出國報告（出國類別：論文發表）

基於模糊強化學習之電動助力車具舒適騎乘電動助力管理機制

A Fuzzy Q-Learning Based Assisted Power Management Method for Comfortable Riding of a Pedelec

服務機關：嘉義大學電機系
出國教師：徐超明 教授
出國學生：劉政廷

派赴國家：紐西蘭 皇后鎮
出國期間：**2015** 年 **2** 月 **12**至**20** 日
報告日期：**2015** 年 **02** 月 **19** 日

摘要

此次出國乃前往於紐西蘭皇后鎮舉行的 2015 The 6th International Conference on Automation, Robotics and Applications (ICARA2015)的國際研討會，發表敝人與研究團隊學生合著的研究論文，並且參與相關熱門主題的議程以吸收新知及與外國教授學者交流。本會議在自動化、機器人及與此兩類研究相關應用的比重很多，期望透過此次發表找出可以更進一步的研究方向或是應用領域，進而深入研究後得以投稿至具有重要影響力的期刊，例如 IEEE Pattern Analysis and Machine Intelligence (IEEE PAMI)期刊。

目次

一、目的

此次出國乃前往於紐西蘭皇后鎮舉行的 2015 The 6th International Conference on Automation, Robotics and Applications (ICARA2015)的國際研討會，發表敝人與研究團隊學生合著的研究論文，並且參與相關熱門主題的議程以吸收新知及與外國教授學者交流。本會議在自動化、機器人及與此兩類研究相關應用的比重很多，期望透過此次發表找出可以更進一步的研究方向或是應用領域，進而深入研究後得以投稿至具有重要影響力的期刊，例如 IEEE Pattern Analysis and Machine Intelligence (IEEE PAMI)期刊。

在本次發表之論文, 提出一個基於模糊強化學習之電動助力車具舒適騎乘電動助力管理機制。在本研究中，使用強化學習來細緻化模糊邏輯控制器的各參數以用於電動助力車（Pedelec）之電動助力管理並達到讓騎乘者滿足舒適騎乘之騎乘經驗。電動助力車是一種特殊的人力-電力混合的移動載具，主要係由騎乘者之腳踏於踏板上產生動力以由鍊條與齒輪帶動輪圈前進，而電動助力車之電動助力控制器亦會經由感測感之騎乘者之騎乘環境並適時提供事先程式好之驅動輪轂馬達之電動助力，以輔助騎乘者之腳踏力，驅動電動助力車。 本研究提出強化學習來細緻化模糊邏輯控制器的各參數（此法一般稱為 Fuzzy Q-Learning，FQL）以用於電動助力車（Pedelec）之電動助力管理。實驗結果顯示，本研究提出之方法（簡寫為

FQLAPM），相較於既有之電動助力管理方法，除了能有讓騎乘者產生更佳之舒適騎乘效果外，亦能節省電池能量，達到更遠的騎乘距離。

二、過程

敝人於 2014 年中即開始著手本次會議論文之研究與撰述，論文初稿完成後即於 2014 年 9 月份進行稿件的送交。並於同年 11 月中收到論文接受通知，隨後根據審稿委員之意見進行論文之修改定稿與論文註冊與費用之繳交。在大會的議程細目公佈後，我們被安排於 2015/2/19 上午發表，發表時間確定後即開始安排行程。

此次會議舉辦地紐西蘭皇后鎮位於紐西蘭南島，本國籍航空公司航班需先飛到澳洲後原機轉機抵達紐西蘭之奧克蘭機場後，還需搭紐西蘭搭乘國內班機飛行約 4 小時才能抵達南島的皇后鎮。由於 2015/2/12 晚上之班機出發，至紐西蘭之奧克蘭機場已是隔天(13 日)下午 5 點多，無至南島的皇后鎮班機可搭乘，而且國際班機至澳洲後原機轉機抵達至紐西蘭之奧克蘭，一路旅途非常疲倦，因此選擇先在奧克蘭休息兩天後，在 2015 年 2 月 16 日搭乘紐西蘭國內線抵達南島的皇后鎮，ICARA2015 研討會報到時間為 2015 年 2 月 17 日，於前一日中午過後抵達皇后鎮。

於報到日上午報到後，即參與各項會議議程，2 月 17 日及 18 日兩天主要有兩個 Keynote Speeches：

(一) 2 月 17 日第一個 Keynote Speech 由在 BEI Technologies Inc.擔任總裁，及前 Chief Operating Officer and CTO 且在 University of California, Los Angeles 擔任 Distinguished Adjunct

Professor/Distinguished Scientist 的 Dr. Asad Madni 進行演講，講題是 Convergence Of Emerging Technologies To Address The Challenges Of The 21st Century

(二) 2 月 18 日第二個 Keynote Speech 則是由在 The University of Western Australia, Perth 擔任教職的 Professor Thomas Braunl 進行演講，其講題為「From Electric Cars to Autonomous Vehicles」。

Professor Thomas Braunl 帶領該校電腦係之 the Robotics & Automation 實驗室進行各項 Renewable Energy Vehicle Project (REV)是世界上此研究領域之註明學者專家之一。

敝人論文發表日期在 2 月 19 日，敝人所被安排在 11:00 S8C: Control 2 的議程中的第一位，之後還有其他三篇論文，如下

(一) 安排在 11:20 的論文「Design and Experimental Testing of Vehicle-Following Control for Small Electric Vehicles with Communication」

本文章由服務於 Tokyo University of Science & Faculty of Science and Technology, Japan 之 Takeki Ogitsu 以及 服務於 Keio University, Japan 的 Manabu Omae 兩位共同作者撰寫。本研究提出一個利用無線網路傳達個人電動車輛(personal electric vehicles)位置已進行車對車(vehicle-to-vehicle)之追循控制系統。經模擬實驗後之成果實證出此控制策略確能達到個人電動車輛車對車(vehicle-to-vehicle)之金的追循。

(二) 安排在 11:40 論文：「Toward Visualising and Controlling Household Electrical Appliances」

本篇論文由 The University of Auckland, New Zealand 三位學者 Latha Karthigaa Murugesan, Rashina Hoda and Zoran Salcic 所合著，

本文章探討如何整合 visualisation, recommendation and control 三種設計引擎以將家電的耗能狀況以視覺化並將控制與顯示以人機介面呈現以達節能功效.

(三) 安排在 12:00 的論文「Configuration space impedance control for continuum manipulators」

此論文是由服務於 Politecnico di Milano, Italy 的 Lorenzo Toscano 、Francesco Braghin ; 服務於 University of Stuttgart, Germany 的 Valentin Falkenhahn 、Oliver Sawodny; 與服務於 Festo AG & Co. KG, Germany 的 Alexander Hildebrandt 五位作者所提出。此論文主要在探討機器手臂之運動學與動力學上之模型與控制，並利用 Bionic Handling Assistant 來進行概念實現。此一控制方法確能達到在無法預測之接觸點以及無法估測接觸力時的機器手臂控制。

三、心得及建議事項

在 ICARA2015 會議中，每個議程中的論文報告者所描述的研究成果都讓與會者感到非常有興趣，並有許多自動化與機器人處理創新的想法。報告者與詢問者之間的問答與交流讓敝人瞭解到更多的研究領域與方向。而在論文報告完畢後，提問者所提的內容大部份關於此方法的實際運用，在問答與交流的過程中也讓我們想到此方法有更多元的運用方向。

四、附錄

(一)會議議場照片與論文發表現場

圖一、主辦單位會議開始前之致詞

圖二、論文發表前之預備工作

圖三、敝人（左）與博士生劉政廷（右）於會場合影

(二) 會議議程

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The 6th International Conference on Automation, Robotics and Applications

ICARA 2015

17-19 February 2015 • Rydges Lakeland Resort • Queenstown • New Zealand

Conference Program and Digest of Abstracts

WELCOME MESSAGE

It gives us immense pleasure in welcoming you to the 6th International Conference on Automation, Robotics and Applications, ICARA 2015 which is being held in the picturesque Queenstown, the adventure capital of the world. This is the first time ICARA is being held in the South Island of New Zealand.

More and more research will be centred on building robots and automation systems that can make a difference in the quality of human life. The days are not far when humanoid robots will be common in many homes and offices. Since 2004, when ICARA was first held in Palmerston North, New Zealand, it has helped to bring together researchers from different fields such as motion control and navigation; embedded systems and communication; artificial neural networks and neuro-fuzzy systems; evolutionary computation and image processing. Sensors are integral to modern automation systems; the importance of sensors is reflected in the large number of sensor related papers that will be presented in the conference. Scientists and engineers will progressively look to nature to find solutions to complex sensing and actuation problems. Biorobotics and biomechatronic systems are making tremendous progress and have a significant role to play in improving human life. Development of robots for edutainment, personal care and companionship is the next growth area.

In ICARA 2015, 144 papers were submitted. Of these, 109 papers were accepted for presentation. ICARA is truly an international conference. Based on author affiliations, 26.6% of the papers are from New Zealand. Of the remainder, 39% of the papers came from the Asia Pacific region, 21.1% from Europe, Middle East and Africa, 7.2% from Latin America and 6.1% from North America. ICARA has indeed established itself in the Australasian region as a premier conference in the rapidly advancing fields of robotics, automation and sensors. The papers accepted for ICARA 2015 will be submitted for indexing by IEEE Xplore digital library.

There are four special sessions on "Mechatronic Music", “Electric Vehicles: Advances in Drives and Steering Mechanism”, “Sensing, Automation and Robotics in Agriculture” and “Humans, software Agents, Robots, Machines and Sensors (HARMS)”. In addition, there will be two keynote addresses and three invited plenary talks. We are pleased to welcome Prof Thomas Braunl and Prof Asad Madni who will deliver the keynote talks. We trust you will find these talks stimulating. Special thanks are also due to Prof Elfed Lewis, Prof B M A Rahman and Dr Mehran Sarkarati for accepting our invitation to deliver the plenary talks.

Several people and organisations need to be thanked and acknowledged for their contribution to the success of the conference. We wish to thank all the authors and special session organisers for their contribution, our sponsors for the technical support and all the members of the organising committee for their tireless efforts. Thanks to all the paper reviewers for doing a thorough and timely job. Without your efforts, ICARA would not be the success that it is.

We hope that you will have a very fruitful and stimulating time at the conference and a pleasant stay in New Zealand.

Gourab Sen Gupta
Eric Matson
General Co-Chairs

Donald Bailey
Dong-Han Kim
Technical Program Co-Chairs

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Peter Xu, NZ
Ruqiang Yan, China
Mengjie Zhang, NZ
Huiyu Zhou, UK

Technical Program

	Tuesday, February 17		Wednesday, February 18		Thursday, February 19
7:30 – 8:00 am	Registration		Registration		
8:00 – 8:45 am					
8:45 – 9:00 am		*Welcome Session*			
9:00 – 10:00 am		K1: *Keynote 1*		K2: *Keynote 2*	S7A: *Health Systems 2* S7B: *Applications 2* S7C: *Applications 3*
10:00 – 10:30 am		*Morning Coffee Break*		*Morning Coffee Break*	*Morning Coffee Break*
10:30 – 11:00 am		S1A: *Special Session on Electric Vehicles* S1B: *Localisation and Mapping* S1C: *Man / Machine Interfacing*		S4A: *Special Session on Sensing, Automation and Robotics in Agriculture* S4B: *Tactile / Haptic Systems* S4C: *Underwater Systems*	IT3: *Invited Talk 3*
11:00 am – 12:10 pm					S8A: *Aerial Systems* S8B: *Optimisation* S8C: *Control 2*
12:10 – 12:20 pm		*Lunch Break*		*Lunch Break*	
12:20 – 12:40 pm					*ICARA Wrapup Session*
12:40 – 1:20 pm					
1:20 – 1:30 pm				IT2: *Invited Talk 2*	
1:30 – 1:50 pm		S2A: *Path Planning / Navigation* S2B: *Manufacturing Systems* S2C: *Control 1*			*NZRAS Workshop Registration*
1:50 – 2:00 pm				S5A: *Bio-inspired Systems* S5B: *Robotic Arms* S5C: *Temperature / Force Sensors*	
2:00 – 3:10 pm					*NZRAS Workshop*
3:10 – 3:30 pm		*Afternoon Coffee Break*		*Afternoon Coffee Break*	
3:30 – 3:40 pm					*Coffee Break*
3:40 – 4:00 pm		IT1: *Invited Talk 1*		S6A: *Special Session on Humans, software Agents, Robots, Machines and Sensors (HARMS)* S6B: *Applications 1* S6C: *Vision Systems*	
4:00 – 4:10 pm					
4:10 – 5:30 pm		S3A: *Special Session on Mechatronic Music* S3B: *Health Systems 1* S3C: *WSN / Communications*			*NZRAS Workshop*
5:30 – 5:40 pm					
5:40 – 6:00 pm					
6:00 – 7:00 pm					
7:00 – 10:30 pm			*Banquet*		

Tuesday, February 17

8:45 AM - 9:00 AM Welcome Session

Gourab Sen Gupta, Donald Bailey
Room: Queenstown

9:00 AM - 10:00 AM K1: Keynote 1

Convergence of Emerging Technologies to Address the Challenges of the 21st Century
Asad Madni
Room: Queenstown
Chair: Gourab Sen Gupta (Massey University, New Zealand)

10:00 AM - 10:30 AM Morning Coffee Break

Room: Foyer (Level 5)

10:30 AM - 12:10 PM (Parallel Sessions S1A, S1B and S1C)

S1A: Special Session on Electric Vehicles Advances in Drives and Steering Mechanism

Room: Queenstown
Chair: Ziming (Tom) Qi (Otago Polytechnic, New Zealand)

10:30 ***Active Electromagnetic Damping for a Lightweight Electric Vehicles***

Alista Fow and Mike Duke (University of Waikato, New Zealand)

By use of a linear electromagnetic element it is possible to create an active damper that has enough authority to provide active damping with a fraction of the weight and power consumption of a hydraulic system. A computer model of an active electromagnetic damper was constructed and the results were compared to a physical prototype. This verified the effectiveness of the damper and the low power consumption. This computer model was then scaled up for the simulation of a real world quarter car model. This simulation demonstrated that the use of the active linear electromagnetic damper was more effective at all frequencies when compared to an ideal passive damper. It was also demonstrated that the active electromagnetic damper had a similar mass to a passive damper and had a power consumption of more than an order of magnitude less than a comparable active hydraulic damper.

10:50 ***The Implementation in VISSIM REALTIME of an Active Electromagnetic Damper Controller for Lightweight Electric Vehicles***

Alista Fow and Mike Duke (University of Waikato, New Zealand)

By using VISSIM REALTIME, a controller was built that controlled a scale linear electromagnetic damper using Karnopp's Skyhook algorithm. This had to deal with issues such as accelerometer drift and signal to noise ratio. These required simple but fast techniques to provide useful information to the damper in a useful timeframe. This controller-damper combination proved effective in reducing the vibration experienced by the sprung mass and was more effective than an ideal passive damper at all frequencies tested by at least a factor of three.

11:10 ***An Engineering Design of Real-time Fault Monitoring Method for Power-on-wheel Electric Vehicles***

Ziming (Tom) Qi, Kuang Ma, Nicholas Sargeant and William Phipps (Otago Polytechnic, New Zealand)

This paper presents an engineering design of a real-time fault monitoring method for power-on-wheel electric vehicles, which have four independent wheel units. Each independent unit has an in-wheel motor with its own steering control system. A central control unit is used to coordinate the four wheels and translate the driver's idea onto the wheels, as such there is no mechanical link between these wheel units. In this respect, the electric car different from traditional vehicles. The experiment from workshop tests and drive tests proved that this real-time fault monitoring method based on motor drive operational current is a feasible design to identify the performance of the in-wheel motors.

