

Peter Fleming
Beatrys Margaretha Lacquet
Saeid Sanei
Kalyanmoy Deb
Andreas Jakobsson *Editors*

Smart and Sustainable Engineering for Next Generation Applications

Proceeding of the Second International
Conference on Emerging Trends in
Electrical, Electronic and Communications
Engineering (ELECOM 2018),
November 28–30, 2018, Mauritius

Lecture Notes in Electrical Engineering

Volume 561

Series Editors

Leopoldo Angrisani, Department of Electrical and Information Technologies Engineering, University of Napoli Federico II, Napoli, Italy

Marco Arteaga, Departament de Control y Robótica, Universidad Nacional Autónoma de México, Coyoacán, Mexico

Bijaya Ketan Panigrahi, Electrical Engineering, Indian Institute of Technology Delhi, New Delhi, Delhi, India
Samarjit Chakraborty, Fakultät für Elektrotechnik und Informationstechnik, TU München, München, Germany
Jiming Chen, Zhejiang University, Hangzhou, Zhejiang, China

Shanben Chen, Materials Science & Engineering, Shanghai Jiao Tong University, Shanghai, China

Tan Kay Chen, Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Singapore

Rüdiger Dillmann, Humanoids and Intelligent Systems Lab, Karlsruhe Institute for Technology, Karlsruhe, Baden-Württemberg, Germany

Haibin Duan, Beijing University of Aeronautics and Astronautics, Beijing, China

Gianluigi Ferrari, Università di Parma, Parma, Italy

Manuel Ferre, Centre for Automation and Robotics CAR (UPM-CSIC), Universidad Politécnica de Madrid, Madrid, Madrid, Spain

Sandra Hirche, Department of Electrical Engineering and Information Science, Technische Universität München, München, Germany

Faryar Jabbari, Department of Mechanical and Aerospace Engineering, University of California, Irvine, CA, USA

Limin Jia, State Key Laboratory of Rail Traffic Control and Safety, Beijing Jiaotong University, Beijing, China

Janusz Kacprzyk, Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland

Alaa Khamis, German University in Egypt El Tagamoa El Khames, New Cairo City, Egypt

Torsten Kroeger, Stanford University, Stanford, CA, USA

Qilian Liang, Department of Electrical Engineering, University of Texas at Arlington, Arlington, TX, USA

Ferran Martin, Departament d'Enginyeria Electrònica, Universitat Autònoma de Barcelona, Bellaterra, Barcelona, Spain

Tan Cher Ming, College of Engineering, Nanyang Technological University, Singapore, Singapore

Wolfgang Minker, Institute of Information Technology, University of Ulm, Ulm, Germany

Pradeep Misra, Department of Electrical Engineering, Wright State University, Dayton, OH, USA

Sebastian Möller, Quality and Usability Lab, TU Berlin, Berlin, Germany

Subhas Mukhopadhyay, School of Engineering & Advanced Technology, Massey University, Palmerston North, Manawatu-Wanganui, New Zealand

Cun-Zheng Ning, Electrical Engineering, Arizona State University, Tempe, AZ, USA

Toyooki Nishida, Graduate School of Informatics, Kyoto University, Kyoto, Kyoto, Japan

Federica Pascucci, Dipartimento di Ingegneria, Università degli Studi "Roma Tre", Rome, Italy

Yong Qin, State Key Laboratory of Rail Traffic Control and Safety, Beijing Jiaotong University, Beijing, China

Gan Woon Seng, School of Electrical & Electronic Engineering, Nanyang Technological University, Singapore, Singapore

Joachim Speidel, Institute of Telecommunications, Universität Stuttgart, Stuttgart, Baden-Württemberg, Germany

Germano Veiga, Campus da FEUP, INESC Porto, Porto, Portugal

Haitao Wu, Academy of Opto-electronics, Chinese Academy of Sciences, Beijing, China

Junjie James Zhang, Charlotte, NC, USA

The book series *Lecture Notes in Electrical Engineering* (LNEE) publishes the latest developments in Electrical Engineering - quickly, informally and in high quality. While original research reported in proceedings and monographs has traditionally formed the core of LNEE, we also encourage authors to submit books devoted to supporting student education and professional training in the various fields and applications areas of electrical engineering. The series cover classical and emerging topics concerning:

- Communication Engineering, Information Theory and Networks
- Electronics Engineering and Microelectronics
- Signal, Image and Speech Processing
- Wireless and Mobile Communication
- Circuits and Systems
- Energy Systems, Power Electronics and Electrical Machines
- Electro-optical Engineering
- Instrumentation Engineering
- Avionics Engineering
- Control Systems
- Internet-of-Things and Cybersecurity
- Biomedical Devices, MEMS and NEMS

For general information about this book series, comments or suggestions, please contact leontina.dicecco@springer.com.

To submit a proposal or request further information, please contact the Publishing Editor in your country:

China

Jasmine Dou, Associate Editor (jasmine.dou@springer.com)

India

Swati Meherishi, Executive Editor (swati.meherishi@springer.com)

Aninda Bose, Senior Editor (aninda.bose@springer.com)

Japan

Takeyuki Yonezawa, Editorial Director (takeyuki.yonezawa@springer.com)

South Korea

Smith (Ahram) Chae, Editor (smith.chae@springer.com)

Southeast Asia

Ramesh Nath Premnath, Editor (ramesh.premnath@springer.com)

USA, Canada:

Michael Luby, Senior Editor (michael.luby@springer.com)

All other Countries:

Leontina Di Cecco, Senior Editor (leontina.dicecco@springer.com)

Christoph Baumann, Executive Editor (christoph.baumann@springer.com)

