



## **Robotics & Mechatronics Conference**

of South Africa



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23 - 25 November 2011 CSIR International Convention Centre, Gauteng, South Africa

www.robmech.co.za

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#### **Contact Details**

#### **Conference Chairman**

Jeremy Green CSIR PO Box 91230, Auckland Park, 2006 Tel: +27 11 358 0084 Fax: +27 11 726 5405 Email: jgreen@csir.co.za

#### **Conference Secretary**

Kelly Matthews CSIR Materials Science and Manufacturing PO Box 1124, Port Elizabeth 6000 South Africa Tel: +27 41 508 3200 Fax: +27 41 583 2325 Email: kmatthew@csir.co.za

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# 4th Robotics and Mechatronics Conference of South Africa ROBMECH 2011

23 - 25 November 2011

CSIR International Convention Centre, Gauteng, South Africa

www.robmech.co.za

ISBN: 978-0-620-51897-0

#### **Organising Committee**

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#### MESSAGE FROM THE CHAIRMAN

Welcome to the 4th Robotics and Mechatronics conference of South Africa. After a year's break from the international CARS&FOF conference, we are back on track and already talking about ROBMECH 2012, building on this year's success. Communication in the South African robotics research field is not where it could be, or should be. Universities (and indeed the CSIR) have multiple groups doing robotics work, which is good news, but they are not aware of each others efforts and are by and large not persuing collaborative projects.



Robotics is by definition a multidisciplinary research field. Success for South Africa will only be achieved with

collaborative research efforts between departments, universities, and other research institutions. That fact that the current research effort is being undertaken in a vast array of departments is reassuring. There are, amongst others, Mechatronics, Mechanical, Electrical, Industrial Engineering, Computer Science and Materials Science departments, all involved in robotics research in various locations throughout South Africa. It is in this context that the importance of the RobMech conferences becomes apparent. Communication and presentation of research outputs between the institutions is the first step in creating successful collaborations and alignment to nationwide research strategy.

We hope that the Robotics Strategy of South Africa (ROSSA) discussions on Wednesday will be the starting point to a national research approach, one that is targeted at directly benefiting South Africa's industries, where robotics can make a positive impact, particularly in the context of South Africa's need for job creation.

So I encourage you to take this opportunity to seek out the people you don't know. Find out what it is that they are doing, where they are from, and how it might be possible to work together in the coming years to make Robotics a significant contributor, initially to South Africa's research output, and ultimately to South Africa's industrial capability.

Jeremy Green CSIR

#### GENERAL INFORMATION

The Robotics and Mechatronics Symposium provides a platform to showcase and establish the current state of advanced robotics and mechatronics research in South Africa. Research facilities in southern Africa and beyond are invited to present and share their work. The symposium is open to all industries and members of the public as well as research institutions and hobbyists. The symposium will bring together, on a common platform, researchers, application engineers, users of CAD/CAM, robotics and factory automation technologies and methodologies and policy makers.

The Advanced Robotics and Mechatronics Research Network, (ARMRN) allows the sharing of expensive infrastructure, while contributing to human capital development through studentships at the CSIR. ARMRN is made up of representatives from the CSIR, The University of Kwa Zulu Natal, the Central University of Technology in the Free State, the Nelson Mandela Metropolitan University in Port Elizabeth, the University of Stellenbosch, the Tshwane University of Technology and others.

#### **RobMech Welcome Cocktail Function**

Date: Wednesday 23 November 2011 Venue: CSIR ICC Deck Time: 18:00 For all RobMech and ROSSA delegates, please note cash bar

#### National Instruments Traditional Braai

Date: Thursday 24 November 2011 Time: 18:00 Venue: CSIR ICC Deck Cash Bar

#### **RoboCup Soccer at University of Pretoria**

Date: Friday 25 November 2011 Time: 15:00

Directions: From the CSIR ICC exit, turn left (south) into Meiring Naudé Drive. Turn right (west) onto Lynnwood Road. Continue past Duncan Street. The next traffic light is at Roper Street, at which point you turn right into the University of Pretoria. Ask for directions to CEFIM (the Carl and Emily Fuchs Institute for Microelectronics). A staff member will meet us at the entrance.

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#### TIA SPONSORSHIP FOR ROBMECH 2011

The Technology Innovation Agency (TIA) is proud to be a sponsor for RobMech 2011. The objectives of the conference are in line with those of TIA. These include recognising and using Advanced Manufacturing Technology for the development of South Africa's manufacturing and automation industries

The main task of TIA, as encompassed in its official mandate is to enable and support technological innovation across all sectors of the economy in order to achieve socioeconomic benefits for South Africa and enhance its global competitiveness. The sponsorship of RobMech 2011 is for TIA a way to engage with those whose interests are in line with this.

This association with RobMech is also in line with TIA's objective to support the development and commercialisation of research outputs from universities, science councils and other research organisations.

This conference, given the increasing international and South African interest in robotics and mechatronics, join researchers and industry together to notify each other about the latest technologies and research within this field.

The Advanced Manufacturing sector is one of TIA seven industry sectors. It is informed by national imperatives and the type of technology development and innovation envisioned would foster the shift from low-tech-manufacturing to advanced manufacturing. Greater integration of technology into systems, processes and products would enable the development of new industries and companies, and the creation of sustainable jobs.

The RobMech 2011 conference serves as the appropriate platform to share information, network, learn and in so doing catapult this sector of the South African economy to globally competitive standards.

TIA would like to congratulate the organizers for all the work done so far and wish them and all the delegates a successful conference.





Thursday 24 November 2011

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The Mobile Robot competition aims to provide research direction and motivation for undergraduate and postgraduate students by presenting a competition to be held annually in conjunction with the **ROBMECH** conference. As mining, particularly gold mining, is struggling with increasing costs, mainly because of decreasing grades and increasing mining depths, there is an opportunity to use mining as a focus for this competition and thus promote mining robotics in South Africa. This will enable both the development of technology to meet the challenges facing

deep level mining, and also generate the human capital to meet what will become an expanding market in an already skills-scarce mining industry.