11:30 ***A New Motors Fault Tolerance Control Strategy to 4WID Electric Vehicle***

Hao Qiu (Shenzhen Polytechnic, P.R. China); Ziming (Tom) Qi (Otago Polytechnic, New Zealand)

Four wheels independent driving (4WID) electric vehicle uses four motors. if some motors get faults, the whole vehicle would loss the stability to cause casualties. To solve the problem mentioned above, the fault tolerance control strategy of two motors of the 4WID electric vehicle running in straight line was studied and solved in this paper. The two-motor-fault modes were listed in all its aspects and the mathematic models of seven degrees of freedom were established. To achieve a good driving stability and dynamic characteristic with motors in failure state, the motors fault tolerance control strategies were proposed based on the performance of the 4WID electric vehicle and simulated by MATLAB/Simulink. The results show that the control strategies for torque re-allocation with motors in failure states can meet the designed demands, which provides a basis for the designing of whole vehicle's control strategy of the 4WID electric vehicle.

11:50 ***4-wheel Independent In-wheel-motor Drive and Independent Steering Electric Vehicle Safety Analysis Method Based on Mass Re-distribution Experiment***

Ziming (Tom) Qi, Xu Zhao, Kuang Ma and Matthew King (Otago Polytechnic, New Zealand); Wei-chen Lee (National Taiwan University of Science and Technology, Taiwan); Ji-Wei Lin and Shao-Min Lee (National Taiwan University of Science & Technology, Taiwan)

This paper presents a safety analysis guideline based on mass re-distribution experiment of the novel 4-Wheel Independent in-wheel-motor Drive and Independent Steering Electrical Vehicle (4WIDIS EV), which has four independent wheel units with the central engine, gearbox and steering mechanism all removed, as each independent unit has an in-wheel motor with its own steering control system. A central control unit is used to coordinate the 4 wheels and translate the driver's input to the wheels so that there is no mechanical link between these wheel units. In such a design, as compare to traditional vehicle, the mass distribution could be more flexible. Based on this flexibility and extra space, the guideline is proposed to experiment the distribution of mass by re-arranging the battery pack(s) in the vehicle to improve the safety.

S1B: Localisation and Mapping

Room: Clancys

Chair: Tom Botterill (University of Canterbury, New Zealand)

10:30 ***Enhanced Noise Models for GPS positioning***

Andrew Soundy, Bradley Panckhurst and Tim C. A. Molteno (University of Otago, New Zealand)

We analyze GPS position recordings, and show that they have long term autocorrelation functions. The traditional approach of assuming Gaussian uncertainties is therefore potentially problematic. We suggest some alternative noise models such as the Ornstein-Uhlenbeck process or autoregressive process, that can be used for state estimation.

10:50 ***Robotics Audition Using Kinect***

Vempada Ramu Reddy and Parijat Deshpande (Tata Consultancy Services, India); Ranjan Dasgupta (Tata Consultancy Services Ltd, India)

In this paper, we have developed sound source localization system for our FireBird VI robot. Localization algorithms like cross correlation, phase transform and maximum-likelihood are explored to find the DOA by estimating the time delay of arrival from the received signals of linear array microphones of Kinect sensor. The sound signals comprising of different sample pings and pause durations ranging from 0.003 to 3 s durations, frequencies varying from 100 Hz to 5 kHz are tested using Kinect in different azimuths ranging and across different distances. The performance of localization algorithms is evaluated by computing the error between estimated DOA and actual DOA. It is found that PHAT algorithm outperformed others, however some errors are obtained due to inherent reverberation affects may have caused by room. The authors also present practical limitations which result in errors for different azimuths based on distance between microphone pairs and sampling frequency of signals.

11:10 ***Topological Mapping for Robot Navigation using Affordance Features***

Karthik Mahesh Varadarajan (TU Vienna, Austria)

In this paper, we use AfRob, an affordance based framework for robotics as base for building topological maps. Traditional approaches to robotic navigation use metric maps or topological maps or hybrid systems that combine the two approaches at different levels of resolution or granularity. While metric and grid based maps provide high accuracy results for optimal path planning schemes, they require high space-time requirements for computation and storage, reducing real-time applicability. On the other hand, topological maps being graph based abstract structures are extremely light and convenient for goal driven navigation, but suffer from lack of resolution, poor self-localization and loop closing. This paper presents a novel approach to topological map building that takes into account affordance features that can help build lightweight, high-resolution, holistic and cognitive maps by predicting positional and functional characteristics of unseen objects. Results on synthetic and real scenes demonstrate the benefits of the proposed approach.

11:30 ***Constructing contextual SLAM priors using architectural drawings***

Christina Georgiou (The University of Sheffield, United Kingdom); Sean Anderson (University of Sheffield, United Kingdom); Tony Dodd (The University of Sheffield, United Kingdom)

Accurate robot mapping, localisation and navigation remains an unsolved problem for challenging real-life indoor environments. Many approaches to Simultaneous Localisation And Mapping (SLAM) have been proposed but few attempts have been made to improve performance by using appropriate prior maps. Information such as floor plans or architectural drawings is available and there is a rich literature of processing floor plans to extract information. However, the problem of converting drawings to an appropriate SLAM prior format has not been addressed. This paper addresses this problem and proposes a way to process such plans using a simple set of geometric constraints to extract useful information and construct appropriate SLAM priors. It also proposes a set of criteria and a method to assess the quality of constructed SLAM priors.

11:50 ***Utilization of Terrain Elevation Map in SLAM for Unmanned Aircraft***

Youngjoo Kim (Korea Advanced Institute of Science and Technology, Korea); Hyochoong Bang (KAIST, Korea)

An approach to vision-based navigation system for autonomous navigation of unmanned aircraft with use of terrain elevation map is addressed. We considered simultaneous localization and mapping (SLAM) algorithm to be the system to which the digital terrain elevation data (DTED) is merged. The proposed algorithm acquires range measurement by line-of-sight (LOS) intersection and provides it to the SLAM algorithm. Simulation study verifies that the proposed method can estimate absolute position of unmanned aircraft even for the case that the features are not on the surface of the DTED. The uses of DTED makes the SLAM algorithm more feasible for airborne applications.

S1C: Man / Machine Interfacing

Room: Wakatipu

Chair: Tim C. A. Molteno (University of Otago, New Zealand)

10:30 ***Augmented Reality behind the Wheel - Human Interactive Assistance by Mobile Robots***

Nuno Costa (Instituto Superior Tecnico & YDreamsRobotics, Portugal); Artur Arsenio (IST-ID, Universidade da Beira Interior & YDreamsRobotics, Portugal)

Novel approaches have taken Augmented Reality (AR) beyond traditional body-worn or hand-held displays, leading to the creation of a new branch of AR: Spatial Augmented Reality (SAR) providing additional application areas. SAR is a rapidly emerging field that uses digital projectors to render virtual objects onto 3D objects in the real space. When mounting digital projectors on

robots, this collaboration paves the way for unique Human-Robot Interactions (HRI) that otherwise would not be possible. Adding to robots the capability of projecting interactive Augmented Reality content, enables new forms of interactions between humans, robots, and virtual objects, enabling new applications. In this work it is investigated the use of SAR techniques on mobile robots for better enabling this to interact with elderly or injured people during rehabilitation, or with children in the pediatric ward of a hospital.

10:50 ***Human-Driven Multi-Robot Design Process - for Social Interactions with Children on Complex Environments***

David Gonçalves (YDreamsRobotics, Portugal); Artur Arsenio (Universidade da Beira Interior & YDreamsRobotics, Portugal)

Robots have been traditionally in operation away from people, for instance in industrial environments. More recently, there has been a trend for bringing robots to market for helping people. In particular, children constitute a challenging group for robot interaction, due to their curiosity and energy, as well as safety concerns. This paper describes the construction process of an external structure for a fleet of mobile robots designed for interactions with children in a hospital environment. We address several challenges on the design process, critical for the robots to be able to operate safely, while interacting social, among a group of children with specific needs.

11:10 ***Vietnamese Sign Language Reader using Intel Creative Senz3D***

Duc Nguyen (RMIT International University Vietnam, Vietnam); Moi Tin Chew (Massey University, New Zealand); Serge Demidenko (Massey University, New Zealand)

This paper describes a computer based system that utilizes a 3D sensor to bridge the communication barrier between hearing (and/or speech) impaired people and hearing ones. The proposed Vietnamese sign language reader successfully recognizes 28 static and 7 dynamic gestures taken from the Vietnam sign language dictionary. To recognize the gestures of a static type, various techniques have been deployed, such as Gabor Filtering, Fisher's Discriminant Analysis and Cosine Metric Distance method. The proposed technique achieves a good result with 93.89% accuracy and speed of 14 frames per second. Recognition of the dynamic gestures is based on the $1 Recognizer algorithm providing quite a good accuracy with 97.14% of accurate recognition with real-time running at 15 frames per second.

11:30 ***Design for Robots: A Robot Inclusive Optimization Framework for Service Applications***

Samarth Gupta (National University of Singapore, Singapore); Arnab Sinha (Singapore University of Technology and Design & University of Rome, Sapienza, Singapore); Mohan Rajesh Elara and Qinqi Xu (Singapore University of Technology and Design, Singapore)

Robots are increasingly entering our everyday social life within domestic setting and gradually being recognized as social partners rather than industrial tools. While much has been researched about ``designing robots'' focusing on component technologies in accomplishing social missions, little work has been done on ``design for robots'' that looks at designing environments and products that such robots (would) prefer. To this end, an optimization framework targeting design for robots is proposed for furniture layout problem and validated in the context of a residential floor cleaning robot. Three objective functions are proposed to optimize the spatial layout of the furniture, including CleanArea, SelfReachability, and ShadowEffect. We have demonstrated the efficacy and validity of our optimization framework in synthesizing robot inclusive optimal furniture layout solutions for social settings.

11:50 ***Changes in perception of a small humanoid robot***

Kerstin Haring and Katsumi Watanabe (The University of Tokyo, Japan); David Silvera-Tawil and Mari Velonaki (The University of New South Wales, Australia); Tomotaka Takahashi (The University of Tokyo, Japan)

Humanoid robots are designed to interact with people. To improve the development and design better social robots for human-robot interaction, it is important to consider how people perceive the physical design and behaviour of these robots. This paper presents the results of a study on the perception and the changes after passive and active interaction with a physically present humanoid robot in terms of anthropomorphism, animacy, likeability, perceived intelligence and perceived safety. Experimental results show that the perception of the robot changes mainly after the first interaction with the robot and not afterwards, the robot is perceived highly likeable and passive but not active interaction increased the perception of animacy.

12:10 PM - 1:30 PM Lunch Break

Room: Ben Lomond Restaurant

1:30 PM - 3:10 PM (Parallel Sessions S2A, S2B and S2C)

S2A: Path Planning / Navigation

Room: Queenstown
Chair: Bruce MacDonald (The University of Auckland, New Zealand)

1:30 ***Construction Site Navigation for the Autonomous Excavator Thor***

Daniel Schmidt (University of Kaiserslautern, Germany); Karsten Berns (Technische Universität Kaiserslautern, Germany)

The paper is part of the autonomous excavator project Thor (Terraforming Heavy Outdoor Robot) who's goal is the development of a construction machine which performs landscaping on a construction site without an operator. So far the project mainly focused on the local excavation on one position. Due to the high digging forces the machine permanently changes its position during excavation. Furthermore, the global goal is to shape the complete construction site. Therefore, a final test platform needs to permanently reposition itself on the site. Within this paper the construction site navigation function is described which guarantees safe traveling from one pose to another one. It is based on an extended A$*$ path planning algorithm, executed on a 2D gridmap including region growing for obstacles, including forward and backward movement. In combination with an intelligent path following algorithm the machine proved to safely reach its position with the desired orientation.

1:50 ***A comparison of sampling-based path planners for a grape vine pruning robot arm***

Scott Paulin, Tom Botterill, Jessica Lin, XiaoQi Chen and Richard Green (University of Canterbury, New Zealand)

We compare eight commonly used path planning algorithms on a robot arm for pruning grape vines. Pruning grape vines involves planning a path that reaches into cluttered regions and through narrow passages. These problems are known to be difficult for sampling based planners. We show that the choice of milestone expansion method has more of an effect on path planner performance than search directionality or laziness. We found the Rapidly Expanding Random Trees algorithm and its variations had the best overall performance.

2:10 ***Controller Comparisons for Autonomous Railway Following with a Fixed-Wing UAV***

Christopher Jarrett and Karl Perry (The University of Auckland, New Zealand); Karl Stol (University of Auckland, New Zealand)

The development of an on board vision-based path following system for a fixed-wing UAV is presented. The application is railway following and three path-following controllers have been investigated for their suitability for this task. The system is novel in that it includes all system components on board the UAV. A vision system has been developed to characterise railway lines as first-order polynomials and relay this information to a flight controller. In simulation, the Non-Linear Guidance Law was found to be the controller that yielded the fastest settling times and least overshoot values; followed by the Vector Field method. A baseline PID method was the worst performing controller. In experiment, the Vector Field controller had an RMS error of 2.88m, the Non-Linear Guidance Law had an RMS error of 3.36m and the baseline PID controller did not have enough data points to form a certain conclusion.

2:30 ***SAMMY - an algorithm for efficient computation of a smooth path for reference trajectory generation***

Alexander Keck and Karl Lukas Knierim (Institute for System Dynamics, University of Stuttgart, Germany); Oliver Sawodny (University of Stuttgart, Germany)

An efficient algorithm to generate smooth paths from polygonal lines is presented. The smooth path is used in combination with a trajectory generator to create reference values for the 2DOF control of a multi-sensor measuring system. The algorithm handles large amounts of target points without an increase in computation time and is able to construct a path based on noisy measurement data.

2:50 ***Fuzzy Gain Scheduled EKF for Model-Based Skid-Steered Mobile Robot***

Bourhane Kadmiry (Callaghan Innovation (MBIE), New Zealand)

This article describes an approach to autonomous robotic for agricultural applications. Technological setup aims at stable navigation based on estimation through Extended Kalman filtering, to enforce robust SSMR navigation. The scientific contribution is the implementation of two model-based estimators, using EKF algorithms, one on a nonlinear model, and one on a piece-wise linearized robot model. The later is a Fuzzy Gain Scheduled-based developement. The process is taking into account tire-road modelling of friction forces in order to improve model performance. State estimation and correction using sensor data fusion (Odometry-IMU-GPS) is considered, to improve the SSMR control in critical motions, reducing inherent drifts due to skid-steer properties; for the purpose of better regulation and tracking control designs. Whilst the experimental results demonstrated the usefulness of FGS approach for optimal EKF estimation, further modelling and live testing are required to determine robot ability to cope with different scenarios in naturally varying environment.

S2B: Manufacturing Systems

Room: Clancys
Chair: Rini Akmeliawati (International Islamic University, Malaysia)

1:30 ***A backward-oriented approach for offline programming of complex manufacturing tasks***

Ludwig Nägele, Miroslav Macho, Andreas Angerer, Alwin Hoffmann and Michael Vistein (University of Augsburg, Germany); Manfred Schönheits (German Aerospace Center (DLR), Germany); Wolfgang Reif (University of Augsburg, Germany)

The automation of production processes with large process variability and a low batch size can be very difficult and non-economic. Using the example of manufacturing carbon-fibre-reinforced polymers (CFRP) which represents a complex, currently hardly automated process, we present a backward-oriented approach for offline programming of complex manufacturing tasks. We focus on an automatic process definition which is supported by expert knowledge where required. Due to domain specific software modules, user interaction is intuitive and tailored to CFRP experts. This leads to significant time-savings compared to currently used teach-in approaches. Moreover, we introduce an extensible offline programming platform which is able to meet the high requirements of CFRP manufacturing.

