LNAI 9622

Ngoc Thanh Nguyen · Bogdan Trawiński
Hamido Fujita · Tzung-Pei Hong (Eds.)

Intelligent Information and Database Systems

8th Asian Conference, ACIIDS 2016
Da Nang, Vietnam, March 14–16, 2016
Proceedings, Part II

2 Part II

ACIIDS 2016

Springer

Lecture Notes in Artificial Intelligence 9622

Subseries of Lecture Notes in Computer Science

More information about this series at http://www.springer.com/series/1244

Ngoc Thanh Nguyen · Bogdan Trawiński
Hamido Fujita · Tzung-Pei Hong (Eds.)

Intelligent Information and Database Systems

8th Asian Conference, ACIIDS 2016
Da Nang, Vietnam, March 14–16, 2016
Proceedings, Part II

Springer

Editors
Ngoc Thanh Nguyen
Wrocław University of Technology
Wrocław
Poland

Bogdan Trawiński
Wrocław University of Technology
Wrocław
Poland

Hamido Fujita
Iwate Prefectural University
Takizawa
Japan

Tzung-Pei Hong
National University of Kaohsiung
Kaohsiung
Taiwan

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Artificial Intelligence
ISBN 978-3-662-49389-2 ISBN 978-3-662-49390-8 (eBook)
DOI 10.1007/978-3-662-49390-8

Library of Congress Control Number: 2016930675

LNCS Sublibrary: SL7 – Artificial Intelligence

Printed on acid-free paper

This Springer imprint is published by SpringerNature
The registered company is Springer-Verlag GmbH Berlin Heidelberg

Preface

ACIIDS 2016 was the eighth event of the series of international scientific conferences for research and applications in the field of intelligent information and database systems. The aim of ACIIDS 2016 was to provide an internationally respected forum for scientific research in the technologies and applications of intelligent information and database systems. ACIIDS 2016 was co-organized by the Vietnam–Korea Friendship Information Technology College (Vietnam) and Wrocław University of Technology (Poland) in co-operation with IEEE SMC Technical Committee on Computational Collective Intelligence, Bina Nusantara University (Indonesia), Ton Duc Thang University (Vietnam), and Quang Binh University (Vietnam). It took place in Da Nang (Vietnam) during March 14–16, 2016.

The ACIIDS conference series is well established. The first two events, ACIIDS 2009 and ACIIDS 2010, took place in Dong Hoi City and Hue City in Vietnam, respectively. The third event, ACIIDS 2011, took place in Daegu (Korea), while the fourth event, ACIIDS 2012, took place in Kaohsiung (Taiwan). The fifth event, ACIIDS 2013, was held in Kuala Lumpur in Malaysia, while the sixth event, ACIIDS 2014, was held in Bangkok, Thailand. The last event, ACIIDS 2015, took place in Bali (Indonesia).

We received papers from 36 countries all over the world. Each paper was peer reviewed by at least two members of the international Program Committee and international reviewer board. Only 153 papers with the highest quality were selected for oral presentation and publication in the two-volume proceedings of ACIIDS 2016.

Papers included in the proceedings cover the following topics: knowledge engineering and the Semantic Web, social networks and recommender systems, text processing and information retrieval, database systems and software engineering, intelligent information systems, decision support and control systems, machine learning and data mining, computer vision techniques, intelligent big data exploitation, cloud and network computing, multiple model approach to machine learning, advanced data mining techniques and applications, computational intelligence in data mining for complex problems, collective intelligence for service innovation, technology opportunity, e-learning and fuzzy intelligent systems, analysis of image, video, and motion data in life sciences, real-world applications in engineering and technology, ontology-based software development, intelligent and context systems, modeling and optimization techniques in information systems, database systems, and industrial systems, smart pattern processing for sports, and intelligent services for smart cities.

Accepted and presented papers highlight the new trends and challenges of intelligent information and database systems. The presenters showed how new research could lead to novel and innovative applications. We hope you will find these results useful and inspiring for your future research.

We would like to extend our heartfelt thanks to Mr. Jarosław Gowin, the Deputy Prime Minister of the Republic of Poland and Minister of Science and Higher Education for his support and honorary patronage over the conference.

We would like to express our sincere thanks to the honorary chairs, Mr. Minh Hong Nguyen (Deputy Minister of Information and Communications, Vietnam), and Prof. Tadeusz Więckowski (Rector of the Wrocław University of Technology, Poland) for their support.

Our special thanks go to the program chairs, special session chairs, organizing chairs, publicity chairs, liaison chairs, and local Organizing Committee for their work for the conference. We sincerely thank all members of the international Program Committee for their valuable efforts in the review process, which helped us to guarantee the highest quality of the selected papers for the conference. We cordially thank the organizers and chairs of special sessions, who essentially contributed to the success of the conference.

We also would like to express our thanks to the keynote speakers (Prof. Tzung-Pei Hong, Prof. Saeid Nahavandi, Prof. Jun Wang, and Prof. Piotr Wierzchoń) for their interesting and informative talks of world-class standard.

We cordially thank our main sponsors, Vietnam–Korea Friendship Information Technology College (Vietnam), Wrocław University of Technology (Poland), IEEE SMC Technical Committee on Computational Collective Intelligence, Bina Nusantara University (Indonesia), Ton Duc Thang University (Vietnam), and Quang Binh University (Vietnam). Our special thanks are due to Springer for publishing the proceedings, and all our other sponsors for their kind support.

We wish to thank the members of the Organizing Committee for their very substantial work and the members of the local Organizing Committee for their excellent work.

We cordially thank all the authors for their valuable contributions and other participants of this conference. The conference would not have been possible without their input.

Thanks are also due to many experts who contributed to making the event a success.

March 2016

Ngoc Thanh Nguyen
Bogdan Trawiński
Hamido Fujita
Tzung-Pei Hong

Conference Organization

Honorary Chairs

Minh Hong Nguyen	Deputy Minister of Information and Communications, Vietnam
Tadeusz Więckowski	Rector of Wrocław University of Technology, Poland

General Chairs

Ngoc Thanh Nguyen	Wrocław University of Technology, Poland
Bao Hung Hoang	Vietnam–Korea Friendship Information Technology College, Vietnam

Program Chairs

Bogdan Trawiński	Wrocław University of Technology, Poland
Tzung-Pei Hong	National University of Kaohsiung, Taiwan
Hamido Fujita	Iwate Prefectural University, Japan
Duc Dung Nguyen	IOIT – Vietnamese Academy of Science and Technology, Vietnam

Special Session Chairs

Dariusz Król	Wrocław University of Technology, Poland
Lech Madeyski	Wrocław University of Technology, Poland
Bay Vo	Ton Duc Thang University, Vietnam

Publicity Chairs

Khanh Van Hoang Thi	Vietnam–Korea Friendship Information Technology College, Vietnam
Adrianna Kozierkiewicz-Hetmańska	Wrocław University of Technology, Poland

Liaison Chairs

Ford Lumban Gaol	Bina Nusantara University, Indonesia
Tan Hanh	Posts and Telecommunications Institute of Technology, Vietnam

Mong-Fong Horng	National Kaohsiung University of Applied Sciences, Taiwan
Jason J. Jung	Chung-Ang University, Korea
Ali Selamat	Universiti Teknologi Malaysia, Malaysia

Organizing Chairs

The Son Tran	Vietnam–Korea Friendship Information Technology College, Vietnam
Elżbieta Kukla	Wrocław University of Technology, Poland

Local Organizing Committee

Marcin Maleszka	Wrocław University of Technology, Poland
Zbigniew Telec	Wrocław University of Technology, Poland
Bernadetta Maleszka	Wrocław University of Technology, Poland
Marcin Pietranik	Wrocław University of Technology, Poland
Nguyen Quang Vu	Vietnam–Korea Friendship Information Technology College, Vietnam
Ngo Viet Phuong	Vietnam–Korea Friendship Information Technology College, Vietnam
Le Tu Thanh	Vietnam–Korea Friendship Information Technology College, Vietnam

Webmaster

Jarosław Bernacki	Wrocław University of Technology, Poland

Steering Committee

Ngoc Thanh Nguyen (Chair)	Wrocław University of Technology, Poland
Longbing Cao	University of Technology Sydney, Australia
Suphamit Chittayasothorn	King Mongkut's Institute of Technology Ladkrabang, Thailand
Ford Lumban Gaol	Bina Nusantara University, Indonesia
Tu Bao Ho	Japan Advanced Institute of Science and Technology, Japan
Tzung-Pei Hong	National University of Kaohsiung, Taiwan
Dosam Hwang	Yeungnam University, Korea
Lakhmi C. Jain	University of South Australia, Australia
Geun-Sik Jo	Inha University, Korea
Jason J. Jung	Chung-Ang University, Korea
Hoai An Le-Thi	University of Lorraine, France