2012 will see the competition again form part of the ROBMECH 2012 conference, where universities will be able to build upon their 2011 success and be more successful in tackling the mining robotics challenges, as well as start contemplating the challenges of lunar robotics with the winning team gaining an opportunity to go to the NASA lunarbotics competition in 2013. www.nasa.gov/lunabotics/

#### 2011 Competition schedule

Thursday 24 November 2011			
	Arena 1	Arena 2	
Lunch - 13h00	WITS Mech	DebTech	
Теа			
15:30	Festo	WITS Elec	
16:00	UJ	UP	
16:30	UCT auto	NWU - iRobot	
17:00	UCT Tele	NWU - Wacked	



## ROBOCUP SOCCER

During 2007, the German Embassy in Pretoria and the foreign department of the DST brought Alexander Ferrein of RWTH in Aachen, Germany, to South Africa. Dr Ferrein was hosted by the CSIR Meraka Institute, and visited most of the tertiary institutions with an interest in robotics. Based on his inputs, CSIR submitted a proposal to DST for a research project based



on the RoboCup Small-Size League. The project would involve four tertiary institutions, to be selected from responses to an open call for proposals.

The intention of the project is to foster meaningful robotics research. RoboCup is regarded as a vehicle for arousing interest in participants, and was rendered particularly relevant by the then-impending Soccer World Cup.

Funding was provided during 2008, and four universities were selected. Activities commenced in the 2008 and 2009 academic years and continue into 2011.

The project has lead the four institutions (Stellenbosch University, the University of Cape Town, the University of KwaZulu Natal and the Universitiy of Pretoria) to establish or expand research activities in the field and has produced numerous research publications. Five post-graduate students funded by this project have graduated, with a further 14 students in various stages of completion.

The continuation of this project is being considered as part of the National Robotics Strategy. For the moment, participants are considering future avenues for research that will provide a means of applying the lessons learned into real-world applications. These discussions are in progress and it is hoped that the workshop at RobMech 2011 will help to crystallise future strategy.

The RoboCup project was the first demonstration of the DST's awareness of the strategic importance of robotics. The project has already contributed to establishing meaningful research, and it is hoped that this momentum will continue to increase as the National Robotics Strategy starts to take shape.



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Wednesday 23 November 2011

Time	Venue 1: Ruby Auditorium
08:30 – 14:00	Robotics Strategy of South Africa (ROSSA) Chairperson: Nkgatho Tlale The key objective of the robotics strategy is to create a co-ordinated research, development and innovation program for robotics in South Africa. The strategy aims to build on the current research capabilities (developed in academia, industry, and research councils) and strengths. It also aims to identify and develop capability in application areas for robotics where South Africa can develop a competitive edge.
12:30 – 13:30	Lunch in the Amber Dining Room
	Venue 2: Emerald Auditorium
14:30 – 17:30	Robotics Workshop University Robotics Research Competitions From robot soccer to rescue. What are the opportunities and needs for South Africa? Presented by Gerald Steinbauer Open to all delegates
	Venue: Deck
17:30 for 18:00	RobMech Welcome Cocktail Function & Cash Bar CSIR ICC Deck For all RobMech and ROSSA delegates



### PROGRAMME

#### Thursday 24 November 2011

Time	Venue 1: Ruby Auditorium		
07:30	Registration Desk Opens		
09:00 - 09:10	Opening remarks: Conference Chair, Jeremy Green		
09:10 – 09:50	<i>Keynote Speaker: Olaf Diegal</i> Institute, Auckland University of Technology, Auckland, New Zealand Additive manufacturing; The software gap		
09:50 – 10:30	Keynote Speaker: Gerald Steinbauer Institute for Software Technology at the Graz University of Technology How to achieve and evaluate dependability of autonomous intelligent systems		
10:30 – 11:00	Morning Refreshments Poster Session		
	Venue 1: Ruby Auditorium	Venue 2: Emerald Auditorium	
	Navigation and Control Chairperson: Simukai Utete	Robot Kinematics and Dynamics Chairperson: Riaan Stopforth	
11:00 – 11:20	Towards the Certification of Non- Deterministic Control Systems for Safety-Critical Applications Chris R. Burger, Thomas Jones	Modelling the manipulator and flipper pose effects on tip over stability of a tracked mobile manipulator Chioniso Dube	
11:20 – 11:40	Rotor Aerodynamic Analysis of a Quadrotor for Thrust Critical Applications Yogianandh Naidoo, Riaan Stopforth, Glen Bright	Techniques applied in design optimization of parallel manipulators Dithoto Modungwa, Nkgatho Tlale, Bheki Twala	
11:40 – 12:00	Literature Review of SLAM and DATMO Ardhisha Pancham, Nkgatho Tlale, Glen Bright	6 DOF, Low Inertia, Concept Design for an Industrial Robotic Arm Ahmed Shaik, Nkgatho Tlale, Glen Bright	
12:00 – 12:20	Empirical Comparison of Meathods for Handling Out-Of-Sequence Measurements Bhekisipho Twala	On the Mentor Arm Position Placement Problem: A Forward Kinematics Analysis VOS Olunloyo, Mike Ayomoh, I Adeoti	
12:20 – 12:40	Design of a position and orientation measurement robot Akshay Lakhani, Igor Gorlach, Farouk Smith	The use of parallel mechanism micro-CMM in micrometrology Ali Rugbani, Kristiaan Schreve	



Thursday 24 November 2011 (cont)

12:40 – 13:30	Lunch on the ICC Deck Mobile Robotic Demonstration in the Atrium
	Venue 1: Ruby Auditorium
	Mining Robotics Chairperson: Francois Du Plessis
13:30- 13:50	Space Mining Application for South African Mining Robotics <i>AM Neale</i>
13:50 – 14:10	Modeling of Breakdown Voltage by Artificial Neural Network Bessie Monchusi, Stephen Letlotla, Hartmut Ilgner, Jeannette McGill
14:10 - 14:30	An Embedded Underground Navigation System Khonzi Hlophe
14:30 – 14:50	Automated Tools to Be Used for Ascertaining Structural Condition in South African Hard Rock Mines Ruth Teleka, Jeremy Green, Stefan Brink, John Sheer
14:50 – 15:10	Segmentation techniques for extracting humans from thermal images John Dickens, Jeremy Green
15:10 – 15:40	Afternoon Tea/Coffee Poster Session
15:30 – 18:00	Mobile Robot Competition Please see page vii for competition schedule. R2000 Cash Prize Sponsored by National Instruments for the best Robot
18:00 for 18:30	National Instruments Traditional Braai on the Deck Cash Bar Talk by Spoor and Fisher – The lighter side of IP