1:50 ***Automatic programming for industrial robot to weld intersecting pipes***

Lei Shi and Xincheng Tian (Shandong University, P.R. China)

An articulated robot cooperated with a positioner is widely used in the field of intersecting pipes welding. In order to resolve the bottlenecks in productivity caused by the burdensome manual teaching process, this article presents an algorithm to generate motion codes for industrial robot to weld intersecting pipes. The geometrical models of intersecting pipes and weld torch are established successively. Based on these models, a dynamic model adequately expressing the kinematic characteristics of the robot and positioner is created. The spatial relationship between the welding torch and the robot base is described with homogeneous transformation matrix. Finally, an algorithm flow chart is provided for generating robot motion codes. Welding experiment verify the feasibility of the algorithm.

2:10 ***Adaptive-VDHMM for Prognostics in Tool Condition Monitoring***

Yue Wu, Yoke-San Wong and Geok Soon Hong (National University of Singapore, Singapore)

Among techniques used in condition monitoring, those for prognostics are the most challenging. This paper presents a Hidden Markov Model (HMM) based approach for prognostics in TCM. A HMM model usually employs a typical working condition for establishing and verifying the model. However, in tool condition monitoring (TCM), the cutting tool encounters a range of cutting conditions. It is not economical to establish a HMM for every cutting condition. Therefore, an adaptive-Variable Duration Hidden Markov Model (VDHMM) is proposed whereby the training information is adapted to a target test under different cutting conditions to those for establishing the initial model. It is found that with an appropriately selected feature set and state number, the proposed algorithm can significantly reduce the mean absolute percentage error (MAPE).

2:30 ***Realistic Simulation of Industrial Bin-Picking Systems***

Adrian Schyja (Institute for Research and Transfer (RIF), Germany); Bernd Kuhlenkötter (TU Dortmund University, Institute of Production Systems, Germany)

Although bin-picking is a well-researched and popular topic, planning and designing bin-picking systems is still a challenge. One reason for this is the fact that no comprehensive tools for planning such systems in an early engineering stage exist. Hence, there is no possibility to determine optimal system components and their configuration. In particular, there is no chance to provide a complete simulation and verification in advance, which is state of the art in many areas of virtual commissioning. In this paper, we present a versatile solution for planning, configuration and simulation of bin-picking systems within a virtual environment. Thus, a qualitative and quantitative evidence of bin-picking becomes possible.

2:50 ***Optimisation of Ink-Jet 3D printing Ceramic Components: Development of Low Cost Ink-Jet 3D Printer***

Blair Dixon (Massey University Albany, New Zealand); Johan Potgieter and Steven Matthews (Supervisor, New Zealand); Arno Ferreira (Co-Author, New Zealand)

Three-Dimensional printing technology has developed to be able to produce prototypes quickly and cheaply, and is capable of producing final products. Currently available technologies are discussed as well as the advantages/disadvantages of different Ink-jet 3D printing methods. Ink-jet 3D printing has multiple variables that will affect the strength and accuracy of 3D printed components. These variables are discussed and will be experimentally tested in order to optimise the strength and accuracy of 3D printed components.

S2C: Control 1

Room: Wakatipu
Chair: Praneel Chand (University of the South Pacific, Fiji)

1:30 ***Simultaneous Base and End-Effector Motion Control of a Nonholonomic Mobile Manipulator***

Shengfeng Zhou, Yazhini C. Pradeep and Peter C.Y. Chen (National University of Singapore, Singapore)

This paper investigates the motion control for a nonholonomic mobile manipulator with the objective of simultaneously controlling the velocity of the mobile base and the motion of the end-effector. Both the reference velocity for the mobile base and the reference trajectory for the end-effector are specified in the task-space. A steering velocity is designed based on the steering system of the mobile base via dynamic feedback linearization, with the advantage of directly using the reference velocity set in task-space. A torque controller is subsequently designed via backstepping based on the dynamics of the mobile manipulator to ensure that the mobile base tracks the designed steering velocity and the end-effector tracks the reference trajectory. The asymptotic stability of both the velocity tracking error and the end-effector motion tracking error is achieved. Simulations are conducted to demonstrate the effectiveness of the proposed controller.

1:50 ***Uniform Ultimate Boundedness of a Model Reference Adaptive Controller in the Presence of Unmatched Parametric Uncertainties***

Christian Heise and Florian Holzapfel (Technische Universität München, Germany)

In this paper, a novel Linear Matrix Inequality (LMI) condition for Uniform Ultimate Boundedness (UUB) of Model Reference Adaptive Control with σ-Modification in the presence of unmatched parametric uncertainties is presented. Due to the presence of unmatched uncertainties and due to the usage of the σ-Modification, the control objective of tracking a reference model may only be achieved approximately. A formulation of the UUB condition within the LMI framework provides less conservative bounds on the tracking error. This feature also enables the extension of the UUB condition towards a gain synthesis procedure, which allows the explicit specification of tracking error requirements. For a low-order system, it is demonstrated that the theoretically guaranteed bound on the tracking error of the synthesized adaptive controller is not overly conservative.

2:10 ***Application of Inverse Simulation to a Wheeled Mobile Robot***

Kevin Worrall, Douglas Thomson and Euan McGookin (University of Glasgow, United Kingdom)

This paper presents the application of Inverse Simulation to the control of a mobile robot. The implementation of this technique for motion control has been found to provide accurate trajectory tracking. Since the input to the Inverse Simulation is a time history of the desired response, then greater control over the mobile robot can be achieved. There are many situations where the desired path of a mobile robot is known e.g. planetary rover navigation, factory or warehouse floor. Typically the robot is either controlled remotely or runs an online controller to navigate the desired path. For a given path, a navigation system generates the desired drive parameters and the associated controllers drive the corresponding actuators. Traditionally the controllers are required to be tuned using knowledge of the limitations of the mobile robot. Inverse Simulation provides a means of generating the required control signals with no need for controller tuning.

2:30 ***Step Ascension of a Two-Wheeled Robot using Feedback Linearisation***

Jérémie X. J. Bannwarth, Callum Munster and Karl Stol (University of Auckland, New Zealand)

This paper investigates the modelling and control of step traversal using a two-wheeled robot (TWR). The traversal of TWRs over steps and other uneven terrain requires large platform tilt angles to adjust the centre of mass. This process is highly nonlinear, which complicates the controller design process. An auxiliary reaction wheel actuator is used in a novel way to facilitate step traversal. A mathematical model of step ascent is derived and used to create a feedback linearisation controller. The performance of the controller is assessed in simulation against a baseline controller from literature. The feedback linearisation controller yields significant improvements in tracking performance, with a decrease in tracking error of up to 86% when climbing a step in 1 second. Furthermore, the effects of varying the ascent conditions on performance are assessed. The controller is shown to operate over a large range of ascent times and reference tilt angles.

2:50 ***Fuzzy Reactive Control for Wheeled Mobile Robots***

Praneel Chand (University of the South Pacific, Fiji)

A mobile robot's ability to negotiate obstacles is important for successful point-to-point navigation. Hence, this paper presents a two stage fuzzy reactive control method. The first stage consists of a direction sensor that employs a fuzzy objective function to compute a direction (heading angle) for a robot to travel. At the second stage, a fuzzy dynamic window method utilizes a fuzzy objective function to determine the target wheel velocities of the robot. Simulations with two heterogeneous robots are performed in multiple environments. Initial results indicate that the fuzzy methods improve path length and are better at reducing speed around obstacles than linear methods.

3:10 PM - 3:40 PM Afternoon Coffee Break

Room: Foyer (Level 5)

3:40 PM - 4:10 PM IT1: Invited Talk 1

Characterization of a New Generation of Optical Sensors

B M A Rahman

Room: Queenstown

Chair: Serge Demidenko (Massey University, New Zealand)

4:10 PM - 5:30 PM (Parallel Sessions S3A, S3B and S3C)

S3A: Special Session on Mechatronic Music

Room: Queenstown

Chair: Jim Murphy (Victoria University of Wellington, New Zealand)

4:10 ***A Comparative Evaluation of Percussion Mechanisms for Musical Robotics Applications***

Jason Long (Victoria University of Wellington, New Zealand); Jim Murphy (New Zealand School of Music, New Zealand); Ajay Kapur (California Institute of the Arts, USA); Dale A Carnegie (Victoria University of Wellington, New Zealand)

This paper presents a summary of several of the various types of percussion mechanisms commonly utilized in the field of musical robotics, with a goal of comparing their effectiveness regarding a number of musical outcomes. A testing system was set up to compare the devices and analyze a number of relevant attributes of their performance, such as maximum speed and volume, consistency and latency. The advantages and disadvantages of each of the types of mechanisms are discussed, and suggestions are offered about which types of mechanisms are suitable for various musical contexts.

4:30 ***An Overview of MechBass: A Four String Robotic Bass Guitar***

James McVay and Dale A Carnegie (Victoria University of Wellington, New Zealand); Jim Murphy (New Zealand School of Music, New Zealand)

Traditional robotic guitar-like stringed instruments have lacked sufficient degrees of freedom and responsivity required to emulate even an average human guitar player. We seek to address this in the design and construction of a modular four-string robotic bass guitar, MechBass. This paper describes the various components of each module and the system-level operation of MechBass. The result is an instrument that can outperform (in terms of capability and consistency) even a highly skilled human guitar player.

4:50 ***A Study on Improving Sound Quality of Violin Playing Robot***

Won-se Jo and Hyeon jun Park (Kyung-Hee University, Korea); Bumjoo Lee (Myongji University, Korea); Donghan Kim (Kyung Hee University, Korea)

This paper introduces a violin playing robot that imitates the playing technique of human. A violinist learns how to play through an endless practice. A bowing velocity, bowing force, and sound point are important factors in determining the sound quality. Thus, in this paper, the sound quality has been analyzed in the variable speed using the violin playing robot, where an industrial vertical multi-joint robot arm is used. Fast Fourier transform is used to convert the played sound using a 32-bit microcontroller, and then the result is compared to the natural frequency of the G string. In order to measure the contact force of the violin bow, a two-axis load cell is produced and mounted on the bow handle. This paper also studies the impact speed of the bow on the violin. Lastly, this paper concludes with introducing the violin robot system using auditory feedback

5:10 ***Towards an Automated Pan Flute Player***

Kishan Kumar and Kishen Kumar (The University of the South Pacific, Fiji); Praneel Chand (University of the South Pacific, Fiji); Dale A Carnegie (Victoria University of Wellington, New Zealand)

This paper outlines some of the design details of creating an automated Pan Flute player targeting the Solomon Island's Pan Flute in the Pacific Region. Hence, the system functionality will be discussed first through a block diagram. Then the design will be further elaborated through discussion of the hardware assembly and different system modules. Thereafter, the results with overview of the system implementation will be seen. Finally, implications of the automated pan flute player on the society and future improvements will be discussed.

S3B: Health Systems 1

Room: Clancys
Chair: Julia Taylor (Purdue University, USA)

4:10 ***Gaussian Process Learning and Interpolation of Gait Motion for Rehabilitation Robots***

Changmook Chun (Korea Institute of Science and Technology, Korea); Jisoo Hong (Seoul National University, Korea); Seung-Jong Kim (Korea Institute of Science and Technology, Korea); Frank Park (Seoul National University, Korea)

We present an alternative approach to generate gait motion at arbitrary speed for gait rehabilitation robots. The methodology utilizes Gaussian process dynamical model~(GPDM), which is a nonlinear dimensionality reduction technique. GPDM consists of a dynamics in low-dimensional latent space and a mapping from the space to configuration space, and GPDM learning results in the low-dimensional representation of training data and parameters for the dynamics and mapping. We use second-order Markov process dynamics model, and hence given a pair of initial points, the dynamics generates a latent trajectory at arbitrary speed. We use linear regression to obtain the initial points. Mapping from the latent to configuration spaces constructs trajectories of walking motion. We verify the algorithm with motion capture data from 50 healthy subjects, who walked on a treadmill at 1, 2, and 3km/h. We show examples and compare the original and interpolated trajectories to prove the efficacy of the algorithm.

4:30 ***Spatial Probability Distribution for Port Planning in Minimal Invasive Robotic Surgery (MIRS)***

Jessica Hutzl (KIT Karlsruhe, Germany); Heinz Wörn (Karlsruhe Institute of Technology (KIT), Germany)

The objective of this paper is to predict the operation workflow of the surgical instruments, which pictures a trajectory of interest and gives a spatial analysis of points of interest. The information which is presented in a knowledge base of recorded trajectories of one specific type of operation will be used. The master trajectory builds up the generally motion with a probability distribution in space. A workspace analysis of the robot within a selected port position has to be done. The dexterity of the robot to move along the generated master trajectory should be an indicator for a good placed port and the robot position.

4:50 ***The Kinematic Synthesis of a Spatial, Hyper-Redundant System based on Binary Electromagnetic Actuators***

Svenja Tappe, Jens Kotlarski, Tobias Ortmaier, Michael Dörbaum, Axel Mertens and Bernd Ponick (Leibniz Universität Hannover, Germany)

Flexible endoscopes are a common instrument for different tasks in minimally invasive surgery. The motion and capability of resistance against manipulation forces of common endoscopes is restricted due to their flexibility. They tend to form loops and stress their surroundings. This paper proposes an active shaft concept based on a new actuation concept: the shaft is a hyper-redundant snake- like robot with binary electromagnetic actuators. This system combines good path following capabilities through actively controlling the whole endoscope body with good resistance with respect to manipulation forces through electromagnetism. The functional concept is presented and the influence of design parameters on kinematic characteristics such as workspace and radius of curvature is evaluated. Additionally, a set of kinematic design parameters is synthesized by minimizing the contouring error. Therefore, a path fitting algorithm is proposed.

5:10 ***Entertainment Services of a Healthcare Robot System for Older People in Private and Public Spaces***

Ho Seok Ahn (The University of Auckland, New Zealand); Chandan Datta (University of Auckland, New Zealand); I-Han Kuo (Unitec Institute of Technology, New Zealand); Rebecca Stafford (University of Auckland, New Zealand); Ngaire Kerse and Kathy Peri (The University of Auckland, New Zealand); Elizabeth Broadbent (University of Auckland, New Zealand); Bruce MacDonald (The University of Auckland, New Zealand)

In this paper, we analyze the use of entertainment services on our healthcare robot system, and find 1) how long robots were used, 2) which entertainment service was most used, 3) which music video category was most preferred, and 4) which music video was most preferred. We developed a healthcare robot system, HealthBot, and deployed several of them in an older care facility, and obtained the usage histories of three kinds of entertainment services: music videos, quotes, and pictures. We report results about the preferences of participants in private and public spaces.

S3C: WSN / Communications

Room: Wakatipu
Chair: Eric Matson (Purdue University, USA)

4:10 ***Helping Secure Robots in WSN Environments by Monitoring WSN Software Updates for Intrusion***

A S M Ashraful Alam, David Eyers and Zhiyi Huang (University of Otago, New Zealand)

Robotics and Wireless Sensor Network (WSN) collaboration is an emerging research field in which both technologies can benefit from integrated implementations. A robot operating in WSN assisted environments can dynamically push instructions using over the air (OTA) update protocols to alter sensors to suit the requirements. In this paper, an Intrusion Detection System (IDS) for a WSN software update protocol is designed and simulated. When the protocol modifies the running software in a mote, the mote sends related information to the WSN sink. The IDS analyses the update phenomena of each of the motes in the network and computes an Intrusion Warning Score (IWS) that indicates a possible intrusion due to an illegitimate software update.