**** Indexing: The books of this series are submitted to ISI Proceedings, EI-Compindex, SCOPUS, MetaPress, Web of Science and Springerlink ****

More information about this series at <http://www.springer.com/series/7818>

Peter Fleming · Beatrys Margaretha Lacquet ·
Saeid Sanei · Kalyanmoy Deb ·
Andreas Jakobsson
Editors

Smart and Sustainable Engineering for Next Generation Applications

Proceeding of the Second International
Conference on Emerging Trends in Electrical,
Electronic and Communications Engineering
(ELECOM 2018), November 28–30, 2018,
Mauritius

Editors

Peter Fleming
Department of Automatic Control
and Systems Engineering
University of Sheffield
Sheffield, UK

Saeid Sanei
Department of Computer Science
University of Surrey
Guildford, UK

Andreas Jakobsson
Department of Mathematical Statistics
Lund University
Lund, Sweden

Beatrys Margaretha Lacquet
Transnet Centre of Systems Engineering
University of the Witwatersrand
Wits, South Africa

Kalyanmoy Deb
Michigan State University
East Lansing, MI, USA

ISSN 1876-1100 ISSN 1876-1119 (electronic)
Lecture Notes in Electrical Engineering
ISBN 978-3-030-18239-7 ISBN 978-3-030-18240-3 (eBook)
<https://doi.org/10.1007/978-3-030-18240-3>

© Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The Second International Conference on Emerging Trends in Electrical, Electronic and Communications Engineering (ELECOM 2018) is a continuation of the very successful ELECOM 2016 conference. In line with the main objective of ELECOM 2016, ELECOM 2018 will also bring together industry professionals, academics, and individuals from government agencies and other institutions to exchange information and ideas on electrical, electronic, communications engineering and computing. The conference will feature a comprehensive technical program offering numerous technical sessions with papers showcasing the latest technologies, applications, and services. Additionally, it will aim at a much greater outreach than ELECOM 2016 by including special sessions chaired by leading international experts in the fields of electrical, electronic, and communications engineering.

ELECOM 2018 was organized by the University of Mauritius, a leading tertiary education institution. The event received positive responses from a multitude of stakeholders including public and private sectors, local and international universities, and research institutions. Thirty-eight papers were accepted following a rigorous blind review process, and all papers were screened using Turnitin. Among the accepted papers, three papers form part of a special session on Open Research Challenges in 5G Multimedia Communications and four of them are from the workshop on Fascination with Systems Engineering. There were four keynote addresses by the following experts: Namely, Prof. Saeid Sanei from the Nottingham Trent University gave a keynote address on Multitask Cooperative Networks and their Applications; Prof. Beatrys Lacquet from the University of the Witwatersrand gave a keynote speech on Bridging the Skills Gap for Industry 4.0; Prof. Nikola Djuric from the University of Novi Sad gave a keynote speech on Continuous Electromagnetic (EMF) Investigation Using Wireless Sensor Network (WSN); and Mr. Stuart Michie, ABB Ability Manager, Southern Africa, gave a keynote speech on How to Run the World Without Consuming the Earth (How digitalisation Will Help Secure Our Future).

This book contains a selection of revised manuscripts presented at ELECOM 2018 within the three main conference themes, which are Electrical and Electronic Engineering, Communications and Engineering and Computing and IT. This book covers various aspects of advanced electrical and communications engineering and computing.

The conference chairs wish to acknowledge the University of Mauritius for successfully organizing the conference and Tertiary Education Commission, Central Electricity Board, and the Information and Communication Technologies Authority for sponsoring this event.

Robert T. F. Ah King
Tulsi Pawan Fowdur

Message from International Chairs

It is our great pleasure to welcome you to the second International Conference on Emerging Trends in Electrical, Electronic and Communications Engineering (ELECOM 2018), held in Mauritius, a volcanic island of lagoons and palm-fringed beaches with coral reefs surrounding most of the coastline. Mauritius is a multi-cultural nation, known for its dreaming beaches, lagoons and reefs with colourful mountainous and rainforests, waterfalls, hiking trails and wildlife yet carrying a long history of cultural and social changes.

The conference, held during Nov. 28–30, 2018, is a premier forum for the exchange of ideas, open and direct discussion in the fields of Electrical and Electronic Engineering, Communications and Engineering as well as Computing and IT, and its related disciplines. It attracted high quality and impact research articles in science and technology which were peer reviewed by eminent scholars. Therefore, this Proceeding includes rigorously peer-reviewed articles submitted by research scholars from all over the world reflecting the conference value as an international event. We were also pleased to see the broad range of subjects addressed in these submissions which covered the conference themes.

We wish to use this opportunity to express my appreciation to the excellent Organising Team, Program Committee Members and reviewers for their hard work and valuable contribution. Certainly, ELECOM wouldn't take place without such outstanding effort.

In addition, the conference content has been enriched by outstanding keynote talks delivered by international expert guest speakers.

We trust that this conference has started on a very solid foundation and indeed the forthcoming editions of this conference will have an even greater impact while significantly extend their reach to the international community in the related fields.

Saeid Sanei
Beatrys Lacquet

Proceedings Editors



Emeritus Professor Peter Fleming is Professor of Industrial Systems and Control in the Department of Automatic Control and Systems Engineering at the University of Sheffield, UK. His control and systems engineering research interests include control system design, system health monitoring, multicriteria decision-making, optimization and scheduling, and applications of e-Science.

He has over 400 research publications, including six books, and his research interests have led to the development of close links with a variety of industries in sectors such as automotive, aerospace, energy, food processing, pharmaceuticals, and manufacturing.

