Advisory Board

Professor Dr. Govind Pd. Dhakal (Tribhuvan University, Nepal)
Professor Dr. Tek Nath Dhakal (Tribhuvan University, Nepal)
Professor Joanne Finkelstein (University of Greenwich, UK)
Associate Professor Dr. Donald Hsu (Dominican College, USA)
Professor Dr. Joseph Tse-Hei Lee (Pace University, New York, USA)
Professor Dr. Romeo Lee (De La Salle University-Manila, Philippines)
Dr. Rer. Nat. Claus-Peter Rückemann (Leibniz Universität Hannover and the Westfälische Wilhelms-Universität Münster, Germany)
Associate Professor Dr. Dianne Waddell (Deakin University, Australia)
Professor Dr. Graeme Wines (Deakin University, Australia)

Co-Editors in Chief

Dr. Huong Ha (University of Newcastle, Singapore)
Dr. John Teo (TMC Academy, Singapore)

Guest Editor

Dr. Rer. Nat. Claus-Peter Rückemann (Leibniz Universität Hannover and the Westfälische Wilhelms-Universität Münster, Germany)

Review Committee (Volume 7, Issue 2)

Dr. Bernhard Bandow (Max Planck Institute for Solar System Research, Germany)
Dr. Ho Ree Chan (TMC Academy, Singapore)
Ms. Birgit Frida Stefanie Gersbeck-Schierholz (Leibniz Universität Hannover, Germany)
Dr. Huong Ha (University of Newcastle, Singapore)
Dr. Ann Latham (University of Wolverhampton, UK)
Professor Dr. Romeo Lee (De La Salle University-Manila, Philippines)
Dr. Georgios V. Lioudakis (National Technical University of Athens, Greece)
Dr Rafia Naz (JCU, Australia)
Dr. Sebastian Ritterbusch (Karlsruhe Institute of Technology, Germany)
Dr. Rer. Nat. Claus-Peter Rückemann (Leibniz Universität Hannover and the Westfälische Wilhelms-Universität Münster, Germany)

Publishing Office: TMC Academy
38C Jalan Pemimpin
Singapore 577180

Frequency: TMC Academic Journal is published twice a year.
Aims and Scope

*TMC Academic Journal* was first published in 2005. It was registered with and obtained an ISSN from the National Library Board of Singapore in December 2007. TMC Academic Journal has also been listed on the database of Ulrichsweb.com since 2008, and in the Australian ERA list since 2010.

TMC Academic Journal provides opportunities for publication of *original and unpublished works* of the Staff of TMC Academy and any other contributors whose work is accepted by TMC Academy for publication. The contributions must be in English. All works are invited for publication in the fields of Business, Mass Communication, Hospitality and Tourism, Psychology, Law and Information Technology.

Upon acceptance of any literary work, the author/s will be asked to transfer the copyright of the work to the publisher, TMC Academy.

TMC Academy does not take responsibility for any issue arising out of the contents, such as copyrights, plagiarism or self-plagiarism, etc. The author/s take full responsibility for the contents. The views expressed in the literary works are that of the author/s only.

Copyright@2013, TMC Academy. All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, without the permission of TMC Academy.

The publisher will not be responsible for any injury and/or damage to persons or property as a matter of product liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the materials herein. Although all publishing materials are expected to conform to ethical standards, the publisher does not guarantee or endorse the quality of value of such or of the claims made by the authors.
## Contents

**VOLUME 7, ISSUE 2, FEBRUARY/MARCH 2013**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Editor’s Note</td>
<td>i-ii</td>
</tr>
<tr>
<td>Bio-data of authors</td>
<td>iii-v</td>
</tr>
<tr>
<td>Bio-data of reviewers</td>
<td>vi-x</td>
</tr>
<tr>
<td>RESEARCH ARTICLES – BEST PAPERS</td>
<td></td>
</tr>
<tr>
<td>3D Measures Computed in Monocular Camera System and SVM-based Classifier for Humans Fall Detection</td>
<td>1-14</td>
</tr>
<tr>
<td>Konstantinos Makantasis and Anastasios Doulamis</td>
<td></td>
</tr>
<tr>
<td>Towards a Discretion-to-Act Control Architecture by Decoupling Modeling from Complexity</td>
<td>15-38</td>
</tr>
<tr>
<td>Udo Inden, Sergej Naimark, and Claus-Peter Rückemann</td>
<td></td>
</tr>
<tr>
<td>Planar Layout of Data Vortex Optical Interconnection Network</td>
<td>39-57</td>
</tr>
<tr>
<td>Qimin Yang</td>
<td></td>
</tr>
<tr>
<td>Parallel Interference Cancellation in DS-OCDMA System Using Novel Multilevel Periodic Codes: Performance Analysis</td>
<td>58-70</td>
</tr>
<tr>
<td>Besma Hammami, Habib Fathallah, and Houria Rezig</td>
<td></td>
</tr>
<tr>
<td>ON GOING RESEARCH</td>
<td></td>
</tr>
<tr>
<td>Categorization of User Behavior Using Scoring</td>
<td>71-81</td>
</tr>
<tr>
<td>Komalavalli B</td>
<td></td>
</tr>
<tr>
<td>BOOK REVIEW</td>
<td></td>
</tr>
<tr>
<td>Letting Go of Your Bananas: How to Become More Successful by Getting Rid of Everything Rotten in Your Life</td>
<td>82-85</td>
</tr>
<tr>
<td>Ng Choon Lai</td>
<td></td>
</tr>
</tbody>
</table>
Editors’ Note

The Second International Conference on Advanced Communications and Computation (INFOCOMP 2012), held between October 21-26, 2012 in Venice, Italy, continued a series of events dedicated to advanced communications and computing, covering a wide range of academic and industrial achievements and visions.

A number of papers have been selected on the basis of their contents, specifically for lending themselves to an interesting extended work. In cooperation of INFOCOMP and the TMC Academic Journal, the authors of these papers have received invitations to submit an extended article version to the TMC Academic Journal for this Special Issue on Advanced Communications and Computation. This Special Issue starts with the extended papers that have been contributed and accepted for this issue.

We take here the opportunity to warmly thank the INFOCOMP 2012 Advisory Chairs, the Academia-, Research-, Industry-, and Special Area Chairs and all the members of the Technical Program Committee, as well as the numerous peer reviewers, the International Academy, Research, and Industry Association (IARIA) and especially the IARIA Advisory Committees Board Chair, Prof. Dr. Petre Dini for his continuous, excellent, and outstanding scientific support.

We are very pleased to have new distinguished academics, to join the Review Committee of TMC Academic Journal for this special issue. Our warmest congratulations go to all reviewers. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to INFOCOMP 2012. We truly believe that, thanks to all these efforts, the final conference program consists of top quality contributions. Also, this event could not have been a reality without the support of many individuals, organisations, and sponsors. We are grateful to the members of the INFOCOMP 2012 organising committee for their help in handling the logistics and for their work to make this professional scientific meeting a success. Our thanks also go to the technical co-sponsors and logistics supporters: Computation Institute, Chicago, USA; SARA, Amsterdam, The Netherlands; NASA, USA; Umea University, Finland; WWU Münster, Germany; KISTI, Korea; DLR, Germany; HLRS, Germany; Los Alamos National Laboratory, USA; LRZ, Germany; T-Systems, Germany; Forschungszentrum Jülich, Germany; ISSE and Universität Augsburg, Germany; Max Planck Institute for Solar System Research, Germany; University of Newcastle, Australia; Biometry.com, Switzerland; Frankfurt Institute for Advanced Studies, Germany; Lawrence Livermore National Laboratory, USA; University of Tartu, Estonia.

We are most grateful for the support of the TMC Academy, the TMC Academic Journal and all the peer reviewers of the TMC Academic Journal as well as to all supporters for making this Special Issue possible!

Thank you!

Dr. Claus-Peter Rückemann, INFOCOMP General Chair, (Westfälische Wilhelms-Universität Münster and Leibniz Universität Hannover and North-German Supercomputing Alliance, Germany) - Guest Editor

Dr. Huong Ha (University of Newcastle, Singapore) - Co-Editor-in-Chief

Dr. John Teo (TMC Academy, Singapore) - Co-Editor-in-Chief
INVITED PAPERS FEATURED IN THIS SPECIAL ISSUE

3D Measures Computed in Monocular Camera System and SVM-based Classifier for Humans Fall Detection
Konstantinos Makantasis and Anastasios Doulamis

Towards a Discretion-to-Act Control Architecture by Decoupling Modelling from Complexity
Udo Inden, Sergej Naimark, and Claus-Peter Rückemann

Performance Evaluation of a Planar Layout of Data Vortex Optical Interconnection Network
Qimin Yang

Parallel Interference Cancellation in DS-OCDMA System Using Novel Multilevel Periodic Codes: Performance Analysis
Besma Hammami, Habib Fathallah, and Houria Rezig

INFOCOMP on the Web:

INFOCOMP 2012 Proceedings:
Bio-data of Authors

**Prof. Dr. Anastasios Doulamis** (Technical University of Crete, Greece) received the Diploma degree in Electrical and Computer Engineering from the National Technical University of Athens (NTUA) in 1995 with the highest honor (9.52 out of 10, first ranked among all classmates) and the PhD degree in Electrical and Computer Engineering from NTUA in 2000. He is currently Associate Professor in Technical University of Crete. Prof. Anastasios Doulamis has received several awards and prizes during his studies, including the Best Greek Student in all fields of engineering in national level in 1995, the Best Graduate Thesis Award in the area of Electrical Engineering in 1996 and several prizes from the National Technical University of Athens, the National Scholarship Foundation and the Technical Chamber of Greece. In 1997, he was given the NTUA Medal as Best Young Engineer. In 2000, he received the best Phd thesis award by the Thomaidion Foundation. He is author of more 150 papers in the area of multimedia processing and artificial intelligence among them more than 15 in IEEE/ACM journals papers and more than 43 journal papers. He has also more than 500 citations in the respective field. He is Technical Program Committee of European Signal Processing Conference (EUSIPCO) in years 2008 and 2007, IEEE International Conference on Pattern Recognition (ICPR), Robotics and Automation. Prof. Anastasios Doulamis is the Coordinator of the EU funded project 4D CH World, was served as technical coordinator of the SCOVIS EU project “Self Configurable Cognitive Video Supervision” starting in March 2008 with the aim of promoting research in the field of detecting high level semantic concepts, activities and procedures in video streams. He is involved in many other European research projects, such as EXPERIMEDIA, +Spaces, SOCIOS, OLYMPIC, e-Director, GRIA, GRIBLAD, AKOGRIMO in the area of multimedia processing. He has served as general program chair of the 1st ACM AREA, and all the ARTEMIS workshops. He is also general chair of more than 10 workshops in this area and TPC in more than 40 conferences.

**Dr. Habib Fathallah** (S’96, M’01) received the B.S.E.E. degree from the National Engineering School of Tunis in 1994 and the M.S.C. and Ph.D. degrees in electrical engineering from Université Laval, Québec, Canada, in 1997 and 2001, respectively. He initiated the use of Bragg Gratings technology for all-optical/all-fiber coding/decoding in optical CDMA systems. He was the founder of Access Photonic Networks (2001–2006). He is currently with the Electrical Engineering Department, College of Engineering, King Saud University (Riyadh, Saudi Arabia) and an Adjunct Professor with the Electrical and Computer Engineering Department of Laval University (Quebec, Canada). His research interests include photonics and optical communications systems, Optical Sensing, OCDMA, PONs, FiWi, Complex Modulation, Optical Space and Mode division multiplexing.

**Besma Hammami** student PhD in Telecommunication, affiliated to SYSCOM Laboratory at National School of Engineering of Tunisia (ENIT). Her research areas include optical communication.
Dip. Oec. Udo Inden lectures at Cologne University of Applied Sciences since 1996 and is co-director of the Centre for Knowledge Management and Intelligent Applications with a primary focus on project development and management of large collaborative national and international research projects in intelligent logistics, manufacturing and the management of complex service networks, e.g., in aviation industry. He served as Director Strategic Research of Lufthansa Cargo (focus: global and intelligent, interactive logistics systems, guidelines for LHC service networks) and served in a consulting contract as Director for Logistics of the CargoLifter Project (focus: market-based integration of design & development of airship technology, operations, infrastructures, networks, economics, incl. global lead-user program and market-based support of investor relations). He works as consultant on management of complex service systems and intelligent pricing. Udo initiated, consulted or managed more than 150 projects in applied sciences of a scale up to about 400 Mio. €.

Mr. Konstantinos Makantasis (Technical University of Crete, Greece) was born in Athens, Greece, in 1984. He obtained his Diploma Degree from the department of Electronic and Computer Engineering at TUC and his Master from the department of Production Engineering and Management at TUC. He joined the Computer Vision and Decision Support Laboratory of TUC in 2011 where he is currently working towards the PhD degree. His research areas include digital image and signal processing, computer vision and machine learning, multimedia and 3D graphics. Mr. Makantasis is a member of Technical Chamber of Greece since 2010.

Dip.-Ing. Sergej Naimark studied Computer Sciences at Vladimir State University, Russia, and works in Germany since about 20 years as consultant and senior software architect. His projects include work in the tele-communication industry as member of the technical board and architect for the integration strategy of local markets of Vodafone (Germany), in banking and finance as among others as reviewer of international data-warehouse projects and developer of emergency plans and SAP integration for major German institutes as Deutsche Bundesbank, Commerzbank, Nord LB, and German homestead associations, in IT industry e.g. in incident analysis and performance tuning of large intranet applications with Atos Origin (Spain), as well as on Enterprise Planning integration in different industries (T-Systems, Bosch, Insurances). Since 2010 Sergey collaborates with Cologne University of Applied Sciences in various projects on applications of intelligent systems and related technologies.