4:30 ***Protocol for Improved Energy Efficiency in Wireless Sensor Networks to Support Mobile Robots***

Debraj Basu, Gourab Sen Gupta, Xiang Gui and Giovanni Moretti (Massey University, New Zealand)

This research paper proposes a low cost and computationally inexpensive adaptive transmission power control algorithm for wireless sensors to communicate with the base station or hub. This power control algorithm can be used in scenarios where the transmitting station is not static and the distance between the transmitter and the receiving station changes with time. In addition to that there can be unwanted obstructions in between the transmitter and the receiver. Since the primary reason for drop in received signal strength is distance, it is important to select a set of power levels that will deliver the packets within a threshold error rate while saving energy. This adaptive algorithm does not use received signal strength indicator (RSSI) based beacon or probe packet for channel estimation nor listens for any busy channel before actual packet transmission. The hardware used for evaluating the protocol parameters is nRF24L01+ transceiver module from Nordic Semiconductor Inc. This chip is extremely cheap and the application of the adaptive power control protocol can reduce the overall deployment cost of sensor network. This algorithm is designed to meet the challenge of responding to an unknown and variable radio channel in an energy-efficient manner. The adaptive protocol uses past transmission experience or memory to decide the power level at which the new packet transmission will start. This lightweight protocol can be applied in mobile robots that collect data in real time from sensors and transmit to the base station.

4:50 ***A Novel Approach of Sensor Data Retrieving using a Quadcopter in Wireless Sensor Network Forming Concentric Circular Topology***

Ranjan Dasgupta (Tata Consultancy Services Ltd, India); Ritwick Mukherjee (Oracle India Pvt. Ltd., Bangalore, India); Amitava Gupta (Jadavpur University, Calcutta, India)

Paper describes a concentric circular wireless sensor network topology and sensor data retrieving strategy using a mobile sink. It states how to improve network lifetime by reducing energy consumption of power constrained sensor nodes. It eliminates packet routing and optimizes packet retransmissions. Sensors are uniformly distributed across the sensor field of size r x r so that they are all placed inside a disk D of radius r. Network is formed by creating concentric circles around the center and partitions the disk into n annuli. Each annulus is further divided into m wedges by partitioning the disk into sectors. Sensors belong to each wedge form Star network with the sink. At each level, sink optimizes its pose so that every node can send their data by one hop communication. The strategy holds good even when large holes are formed inside the network due to nodes failure and creates network partition.

5:10 ***OPART: Towards an Open Platform for Abstraction of Real-Time Communication in Cross-Domain Applications***

Morteza Hashemi Farzaneh (Tech Univ Muenchen TUM, Germany); Alois Knoll (Technical University Munich Garching, Germany); Jonas Pfeiffer (TU München, Germany)

Developing real-time communication in various application fields such as robotics, factory automation, etc. is one the most important steps achieving a deterministic system. However, the development of this step is very complex and requires low level and advanced knowledge about the real-time communication systems. This complexity decelerates the developing process specially in cross-domain applications e.g. surgical control applications in Networked Medical Systems (NMS)requiring real-time communication and deterministic system behavior. General complexities developing real-time communication systems are classified. The architecture of an Open Platform for Abstraction of Real-Time Communication (OPART) is introduced for reducing these complexities. The architecture of OPART is based on the Ethernet-based real-time communication protocol openPOWERLINK. An experimental setup of OPART using a medical sensor and actuator is demonstrated.

Wednesday, February 18

9:00 AM - 10:00 AM K2: Keynote 2

From Electric Cars to Autonomous Vehicles

Thomas Braunl

Room: Queenstown

Chair: Donald G. Bailey (Massey University, New Zealand)

10:00 AM - 10:30 AM Morning Coffee Break

Room: Foyer (Level 5)

10:30 AM - 12:10 PM (Parallel Sessions S4A, S4B and S4C)

S4A: Special Session on Sensing, Automation and Robotics in Agriculture

Room: Queenstown

Chair: Ian M Woodhead (Lincoln, New Zealand)

10:30 ***A Novel Vision Based Row Guidance Approach for Navigation of Agricultural Mobile Robots in Orchards***

Mostafa Sharifi and XiaoQi Chen (University of Canterbury, New Zealand)

This paper presents a novel vision based technique for navigation of agricultural mobile robots in orchards. In this technique, the captured color image is clustered by mean-shift algorithm and then a novel classification technique based on graph partitioning theory classifies the clustered image into defined classes including terrain, trees and sky. Then, Hough transform is applied to extract the features required to have desired central path for robot navigation in an orchard row between trees. Finally using this technique, the mobile robot can change and improve its direction with respect to desired path. The results show this technique classify and orchard image properly into defined elements and can produce the optimal path for the mobile robot.

10:50 ***Design and Implementation of a Wireless Sensor Network for Rose Greenhouses Monitoring***

Mayra Erazo, David Rivas, Milton Pérez, Omar Galarza and Víctor Bautista, Naranjo (Universidad de las Fuerzas Armadas ESPE, Ecuador); Monica Karel Huerta (Simon Bolivar University, Venezuela); Jose Luis Rojo-Alvarez (University Rey Juan Carlos, Spain)

This work presents the design and implementation of a wireless sensor network, by using the ZIGBEE communication standard, for system monitoring on watering, climate control, and lighting on rose greenhouses. Our aim is to developed a remote and low-cost supervision system, hence providing farmers in small and medium enterprises in the flower-growing sector with the possibility of continuous follow-up of greenhouses and of immediate corrective actions on them, hence improving the productivity. Our results show that after three months of the network deployed and being operative on an Ecuadorian greenhouse, climate changes impact on the rose quality and diseases have dramatically reduced.

11:10 ***Laser-Induced Breakdown Spectroscopy Analysis of Sodium in Pelletised Pasture Samples***

Harrisson Jull, Rainer Kunnemeyer and Sadhana Talele (University of Waikato, New Zealand); Peter Schaare (The New Zealand Institute for Plant and Food Research Ltd, New Zealand); Mark Seelye (Massey University, New Zealand)

Sodium concentration in plants inhibit shoot and root growth. Traditional wet-chemical methods of determining elemental concentrations require pre-treatment and leave unwanted by-products. Laser-induced breakdown spectroscopy (LIBS) needs little pre-treatment and produces no secondary waste. LIBS is used in this work to determine sodium concentrations in dried pasture samples. Temperature correction on the gathered spectra was attempted using Boltzmann/Saha-Boltzmann plots. These methods failed to deliver satisfactory results. Different combinations of internal reference standards were used which resulted in an improved correlation with sodium concentrations. Partial least squares regression was used on the gathered spectra to find emission lines that vary with the sodium concentration. Calcium, sodium, potassium and an argon line demonstrated high predictor weights. Potassium exhibited a large dependence on the sodium concentration. Building a calibration curve of sodium to potassium emission line intensity versus sodium to potassium concentration in the samples produced a correlation of R2 = 0.918.

11:30 ***Impulse Radar – a New Sensor for Robots***

Ian M Woodhead (Lincoln Agritech Ltd, New Zealand); Adrian Tan (Lincoln Agritech Limited & Lincoln University, New Zealand); Sean Richards (Lincoln Agritech Limited, New Zealand); Ian G Platt (Lincoln Agritech Ltd, New Zealand)

Ground-based robots for agricultural applications are receiving increased attention as labour availability and cost drives interest and uptake. Here we describe a radar method that is suitable for soil moisture measurement from a moving vehicle. We have employed techniques from impulse radar that enable measurement of soil reflection at resolutions smaller than the antenna beam width. We show how the resolution is affected by the radar pulse-width, antenna parameters, radar location and sensing angle. The radar backscatter coefficient is calculated from the radar signals themselves, and demonstrated by measurements taken on wet pasture at different elevation angles. Measurements show that radar backscatter coefficients can be reliably measured at angles up to 60 degrees from the nadir.

11:50 ***Automated weighing by sequential inference in dynamic environments***

Andrew Martin and Tim C. A. Molteno (University of Otago, New Zealand)

We demonstrate sequential mass inference of a suspended bag of milk powder from simulated measurements of the vertical force component at the pivot while the bag is being filled. We compare the predictions of various sequential inference methods both with and without a physics model to capture the system dynamics. We find that a non-augmented unscented Kalman filter (UKF) in conjunction with a physics model of a pendulum of varying mass and length provides rapid and accurate predictions of the milk powder mass as a function of time. The non-augmented UKF outperforms the other methods tested: an augmented-state UKF and a particle filter. Moreover, inference methods which incorporate a physics model outperform equivalent algorithms which do not.

S4B: Tactile / Haptic Systems

Room: Clancys

Chair: Mohan Rajesh Elara (Singapore University of Technology and Design, Singapore)

10:30 ***Discriminative touch from pressure sensors***

Adrien Jule (ISEN, France); Brendan McCane, Alistair Knott and Steven Mills (University of Otago, New Zealand)

Touch is an important sensory pathway for exploring the world, but most robotic systems either have no sense of touch, use simple binary bump switches, or require expensive custom sensors. In this work we investigate the use of low-cost sensors to acquire more discriminative representations of touch sensations. We show that using two pressure sensors in a 3D-printed housing we can determine the location of a touch along a one dimensional axis. Furthermore, we can distinguish between different types of touches by the profile of the sensor response.

10:50 ***Verification of Sinusoidal Steady State system identification of a Phantom Omni haptic device using Data Driven modeling***

Bartholomew Milne (University of Canterbury, New Zealand); Henrik Beelen, Ruben Merks and Siep Weiland (Technische Universiteit Eindhoven, The Netherlands); XiaoQi Chen and Christopher Hann (University of Canterbury, New Zealand); Richard Parker (Scion New Zealand, New Zealand)

Haptic feedback has two important sources of dynamics: the machine being controlled and the haptic device itself. This paper concentrates on the means of identifying the dynamics of a Phantom Omni haptic feedback device. Two models are compared: a dynamic model with parameters using results from sinusoidal steady state analysis and a data driven model that uses pseudo-random binary sequences (PBRS) for identification. The overall form of the frequency and phase response is well-defined for the dynamics model but for the data driven model a spectral estimate from PBRS response data is used to determine the model order. The results in this paper show that a dynamic equation based minimal model produces acceptable accuracy compared to the data driven model. Future work includes development and verification an arm inertia model that allows system parameters to be identified from response data at arbitrary arm angles.

11:10 ***A multimodal human machine interface for a robotic mobility aid***

Johannes Schneider (Karlsruher Institut für Technologie, Germany); Stephan Irgenfried (Karlsruhe Institute of Technology (KIT), Germany); Wilhelm Stork (Karlsruhe Institute of Technology, Germany); Heinz Wörn (Karlsruhe Institute of Technology (KIT), Germany)

This paper presents design, implementation details and field trial results for a multimodal human machine interface for a robotic walking and sit to stand transfer assisting device with force-torque-sensor, user intention detection and active fall prevention. Two different human machine interfaces are described, a purely haptic version with buttons only and an alternative approach using a tablet computer. It is described, how the different modalities, optimized for the target user group of elderly persons, make the interaction with the system intuitive and reduce fear of contact with such a technical system. For the tablet PC based touch sensitive interface we describe our approach to automatically track user interactions with the system for detailed analysis and user interface optimization.

11:30 ***Tactile Sensing System Using Electro-tactile Feedback***

Daniel Pamungkas and Koren Ward (University of Wollongong, Australia)

Tactile or touch sensing can enable an object's surface texture and other properties to be perceived which can facilitate grasping and manipulating various objects. Prosthetic hand users and operators of tele-operated robot arms also need to perceive these tactile properties by some means to effectively manipulate objects and performed skilled work. This paper introduces a tactile sensing and feedback system that is based on detecting minute surface vibrations in an artificial finger, when contact with a surface is made, and appropriately stimulating nerves in the user's skin with electro-tactile feedback. This feedback system has benefits over existing systems because it can deliver a wide variety of sensations to the user and is compact, non-mechanical, wireless and comfortable for the user to wear. Experimental results are provided which show the potential of our system at achieving remote tactile sensing and feedback of textured surfaces

11:50 ***Immersive Teleoperation of a Robot Arm Using Electro-tactile Feedback***

Daniel Pamungkas and Koren Ward (University of Wollongong, Australia)

To achieve more dexterous control of a tele-operated robot some researchers are developing user interfaces equipped with vision and tactile feedback. 3D visual perception and tactile feedback can also assist the operator to feel immersed in the robot's environment and embodied within the robot to some extent. Most existing tactile feedback systems use electro-mechanical actuators and linkages. However, these systems are complex, cumbersome and consequently make it difficult for the operator feel embodied within the robot. To improve on these drawbacks, this paper introduces an immersive tele-operation system comprised of a 3D stereo vision combined with an electro-tactile feedback system. This feedback system is compact, non-mechanical and versatile. Experimental results are provided which show how this form of immersive feedback system can enable the user to achieve more dexterous control of a robot arm by enabling the operator to effectively see what robot sees and experience what the robot feels.

S4C: Underwater Systems

Room: Wakatipu

Chair: Donghan Kim (Kyung Hee University, Korea)

10:30 ***Review of Underwater SLAM Techniques***

Franco Hidalgo and Thomas Bräunl (University of Western Australia, Australia)

SLAM (Simultaneous Localization and Mapping) for underwater vehicles is a challenging research topic due to the limitations of underwater localization sensors and error accumulation over long-term operations. Furthermore, acoustic sensors for mapping often provide noisy and distorted images or low-resolution ranging, while visual images provide highly detailed images but are often limited due to turbidity and lighting. This paper presents a review of the approaches used in state-of-the-art SLAM techniques: Extended Kalman Filter SLAM(EKF-SLAM), FastSLAM, GraphSLAM and its application in underwater environments.

10:50 ***Hybrid path planning algorithm in two-dimensional and three-dimensional spaces***

Andrey Kirsanov (The University of New South Wales at Australian Defence Force Academy, Australia); Sreenatha Anavatti (University College, ADFA & University of New South Wales, Australia); Tapabrata Ray (University of New South Wales at ADFA, Australia)

The task of path planning for autonomous underwater vehicles (AUVs) has received considerable attention in the research literature. Most of the works assume that the AUV has complete trajectories with final destination and prior known distance. Less attention has been paid to the problem of path planning with different distances. This problem occurs for an AUV that must explore

new paths with as unknown environment. There are various path planning algorithms that can be applied to robotic systems depending on the task of path planning, distances of the path, and parameters of obstacles on the map. Sometimes it is necessary to combine the tasks which in conjunction with each other does not give effective results on time, range, and accuracy obstacle avoidance. This paper considers different algorithms to determine the most effective path planning algorithm. The hybrid algorithm is shown to be more efficient compared to the existing ones.

11:10 ***Intelligent underwater vehicle with multirole capabilities***

Nataliya Derevyanko (The University of New South Wales UNSW Canberra, Australia); Sreenatha Anavatti (University College, ADFA & University of New South Wales, Australia); Tapabrata Ray (University of New South Wales at ADFA, Australia)

Autonomous underwater vehicles (AUV) have serious limitations in terms of range and mission capabilities. We introduce an intelligent AUV able to adjust its shape and control system for efficient performance during different missions. In this paper, we evaluate such approach by analyzing the benefits associated with the use of morphed shape for vertical motion, i.e. diving or surfacing mission. The results show, that the morphed shape allows reducing the drag coefficient, thus increasing vehicle range on 25% compared to the traditional torpedo shape (at 2 m/s) for diving and surfacing operations.