He is Fellow of the Royal Academy of Engineering, Fellow of the International Federation of Automatic Control, Fellow of the Institution of Engineering and Technology, Fellow of the Institute of Measurement and Control, and Editor-in-Chief of *International Journal of Systems Science*. He was Director of the Rolls-Royce University Technology Centre for Control and Systems Engineering (1993–2012).

Further details may be found at http://www.shef.ac.uk/acse/staff/peter_fleming



Professor Beatrys Margaretha Lacquet received her Doctor Ingenieriae, Magister Ingenieriae, and B.Sc. (Hons) in electrical and electronic engineering from Rand Afrikaans University (now University of Johannesburg), South Africa. Currently, she is with the University of the Witwatersrand as Director of Transnet Center of Systems Engineering and Transnet Matlofatso Centre. She was formerly Deputy Vice-Chancellor, Knowledge and Information Management, Infrastructure and Operations, and Dean,

Faculty of Engineering and the Built Environment. She is a registered professional engineer in South Africa, Senior Member of IEEE, Fellow of SAIEE, Fellow and Exco Member of South African Academy of Engineering, and Member of INCOSE SA. She has held leadership and management positions at Rand Afrikaans University and University of the Witwatersrand, and other professional bodies such as The Engineering Council of South Africa, Engineering Standards Generating Body, and The South African Institute of Electrical Engineers. During the past 36 years, she had been working in the Solid-State Electronics Group, the Sensors Sources and Signal Processing Research Group, and the Centre for Optical Communications and Sensors at the Rand Afrikaans University, and in three laboratories in the USA and Canada. She has authored and co-authored more than 190 peer-reviewed journal papers, conference contributions, and seminars and was an NRF C-rated researcher and jointly hold a few patents.



Professor Saeid Sanei received his PhD from Imperial College London, UK, in 1991. Since then, he has gained much professional experience from working in both academia and industry and being a member of seven institutions in four different countries. He has published 3 books, a number of chapters, and more than 350 papers in refereed journals and prestigious conference proceedings. He supervised 32 very successful PhD students and a number of postdoctoral researchers. He has been Associate Editor for the IEEE Signal Processing Letters and IEEE Signal Processing Magazine and a number of other journals. He will chair the IEEE ICASSP in the UK and is Member of the

IEEE Machine Learning for Signal Processing Technical Committee. Currently, he is Member of academic staff in Nottingham Trent University, UK, and Academic Visitor to Imperial College London, King's College London, and University of Surrey, UK.



Professor Kalyanmoy Deb is Koenig Endowed Chair Professor at the Department of Electrical and Computer Engineering in Michigan State University (MSU), East Lansing, USA. He also holds a professor position at the Department of Computer Science and Engineering and at the Department of Mechanical Engineering in MSU.

His main research interests are in genetic and evolutionary optimization algorithms and their application in optimization, modeling, and machine learning. He is largely known for his seminal research in developing and applying evolutionary multi-objective optimization. His Computational Optimization and Innovation (COIN) Laboratory (<http://www.coin-laboratory.com>)

at Michigan State University promotes research in these areas. He consults with various industries and software companies.

He was awarded the prestigious ‘Infosys Prize’ in 2012, ‘TWAS Prize’ in Engineering Sciences in 2012, ‘CajAstur Mamdani Prize’ in 2011, ‘JC Bose National Fellowship’ in 2011, ‘Distinguished Alumni Award’ from IIT Kharagpur in 2011, ‘Edgeworth-Pareto’ Award in 2008, Shanti Swarup Bhatnagar Prize in Engineering Sciences in 2005, and ‘Thomson Citation Laureate Award’ from Thompson Reuters. Recently, he has been awarded an Honorary Doctorate from University of Jyväskylä, Finland. His 2002 IEEE-TEC NSGA-II paper is judged as the Most Highly Cited Paper and a Current Classic by Thomson Reuters having more than 20,000+ citations. He is a fellow of IEEE, ASME, Indian National Science Academy (INSA), Indian National Academy of Engineering (INAE), Indian Academy of Sciences (IASc), and International Society for Genetic and Evolutionary Computation (ISGEC). He has written two textbooks on optimization and more than 435 international journal and conference research papers with Google Scholar citations of 90,000+ with h-index of 100. He is in the editorial board on 20 major international journals. More information about his research can be found from <http://www.egr.msu.edu/~kdeb>.



Professor Andreas Jakobsson received his M.Sc. from Lund University and his PhD in signal processing from Uppsala University, respectively. Since then, he has held positions with Global IP Sound AB, the Swedish Royal Institute of Technology, King’s College London, and Karlstad University and been Honorary Research Fellow at Cardiff University. He has been Visiting Researcher at King’s College London, Brigham Young University, Stanford University, Katholieke Universiteit Leuven, and University of California, San Diego, as well as acted as an expert for the IAEA. He is Member of The Royal Swedish Physiographic Society, Member of the EURASIP

Special Area Team on Signal Processing for Multisensor Systems, Senior Member of IEEE, Senior Associate Editor for IEEE Transactions on Signal Processing, and Associate Editor for Elsevier Signal Processing. He has previously also been Member of the IEEE Sensor Array and Multichannel (SAM) Signal Processing Technical Committee (2008–2013), Associate Editor for the IEEE Transactions on Signal Processing (2006–2010), the IEEE Signal Processing Letters (2007–2011), the Research Letters in Signal Processing (2007–2009), and the Journal of Electrical and Computer Engineering (2009–2014). His research interests include statistical and array signal processing, detection and estimation theory, and related application in remote sensing, telecommunication, and biomedicine.

