetrahedron regardless of their initial positions and they require minimum amount of information about their neighbors. The control strategy is made scalable by integrating a neighbor selection procedure so that it can be expanded to large swarms easily. In addition, an obstacle avoidance mecha-nism, based on artificial physics, is also introduced. By utilizing this control strategy, basic swarm behaviors such as aggregation, flocking and obstacle avoidance are demonstrated through simulations in an unknown three dimensional environment.

D3-T3B-5 15:20-15:40

Nonlinear Analysis and Application of Servo Control System Based on Relay Feedback

Donglin Pu, Jianhua Wu, Zhenhua Xiong, Xinjun Sheng and Han Ding

In this paper, a PID controller tuning technology under different loads and velocities based on relay feedback for motor servo systems is proposed. Furthermore, the study on the relationship between relay parameters and plants' identification processes and results is novelly explored in depth. Through the theoretical analysis and experimental verification on the control loops of motor servo systems, we found that the major reason for the influence on relay feedback identification results is the nonlinear factors such as nonlinear friction in control loops. According to the analysis, the advices for optimizing the selection of relay parameters are given. Finally, a series of experiments on the general XY motion table and Zero-friction high precision air-cushion XY motion table have been conducted to prove the high performance of the proposed method. These experiments also validated the inference that the nonlinear factors have impacts on the results and processes of relay feedback identification.

Friday, December 18, 16:00-17:20

Fri. 16:00-17:20 **Lavender 2**

Session D3-T2C
Robot Experimentation(2)
Chair: Zhencheng Hu, Kumamoto University

D3-T2C-1 16:00-16:20
The Flexible Two-wheeled Self-balancing Robot Based on Hopfield
Xiangang Ruan and Jianwei Zhao

The linear model of flexible two-wheeled self-balancing robot that has been proved is used in the paper. The lumbar of robot is the spring. The discrete Hopfield neural network is used for controlling robot's posture based on association study. Study of biological control method to realize flexible robot posture control in the adaptive, self-organizing capacity, the reasonable energy function is defined for the non-linear and strong coupling robot, then design the Hopfield controller, used the dynamic function of flexible robot, which satisfied the need of robot's dynamic process. Analyze the convergence of the controller. Simulation experiments show the effectiveness of the method and proved the stability of system. Validity and rationality of the system controller designed are verified through the performance experiments of the prototype and analyzed the experiment result in detail. The robot like the human being not only structure, but also physiological intelligence.

D3-T2C-2 16:20-16:40
Real-time Simulation System of Virtual Picking Manipulator Based on Parametric Design
Haixin Zou, Xiangjun Zou , Yinle Chen, Yan Chen, Quan Sun, Hongjun Wang and Tianhu Liu

Aiming at the complexity of operation and control of the agricultural picking manipulator, a simulation system of the manipulator based on virtual design was developed. Firstly, the mechanism models and mathematical models of the manipulator were constructed. The simulation platform of virtual picking manipulator was developed. The designers can make parametric design of the manipulator real-timely; secondly, constraint and routing design for the motion trace of the virtual manipulator were made to realize real-time simulation of the manipulator; thirdly, the positive and inverse solutions of the kinematical equation of the manipulator was solved in the system, obtained from which the parameters were transferred to the motion node of the manipulator in the virtual scene to control its motion; finally, the visual and interactive dynamic simulation of the manipulator's operation behaviors and controls was realized. The results shows that the system is practical and can realize optimized design and motion control.

D3-T2C-3 16:40-17:00
Study of modeling and simulating for Picking Manipulator Based on Modelica
Yan Chen , Shuang Jin , Xiangjun Zou , Dongfen Xu and Weiliang Cai

In order to process the study of Picking Manipulator for litchi, multi-field unified modeling language Modelica is used to model and simulate Picking Manipulator. In this paper, the structure of Picking Manipulator is analyzed and the mathematical model of manipulator control system is built by adopting multi-cooperating controlling model. More, the process of modeling Picking Manipulator under Modelica/Dymola is introduced, and the model of Picking Manipulator system is built while the extensible modeling base is established. Finally, the model will be simulated and the validity of models will be validated. Through the thesis, the basic for the further study of Litchi Picking Manipulator will be provided.