Mr. Ng Choon Lai is a Senior Lecturer at TMC Educational Group for more than nine years. He holds a Bachelor of Property Economics with 2nd Class Honours from the University of Technology, Sydney. He also holds an Appraiser Licence for Lands and Buildings, Singapore. Before he joined TMC, he had worked in the Property and Building Industry for twenty- nine years taking care of commercial and industrial properties for the government and private sectors. In TMC, he has been the local tutor for the Bachelor in Construction Management (Building) programme offered by University of Newcastle, Australia since year 2000. He also teaches marketing, management and business communication modules to students taking Diploma and Higher Diploma programmes offered by TMC and validated by Cambridge International Examination.
Dr. Houria Rezig is currently a Full Professor in “Telecommunications” at National School of Engineering of Tunisia (ENIT). She obtained his PhD in Electronics from University of Science and Techniques of Montpellier (CEM2) France.

Affiliated to SYSCOM Laboratory at ENIT and Head of a Research Group “Optical Communications” since 2005. Responsible of numbers of Research Projects in the frame of Bilateral Tunisian French Scientific Cooperation, she has been a member IEEE since 10 years ago.

Dr. rer. nat. Claus-Peter Rückemann is a lecturer and researcher at the Leibniz Universität Hannover and the Westfälische Wilhelms-Universität Münster (WWU), Germany. He holds an University-Diplom degree in geophysics and a Doctorate degree for natural sciences in geoinformatics, informatics, and geosciences from the Faculty of Mathematical and Natural Sciences, WWU. Dr. Rückemann teaches Information Science, Security, and Computing at the University of Hannover, Faculty of Law, in the European Legal Informatics Study Programme (EULISP), for the postgraduate LL.M. programme in IT-Law and Intellectual Property Law, awarded by the German Academic Exchange Service and the Donors' Association for the Promotion of the Sciences and Humanities. He studied geophysics, theoretical and applied physics, mathematics, computer science, archaeology, and philosophy. For the last two decades he is in professional practice in natural and information sciences, advanced scientific and High Performance Computing (HPC), in research, management, and supervising positions. He is the head of research of the LX Foundation, director of the GEXI Consortium, serves in international scientific advisory boards, research grants committees, research networks, and panels and as an auditor. He is the general chair of the International Conference on Advanced Communications and Computation (INFOCOMP), advisory chair of the GEOProcessing and CYBERLAWS conferences and advisory board and board member of international scientific journals and editor of scientific proceedings and books. He is also on duty for HLRN, managing the largest supercomputer resources in Northern Germany. Dr. Rückemann is the founder, representative, and scientific consultant of several research projects and author of numerous scientific contributions and peer reviewed publications, awarded with several Best Paper Awards. He has been distinguished with the Grade IARIA Fellow of the International Academy, Research, and Industry Association for his scientific research on the state of the art improvement in HPC, Information Systems, Distributed Computing, and international collaboration.

Dr. Qimin Yang is currently an Associate Professor in Engineering Department at Harvey Mudd College. She obtained her PhD from Princeton University in Electrical Engineering. Her main research interests include high capacity fibre optic networks, network architecture design and system implementations. She is a member of IEEE.
Bio-data of Reviewers

Dr. Bernhard Bandow is a specialist for high performance computing at the Max Planck Institute for Solar System Research, Germany. He holds a university degree in physics from the Technische Universität Berlin, Germany and a doctorate degree in physical chemistry from the Christian-Albrechts-Universität zu Kiel, Germany.

His scientific background is on the properties of neutral water clusters and the appliance and development of efficient parallel algorithms on high performance computers.

For several years he worked as scientific consultant for chemistry and physics at the North-German Supercomputing Alliance (HLRN). He is special area chair on advanced applications and program committee member of the International Conference on Advanced Communications and Computation (INFOCOMP) and peer reviewer for international scientific conferences and for the American Institute of Physics (AIP) conference proceedings.

Ms. Birgit Frida Stefanie Gersbeck-Schierholz holds a University Diploma in Biology from the University of Hannover, Germany. As a scientific research associate, currently working for the Leibniz Universität Hannover, her scientific focus is on natural sciences, computer security sciences, and informatics. Her latest research has been presented at the DigitalWorld held in Gosier, Guadeloupe, France (2011). Birgit is in professional practice for over two decades. Since 2001 she is attached with the Computer Security Department of the Leibniz Universität Hannover, where she collected extensive experiences in the field of security consultancy, and as a lecturer for undergraduate courses on cryptographic techniques and security. She is the initial coordinator of the Leibniz Universität Hannover Certification Authority (UH-CA), where she has been head of for eight years. Birgit is active in international scientific conferences: ICDS, CYBERLAWS, INFOCOMP, DataSys. She is a member of international scientific editorial boards, advisory boards, and program committees and peer reviewer for international conferences, journals, and books. Her current research interests are interdisciplinary science, global public key infrastructure, public health and the new biology.

Dr. Huong Ha is the Academic Coordinator and is lecturing at University of Newcastle, Australia (Singapore). She was the Dean of TMC Business School, and Director of Research & Development, TMC Academy (Singapore). She holds a PhD in Management from Monash University, Australia and a Master Degree in Public Policy from Lee Kuan Yew School of Public Policy, National University of Singapore. She was a recipient of PhD Scholarship awarded by Monash University, Temasek Scholarship awarded by National University of Singapore, and a scholarship awarded by United Nations University (UNU), International Leadership Academy (ILA), and many other professional and academic awards. She has more than 20 years of working experience and teaching experience in tertiary educational institutes/universities, manufacturing, marketing research and business consultancy/development in Australia, Singapore and Vietnam.
Since 2002, she has been the Vice President (Member Service) of HRD Gateway (www.hrdgateway.org), an international non-profit organisation with thousands of members, dedicated to facilitate knowledge sharing between human resource development professionals worldwide. She has been an invited member of (i) the CYBERLAWS 2010, 2011 and 2012 conference committees, dealing with the technical and legal aspects of the e-society, (ii) the International Advisory Board of South Asia Association in Criminology & Victimology (India), (iii) the Chinese American Scholars Association Board, (iv) the 4th International Online Conference on Business and Management, etc. and many other. She has been a reviewer of many journals and international conferences, such as Thunderbird International Business Review, International Journal of e-Education, e-Business, e-Management and e-Learning, International Journal of Environment and Sustainable Development, CYBERLAWS Conference 2010, 2011, 2012, African Journal of Marketing Management, International Journal of Consumer Studies, Academy of Management Annual Meeting, Montreal, Canada, 6 - 8 August, 2010, IEEE International Conference on Computer Science and Information Technology (ICCSIT) 2011, and many others.

Dr. Ho Ree Chan was the Dean, School of Information Technology, Digital Media and Mass Communication. Dr. Ho has more than 10 years of teaching and administrative experiences in tertiary education for both Australian and British universities. He has pioneered and involved in the development of course curriculum and learning materials for many offshore transnational programmes. Prior to his academic career, Dr. Ho worked in Information Technology industry in a variety of positions, including systems analyst and project leader in the development of enterprise systems, particularly in the area of banking, finance and real estate. He also served as the Asia Pacific regional manager for a US-based consultant firm.

Dr. Ann Latham is an Associate Dean in the School of Technology at University of Wolverhampton, UK. She received her Ph.D. from the University of Warwick. Dr Latham has carried out considerable research into the needs of the IT industry, studying the impact on the skills and knowledge required. Her current research interests include the use of IS/IT in business and IS/IT in strategic planning.

Professor Romeo B. Lee holds a doctorate degree in demography from the Australian National University. A Filipino, he has been affiliated with the Behavioural Sciences Department of De La Salle University-Manila for about 15 years now, teaching undergraduate and graduate courses on gender, sexuality and reproductive health, population studies, family, adolescent health, and research methods. His research interests and publications revolve around men's health, global health and social development issues. In 2009-2011, he was appointed as a visiting professor at Hokkaido University in Japan.

Dr. Georgios V. Lioudakis received his Dr.-Ing. degree in Electrical and Computer Engineering from the National Technical University of Athens in 2008. As a research fellow of the National Technical University of Athens (NTUA) and the affiliated Institute of Communications and Computer Systems (ICCS) since 2000, he has participated in several European and national R&D projects, such as EU FP6 DISCREET, FP7 PRISM, DEMONS and ARUM. He has also significant industrial
experience, having participated in various small-, medium-, and large-scale software engineering projects. His research interests include security and privacy protection, software engineering, middleware and distributed systems, workflow management systems, and semantic technologies. He has several publications in international journals, conferences and books related to these fields. Since 2009, he participates in activities of the European Telecommunications Standards Institute (ETSI). During the period 2008—2011, George has been an Adjunct Lecturer at the Department of Telecommunications Science and Technology, University of Peloponnese, Greece, teaching Network Security and Operating Systems.

**Dr Rafia Naz**, prior to joining JCU Singapore, was a Lecturer at the University of the South Pacific, Fiji Islands in the School of Management & Public Administration, Faculty of Business and Economics. She graduated from the University of the South Pacific with Bachelor of Arts in Management and Public Administration and Information Systems in 2002 after which she pursued her Postgraduate studies in Management and Public Administration and completed the programme in 2005. Following this, she enrolled into the Master of Arts programme and graduated with her M.A in Management from USP in 2007. She has completed her PhD in Management and Public Administration in 2010. Prior to joining the School of Management, at the University of the South Pacific as a full-time tutor, Rafia was involved with part-time tutoring and had also served as a Graduate Assistant in the School.

Rafia has 8.5 years of teaching expertise. She has also worked as a research assistant. Rafia has been associated with international projects namely: Global Manufacturing Research group (GMRG), Global Leadership and Organizational Behaviour Research (GLOBE), Pacific Agricultural Research for Development Activity project (PARDI).

She has published a number of research papers in refereed journals and conference proceedings including International Journal of Emerging Markets (Emerald Publishers); International Journal of Entrepreneurship and Small Business (Inderscience Publishers); Journal of Administration & Governance (NAPSIPAG); SASIN Journal of Management, Hong Kong; amongst others. She has also attended a number of workshops and conferences. Dr Rafia has been the reviewer for Journal of Innovative Education Strategies, Journal of Administration & Governance, Journal of Pacific Studies, Journal of Public Administration & Policy Research and International Journal of Information Systems and Change Management.

**Dr. Sebastian Ritterbusch** is a researcher in the Engineering Mathematics and Computing Lab (EMCL) at the Karlsruhe Institute of Technology (KIT). He holds a M.Sc. degree in Applied Mathematics of the University of Massachusetts in Amherst, a degree in Techno-Mathematics and a Doctorate in Mathematics of the University of Karlsruhe. Since 2003, he is teaching and conducting research at the University of Karlsruhe and has received a distinguished teaching award of the state of Baden-Württemberg. Since 2009, he is the head of the Research Laboratory for Scientific Visualization in the EMCL, where he is also managing projects funded by the European Union and the German Research Ministry (BMBF) in the field of scientific
visualization and augmented reality on mobile devices, in medical engineering and meteorology, and of large numerical simulations from High Performance Computing.

**Dr. rer. nat. Claus-Peter Rückemann** is a lecturer and researcher at the Leibniz Universität Hannover and the Westfälische Wilhelms-Universität Münster (WWU), Germany. He holds an University-Diplom degree in geophysics and a Doctorate degree for natural sciences in geoinformatics, informatics, and geosciences from the Faculty of Mathematical and Natural Sciences, WWU. Dr. Rückemann teaches Information Science, Security, and Computing at the University of Hannover, Faculty of Law, in the European Legal Informatics Study Programme (EULISP), for the postgraduate LL.M. programme in IT-Law and Intellectual Property Law, awarded by the German Academic Exchange Service and the Donors' Association for the Promotion of the Sciences and Humanities. He studied geophysics, theoretical and applied physics, mathematics, computer science, archaeology, and philosophy. For the last two decades he is in professional practice in natural and information sciences, advanced scientific and High Performance Computing (HPC), in research, management, and supervising positions. He is the head of research of the LX Foundation, director of the GEXI Consortium, serves in international scientific advisory boards, research grants committees, research networks, and panels and as an auditor. He is the general chair of the International Conference on Advanced Communications and Computation (INFOCOMP), advisory chair of the GEOProcessing and CYBERLAWS conferences and advisory board and board member of international scientific journals and editor of scientific proceedings and books. He is also on duty for HLRN, managing the largest supercomputer resources in Northern Germany. Dr. Rückemann is the founder, representative, and scientific consultant of several research projects and author of numerous scientific contributions and peer reviewed publications, awarded with several Best Paper Awards. He has been distinguished with the Grade IARIA Fellow of the International Academy, Research, and Industry Association for his scientific research on the state of the art improvement in HPC, Information Systems, Distributed Computing, and international collaboration.
3D Measures Computed in Monocular Camera System and SVM-based Classifier for Humans Fall Detection

Konstantinos Makantasis
Technical University of Crete, Chania, Greece

Anastasios Doulamis
Technical University of Crete, Chania, Greece

Abstract

Population in developed countries is ageing. The quality of life for elderly is associated with their ability to live independently and with dignity without having the need to be attached to any person whose help they would need for their daily life and social behavior. However, traumas resulting from falls have been reported as the second most common cause of death. For this reason, a major research effort has been conducted in the recent years for automatically detecting persons’ falls. Such identification is prime research issue in computer vision society due to the complexity of the problem as far as the visual content is concerned. In this paper, we extend the work of (Makantasis et al., 2012) by proposing a fast, real-time computer vision algorithm capable to discriminate humans’ falls in complex dynamically changing conditions in a supervised way. It exploits the motion information in the scene and 3D space’s measures. This algorithm is using a single monocular low cost camera and it requires minimal computational cost and minimal memory requirements that make it suitable for large scale implementations in clinical institutes and home environments.