Plenary Speakers



Professor Saeid Sanei received his PhD from Imperial College London, UK, in 1991. Since then, he has gained much professional experience from working in both academia and industry and being a member of seven institutions in four different countries. He has published 3 books, a number of chapters, and more than 350 papers in refereed journals and prestigious conference proceedings. He supervised 32 very successful PhD students and a number of postdoctoral researchers. He has been Associate Editor for the IEEE Signal Processing Letters and IEEE Signal Processing Magazine and a number of other journals. He will chair the IEEE ICASSP in the UK and is Member

of the IEEE Machine Learning for Signal Processing Technical Committee. Currently, he is Member of academic staff in Nottingham Trent University, UK, and Academic Visitor to Imperial College London, King's College London, and University of Surrey, UK.

Keynote Speech: Multitask Cooperative Networks and Their Applications

The notion of cooperative networks and their extensions to multitask systems will be visited in this talk. The details of a new approach for analysing such networks namely diffusion adaptation will be discussed before moving to the multitask scenario where the groups of agents or nodes in the network can have different objectives. In addition, despite their wide applications in communication systems, it will be demonstrated that such networks can also be used in machine learning and mathematical modelling. Moreover, we will see that a new formulation for information credibility over cooperative networks can be introduced whereby some network security measures can be achieved. Most recently, such networks have opened new directions in smart grid research, power and energy control, and also biomedical engineering and biosciences. These applications will be further elaborated and the implementation results demonstrated.



Professor Beatrys Margaretha Lacquet received her Doctor Ingenieriae, Magister Ingenieriae, and B.Sc. (Hons) in electrical and electronic engineering from Rand Afrikaans University (now University of Johannesburg), South Africa. Currently, she is with the University of the Witwatersrand as Director of Transnet Center of Systems Engineering and Transnet Matlofatso Centre. She was formerly Deputy Vice-Chancellor, Knowledge and Information Management, Infrastructure and Operations and Dean, Faculty of Engineering and the Built Environment. She is a registered professional engineer in South Africa, Senior Member of IEEE, Fellow of SAIEEE, Fellow and

Exco Member of South African Academy of Engineering, and Member of INCOSE SA. She has held leadership and management positions at Rand Afrikaans University and University of the Witwatersrand, and other professional bodies such as The Engineering Council of South Africa, Engineering Standards Generating Body, and The South African Institute of Electrical Engineers. During the past 36 years, she had been working in the Solid-State Electronics Group, the Sensors Sources and Signal Processing Research Group, and the Centre for Optical Communications and Sensors at the Rand Afrikaans University, and in three laboratories in the USA and Canada. She has authored and co-authored more than 190 peer-reviewed journal papers, conference contributions, and seminars and was an NRF C-rated researcher and jointly hold a few patents.

Keynote Speech: Bridging the Skills Gap for Industry 4.0

The fourth industrial revolution is upon us. Because this phase of economic and technological development is flowing from the third industrial revolution – the digital evolution, it may not be fully visible or recognised in all domains of our society at present. Increasingly, science fiction as we experienced and revered it, is becoming science fact. We have a choice to fear it, or to embrace it!

Whereas the first industrial revolution, a term coined in circa 1884, swapped animal power with water and steam power to mechanise production, the second used the recently introduced electric power to mass produce products to drive the economies. The natural successor since the middle of the previous century, the third industrial revolution, was associated with the automation of production using electronics and information technology. Now, a fourth industrial revolution is building on the third. This new wave is characterised by a fusion of many technologies to create exciting new and innovative products and services. The fourth industrial revolution will empower billions of people to connect through mobile devices that have almost unlimited processing power and storage capacity, and access to knowledge. And, these possibilities will be amplified by technology

breakthroughs that will emerge in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D/4-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing. Physical, digital and biological paradigms will fuse and the societal fabric of our times will change in ways that were previously only imagined in science fiction.

The question arises who will create this new world. Our view of the place of work and the nature of ‘jobs’ will soon be outdated and as stated by Sugate Mitra in 2013, “In the future, no one will pay you for knowledge they can look up”. We have to prepare young people and upskill incumbents for jobs that do not exist yet, and for flexible ways of working.

A bigger question is how do we predict the required skills and knowledge base and develop the new generation to deliver on the expectations of products and services for a very different and mostly unknown world in the fourth industrial revolution. This industrial age will evolve exponentially and involve the transformation of complete multidimensional and different systems, across various countries, economic sectors, and society in its entirety, into highly complex and interconnected systems.

We will present our current thinking on systems methodologies to predict skills gaps that may arise in this industrial age. A few scenarios will be considered and proposals presented to bridge the skills gaps. We will also share some thoughts on a new systems oriented education and training paradigm.



Professor Nikola Djuric received his PhD degrees in telecommunication and signal processing from the Faculty of Technical Sciences (FTN-UNS), University of Novi Sad. His research interests include computational and applied electromagnetics. He is Deputy Director of the accredited Laboratory for Electromagnetic Compatibility at FTN-UNS and the leader of the research team that has been specialized in the area of computational and applied electromagnetics. His team is well experienced in environmental electromagnetic field (EMF) measurement and monitoring for EMF compliance testing, as well as in estimation and simulation of the whole-body exposure to

EMF. In the last four years, he has been a project coordinator of four nationally funded projects, while currently he is MC Member and Serbian Coordinator for the EU COST BM1309 Action—“European network for innovative uses of EMFs in biomedical applications (EMF-MED)”. He is Member of the Technical Committee of the Accreditation Body of the Republic of Serbia (ATS), then the ATS Commission for the Accreditation of Laboratories for EMF Compliance Testing and the ATS Commission for the Adaptation of Legislative Acts. Additionally, he is IEEE Member and the author of more than 70 journal and conference articles.