11:30 ***Smart vehicle design for underwater applications with low hydro-acoustics noise***

Andrey Kirsanov (The University of New South Wales at Australian Defence Force Academy, Australia); Sreenatha Anavatti (University College, ADFA & University of New South Wales, Australia); Tapabrata Ray (University of New South Wales at ADFA, Australia)

Smart vehicles are becoming a necessary part of the modern fleet for various missions. Hydro-acoustic emission is a major source for identification of a vehicle and also a source of disturbance for environmental monitoring applications. The sources for these emissions vary from engine and other internal parts along with the speed as well. This paper addresses the shape design of smart underwater vehicles for reduced acoustic emissions. In this paper, a double layered shape design of underwater vehicle is proposed. Numerical results are calculated for the hydro-acoustic emissions at different locations. The effectiveness of the proposed shape is judged by comparing two well-known shapes of underwater vehicles in terms of hydro-acoustics efficiency. The double layered shape design allows reduction in acoustic emission by about 15% compared to the conventional shapes. This is likely to benefit military as well as civilian underwater applications of underwater vehicles.

11:50 ***Analysis of the Group Structure of a School of Biomimetic AUVS Coordinated Using Nearest Neighbour Principles***

Jonathan McColgan, Euan McGookin and Ahmad Naddi Ahmad Mazlan (University of Glasgow, United Kingdom)

Currently, the majority of Autonomous Underwater Vehicle (AUV) missions are completed by a single AUV. However, there is now the demand for AUVs to be operated within a multi-vehicle scenario to allow large area scanning to be achieved. Consequently, this paper uses a mathematical model of a biomimetic AUV (RoboSalmon) to propose the implementation of coordination algorithms based on the behavioural mechanisms exhibited by schools of fish to allow a group of Biomimetic AUVs to be self-organising. The resulting group structure will be analysed with reference to the group structure as well as the number of AUVs taken advantage of the hydrodynamic benefits known to exist from fish swimming in close formation. The results demonstrate that the number of nearest neighbours taking into consideration greatly affects the formation of a stable school structure whereas the size of the school dictates the number of AUVs within the group benefitting hydro-dynamically.

12:10 PM - 1:20 PM Lunch Break

Room: Ben Lomond Restaurant

1:20 PM - 1:50 PM IT2: Invited Talk 2

How to Plug-in Your Rover into a Space Mission to Moon or Mars

Mehran Sarkarati

Room: Queenstown

Chair: Gourab Sen Gupta (Massey University, New Zealand)

1:20 ***How To Plug-in Your Rover into a Space Mission to Moon or Mars***

Mehran Sarkarati, Mario Merri, Kim Nergaard and Paul Steele (European Space Agency, Germany)

ESA has been working on specifying a set of standardised Telerobotic Service Interfaces in the context of the METERON project. These Services shall facilitate integration of new Robotic agents into the generic infrastructure of future human-robotic space missions. The METERON Robotic Services were used for the first time as part of the METERON OPSCOM-2 experiment, during which an ESA astronaut monitored and controlled from the International Space Station (ISS) a car-size rover on the ground via the Delay Tolerant Network (DTN), while the same service interfaces were used via a different communication protocol to perform distributed monitoring of the activities on the ground. At multi-agency level, the Telerobotics working group of the Consultative Committee for Space Data Systems (CCSDS) has similar objective of specifying of a set of generalised service interfaces, which shall facilitate interoperability of robotic agents. The specified METERON Robotic Services are an input to this standardisation effort.

1:50 PM - 3:10 PM (Parallel Sessions S5A, S5B and S5C)

S5A: Bio-inspired Systems

Room: Queenstown

Chair: Dale A Carnegie (Victoria University of Wellington, New Zealand)

1:50 ***Bio-inspired Knee Joint Mechanism for a Hydraulic Quadruped Robot***

Hamza Khan, Roy Featherstone, Darwin Caldwell and Claudio Semini (Istituto Italiano di Tecnologia, Italy)

Legged robots are becoming a promising solution for rough terrain navigation, however, existing legged machines often lack versatility to perform a wide range of different gaits. To build a highly dynamic legged robot, it is essential to have lightweight legs with optimized design and actuators for the desired robot performance and tasks. The goals are to achieve 1)a wide range of motion for bigger foot workspace which will increase rough terrain walking performance by increasing the number of reachable footholds for each step, 2)optimized joint torque curve since torque demand is related to joint angle. In this paper, we focus on the knee joint and propose the adaptation and optimization of the so-called isogram mechanism. It exhibits a changeable instantaneous center of rotation,similar to a human knee joint. We will show how an optimization of design parameters lead to a knee joint design that satisfies the above mentioned goals.

2:10 ***Concepts and simulations of a soft robot mimicking human tongue***

Xuanming Lu and Peter Xu (The University of Auckland, New Zealand); Xiaoning Li (Nanjing University of Science & Technology, P.R. China)

The structure of a novel soft robot which can mimic a few movements of human tongue was designed with a series of embedded chambers using pneumatic actuation pattern. Two silicone materials (Ecoflex 0030 and PDMS) were chosen to fabricate the body of the robot. FEM simulations have been carried out using software Abaqus. Four types of deformation have been achieved in simulation including roll, groove, elongation and twist when different combinations of chambers were pressurized with the same pressure of 17 kPa. The relationship between deformation range and structural parameters, the pressure in each chamber was also discovered during simulation.

2:30 ***Wheel Spider with Rolling Locomotion: Modeling and Simulation***

Takuma Nemoto (Tokyo Denki University, Japan); Mohan Rajesh Elara (Singapore University of Technology and Design, Singapore); Syunsuke Nansai and Masami Iwase (Tokyo Denki University, Japan)

This study aims to develop mathematical model which can capture behavior of wheel spider that can perform rolling locomotion and analyze characteristics of the behavior to realize biologically inspired locomotion by robots. Therefore, a rolling wheel spider model is developed by applying constraint force on the ground to a wheel spider model without the ground and considering velocity transformation due to collision. As a result, it was found that the wheel spider goes downhill at a constant speed with rolling whether it is provided with initial velocity or not. In conclusion, the wheel spider can go down the slope over a certain pitch without providing initial velocity.

2:50 ***Rise time based characterization of sub-millimeter SMA helical actuator for sensorless displacement estimation***

Sreekanth M, Abraham Mathew and Vijayakumar R (National Institute of Technology Calicut, India)

Bio mimicking micro/miniature robots require design aesthetics, simplicity, low power, lower computational requirement, resilient operation and repeatability. The main choice of actuators in such systems are Shape Memory Alloys (SMA). The larger strain and reduced size of the SMA sub millimeter diameter helical springs make them a potential choice in such systems. In sub-millimeter helical SMA actuators, sensorless position control is preferred due to physical limitation. For position estimation, electrical parameters like Inductance and Resistance are considered normally. This paper presents a new approach based on the Rise time variation along the actuation of SMA spring. Considering SMA spring as RL element, a characterization technique is proposed for sensorless position estimation based on rise time variation. The proposed method independent of ambient temperature variations. Investigations have shown that rise time based position control through PWM based current drives can be implemented for manipulating displacement without a sensor.

S5B: Robotic Arms

Room: Clancys

Chair: Rini Akmeliawati (International Islamic University, Malaysia)

1:50 ***Development of two degrees of freedom deterministic parallel robotic arm unit***

Jimin Liang and Gong Zhang (Guangzhou Institutes of Advanced Technology, Chinese Academy of Science, P.R. China); Xianshuai Chen and Dazhi Wang (Guangzhou Institutes of Advanced Technology, Chinese Academy of Science, P.R. China)

This paper investigates the development of an exact constraint parallel robotic arm unit. In addition to the advantages of simple structure and compact size, the six points exactly constrained parallel robotic arm unit is both statically and kinematically deterministic, thus is more suitable for clinical application. Theoretical analysis based on the principle of exact constraint is given to explore the degree of freedom and constrain pattern of the parallel robotic arm unit. Furthermore, the orientation adjusting principles at various input statuses are presented to promote the orientation process. The performances of the fabricated parallel robotic arm unit are confirmed by experimental studies. As the parallel robotic arm unit has relatively small workspace, numerous parallel robotic arm units, with various sizes, should be cooperated to achieved the desired workspace.

2:10 ***Inverse Engineering Design and Construction of an ABS Plastic, Six DOF Robotic Arm Structure***

David Rivas (Universidad de las Fuerzas Armadas ESPE, Ecuador); José Luis Carrillo-Medina (Universidad de las Fuerzas Armadas ESPE & Extensión Latacunga, Ecuador); Víctor Bautista, Naranjo, Mayra Erazo, Milton Pérez and Omar Galarza (Universidad de las Fuerzas Armadas ESPE, Ecuador)

Robotic arms have been proposed since the 50's and have evolved to play a key role in a number of applications, such as food, auto motion, and entertainment industry. Two of the paramount parameters in the design of arm robots are their weight and their strength efficiency. Our aim was to improve these two key parameters by using ABS plastic in the design and construction of a robotic arm structure with six degrees of freedom. ABS plastic is a highly stiff and hard material even at low temperatures. More, it represents a low-cost solution compared to conventional materials such as aluminum and steel, hence it is widely used in many engineering applications.

2:30 ***BRACON: Control system for a robotic arm with 6 degrees of freedom for education systems***

David Rivas (Universidad de las Fuerzas Armadas ESPE, Ecuador); Javier Mamarandi (Universidad de las Fuerzas Armadas ESPE-L, Ecuador); José Luis Carrillo-Medina (Universidad de las Fuerzas Armadas ESPE & Extensión Latacunga, Ecuador); Víctor Bautista, Naranjo, Omar Galarza, Wilson Reyes, Mayra Erazo and Milton Pérez (Universidad de las Fuerzas Armadas ESPE, Ecuador)

This article focuses on the design and development of a control system for a robotic arm designed at the Universidad de las Fuerzas Armadas, Latacunga extension, by using Dynamixel servomotors. The use of Python software, with advantages and features of being a free programming language, provides the project with reliability and ease of communication with a computer arm. The use of these techniques allow us to obtain solutions much cheaper than the current ones by using open source software.

2:50 ***Inverse Kinematics Solution for Trajectory Tracking using Artificial Neural Networks for SCORBOT ER-4u***

Rahul Kumar (The University of the South Pacific, Fiji); Praneel Chand (University of the South Pacific, Fiji)

This paper presents the kinematic analysis of the SCORBOT-ER 4u robot arm using Artificial Neural Networks (ANN). The SCORBOT-ER 4u is a 5-DOF vertical articulated educational robot whose all joints are revolute. The inverse kinematics solution is found using the ANN. This paper uses the forward kinematics to train the ANN. The Denavit-Hartenberg and Geometrical methods act as a feed-forward network (forward kinematic algorithms) to generate data and train the ANN. The algorithm is tested on a real physical robot (SCORBOT-ER 4u) and reliable results are obtained. The modeling and simulations are done using MATLAB 8.0 software.

S5C: Temperature / Force Sensors

Room: Wakatipu
Chair: Ian M Woodhead (Lincoln, New Zealand)

1:50 ***Junction Temperature Measurement of MOSFET Using Foward Voltage Drop***

Byong Jo Hyon (Korea Electronics Technology Institute, Korea); Jun-Hyuk Choi (KETI, Korea); Joon Sung Park (KETI & Korea Electronics Technology Institute, Korea); Jin-Hong Kim (KETI, Korea)

Due to concerns about energy saving, inverter system which can achieve high efficiency through the frequency modulation has been widely spread. The inverter system is widely used in robot, home appliance, and vehicle industry due to high efficiency and motor control. The power switch is essential for the configuration of such a drive system. Reliability of power switch is important for the variable applications. In this paper, a method for a junction temperature measurement is introduced. For the junction temperature measurement, the protection circuit allows the calibration of a power MOSFET. The evaluation is demonstrated experimentally.

2:10 ***Analysis and Selection of the Force Sensitive Resistors for Gait Characterisation***

Muhammad Shaikh, Zoran Salcic and Kevin I-Kai Wang (The University of Auckland, New Zealand)

Force Sensitive Resistors (FSRs) are used for kinetic evaluation of human gait by measuring under foot pressures during gait. FSRs from different manufacturers, with variation in morphologies and loading capacities were selected in past research projects. However a functional comparison of different FSRs and options on how to choose them for gait analysis is not established yet. In this work we investigate and compare behavioral patterns in measuring normal gait from two major FSR sensors, which had been utilised previously for the purpose of gait sensing. They were placed underneath the heel alternatively to detect heel pressures while wearing footwear with laces and with another footwear possessing straps for harnessing. Both sensors are connected to a miniature low power wireless senor node used for data collection and wireless transmission for off-line analysis of pressure patterns. The results give good indications on capabilities and trade-offs when using the two sensors types

2:30 ***A Fabry-Perot Optical Fiber Force Sensor Based on Intensity Modulation for Needle Tip Force Sensing***

Zonglai Mo, Peter Xu and Neil Broderick (The University of Auckland, New Zealand)

The force feedback absence in minimally invasive surgeries (MIS) is a chronic problem. The main obstacle is the intensive magnetic resonance (MR) influence on traditional electronic signals. This paper proposes a miniature and MR compatible optical force sensor based on Fabry-Perot interference (FPI) principle and interferometric-intensity modulation method. The FPI sensor, with 400μm outer diameter, is embedded in the tip of a rigid puncture needle with 1.0mm inner diameter. The sensor is simulated and fabricated, followed by signal processing using Fourier and wavelet transform analysis. Calibration results at 20 ℃ show that the force sensing range and resolution are 0-5N and 0.1N, respectively. Silicon rubber skin phantom insertion experiments suggest that the FPI sensor could identify clearly the type of tissues during the insertion and extraction procedure.

2:50 ***Towards Building an Accurate Low-Cost Biofeedback Platform using Force Sensors***

Johann Nel, Aaron Dalbeth, Gourab Sen Gupta and Ken Mercer (Massey University, New Zealand)

This paper details the design and development of a biofeedback platform. The platform is customizable; it has a load cell slider allowing the user to change the location of the load cells. A 24-bit sigma-delta ADC is used to interface with the load cells, these values are then transmitted to a computer via a microcontroller. The load cell values are extracted and scaled in real-time. The individuals load cell weights, total weight and center of pressure is displayed on the computer monitor. Experiments confirm that the load cells and ADC used in the biofeedback platform was highly accurate and responsive. A simple game was then developed, giving the user some physical exercise, also known as exergaming.

3:10 PM - 3:40 PM Afternoon Coffee Break

Room: Foyer (Level 5)

3:40 PM - 5:40 PM (Parallel Sessions S6A, S6B and S6C)

S6A: Special Session on Humans, software Agents, Robots, Machines and Sensors (HARMS)

Room: Queenstown
Chair: Eric Matson (Purdue University, USA)

3:40 ***An Intuitive Interaction System for Fire Safety Using A Speech Recognition Technology***

Seongha Park and Yongho Kim (Purdue University, USA); Changwha Lee (Ajou University, Korea); Hyeonae Jang (Dongguk University, Korea); Wooram Park (Gangneung-Wonju National University, Korea)

we propose an intuitive interaction system, which is a part of Cooperative Fire Security System using HARMS (CFH2S), to readily deal with fire in a high-rise building. The interaction system is a bridge connecting human as an operator to the whole system. Utilizing a natural language processing (NLP) technology using Microsoft Kinect makes the interaction system intuitive and have human-oriented operations. Human-Agent-Robot-Machine-Sensor (HARMS) provides a distributed network so that the systems are able to communicate with a high-level communication protocol. We established a scenario to verify the interaction system as well as the whole system. The result of the verification has remained several technical issues and challenges.