Toyoaki Nishida	Kyoto University, Japan
Leszek Rutkowski	Technical University of Czestochowa, Poland
Ali Selamat	Universiti Teknologi Malaysia, Malaysia

Keynote Speakers

Tzung-Pei Hong	National University of Kaohsiung, Taiwan
Saeid Nahavandi	Deakin University, Victoria, Australia
Jun Wang	City University of Hong Kong, Hong Kong, SAR China
Piotr Wierzchoń	Adam Mickiewicz University in Poznań, Poland

Special Sessions Organizers

1. Multiple Model Approach to Machine Learning (MMAML 20165)

Tomasz Kajdanowicz	Wrocław University of Technology, Poland
Edwin Lughofer	Johannes Kepler University Linz, Austria
Bogdan Trawiński	Wrocław University of Technology, Poland

2. Workshop on Real-World Applications in Engineering and Technology (RWAET 2016)

Pandian Vasant	Universiti Teknologi PETRONAS, Malaysia
Vish Kallimani	Universiti Teknologi PETRONAS, Malaysia
Sujan Chowdhury	Universiti Teknologi PETRONAS, Malaysia

3. Special Session on Intelligent Services for Smart Cities (IS4SC 2016)

David Camacho	Universidad Autónoma de Madrid, Spain
Jason J. Jung	Chung-Ang University, Korea
Paulo Novais	University of Minho, Portugal
Salvatore Venticinque	Seconda Università Degli Studi di Napoli, Italy

4. Special Session on Ontology-Based Software Development (OSD 2016)

Zbigniew Huzar	Wrocław University of Technology, Poland
Bogumiła Hnatkowska	Wrocław University of Technology, Poland

5. Special Session on Intelligent Big Data Exploitation (IBDE 2016)

Gottfried Vossen	University of Münster, Germany
Stuart Dillon	University of Waikato, New Zealand

6. Special Session on Intelligent and Context Systems (ICxS 2016)

Maciej Huk	Wrocław University of Technology, Poland
Jan Kwiatkowski	Wrocław University of Technology, Poland
Anita Pinheiro Sant'Anna	Halmstad University, Sweden

7. Special Session on Analysis of Image, Video, and Motion Data in Life Sciences (IVMLS 2016)

Kondrad Wojciechowski	Polish–Japanese Academy of Information Technology, Poland
Marek Kulbacki	Polish–Japanese Academy of Information Technology, Poland
Jakub Segen	Gest3D, USA
Andrzej Polański	Silesian University of Technology, Poland

8. Special Session on Collective Intelligence for Service Innovation, Technology Opportunity, E-Learning, and Fuzzy Intelligent Systems (CISTEF 2016)

Chao-Fu Hong	Aletheia University, Taiwan
Tzu-Fu Chiu	Aletheia University, Taiwan
Kuo-Sui Lin	Aletheia University, Taiwan

9. Special Session on Advanced Data Mining Techniques and Applications (ADMTA 2016)

Bay Vo	Ton Duc Thang University, Vietnam
Tzung-Pei Hong	National University of Kaohsiung, Taiwan
Bac Le	University of Science, VNU-HCM, Vietnam

10. Special Session on Modeling and Optimization Techniques in Information Systems, Database Systems, and Industrial Systems (MOT 2016)

Le Thi Hoai An	University of Lorraine, France
Pham Dinh Tao	National Institute for Applied Science – Rouen, France

11. Special Session on Computational Intelligence in Data Mining for Complex Problems (CIDMCP 2016)

Habiba Drias	University of Science and Technology USTHB Algiers, Algeria
Gabriella Pasi	University of Milano-Bicocca, Italy

12. Special Session on Smart Pattern Processing for Sports (SP2S 2016)

S.M.N. Arosha Senanayake	Universiti Brunei Darussalam, Brunei
Chu Kiong Loo	University of Malaya, Malaysia

International Program Committee

Ajith Abraham	Machine Intelligence Research Labs, USA
Muhammad Abulaish	Jamia Millia Islamia, India
El-Houssaine Aghezzaf	Ghent University, Belgium
Waseem Ahmad	International College of Auckland, New Zealand
Jesus Alcala-Fdez	University of Granada, Spain

Haider Alsabbagh	Basra University, Iraq
Ahmad Taher Azar	Benha University, Egypt
Le Hoai Bac	University of Science, VNU-HCM, Vietnam
Amelia Badica	University of Craiova, Romania
Costin Badica	University of Craiova, Romania
Emili Balaguer-Ballester	Bournemouth University, UK
Zbigniew Banaszak	Warsaw University of Technology, Poland
Dariusz Barbucha	Gdynia Maritime University, Poland
John Batubara	Bina Nusantara University, Indonesia
Ramazan Bayindir	Gazi University, Turkey
Maumita Bhattacharya	Charles Sturt University, Australia
Jacek Błażewicz	Poznań University of Technology, Poland
Veera Boonjing	King Mongkut's Institute of Technology Ladkrabang, Thailand
Mariusz Boryczka	University of Silesia, Poland
Urszula Boryczka	University of Silesia, Poland
Abdelhamid Bouchachia	Bournemouth University, UK
Zouhaier Brahmia	University of Sfax, Tunisia
Stephane Bressan	National University of Singapore, Singapore
Peter Brida	University of Zilina, Slovakia
Andrej Brodnik	University of Ljubljana, Slovenia
Grazyna Brzykcy	Poznań University of Technology, Poland
The Duy Bui	University of Engineering and Technology, VNU Hanoi, Vietnam
Robert Burduk	Wrocław University of Technology, Poland
David Camacho	Universidad Autonoma de Madrid, Spain
Frantisek Capkovic	Institute of Informatics, Slovak Academy of Sciences, Slovakia
Leopoldo Eduardo Cardenas-Barron	Tecnologico de Monterrey, Mexico
Oscar Castillo	Tijuana Institute of Technology, Mexico
Dariusz Ceglarek	Poznań School of Banking, Poland
Rituparna Chaki	University of Calcutta, India
Kit Yan Chan	Curtin University, Australia
Somchai Chatvichienchai	University of Nagasaki, Japan
Meng Chang Chen	Academia Sinica, Taiwan
Rung-Ching Chen	Chaoyang University of Technology, Taiwan
Shyi-Ming Chen	National Taiwan University of Science and Technology, Taiwan
Yi-Ping Phoebe Chen	La Trobe University, Australia
Yiu-Ming Cheung	Hong Kong Baptist University, Hong Kong, SAR China
Suphamit Chittayasothorn	King Mongkut's Institute of Technology Ladkrabang, Thailand
Tzu-Fu Chiu	Aletheia University, Taiwan
Sung-Bae Cho	Yonsei University, Korea

Kazimierz Choroś	Wrocław University of Technology, Poland
Kun-Ta Chuang	National Cheng Kung University, Taiwan
Robert Cierniak	Czestochowa University of Technology, Poland
Dorian Cojocaru	University of Craiova, Romania
Phan Cong-Vinh	NTT University, Vietnam
Jose Alfredo Ferreira Costa	UFRN – Federal University of Rio Grande do Norte, Brazil
Keeley Crockett	Manchester Metropolitan University, UK
Bogusław Cyganek	AGH University of Science and Technology, Poland
Ireneusz Czarnowski	Gdynia Maritime University, Poland
Piotr Czekalski	Silesian University of Technology, Poland
Paul Davidsson	Malmo University, Sweden
Roberto De Virgilio	Università degli Studi Roma Tre, Italy
Phuc Do	Vietnam National University, HCMC, Vietnam
Tien V. Do	Budapest University of Technology and Economics, Hungary
Grzegorz Dobrowolski	AGH University of Science and Technology, Poland
Rafał Doroz	University of Silesia, Poland
Habiba Drias	University of Science and Technology Houari Boumediene, Algeria
El-Sayed M. El-Alfy	King Fahd University of Petroleum and Minerals, Saudi Arabia
Irraivan Elamvazuthi	Universiti Teknologi PETRONAS, Malaysia
Rim Faiz	University of Carthage, Tunisia
Victor Falea	Alexandru Ioan Cuza University of Iasi, Romania
Thomas Fober	University of Marburg, Germany
Simon Fong	University of Macau, Macau
Dariusz Frejlichowski	West Pomeranian University of Technology, Poland
Hamido Fujita	Iwate Prefectural University, Japan
Mohamed Gaber	Robert Gordon University, UK
Patrick Gallinari	LIP6 – University of Paris 6, France
Junbin Gao	Charles Sturt University, Australia
Dariusz Gąsior	Wrocław University of Technology, Poland
Janusz Getta	University of Wollongong, Australia
Dejan Gjorgjevikj	Ss. Cyril and Methodius University in Skopje, Macedonia
Daniela Godoy	ISISTAN Research Institute, Argentina
Gergo Gombos	Eotvos Lorand University, Hungary
Fernando Gomide	University of Campinas, Brazil
Antonio Gonzalez-Pardo	Bilbao Center for Applied Mathematics, Spain
Janis Grundspenkis	Riga Technical University, Latvia
Claudio Gutierrez	Universidad de Chile, Chile
Sung Ho Ha	Kyungpook National University, Korea
Sajjad Haider	Institute of Business Administration, Karachi, Pakistan
Marcin Hajdul	Institute of Logistics and Warehousing, Poland
Pei-Yi Hao	National Kaohsiung University of Applied Sciences, Taiwan