## PROGRAMME

Friday 25 November 2011

Time	Venue 1: Ruby Auditorium		
8:00 –	Registration Desk Open		
09:00 – 9:40	Keynote Speaker: Jose Neira Computer Science and Systems Engineering dept., Universidad de Zaragoza, Spain Environment Modelling for Robots using Cameras		
09:40 – 10:00	Creating Three-Dimensional Thermal Maps Mathew Price, Jeremy Green, John Dickens		
10:10 - 10:30	Process Planning for Reconfigurable Manufacturing System for Mould/Die Making A.O. Oke, K. Abou-El-Hossein, N.J. Theron		
10:30 - 10:50	Optimal Placement of Range-only Beacons for Mobile Robot Localisation Michael Burke, Nico Bos		
10:50 – 11:20	Morning Refreshments Poster Session		
	Venue 1: Ruby Auditorium	Venue 2: Emerald Auditorium	
	Robots and Automation Chairperson: Nkgatho Tlale	<b>Bio-Robotics</b> Chairperson: Kristiaan Schreve	
11:20 - 11:40	Analysis and Evaluation of an Autonomous Self-balancing Mobile Materials Handling Platform for Advanced Manufacturing Systems Louwrens Butler, Glen Bright	Upper and Lower Exoskeleton Limbs for Assistive and Rehabilita- tive Applications Dasheek Naidu, Calvin Cunniffe, Riaan Stopforth, Shaniel Davrajh, Glen Bright	
11:40 - 12:00	A Theoretical Framework for a Manufacturing Planning System for RMSs Jared Padayachee, Glen Bright	Biological considerations in the structural design of smart prosthetics Khumbulani Mpofu, Unene N. Manganyi	



#### PROGRAMME

Friday 25 November 2011 (cont)

12:00 – 12:20	Tool Wear Monitoring Using Acous- tic Emission Oluwole Olufayo, Khaled Abou-El- Hossein, Theo van Niekerk	Robotics and the Brain-Computer Interface System: Critical Review for Manufacturing Application Chiemela Onunka, Glen Bright
12:20 – 12:40	Shape Memory Alloy Actuator for the Tool End-Feed in Lathe Machin- ing Timothy Otieno, Khaled Abou-El- Hossein	Pothole Tagging System Deon Joubert, Ayanda Tyatyantsi, Viv- ian Manchidi, Jeffry Mphahlele
	Venue 2: Emerald Auditorium	
12:40 - 13:00	Closing comments By J Green – conference chair	
13:00 – 14:00	Lunch on the deck	
15:00 - 17:30	RoboCup Soccer at University of Pretori Please see page v for directions to the v	ia /enue.

## STATEMENT OF PEER REVIEW

While the printed proceedings contain only abstracts, the papers in their entirety were peer-reviewed according to the following definition:

"An acceptable peer review process is one that involves an assessment or review of the research publication in its entirety before publication by independent, qualified experts. Independent in this context means independent of the author."

The editorial committee that undertook the review process can be found on page i, and the full papers can be downloaded from the conference website - www.robmech.co.za after the conclusion of the conference.



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#### PLENARY SPEAKERS

#### **Robotics Workshop**

Gerald Steinbauer received a MSc in Computer Engineering (Telematics) and a PhD in Computer Science in 2001 and 2006 from Graz University of Technology. He is currently assistant professor at the Institute for Software Technology at the Graz University of Technology and works on intelligent robust control of autonomous mobile robots. His research interests include autonomous mobile robots. robust high-level robot control, cognitive robotics, rescue robots, automated diagnosis and RoboCup. He built up several RoboCup teams at Graz University of Technology and currently works as their scientific coordinator. Furthermore, he coordinates RoboCup activities in Austria. He has published several dozen papers in journals, conferences and workshops. He has organised a number of workshops and other scientific events and is very active in the RoboCup



community. In 2009 he served as General Chair of the RoboCup 2009. He is a member of the IEEE Robotics and Automation Society, ACM and the Austrian Society for Artificial Intelligence. Moreover, he is founding president of the Austrian RoboCup National Chapter and the Austrian IEEE Robotics and Automation Chapter.

Jose Neira is full professor at the Computer Science and Systems Engineering dept., Universidad de Zaragoza, Spain. He has published 2 books, 16 journal papers and 35 conference papers on the subject of environment modeling for robotics. Jose has been involved in the organization of many scientific events, including Robotics: Science and System (RSS), the IEEE International Conference on Robotics and Automation (ICRA), and the IEEE/RSJ International Conference on Intelligent Robots (IROS). He frequently gives invited seminars in workshops at RSS, ICRA, and IROS, and in universities including MIT, Oxford, Imperial College, and TU Munich. Currently he serves as associate editor for the IEEE Transactions on Robotics, and has been invited editor for Robotics and Autonomous Systems, the Journal of Field Robotics, Autonomous Robots, and the IEEE Transactions on Robotics.



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**Olaf Diegel** is an educator and a practitioner of engineering product development with an excellent track record of developing innovative solutions to engineering problems.

In his role at Auckland University of Technology, he is director of the Creative Industries Research Institute, an interdisciplinary research institute that crosses over between Engineering, Art & Design, Computing and Communications. In his consulting practice he develops a wide range of products for New Zealand and international companies. Over the past 10 years he has developed over 40 successfully commercialized new products including innovative new theatre lighting products, security and marine products and several home health monitoring products.

He has received numerous awards including the 2008 Bayer Innovation Awards in the Health and Science category for his innovative work in the area of predictive health monitoring products, and the 2006 New Zealand Engineering Excellence Awards Engineering Innovator of the Year prize.



#### ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Navigation and Control

## Towards the Certification of Non-Deterministic Control Systems for Safety-Critical Applications

#### Chris R. Burger, Thomas Jones

Abstract — Current certification criteria for safety-critical systems exclude non-deterministic control systems. This paper investigates the feasibility of using human-like monitoring strategies to achieve safe non-deterministic control using multiple independent controllers. An architecture is presented that could form the basis for a stochastic description based on knowledge representation, so that the behaviour of a non-deterministic control system can be constrained within safe boundaries.

Keywords - certification; learning systems; safety-critical systems.