4:00 ***Design of Virtual Instrument for Automatic Temperature Visualization in Magnetic Fields Using LabVIEW in Combination With Fiber-Optical Temperature Measurement***

Eko Supriyanto (UTM, Malaysia); Christina Pahl (University of Technology Malaysia, Malaysia); Hanie Mazle (University Technology Malaysia, Malaysia)

Temperature measurement in magnetic fields is indispensable for Magnetic Resonance safety studies and for temperature calibrations during Magnetic Resonance applications. The existing problem is that for the software version NI LabVIEW 2013, there is no instrument provided to automatically process data from a fiber-optical temperature measurement device. In this work a virtual instrument for that software version is designed to automatically visualize temperature in magnetic fields. The setup consists of a magnetic field tolerant fiber-optical temperature measurement device being connected to temperature samples and a Microsoft based Computer System. Results show a functional software instrument for automatic temperature measurement with a maximum delay of 0.14s. We conclude that the developed instrument is highly suitable for biomedical applications and is adaptable for future versions of the LabVIEW software.

4:20 ***UGVs Spotting Fire Location for Cooperative Fire Security System using HARMS***

Mauricio Gomez (Purdue University, USA); JiHyun Song (Chonbuk National University, Korea); Junho Kim (Kyung Hee University, Korea); Siyoung Baek (KyungPook National University, Korea); Eric Matson (Purdue University, USA)

Recent trends are to build tall buildings in big cities as a way out of the current housing overpopulation problem. These new structures unveil problems that if not addressed in time could cause catastrophes of unimaginable impact. One of those problems is the incidence of a fire threat happening upstairs in one of those buildings. Research solutions include implementation of multi-agent fire safety systems for fire threats in high rise buildings. Human, agent, robot, machine and sensor communication model is used for indistinguishability of actors. This work discusses the implementation of the unmanned ground vehicles to spot the real location of the fire.

4:40 ***Wireless Sensor Network and Big Data in Cooperative Fire Security System using HARMS***

Bakytgul Khaday and Eric Matson (Purdue University, USA); Young Ki Kwon (Chung-Ang University, Korea); John Springer and Daulet Kenzhebalin (Purdue University, USA); Hansu Kim (Dongguk University, Korea); Sukyeong Cho (Hanbat Natinal University, Korea); Sunbin Kim (MyongJi University, Korea); Hong Seung Woo and Jinwoong Yoon (Konkuk University, Korea)

Growing population and shortage of land in urban areas led to development of tall buildings. Tall buildings have advantages and at the same time disadvantages. One of the disadvantages is that they are not fully safe in fire situations, because fire trucks cannot reach them. Fire danger can be prevented and eliminated if it is detected early. Implementing Wireless Sensor Network and Big Data and collecting-sending data to other members of Cooperative Fire Security System using Human Agent Robot Machine Sensor messaging protocol establish faster communication and collaboration among all the members of the whole system. The stationary WSN generates and analyzes the data and wirelessly communicates with other members of the system. Big Data is the central data manipulating center which communicates with all the system members and controls the whole system work. This paper presents detailed implementation and application of WSN and Big Data in cooperative firefighting system.

5:00 ***Humanoid Robots Rescuing Humans and Extinguishing Fires for Cooperative Fire Security System using HARMS***

Amy Wagoner (Purdue University, USA); EunSeop Lee (Kyunepooke National University, Korea); Adith Jagadish (Purdue University, USA); Kyeong Tae Kim and Dong Hyung Lee (Soongsil University, Korea); Yoanna Nah (Sogang University, Korea); Ju-Eun Joeng (Mokpo National University, Korea); Eric Matson (Purdue University, USA)

Fires cause millions of dollars in damage and thousands of deaths each year. Firefighting robots are being deployed around the world to reduce the loss of human life property damage. Highrise buildings present a great challenge to firefighters. Firefighter ladders cannot reach high enough to fight fires at the top of the building. Going into the building itself in order to extinguish the blazing fire is typically too dangerous and puts firefighters at risk. Monitoring, locating, and extinguishing the fire in the smallest amount of time is crucial to controlling fires in highrise buildings. This paper introduces humanoid robots capable of moving towards and extinguishing a fire and locating and rescuing any humans trapped in the inferno. This paper is one part of a Cooperative Fire Security System using HARMS (CFS^2H) that detects, locates, and extinguishes a fire and rescues human beings using HARMS protocol.

5:20 ***Implementing a HARMS-Based Software System for use in Collective Robotics Applications***

Alex Ryker (Purdue University, USA)

As robotic technology advances, robots become increasingly ubiquitous in the lives of humans. To facilitate this ubiquity, systems must be created that allow robots to interact easily with human beings. These systems must provide for communication between an arbitrary number of agents; for example, a home automation system with half a dozen environment sensors or a city-wide fire prevention system with hundreds of firefighting robots. In addition, these systems must support agents of varying complexity levels which could range from simple temperature sensors to database systems to autonomous robots. In this paper, we present the results of an experimental implementation of a HARMS-based system, the model for which has been proposed by Lewis et al.

S6B: Applications 1

Room: Clancys

Chair: Rainer Kunnemeyer (University of Waikato, New Zealand)

3:40 ***A Fluid Dynamics Model for Wind Turbine Generators in Equatorial Environments***

Milton Pérez, David Rivas, Mayra Erazo, Víctor Bautista, Naranjo, Omar Galarza and Wilson Reyes (Universidad de las Fuerzas Armadas ESPE, Ecuador); Monica Karel Huerta (Simon Bolivar University, Venezuela); Jose Luis Rojo-Alvarez (University Rey Juan Carlos, Spain)

Wind turbine generators represent a valid and sustainable alter-native for a significant energy provision, which is increasingly demanded by the planet, and a number of generator models have been proposed for supporting their design. However, equatorial regions have very special conditions for their gravity and wind behavior. Therefore, we present here a new wind turbine-generator model suitable for equatorial environments. Our simu-lation system is based on computational fluid dynamics and the Navier-Stokes equation, accounting both for structural and ener-gy efficiency considerations. The most relevant simulation param-eters were shown to be the Shovel number, the rotor diameter, the generated power, and the working frequency. Simulation results were consistent with different gravity conditions affecting to the fluid viscosity and the blades weight, as well as with differ-ences in uniform and turbulent wind flow behavior. The pro-posed model allows us to make decisions about the structure and optimal requirements suitable for equatorial regions.

4:00 ***Rolling Element Bearing Fault Diagnosis based on NLM de-noising and EMD-based Feature Extraction and PNN Classifier***

Van Mien and Hee-Jun Kang (University of Ulsan, Korea)

In this paper, an automatic fault diagnosis of different rolling element bearing faults is presented. First, the nonlocal means (NLM) de-noising and empirical mode decomposition (EMD) is proposed to preprocess the original vibration signal to obtain fault characteristic information more accurately. Then, features in time domains are extracted from each of the original signal and some useful IMFs to generate a rich combined feature set. In the feature selection task, a distance evaluation technique (DET) is used to remove the redundant and irrelevant information and select the most discrimination features. Finally, the selected feature set is used as the input to the probabilistic neural network (PNN) classifier to evaluate the system performance, in the classification task. To seek the optimal value for smoothing parameter of PNN classifier, particle swarm optimization (PSO) algorithm is applied. The experiment results for bearing vibration signal demonstrate that the proposed method has effectiveness.

4:20 ***Sensorless position control of voice-coil motors for needle-free jet injection***

James Mckeage, Rhys Williams, Bryan P. Ruddy, Poul F Nielsen and Andrew Taberner (University of Auckland, New Zealand)

This paper demonstrates a simple method for sensorless position estimation and control of a linear voice-coil actuator. Such actuators are currently used in needle-free jet injector prototypes. The sensorless method makes use of the position dependent impedance of the voice-coil at high frequencies to produce an estimate of coil position. This is achieved through the addition of a high frequency signal to the motor's driving signal. The position and frequency dependence of the voice-coil impedance is presented. The ability of this sensorless position estimation method to control position to a square set point is demonstrated using PID control. A jet injection is performed in order to observe the ability of this position sensing method to track position in such a high speed application.

4:40 ***An Efficient Solution Method for Multibody Systems with Loops Using Multiple Processors***

Tushar Ghosh and Luong Nguyen (L-3 Communications, NSS, USA); Leslie Quiocho (NASA Johnson Space Center, USA)

This paper describes a multibody dynamics algorithm formulated for parallel implementation on multiprocessor computing platforms using the divide-and-conquer approach. The system of interest is a general topology of rigid and elastic articulated bodies with or without loops. The algorithm divides the multibody system into a number of smaller sets of bodies in chain or tree structures, called "branches" at convenient joints called "connection points", and uses an Order-N (O (N)) approach to formulate the dynamics of each branch in terms of the unknown spatial connection forces. The equations of motion for the branches, leaving the connection forces as unknowns, are implemented in separate processors in parallel for computational efficiency, and the equations for all the unknown connection forces are synthesized and solved in one or several processors. The performances of two implementations of this divide-and-conquer algorithm in multiple processors are compared with an existing method implemented on a single processor.

5:00 ***A Connected Component Labeling Algorithm for Sparse Lidar Data Segmentation***

Abhijeet Ravankar, Yukinori Kobayashi, Ankit Ravankar and Takanori Emaru (Hokkaido University, Japan)

This paper proposes an extended connected components labeling algorithm for sparse Lidar (Light detection and ranging) sensor data. It is difficult to label sparse Lidar data using the general connected-component labeling algorithm. The proposed technique first increases the density of the sparse data by performing mathematical morphological operation of dilation. Next, labeling is performed on the dilated data, and the resultant labels are mapped to the input sparse Lidar data. We show the application of the proposed algorithm in map building using clustering. Results show that the proposed method can label sparse Lidar data to build maps.

5:20 ***A view-based method for local homing of unmanned rotorcraft***

Aymeric Denuelle and Saul Thurrowgood (The University of Queensland, Australia); Farid Kendoul (CSIRO, Australia); Mandyam Srinivasan (The University of Queensland, Australia)

This paper describes a novel view-based method using panoramic images to perform local homing in outdoor environments. This holistic algorithm makes uses of difference images (in relation to a reference snapshot) to build an image reference frame centred at the home position. The currently experienced view at any local position is then projected onto this reference frame to determine the image coordinates and the homing vector. We present here results obtained in a simulated environment as well as from static outdoor tests. The biologically inspired algorithm described in this study is a feasible alternative to the local homing schemes that strongly rely on odometry or landmark extraction, making it therefore well suited for implementation onboard unmanned aerial vehicles.

S6C: Vision Systems

Room: Wakatipu

Chair: Richard Green (University of Canterbury, New Zealand)

3:40 ***Monocular and Range Camera Cross-Calibration for RGB-D Sensor Architectures***

Karthik Mahesh Varadarajan (TU Vienna, Austria)

RGB-D sensor frameworks such as the PrimeSense/ Kinect have brought a massive change in the range of applications for the usage of depth data in not just core robotic and computer vision systems, but also in security, entertainment among others. On the other hand, generic RGB-D sensor frameworks (as opposed to integrated RGB-D cameras) that provide flexibility in terms of usage of variegated monocular color and range image sensors form the future of computer vision applications. These generic frameworks require explicit cross-calibration between the range and the monocular color image sensors. Traditional 2D checkerboard or similar alternate calibration patterns do not provide the necessary sensory response across the varied sensing modalities for accurate cross-calibration. To address this concern, we present a novel framework for extrinsic cross-calibration of variegated monocular and range sensors. Results presented show successful detection of correspondence points and estimation of extrinsic parameters for cross-calibration.

4:00 ***Dominant Plane Detection using a RGB-D Camera for Autonomous Navigation***

Jiefei Wang and Matthew Garratt (University of New South Wales, Australia); Sreenatha Anavatti (University College, ADFA & University of New South Wales, Australia)

Dominant plane estimation is an fundamental task not only for trajectory finding problems but also autonomous navigation of mobile robots and MAVs (Micro Air Vehicles). In this paper, we illustrate a novel dominant plane detection approach from a RGB-D camera image sequences. A plane fitting as region growing technique is used in this work, rather than implementing the original algorithm, we modified it and updated to a incremental version, and optimised the plane calculation and mean square error calculation, to improve the accuracy and efficiency. The preliminary experimental results in different scenarios are presented by implementing the algorithm.

4:20 ***Gibbs Sampling for 2D Cane Structure Extraction From Images***

Ricardo Castaneda Marin and Richard Green (University of Canterbury, New Zealand)

In this paper we are interested in recovering 2D tree structure of vines from binary images. We propose a bottom-up approach that firstly segments an input image into cane parts, and second infer their connectivity by using Gibbs Sampling. Our approach is similar to previous work on vine structure inference, but instead of the use of heuristics for connecting cane parts, our method uses Gibbs sampling which has been successfully used in similar computer vision tasks. We show comparative results against this previous work, and we provide directions on how this work could be extended in the future.

4:40 ***Colour Identification using an Adaptive Colour Model***

Feng (Teddy) Su and Gu Fang (University of Western Sydney, Australia)

Colour identification is a common task for many applications in computer vision. Many existing colour identification methods are application dependent. Therefore, they could only operate in certain environments and their performances are highly dependent on the lighting condition and quality of the images. In this paper, a novel colour identification method is introduced using an adaptive hue based colour model. The proposed method firstly analyses the image by collecting a variety of information from the given image. It is then followed by a colour space selection scheme in which the most suitable hue based colour space is selected based on properties obtained through image analysis. Finally, the image is filtered through the channels of the selected colour model to identify the target colour. Tests on various images from different datasets have shown that this method is capable of extracting the required colour effectively from images with varying qualities.

5:00 ***Eye Tracking System to Detect Driver Drowsiness***

Phuong Nguyen (RMIT International University, Vietnam); Moi Tin Chew (Massey University, New Zealand); Serge Demidenko (Massey University, New Zealand)

This paper describes an eye tracking system for drowsiness detection of a driver. It is based on application of Viola Jones algorithm and Percentage of Eyelid Closure (PERCLOS). The system alerts the driver if the drowsiness index exceeds a pre-specified level.

5:20 ***Towards Automatic Colour Segmentation for Robot Soccer***

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

Tuning the colour thresholds within robot soccer is laborious, and sensitive to changes in illumination. An algorithm is described for automatic gain control and white balancing within the camera is described. This significantly reduces the effects of the variations in lighting on the thresholds. Next, a new colour space is proposed which maximises the hue separation of the different coloured regions to improve the colour discrimination. Finally a several automatic segmentation techniques are briefly discussed. All of the algorithms are designed to operate on data directly streamed from the camera, enabling a low latency FPGA implementation.