Keywords: Machine vision, image motion analysis, features extraction, subtraction techniques

INTRODUCTION

Life expectancy in developed countries is increasing and population is aging. However, the quality of life, especially for elderly, is associated with their ability to live independently and with dignity, without having the need to be attached to any person in order to live a normal life and fulfill daily living. According to medical records, falls are the leading cause of injury-related visits to emergency departments and the primary etiology of accidental deaths in persons over the age of 65 years. The mortality rate for falls increases dramatically with age in both sexes and in all racial and ethnic groups, making this one of the most important problems that hinders these people’s ability to have an independent life, making necessary the presence and monitoring of their daily activities by care-givers.
For this reason, a major research effort has been conducted in the recent years for automatically detecting persons’ falls. One common way is through the use of specialized sensors, such as accelerometers, floor vibration sensors, barometric pressure sensors, gyroscope sensors, or combination/fusion of them (Wang et al., 2005; Tay and Murugasu, 2008; Le and Pan, 2009; Nyan, Zigel, Litvak and Gannot, 2009; Bianchi et al., 2010). However, most of the previous techniques require the use of specialized wearable devices that should be attached to human body and thus their efficiency relies on the person’s ability and willingness to wear them, while external sensors such as floor vibration detectors require a complex setup and are still in their infancy.

On the other hand, a more research challenging alternative is the use of visual cameras, which is however, a prime research issue due to the complexity of the problem as far as the visual content is concerned. For instance, the algorithm should ideally, a) detect falls in real time (or at least just in time), i.e., without losing the resolution accuracy for the fall detection, b) be robust to background changes and illumination changes, c) be robust when more than one person are present in the scene, d) identify falls occurring in any position with respect to the camera, e) be tolerant to camera changes (active cameras) and e) discriminate falls than other ordinary activities that may look like a fall such as bending or sitting. Furthermore, vision-based systems present several advantages as they are less intrusive, installed on building (not worn by users), they are able to detect multiple events simultaneously and the recorded video can be used for post verification analysis. Towards this direction, some works exploit 2D image data like (Foroughi, Rezvanian and Pazirae, 2008; Fu et al., 2008; Doulamis, 2010; Doulamis and Makantasis, 2011). These works exploit the foreground object’s shape as well as its vertical motion velocity in order to detect a fall incident. Qian et al. (Qian et al., 2008) are based on human anatomy according to which each part of the human body occupies an almost fixed percentage in length relative to body height, in order to train a classifier capable of six indoor human activities, including fall incidents. However, none of these works exploit 3D information to increase system robustness. A 3D active vision system based on Time of Flight (ToF) cameras is proposed by Diraco et al. (Diraco, Leone and Siciliano, 2010). Mastorakis and Makris (Mastorakis and Makris, 2012) use a 3D box that bounds the foreground object to measure its vertical velocity. Based on this velocity and inactivity duration discriminate falls than other ordinary activities. Dubey et al. (Dubey et al., 2012) use a depth camera to create 3D Motion History Images that contains three channels. For each channel the seven hu-moments are calculated and the 21 extracted features are used as input to a Support Vector Machine in order to classify falls from other actions. Although, these works take into consideration 3D information by using depth cameras, they don’t take into account the orientation of motion of the moving blob, and the measures that are provided by the camera could be affected by reflectivity objects properties and aliasing effects when the camera-target distance overcomes the non-ambiguity range. Multi-camera systems have been also proposed (Thome, Miguet and Ambelouis, 2008; Hazelhoff et al., 2008; Auvinet et al., 2011), to exploit stereo vision. 3D processing, though more robust than a 2D image analysis in terms of fall
detection and discrimination of a fall than other daily human activities; require high computational cost making these systems unsuitable for real-time large scale implementations.

In this paper, a new innovative approach is presented that exploits, on the one hand, monocular cameras to detect in real-time fall incidents in complex dynamically changing visual conditions and, on the other, it is capable to exploit actual 3D physical space measures, through camera calibration and inverse perspective mapping, to increase system robustness. We extend the work of (Makantasis et al., 2012) by using an supervised learning approach for discriminating fall incidents against other ordinary human activities. The presented algorithm, due to its minimum computational cost and minimum memory requirements, is suitable for large scale implementations, let alone its low financial cost since simple ordinary low-resolution cameras are used, making it affordable for a large scale. In contrast to other 2D fall detection methods (Fu et al., 2008; Doulamis, 2010; Doulamis and Makantasis, 2011), our system is very robust for wider range of camera positions and mountings, as is proven by the experiments.

The main contributions of the proposed system are:

1. **3D measures exploitation using a single monocular camera.** Using a single monocular camera along with the exploitation of 3D measures, gives our system the opportunity to detect falls in real-time, like 2D fall detection methods, and to approximate the robustness of 3D ones.

2. **Unsupervised learning for fall detection algorithm.** By introducing the SVM-based classifier, we absolve the user from tedious heuristic processes that are necessary for estimating appropriate thresholds for discriminating falls and thus we reduce installation and reconfiguration cost.

3. **Real-time and long-period operation.** Our system is characterized by minimal computational cost and memory requirements that make it suitable for real-time, long-period large scale implementations.

The rest of this paper is organized as follows: in Section 2 problem formulation is presented. Section 3 presents 2D and 3D measures for features. In Section 4 experimental results along with the fall detection algorithm are presented, and, finally, Section 5 concludes this work.

**APPROACH OVERVIEW**

Humans’ fall incidents can be characterized by motion features that are very discriminative in the fall detection context and in humans’ posture. Information about humans’ posture can be derived by the actual width-height ratio, and it is valid that in a 3D space this ratio is bigger in value when a fall event occurs than the same ratio with humans in standing position. The most commonly used feature to detect a fall is that of vertical motion velocity, which, besides fall incidents discrimination, is also able to
provide useful information about fall intensity and thus possible injuries. Vertical motion velocity $V$, during a sequence of frames, can be expressed by (1).

$$V = \sum_{i=k-m}^{k} h_a(i) - h_a(i-1)$$

where $h_a(k)$ stands for the actual height of a human in 3D space at the $k^{th}$ image frame (time). Vertical motion velocity is calculated over a time window of length $m$ to estimate the speed of the motion which is also an evident of how severe a fall would be. Index $k$ denotes the current frame for processing. We choose to use actual humans’ height, measured in physical world units (e.g., cm, inches), and not their projected height being measured in pixel units, since this yields a more robust performance not be affected by cases where the human is far away or very close to the camera. To measure the actual height, however, we need to exploit 3D information. In addition, actual height can provide information about the moving object, in a way that the system becomes capable to discriminate if the moving object might be a human or something else, like a pet.

Width-height ratio computation requires firstly, foreground extraction (Section 3.1), to extract the foreground object, which initially is unknown, and secondly, information about its left-most, right-most, top-most and bottom-most points, to calculate its projected height and projected width, as explained in Section 3.2.

Vertical motion velocity, $V$, computation requires knowledge of the actual height of foreground object in 3D space. Representation of an object in camera’s plane is presented in Figure 1. From Figure 1, it appears that the actual height of foreground object can be given through (2), if camera’s focal length $f$, distance $Z$ between the camera and foreground object and foreground object’s projected height $h_p$ are known.

$$h_a = Z \frac{h_p}{f}$$

The projected height can be obtained by the use of a foreground detection algorithm (Section 3.2), the focal length can be obtained through camera calibration, as this process provides information about camera’s geometry, and the distance between the camera and the foreground object can be obtained through the construction of a reference plane that is the orthographic view of the floor, as explained in Section 3.3.
Figure 1: Object in camera’s plane and 3D space


3D MEASURES FOR FALL DETECTION

This Section presents 2D and 3D measures used for features extraction, as well as, the fall detection algorithm.

Foreground Extraction

For foreground extraction we use the iterative scene learning algorithm described in Doulamis and Makantasis (Doulamis and Makantasis, 2011). This algorithm, unlike the classic background subtraction techniques, which fail in large scale implementations because of their computational cost and memory requirements, is computationally efficient and has the ability to operate properly in real-time and in complex, dynamic background visual content, and unexpected environments.

It exploits the intensity of motion vectors along with their directions to identify humans’ movements. For motion vectors estimation, the “pyramidal” Lucas-Kanade algorithm (Lucas and Kanade, 1981) was used, which has the ability to catch large motions by using an image pyramid. Motion vectors estimation is followed by the creation of a binary mask in order to indicate areas of high motion information.

This information is used as a computationally efficient background/foreground updating mechanism that updates the background at every frame instance by using the intensity of motion vectors within an area. If motion vectors’ intensity is greater than a threshold then this area is denoted as foreground, otherwise it is denoted as background.
2D Foreground Object Width-Height Ratio

Width-height ratio estimation requires information about the projected width and projected height of foreground object. In order to estimate the projected width and projected height of foreground object a minimum bounding box was created. Figure 2 shows foreground extraction and minimum bounding box for a captured frame. By using the four corners of the bounding box the left-most, right-most, top-most and bottom-most points of foreground object can be estimated and width-height ratio can be expressed by (3).

\[
R = \frac{w_p}{h_p} = \frac{p_{rm} - p_{bm}}{p_{tm} - p_{bm}}
\]

where \(w_p\) and \(h_p\) are projected width and projected height and \(p_{rm}, p_{lm}, p_{tm}, p_{bm}\) are the left-most, right-most, top-most and bottom-most points of foreground object respectively.

Estimation of 3D Measures for Detecting Falls

As mentioned before, vertical motion velocity computation requires camera calibration as this process relates camera measurements with measurements in the real, three dimensional, world according to (4). This relation is a critical component in any attempt to find the dimensions of an object in a three dimensional scene.

\[
q = MQ, \quad q = \begin{bmatrix} x \\ y \\ w \\ \end{bmatrix}, \quad M = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}, \quad Q = \begin{bmatrix} X \\ Y \\ W \end{bmatrix}
\]

where \(q\) is a point on camera’s plane, \(Q\) is the same point in three dimensional world and \(M\) is camera’s intrinsic matrix. The two parameters, \(c_x\) and \(c_y\), have to be introduced to model a possible displacement between the principle point and the center of the imager, while two different focal lengths are used because the individual pixels on a typical low-
cost imager are rectangular rather than square. Our approach to camera calibration is derived from Heikkila and Silven (Heikkila and Silven, 1997), which tries to determine optimal values for intrinsic parameters based on image observations of a known target.

Besides camera calibration, vertical motion velocity computation requires the construction of a reference plane that is the orthographic view of the floor. This construction is a perspective transformation, which can be thought of as a specific case of projective homographies. As described by Cyganeck and Siebert (Cyganeck and Siebert, 2009), an affine space \( \mathbb{R}^n \) is transformed to a projective space \( \mathbb{P}^n \) by the following mapping:

\[
(x_1, x_2, \ldots, x_n)^T \rightarrow (x'_1, x'_2, \ldots, x'_{n+1})^T = (x_1, x_2, \ldots, x_n, 1)^T
\]

and the inverse mapping, from the projective space \( \mathbb{P}^n \) to the affine space \( \mathbb{R}^n \), is given as:

\[
(x'_1, x'_2, \ldots, x'_{n+1})^T \rightarrow (x_1, x_2, \ldots, x_n)^T = \left(\frac{x'_1}{x'_{n+1}}, \frac{x'_2}{x'_{n+1}}, \ldots, \frac{x'_n}{x'_{n+1}}\right)^T
\]

where \( x'_{n+1} \neq 0 \).

For a projective space \( \mathbb{P}^n \), a projective homography is defined as a nonsingular matrix \( H_{(n+1)\times(n+1)} \). A point \( x \) is projectively transformed to \( x' \) as follows:

\[
x' = Hx, \quad x, x' \in \mathbb{P}^n
\]

where \( x \) denotes pixel coordinates in the homogeneous coordinates and \( x' \) is a new position of a pixel in the wrapped output image.

By using perspective transformations, any parallelogram can be transformed to any trapezoid, and vice versa. In our case, we want to transform the camera's plane to a reference plane that represents the orthographic view from above of the camera's plane. Then according to the inverse perspective mapping algorithm described by Bevilacqua et al. (Bevilacqua, Gherardi and Carozza, 2008), \( x \) and \( x' \) can be expressed by the following relations:

\[
x' = [x' \quad y' \quad 1] \quad \text{and} \quad x = [x \quad y \quad 1]
\]

where \( x, y, x', y' \) represent Cartesian coordinates on image plane and reference plane respectively, homography matrix \( H = [h_{ij}] \) can be normalized so to have \( h_{33} = 1 \) and through (6) equation (5) is expressed as:

\[
\begin{bmatrix}
x' \\
y' \\
1
\end{bmatrix} =
\begin{bmatrix}
h_{11} & h_{12} & h_{13} \\
h_{21} & h_{22} & h_{23} \\
h_{31} & h_{32} & h_{33}
\end{bmatrix}
\begin{bmatrix}
x \\
y \\
1
\end{bmatrix}
\]

(7)
This equation that represents a perspective transformation requires at least four non-collinear points in order to be solved. By using observations of a known target, a larger set of points can be found and this equation can be solved in a least square sense. The quality of the transformation is measured by the Back Projection Error (Bevilacqua et al., 2008), associated with $H(8)$.

$$E = \sum_{i=1}^{n} \left( \frac{x'_{i} - h_{11}x_{i} + h_{12}y_{i} + h_{13}}{h_{31}x_{i} + h_{32}y_{i} + h_{33}} \right)^{2} + \left( \frac{y'_{i} - h_{21}x_{i} + h_{22}y_{i} + h_{23}}{h_{31}x_{i} + h_{32}y_{i} + h_{33}} \right)^{2}$$ (8)

**Figure 3: (a) camera’s plane, (b) reference plane**

Source: by the authors

Figure 3 shows both camera’s and reference planes. To approximate the distance $Z$ between foreground object and camera, we use the bottom-most point of foreground object, $p_{bm}$. As shown in Figure 3(b), on the reference plane the relation between camera’s natural units (pixels) and the units of the physical world (cm) is linear and thus distance $Z$ is straightforwardly calculated.