Chris R. Burger CSIR Meraka Institute P O Box 395, 0001 Pretoria, South Africa Email: crburger@csir.co.za

Thomas Jones Department of Electrical and Electronic Engineering Stellenbosch University Private Bag X1, 7602 Matieland, South Africa Email: jones@sun.ac.za



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#### ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Navigation and Control

# Rotor Aerodynamic Analysis of a Quadrotor for Thrust Critical Applications

#### Yogianandh Naidoo, Riaan Stopforth, Glen Bright

Abstract — Field robots are becoming more useful in search and rescue operations due to their ability to be deployed into a disaster site with minimal assessment to the area. This allows a rescue team to respond swiftly, increasing the possibility of survival for victims. In this paper, an aerodynamic analysis was conducted on the rotors of a quadrotor unmanned aerial vehicle (UAV) intended to be utilised in search and rescue operations. A combination of blade element and vortex theory was investigated to model the aerodynamics of a fixed pitch propeller, used in the rotors of the vehicle. This model was simulated using the JavaProp© software package to establish the performance characteristics of the rotorcraft. This was necessary to determine the efficiency of the rotors and possible payload capacities. The rotorcraft also requires high thrust capabilities in order to cope in harsh environments of disaster sites.

Keywords - Quadrotor, UAV, Aerodynamics

Yogianandh Naidoo University of KwaZulu Natal MR2G – Search & Rescue Division Durban, South Africa Email: 205506529@ukzn.ac.za

Riaan Stopforth University of KwaZulu Natal MR2G – Search & Rescue Division Durban, South Africa Email: Stopforth@ukzn.ac.za

Glen Bright University of KwaZulu Natal Mechatronics & Robotics Research Group (MR2G) Durban, South Africa Email: brightg@ukzn.ac.za



## ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Navigation and Control

## Literature Review of SLAM and DATMO

#### Ardhisha Pancham, Dr Nkgatho Tlale, Prof Glen Bright

Abstract — Simultaneous Localization And Mapping (SLAM) allows a mobile robot to be completely autonomous in an unknown environment and perform its tasks. The robot is able to create a map of its environment and at the same time locate itself. Real world environments however, are characterized by moving objects such as people, cars, robots and mobile furniture. In order for the robot to interact safely with these moving objects the robot would have to perform Detection And Tracking Of Moving Objects (DATMO). Moving object detection and tracking would eliminate errors in maps, resulting in a reliable map that would enable the robot to localize itself in the environment and execute its tasks. This paper provides a literature review of the techniques and sensors employed to allow a mobile robot to perform SLAM and DATMO.

Keywords - SLAM; DATMO; dynamic; detecting and tracking; Kinect

Ardhisha Pancham<sup>1,2</sup>, Dr Nkgatho Tlale<sup>1</sup>, Prof Glen Bright<sup>1,2</sup> 1) CSIR, Pretoria, South Africa 2) UKZN, Durban, South Africa

Glen Bright University of KwaZulu Natal Mechatronics & Robotics Research Group (MR2G) Durban, South Africa Email: brightg@ukzn.ac.za

Nkgatho S. Tlale Mobile Intelligent Autonomous Systems Council for Scientific and Industrial Research Pretoria, South Africa Email: ntlale@csir.co.za

#### ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Navigation and Control

#### **Empirical Comparison of Meathods for Handling Out-Of-Sequence Measurements**

#### **Bhekisipho Twala**

Abstract — One primary concern of engineers, particularly those dealing with target tracking and filtering, is effectively dealing with out-of-sequence measurements (OOSM). Recently, the use of Kalman filters has proven to be of great practical value in solving a variety of OOSM problems including multi-target tracking prediction. In this paper we argue that delayed and existing measurements are typically correlated and could be described by a joint distribution. Thus, the use of a copula-based approach will not only provide versatile means to model the dependence structure of both measurements but also handle OOSM effectively. Benchmarking results on simulated datasets show the use of copulas as more robust to handling OOSM as compared to current methods.

Keywords - out-of-sequence measurements, multi-sensor data, target tracking, copulas

**Bhekisipho Twala** Department of Electrical and Electronic Engineering Science University of Johannesburg Johannesburg, South Africa Email: btwala@uj.ac.za

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## ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Navigation and Control

## Design of a position and orientation measurement robot

#### Akshay Lakhani, Igor Gorlach, Farouk Smith

Abstract — Mobile robotics plays an ever increasing role not only in an industrial environment but in all aspects of modern life. Mobile robots can be found in offices, shops and hospitals. As an important engineering task when designing mobile robots is the navigation strategy, this research presents a dead-reckoning system for an accurate localisation of mobile robots. The deadreckoning system is based on the calculations of the increments of the robot movements, which utilise the odometry parameters obtained from optical sensors. The proposed solution for controlling mobile robots has the advantage of low-cost as it utilises an optical mouse sensor.

Keywords – dead reckoning; mobile robot; optical mouse sensor.

A Lakhani, I Gorlach, F Smith **Department of Mechatronics** Nelson Mandela Metropolitan University Port Elizabeth, South Africa Email: s207063172@live.nmmu.ac.za

#### ABSTRACTS

Thursday 24 November, Venue 2: Emerald Auditorium, Robot Kinematics and Dynamics

#### Modeling the manipulator and flipper pose effects on tip over stability of a tracked mobile manipulator

#### Chioniso Dube

Abstract — Mobile manipulators are used in a number of different applications such as bomb disposal, mining robotics, and search and rescue operations. These mobile manipulators are highly susceptible to tip over due to the motion of the manipulator or the gradient of the slope being traversed by the platform. This paper presents the model of a tracked mobile manipulator for tipover stability analysis in stope mining environments. The Force Angle stability measure is used to compute the stability index of the platform. An environment is simulated using a gradient vector field and a simulated iRobot PackBot platform is modeled moving through the environment. The PackBot manipulator motion is modeled using the forward kinematics of serial structured manipulators. Action of the flippers has the effect of changing the tip over axis and stability index of the platform. The geometry of the platform is used to compute the resultant tip over axis given the angle of the flippers. The overall stability based on the slope of the environment, the manipulator pose and the flipper angle is then computed. The results give new insight into tip over prevention for tracked mobile manipulators.

Mobile Intelligent Autonomous Systems Council for Scientific and Industrial Research, South Africa Email: cdube@csir.co.za

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#### ABSTRACTS

Thursday 24 November, Venue 2: Emerald Auditorium, Robot Kinematics and Dynamics

# Techniques applied in design optimization of parallel manipulators

#### Dithoto Modungwa, Nkgatho Tlale, Bheki Twala

Abstract — There are some key advantages associated with parallel robots, which have warranted their continued research and wide application in both university laboratories and industry. To obtain a parallel manipulator with good properties, as customized by user specifications, the design parameters of a parallel manipulator must be optimized. The optimal design of the general parallel manipulator's kinematic parameters may be decomposed into two processes: structural synthesis and dimensional synthesis. Although both these processes will be described, the scope of this paper explores the dimensional synthesis aspect.