Keynote Speech: Continuous Electromagnetic (EMF) Investigation Using Wireless Sensor Network (WSN)

Regarding wide technological development of wireless communication and services, based on electromagnetic fields (EMF) as carrier, as well as their communication infrastructure, the EMF has become an inevitable element of the living or working environment. Having in mind that those fields are generated artificially, in addition to the natural ones, the considerable effort is devoted to investigation of their influence on a living organism, as well as prevention of dangerous EMF levels.

Respecting those essentials, the modern EMF investigation approach suggest continuous and long-term EMF monitoring, initiating development of several progressive monitoring systems. This keynote speech will present concept and technical details of the state-of-the-art continuous EMF investigation using wireless sensor network (WSN) of EMF monitoring sensors.

The sensors perform wideband monitoring of cumulative field level, counting contribution of all active EMF field sources in vicinity of particular location, in order to determine its fluctuation over a long period of time and across the territory that this sensors network covers. In addition, the EMF monitoring system perform the assessment of population exposure, according to the prescribed reference limits.

The main objective of system for continuous EMF investigation is to become useful and user-friendly tool for general population, interested about on daily EMF levels, as well as for regulatory agencies, which are in charge for regulation and installation of new EMF sources, in order to protect environment from possible harmful level of non-ionizing radiation.



Stuart Michie, ABB Ability Manager, Southern Africa, appointed to the Country Management Team of ABB South Africa as Digital Lead, is responsible for driving the digitalization agenda of ABB in Southern Africa. ABB Ability brings together the worlds of operation technology and information technology, recognizing the importance of digitalization as a key driver as the world moves into the Fourth Industrial Revolution. He is a registered professional engineer and has bachelor's and master's degrees in electrical engineering from the University of Cape Town. He has spent 22 years working in the area of automation in the power industry, starting in the operations of a medium-sized electrical distribution utility and, since 2001, progressing through various engineering, sales, and management positions in ABB South Africa.

Keynote Speech: How to Run the World Without Consuming the Earth (How Digitalisation Will Help Secure Our Future)

As the world grows to an expected 9 billion people by 2050, we need to embrace new ways of managing energy, water, food and transport. For there to be a sustainable world, we need to move bits and not atoms. This talk will unpack how digitalisation will help secure our future.

Organization

Committee

International Chairs

Saeid Sanei

University of Surrey, UK

Lacquet Beatrys Margaretha

University of the Witwatersrand, Johannesburg,
South Africa

Organizing Committee

General Chair

Robert T. F. Ah King

University of Mauritius, Mauritius

General Co-chair

Tulsi Pawan Fowdur

University of Mauritius, Mauritius

Secretary

V. Ramnarain-Seetohul

University of Mauritius, Mauritius

Web Site and Advertisement Committee

Chair

Anshu Prakash Murdan

University of Mauritius, Mauritius

Co-chair

Avinash Mungur University of Mauritius, Mauritius

Member

Vishwamitra Oree University of Mauritius, Mauritius

Finance and Registration Committee**Chair**

Vandana Bassoo University of Mauritius, Mauritius

Co-chairs

Bhimsen Rajkumarsingh University of Mauritius, Mauritius

R. Ramjug-Ballgobin University of Mauritius, Mauritius

Paper Submissions Committee**Chair**

Visham Hurbungs University of Mauritius, Mauritius

Co-chair

Vidasha Ramanarain Seetohul University of Mauritius, Mauritius

Review Committee**TPC Chair**

S. Z. Sayed Hassen University of Mauritius, Mauritius

Co-chairs

I. Jahmeerbacus University of Mauritius, Mauritius

M. A. Hosany University of Mauritius, Mauritius

Y. Beeharry University of Mauritius, Mauritius

Chair

Rameshwar Jugurnauth University of Mauritius, Mauritius

Vishwamitra Oree University of Mauritius, Mauritius

Abdel Khoodaruth University of Mauritius, Mauritius

Chair

Avinash Mungur University of Mauritius, Mauritius

Nitish Chooramun University of Mauritius, Mauritius
V. Ramnarain-Seetohul University of Mauritius, Mauritius

Yogesh Beeharry University of Mauritius, Mauritius

International Technical Program Committee Members

Peter Fleming	University of Sheffield, UK
Lacquet Beatrys Margaretha	University of the Witwatersrand, Johannesburg, South Africa
Kalyanmoy Deb	Michigan State University, USA
Poompat Saengudomlert	Bangkok University, Thailand
Zoran Bojkovic	University of Belgrade, Serbia
Chandra Sekhar Paidimarry	Osmania University, Telangana, India

Keshav Dahal	University of the West of Scotland, UK
Santosh Nagaraj	San Diego State University, USA
Cheng-Hsiung Hsieh	University of Technology, Taiwan
Chaoyang	
Nikos Mastorakis	Technical University, Sofia, Bulgaria, Hungary
João Duro	University of Sheffield, UK
Ales Prochazka	Institute of Chemical and Technology, Prague, Czech Republic
Athanassios Skodras	University of Patras, Greek
Clive Cheong Took	University of Surrey, UK
Anthony T. S. Ho	University of Surrey, UK
Mohamed Djemai	University of Valenciennes, France
Jean Pierre Barbot	ENSEA, France
Yue Wang	Northumbria University, UK
Richard Binns	Northumbria University, UK
Mousa Marzband	Northumbria University, UK
Michael Elsdon	Northumbria University, UK
Mousa Marzband	Northumbria University, UK
Susan Wang	Northumbria University, UK
Ghanim Putrus	Northumbria University, UK
Edris Pouresmaeil	ESTIA Institute of Technology, Bidart, France
Brahim Cherki	University of Tlemcen, Algeria
Patrick Johnson	Sheffield Hallam University, UK
Tracey K. M. Lee	Singapore Polytechnic, Singapore
Mehrdad Saif	University of Windsor, Canada
Fezal Ackburally	CS Viamonde, Canada