This results in a simple model and a single solution in which a point in the physical world $(X, Y, Z)$ with actual height $h_{a}$ is projected on the image plane with projected height $h_{p}$ in accordance with (9). However, the appearance of errors during perspective transformations affects the actual height estimation, as it depends on distance estimation on created reference plane.

$$h_{a} = Z \left( \frac{h_{p} - c_{y}}{f_{y}} \right)$$ (9)

In order to use (1), actual height has to be approximated for every captured frame. Because of the motion of foreground object, errors in the calculation of its height may
occur. Let us denote as $\hat{h}(i)$ this approximate height of the foreground object at the current frame of analysis $i$. In our approach, to reduce accumulation of the approximation errors to the following frames to process we use a heuristic iterative methodology, which updates the foreground height taking into account previous height information and the current one, yielding to a robust approximate solution, denoted as $h(i)$, which is computed by (10). This iterative procedure requires an initial value of $h(i)$ which in our case is set to average height for adult males, e.g., 175cm.

$$h(i) = \lambda h(i-1) + (1 - \lambda)\hat{h}(i)$$  \hspace{1cm} (10)

where $\lambda$ is a parameter that regulates the importance of $\hat{h}(i)$ to the iterative procedure. For our experiments, $\lambda$ is set to 0.8, since this value yields the more reliable performance.

\textbf{Figure 4: Actual height approximation}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Actual height approximation}
\end{figure}

By using this form for every captured frame, $h(i)$ converges to the actual height of foreground object. In order to reduce wrong estimations when a fall event occurs and height is significantly decreased, height $h(i)$ is being updated only if $\hat{h}(i)$ is bigger and smaller than a threshold (in our case ±20 cm). Figure 4 shows the approximation of foreground object’s actual height. The gray line represents the approximation of foreground object’s actual height for the first 1,000 frames of system operation, while the horizontal line represents its actual height.

\section*{EXPERIMENTAL RESULTS}

The application was developed on a PC with 4GB RAM and a dual-core Intel processor at 2.1GHz. The camera that was used was a simple USB webcam with 640x480 pixels resolution. The code was written in C by using OpenCV library. By using this hardware, this algorithm operates in real time at 14fps. In quad-core computers, the time can be reached up to 17fps.

The workflow of the system is presented in Figure 5. For every captured frame, initially, the background subtraction algorithm takes place. The output of this algorithm leads to the extraction of the foreground, and thus, the features that are used by the fall detection...
algorithm (vertical motion velocity and width-height ratio). At this point it has to be mentioned that by measuring vertical motion velocity in cm, the performance of the system is not affected by cases where the foreground object is far away or close to the camera. The fall detection algorithm is a non-probabilistic binary classifier based on the supervised learning approach of Support Vector Machines (SVM). Our choice to use SVM is justified by the fact that; a) we want to separate events in two different classes (fall and non-fall class), b) SVM construct a hyperplane that has the largest distance to the nearest training data point of any class decreasing this way the generalization error of the classifier and c) as mentioned by Burges (Burges, 1998) in most of cases, SVM generalization performance (i.e. error rates on test sets) either matches or is significantly better than that of other competing methods. For the training of the classifier we used Gaussian Radial Basis Function kernel, as this configuration leads to the largest functional margin. The training of the classifier takes place offline. For detecting falls every new example is mapped into one of the two classes. If a new example is mapped into the fall class, then a fall alarm occurs. Figure 6 presents SVM classification results. In this case we used \( N \) fall samples and \( 3N \) randomly selected non-fall samples. SVM classifier performs very well. Although its performance is inherently depended on environmental conditions, such as illumination changes, cluttered background, etc., it is presented to be very robust in dynamically changing visual conditions.

**Figure 5: Workflow diagram of presented fall detection scheme**

![Workflow diagram of presented fall detection scheme](image)

**Source:** by the authors

During the experimentation process one person simulated falls, in every direction according to the camera position, as this affects the values of the features and thus their temporal evolution, and normal every day activities that may look like falls; but, they are not real falls; see Figure 7.
Table I summarizes its performance and compares it with system performance proposed by Makantasis et al. (Makantasis et al., 2012). As this system is an expansion of (Makantasis et al., 2012), it performs slightly better. Besides improving performance, our main contribution is that this system absolves the user from the tedious and monotonous trial-and-error process for estimating appropriate values for features’ thresholds, in order to discriminate efficiently fall incidents. Both systems are not affected by the camera’s position and are robust for a wide range of placements that permits a camera to be mounted in a higher position, favoring fall detection process by providing better coverage with less obstacles inserted into its field of view. This comparison was performed by using the same demo video as input into both fall detection systems.

Table I: Performance when camera placed at different heights

<table>
<thead>
<tr>
<th>Camera’s height</th>
<th>Proposed system</th>
<th>System of (Makantasis et al., 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40cm</td>
<td>Falls detected</td>
<td>93.2%</td>
</tr>
<tr>
<td></td>
<td>Wrong detections</td>
<td>4</td>
</tr>
<tr>
<td>220cm</td>
<td>Falls detected</td>
<td>92.7%</td>
</tr>
<tr>
<td></td>
<td>Wrong detections</td>
<td>6</td>
</tr>
<tr>
<td>260cm</td>
<td>Falls detected</td>
<td>96%</td>
</tr>
<tr>
<td></td>
<td>Wrong detections</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 6: SVM Classifier performance for randomly selected fall and non-fall samples

Source: by the authors
CONCLUSION AND FUTURE WORK

As people in developed countries are ageing, the humans’ falls become one of the most important problems in human society with physical, psychological and economical consequences. This problem especially is concerning on the elderly and patients with mental cognitive problems like mild dementia or epilepsy. This paper presents a fall detection scheme that exploits 3D measures by using a single monocular camera capable to automatically detect humans’ fall incidents. By introducing the SVM-based classifier, we absolve the user from tedious heuristic processes that are necessary for estimating appropriate thresholds for discriminating falls and thus we reduce installation and reconfiguration cost. The viability of this algorithm is justified by the fact that it operates properly in complex and dynamically changing conditions and has minimal computational cost and minimal memory requirements. These characteristics are making it suitable for real-time operation in large scale implementations in clinical/hospital or home environments.

As experimental results show, our algorithm is capable to detect over 95% of fall incidents in complex and dynamically changing visual conditions, while it presents low false positive rate. Besides the contribution to humans’ fall problem, this algorithm contributes to computation of significant measures of a scene like real height of the foreground object and distance between foreground object and camera position, by using a single and low cost camera, like a webcam. By using these measures much more information about a scene can be revealed which will be useful in different kind of applications.
Reference List


Second International Conference on Advanced Communications and Computation, pp. 68–73.
Towards a Discretion-to-Act Control Architecture by Decoupling Modelling from Complexity

Udo Inden  
Cologne University of Applied Sciences, Germany

Sergej Naimark  
Controlling Chaos Technologies GmbH, Germany

Claus-Peter Rückemann  
Leibniz Universität Hannover / Westfälische Wilhelms-Universität Münster, Germany

Abstract

In this paper we explore how complexity in industrial operations continues to grow and impend to escape from capabilities of modelling and with this from control in general. To recover, control respective architectures need to systematically draw level with growing complexity and its dynamic impact. We suggest semantic methodology to decouple modelling from domain complexity and using ontology-based reasoning for processing such models – i.e. to emerge complexity in the controller that, in the reach of the model, matches complexity to be controlled. On both sides complexity is treated as it is: a system’s property that emerges from interactions of objects respectively agents identifying and exploiting the discretions to act they dispose of. On the side of controllers this very much depends on the completeness and consistency of the model, thus from overcoming complexity-driven dis-economies in modelling itself. In detail, aspects of interactions between complexity, disambiguation of meaning, relations in modelling and discretions to act (DTA) are discussed.1

Keywords: operations’ control, adaptation, complexity of modelling; semantic modelling, meaning, service-orientation, discretion-to-act

INTRODUCTION

Operations’ control relies on plans that, in terms of, e.g., costs, or deadlines, optimise flows of activity and related allocation of objects. If due to unplanned events (planned ones should be sheltered) actual operations deviate from the plan, activity and allocation are re-structured to minimize impact. Then the challenge is to identify, assess and efficiently exploit discretions to act (DTA) available in the scene. They are pre-determined by budgets of resource or time conceded in planning and by operations’ dynamics that likely caused the problem now to be tackled. Clearly the “resolution of object and time” (Müller-Stewens et al., 2008), i.e., the likelihood that more objects become source or target of more events, drive the challenge. Mainstream operations’ management addresses

---

1 This paper relies on a paper presented in the INFOCOMP conference 2012 (Inden, Naimark, Rückemann, 2012)
this problem by integrating sources of data. But diseconomies appear with the extent of integration (PCS, 2009).

Peer-to-peer networks formed by swarms of autonomous (software) agents are a known strategy to overcome the problem because each object "knows" its DTA and negotiates their exploitation in the network. But in spite of their advantages, they failed joining the mainstream not at least because of lacking visibility of emergent processes of solution finding. (Vrba et al., 2011) The strategy has been adopted in the development of networks of web-services in the internet economy, and with reference to problems to scale to demand (Fensel et al., 2008).

But irrespective of architectures everything starts from the capability of modelling to provide effective concepts to identify and evaluate DTA. Essentially models reduce complexity for a particular purpose, e.g. control. But what may under uncertainty guide the decision what to reduce? And how may architectures of models restrict their adaptiveness? We consider the growing complexity of models to be the core problem. It may be counter-intuitive, but it requires decoupling models from the complexity of their subject matter. The argumentation starts with a brief overview about operations' challenges we have in mind:

Airlines plan the service of aircrafts as sequences of flights executed in a period of time. The cost-efficiency of these ‘rotations’ and the service quality they deliver to customers depend on a manifold of interacting factors spanning air- and ground operations and involving thousands of aircrafts and flights of hundreds of airlines or numerous supporting services. Well established international proceedings, synchronize flight plans global networks. Before a flight this abstract plan is to be particularized and confirmed. But in execution, plans are troubled by a constant floor of interference which easily can get out of control (Inden et al., 2011). The challenge lies in the continuous process of adapting to reality by correcting, mitigating or recovering active plans. In large cases ten thousands of autonomous actors and legacy systems are to be re-synchronized in almost real-time – repeatedly because the solution of the next problem may affect the solution of previous ones.

The ‘time-to-volume’ of industrial series production begins with the start of development of products and production processes and ends with reaching stable output as planned for amortization of invest. But, there are trade-offs, e.g., more engineering time drives costs and postpones the product launch, while less effort drives quality risk emerging from butterfly effects (non-linear behaviour) or from black swans (long-tail risks). In the cases of B787 or A380 such effects delayed ramp-up and planned volumes for years (Aero, 2009; Kinsey-Jones, 2010). For ramp-up, Boeing implemented a virtual ramp-up system (VRS, a simulator and planner) covering major stakeholders and components in the supply-chain – except the fasteners for carbon-fibre parts. Apparently, these tiny parts were ignored to limit model complexity. The supplier failed and fasteners became a problem. As example of black swans (Taleb, 2007) the uncontained engine failure of a Trent 900 engine in Qantas A380, flight QF32, November 4th 2010 (Ostrower, 2010), may serve.
Also in airliner business complexity increases: In terms of the number of aircrafts and the number of flights, air traffic is expected to more than double by 2020 while in America or Europe air- and ground infrastructures are lacking behind (SESAR, 2009). Airlines’ competition gets harder and new competitors of Boeing and Airbus appear in emerging markets. Solutions are asked to increase service capabilities, reduce costs or CO\textsubscript{2} footprints, and get to volume faster. These examples suggest that architectures need to support, respectively, adapt to

- the pace of change, driven by competition that defines opportunity windows
- the need of catching up with ignored or not captured aspects like “black swans”.
- the fact that more and more details matter (resolution of object) and become source or target of events, i.e., the resolution of time increases (Müller-Stewens et al, 2008).

These developments are addressed by the law of requisite variety saying that only complexity can control complexity (Ashby, 1956): With efforts to draw level with growing complexity the complexity of models becomes a problem. Either real-world complexity escapes from modelling or the complexity of models defies the capability of delivering their core service: to reduce complexity. To discuss this dilemma the paper is organized as follows: Section Two shows how mainstream architectures relate to complexity in industrial operations. In Section Three, basic principles of decoupling of modelling are discussed and in section Four the modelling and processing of discretions to act (DTA). Section Five draws a conclusion and sketches selected aspects of further work.

ON THE DEVELOPMENT OF COMPLEXITY IN INDUSTRIAL OPERATIONS

In the mainstream of industrial operations’ systems, different regimes of operations management and modelling developed: function-, process-, and service-orientation as well as nowadays internet-based automation and related semantic technologies. With each step the competitive landscape grew without the option to return to a previous state (Kaufmann, 1995). With regard to modelling the most important aspect is that the “fitness” to compete in the past always relied on the apparently obvious approach to also increase complexity in modelling.