Historical optimization methods adopted by researchers are discussed. This paper presents dimensional synthesis approaches based on performance requirements that have a potential to obtain almost all feasible design solutions that satisfy the requirements. The optimal design problem is a constrained nonlinear optimization problem with no explicit analytical expression. This makes the process of optimization a cumbersome and time-consuming endeavour, especially when the variables are diverse and objective functions are excessively complex. Thus, several techniques devised by researchers to solve the problem are reviewed in this paper.

Keywords - dimensional synthesis; optimization; parallel manipulators

Dithoto Modungwa Mechatronics and Micro-Manufacturing Council for Scientific and Industrial Research Pretoria, South Africa Email: dmodungwa@csir.co.za

Nkgatho S. Tlale Mobile Intelligent Autonomous Systems Council for Scientific and Industrial Research Pretoria, South Africa Email: ntlale@csir.co.za

Bheki Twala Dept.of Electrical and Electronic Eng. Science University of Johannesburg Kingsway Campus Johaanesburg, South Africa Email: btwala@uj.ac.za

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#### ABSTRACTS

Thursday 24 November, Venue 2: Emerald Auditorium, Robot Kinematics and Dynamics

#### 6 DOF, Low Inertia, Concept Design for an Industrial Robotic Arm

#### Ahmed Shaik, Nkgatho Tlale, Glen Bright

Abstract — Serial robotic arms are a central part of most manufacturing industries and are widespread. They are used for component assembly, welding, cutting and spray painting, but can be programmed to accomplish a wide variety of tasks within its workspace. Due to the location of the motors and gearboxes the serial arm contains significant inertia, which is a significant disadvantage. It affects accuracy and contributes to dynamic vibration problems. The research presented here will focus on a novel hybrid machine design to overcome these problems. Its architecture is hybrid as it does not explicitly conform to the exact definition of either Serial Kinematics Machines (SKMs) or Parallel Kinematics Machines (PKMs). The goal of its hybrid nature is to combine the best advantages of both architectures which is to have an optimized workspace to footprint ratio equivalent to that of a serial robot, with the machine moving mass and agility of a parallel robot. These advantages are conflicting requirements and do not coexist in pure serial or pure parallel topologies. The unique hybrid design presented here, uses a few novel mechanisms that enables a full range of 6 DOF (degrees of freedom), with the advantages mentioned and thus has the potential to be a better option to present-day industry technology. Keywords-Serial kinematics, parallel kinematics, hybrid machine, 6 DOF.

Ahmed A. Shaik CSIR; Material Science and Manufacturing; Mechatronics and Micro-Manufacturing Pretoria, South Africa Email: ashaik@csir.co.za

Prof. G. Bright UKZN; Department of Mechanical Engineering; Mechatronics and Robotics Research Group Durban, South Africa Email: Brightg@ukzn.ac.za

Dr. Nkgatho S. Tlale CSIR; Mobile Intelligent Autonomous Systems; Modelling and Digital Sciences Pretoria, South Africa Email: ntlale@csir.co.za



#### ABSTRACTS

Thursday 24 November, Venue 2: Emerald Auditorium, Robot Kinematics and Dynamics

# On the Mentor Arm Position Placement Problem: A Forward Kinematics Analysis

#### VOS Olunloyo, Mike Ayomoh, I Adeoti

Abstract — This paper presents a forward kinematics model predicated on Denavit Hartenberg's (DH) analytical scheme for robot arm position analysis. The developed model aims at predicting and recovering the end-effecter's position of a real robot nomenclatured "Mentor arm" for different joint variables. The Mentor arm is an articulated robot arm characterized with five rotary joint axes. It is basically a serial manipulator whose geometrical configuration consists of a waist, shoulder, elbow, left wrist axle, right wrist axle and an end-effecter gripping mechanism. The basic challenge associated with the Mentor arm is the limited information available on its governing control model for position placement. Two ways by which control can be effected on the Mentor arm include: the use of a simulator and the Workcell Amalgamated Logical Linguistic Instructions (WALLI) software. The non-versatility of this control software is seen in the non-availability of a programmable environment by users. The user interface of WALLI allows for numeric keyboard inputs such that each input results in the orientation of a specific joint by a margin equivalent to the input. The relationship between the keyboard inputs and joint motion of the arm is not feasible to the users. The proposed DH scheme as presented herein has successfully reproduced the end-effecter position of the Mentor arm with marginal differences for different experimental trials.

Keywords - Forward Kinematics, D-H Concept, Mentor arm, Walli Software

Vincent O.S. Olunloyo M.K.O. Ayomoh I. Adeoti

Departement of Systems Engineering Departement of Systems Engineering Departement of Systems Engineering

University of Lagos University of Lagos University of Lagos

- Lagos, Nigeria Lagos, Nigeria Lagos, Nigeria
- Email: vosolunloyo@hotmail.com
- Email: mikeayomoh@yahoo.com
- Email: adeoti@yahoo.com

#### ABSTRACTS

Thursday 24 November, Venue 2: Emerald Auditorium, Robot Kinematics and Dynamics

#### The use of parallel mechanism micro-CMM in micrometrology

#### Ali Rugbani, Kristiaan Schreve

Abstract — Over the past two decades there has been a surge in demand for accurate and precise 3D metrology machines to provide measurements in micron scale. This demand is encouraged by the need for guality and process control for the promised technological development of micro electromechanical systems (MEMS). Parallel mechanisms have been the subject of study as positioning machines. Parallel manipulators used as small scale coordinate measuring machine, micro-CMMs, to provide measurements with submicron accuracy for MEMS products with ever decreasing dimensions. This paper highlights some research activities in micro-CMMs. Initially, the advantages of the parallel mechanisms over their serial counterpart CMMs (such as high stiffness, high accuracy, and low inertia), as well as the disadvantages (such as complex forward kinematics, small workspace, complicated structures, and a high cost) are introduced. Then an identification of the major error sources in these structures is presented. Later, the kinematics and the concept of calibration is introduced. Additionally, the main characteristics of the existing methods of calibration and error compensation are discussed. Finally, concluding remarks concerning micro measurements using micro- CMMs are given.