Harisno	Bina Nusantara University, Indonesia
Tutut Herawan	University of Malaya, Malaysia
Marcin Hernes	Wrocław University of Economics, Poland
Bogumiła Hnatkowska	Wrocław University of Technology, Poland
Huu Hanh Hoang	Hue University, Vietnam
Jaakko Hollmen	Aalto University School of Science, Finland
Tzung-Pei Hong	National University of Kaohsiung, Taiwan
Mong-Fong Horng	National Kaohsiung University of Applied Sciences, Taiwan
Chia-Ling Hsu	Tamkang University, Taiwan
Jen-Wei Huang	National Cheng Kung University, Taiwan
Maciej Huk	Wrocław University of Technology, Poland
Zbigniew Huzar	Wrocław University of Technology, Poland
Dosam Hwang	Yeungnam University, Korea
Roliana Ibrahim	Universiti Teknologi Malaysia, Malaysia
Dmitry Ignatov	National Research University Higher School of Economics, Russia
Lazaros Iliadis	Democritus University of Thrace, Greece
Hazra Imran	Athabasca University, Canada
Agnieszka Indyka-Piasecka	Wrocław University of Technology, Poland
Mirjana Ivanovic	University of Novi Sad, Serbia
Sanjay Jain	National University of Singapore, Singapore
Chuleerat Jaruskulchai	Kasetsart University, Thailand
Khalid Jebari	LCS Rabat, Morocco
Joanna Jędrzejowicz	University of Gdańsk, Poland
Piotr Jędrzejowicz	Gdynia Maritime University, Poland
Janusz Jeżewski	Institute of Medical Technology and Equipment ITAM, Poland
Geun-Sik Jo	Inha University, Korea
Kang-Hyun Jo	University of Ulsan, Korea
Jason J. Jung	Chung-Ang University, Korea
Janusz Kacprzyk	Systems Research Institute, Polish Academy of Sciences, Poland
Tomasz Kajdanowicz	Wrocław University of Technology, Poland
Nadjet Kamel	Ferhat Abbas University of Setif, Algeria
Hung-Yu Kao	National Cheng Kung University, Taiwan
Mehmet Hakan Karaata	Kuwait University, Kuwait
Nikola Kasabov	Auckland University of Technology, New Zealand
Arkadiusz Kawa	Poznań University of Economics, Poland
Muhammad Khurram Khan	King Saud University, Saudi Arabia
Pan-Koo Kim	Chosun University, Korea
Yong Seog Kim	Utah State University, USA
Attila Kiss	Eotvos Lorand University, Hungary
Jerzy Klamka	Silesian University of Technology, Poland

Frank Klawonn	Ostfalia University of Applied Sciences, Germany
Goran Klepac	Raiffeisen Bank, Croatia
Joanna Kołodziej	Cracow University of Technology, Poland
Marek Kopel	Wrocław University of Technology, Poland
Józef Korbicz	University of Zielona Góra, Poland
Jacek Koronacki	Institute of Computer Science, Polish Academy of Sciences, Poland
Raymond Kosala	Bina Nusantara University, Indonesia
Leszek Koszałka	Wrocław University of Technology, Poland
Jan Kozak	University of Silesia, Poland
Adrianna Kozierkiewicz-Hetmańska	Wrocław University of Technology, Poland
Bartosz Krawczyk	Wrocław University of Technology, Poland
Ondrej Krejcar	University of Hradec Kralove, Czech Republic
Dalia Kriksciuniene	Vilnius University, Lithuania
Marzena Kryszkiewicz	Warsaw University of Technology, Poland
Adam Krzyzak	Concordia University, Canada
Elżbieta Kukla	Wrocław University of Technology, Poland
Marek Kulbacki	Polish–Japanese Academy of Information Technology, Poland
Marek Kurzyński	Wrocław University of Technology, Poland
Kazuhiro Kuwabara	Ritsumeikan University, Japan
Halina Kwaśnicka	Wrocław University of Technology, Poland
Mark Last	Ben-Gurion University of the Negev, Israel
Anabel Latham	Manchester Metropolitan University, UK
Hoai An Le Thi	Université de Lorraine, France
Chang-Hwan Lee	DongGuk University, Korea
Kun Chang Lee	Sungkyunkwan University, Korea
Yue-Shi Lee	Ming Chuan University, Taiwan
Philippe Lenca	Telecom Bretagne, France
Chunshien Li	National Central University, Taiwan
Jiuyong Li	University of South Australia, Australia
Rita Yi Man Li	Hong Kong Shue Yan University, Hong Kong, SAR China
Horst Lichter	RWTH Aachen University, Germany
Sebastian Link	University of Auckland, New Zealand
Igor Litvinchev	Nuevo Leon State University, Mexico
Lian Liu	University of Kentucky, USA
Rey-Long Liu	Tzu Chi University, Taiwan
Heitor Silverio Lopes	UTFPR, Federal University of Technology, Parana, Brazil
Edwin Lughofer	Johannes Kepler University Linz, Austria
Lech Madeyski	Wrocław University of Technology, Poland
Nezam Mahdavi-Amiri	Sharif University of Technology, Iran
Bernadetta Maleszka	Wrocław University of Technology, Poland
Marcin Maleszka	Wrocław University of Technology, Poland
Yannis Manolopoulos	Aristotle University of Thessaloniki, Greece

Konstantinos Margaritis	University of Macedonia, Greece
Francesco Masulli	University of Genoa, Italy
Mustafa Mat Deris	Universiti Tun Hussein Onn Malaysia, Malaysia
Tamas Matuszka	Eotvos Lorand University, Hungary
Joao Mendes-Moreira	University of Porto, Portugal
Gerardo Mendez	Instituto Tecnologico de Nuevo Leon, Mexico
Hector D. Menendez	University College London, UK
Jacek Mercik	Wrocław School of Banking, Poland
Radosław Michalski	Wrocław University of Technology, Poland
Peter Mikulecky	University of Hradec Kralove, Czech Republic
Marek Miłosz	Lublin University of Technology, Poland
Yang-Sae Moon	Kangwon National University, Korea
Leo Mrsic	IN2data Ltd Data Science Company, Croatia
Grzegorz J. Nalepa	AGH University of Science and Technology, Poland
Mahyuddin K.M. Nasution	Universitas Sumatera Utara, Indonesia
Prospero Naval	University of the Philippines, Philippines
Richi Nayak	Queensland University of Technology, Australia
Fulufhelo Nelwamondo	Council for Scientific and Industrial Research, South Africa
Dieu Ngoc Vo	Ho Chi Minh City University of Technology, Vietnam
Huu-Tuan Nguyen	Vietnam Maritime University, Vietnam
Loan T.T. Nguyen	Broadcasting College II, Vietnam
Thai-Nghe Nguyen	Can Tho University, Vietnam
Vinh Nguyen	University of Melbourne, Australia
Toyoaki Nishida	Kyoto University, Japan
Yusuke Nojima	Osaka Prefecture University, Japan
Mariusz Nowostawski	Norwegian University of Science and Technology, Norway
Alberto Nunez	Universidad Complutense de Madrid, Spain
Manuel Nunez	Universidad Complutense de Madrid, Spain
Richard Jayadi Oentaryo	Singapore Management University, Singapore
Kouzou Ohara	Aoyama Gakuin University, Japan
Tomasz Orczyk	University of Silesia, Poland
Shingo Otsuka	Kanagawa Institute of Technology, Japan
Marcin Paprzycki	Systems Research Institute, Polish Academy of Sciences, Poland
Jakub Peksiński	West Pomeranian University of Technology, Poland
Danilo Pelusi	University of Teramo, Italy
Xuan Hau Pham	Quang Binh University, Vietnam
Tao Pham Dinh	National Institute for Applied Sciences, France
Xuan-Hieu Phan	Vietnam National University, Hanoi, Vietnam
Maciej Piasecki	Wrocław University of Technology, Poland
Dariusz Pierzchała	Military University of Technology, Poland
Marcin Pietranik	Wrocław University of Technology, Poland
Elvira Popescu	University of Craiova, Romania