Encapsulating Complexity in Organizational Silos: The Function-oriented Regime

Initially, modelling as effort and tool of operations management is bound to the work of Taylor (1911) and has been translated into an operations’ strategy of Ford (Huges, 2004). This strategy lead to “organizational silos”—differentiated by functionality, each growing expertise of engineers or administrators (knowledge workers) and, to compensate the initial lack of educated workers for assembly lines, by simplification of jobs. Figure 1 depicts a model of a "value chain". It is a draft by Porter (1985) showing how value is directly produced in operations departments (lower group) and non-directly in the overhead-layer of knowledge workers (IT is not yet mentioned).
Figure 1: The Value Chain

The image has a commercial interpretation: Its expanse represents financial flows passing the firm. Reading the grey block as costs of direct and indirect operations, hopefully a positive difference to revenue is left, a profit (margin). Therefore function-orientation creates self-referential silo-behaviour: If resources are to be distributed (more staff) or costs to be cut (less staff) competition appears: Who is more important, who to be blamed for failure? Also careers are built on affiliation to silos. Also value creating processes are marked by silo-driven discontinuity turning into high coordination effort and long processing-times.

Tackling the Complexity of Interactions: The Process-oriented Regime

In functional models, business processes are implicit: Processes have to eke out organisational units (silos) shown in Figure 1. In order to overcome disadvantages they had to be made explicit. The motivation was induced by competition, again starting from car industry: When Taiichi Ohno, CTO of Toyota, visited Ford, he learned that silos or radical simplification of assembly jobs produce problems rather than solutions: High simplification turns into a waste of talent and silos into self-inflicted complexity. Mainly, they obstruct the view at real challenges: effectiveness (value delivered) and efficiency (costs) of operations.

So Ohno invented strategies that avoid redundancy (muda): Just in Time delivery replacing inventories or continuous improvement (kaizen) exploiting knowledge at all workplaces. Later these ideas were united as Lean Management. They aim at unbarrred flows of orders, material, or information as well as purposeful collaboration across functions and also with suppliers. Workers, formerly just repeating simple jobs, became autonomous and creative partakers in implementing and improving operations. Knowledge and intelligence became strategic resources.
An MIT study (Womack et al., 1990), uncovering advantages of Lean Management, became a wake-up call to American or European car makers and finally new strategies changed the rules of competition and formed a new fitness landscape (Kauffman, 1995). Initially, managers misunderstood the call to become lean as a call for cutting cost. But, in fact, it was a call to change minds towards integrative thinking and modelling. Rather than optimizing functionality in the "silos", the new heading geared towards the efficiency of functions linked across business processes and improved value propositions – a far more complex challenge than just managing silos.

Organizations had to learn how to create value from this. Cost-driving complexity was to be exchanged by value-driving complexity. It asked taking care for interdependencies beyond boxes or to enrich responsibility of knowledge- and of assembly-line workers: Managerial excellence now is marked by model-literacy and self-management on all hierarchical levels (Ohno, 1995).

Models of functions and processes became representations of complex interdependent activity. In parallel, ICT became a driver of model complexity since automation asked elaborating models with high precision and detail. Figure 2 depicts a diagram accordingly to the Business Process Modelling Notation (BPMN, 2012), an advanced standard, capturing organizational structures in horizontal lanes (remains of the silos) as well as structures and rules of proceedings and interaction (connectors or auxiliary information).

It answers the question: Who does what (why), where, when, how and with what and whom? Functions now are embedded as physical or intellectual resources. With growing vertical (along managerial hierarchy) and horizontal (same level of activity) integration of automation current ICT covers the value chain depicted in Figure 1, while process- cost accounting Mayer, 1998) enabled new strategies of controlling economics of managing operations complexity.

But, scale and complexity of models grew (consider the complexity of operations landscapes drafted in the introduction) and in accordance to Ashby’s Law of requisite variety (Ashby, 1956), richness and heterogeneity of detail or the manifold of interfaces did not turn into economies of scale but became drivers of costs and risks to run out of budgets. Complexity started escaping from modelling capabilities.
Modularizing Functionality: The Regime of Services

There can be solved by modularization and virtualization: Modules with standardized interfaces reduce variety and hide details how functionality is provided. Challenged by faster change and increasing demandingness in markets or by increasing costs, automotive industry introduced that decoupling variety of car-models from the variety of parts they are built from. This concept of functionality provided by a module also was adopted by ICT in service-oriented architectures (SOA) for services collaborating via the Internet (Figure 3). Promises reach from risk reduction or portability and re-usability in software development to integrated, intelligent operations like in the vision of the Internet of Things and Services (Ten Hompel et al., 2008; Karnouskos et al., 2010).

Figure 3: SOA-based Architecture.

Figure 3 shows that demand and supply of services is coordinated by describing and publishing the service profile based on a standardised Web Services Description Language (w3schools, 2012) and a central registration service. This infrastructure enables services to autonomously compose complex dynamic networks from such modules that may involve things (in the simplest case via radio tags, in future also enabled by embedded multi-core computing capacity), legacy systems as well as human users in the roles of operations’ supervisors or IT operators.

Due to latency times or high customization, legacy IT is hard to be integrated into service landscapes or to be decomposed into sub-services (Weiss, 2001). Also the competition of big players (IBM, Oracle, SAP, etc.) in direction will fragment web-standards. Or, the vulnerability of Internet-based services and dependencies on intermediaries raise security concerns. Yet, in spite of achievements, also the modularization of service architectures does not sustainably reduce the complexity of models (den Haan, 2007; de Groot, 2008).

A new platform, the Modular Transverse Matrix, is the strategy of VW to not get lost in variety. It reduces the number of modules by up to 90 % across 10 brands including, e.g., Seat, VW, Audi or Porsche (VW, 2012). Yet, it is hard to believe that this is applicable to the examples from aviation industry or to digital economy. But by and by markets will also coerce VW to accept and to accommodate new variety. So across all industries complexity will re-conquer modularized operations and related models or applications’ architectures (Muhammad, 2011; Tran et al., 2007): there is no escape from complexity and complexity continues to escape from control.
Introducing Meaning: The Regime of Semantic Modelling and Ontologies

Figure 4: The Semantic Layer in the W3 Architecture

Adopting Internet-based communication and cooperation semantic models became relevant: Languages are sets of tools to create meaning of signs or symbols in communities. So far, however, technology only can interpret sequences of signs obeying syntactic rules, e.g., as command to delete a text. There is no understanding of meaning. The idea of the semantic web (Berners-Lee et al., 2001) is to encode semantic information into web-pages.

In the W3-architecture of Berners-Lee (Figure 4) ontologies provide the vocabulary, more generally, the knowledge enabling to recognize and associate services. The common vocabulary enables modelling of relations to other objects and of attributes relevant to these relations – but the computer does not "understand" the know-why and context, i.e., the content of the service it provides: Which idea leads a search? What is the function about? Does it fit into an actual scene? What is the meaning of responses to events in a contradictory context (costs, quality, security, sustainability …)? For answering such questions computers need to become able of disambiguating complex operations' scenes.

Ontologies enable capturing local knowledge about objects engaged in operations like orders or resources. Given that these local models are semantically interoperable, i.e. implement a shared semantics in a consistent way, this enables e.g. the designer of a web service or the operator of a real business to participate in large scale, self-organising operations' systems that highly adaptively respond to change like new demand and new, collaborative bundles of offers. It is a continuous flow of variety which later, in the discussion of handling discretions to act in operations control, will be discussed as the "food" of multi-agent systems.

Semantic interoperability however needs a non-trivial degree of accuracy of the model, which, with increasing complexity becomes harder to maintain. Although semantic modelling is a great step for itself, it does not decouple from complexity.
IMPLICIT ASPECTS OF DECOUPLING MODELLING FROM DOMAIN COMPLEXITY

The examples of Boeing or Airbus show that complexity drives a trade-off between simplification reducing costs of modelling and risk that butterfly effects or "black swans" (Taleb, 2007) materialize, each of them potentially growing into very large financial problems. So cost-driven simplification of models may be a "bad bet" to manage complexity. But to do something meaningful first needs to disambiguate meaning in the domain and the concept of "meaning" needs to be clear.

Semantic modelling and computing, particularly ontology-based multi-agent systems (Allan, 2009; Rzevski, 2011), are well known but still far from the mainstream of industrial applications. It is the idea of connecting the world in meaningful ways through the internet of things and services as well as of internet-based automation of operations that now is driving semantic technologies. In the following the impact of "variety" or, more general, of complexity to semantic modelling will be discussed in order to prepare the translation of semantic models into the identification and exploitation of discretions to act in a meaningful, targeted way in complex environments.

What cannot be modelled, that is understood, structured, and decided, cannot be controlled. But the promise of semantic technologies to compute meaning that it will win back control cannot imply that computing in the past was meaningless or that computers in future will process more than bytes. So if there are differences in the performance of handling complexity the answer lies in the difference how conventional and semantic technologies make computing meaningful.

Conventional Strategies to Disambiguate Meaning

In principle everybody has an intuitive understanding of "meaning" as "that what a sign stands for". (Eco, 1990) Search engines disambiguate meaning in large and heterogeneous volumes of data like the Internet. Recently we started a research project named "ARUM - Advanced Ramp-up Management" (ARUM 2012) tackling problems like those sketched in the introduction chapter above by developing and implementing semantic technologies. So entering the string "ARUM", Google returned (Dec. 12th 2012) about 25 million results, at first that "Arum is a genus of about 25 species of flowering plants in the family Araceae …". Entering "ARUM & production" Google still returned as #1 a paper on flowers, but as #2 the ARUM page of the European Framework 7 research program. So Google does not compute meaning but finds, evaluates and exploits associations between strings finally returning something meaningful to the user.

This way of distracting meaning by indexing and computing vast volumes of data in the internet is a brute force approach. Reversely meaning can also be incorporated into data, e.g., by self-declaration as proposed by Berners-Lee (2000). But a recently finished European research project on web-based reasoning started from the insight that current Semantic Web reasoning systems do not scale to the requirements of their hottest applications, such as analysing data from millions of mobile devices, dealing with terabytes of scientific data, and content management in enterprises with thousands of knowledge workers. In this paper we present our plan of building the Large Knowledge Collider
[LarKC], a [High-Performance Computing] platform for massive distributed incomplete reasoning that will remove these scalability barriers." (Fensel, 2008). It obviously needs significant capacity for analysing the volume of related semantic and related conventional data. And regarding self-declaration it should be mentioned that Umberto Eco, one of the most prominent semioticians, defines his science as "discipline studying everything that may exploited for lying". (Eco, 1990, P. 15; translation: ui) To disambiguate these strategies and to understand their impact on an effective modelling and processing of meaning the following paragraphs shall provide a short review of options to code meaning in computing.

**Figure 5: Conventional Database Architectures**

Hierarchical databases and entity-relationship models (Bachmann, 1972; Chen, 2011) are architectures of **coding meaning into databases** (Figure 5). Relational architectures are more flexible because the knowledge about objects is stored in tables of properties relevant to operations and the "meaning" finally is "activated" in queries gathering information from the tables while in hierarchies meaning is equal to a hard-coded position in the hierarchy. Thus the architectures significantly differ in terms of performance of accommodating variety and change.²

**Mastering Complexity-driven Dis-economies of Architectures**

Figure 6 shows impacts of alternative strategies to create such networks and to deal with knowledge. The diagram stems from a Pricewaterhouse Coopers report (PWC, 2009) on the relevance of semantic technologies to the costs of integrating and using data. "Integrating’ refers to databases conventionally organized accordingly to the entity-relationship model – contrasted by semantic modelling (ontologies) and using’ to the computing of meaning. Obviously there are dis-economies of scale: "Bigger is no longer better.” (Perrumal et al., 2012) This is because complexity escapes from capabilities: Large systems and related sets of data suffer from non-linear increases of risk and costs driven by the volume, heterogeneity, interdependency and ambiguity of data. The linear increase of ontology-based modelling again indicates, that semantic technologies may enable to effectively decouple of complexity.

To understand the difference between conventional and semantic technologies requires a deeper understanding how knowledge, meaning and complexity are linked. For this a short **experiment of thought** may be useful: Consider a member of a primitive tribe de-

² The Unified Modeling Language (UML) is widely similar to the Entity-Relationship database model
pending on stone age technology meeting the very first time a team of anthropologists equipped with computers and related things: How will he perceive a computer mouse? As a badly designed hand axe?

The experiment tells that perceptions of signs and of concepts (knowledge) attributed to them rely on the disambiguation from and relations to other signs respectively concepts: It looks like (sign) a hand axe (concept) so it is a hand axe. Association to and -disambiguation from (the Sentence of Identity, Heidegger 1957) form the algorithm assigning meaning to objects. In the brain context is based on processing knowledge, in search engines on the co-appearance of strings, in databases by positions in hierarchies or by descriptions or of -entities by their links to tables containing information about properties relevant to specific operations. Thus knowledge is equal to the network of associations available to persons, groups, organizations or computers and meaning is a context-specific application of that knowledge.  

**Figure 6: “An ontological approach offers scalability”**

A tenacious memory is helpful. But a print-out neither delivers contiguity nor any coherent argumentation. The network of associations is a complex system by itself and knowledge is a volatile resource emerging from almost continuous efforts of disambiguation. With respect to new physical or mental objects Eco (1989, P. 17) calls it interpretational response. The thought leads back to Aristotle (379 B.C.) ascribing association to similarity, contrast, co-existence and succession, later developed into a theory of thought (Mill, 1869). E.g., Lipps (1928) took an existential view at ontologies (there is no ontology of everything), Wittgenstein’s (1953) -games of language deal with -What can be said?, or Latmann (1993) who analysed economic impacts. In the context of complex systems we may define associations as emergent relations.  