Keywords – micro-CMM; parallel manipulator; micromeasurement.

Ali Rugbani Department of Mechanical and Mechatronic Engineering University of Stellenbosch Stellenbosch, South Africa Email: rugbani@sun.ac.za

**Kristiaan Schreve** Department of Mechanical and Mechatronic Engineering University of Stellenbosch Stellenbosch, South Africa Email: kschreve@sun.ac.za

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Thursday 24 November, Venue 1: Ruby Auditorium, Mining Robotics

## **Space Mining Application for South African Mining Robotics**

#### AM Neale

Abstract — The concept of mining in space in not new, but the topic has been getting more attention in recent years. Many authors agree that mining space resources and the settlement of space would require extensive use of robotics. This paper explores the notion that future South African mining robotics could make the country a key player in the space mining industry. South Africa has fairly unique ultra-deep narrow tabular gold deposits, which lends itself to mechanization/ automation for a number of reasons. The challenges to overcome before successfully implementing robotics in these deposits are similar to some of the robotics challenges in mining space resources. This paper discusses these challenges as applied to both the SA gold deposits and in space mining. This overlap can be mutually beneficial. There are a number of ways, suggested in this paper, in which the SA mining robotics industry could benefit from co-operating with the space mining industry.

Keywords - space, mining, robotics, South Africa

Mining Engineer Hatch Africa Johannesburg, South Africa Email: mneale@hatch.co.za

President South African Space Resources Association Pretoria, South Africa Email: president@sasra.co.za



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#### ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Mining Robotics

#### Modeling of Breakdown Voltage by Artificial Neural Network

#### Bessie Monchusi, Stephen Letlotla, Hartmut Ilgner, Jeannette McGill

Abstract — The paper presents a model to determine the breakdown voltage of rocks under AC excitation conditions by employing the Artificial Neural Network (ANN) method. A relationship between the input parameters and the breakdown voltage is demonstrated. The inputs to the neural network are the starting temperature, input current and power. The output of the ANN is the breakdown voltage. A Multi-layer Feedforward Neural Network (MFNN) employing back propagation algorithm is used for learning and to train the ANN. The ANN is designed, trained and tested with Matlab software.

Keywords - breakdown voltage; ANN; rock breaking; multi-layer feedforward neural network.

B. Monchusi, S. Letlotla Centre for Mining Innovation CSIR Johannesburg, South Africa Email: bmonchusi@csir.co.za Email: SLetlotl@csir.co.za

H. Ilgner, J. McGill Centre for Mining Innovation CSIR Johannesburg, South Africa Email: HIlgner@csir.co.za Email: JMcGill@csir.co.za



#### ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Mining Robotics

## An Embedded Underground Navigation System

#### Khonzi Hlophe

Abstract — Platform pose (localization and orientation) information is a key requirement for autonomous mobile systems. The severe natural conditions and complex terrain of underground mines diminish the capability of most pose estimation systems, especially GPS. Our research interest is focused on using lowcost off-the-shelf IMU to improve the Active Beacon Positioning System (ABPS) developed here at the CSIR. This paper proposes a novel pose estimator, for underground mines, that fuses together data from the ABPS and a low-cost MEMS based IMU. This pose estimator uses an unscented Kalman filter (UKF) to fuse the data together. The method is evaluated by building a complete system in a lab.

Khonzi Hlophe Novel Mining Methods Research Group CSIR: Centre for Mining Innovations Johannesburg, South Africa Email: hlophek@gmail.com

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#### ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Mining Robotics

#### Automated Tools to Be Used for Ascertaining Structural Condition in South African Hard Rock Mines

Ruth Teleka, Jeremy Green, Stefan Brink, John Sheer

Abstract — The use of automation in deep level hard rock mines has over the years been overshadowed by mechanized mining. However, more and more readily, the industry is starting to recognize the validity of considering automation as an option both in the mining operations and in the efforts to improve mine safety. If mines are safe, the belief is that more skilled labor will express interest in it unlike the way it currently is. The purpose of this paper is to discuss the possibility of using automated tools in the pre-entry examination or making safe exercise.

Keywords – making safe; pre-entry examination, electronic sounding device (ESD), thermal imagery, sonic beacons

R Teleka<sup>1</sup>, J Green<sup>2</sup>, S Brink<sup>3</sup> Centre for Mining Innovation CSIR Johannesburg, South Africa Email: rteleka@csir.co.za Email: jgreen@csir.co.za Email: sbrink@csir.co.za

Prof. J Sheer Centre for Mechanized Mining University of Witwatersrand Johannesburg, South Africa Email: John.Sheer@wits.ac.za



#### ABSTRACTS

Thursday 24 November, Venue 1: Ruby Auditorium, Mining Robotics

# Segmentation techniques for extracting humans from thermal images

#### John Dickens, Jeremy Green

Abstract — A pedestrian detection system for underground mine vehicles is being developed that requires the segmentation of people from thermal images in underground mine tunnels. A number of thresholding techniques are outlined and their performance on a number of thermal images is investigated. The thresholding techniques are evaluated on images in various ambient conditions and it is shown that a minimum error thresholding technique is the most effective.

J.S. Dickens CSIR Centre for Mining Innovation PO Box 91230 Auckland Park 2006 Johannesburg, South Africa Email: jdickens@csir.co.za

J.J. Green CSIR Centre for Mining Innovation PO Box 91230 Auckland Park 2006 Johannesburg, South Africa Email: jgreen@csir.co.za

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#### ABSTRACTS

Friday 25th November, Venue 1: Ruby Auditorium

#### **Creating Three-Dimensional Thermal Maps**

#### Mathew Price, Jeremy Green, John Dickens

Abstract — A method for generating 3D maps of mines with thermal imaging texture from a robotic platform is presented. The objective is to use these models to generate risk maps that can be used to assess mine safety. Analysis will take place offline, but the data collection platform will be autonomous. Our registration method is based on aligning 3D descriptors that are extracted from range images and uses ICP for refinement. The descriptors encode the distribution of radial distances in the vicinity of keypoints, and enable alignment of non-sequential scans that are visibly different. Thermal texture is added to the registered point cloud using a once-off calibration between the 3D and thermal cameras. Two alternate visualisation schemes are discussed, and results are shown for a real mine stope.