Piotr Porwik	University of Silesia, Poland
Bhanu Prasad	Florida A&M University, USA
Paulo Quaresma	Universidade de Evora, Portugal
R. Rajesh	Central University of Bihar, India
Mohammad Rashedur Rahman	North South University, Bangladesh
Ewa Ratajczak-Ropel	Gdynia Maritime University, Poland
Patricia Riddle	University of Auckland, New Zealand
Sebastian A. Rios	University of Chile, Chile
Miguel Angel Romero Orth	Universidad de Chile, Chile
Manuel Roveri	Politecnico di Milano, Italy
Przemysław Różewski	West Pomeranian University of Technology, Poland
Leszek Rutkowski	Czestochowa University of Technology, Poland
Alexander Ryjov	Lomonosov Moscow State University, Russia
Virgilijus Sakalauskas	Vilnius University, Lithuania
Daniel Sanchez	University of Granada, Spain
Cesar Sanin	University of Newcastle, Australia
Moamar Sayed-Mouchaweh	Ecole des Mines de Douai, France
Juergen Schmidhuber	Swiss AI Lab IDSIA, Switzerland
Bjorn Schuller	University of Passau, Germany
Jakub Segen	Gest3D, USA
Ali Selamat	Universiti Teknologi Malaysia, Malaysia
S.M.N. Arosha Senanayake	Universiti Brunei Darussalam, Brunei
Natalya Shakhovska	Lviv Polytechnic National University, Ukraine
Alexei Sharpanskykh	Delft University of Technology, The Netherlands
Andrzej Siemiński	Wrocław University of Technology, Poland
Guillermo R. Simari	Universidad Nacional del Sur, Argentina
Dragan Simic	University of Novi Sad, Serbia
Andrzej Skowron	Warsaw University, Poland
Adam Słowik	Koszalin University of Technology, Poland
Vladimir Sobeslav	University of Hradec Kralove, Czech Republic
Kulwadee Somboonviwat	University of Electro-Communications, Japan
Zenon A. Sosnowski	Białystok University of Technology, Poland
Jerzy Stefanowski	Poznań University of Technology, Poland
Serge Stinckwich	University of Caen-Lower Normandy, France
Stanimir Stoyanov	University of Plovdiv Paisii Hilendarski, Bulgaria
Suharjito	Bina Nusantara University, Indonesia
Jerzy Świątek	Wrocław University of Technology, Poland
Paweł Świątek	Wrocław University of Technology, Poland
Andrzej Świerniak	Silesian University of Technology, Poland
Edward Szczerbicki	University of Newcastle, Australia
Julian Szymański	Gdańsk University of Technology, Poland

Ryszard Tadeusiewicz	AGH University of Science and Technology, Poland
Yasufumi Takama	Tokyo Metropolitan University, Japan
Zbigniew Telec	Wrocław University of Technology, Poland
Krzysztof Tokarz	Silesian University of Technology, Poland
Behcet Ugur Toreyin	Cankaya University, Turkey
Bogdan Trawiński	Wrocław University of Technology, Poland
Krzysztof Trawiński	European Centre for Soft Computing, Spain
Hong-Linh Truong	Vienna University of Technology, Austria
Ualsher Tukeyev	Al-Farabi Kazakh National University, Kazakhstan
Olgierd Unold	Wrocław University of Technology, Poland
Pandian Vasant	Universiti Teknologi PETRONAS, Malaysia
Joost Vennekens	Katholieke Universiteit Leuven, Belgium
Jorgen Villadsen	Technical University of Denmark, Denmark
Maria Virvou	University of Piraeus, Greece
Bay Vo	Ton Duc Thang University, Vietnam
Gottfried Vossen	ERCIS Münster, Germany
M. Abdullah-Al Wadud	King Saud University, Saudi Arabia
Can Wang	CSIRO, Australia
Lipo Wang	Nanyang Technological University, Singapore
Yongkun Wang	University of Tokyo, Japan
Izabela Wierzbowska	Gdynia Maritime University, Poland
Konrad Wojciechowski	Silesian University of Technology, Poland
Michal Woźniak	Wrocław University of Technology, Poland
Krzysztof Wróbel	University of Silesia, Poland
Marian Wysocki	Rzeszow University of Technology, Poland
Guandong Xu	University of Technology Sydney, Australia
Xin-She Yang	Middlesex University, UK
Lina Yao	University of Adelaide, Australia
Shi-Jim Yen	National Dong Hwa University, Taiwan
Lean Yu	Chinese Academy of Sciences, AMSS, China
Sławomir Zadrożny	Systems Research Institute, Polish Academy of Sciences, Poland
Drago Zagar	University of Osijek, Croatia
Danuta Zakrzewska	Łódź University of Technology, Poland
Constantin-Bala Zamfirescu	Lucian Blaga University of Sibiu, Romania
Katerina Zdravkova	Ss. Cyril and Methodius University in Skopje, Macedonia
Vesna Zeljkovic	Lincoln University, USA
Aleksander Zgrzywa	Wrocław University of Technology, Poland
Zhongwei Zhang	University of Southern Queensland, Australia
Zhi-Hua Zhou	Nanjing University, China
Zhandos Zhumanov	Al-Farabi Kazakh National University, Kazakhstan
Maciej Zięba	Wrocław University of Technology, Poland

Program Committees of Special Sessions

Multiple Model Approach to Machine Learning (MMAML 2016)

Emili Balaguer-Ballester	Bournemouth University, UK
Urszula Boryczka	University of Silesia, Poland
Abdelhamid Bouchachia	Bournemouth University, UK
Robert Burduk	Wrocław University of Technology, Poland
Oscar Castillo	Tijuana Institute of Technology, Mexico
Dariusz Ceglarek	Poznań High School of Banking, Poland
Manuel Chica	European Centre for Soft Computing, Spain
Rung-Ching Chen	Chaoyang University of Technology, Taiwan
Suphamit Chittayasothorn	King Mongkut's Institute of Technology Ladkrabang, Thailand
José Alfredo F. Costa	Federal University (UFRN), Brazil
Bogusław Cyganek	AGH University of Science and Technology, Poland
Ireneusz Czarnowski	Gdynia Maritime University, Poland
Patrick Gallinari	Pierre et Marie Curie University, France
Fernando Gomide	State University of Campinas, Brazil
Tzung-Pei Hong	National University of Kaohsiung, Taiwan
Roliana Ibrahim	Universiti Teknologi Malaysia, Malaysia
Konrad Jackowski	Wrocław University of Technology, Poland
Piotr Jędrzejowicz	Gdynia Maritime University, Poland
Tomasz Kajdanowicz	Wrocław University of Technology, Poland
Yong Seog Kim	Utah State University, USA
Bartosz Krawczyk	Wrocław University of Technology, Poland
Elżbieta Kukla	Wrocław University of Technology, Poland
Kun Chang Lee	Sungkyunkwan University, Korea
Edwin Lughofer	Johannes Kepler University Linz, Austria
Hector Quintian	University of Salamanca, Spain
Andrzej Sieminski	Wrocław University of Technology, Poland
Dragan Simic	University of Novi Sad, Serbia
Adam Słowik	Koszalin University of Technology, Poland
Kulwadee Somboonviwat	University of Electro-Communications, Japan
Zbigniew Telec	Wrocław University of Technology, Poland
Bogdan Trawiński	Wrocław University of Technology, Poland
Krzysztof Trawiński	European Centre for Soft Computing, Spain
Olgierd Unold	Wrocław University of Technology, Poland
Pandian Vasant	University Technology Petronas, Malaysia
Michał Woźniak	Wrocław University of Technology, Poland
Zhongwei Zhang	University of Southern Queensland, Australia
Zhi-Hua Zhou	Nanjing University, China

Workshop on Real-World Applications in Engineering and Technology (RWAET 2016)

Vassili Kolokoltsov	University of Warwick, UK
Gerhard-Wilhelm Weber	METU, Turkey
Junzo Watada	Waseda University, Japan
Morteza Kalaji	Universiti Teknologi PETRONAS, Malaysia
Kwon-Hee Lee	Dong-A University, South Korea
Igor Litvinchev	Nuevo Leon State University, Mexico
Mohammad Abdullah-Al-Wadud	King Saud University, Saudi Arabia
Subhash Kamal	Universiti Teknologi PETRONAS, Malaysia
Vo Ngoc Dieu	HCMC University of Technology, Vietnam
Gerardo Maximiliano Mendez	Instituto Tecnologico de Nuevo Leon, Mexico
Leopoldo Eduardo Cárdenas Barrón	Tecnológico de Monterrey, Mexico
Hassan Soliemani	Universiti Teknologi PETRONAS, Malaysia
Denis Sidorov	Irkutsk State University, Russia
Weerakorn Ongsakul	Asian Institute of Technology, Thailand
Goran Klepac	Raiffeisen Bank Austria, Croatia
Jean Leveque	Universiti Teknologi PETRONAS, Malaysia
Herman Mawengkang	The University of Sumatera Utara, Indonesia
Igor Tyukhov	Moscow State University of Mechanical Engineering, Russia
Hayato Ohwada	Tokyo University of Science, Japan
Joga Setiawan	Universiti Teknologi PETRONAS, Malaysia
Ugo Fiore	Federico II University, Italy
Leo Mrsic	University College for Law and Finance Effectus Zagreb, Croatia
Nguyen Trung Thang	Ton Duc Thang University, Vietnam
Nikolai Voropai	Energy Systems Institute, Russia
Shiferaw Jufar	Universiti Teknologi PETRONAS, Malaysia
Xueguan Song	Dalian University of Technology, China
Ruhul A. Sarker	UNSW, Australia
Vipul Sharma	Lovely Professional University, India