3 From this point of view learning (and dis-learning) can be defined as re-organizing the network, creativity as capability to find potentially meaningful new patterns and intelligence is the related measure of performance.
But the stone age man may have another problem: His belief in a spirit world that for him works as a container for everything he does not understand. So observing the use of the mouse he may conceive it as a kind of magic wand. From his perspective spiritual knowledge is real and effective and in his society it maintains his cultural context. But obviously it impedes his understanding of the actual character of the mouse. In other words: Accordingly to “Ockham’s Razor”\(^4\), saying that of two theories the less complicated one is to be preferred, his model has to become more simple by questioning spiritual associations being bar to realistic ones. Ockham’s Razor is a heuristics strategy to improve overview by straightening up the network of associations by trading the explanatory efficiency of theories against their complicatedness.

As the history of industrial architectures shows, straightening up believes and knowledge is not easy – but may avoid a loss of control: Toyota had already become the most efficient car-producer in the world long before European and American producers became aware of, not to speak about any realistic idea how to answer to this challenge. They were stuck in their belief to be market leaders and these beliefs made them blind. Before the “old world” had realised actual sources of self-inflicted complexity Toyota had become the largest car producer in the world. Similarly Nokia still convinced itself to be the market leader when smart-phones were massively eroding their position. Like the stone age man also managements in these firms had containers for irritating information e.g. for emails rising questions: the recycle bin. The trap is that in such cases also customers widely share this confidence. (Bower, 1995) To effectively overcome this trap requires working on solutions customers do not yet know – before competitors offer them.

Taking a consequence from these practical cases for control, Ockham’s Razor has to become an integral strategy of modelling. Before elaborating further aspects of “lean modelling” showing how ontologies may decouple from domain complexity and with this enable recovering of control.

**Semantic Strategies to Identify and Allocate Discretions to Act**

On the left side Figure 7 shows a high-level model of the “Linked Data” ontology claiming at “… a best practice for exposing, sharing, and connecting pieces of data, information, and knowledge on the Semantic Web using URIs and RDF.” It is a graph-based semantic network with concepts (objects) as nodes, that, as in entity-relation modelling, are connected by explicitly defined relations. (LOD Cloud, 2012) But even without drilling into detail the very rough overview gives an idea about the inherent complexity of the model and efforts to maintain it – particularly to catch up with an accelerating growth of variety and volatility to be controlled. In other words, the model may be suitable for widely static rather than for complex and dynamic environments.

---

\(^4\) The “lex parsimoniae”, in science or philosophy mostly referred to as “Ockham’s Razor”(Ockham has been an English theologian and logician in the 14\(^{th}\) century), has a long history. This figure of thought has been used by Aristotle even in an ontological context in discussing Anaxagoras’ answer to the question, how physical objects achieve “existence” (being) and about the innumerability of principles, (Physics, Book I, Ch. 4, 188a 12-18 and 189a 15-17) or by Ptolemy (2\(^{nd}\) century): “We consider it a good principle to explain the phenomena by the simplest hypothesis possible”. In the 13\(^{th}\) century the thought became a part of Scholastic discourses (Thomas Aquinas) – and after some hundred years later Toyota made a success of the idea by applying it to car manufacturing.
While the left figure only shows a network of relations between objects (entities) on the example of a very large ontology, the right side of Figure 7 drafts a class-architecture of an ontology. O* stands for classes of objects and M* for "classes of classes" capturing and inheriting properties to their subclasses in order to reduce redundancy and increase manageability of the model. P represents properties of classes and the colours mark the heritage of properties from the higher classes.

In contrary to relational databases (Figure 5) which distribute properties of entities across a number of linked tables, ontologies keep entities and their properties as a unit. Objects "know" their states like in real life: e.g., persons know their property -age". In terms of modelling – and that is the focus here – this is a significant reduction of complexity and flexibility:

- The structure of properties can be changed without changing any network of tables.
- Any proficient person is able to describe objects and their properties he is concerned with in daily business – without need to know tables and their relations.

**Figure 7: Ontology Architectures**


But the model drafted above indicates another step: In contrary to the LOD-Cloud model it does not include explicit relation between the classes but links between properties (dotted lines). The message is: **Ontologies can be further simplified by waving explicit modelling of relations.** This also looks counter intuitive, particularly considering the hand axe / mouse case: Meaning of objects, i.e., the disambiguation between objects, emerges from the dynamics of associations. But instead of coding relations in the ontology they can be left to processing the ontology: Like in real live properties are with the entities (e.g. a colour with a car, skills with a person). Relations appear when somebody interested in a car matches his demand with the offer he finds the shop or car dealer or when a HR manager interviews candidates to find the best match with the required profile. Yet "waiving explicit modelling of relations" does relinquish relations: Rather they will appear when "objects meet". Clearly the effort depends on information asymmetry.

**Translated into the example about aircraft manufacturing** (introduction chapter) consider an instance of one of the classes represents clips holding a bundle of cables to-
gether and a second class the specification of requirements of these clips. Now, in the assembly process, one of the clips fails. Under ramp-up conditions and given the very strict safety procedures in aviation industry this may cause a request to engineering to investigate whether properties of the clips to the requirements. If operations will be interrupted it is to be analysed which further assemblies will be affected (depending on the availability of the harnessing) and reorganize work to minimize overall impact. And if engineering declares the clips not to be in conformity to requirements the problem may propagate to some kilometres of harnessing that have already been mounted and are now to be replaced. This is the stuff nightmares are made of.

Networks of web-services (Figure 3) may compare to these networks of properties to. But the latter aim at the identification and exploitation of discretions to act in order to hedge the impact of unplanned events: Services may support the gathering of information required. But it is hardly possible to predefine services casting out unexpected nightmares. Rather the DTA approach goes deeper into the profiles of resources services are made from. If there are DTA to respond to unplanned events they lie in these deep dynamics. In the ARUM project we are working on ontology architectures at least coming close to a model enabling processing of networks of properties to emerge effective relations between objects.

DECOUPLING MODELS AND PROCESSING DISCRETIONS TO ACT

The headline of this chapter may still look counterintuitive. But it again is about distinguishing “bad” and “good” complexity: Controlling complexity requires one to understand where it is useful and where not in order to regain rather than impede control.

Making Implicit Relations Explicit: Ontology-, Agent- and Service-based Reasoning

Implicit modelling of relations needs to establish them “in actu”: By trying to skin an elk with the mouse properties become obvious confuting first ideas. Whether the stone-age man will realize and control functionality of the mouse depends on his intelligence (and courage to wave believes). The process is: reasoning about models, experimenting and re-modelling with networks of properties under the regime of Ockham’s Razor. In the our approach explicit relations felt victim to this principle. It makes models “flat” because it reduces content to the description of the properties of objects feeding the activity complexity emerges from. Modelling is decoupled.

There is a deeper relation to Service-oriented Architectures: As the stone age man used two objects, the mouse and an elk to test his idea by performing the service of skinning or the HR-manager tested candidates whether their “properties” match the needs of the service a candidate shall be employed for: It is always about a service-driven match of properties. With this the concept of service-oriented reasoning can be introduced to further reduce the variety of relations – whether implicit or explicit.  

In formal models this is called a “triple” (subject – operation – object → “mouse” – skinning – elk) Referring to the definition of “associations as emergent relations” and some philosophical backgrounds (page 9) an overview about the richness of facets related to this and its impact on the complexity of on-
In contrary to centralised registration-based coordination (see Figure 3), services can be organised in dynamic networks, organized in virtual service-markets (Rzevski 2011) where autonomous agents browse for opportunities to provide or procure services accordingly to their profiles. Control can be provided by implementing economic parameters like costs, price, respectively models to calculate contributions to margins, opportunity costs or options’ values. But the idea is not only about reducing the demand for computing capacity in agent-based reasoning. Reducing the variety of relations increases the transparency, verifiability and with this the costs of developing and maintaining of ontologies, too.

Any relation may be modelled as a traded service. E.g. the relations table_has_legs or leg_is_part_of_table translate into: "the service of the leg is to provide a height of the table of 72 cm" and into sequences like: "user agent asks for table of 72 cm" → "table agent asks ...". In recent years service-oriented architectures almost became a standard of modelling respectively organizing distributed systems. (MDSN 2004 and 2005, Gartner 2005) So assumptions that any model can be translated into a network of services may be obvious from conceptual point of view. But under conditions of complexity we prefer to argue based on proven practical value and for the time being we rely on a number of large industrial as well as research projects:

- **“Interactive Tracking”** (Lufthansa / Volkswagen 1996; industry, consulting): Dynamic re-assigning shipments to consignees and flights accordingly to changing urgency.
- **“Knowledge Integrator”** (CargoLifter 1999 / 2000; industry, consulting): MAS-based experimental learning about interdependencies in technical design, production, air- and ground operations and collaborative transport networks in realistic market scenarios (based on history project data from lead-users and global market studies).\(^7\)
- **“intelligent RFID-based Catering Services”** (iC-RFID Consortium, 2007/2010; research): Prototype for designing, planning and scheduling air-catering for alternative fleets of aircrafts, flight rotations, shopfloor architectures and airport ground services. (Franken, 2011)
- **“Air Taxi”** (AirTaxi 2009 / 2010; industry, consulting): Designing and implementing an Air-Taxi network in Europe (development, management, strategic and operations’ planning).

\(^7\) This is an example from ergonomics and logistics of office furniture in a large organization.
\(^8\) Currently these projects are reviewed in a meta-study for formal proof and further exemplification.
\(^9\) CargoLifter was a project aiming at the development and operation of very large airships (with ~ 500.000 m\(^3\) larger than most air carriers) serving for point-to-point transport of heavy (up to 160 to) and oversized (8*8*50 m) items. After sinking ~ 400 Mill. € the project failed in 2002 because of its overcomplexity. (Hermanns, 2012)

Advanced Ramp-up Management (ARUM Consortium 2012; research): Strategic, tactical and real-time management in small-lot production and ramp-up. (ARUM a, b; 2012)

Understanding and Exploiting Discretions to Act to Recover Control

Ashby's Law refers to the variety of states a object (or agent) can realize by exploiting their discretions to act (DTA), i.e. their actual possibilities to alter at least one state. Thus DTA are sources of both: variety and control. I.e. the controller has a chance to draw level if the model provides means enabling him to realize and dispose of the discretions to act and their dynamics.

A serious challenge is to adapt to structural change of DTA (new objects, new kinds of variety ...) – if need be on the fly: The candidate in the human resource case may have an educated view at the scene and may get the job because, to compensate his partly insufficient profile, he agrees in a temporarily lower salary or is ready to take training lessons. Obviously the most important resources are the mind-set (spirit) to systematically question an approach and the readiness to question positions and engage in experimental learning.  

In operations complexity needs a continuous search for and evaluation of change and related upside or downside potentials. The problem lies in uncertainty, e.g., in the nonlinearity of "butterfly-effects" or the "black swans" (e.g., in the case of aircraft production ramp-up) hidden behind horizons of imagination or in the long tail of event risk, nevertheless calling for effective context-aware learning, structuring, evaluating, deciding and implementing when they appear. It challenges the "brain-to-implementation-cycle".  

---

10 By failing this kind of learning, e.g., Nokia lost its position as market leader by mistaking the concept of internet- and community oriented — smartphones — with the technological sophistication and functional integration of their products. Or IBM lost the PC-business by mistaking the service of hardware with the service of computing. For a general analysis of this problem see Bower, Christensen (1995, p. 44): "Managers must beware of ignoring new technologies that don't initially meet the needs of their mainstream customers."

In the "new division of labour" between modelling and computing operations' workflows emerge from interactions – as complexity emerges in real world. In the view of conventional management there are downsides. Particularly emergent solutions are not traceable although they rely on deterministic interaction of agents. But in any business control implies to develop and implement plans defining optimal settings of relevant states asking to minimize any undesired use of DTA. The only option to achieve this "suppression" is to maximize variety of the controller (Ashby, p. 207). The point however is, that a DTA-based strategy may be able of taking advantage from not suppressing variety of the system, i.e., taking complexity and variety (also) as a resource of operations management. This again may be counter-intuitive, but under conditions of high complexity suppression may be counter-productive.

**Exploiting Complexity as a Resource of Control**

In agent-based modelling ontologies do not only serve as dictionaries but as frameworks guiding agents' behaviour in processing their DTA. If required each object modelled can be represented by a software agent acting as and like its real counterpart in a meaningful context in simulation or in (almost) real-time operations. Conditions are, that the model is valid (complete and consistent) and that in real-time use the MAS is continuously updated about events that change DTA in real and with this of agents in the virtual world of the MAS. This compares to real behaviour in many businesses that in fact frequently process DTA in a mode that is called *improvisation*:

Experienced and attentive operators understand the scene and know the DTA of "their" resources and with this the option available for mitigation or remedy. It is the intelligence to achieve objectives *despite* of accidental events as good as possible: Semantic technologies can support this intelligence by agents, each aware of their actual states and related DTA. This awareness enables exploiting them at the best in collaboration with other agents. The higher the complexity the more likely but the less predictable events become and propagate: The change of DTA of one agent is likely to change DTA of further agents. In consequence of these interactions a *continuous floor of fluctuating DTA* emerges that in the light of Ashby's Law can be interpreted in two ways:
Either it is an unwanted but not or hardly avoidable deviation from the plan ("noise").

**Or fluctuating DTA are a resource that can be exploited to keep on target in spite of the unexpected.**

The latter is possible if systems are available to enhance immediate awareness and control of fluctuations.