7:00 PM - 10:30 PM Banquet

Room: Skyline Restaurant

Thursday, February 19

9:00 AM - 10:00 AM (Parallel Sessions S7A, S7B and S7C)

S7A: Health Systems 2

Room: Queenstown
Chair: Debraj Basu (Massey University, New Zealand)

9:00 ***Speech-to-Speech Translation Humanoid Robot in Doctor's Office***

Sangmi Shin and Eric Matson (Purdue University, USA); Jinok Park, Bowon Yang, Juhee Lee and Jin-Woo Jung (Dongguk University, Korea)

This paper illustrates the implementation of a preliminary model of speech-to-speech translation humanoid robot in the domain of internal medicine. This humanoid robot application can translate a patient's symptoms from English speech to Korean speech in a limited domain. It is designed to help English speaking patients who need to describe their internal symptoms that should be explained by patients themselves. It consists of three main parts - voice recognition, English-Korean translation, and the translator robot's Korean voice output as a result of translation process. CMU Sphinx-4 is used as a speech recognition tool. Then the translation algorithm changes the syntactic rule of English sentences in forms of 'Subject + Verb', 'Subject + Verb + Complement' and 'Subject + Verb + Object' by rearranging each components in Korean grammar order. The results of translation is reliable as the input of sentence structures are restricted at this stage.

9:20 ***A novel real time alarm detecting device for the operating room***

Max Dingler and Jonas Pfeiffer (TU München, Germany); Tim Lüth (Technische Universität München, Germany)

Among numerous medical devices that generate noise, music is gaining increasing importance in modern operating rooms. Many surgeons perceive music as concentration enhancing during surgery. In safety-critical situations instead, e.g. when a medical device emits an alarm, the additional noise exposure induced by music is considered distracting. We present a novel modular device that automatically turns off music in real time, as soon as a medical device emits an alarm. The device can easily be adapted to every common alarm-generating medical device and to every music source and pair of speakers, assuming the player is connected to its speakers via a 3.5mm audio jack cable. There is no need to modify the respective devices. The device aims at minimizing the noise exposure in safety-critical situations and thus protecting the patient's safety against stress-induced mistakes. Experiments show, that it works faultlessly under common conditions regarding noise-exposure in an operating room.

9:40 ***Application of a Commodity Smartphone for Fall Detection***

Moi Tin Chew (Massey University, New Zealand)

This paper presents a low-cost fall detection solution based on the use of a commodity smartphone. By collecting,processing and analyzing in real-time signals collected from the smartphone built-in sensors (tri-axis accelerometer and tri-axis gyroscope), the device is able to differentiate a genuine fall occurrence from routine motions of normal daily activities. This enables to generate an immediate alert to a caretaker (such as healthcare personnel, a family member or helper) if a monitored person falls.

S7B: Applications 2

Room: Clancys
Chair: Moi Tin Chew (Massey University, New Zealand)

9:00 ***General Plans for Removing Main Components in Cognitive Robotic Disassembly Automation***

Supachai Vongbunyong, Sami Kara and Maurice Pagnucco (The University of New South Wales, Australia)

A principle of cognitive robotics has been introduced to resolve the problems associated with uncertainties and variations found in automated disassembly process. The general plans are used to compensate the inaccurate information perceived by the sensors. They are used in the trial-and-error phase to remove particular types of main components according to cognitive behaviours. Statistical information is used to identify the operation plans and the parameters for (semi-)destructive disassembly. Effectiveness of these plans determines the success rate of the disassembly and the degree of autonomy. In this paper, PCBs and PCB cover in various model LCD screens were used as a case-study.

9:20 ***Iterative Learning System to Intercept a Ball for Humanoid Soccer***

Mauricio Gomez, Yongho Kim and Eric Matson (Purdue University, USA)

Soccer for humanoid robots has been a field of study for a long time, and the majority of the teams that compete in a tournament only focus until now in reaching the ball and drive it to score. That is the reason why we think that a more collaborative work would be a real improvement towards accomplishing the RoboCup 2050 ultimate goal of a fully autonomous humanoid team should defeat the winner team of the FIFAWorld Cup Championship of the same year. In this paper, we proposed a training system for humanoidtype soccer robot, that will learn to make precise ball pass interception of a ball when is kicked by one robot of the same team. Vision system for ball detection is used as input to predict trajectory of the ball. Also knowledge based learning algorithm enables the player to get higher chance to intercept the ball.

9:40 ***An interactive finger-gaming robot with real-time emotion feedback***

Chyi-Yeu Lin (Naitional Taiwan University of Science and Technology, Taiwan); Li-Wen Chuang, Li-Chieh Cheng and Ke-Jeng Lin (National Taiwan University of Science and Technology, Taiwan)

This paper aims to develop an autonomous humanoid finger gaming robot that can interact with humans. The finger gaming robot will have 9-inch panel display to show the robot face, two robotic arms of which each contains a hand with five fingers, a mechanical chest, and a wheel-type mobile platform. The mechanical arm and hand can smoothly carry out all actions required in a finger guessing game. The robot can recognize human hand gestures and tell the number of fingers shown. Aided with speech recognition capability, the robot can identify the content of human players' finger guessing. The finger gaming robot can, in the absence of human help, independently detect intelligence, and autonomously carry out a variety of finger guessing game contests with humans, providing a brand new entertainment robot in the catering sector.

S7C: Applications 3

Room: Wakatipu

Chair: XiaoQi Chen (University of Canterbury, New Zealand)

9:00 ***Comprehensive Semantics in Robotic Intelligence and Communication: Necessity and Feasibility***

Victor Raskin and Julia Taylor (Purdue University, USA)

The paper asserts the urgent need to semanticalize robotic intelligence and communication. It also circumscribed the volume of work that needs to be accomplished for the robot to approach the level of human understanding. Now, robotic intelligence is a specific part of artificial intelligence, and the need to semanticalize pertains to the whole field but the world of the robot seems "smaller," and the task may seem less daunting than for AI as a whole. An interesting issue of interaction between the robot's sensory information and the ontology is raised.

9:20 ***Force Trajectory Generation for the Redundant Actuator in a Pneumatically Actuated Stewart Platform***

Justin Pradipta (University of Stuttgart & Institute for System Dynamics, Germany); Karl Lukas Knierim (Institute for System Dynamics, University of Stuttgart, Germany); Oliver Sawodny (University of Stuttgart, Germany)

Force distribution is one of the advantage of a redundant parallel manipulator configuration, making the utilization of less powerful actuator feasible. In this contribution, a force trajectory for a redundant actuator in a seven-cylinder pneumatically-actuated Stewart platform is derived analytically using the inverse dynamic model to maximize the benefit of the additional actuator. A feed-forward scheme is proposed with a requirement of good position tracking control. A Input/output linearization is applied for the redundant actuator force control design with good force tracking capability. The designed force trajectory generator is implemented in full-size pneumatically actuated Stewart platform, and the results show improvement in force reduction of the six outer cylinders and better utilization of the redundant cylinder force capacity.

9:40 ***Response-time Analysis for Multi-Criticality Mixed Criticality Systems with Pessimistic Period***

Ning Zhang (Hunan University, P.R. China)

The aim of a mixed-criticality (MC) system is to integrate multiple functionalities in a common platform for lower cost and higher power efficiency. Some functionalities in many safety-critical embedded systems are subject to certification requirements. These MC systems generate challenges in run-time monitoring and static schedulability analysis. In prior researches, many papers studied the response-time analysis algorithm in MC systems considering pessimistic WCET parameter and dual-criticality levels. But in some real MC systems, the tasks with pessimistic period and multi-criticality levels usually exist. In this paper, we presents a new response-time analysis for MC systems considering both pessimistic period parameter and multi-criticality levels, and a optimal priority assignment scheme for fixed-priority uniprocessor scheduling of MC system.

10:00 AM - 10:30 AM Morning Coffee Break

Room: Foyer (Level 5)

10:30 AM - 11:00 AM IT3: Invited Talk 3

Recent Developments on Optical Fibre Sensors for Medical Oncology Applications

Elfed Lewis

Room: Queenstown

Chair: Donald G. Bailey (Massey University, New Zealand)

11:00 AM - 12:20 PM (Parallel Sessions S8A, S8B and S8C)

S8A: Aerial Systems

Room: Queenstown

Chair: Moi Tin Chew (Massey University, New Zealand)

11:00 ***Experimental Validation of Cooperative Formation Control with Collision Avoidance for a Multi-UAV System***

Yasuhiro Kuriki and Toru Namerikawa (Keio University, Japan)

In this study, we consider cooperative control issues for a multi-unmanned aerial vehicle (UAV) system. Specifically, we present a cooperative formation control strategy for a multi-UAV system with unidirectional network links. Our strategy is to apply a consensus-based algorithm and leader-follower structure to the UAVs so that they can cooperatively fly in formation. The leader provides each UAV with commands to generate a geometric configuration of the formation. Convergence is guaranteed when the cooperative formation control algorithm is applied to the UAVs. Collisions among UAVs can occur when they are flying with the cooperative control UAVs. Our strategy for collision avoidance is to simultaneously apply an artificial potential approach to the UAVs. Experiments are performed on multiple commercial small UAVs to validate the proposed formation control algorithm with collision-avoidance capability.

11:20 ***Decentralized formation control of quadcopters using feeback linearization***

Arshad Mahmood and Yoonsoo Kim (Gyeongsang National University, Korea)

This paper proposes a decentralized formation control scheme for a group of quadcopters using feedback linearization. Unlike most of existing works that involve a complex design of nonlinear formation control laws, this work simplifies the design to yield an almost linear control law for nonlinear and under-actuated quadcopters. In fact, a singularity-free dynamic inversion scheme is utilized such that the quadcopter dynamics can be treated as a linear system. Consequently, a linear formation control law can be designed for the resulting linear system to achieve desired

positions and an identical heading angle through local information exchanges only. Although the present work considers quadcopter dynamics only, the proposed methodology can also be directly applied to attitude synchronization problems arising in space and robotic applications.

11:40 ***Stabilization and Control of Autonomous Hexacopter via Visual-Servoing and Cascaded-Proportional and Derivative (PD) Controllers***

Omar Ahmed, Marsad Latief and Md A Ali (International Islamic University Malaysia, Malaysia); Rini Akmeliawati (International Islamic University, Malaysia)

This paper presents modelling and simulation of visual servoing control of a hexacopter. Cascaded proportional derivative (PD) controllers are designed to control the altitude and heading of the hexacopter. In addition, spherical image based visual servoing is used to visual servoing control the hexacopter to a desired pose with respect to an arbitrary target in 3D workspace. The proposed control strategy is compared with the nested saturation control laws which are adapted to control the horizontal trajectory of the vehicle along X and Y-axes. Simulation results show the ability of the proposed controller in driving the unmanned aerial vehicle (UAV) to the desired pose successfully. The proposed controller outperforms the nested saturation controller in tracking fixed target.

12:00 ***Fault-Tolerant Position Tracking of a Hexacopter using an Extended State Observer***

Guillermo P. Falconí, Christian Heise and Florian Holzapfel (Technische Universität München, Germany)

A position tracking controller for a hexacopter is presented which is robust against disturbances like modeling errors or propulsion efficiency degradation. The presented controller stands out because of its simple design which does not resort to reconfiguration and avoids the necessity of a Failure Detection and Isolation (FDI) filter. The baseline controller has a cascaded structure with two loops. The outer loop corresponds to the position and velocity control and is designed using linear control. The inner loop corresponds to the attitude control which is a Nonlinear Dynamic Inversion (NDI). The baseline controller is augmented by an Extended State Observer (ESO) which provides an estimate of the disturbances and modeling errors which is then fed back to the control law. The performance as well as the robustness of the control system is significantly improved as demonstrated in simulation, where controlled flight is achieved even under severe actuator degradation.

S8B: Optimisation

Room: Clancys

Chair: Serge Demidenko (Massey University, New Zealand)

11:00 ***Nonlinear Model Predictive Control of a Hydraulic Excavator using Hammerstein Models***

Frank Bender, Marcus Sonntag and Oliver Sawodny (University of Stuttgart, Germany)

Hydraulic excavators play a crucial role on worldwide construction sites. Efficient operation of these machines therefore contributes to a quick completion of the construction task. In particular, optimized control strategies can lead to improvements with regard to machine performance, fuel consumption, and pollutant emissions. In this work, a nonlinear model of a hydraulic excavator is considered. It is shown that a simplified nonlinear model with Hammerstein structure can accurately represent the underlying dynamics for the purpose of control. Based on this model, a nonlinear model predictive control approach including an optimization algorithm is developed in order to have the excavator perform a task given through target positions of the four motion axes. Simulation results based on an application of the developed controller to a complex physical model of the excavator indicate good tracking performance and fast execution of the task.

11:20 ***Ordered Escape Routing Using Network Flow and Optimization Model***

Kashif Sattar (NUST School of EE and CS, Islamabad, Pakistan); Anjum Naveed (National University of Sciences and Technology, Pakistan)

With the advancement in technology, BGA based integrated circuits for robotics and other devices are being prepared in small sizes with more pin count. This increase in number requires more number of pins to be escaped from the inner side of the IC towards the escape boundary. Ordered escape routing is very important due to its great impact on area and length routing at later stage. Basic design rules of planarity and capacity along with constraints like length matching make the ordered escape routing problem more difficult. In this paper we formulate flow model on the basis of inter-pin capacity. Using flow model we propose optimization model that solves ordered escape routing problem under design constraints. Evaluation of model using randomly generated examples shows that maximum possible nets are being routed by the model.

11:40 ***Switching Strategy for Direct Model Predictive Control in Power Converter and Drive Applications with high Switching Frequency***

Michael Leuer and Joachim Böcker (University of Paderborn, Germany)

Model Predictive Control includes a mathematical plant model. Based on that model optimal actuating variables for future timesteps are determined in every sampling step. Thus the MPC exhibits a better reference response compared to conventional control. The problem with MPC is the high computational cost and the associated long control cycle time. Thus MPC is unattractive for processes with small time constants. In this paper a Direct MPC method for nonlinear systems with inherent output saturation is presented. In contrast to other Direct-MPC approaches, a more flexible gate-signal generation method which enables switching during the sampling period is utilized. In addition the switching frequency can be increased while maintaining the same controller cycle time. This results in a reduction of the current ripple. Since this approach is based on a computational efficient optimization algorithm, it provides real-time capability for online-MPC even with process time constants in the millisecond range.

12:00 ***Stability Control for Manipulator Space Capture by Using Particle Swarm Optimization Based on Distributed Controllable Dampers***

Yichi Zhang, Ming Chu and Hanxu Sun (Beijing University of Posts and Telecommunications, P.R. China); Zhenghong Dong (Academy of Equipment, P.R. China)

The capture for space floating target tends to excite the oscillation of the manipulator's base. In this paper, a multi-dof manipulator with controllable damper in all the joints is proposed to realize the stability control for the base. Firstly, the general dynamical equations including the controllable damping matrix are established by using Kane method. Then, the Particle Swarm Optimization (PSO) is employed to calculate the optimal damping torques from all the dampers, which are used to consume the capture energy. The numerical experiments for a two-joint manipulator space capture with four-dof controllable dampers are researched to validate the effectiveness. The simulation results show that the proposed method can significantly reduce the base attitude changes and ensure the stabilization.

S8C: Control 2

Room: Wakatipu

Chair: Donghan Kim (Kyung Hee University, Korea)

11:00 ***A Fuzzy Q-Learning Based Assisted Power Management Method for Comfortable Riding of Pedelec***

Cheng-Ting Liu and Roy Chaoming Hsu (National Chiayi University, Taiwan)

In this study, a fuzzy logic controller with Q-learning is proposed for the assisted power management of a pedelec. The pedelec is a human-electric hybrid vehicle driven by the rider's pedal force with the assisted power from electric motor. The proposed assisted power management (APM) method adaptively provides an appropriate assisted power (action) according to the environmental changes via fuzzy inference coordinated Q-learning, i.e. fuzzy Q-learning. Simulations of the proposed method, hereafter abbreviated as FQLAPM, on a pedelec are performed, and the results exhibit better performance in comparing with other existent assisted power methods.