Special Session on Intelligent Services for Smart Cities (IS4SC 2016)

Antonio Gonzalez	Basque Center for Applied Mathematics-TECNALIA, Spain
Jason J. Jung	Chung-Ang University, Korea
Pankoo Kim	Chosun University, Korea
Héctor D. Menéndez	University College London, UK
Xuan Hau Pham	Quang Binh University, Vietnam
Javier del Ser	Tecnalia, Spain

Special Session on Ontology-Based Software Development (OSD 2016)

Jose Maria Alvarez-Rodríguez	Universidad Carlos III de Madrid, Spain
Veera Boonjing	King Mongkut's Institute of Technology Ladkrabang, Bangkok Thailand
Somchai Chatvichienchai	University of Nagasaki, Japan
Rung-Ching Chen	Chaoyang University of Technology, Taiwan
Mustafa Mat Deris	Universiti Tun Hussein Onn, Malaysia
Iwona Dubielewicz	Wrocław University of Technology, Poland
Mirjana Ivanovic	University of Novi Sad, Serbia
Mark Last	Ben-Gurion University of the Negev, Israel
Adam Pease	R&D Manager at IPsoft, Hong Kong Polytechnic University, Hong Kong, SAR China
Sławomir Zadrożny	Systems Research Institute, Polish Academy of Sciences, Poland

Special Session on Intelligent Big Data Exploitation (IBDE 2016)

Alfredo Cuzzocrea	University of Trieste, Italy
Ernesto Damiani	University of Milan, Italy
Stuart Dillon	University of Waikato, New Zealand
Stefan Gruner	University of Pretoria, South Africa
Birgit Hofreiter	Technical University of Vienna, Austria
Christopher Holland	Manchester Business School, UK
Alexander Löser	Beuth University of Applied Sciences, Berlin, Germany
Ute Masermann	Decadis AG, Koblenz, Germany
Tadeusz Morzy	Technical University of Poznań, Poland
Florian Stahl	ERCIS, University of Münster, Germany
Heike Trautmann	ERCIS, University of Münster, Germany
Gottfried Vossen	ERCIS, University of Münster, Germany

Special Session on Intelligent and Context Systems (ICxS 2016)

Qiangfu Zhao	University of Aizu, Japan
Goutam Chakraborty	Iwate Prefectural University, Japan
Anita Sant'Anna	Halmstad University, Sweden
Michael Spratling	University of London, UK
Anna Fabijańska	Łódź University of Technology, Poland
Józef Korbicz	University of Zielona Góra, Poland
Jerzy Świątek	Wrocław University of Technology, Poland
Maciej Piasecki	Wrocław University of Technology, Poland
Michał Kędziora	Wrocław University of Technology, Poland
Nguyen Thanh Binh	Ho Chi Minh City University of Technology, Vietnam
Quan Thanh Tho	Ho Chi Minh City University of Technology, Vietnam
Ha Manh Tran	Ho Chi Minh City International University, Vietnam
Nguyen Khang Pham	Can Tho University, Vietnam

Nguyen Thai-Nghe	Can Tho University, Vietnam
Pedro Medeiros	University Nova of Lisbon, Portugal
Jan Kwiatkowski	Wrocław University of Technology, Poland
Maciej Huk	Wrocław University of Technology, Poland
Emilio Luque	University Autonoma of Barcelona, Spain
Dolores Rexachs	University Autonoma of Barcelona, Spain
Philip Moore	Lanzhou University, China
Norbert Jankowski	Nicholas Copernicus University, Poland
Bartlett W. Mel	University of Southern California, USA
Gregory Hager	Johns Hopkins University, USA
Shimon Ullman	Weizmann Institute of Science, Israel
Santosh S. Venkatesh	University of Pennsylvania, USA
Garrison W. Cottrell	University of California, USA
Xiao-Ping Zhang	Ryerson University, Canada
Grażyna Suchacka	Opole University, Poland
Ryszard Tadeusiewicz	AGH, Poland
William Dally	Stanford University, UK
Marek Wróblewski	University of Stuttgart, Germany
Wen Gao	Peking University, China
Elan Barenholtz	Florida Atlantic University, USA

Special Session on Analysis of Image, Video, and Motion Data in Life Sciences (IVMLS 2016)

Artur Bąk	Polish–Japanese Academy of Information Technology, Poland
Leszek Chmielewski	Warsaw University of Life Sciences, Poland
Aldona Barbara Drabik	Polish–Japanese Academy of Information Technology, Poland
Marcin Fojcik	Sogn og Fjordane University College, Norway
Adam Gudyś	Silesian University of Technology, Poland
Celina Imielińska	Vesalius Technologies LLC, USA
Henryk Josiński	Silesian University of Technology, Poland
Ryszard Klempous	Wrocław University of Technology, Poland
Ryszard Kozera	The University of Life Sciences – SGGW, Poland
Julita Kulbacka	Wrocław Medical University, Poland
Marek Kulbacki	Polish–Japanese Academy of Information Technology, Poland
Aleksander Nawrat	Silesian University of Technology, Poland
Jerzy Paweł Nowacki	Polish–Japanese Academy of Information Technology, Poland
Eric Petajan	LiveClips LLC, USA
Andrzej Polański	Silesian University of Technology, Poland
Joanna Rossowska	Polish Academy of Sciences, Institute of Immunology and Experimental Therapy, Poland
Jakub Segen	Gest3D LLC, USA

Aleksander Sieroń	Medical University of Silesia, Poland
Michał Staniszewski	Polish–Japanese Academy of Information Technology, Poland
Adam Świtoński	Silesian University of Technology, Poland
Agnieszka Szczęsna	Silesian University of Technology, Poland
Kamil Wereszczyński	Polish–Japanese Academy of Information Technology, Poland
Konrad Wojciechowski	Polish–Japanese Academy of Information Technology, Poland
Sławomir Wojciechowski	Polish–Japanese Academy of Information Technology, Poland

Special Session on Collective Intelligence for Service Innovation, Technology Opportunity, E-Learning, and Fuzzy Intelligent Systems (CISTEF 2016)

Chang, Ya-Fung	Tamkang University, Taiwan
Chen, Chi-Min	Aletheia University, Taiwan
Chiu, Chih-Chung	Aletheia University, Taiwan
Chiu, Kuan-Shiu	Aletheia University, Taiwan
Chiu, Tzu-Fu	Aletheia University, Taiwan
Chou, Chen-Huei	College of Charleston, USA
Hsu, Chia-Ling	Tamkang University, Taiwan
Hsu, Fang-Cheng	Aletheia University, Taiwan
Lin, Kuo-Sui	Aletheia University, Taiwan
Lin, Min-Huei	Aletheia University, Taiwan
Lin, Yuh-Chang	Aletheia University, Taiwan
Maeno, Yoshiharu	NEC Corporation, Japan
Sun, Pen-Choug	Aletheia University, Taiwan
Wang, Henry	Chinese Academy of Sciences, China
Wang, Leuo-Hong	Aletheia University, Taiwan
Yang, Feng-Sueng	Aletheia University, Taiwan
Yang, Hsiao-Fang	National Chengchi University, Taiwan
Yang, Ming-Chien	Aletheia University, Taiwan

Special Session on Advanced Data Mining Techniques and Applications (ADMTA 2016)

Bay Vo	Ton Duc Thang University, Vietnam
Tzung-Pei Hong	National University of Kaohsiung, Taiwan
Bac Le	University of Science, VNU-HCM, Vietnam
Chun-Hao Chen	Tamkang University, Taiwan
Chun-Wei Lin	Harbin Institute of Technology Shenzhen Graduate School, China
Wen-Yang Lin	National University of Kaohsiung, Taiwan
Yeong-Chyi Lee	Cheng Shiu University, Taiwan
Le Hoang Son	University of Science, Ha Noi, Vietnam
Le Hoang Thai	University of Science, Ho Chi Minh City, Vietnam

Vo Thi Ngoc Chau	Ho Chi Minh City University of Technology, Ho Chi Minh City, Vietnam
Van Vo	Ho Chi Minh University of Industry, Ho Chi Minh City, Vietnam

Special Session on Modeling and Optimization Techniques in Information Systems, Database Systems, and Industrial Systems (MOT 2016)