Figure 9 shows a simple Gantt diagram of air catering ground operations at an airport (Inden, 2010; Franken, 2011). The timeline passes from left to right and resources are for five highloaders (trucks for apron transport and load-exchange with aircraft galleys). Colours mark jobs or coffee breaks of drivers, time for technical reasons (e.g. cleaning), and finally idle times.

**Figure 9: Gantt Diagram with Occupied and Free Capacity**

![Gantt Diagram](image_url)

Source: by authors

Among others we analysed a scenario about an unplanned flight, that was deviated from another airport. Due to peak-time no truck was available for service and efforts failed to re-allocate jobs or to shift breaks in order to free up a slot for a job from fragmented idle slots. But a little later the flow of contingencies provided the option to clear up the situation: Another airline decided to wait for a delayed incoming flight with connecting passengers and so a sufficient slot could be implemented (being aware that another event, a failing truck, also could have made it worse).

There are not only examples of events that extinguish each other: Another strategy tested was to allow condition-based non-standard collaboration such as serving flights with one instead of two trucks serving front and rear galleys in parallel. This means that one truck now has to serve two galleys and to re-position from the front- to the rear-galley of the aircraft. This sequential instead of parallel workflow takes time and, not to delay the flight, needs a change of boarding procedures to be agreed with the passenger gate, passenger bus services and apron control which may have to provide stairs for boarding. Likewise intelligent contingency planning (see the chapter on criticality below) can increase effectiveness to adapt to unplanned events. Considering a large scale operations system with

---

12 Jobs at least include loading at the catering factory, driving to the parking position of the respective aircraft, positioning at the aircraft to access the galley, unloading / loading the galley, returning to the factory, unloading.
a high resolution of objects and events (Müller-Stevens et al., 2008) and a rich variety of policies complexity indeed can be considered to be a resource. 

**Avoiding Self-inflicted “Bad” Complexity in Semantic Modelling**

Some general rules of lean modelling should be addressed. Basically it is about Toyota’s principles of distinguishing -good”, value adding from -bad” cost adding complexity:

- **Scalability**: Limited computing capacity induces trade-offs between costs of inflexible, explicit modelling and costs of computational reasoning across vast numbers of objects. E.g., in ARUM the scale of the bill of parts differs between use-cases by a factor of up to 5,000, while managerial overheads (e.g., quality management and documentation) ask to take care for any detail at any time. This may translate into millions of active agents reasoning about establishing and re-establishing relationships. In result solutions should enable to adjust the resolution of detail to the demand of the scene: In small use-cases everything is accessible for analysis, planning or real-time control. In large ones, the standard is to keep models as small as possible, e.g., modelling pre-assemblies rather than the complete bill of material that may include six million items in case of a large aircraft. But in case of failure the search for reasons or for consequences like the propagation of the failure may lead deep into the details.

- **“Semantic modesty”** is another aspect: Not only relations but also the complexity of semantic concepts can become a challenge to maintain the validity of large and frequently adapted ontologies. An ontology of philosophy will hardly avoid complex concepts. But there are applications that cannot avoid this problem, like abstract economic contexts, e.g., the time to volume (achieving the crestline of production) or the time to amortization (progress of return on investment). Also new managerial regimes introduce new concepts, e.g., of time, like ‘synchronization’ which is highly relevant to lean management but not for Ford’s functional silos. By limiting variety of relations and by being modest in terms of semantic complexity the global consistency of local modelling is significantly easier to validate.

- **Modularization**: As far as connectivity and interoperability are granted ontologies can be modularized in holonic structures (Köstler, 1972; Van Brussel, 1998), with distributed ontologies describing and MAS processing the domains interacting with the others (a system of systems). Or (Figure 7), ontologies can be structured into classes and sub-classes connected by inherited properties. Beyond prima facie domain information there meta-classes can concentrate information about classes or meta-ontologies may serve as frameworks for designing ontologies (Ferstl & Sinz, 2006, p. 86). These modular structures can significantly increase the flexibility and the manageability of the ontologies.

---

13 Another aspect of —modesty” is to accept that there will be no —ontology of everything”, e.g., an ontology of the internet e.g., because of up-front costs (Fensel et al., 2008, P. 3) or for fundamental reasons: Accordingly to Gödel’s Incompleteness Theorems (Gödel, 1931) there are statements in large formal models which by principle can neither be proven nor disproven. This work confuted Hilbert’s program to prove the consistency of mathematics.
CONCLUSION AND OUTLOOK

In the light of Ashby’s Law ‘competing’ is an effort to achieve, maintain or increase control by disposing of more variety than competitors. Therefore, competition in direction drives complexity. That way Ford’s mass-production system exceeded complexity of previous car-by-car garage production. Overcoming self-inflicted complexity of Fordian silos Toyota invented lean manufacturing, again more complex than the regime attacked. Each step introduced a more complex paradigm that changed the ‘landscape of competitive fitness” (Kauffman, 1995). None left options to return to previous models. Now, self-inflicted complexity lies in ignoring the upside potentials of complexity and in consequence new strategies of modelling and of operations emerge exploiting these upsides. To finalize, aspects which slow-down adaptation shall be discussed:

- **Trust in a Black-Box?** In business environments, conceiving and tackling complexity as a resource commonly interferes with conventional concepts of governance and management: Still the ideas of calculability and optimization (full control) prevails and not principles of continuous and potentially experimental adaptation and approximation. So in the regime of lean management redundancy is not considered to be a resource and, e.g. in factory management, unpredicted variety is tried to be controlled by automation (Colombo, 2010) minimizing operations’ variety (Ashby P. 207). The DTA approach may be an effective support. But another aspect counters its implementation: The ‘black-box” character of MAS-based solutions which in the classical design of ICT systems has been purposely excluded. (Müller-Schloer, 2008, P. 31). Projects like ARUM have the potential to prove the potential of exploiting complexity as a resource immediately on the shopfloor.

- **Improving Usability!** There are editors and tools available or strategies reducing semantic complexity that may substantially simplify the management of ontologies. But the support of, e.g., experimental learning is not only about managing ontologies but may also need adapting code in the MAS. This still is a long way. As example including an answer to the problem with the fasteners that have been neglected in Boeing’s Virtual Ramp-up may need significant changes of the model: Fasteners are . To improve handling of experimental simulation the involvement of software developers should be reduced as far as possible. This also may have an impact in terms of model driven software engineering or possible automated code generation and with this increase acceptance of users.

- **Managing Criticality.** Criticality is a global control parameter of the dynamics of complex systems (like the temperature of a solid object). It is defined as scale-free point of a phase transition (Christensen et al., 2005), e.g., from liquid to solid or from able to unable of response to unexpected events, i.e., disposing or not of respective DTA. In order to maintain the flow of operations clearly controllers need to effectively estimate criticality. An approach is to take criticality as holistic parameter of the operations’ system like the temperature of a gas. Though a deeper insight may be provided by analysing patterns deriving from the binary character of DTA as results of previous and as resources of subsequent action. Initially developed in the
In the context of airport operations' management we currently discuss the concept with several industries in the context of managing large-scale landscapes of risk.

- **Convergence with High Performance Computing.** There is indication that processing large networks of properties is growing into High Performance Computing (HPC), but also that some approaches discussed in this paper may contribute to solutions in classical domains of HPC. The LarKC project (Fensel et al., 2008) is an example on HPC-supported semantic reasoning. Comparing a large-scale manufacturing model may include tens or hundreds of thousands interacting factors to be run in large batches of Monte-Carlo simulations, e.g., for analysing propagation patterns of the impact of events or to identify indicators of criticality. Reversely holonic multi-agent system offer effective solutions for modelling and processing multi-domain applications, like interactions of manufacturing and engineering and further sub-domains of operations require strategies. For HPC these concepts may provide ideas for designing so-called multi-level models in technical simulation.
Reference List


Fensel D., van Harmelen F., Andersson B., Brennan P., Cunningham H. Della Valle E.,
Fischer F., Huang Z., Kiryakov A. Kyung-il Lee K., School L., Tresp V., Wesner St.,
Reasoning”. IEEE Computer Society Press Los Alamitos, CA, USA,
(Accessed 21 Sep, 2012)
Oldenbourg, München.
tems in Air-Catering with RFID - Betriebswirtschaftliche Konfiguration, Demonstration,
exemplarischer Workflow— Kölner Arbeitspapiere zur Wirtschaftswissenschaft,
1/2011, Schmalenbach Institut für Wirtschaftswissenschaften. – Cologne open
Science
URL: http://opu.fu-berlin.de/fhk/frontdoor.php?source_opus=26&la=de
Gödel, Kurt (1931). -Über formal unentscheidbare Sätze der Principia Mathematica und
Heidegger, M. (1957). -Der Satz der Identität— In Martin Heidegger, Identität und
Difference, Verlag Günter Neseke Pfullingen, Sechste Auflage 1978
Hermanns, Philipp (2012). -Göranizational hubris – the rise and fall of the celebrity firm
CargoLifter AG". Dissertation, Freie Universität Berlin, Dissertations Online,
URL: http://www.diss.fu-berlin.de/diss/receive/FUDISS_thesis_000000039985;
published version: Kölner Wissenschaftsverlag
International Limited, URL:
12 Jan, 2010)
Inden, U. (2010). -CESSAR - Configuration and Evaluation of Service Systems in Air-
catering with RFID (Fachhochschule Köln)". Intelligentes Catering mit RDF –
Prozesse, Logistik und Integration neuer Technologien im Luftfahr tcatering
- Fraunhofer - Institut für Arbeitwirtschaft und Organisation – IAO
Fraunhofer Verlag, Fraunhofer, Informationszentrum Raum und Bau IRB
Inden, U.; Tieck, St.; and Rückemann, C.-P. (2011). -Rotation-oriented Collaborative Air
Traffic Management". C.-P. Rückemann, W. Christmann, S. Saini, & M. Pankowska,
(Eds.), Proceedings of The First International Conference on Advanced
Complexity Based on a Freedom-to-Act Architecture". Rückemann, C.-P. and Dini, P.
and Hommel, W. and Pankowska, M., & Schubert, L. (Eds.), Proceedings of the
International Conference on Advanced Communications and Computation
(INFOCOMP 2012), October 21-26, 2012, Venice, Italy, pages 47-53. XPS, Xpert
(Accessed 17 February, 2013)
-Real-world Service Interaction with Enterprise Systems in Dynamic Manufacturing
Environments”, Artificial Intelligence Techniques for Networked Manufacturing
200 ff.


SESAR, Single European Sky ATM Research.


Planar Layout of Data Vortex Optical Network

Qimin Yang
Harvey Mudd College, Engineering Department, USA

Abstract

This paper aims to explore an alternative planar layout of the Data Vortex optical network. It is desirable to provide high throughput and low latency information exchange between processors or Input/Output (I/O) ports within advanced multiprocessor computing and communication systems. Optical interconnection networks can overcome many limits in electrical interconnection networks and provide promising routing performance. This paper extends previous research in (Yang, 2012) that proposed an alternative planar layout of the Data Vortex optical network. The original cylindrical structure can be converted to a configuration that consists of multiple parallel planes. Since the new layout is designed to be functionally equivalent to the original network, its routing performance in throughput and latency is shown to be very similar to that of the original network under the same network conditions. A more thorough performance comparison is provided by exploring various traffic conditions, load conditions and network sizes. The effect of the traffic injection angles is investigated for optimized performance. Finally the overall network layouts in physical system implementation have been explored based on the planar cylindrical levels. The proposed designs are simple and flexible to satisfy the synchronization requirement and scalability needs. The modular design is versatile in adapting to different network sizes and it provides an attractive solution for future system integration.

Keywords: data vortex network, packet switched, interconnection network, throughput, planar network

Introduction

Many applications require high performance interconnection networks such as multiprocessor computers and multiple I/O communication systems. These interconnection networks are generally packet-based in operation, and both high throughput and low latency are important performance characteristics (Wonfor, 2011) (Shacham, 2007). As optical fiber technology matured with the optical communication industry, there are more research efforts recently dedicated to developing optically implemented interconnection networks (Nishimura, 2011). It is also important to scale interconnection networks to different sizes for various applications. In particular at very large network sizes, not only a good routing performance in throughput and latency should be guaranteed, but physical implementation of such large systems should also be accomplished with a reasonable cost. The network architecture thus must be designed in such a fashion that these needs are met. Unlike a point-to-point transmission system, a switched optical network must handle tremendous amount of routing decisions whether it is in a centralized or distributed manner. Therefore, a hybrid photonic platform makes sense because there is no simple all-optical logic technology. It is worthwhile to examine recent researches in silicon photonics devices and platforms because these technologies are important developments for seamless integration of the two domains (Liow, 2011; Ophir, 2011). Instead of converting existing electronic interconnection networks, the renewed interests in the area also bring more innovative designs in...
network architectures that can efficiently utilize both electrical and optical domains. Photonic approaches are attractive solutions because they not only achieve the bandwidth requirement easily, but also potentially overcome challenges in energy consumption and scalability issues that current electronic interconnection networks encounter at large sizes (Tucker, 2011; Liboiron-Ladouceur, 2011). A good network design should utilize the broad bandwidth of optical domain while avoiding extensive logic processing or optical buffering due to the lack of the mature technology.