Mathew Price Cogency cc Cape Town Email: mathew@cogency.co.za

Jeremy Green CSIR Centre for Mining Innovation Johannesburg Email: jgreen@csir.co.za

John Dickens CSIR Centre for Mining Innovation Johannesburg Email: jdickens@csir.co.za



#### ABSTRACTS

Friday 25th November, Venue 1: Ruby Auditorium

# Process Planning for Reconfigurable Manufacturing System for Mould/Die Making

#### A.O. Oke, K. Abou-El-Hossein, N.J. Theron

Abstract — For efficient manufacture of moulds and dies and in order to meet the unstable market situation, a well organised reconfigurable manufacturing system is required. The geometric features of moulds and dies are not the same as discrete parts. They are contained elements on a block of steel and are usually in the form of contours, slots, corners, slope faces, curved surfaces and cavities. A lot of techniques are found in literature for process planning of manufacturing system of discrete parts but that of bodies similar to moulds and dies are quite rare. In this research, different techniques from literature are combined to form the process planning of a reconfigurable manufacturing system for mould and die making, which may also be applicable to similarly complex bodies. A technique was developed based on the weight of precedence factors to form a machining precedence order, which can be used to formulate the route sheet that is unique for manufacturing of moulds and dies and other similar complex bodies. A reconfigurable machine layout in which the developed process planning can be applied is also developed.

Keywords - process planning; mould and die; manufacturing system; precedence; machine cell.

A. O. Oke<sup>1</sup>, K. Abou-El-Hossein<sup>2</sup> 1Department of Mechanical and Aeronautical Engineering, University of Pretoria, Pretoria, South Africa 2Department of Mechatronics, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa Email: okekola@yahoo.com Email: Khaled.Abou-El-Hossein@nmmu.ac.za

N. J. Theron1 1Department of Mechanical and Aeronautical Engineering, University of Pretoria, Pretoria, South Africa Email: Nico.Theron@up.ac.za

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#### ABSTRACTS

Friday 25th November, Venue 1: Ruby Auditorium

# Optimal Placement of Range-only Beacons for Mobile Robot Localisation

#### Michael Burke, Nico Bos

Abstract —The ability of an agent to self-localise is crucial to any autonomous task where mobility is required. A common set of techniques solving the localisation problem involve the deployment of active beacons or landmarks, which eliminate problems related to landmark detection and association. The use of beacons providing range-only estimates using time-of-flight measurements is one such approach. Here, range measurements are used in trilateration or range-only SLAM algorithms to provide an accurate measure of a robot's position. Unfortunately, the potential error in a position estimate is related to the relative geometry of the beacons, and poorly placed beacons can result in extremely inaccurate location estimates. This paper presents an optimisation technique for finding optimal beacon positions, so as to minimise the mean positional uncertainty in a given environment. Our work shows that this approach represents an improvement on previous approaches because the resultant uncertainty map can be used as a heuristic to improve path planning algorithms.

Michael Burke Mobile Intelligent Autonomous Systems Council for Scientific and Industrial Research Pretoria, South Africa Email: michaelburke@ieee.org

Nico Bos Dept. Electrical, Electronic and Computer Engineering University of Pretoria Pretoria, South Africa Email: nicbos@gmail.com



#### ABSTRACTS

Friday 25th November, Venue 1: Ruby Auditorium, Robots and Automation

### Analysis and Evaluation of an Autonomous Self-balancing Mobile Materials Handling Platform for Advanced Manufacturing Systems

Louwrens Butler, Glen Bright

Abstract — The novelty of the self-balancing robot has passed, however it has not been applied in the manufacturing industry. The design of a self-balancing mobile materials handling robot for autonomous operation was undertaken in order to evaluate the feasibility of such a device for application in advanced manufacturing systems. The platform itself was designed as a mechatronic system with integration of the three main subsystems of a mechatronic system as one of the main objectives. The platform, as well as the implementation of the platform within an advanced manufacturing environment was evaluated using the Failure Mode, Effects, and Criticality Analysis method.

Keywords – Failure Mode, Effects, and Criticality Analysis; Mechatronic system; Mobile robotics; Advanced manufacturing

School of Mechanical Engineering University of KwaZulu-Natal Durban, South Africa Email: butlerlj@ukzn.ac.za Email: brightg@ukzn.ac.za



#### ABSTRACTS

Friday 25th November, Venue 1: Ruby Auditorium, Robots and Automation

#### A Theoretical Framework for a Manufacturing Planning System for RMSs

#### Jared Padayachee, Glen Bright

Abstract — The Reconfigurable Manufacturing System (RMS) concept has evolved out of the inadequacy of previous manufacturing paradigms in addressing global manufacturing challenges. In order to address these challenges RMSs are envisaged to exhibit transformable system layouts and reconfigurable processes, cells and machines. Existing manufacturing planning systems do not encapsulate concepts of reconfigurability in planning mechanism to obtain optimal system configurations. This paper presents a theoretical framework for a Manufacturing Planning System for RMSs. The framework focuses on the automated selection of optimal shop floor configurations for systems with high product variety and shared resources. The DEVS (Discrete Event System Specification) formalism is used to model reconfigurable equipment and processes. The "reconfiguration engine" in the proposed framework, implements a metaheuristic algorithm for the assembly of optimised system models. This paper also proposes the use of metaheuristic algorithms, such as Genetic Algorithms to assist with the automated exploration of RMS configurations.

Keywords – Reconfigurable Manufacturing Systems, Reconfigurable Manufacturing Planning Systems, Discrete System Modelina, Genetic Alaorithms, Reconfigurable Process Plans.

J. Padayachee School of Mechanical Engineering Howard College University of KwaZulu-Natal Durban South Africa Email: padayacheej@ukzn.ac.za

G. Bright School of Mechanical Engineering Howard College University of KwaZulu-Natal Durban South Africa Email: brightg@ukzn.ac.za

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### ABSTRACTS

Friday 25th November, Venue 1: Ruby Auditorium, Robots and Automation

## **Tool Wear Monitoring Using Acoustic Emission**

#### Oluwole Olufayo, Khaled Abou-El-Hossein, Theo van Niekerk

Abstract — This research work highlights the effects of acoustic emission (AE) signals emitted during the milling of H13 tool steel as an important parameter in the identification of tool wear. These generated AE signals provide information on the chip formation, wear, fracture and general deformation. Furthermore, it is aimed at implementing an online monitoring system for machine tools, using a sensor fusion approach to adequately determine process parameters necessary for creating an adequate tool change timing schedule for machining operations.