Le Thi Hoai An	University of Lorraine, France
Pham Dinh Tao	INSA-Rouen, France
Pham Duc Truong	University of Cardiff, UK
El-Houssaine Aghezzaf	University of Gent, Belgium
Azeddine Beghadi	University of Paris 13, France
Raymond Bisdorff	Université du Luxembourg
Jin-Kao Hao	University of Angers, France
Van-Dat Cung	INPG, France
Joaquim Judice	University Coimbra, Portugal
Amédéo Napoli	LORIA, France
Yann Germeur	LORIA, France
Conan-Guez Brieu	University of Lorraine, France
Gely Alain	University of Lorraine, France
Le Hoai Minh	University of Luxembourg, Luxembourg
Vo Xuan Thanh	University of Lorraine, France
Do Thanh Nghi	Can Tho University, Vietnam
Ibrahima Sakho	University of Lorraine, France

Special Session on Computational Intelligence in Data Mining for Complex Problems (CIDMCP 2016)

Sid Ahmed Benraouane	University of Minnesota, USA
Maria Gini	University of Minnesota, USA
Imed Kacem	University of Lorraine, France
Nadjet Kamel	University of Sétif, Algeria
Mehmed M. Kantardzic	University of Louisville, USA
Saroj Kaushik	Indian Institute of Technology Delhi, India
Samir Kechid	USTHB, Algeria
In-Young Ko	KAIST, Korea
Qin Lv	University of Colorado at Boulder, USA
Ana Maria Madureira	Polytechnic of Porto, Portugal
Brahim Medjahed	University of Michigan, USA
Madjid Merabti	Liverpool John Moores University, UK
Farid Meziane	University of Salford, UK
Erich J. Neuhold	Vienna University, Austria
Mourad Oussalah	Nantes University, France
Myeong Cheol Park	KAIST, Korea
Nelishia Pillay	University of KwaZulu-Natal, South Africa
Kalai Anand Ratnam	APUTI, Malaysia

Jae Jeung Rho	KAIST, Korea
Houari Sahraoui	University of Montreal, Canada
Lakhdar Sais	University of Artois, France
Thouraya Tebibel	ESI, Algeria
Farouk Yalaoui	Troyes University of Technology, France
Ning Zhong Maebashi	Institute of Technology, Japan

Special Session on Smart Pattern Processing for Sports (SP2S 2016)

Minoru Sasaki	Gifu University, Japan
Michael Yu Wang	National University of Singapore, Singapore
Eran Edirisinghe	Loughborough University, UK
Ajith Abraham	MIR Labs, USA
James F. Peters	University of Manitoba, Canada
Sergio Velastin	Kingston University, UK
Tadashi Ishihara	Fukushima University, Japan
Darwin Gouwanda	Monash University, Malaysia
Aaron Leung	The Hong Kong Polytechnic University, Hong Kong, SAR China
Toshiyo Tamura	Osaka Electro-Communication University, Japan
T. Nandha Kumaar	University of Nottingham, Malaysia
James Goh Cho Hong	National University Singapore, Singapore
Tsuyoshi Takagi	Kyushu University, Japan
William C. Rose	University of Delaware, USA

Contents – Part II

Advanced Data Mining Techniques and Applications

Analysis of Image, Video and Motion Data in Life Sciences

Smart Pattern Processing for Sports

Intelligent Services for Smart Cities

Contents – Part I

Knowledge Engineering and Semantic Web

Social Networks and Recommender Systems

Text Processing and Information Retrieval

Database Systems and Software Engineering

Intelligent Information Systems

Decision Support and Control Systems

Machine Learning and Data Mining

Computer Vision Techniques

A New Method for Calibrating Gazis-Herman-Rothery Car-Following Model

Fergyanto E. Gunawan(✉), Elysia Elysia, Benfano Soewito, and Bahtiar S. Abbas

Binus Graduate Programs, Bina Nusantara University, Jakarta 11480, Indonesia
fgunawan@binus.edu, f.e.gunawan@gmail.com

Abstract. Traffic simulation at the microscopic level utilizes car-following model to describe vehicle interactions on a vehicular lane. The most widely used car-following model is the Gazis-Herman-Rothery model, which contains two coefficients: m and l. The coefficients should be determined in calibration tests where the involved vehicles are tracked for their positions, velocities, and accelerations. The existing calibration methods are costly. This study proposes a calibration method using computer vision. Two computer vision algorithms are evaluated, namely, multilayer and Eigen background subtraction. The vehicle movement is tracked on a perspective plane and then is projected to an orthogonal plane. From the verification tests, we determine that the multilayer algorithm has 96.6 % accuracy for the vehicle position and 88.9 % for the velocity. The Eigen algorithm has 92.9 % accuracy for the vehicle position and 84.3 % for the velocity. The estimated model coefficients is 0.4 for m and 1.2 for l. These values are within the range of the most reliable coefficients according to many literatures.

Keywords: Car-following model · Vehicle tracking · Computer vision · Micro-simulation

1 Introduction

Traffic congestion is a huge issue faced by many cities including Jakarta, the capital of Republic of Indonesia [1]. Morichi [2] recommends a number of long-term strategic development to overcome the problem including development of well-structure public transportation systems and decentralized urban form. In 2003, Bus-Rapid-Transit-based public transportation system was initiated in Jakarta [3] and the operational efficiency of the system has been the topics of a number of research works [4–6].

Traffic congestion can also be reduced by traffic management. To yield good traffic management, traffic microsimulation is an indispensable tool. Micro simulation shows the movement of every vehicle that is traced through a road network over time at a small time increment of a fraction of a second [7].

Car-following model is at the heart of the traffic microsimulation. The model governs the vehicle movement along a vehicle lane. Essentially, the model is a

N.T. Nguyen et al. (Eds.): ACIIDS 2016, Part II, LNAI 9622, pp. 765–772, 2016.
DOI: 10.1007/978-3-662-49390-8_74

mathematical description of the stimulus and response interaction [8]. One of the widely used car-following models is Gazis-Herman-Rothery (GHR) model, which has the following mathematical form [9]:

$$a_n(t) = \alpha \frac{v_n^m(t) \cdot \Delta v_n(t - t_d)}{\Delta x_n^l(t - t_d)}, \tag{1}$$

where $a_n(t)$ is the vehicle acceleration, $v_n(t)$ is the vehicle velocity, Δv_n and Δx, respectively, are the relative velocity and the relative position with respect to the leading vehicle. The model has three parameters α, m, and l, and has a delay of t_d. The driver delay or response time t_d is usually about 1 s; α is the driver sensitivity [9].

The central issue to use the micro-simulation model is finding the model parameters for each type of vehicles, road types, traffic conditions, and environment. The parameters are usually determined via a calibration process. There are few existing calibration methods and they are expensive [10–13].

This study intends to establish a significantly low-cost calibration procedure where the vehicle movements will be recorded digitally, tracked with a computer vision technique, and projected with an orthography projection technique.

2 Research Methods

The current proposal is only suitable for vehicle moving along a straight lane. The lane should be marked at four corners. The vehicle position is obtained with the following procedure.

Firstly, a camera is positioned at an elevation and angle from the lane to capture the vehicle movement in the perspective view. The camera is used to produce images of the vehicle movement. Secondly, computer vision is used to obtain the vehicle position in the images [14]. Two algorithms are evaluated in this study: multilayer background subtraction [15] and Eigen background subtraction [16]. Thirdly, the vehicle position is projected from the perspective view to an orthographic view using an orthorectification projection.

The following transformation is used to map the data from the perspective plane to the road/orthographic plane [17]. We consider a unit square S_1 and an arbitrary quadrilateral Q, which is governed by four corner points: x'_1, x'_2, x'_3, and x'_4. These four points have one-to-one relations with those four points in the unit square, see Fig. 1. The following matrix $\mathbf{T}$ projects any point on the unit square to a point on the quadrilateral, or mathematically: $S_1 \xrightarrow{\mathbf{T}} Q$, where the transformation $\mathbf{T}$ is

$$\mathbf{T} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}, \tag{2}$$

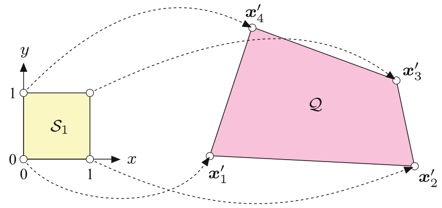

Fig. 1. Projective mapping from the unit square S_1 to an arbitrary quadrilateral Q [17].

where

$$a_{31} = \frac{(x'_1 - x'_2 + x'_3 - x'_4)(y'_4 - y'_3) - (y'_1 - y'_2 + y'_3 - y'_4)(x'_4 - x'_3)}{(x'_2 - x'_3) \cdot (y'_4 - y'_3) - (x'_4 - x'_3) \cdot (y'_2 - y'_3)},$$
$$a_{32} = \frac{(y'_1 - y'_2 + y'_3 - y'_4)(x'_2 - x'_3) - (x'_1 - x'_2 + x'_3 - x'_4)(y'_2 - y'_3)}{(x'_2 - x'_3) \cdot (y'_4 - y'_3) - (x'_4 - x'_3) \cdot (y'_2 - y'_3)},$$
$$a_{11} = x'_2 - x'_1 + a_{31}x'_2 \qquad a_{12} = x'_4 - x'_1 + a_{32}x'_4 \qquad a_{13} = x'_1,$$
$$a_{21} = y'_2 - y'_1 + a_{31}y'_2 \qquad a_{22} = y'_3 - y'_1 + a_{32}y'_4 \qquad a_{23} = y'_1.$$

Inversely, we can project any point on the Q plane to the S_1 plane by the inverse of the transformation matrix $\mathbf{T}^{-1}$.