List of Trackchairs and Reviewers

Trackchairs

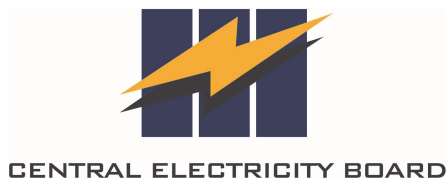
Anshu Murdan
 Bhimsen Rajkumarsingh
 Heman Shamachurn
 Iqbal Jahmeerbacus
 M. A. Hosany
 Nitish Chooramun
 Pawan Fowdur
 Rajeshree Ramjug-Ballgobin
 Rameshwar Ashvin Jugurnauth
 S. Z. Sayed Hassen
 Vandana Bassoo
 Yogesh Beeharry

Reviewers

Amar Seeam
Anshu Murdan
Avinash Mungur
Bhimsen Rajkumarsingh
Datta Singh Goolaub
Gianeshwar Ramsawock
Heman Shamachurn
Horng Gwo-Jiun
Iqbal Jahmeerbacus
Jay Mungur
Laurie Butgereit
Leckraj Nagowah
M. A. Hosany
Neermal Lachoomun
Nimai Charan Patel
Nitish Chooramun
Prateema Ragpot
Rajeshree Ramjug-Ballgobin

Rameshwar Ashvin Jugurnauth
Riaan Stopforth
Robert T. F. Ah King
Roopesh Kevin Sungkur
Roushdatt Elaheebocus
S. Z. Sayed Hassen
Sameerchand Pudaruth
Sandhya Armoogum
Shehzad Jaunbuccus
Somveer Kishnah
Tulsi Pawan Fowdur
Vandana Bassoo
Vikram Goolaub
Visham Hurbungs
Vishwamitra Oree
Yasdeo Bissessur
Yassser Chuttur
Yogesh Beeharry

Sponsors



Central Electricity Board

<http://ceb.intnet.mu/>



**Tertiary Education Commission
in Mauritius**

<http://www.tec.mu/>



**INFORMATION & COMMUNICATION
TECHNOLOGIES AUTHORITY**

**Information and Communication
Technologies Authority**

<https://www.icta.mu/>



**University of Mauritius Students'
Union**

<http://sites.uom.ac.mu/studentsunion/>

Contents

Electrical and Electronic Engineering

Hand Gesture Controller for Robotic-Wheelchair Using Microelectromechanical Sensor ADXL 345	3
Shaaeree Ashrilee Ramessur and Vishwamitra Oree	
A Jaya-Based Invasive Weed Optimization Technique for Load Frequency Control	11
Muhammad Yasser Oozeer and Rajeshree Ramjug-Ballgobin	
A Hybrid Optimisation Algorithm for Voltage Control	22
Tavish Hookoom and Rajeshree Ramjug-Ballgobin	
Optimization of Load Frequency Control for Non-linear System	34
Muhammad Yasser Oozeer and Rajeshree Ramjug-Ballgobin	
Efficiency of VFD Coupled Induction Motors Operating in the Scalar Mode with Different Types of Loads	45
L. Latchoomun, C. Gokhool, R. T. F. Ah King, K. Busawon, and J. P. Barbot	
A Reconfigurable Load Emulator for Multiple Quadrant Motor Drives	60
M. I. Jahmeerbacus	
Multi-objective Optimisation of Distributed Generation Units in Unbalanced Distribution Systems	70
Pamela Ramsami and Robert T. F. Ah King	
Experimentally Investigating the Power Production of Three PV Technologies Under Four Roof Conditions Typical for a Tropical Climate	82
Ranto Erick Randriaharijaona and Heman Shamachurn	

A Comparative Study of Different Solar Power Tracking Control Techniques	93
M. M. R. Mooraby and S. Z. Sayed Hassen	
Communications and Engineering	
A Smart Precision Irrigation and Monitoring System	105
Leevna Patroo, Kooshboo Thacooree, and Avinash Mungur	
Performance Evaluation of an IPv6 IoT Network Based on 802.11 Standard	115
Toshan Kumar Sahye, Wakeel Sandooyea, and Avinash Mungur	
The Parser Function for D61 Files of Narda AMS 8061 Stations in EMF RATEL Monitoring System	126
Nikola Djuric, Nikola Kavecan, Gorana Mijatovic, Dragan Kljajic, Karolina Kasas-Lazetic, and Snezana Djuric	
Software Realization of the Exposure Assessment in EMF RATEL Monitoring System	137
Dragan Kljajic, Nikola Djuric, and Nikola Kavecan	
Forecasting Model for Voice and Internet Data Traffic During Peak Time Using Hidden Markov Model	145
R. A. Jugurnauth and J. Ramashire	
Optimizing the Performance of Triple-Binary Turbo Codes with Hierarchical QAM and K-NN Based Classification	159
Yogesh Beeharry and Tulsi Pawan Fowdur	
Signal Distortion Identification Using Rough Flow Graphs	168
B. Jankar and B. Rajkumarsingh	
Noise Mitigation in a Power Line Communication Channel	180
Bhimsen Rajkumarsingh and Bhargava N. Sokappadu	
Computing and IT	
A Model for Classifying People at Risk of Diabetes Mellitus Using Social Media Analytics	195
Soulakshmee D. Nagowah and Ravesh Joaheer	
A Machine Learning Approach for Idle State Network Anomaly Detection	205
T. P. Fowdur, Y. Beeharry, and K. Aucklah	
Object Storage System Using Replication and Erasure Codes (OSSREC)	215
Aatish Chiniyah and Navishna Ramchurn	