D3-T2C-4 17:00-17:20
Optimal design on cutterhead supporting structure of tunnel boring machine based on continuum topology optimization method
Zhen LI, Wei SUN, Junzhou HUO, Pengcheng SU and Liying DENG

A continuum topology optimization method is introduced to the conceptual design of a cutterhead supporting structure of tunnel boring machine to avoid numerous empirical solutions. The conceptual design of the supporting structure is determined in the guidance of topology optimization combined with given working conditions. A finite element analysis indicates that the deformation and stress of the optimized cutterhead are reduced greatly as compared with those of the original design. Furthermore, the deformation distribution of the optimization is more homogeneous than that of the original one. The present work indicates that the continuum topology optimization plays an effective role in guiding the supporting structure design of cutterhead.

D3-T2C-5 17:20-17:40
Study on External Load Domain of Shield Machine Cutterhead
Weili Wen, Pingfa Feng, Zhijun Wu and Jianhu Liu

The shield machine cutterhead load domain in composite strata is an important and complex problem, which has significant impact on the design of the cutterhead. In this paper, the load model of the cutterhead including resistance and resistance moment is developed through the micro-unit method under composite strata, and responses of cutterheads with different open ratios are analyzed by numerical simulations with the developed load model.

Fri. 16:00-17:20 **Grand Ballroom 3**

Session D3-T3C
Robot Motion Control(2)

Chair: Honghai Liu, University of Portsmouth

D3-T3C-1 16:00-16:20
Kalman estimator-based state-feedback high-precision positioning control for a micro-scale air-bearing stage
Zeguang Dong, Pinkuan Liu and Han Ding

Due to the high positioning precision requirement and the low damping surface effect, the design of high-quality controller for a micro-scale air-bearing positioning stage is a challenging for micro-scale positioning system. Furthermore, the strict synchronization requirement of the linear motors on both sides of the gantry beam even intensifies the difficulty of the controller design. An optimized state-feedback gain has been designed by implementing a suitable Kalman estimator to minimize both the tracking error and the control efforts. Significantly, the merits of such a state-feedback control are the capabilities of handling the coupling of the two motors on the two outputs and compressing the overshooting as well. Finally, the experimental results of the proposed state-feedback controller on the air-bearing stage are displayed in comparison with the traditional PID control law.

D3-T3C-2 16:20-16:40
Discrete-Time Adaptive Sliding Mode Control of Autonomous Underwater Vehicle in the Dive Plane
Baoju Wu , Shuo Li and Xiaohui Wang

This paper presents a discrete-time adaptive sliding mode controller for an autonomous underwater vehicle (AUV) in the presence of parameter uncertainties and external disturbance. The controller makes the system stable in the presence of system uncertainties and external disturbances. The proposed algorithm has a time varying sliding surface which is obtained by parameter estimation method. The presented algorithms have been applied to the problem of depth control of an AUV. Resulting performances have been tested by simulation.

D3-T3C-3 16:40-17:00
Dynamic Control and Analysis of a Nonholonomic Mobile Modular Robot
Jingguo Wang and Yangmin Li

This paper presents a modeling method for a Mobile Modular Robot(MMR) which is composed of a mobile platform and a modular manipulator, the kinematics analysis is made for both the mobile platform and the upper manipulator. Then the dynamic equations are formulated considering the nonholonomic constraints and the controller is proposed with both the redundancy resolution and optimization of null space motion. A 5-DOF modular manipulator mounted on the mobile platform is built up to verify the proposed control law in the simulation and the results show the effectiveness of the proposed method.

D3-T3C-4 17:00-17:20
Inverted Pendulum System Control by Using Modified Iterative Learning Control
Hongxia Gao, Yun Lu, Qian Mai and Yueming Hu

The inverted pendulum is a typical multi?variable and non?linear system. It is hard to improve its performance because of modeling difficulty, parametric uncertainties during actual system operation. Iterative Learning Control (ILC) can achieve perfect tracking or performance when there is model uncertainty or when we have a ”blind” system. This paper proposed a modified iterative learning control method to improve the dynamics of the car with an inverted pendulum. Experiment results demonstrated that the proposed method can improve the dynamic performance of the car with an inverted pendulum.

Friday, December 18, 18:00-21:00

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