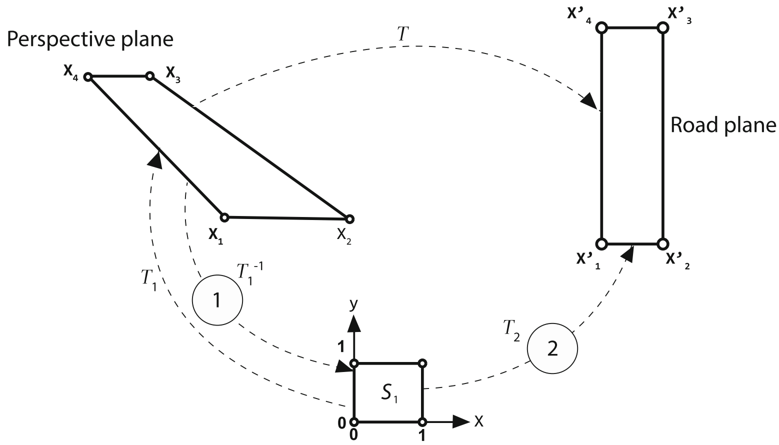

Fig. 2. Two-step projective transformation between perspective plane and road plane. In the first step, the perspective plane Q_1 is transformed to the unit square S_1 by the inverse mapping function $\mathbf{T}_1^{-1}$. In the second step, $\mathbf{T}_2$ transforms the square S_1 to the road plane Q_2. Transformation from the perspective plane Q_1 to the road plane Q_2 can be direct by $\mathbf{T} = \mathbf{T}_1^{-1}\mathbf{T}_2$ [17].

Now, we consider three planes, the perspective plane Q_1, the unit plane S_1, and the road plane Q_2, depicted in Fig. 2. We can map points on the perspective plane Q_1 to points on the road plane Q_2 in two steps: $Q_1 \xrightarrow{\mathbf{T}_1^{-1}} S_1$, and followed by $S_1 \xrightarrow{\mathbf{T}_2} Q_2$. The transformation can be directed from the perspective plane Q_1 to the road plane Q_2 by:

$$\mathbf{T} = \mathbf{T}_2^{-1}\mathbf{T}_1. \tag{3}$$

In the current work, the vehicle movement is also recorded using an accelerometer, which is placed inside the test vehicle. These data are later compared to the data obtained from the above procedure to evaluate the accuracy of the proposed method. The recorded acceleration data are numerically integrated to provide the vehicle velocity and position. The level of accuracy is simply 1 − Relative Error, where the error is defined by

$$\text{Relative Error} = \frac{\|\hat{\mathbf{x}} - \mathbf{x}\|_2}{\|\mathbf{x}\|_2} \times 100\,\%, \tag{4}$$

where $\hat{\mathbf{x}}$ is the vector of the estimated position or velocity and $\mathbf{x}$ is the true value, that is obtained from the accelerometer.

Experimental Procedures

The proposed method was evaluated with a simple experiment described following. The experiment only involved a vehicle. The vehicle was set to travel along a straight trajectory for a distance around 23 m. It was difficult to control the vehicle exact position. Figure 3 respectively show the vehicle initial and final positions. Four cones were placed on the four corners of the vehicle trajectory; see Fig. 3. These four cones were separated by 22.9 m distance longitudinally and 3.5 m distance laterally.

Fig. 3. The test vehicle initial and final positions and the four cones used for orthorectification.

The vehicle movement was recorded by two means: a video camera and an accelerometer. The video camera recorded the vehicle movement at the rate of 25 fps and image size of 720 × 576 pixels. The accelerometer recorded at the sampling time of 0.1 s.

In addition, we also compute the vehicle coefficient m and l by minimizing

$$\text{Error}(t) = a_n(t) - \alpha\, \frac{v_n^m(t) \cdot \Delta v_n(t - t_d)}{\Delta x_n^l(t - t_d)}. \tag{5}$$

All data a_n, Δv_n, Δx_n are from the current proposed method.

3 Results

Two sets of data are necessary for this study. The first set is obtained from the deployed computer-vision-based vehicle tracking methods. The second set is from the accelerometer.

Two different background subtractions in computer vision will be used separately: multilayer and Eigen background subtractions. The computer vision vehicle tracking provides the data of: frame number, blob number, blob area, x blob-centroid, y blob-centroid, and the position of the bottom-right corner of the blob. The frame number and the frame rate data are used to calculate the time associated with the frame number by:

$$\text{Frame Time } t = \frac{\text{Frame Number}}{\text{Frame Rate}}.$$

The frame rate is fixed at 25 fps. Only one vehicle is used in the experiment and it has dimensions of 4.7 m long, 1.8 m wide, and 1.8 m high.

The results of the current study are shown in Fig. 4 for multilayer algorithm and Fig. 5 for Eigen subtraction algorithm. The relative error, absolute error, and accuracy have been computed for every experiments; see Table 1. The results show that the tracking accuracy using multilayer background subtraction is better than that of Eigen background subtraction. Multilayer method has 96.6 % position accuracy and 88.9 % velocity accuracy; meanwhile Eigen method has 92.9 % position accuracy and 84.3 % velocity accuracy.

In Fig. 6, we compare the vehicle acceleration computed the GHR model and the measured one. The estimated GHR car-following parameters are $m = 0.4$ and $l = 1.2$ at 3.2 % of relative error. These estimated parameters are within the range of most reliable estimated parameters according to findings of other researchers for GHR model [18].

Table 1. The relative error of the tracked vehicle position by the computer vision technique with respect to the vehicle position obtained by integrating by the accelerometer data. The relative error is defined by Eq. 4.

Experiment no.	Relative error (%)			
	Position (m)		Velocity (m/s)	
	MultiLayer BGS	Eigen BGS	MultiLayer BGS	Eigen BGS
1	3.41	2.9	13.1	6.9
2	2.49	4.6	6.5	9.1
3	2.40	4.4	8.4	4.0
4	3.84	10.5	12.5	26.3
5	4.37	9.4	10.9	13.1
6	4.30	12.7	12.5	39.3
7	3.07	5.2	13.5	11.2

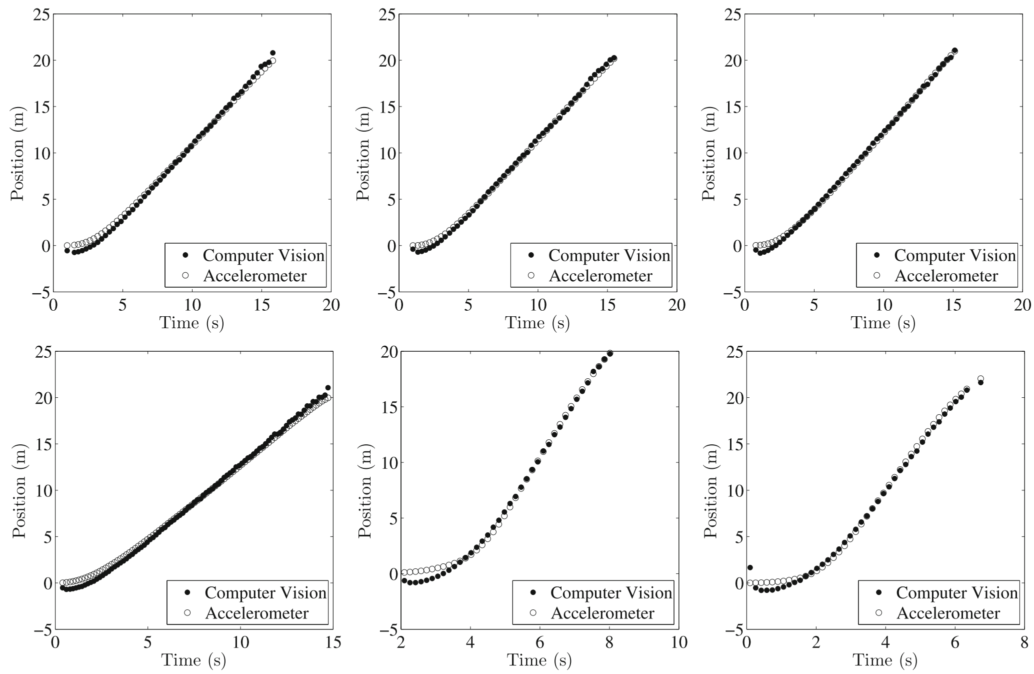

Fig. 4. Comparison of the space-time diagram obtained from computer vision (multi-layer algorithm) and from accelerometer for six experimental replications.