Improving Effectiveness of Honeypots: Predicting Targeted Destination Port Numbers During Attacks Using J48 Algorithm	225
Tanveer Gangabissoon, Amaan Nathoo, Rakshay Ramhith, Bhooneshwar Gopee, and Girish Bekaroo	
Sirius: A Resource for Analyzing Drug-Disease Relationships for Drug Repositioning	235
Muhsin Muhammad Maudarbux, Anisah Wahed Ghoorah, and Tulsi Pawan Fowdur	
Enhancing Learning at Primary School Through Augmented Reality . . .	245
Vidasha Ramnarain-Seetohul, Appa Nishesh, and Lobin Siddish	
Analyzing the Prospects and Acceptance of Mobile-Based Marine Debris Tracking	256
Ashley Thanacoody, Girish Bekaroo, Aditya Santokhee, and Suraj Juddoo	
The Analysis and the Need of Ubiquitous Learning to Engage Children in Coding	268
Yeeshtdevisingh Hosanee and Shireen Panchoo	
Adaptive Smart Car Park System (ASCaPS) Utilising CCTV Nodes and Mobile Technology	277
Jeetun Varshika, Chooraman Aumshankar, and Chiniah Aatish	
Elderly Care Assistant: A Discreet Monitoring Tool	287
Kritesh Sunghoon, Gopalen M. Parasuraman, and Shehzad Jaunbuccus	
A Hybrid Approach for Recommender Systems in a Proximity Based Social Network	302
Soulakshmee D. Nagowah, Kedarnathsingh Rajarai, and Muhammad M. N. Lallmahamood	
A Machine Learning Model to Predict the Performance of University Students	313
Derinsha Canagareddy, Khuslendra Subarayadu, and Visham Hurbungs	
AIML and Sequence-to-Sequence Models to Build Artificial Intelligence Chatbots: Insights from a Comparative Analysis	323
Nishant Teckchandani, Aditya Santokhee, and Girish Bekaroo	
Accurate Footprint Satellite Positioning Space System	334
Abdurazzag A. Aburas and Mohammad Hassan	
Special Session on Open Research Challenges in 5G Multimedia Communications	
Evolution of 5G Mobile Broadband Technology and Multimedia Services Framework	351
Dragorad Milovanovic, Zoran Bojkovic, and Vladan Pantovic	

5G Connectivity Technologies for the IoT: Research and Development Challenges 362
Zoran Bojkovic and Dragorad Milovanovic

5G Ultra Reliable and Low-Latency Communication: Fundamental Aspects and Key Enabling Technologies 372
Dragorad Milovanovic and Zoran Bojkovic

Workshop on Fascination with Systems Engineering

Big Data Innovation and the Application of Systems Thinking and Standards for Business Resiliency in the Banking Sector 383
Caroline Jean Herron and Nic Cloete-Hopkins

Application of Human Factors in a Port Socio-Technical System 396
Jessica Hutchings

Control Theory and System Dynamics Simulations of Electric Vehicle Market Penetration in South Africa 403
Nalini Sooknanan Pillay, Alan Colin Brent, and Josephine Kaviti Musango

System Engineering Methodology – Towards Successful Projects Management 414
Letlotlo Phohole and Nolusindiso Ntwana

Author Index. 425

Electrical and Electronic Engineering



Hand Gesture Controller for Robotic-Wheelchair Using Microelectromechanical Sensor ADXL 345

Shaaeree Ashrilee Ramessur^(✉) and Vishwamitra Oree

Department of Electrical and Electronic Engineering,
University of Mauritius, Réduit, Mauritius
shaaeree.ashrilee.ramessur@gmail.com,
v.oree@uom.ac.mu

Abstract. Robotic wheelchairs help in improving the mobility and safety of people with severe motor handicaps. In this paper, we propose a microelectromechanical sensor integrated in a data glove to record the hand tilt angle. An Arduino microcontroller processes the formulated angle and transmits a corresponding hand command wirelessly to a prototype robotic wheelchair via a Zigbee module employing IEEE 802.15.4 protocol. A Proportional, Integrative, and Derivative controller is added by interfacing the MATLAB® SIMULINK and Arduino® programming environments to optimise the DC motor speed control response of the robotic wheelchair. The resulting automatic tuning system causes the wheelchair speed to remain constant in both ramping up and down conditions. Experimental outcomes show that the proposed mechanism responds accurately to hand gestures of users.

Keywords: Accelerometer · Zigbee wireless module ·
Proportional Integrative Derivative (PID) · Microcontroller

1 Introduction

About 10% of the global population suffer from various disabilities, out of which about 10% need a wheelchair for moving about [1]. Manual wheelchairs require manual propulsion either by the user with a hand-rim attached to the two large rear wheels of the device or by an attendant. This type of wheelchair has been assessed as demanding more effort from upper limbs of users resulting in more fatigue and physical strain. In a bid to reduce manual power, the motorised wheelchair employs an electrical motor propulsion system as defined by World Health Organisation [2]. To alleviate the manual efforts required to actuate the wheelchairs, researchers worldwide have been trying to integrate electromechanical mechanisms into wheelchairs. Besides joystick control of electric wheelchair, new technological advances in hand gesture sensing can translate hand orientation into the wheelchair motion. Ruzaj *et al.* [3] proposed an automated head orientation controlled wheelchair for quadriplegia employing an accelerometer as orientation sensor to direct the motorised wheelchair according to the user's head movement. The system caters for uneven road patterns through a speed

compensation algorithm by detecting the slope angle of the road track. The system, however, does not improve movement stability since the response time at transient state has not been taken into consideration.