11:20 ***Design and Experimental Testing of Vehicle-Following Control for Small Electric Vehicles with Communication***

Takeki Ogitsu (Tokyo University of Science & Faculty of Science and Technology, Japan); Manabu Omae (Keio University, Japan)

This study proposes a vehicle-following control system for personal electric vehicles (EV). Recently, projects aimed at using personal vehicles to solve vehicle transportation problems associated with overcrowding in cities and depopulation in mountain villages have been under way in several regions in Japan. This study was conducted to contribute to improving mobility in depopulated regions by applying vehicle-following control technology to personal vehicles. In this paper, the issues associated with introducing personal vehicles in depopulated regions are summarized by explaining the background of personal vehicles and that of depopulated regions in Japan. Related studies that we have conducted to address these issues are summarized. The details of vehicle-following control technology that is targeted at controlling vehicle-to-vehicle time using wireless communication are explained. Evaluation experiments conducted using small EVs are described. The results of the evaluation experiments confirm the efficient following performance achieved with the proposed vehicle-following control system.

11:40 ***Toward Visualising and Controlling Household Electrical Appliances***

Latha Karthigaa Murugesan, Rashina Hoda and Zoran Salcic (The University of Auckland, New Zealand)

Energy consumption is a vital component in day-to-day life. Visualising energy consumption, recommending energy conserving strategies and, controlling the appliances are some of the widely considered means to motivate and/or to help end-users at household to conserve energy. However, the conventional energy visualisation applications have certain drawbacks, such as lack of energy consumption location, lack of controlling appliances based on energy-saving recommendations, etc. To overcome those, this research would accomplish a simulation model with following objectives: (i) visualisation engine, to visualise household electricity consumption, (ii) recommendation engine, to provide energy-saving recommendations to the end-users, (iii) control engine, to control the household appliances based on the recommendations, and (iv) to integrate visualisation, recommendation and control engines. This research uses a combination of user-centred design

and iterative development methods. Successful implementation of these objectives would provide a significant contribution to this inter-disciplinary research area and would serve to achieve higher energy savings.

12:00 ***Configuration space impedance control for continuum manipulators***

Lorenzo Toscano (Politecnico di Milano, Italy); Valentin Falkenhahn (University of Stuttgart, Germany); Alexander Hildebrandt (Festo AG & Co. KG, Germany); Francesco Braghin (Politecnico di Milano, Italy); Oliver Sawodny (University of Stuttgart, Germany)

Despite their intrinsic structural compliance, a safe interaction of continuum robots with their environment requires a control strategy that is able to manage the compliant motion properly. This paper presents a peculiar strategy of application of the impedance control based on kinematic and dynamic models of the manipulator's sections. The control approach is able to deal with unpredicted contacts which can occur in unknown locations along the whole manipulator while the resulting contact forces don't need to be measured or estimated. The control concept is applied to a single section of the Bionic Handling Assistant, but its application can be extended to all the continuum robots modeled with the piecewise constant curvature approach.

12:20 PM - 12:40 PM ICARA Wrap-up Session

Room: Queenstown

Chair: Gourab Sen Gupta (Massey University, New Zealand)

KEYNOTE SPEAKERS

PROFESSOR THOMAS BRAUNL

THE UNIVERSITY OF WESTERN AUSTRALIA
PERTH, AUSTRALIA

Thomas Braunl is Professor for Computer Engineering at The University of Western Australia, Perth, where he directs the Robotics & Automation Lab and the Renewable Energy Vehicle Project (REV). He is a Senior Member of the IEEE.

Professor Braunl received a Diploma in Informatics from Univ. Kaiserslautern Germany in 1986, an MS in Computer Science from the University of Southern California Los Angeles in 1987, and a PhD and Habilitation in Informatics from Univ. Stuttgart in 1989 and 1994, respectively.

He has worked in the past for BASF (image data bases), Daimler/Mercedes-Benz Research (automated parking based on monocular stereo from motion), and BMW (intelligent electric vehicle charging), where he has filed patents with Daimler and BMW. At Univ. Stuttgart he has been Assoc. Professor for Robotics and Image Understanding (C2) and he has held Guest Professor positions at TU München and Santa Clara University, California.

Professor Braunl has over 100 publications in peer reviewed journals and conferences. He co-edited five conference proceedings published as research books with Springer-Verlag and the IEEE Press, and he has authored four research books on Massively Parallel Programming, Parallel Processing, Image Processing and Robotics with Prentice Hall, Addison-Wesley and Springer-Verlag. His books have been published in five languages: English, German, Russian, Japanese and Chinese.

He has served on numerous conference committees (including Program Chair) and on more than ten IEEE journals and transactions (including Associate Editor).

Professor Braunl combines his research interests in electromobility and autonomous robots by developing autonomous vehicles with electric drive systems. He has developed the EyeBot mobile robot family and the REV electric car series. He converted a Hyundai Getz and a Lotus Elise to road-licensed electric vehicles, as well as a BMW X5 to drive-by-wire for evaluating his vision-based driver assistance systems.

FROM ELECTRIC CARS TO AUTONOMOUS VEHICLES

We are in the middle of the largest revolution in Automotive History. Electric vehicles had come and gone over the last 100 years, but this time they are here to stay. UWA's Renewable Energy Vehicle Project (REV) has been on the forefront of EV research since 2006 by converting two road-registered cars to electric drive, including a Lotus Elise, as well as several Formula SAE racers, and by establishing Western Australia's first EV charging network with 24 outlets.

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KEYNOTE SPEAKERS

DR ASSAD MADNI

PRESIDENT, CHIEF OPERATING OFFICER AND CTO (RETIRED)
BEI TECHNOLOGIES INC.
DISTINGUISHED ADJUNCT PROFESSOR/DISTINGUISHED SCIENTIST
UNIVERSITY OF CALIFORNIA, LOS ANGELES

Dr. Asad Madni served as President, COO & CTO of BEI Technologies Inc. from 1992 until his retirement in 2006. He led the development & commercialization of intelligent micro-sensors, systems, and instrumentation for which he has received worldwide acclaim. Prior to BEI he was with Systron Donner Corporation for 18 years in senior technical & executive positions, eventually as Chairman, President & CEO. Here, he made seminal and pioneering contributions in the development of RF & Microwave Systems & Instrumentation which significantly enhanced the capabilities of the US Tri-Services. He is currently, Distinguished Adjunct Professor/Distinguished Scientist at UCLA, Distinguished Professor at TCI College of Technology, Adjunct Professor at Ryerson University, and Executive Managing Director & CTO of Crocker Capital.

He received an A.A.S. from RCA Institutes Inc., B.S. & M.S. from UCLA, Ph.D. from California Coast University, D.Sc. (H) from Ryerson University, D.Eng. (H) from Technical University of Crete, and Sc.D. (H) from California State University/CSUN. He is also a graduate of the Engineering Management Program at California Institute of Technology, the Executive Institute at Stanford University, and the Program for Senior Executives at MIT Sloan School of Management.

He is credited with over 160 refereed publications, 68 issued or pending patents, and is the recipient of numerous national and international honors and awards. In 2011 he was elected to the US National Academy of Engineering "for contributions to development and commercialization of sensors and systems for aerospace and automotive safety". He is a Fellow/Eminent Engineer of 14 of the world's most prestigious professional academies and societies.

CONVERGENCE OF EMERGING TECHNOLOGIES TO ADDRESS THE CHALLENGES OF THE 21ST CENTURY

There are numerous "Grand Challenges" facing humanity that will have to be addressed by us as a global society in order to maintain our well-being from the standpoint of quality of life, healthcare, environment, energy needs, manufacturing efficiencies, etc., if we are to continue humanity's trajectory of progress. Traditional technologies based on classical disciplines and thought processes of the past several decades are no longer viable in addressing these challenges, and a new approach based on interdisciplinary thinking is necessary. Fortunately, numerous emerging technologies are advancing at an unimaginable rate and it is the convergence of these technologies that demonstrate the potential to have a major impact on our lives, businesses, government, society and our planet. These emerging technologies are establishing the basis for a new paradigm in the development and commercialization of next generation intelligent, miniaturized, highly robust complex systems. This lecture will address some of these major technologies and their applications including, intelligent sensors and wireless sensor networks, intelligent cars and smart highways, tele-health (wireless healthcare), micro-electromechanical systems (MEMS), nanotechnology, clean technology, robotics and automation, smart grid, and ultra-high throughput and wide bandwidth instrumentation.

INVITED SPEAKERS

PROF. ELFED LEWIS

OPTICAL FIBRE SENSOR RESEARCH CENTRE
UNIVERSITY OF LIMERICK, LIMERICK, IRELAND

Elfed Lewis graduated with BEng (Hons) in Electrical and Electronic Engineering from Liverpool University in 1978 and was awarded his PhD from the same institution in 1987. In 1996 he joined University of Limerick at which time he formed the Optical Fibre Sensors Research Centre. He is Associate Professor and Director of the Optical Fibre Sensors Research Centre, which he founded in 1996. He is Fellow of Institute of Physics, IET, BCS and Senior member IEEE. He has authored and co-authored more than 70 journal papers and made in excess of 200 contributions to international conferences. He currently holds 5 patents on Optical Fibre Sensor Devices. The Optical Fibre Sensors Research Centre under the leadership of Professor Lewis is engaged in investigating sensors for environmental monitoring (e.g. water quality, vehicle exhaust emissions,), food quality assessment and parameters of high power microwave sources (e.g. Electric Field, Electron Beam proximity) and medical devices. In 2005 he was recipient of the University of Limerick Special Achievement in Research Award and was a Fulbright Scholar with CREOL (University of Central Florida) in 2008. He is currently Distinguished Lecturer for IEEE Sensors Council for the period July 2013-June 2015.

RECENT DEVELOPMENTS ON OPTICAL FIBRE SENSORS FOR MEDICAL ONCOLOGY APPLICATIONS

This presentation will detail a novel extrinsic optical fibre X-Ray dosimeter for biomedical applications. The scintillation material in the sensor tip emits visible light upon exposure to x-ray energy and the resultant low intensity light is coupled to a PMMA (poly methyl methacrylate) plastic optical fibre, which guides it towards a distal fluorescent optical spectrometer at 30m distance. Initial experimentation has shown the scintillating optical fibre X-ray dosimeter exhibits excellent sensitivity and repeatability upon excitation from a calibrated Clinical Linear Accelerator (LinAC) source. Recent results from extensive on-site testing at radiotherapy clinics at UCLA (USA), Belfast City Hospital (UK) and 1st Hospital Harbin (China) are presented and the performance of the sensor assessed.

PROF B. M. AZIZUR RAHMAN

CITY UNIVERSITY LONDON
NORTHAMPTON SQUARE, LONDON, UK

B. M. Azizur Rahman received the B.Sc.Eng and M.Sc.Eng. degrees in Electrical Engineering with distinctions from Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh, in 1976 and 1979, respectively. He also received two gold medals for being the best undergraduate and graduate student of the university in 1976 and 1979, respectively. In 1979, he was awarded with a Commonwealth Scholarship to study for a PhD degree in the UK and subsequently in 1982 received his PhD degree in Electronics from University College London.

In 1988, he joined City University, London, as a lecturer, where he is now a Professor. At City University, he leads the research group on Photonics Modelling, specialised in the use of rigorous and full-vectorial numerical approaches to design, analyse and optimise a wide range of photonic devices, such as spot-size converters, high-speed optical modulators, compact bend designs, power splitters, polarisation splitters, polarisation rotators, polarization controllers, terahertz devices, etc. He has published more than 450 journal and conference papers, and his journal papers have been cited more than 2900 times, with an h-index value of 27. Prof Rahman is Fellow of both the Optical Society of America, and the SPIE and a Senior Member of IEEE (USA).

CHARACTERIZATION OF A NEW GENERATION OF OPTICAL SENSORS

The design and optimization of a suite of novel optical sensors will be presented, showing the value of using rigorous full-vectorial numerical approaches. Although fibre based optical sensors are well established in the market, designs based on more exotic nanowires and photonic crystal fibres are becoming increasingly important and showing much improved sensitivity by accessing a larger evanescent field. Similarly, novel planar design concept, such as the silicon slot guide-based design which is showing even greater promise, allowing the exploitation of well-developed CMOS fabrication technologies for potentially low-cost sensor elements. Optical sensors using more innovative planar designs will be more compact, integrated with added functionalities which can be mass produced for potentially lower per unit cost. However, the design concept and analyses of such exotic sensors are also very challenging. Some selected results illustrating the value and potential of the numerically efficient finite element method in systems design will be presented.

INVITED SPEAKERS

DR. MEHRAN SARKARATI

HEAD APPLICATION AND SPECIAL PROJECTS SECTION
ESA – EUROPEAN SPACE AGENCY
ESOC / HSO-GDA
ROBERT-BOSCH-STR. 5
64293 DARMSTADT, GERMANY

Dr. Mehran Sarkarati is Head of Application and Special Projects section at the Ground System Engineering department of the European Space Agency, ESA. Mehran has studied at Berlin University of Technology (TU-Berlin) and Arizona State University (ASU) in the context of a student exchange programme. He has graduated with a M.Sc. and a subsequent Ph.D degree in the field of Aerospace Engineering and a second M.Sc. degree in Computing Sciences from TU-Berlin. He started his carrier at the European Space Agency, ESA, in 2004 at the European Space Technology and Research Centre in the Netherlands, moving in 2007 to European Space Operations Centre ESOC. During the last ten years, Mehran has worked at ESA on different subjects, including science planning for planetary missions, simulations, monitoring and control systems for satellite and Robotics. Before joining ESA, he has worked on satellite attitude control systems and development of ground data systems at the German Aerospace Agency (DLR), Computer-Aided Design and assembly of jet engines at BMW Rolls-Royce AeroEngines and simulation of aircraft subsystem for Airbus A380 aircraft.

Mehran has an interest in introducing modern software and system engineering paradigms to the ground systems domain of space missions. He has led a number of related industrial activities in the areas of agile software development, service oriented architectures and cloud computing in the past years. He is also active in the standardisation domain, as a member of the Telerobotics and Spacecraft Monitoring and Control working groups of the Consultative Committee for Space Data Systems and the co-chair of the ESA agile software development working group. Since 2010, Mehran has led in his role as the Data System Manager of the METERON project, the development of software systems for system level monitoring and control of METERON Robotic experiments, which is the context of his talk at ICARA.

HOW TO PLUG-IN YOUR ROVER INTO A SPACE MISSION TO MOON OR MARS

The presentation will elaborate on the concept of standardised Telerobotic Services and their role in collaborative Robotic operation scenarios. It will discuss the advantages and the challenges involved in abstracting from proprietary hardware and software interfaces of diverse Robotic systems. The importance of specifying the subject services in an implementation and communication agnostic manner for achieving interoperability without enforcing a particular technology will be highlighted. The example of the METERON Robotic Services will be used to put these concepts in the context of future human-robotic space mission scenarios. For this purpose, the presentation will provide an overview of the work, performed in this area by the European Space Agency, in the context of the METERON project, its current status and some lessons learnt.

The METERON Robotic Services have been successfully validated as part of the METERON OPSCOM-2 experiment in August 2014, during which an ESA astronaut monitored and controlled from the International Space Station (ISS) a car-size rover on the ground via the Delay Tolerant Network (DTN), while the same service interfaces were used on the ground via a different communication protocol to perform distributed monitoring of the activities. The presentation will conclude with reference to the on-going activities at multi-agency level in the frame of the Telerobotics working group of the Consultative Committee for Space Data Systems (CCSDS).