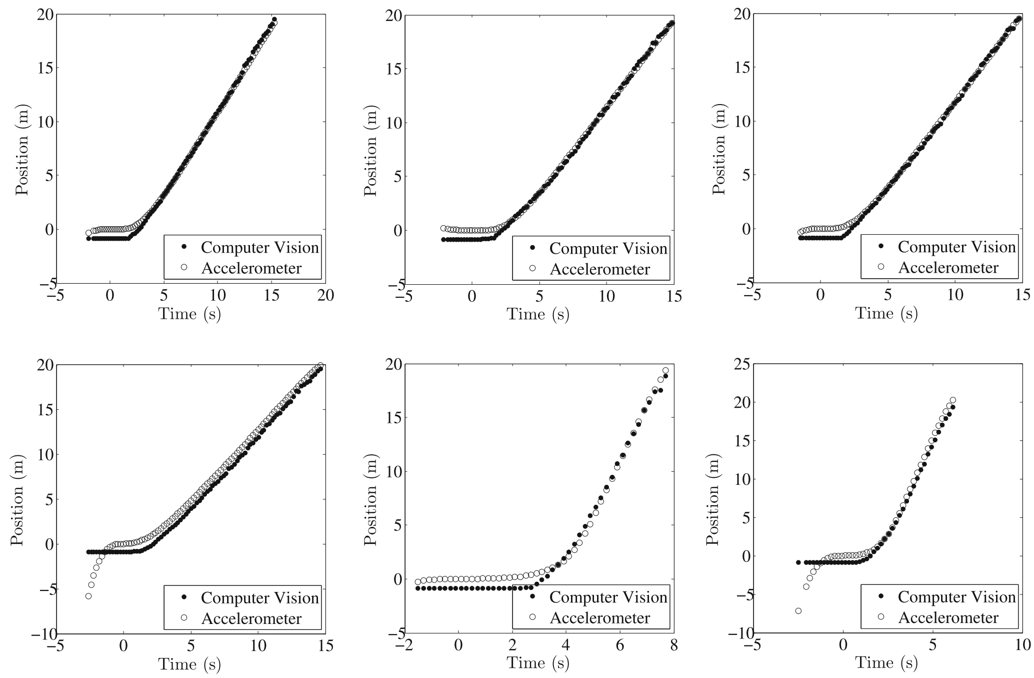

Fig. 5. Comparison of the space-time diagram obtained from computer vision (Eigen background subtraction algorithm) and from accelerometer for six experimental replications.

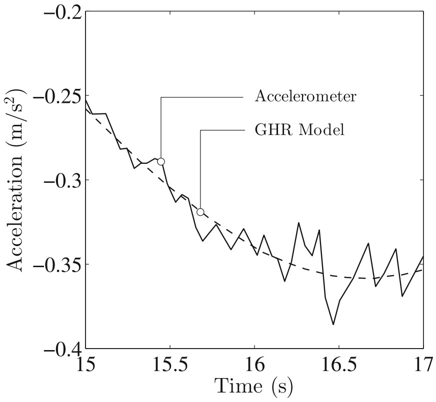

Fig. 6. Comparison of the Vehicle Acceleration between Accelerometer Data and GHR Model Prediction

4 Conclusions

The car-following model has important application in traffic and safety engineering. Unfortunately, finding the model parameters are often costly. For the reason, this research proposed a significantly low-cost method to determine the model coefficients. In the current method, the vehicle movement are recorded digitally and tracked by a computer vision technique. The obtained vehicle position is projected to the road plane with an orthographic projection technique. In the current experiment, to evaluate its accuracy, the method is used to track trajectory of a vehicle moving in a short-straight lane. From comparisons to the data obtained from an accelerometer, it is concluded that the current method is reasonably accurate. The results show that the tracking accuracy of multilayer background subtraction is better than that of Eigen background subtraction. The multilayer method has 96.6 % position accuracy and 88.9 % velocity accuracy; meanwhile, the Eigen method has 92.9 % position accuracy and 84.3 % velocity accuracy. The method estimates the car-following parameters to be $m = 0.4$ and $l = 1.2$ with 3.2 % relative error. These estimated parameters are within the range of the most reliable GHR model parameters according to many references.

References

1. BPS: Perkembangan jumlah kendaraan bermotor menurut jenis tahun 1987–2012 (2013). http://www.bps.go.id/linkTabelStatis/view/id/1413
2. Morichi, S.: Long-term strategy for transport system in Asian megacities. J. East. Asia Soc. Transp. Stud. **6**, 1–22 (2005)
3. Gunawan, F.E.: Empirical assessment on factors affecting travel time of bus rapid transit. Int. J. Eng. Technol. **7**(1), 327–334 (2015). http://www.ijetch.org/show-42-253-1.html
4. Gunawan, F.E.: Design and implementation of discrete-event simulation framework for modeling bus rapid transit system. J. Transp. Syst. Eng. Inf. Technol. **4**, 37–45 (2014). http://www.sciencedirect.com/science/article/pii/S1570667213601397

5. Lumentut, J.S., Gunawan, F.E., Atmadja, W., Abbas, B.S.: A system for real-time passenger monitoring system for bus rapid transit system. In: Nguyen, N.T., Trawiński, B., Kosala, R. (eds.) ACIIDS 2015. LNCS, vol. 9012, pp. 398–407. Springer, Heidelberg (2015). https://dx.doi.org/10.1007/978-3-319-15705-4_39
6. Lumentut, J.S., Gunawan, F.E., Diana, : Evaluation of recursive background subtraction algorithms for real-time passenger counting of bus rapid transit. Procedia Comput. Sci. **59**, 445–453 (2015). http://www.sciencedirect.com/science/article/pii/S1877050915020943
7. Walsh, D., Stewart, D., Luk, J., Tay, J.: The use and application of microsimulation traffic models. Austroads Publications Online (2006). https://www.onlinepublications.austroads.com.au/items/AP-R286-06
8. Ryu, J., Kim, C., Chang, M., Kim, Y., Bae, S.: Simulation and speed classification of car following models. Proc. East. Asia Soc. Transp. Stud. **3**, 123–133 (2001). http://easts.info/on-line/proceedings/vol3no2/320010.pdf
9. Gunawan, F.E.: Two-vehicle dynamics of the car-following models on realistic driving condition. J. Transp. Syst. Eng. Inf. Technol. **12**, 68–75 (2012). http://www.sciencedirect.com/science/article/pii/S1570667211601943
10. Chandler, R.E., Herman, R., Montroll, E.W.: Traffic dynamics: studies in car following. Oper. Res. **6**, 165–184 (1958). http://www.jstor.org/stable/167610
11. Hoogendoorn, S., van Zuylen, H.J., Schreuder, M.: Microscopic traffic data collection by remote sensing. Transp. Res. Rec. **1855**, 121–128 (2007). http://dx.doi.org/10.3141/1855-15
12. Hoogendoorn, S., Schreuder, M.: Toward a robust method for microscopic traffic data collection. In: The 84th Annual Meeting of the Transportation Research Board
13. Ranjitkar, P., Nakatsuji, T., Kawamura, A.: Car-following models: an experiment based benchmarking. J. East. Asia Soc. Transp. Stud. **6**, 1582–1596 (2005). http://www.easts.info/on-line/journal_06/1582.pdf
14. Crist: Blob library for OpenCV, from Google Code (2012). https://code.google.com/p/cvblob/wiki/FAQ. Accessed 11 February 2015
15. Yao, J., Odobez, J.M.: Multi-layer background subtraction based on color and texture. In: IEEE Conference on Computer Vision and Pattern Recognition, June 17–22, pp. 1–8 (2007). http://dx.doi.org/10.1109/CVPR.2007.383497
16. Oliver, N.M., Rosario, B., Pentland, A.P.: A Bayesian computer vision system for modeling human interactions. IEEE Trans. Pattern Anal. Mach. Intell. **22**(8), 831–843 (2000). http://dx.doi.org/10.1109/34.868684
17. Burger, W., Burge, M.: Principles of Digital Image Processing: Core Algorithms. Springer, Heidelberg (2009)
18. Brackstone, M., McDonald, M.: Car-following: a historical review. Transp. Res. Part F **2**, 181–196 (1999). http://www.sciencedirect.com/science/article/pii/S136984780000005X