Keywords – Tool Wear Monitoring, acoustic emission, milling

O.A. Olufayo, K. Abou-El-Hossein, T. van Niekerk Mechatronics Engineering Department Nelson Mandela Metropolitan University 6001 Port Elizabeth, South Africa Email: oluwole.olufayo@nmmu.ac.za



#### ABSTRACTS

Friday 25th November, Venue 1: Ruby Auditorium, Robots and Automation

#### Shape Memory Alloy Actuator for the Tool End-Feed in Lathe Machining

#### Timothy Otieno, Khaled Abou-El-Hossein

Abstract — A shape memory alloy (SMA) is an intermetallic compound able to recover, in a continuous and reversible way, a predetermined shape during a thermal cycle while generating mechanical work. In this paper, its use in developing an actuator for a machining process is investigated. The actuator is to drive the tool cross feed into an aluminium workpiece in a finishing lathe operation, and PID control is implemented to the power supplied to the SMA, thereby providing the position control. This study covers the first stage of the mechatronics system design and development of the actuator.

Keywords - shape memory alloys; sma; smart actuators; machining actuators.

T. Otieno, K. Abou-El-Hossein **Department of Mechatronics** Nelson Mandela Metropolitan University Port Elizabeth, 6031, South Africa Email: timothy.otieno@nmmu.ac.za

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#### ABSTRACTS

Friday 25th November, Venue 2: Emerald Auditorium, Bio-Robotics

# Upper and Lower Exoskeleton Limbs for Assistive and Rehabilitative Applications

## Dasheek Naidu, Calvin Cunniffe, Riaan Stopforth, Glen Bright and Shaniel Davrajh

Abstract — Individuals with tetraplegia have loss of motor function in both their upper and lower extremities. Research is being conducted into the development of an exoskeleton to cater for the tetraplegic user. An exoskeleton system has the advantage of assisting disabled or rehabilitating patients without the need of surgery. This paper includes the conceptual design of an upper and lower limb exoskeleton which will be used for rehabilitative and assistive purposes. The mechanical design, kinematical analysis and control architecture will be outlined. Simulated results of the workspace were conducted for the specific design and kinematic models.

Mechatronics and Robotics Research Group Bioengineering Unit School of Mechanical Engineering University of Kwa-Zulu Natal Durban South Africa Email: dasheekn@gmail.com Email: cunniffec@gmail.com Email: stopforth@ukzn.ac.za Email: brightg@ukzn.ac.za Email: sdavrajh@ukzn.ac.za

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#### ABSTRACTS

Friday 25th November, Venue 2: Emerald Auditorium, Bio-Robotics

## Biological considerations in the structural design of smart prosthetics

#### Khumbulani Mpofu, Unene N. Manganyi

Abstract — The objective of this paper is to highlight the important characteristics, parameters and obstacles that ought to be taken into consideration when designing the mechanical structure or frame of a robotic anthropomorphic arm, also known as a smart prosthetic arm, with a biological system serving as inspiration. This paper examines the attributes of biological bones which give them their mechanical properties, focusing on the humerus, ulna and radius bones with the notion that a similar approach can be used in the analysis of the biological hand. Through the discussion of available alternative materials and their feasibility, both financially and through application, such as demonstrating self-healing capabilities and also discussing possible solutions; this paper indicates the synergy needed between the fields of engineering, both robotics and mechatronics, and medicine for the advancement of smart prosthetics.

Keywords – Biological bone; force-to-weight ratio; smart prosthetics.

Unéné N. Manganyi Department of Mechanical Engineering: Mechatronics Tshwane University of Technology Pretoria South Africa Email: unene-12@hotmail.com

Khumbulani Mpofu Department of Industrial Engineering Tshwane University of Technology Pretoria South Africa Email: mpofuk@tut.ac.za



#### ABSTRACTS

Friday 25th November, Venue 2: Emerald Auditorium, Bio-Robotics

### Robotics and the Brain-Computer Interface System: Critical Review for Manufacturing Application

#### Chiemela Onunka, Glen Bright

Abstract — Robots are employed in variety of applications and are available in a wide range of configurations. The need to respond to the environment without using the nervous system's efferent pathways has initiated a new interaction system that can boost and speed up the human sensor-effector system. To maximize human and machine interaction, Human Threading TM technique has been developed to merge the observations made in human cognitive system, neuro-anatomical structures, finite state machines and their associated relationships. The Brain-Computer Interface (BCI) is used to create a robust communication system that can interpret human intentions and cognitive emotions reflected by appropriate brain signals into control signals for robotic manipulations. Efficient braincomputer interfaces use efficient neural signal recording devices that are able to record neural signals continuous over long periods of time through Positron Emission Tomography (PET), functional Magnetic Resonance Imaging (fMRI), functional Near-Infrared Imaging (fNIR), Electroencephalography (EEG) and Electrocorticographic (ECoG) methods. The paper presents critical review of the brain-computer interface system and robotics for manufacturing applications.

Keywords – BCI, EEG, ECoG, Robotic Control, Human Threading

Chiemla Onunka Mechanical Engineering Department University of KwaZulu Natal Durban, South Africa Email: 205512204@ukzn.ac.za

Glen Bright Mechanical Engineering Department University of KwaZulu Natal Durban, South Africa Email: brightg@ukzn.ac.za

#### ABSTRACTS

Friday 25th November, Venue 2: Emerald Auditorium, Bio-Robotics

## **Pothole Tagging System**

#### Deon Joubert, Ayanda Tyatyantsi, Vivian Manchidi, Jeffry Mphahlele

Abstract — Potholes are not only a source of frustration to drivers but also negatively impact the economy due to damage to vehicles and costly road repairs. Regular and rapid pavement inspection and maintenance is key to preventing pothole formation and growth. To improve the efficiency of maintenance and reduce the cost thereof, a vehicle mounted sensor system is being developed that will automatically detect and analyse potholes. The results will then be packaged together with the Global Positioning System (GPS) coordinates of the pothole for use by technical experts and maintenance schedulers. The system will utilise a Microsoft Kinect and a high-speed USB camera as sensing devices.

Deon Joubert, Ayanda Tyatyantsi, Jeffry Mphahlehle and Vivian Manchidi Council for Scientific and Industrial Research Pretoria South Africa Email: djoubert@csir.co.za

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