Non-contact infrared head sensor system for wheelchair control was proposed by Christensen *et al.* [4] which determines the head position using infrared sensors placed behind the user's head. This system ensured a reliable field of view and proper functioning in real life. The wheelchair could be driven at different speeds in a simple manner and applies a codification which neglects head turns allowing the user to freely look around. More recently, rehabilitation products have been enhanced by the application of Voice Recognition (VR) technology designed for quadriplegia patients. The patient's voice acts as an input control signal which is converted to an electrical signal and processed by a microcontroller. Researchers proposed different methods for the processing unit, including a Digital Signal Processing kit or computer software. Voice commands such as 'Forward', 'Backward', 'Right', 'Left', 'SpeedX', and 'Stop' are captured by a microphone and processed by the VR system. Rockland *et al.* [5] proposed a voice-controlled wheelchair equipped with an IC that stores forty spoken commands. The IC outputs its data in the Binary Coded Decimal (BCD) format so that it can be easily processed by the microcontroller. However, this system has considerable error rates in noisy environments.

Evolution in modern nanotechnology applications for microelectromechanical systems (MEMS) has facilitated signal processing on a single silicon chip platform for acceleration measurement. In this paper, a digital accelerometer, more precisely the ADXL 345, is used as a navigational aid that senses gravitational acceleration in two dimensions. The accelerometer solves the issue of bulkiness posed by a computerised wheelchair, due to its light weight and small size. The digital MEMS sensor measures the hand tilt angles according to static accelerations of gravity and is accommodated on a data glove. The latter is also equipped with an Arduino microcontroller that interfaces the sensor to a Zigbee wireless transmitter module. To this end, it collects data from the sensor and converts it in a serial form for transmission via a wireless communication link. The data is received by a similar communication module mounted on the prototype robotic-wheelchair.

According to the Disability Act implemented in the 1996 [6], people with disabilities must be able to access all public buildings through ramps for wheelchair mobility. For this purpose, the proposed system must be able to provide accurate movement stability for secure operation of the wheelchair and its user. In this context, this study considers the integration of a Proportional Integrative Derivative (PID) control system with the propulsion system to ensure smooth motion of the robotic-wheelchair both indoors and outdoors.

2 System Development

2.1 Data Glove - The Orientation Sensor Unit

The data glove consists of the ADXL 345 digital accelerometer which measures the three Cartesian components of gravitational acceleration in g units, where 1 g equals

9.8 m/s^2 . The sensor is deployed with a large selectable range of $\pm 16 \text{ g}$, a sensitivity of 256 LSB/g , a high-resolution amounting to 3.9 mg/LSB , and an ultra-low power consumption of $23 \mu\text{A}$ [7]. An Arduino Nano 3.0 microcontroller captures the hand tilt angle sensed by the accelerometer. It communicates with the sensor by the Inter-Integrated Circuit (I2C) communication protocol [8]. The communication is established by only a two-line connection for hardware efficiency in building the data glove circuit. A wireless connection between the data glove and the robotic-wheelchair is implemented to enhance the comfort of the user. For this purpose, the XBee Series 1 (XBee S1) transceiver from Digi International Inc. is selected based on its low power profile, high data rate, and 30 m range (both indoors and outdoors). It is configured for wireless connectivity between the data glove and the robotic wheelchair by setting its PAN ID, MY address, and destination address using the X-CTU software by Digi International Inc. Figure 1 shows the different components mounted on the data glove.

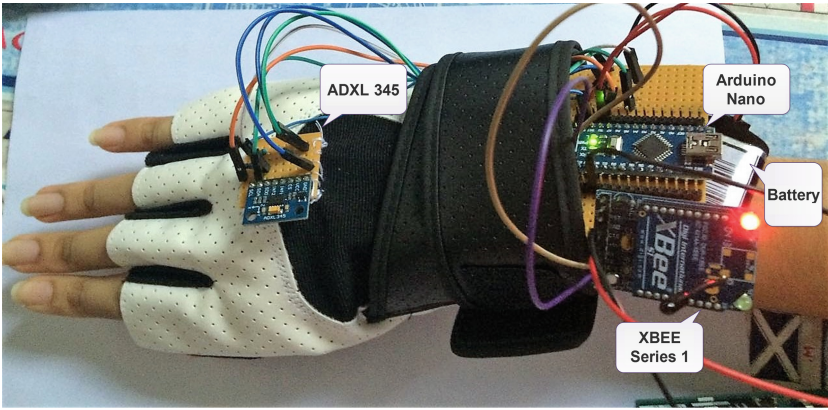


Fig. 1. The components mounted on the data glove on the transmitter side.

2.2 The Tilt Angle and Static Acceleration Measurements

The tilt angle measurement is chosen to capture the user's hand gesture by computing the inclination angle according to the static acceleration of the ADXL 345. The two fundamental tilt angles considered are the pitch and roll angles, known as the Euler angles [3], which formulate the Forward/Backward and Right/Left motion of the robotic wheelchair on the X and Y axes respectively. The computations of the Euler angles are given by Eqs. (1) and (2) respectively.

$$\text{Pitch} = \arctan\left(\frac{x}{\sqrt{y^2 + z^2}}\right). \quad (1)$$

$$\text{Roll} = \arctan\left(\frac{y}{\sqrt{x^2 + z^2}}\right). \quad (2)$$