Data Vortex network architecture is designed for localized high performance interconnection purpose, and it is scalable to a very large number of communication ports operated in packet switched mode (Yang, 2001; Hawkins, 2007; Hawkins, 2007). With reasonable expense in routing resource redundancy, it is able to achieve very high traffic throughput while maintaining low latency and narrow latency distribution, both of which are extremely important for guarantee of packet’s signal quality at the physical layer (Liboiron-Ladouceur, 2006; Shacham, 2005). Data Vortex optical interconnection network relies on a three dimensional cylindrical topology to efficiently move the data flow from input to output ports (Sharma, 2007; Shacham, 2007; Shacham, 2007). Considering the benefit of planar structure for physical implementation (Ye, 2009; Zhang, 2010; Kash, 2008), this work focuses on converting the three dimensional topology to multiple planes of routing levels to facilitate construction and integration. While the proposed routing level configuration has been reported in (Yang, 2012), this paper extends such study to include a more thorough performance study. In addition, overall network construction is discussed in details with consideration in modularity, flexibility and scalability.

The rest of the paper is organized as follows: Section II explains the original Data Vortex switching topology, and difficulty with large scale system construction in cylinders. Section III presents the proposed planar layout of each cylinder level which allows for an equivalent routing topology. Section IV presents the routing performance comparison with the original layout and confirms the feasibility of the proposed system. Section V provides overall network layout strategy and considerations and provides a few possible designs, and Section VI concludes the study.

ORIGINAL DATA VORTEX DESIGN

The original Data Vortex network uses a cylindrical layout with multiple cylinders of routing nodes along angle and height dimensions. As an example, Figure 1 (a) shows the two outer cylinders’ routing paths in a network of A=4 angles and H=4 in height. To allow for clear view, intra-cylinder paths patterns are also individually shown in Figure 1(b) for each of the three cylinders. The number of cylinders required is given by \( \log_2 H + 1 \) due to the binary decoding nature of the routing process. The last cylinder is typically added, as shown in cylinder c=2 (=C) in Figure 1 (b), and it maintains the height position; but, it allows for angular resolution if each angle connects to a different sets of I/O ports. In addition, the last cylinder provides optical buffering in addition to the electrical buffers situated at I/O ports.

The number of active angles \( A_{in} \) are connected to I/O ports, so that the ratio \( A_{in}/A \) controls the redundancy in network operation. The choice of \( A_{in} \) needs to balance between the support of I/O ports for the given network cost and the routing performance. The smaller \( A_{in}/A \) results in better routing performance, but also means supporting of
smaller I/O ports or more expensive implementation as the required number of routing nodes and optical switches is proportional to the total number of angle A. The typical choice of A is a small number around 5 because an ideal operation with $A_{in}/A=1/5$ results in the optimum routing performance (Yang, 2001). A much larger angle introduces much longer delay due to the latency associated with the angular resolution at the last cylinder.

Figure 1: (a) Two outer cylinders of Data Vortex topology for $A=4$, $H=4$. (b) Intra-cylinder routing paths for each of the cylinders.


The routing process starts with packets injected at the outermost cylinder, and after through each of the cylinders exit to output ports at the innermost cylinder. As shown in Figure 1, at the specific cylinder, the semi-twisted routing path patterns repeat from angle to angle which forms a cylinder by connecting the last angle to the first angle, allowing the packet to switch between two groups of height where the corresponding binary bit of the height position flip back and forth between “1” and “0”. This not only allows the packets to quickly reach the correct height group, but also provide multiple open paths to reach their destination. Once the position group matches the desired group at the specific cylinder, the packet is forwarded to the inner cylinder by inter-cylinder paths (gray lines shown) that simply maintain the current height position. Such routing process continues until the packet reaches the innermost cylinder and exits the network.

Another important design of the network is to guarantee single packet routing for each routing node through a traffic control mechanism. This greatly simplifies the node implementation and routing decisions, where electronic processing will not impose serious speed limitation. These traffic control signals are distributed throughout the network, and they are used between a pair of relevant nodes, sent from inner cylinder nodes to inform their outer cylinder neighbors its traffic condition. In case both have packets arriving, the inner node is always given higher priority and the outer cylinder
traffic is deflected by staying at the outer cylinder instead. These control lines are shown as dash lines between the pair of nodes in Figure 1(a).

For the physical implementation, the switches within the routing node are based on semiconductor optical amplifier (SOA). It not only allows for fast switching required for packet switching, but also provides broadband operation which allows for utilization of wavelength division multiplexing (WDM) techniques. Specifically, payload data is modulated onto WDM channels to keep short packet length while maintaining high data bandwidth, and header bits that contain the destination information are also modulated onto different wavelength channels for simple decoding within the routing nodes. In addition, any power loss in routing nodes can be easily compensated by the gain provided by semiconductor optical amplifier (Hawkins, 2007).

**Figure 2: Routing node photonic implementation**

A detailed routing node implementation using optical components is shown in Figure 2. There are two input paths, where N (North) connects to the outer cylinder node, and W (West) connects to the same cylinder node. Since the control mechanism mentioned above guarantees that at most one packet enters the node, the input paths from N and W are combined before the header bit extraction and decoding. The binary header bits of the target address are encoded using distinct wavelength channels, therefore simple passive filters and low packet rate optoelectronic (O/E) detector are used to extract such information from the optical packet. The single packet is then split to two potential output paths, one to S (South) to inner cylinder or one to E (East) to the same cylinder. The routing decision not only examine the header bit and correct height group, but also depend on an input control signal C_{in} so that ensure it only enters the inner cylinder node when there is no potential conflict for single packet condition. Similarly, the routing logic generates a new control signal C_{out} for its outer cylinder node for the same purpose. As a result of control mechanism, packet deflection can happen in Data Vortex network without packet loss. Packets that are deflected to stay on the outer cylinder can take advantage of the multiple open paths, and this causes a rather small latency penalty in comparison to other existing networks. SOA switches are used for their fast sub-nanoseconds switching speeds and internal gain for power compensation occurring at taps and splitters. More details of signaling and path connections can be found in the references (Yang, 2001; Hawkins, 2007).

Previous researches on Data Vortex network have been mainly focused on network’s routing performance and physical layer system performances. As more applications call for such optical interconnection networks, making them more flexible and easier for
construction are of great importance. So far only a 12x12 small testbed has been built mainly because it heavily relies on discrete components. On one hand, recent researches in either SOA switching fabric or novel silicon photonic devices provide more potential for integration at the device and routing node level. On the other hand, network architectures may not have the same upgrades for easier implementation. For example, a small scale Data Vortex can be easily implemented using fiber waveguides and individual node modules in three dimensions. But, such arrangement could be very complex and cumbersome for a much larger network. The difficulties also include keeping every level aligned and synchronized for proper routing operation. For all paths to be the same physical length at all levels, inner levels must somehow wind up paths to occupy a smaller physical space than its outer level in cylindrical arrangement. In addition, there is close coupling between the optical layer which is for packet transmission and the electrical layer which is for decision for switching packets. Thus a fully three dimensional fabrication is not compatible to integration solutions traditionally in electronics. One solution is if each of the routing levels or cylinders can be integrated as a subsystem on a plane as the electrical circuits naturally arrange on planes, it becomes a much more manageable overall system which simply interconnects the planes of subsystems. The complexity would not grow drastically as the size of the system. Because connections between the levels are parallel links, either fiber based on other type of waveguides in more integrated form can be used.

**PLANAR LAYOUT DESIGN**

To eliminate the incompatibility of integration of electrical layer in the cylindrical arrangement, and make Data Vortex easier to construct in large scale networks, this study explores an alternative layout of the Data Vortex architecture to allow for planar construction of the multiple routing levels.

In the logical level, we want to maintain the same principle of minimizing deflection probability by arranging the same semi-twisted routing patterns, while allowing for parallel planes for easy layered integration. To achieve this, instead of connecting the last angle of routing nodes to the first angle in the original Data Vortex, we added paths along the same angle at the first and the last angle (green paths as shown in Figure 3 and Figure 4), while changing half of the routing paths in the opposite traveling direction (red paths vs. blue paths). As a result, traveling on the same plane now forms a looping pattern similar to the ones by staying on the same cylinder in the original Data Vortex network. As examples, Figure 3 and Figure 4 show a network with H=4 at the first two routing levels (in comparison to the two outermost cylinders in the original network layout in Figure 1) for A=4 and A=5, respectively. As shown, the direction of the same angle green paths at the first and last angle depends on whether the angle A is even or odd, and the connection pattern follows the same pattern between the nodes as in between angles. The same cylinder paths’ direction also depends on whether A is even or odd accordingly as shown.

The new layout now allows for parallel planes of different routing levels that correspond to the original cylinders. Between different planes, only parallel routing paths are needed as that in the original Data Vortex networks. The control signal paths are not shown for a clear view, but they should be set up similarly between the pair of nodes from inner cylinder to the outer cylinder whenever two nodes try to send packets to the same node. These control paths can be integrated with the optical routing path on another plane that
would be perpendicular to the planes of routing levels. The control signals apply to the edge angle nodes in a similar fashion even though the output node could be located on the same angle. The detailed organization of nodal circuits on the plane is beyond this study. Either all nodes of the same plane are fabricated on a same platform/board which requires planar optical waveguide technology, or nodes of the same angle can be fabricated on a same board if angles are interconnected by more flexible fiber waveguides. Three dimensional arrangements are still open, but without the difficulty of occupying a different size space as in cylindrical networks.

**Figure 3: Routing paths in planar layout for A=5 (odd) and H=4 at the first two cylinders.**

Figure 4: Routing paths in planar layout for $A=4$ (even) and $H=4$ at the first two cylinders.


Logically, the new layout forms a very similar connection as that of the original Data Vortex network, and the rest designs such as parallel inter-level forwarding paths, control mechanism and additional last cylinder will all remain the same. Therefore, we should expect very similar routing performance when comparing the new layout to the original Data Vortex cylindrical layout. On the other hand, the new same angle paths may affect the routing performance because nodes at different angles may carry slightly different traffic load and may result in different traffic distribution within the network. Packet injection at different angle should also be investigated with further details to make sure the planar layout can achieve the same routing performance as desired.

PERFORMANCE EVALUATION

A custom written C/C++ event simulator is used to evaluate the new layout Data Vortex architecture. The simulator allows for each I/O port to generate either random or bursty traffic, which are based on either a set load or parameters describe the burstiness of the traffic. The target address for each packet or each burst is independently generated, and it is assumed to be equally distributed among all possible heights. The simulator is an event simulator, where each of the routing nodes within the network will examine the incoming packet, and determine the correct output while update the traffic control bits. Due to the nature of control mechanism, inner cylinder nodes will start the routing event ahead of outer cylinder nodes in the simulation. Therefore, at the end of each clock run, all the arrival packets at specified node locations will be updated as well as the traffic control information. The routing for the following clock repeats the same process until the end of the simulation cycle. When a packet arrives at the innermost cylinder, i.e. its target height is reached; the packet simply exits the network and at the same time the latency statistics is updated based on all arrival packets so far. On the other hand, the network throughput statistics is updated at the injection ports which interface with the
outermost cylinder. If an active traffic is blocked due to control at the outermost cylinder, this information will update the throughput statistics. The simulation cycles are selected to be sufficiently long to reach a typical 99% accuracy. This is when compared with different random seeds and much longer simulation cycles.

For this study, same network size is chosen for two layouts while different traffic load and network redundancy to ensure the performance comparison at various operation conditions. We choose the network angle to be $A=5$ as in earlier studies. A less redundant condition with increased $A_n>1$ for the same given $A$ is also studied (Yang, 2001). The delay performance examines the average number of hops packets experience in the network over a long period of simulation time after a steady state is reached. The throughput performance is presented by the successful injection rate at the input ports over the same simulation period. Because it is a non-blocking network, the successful injection rate reflects the overall data capacity that the network can handle. A more congested or saturated network essentially deflects more traffic at outer levels and creates traffic backpressure up to the injection ports. We always choose the same angle parameter for comparison to the original network layout, so angular resolution is not included for this study.

First, we study the angular dependence of injection port in the new planar layout. Due to the symmetry of the layout, in a network of $A=5$, we only need to compare routing performance with injection occur at $a=0$ (end angle), $a=1$ and $a=2$ (middle angle) respectively. Figure 5(a) and 5(b) present the latency and throughput performance for $A=5$ and $H=128$ with one injection angle $A_n=1$ at the specified angle $a$. Table 1 presents the numerical results. The ratio of $A_n/A$ is chosen for the optimized throughput performance as suggested in previous study. As shown, we should avoid inject at the end angles where we loop the packets back in the opposite direction on the same angle because the injection rate and throughput performance is shown to be significantly lower. The performance difference between the two middle angles however is shown to be negligible. More case studies with multiple injection angles also show similar results, which indicates that edge angles should be generally avoided if possible. The middle angle or angles close to the middle are preferred to achieve the best overall performance in throughput and latency in the modified planar layout. In case the network operates in much less redundant condition such as injecting at all $A$ angles, then the edge angles have to be used as well.
Table 1: Latency (left) and throughput (right) performance comparison for injection at different angles

<table>
<thead>
<tr>
<th>Load \ Latency (hops)</th>
<th>Inject @a=0</th>
<th>Inject @a=1</th>
<th>Inject @a=2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.99</td>
<td>12.78</td>
<td>13.60</td>
<td>13.68</td>
</tr>
<tr>
<td>0.80</td>
<td>12.54</td>
<td>13.04</td>
<td>13.08</td>
</tr>
<tr>
<td>0.60</td>
<td>12.29</td>
<td>12.54</td>
<td>12.57</td>
</tr>
<tr>
<td>0.41</td>
<td>12.03</td>
<td>12.13</td>
<td>12.15</td>
</tr>
<tr>
<td>0.21</td>
<td>11.76</td>
<td>11.81</td>
<td>11.81</td>
</tr>
</tbody>
</table>

| Load \ Throughput (%) | | | |
|----------------------| | | |
| 0.99                 | 73.02 | 94.28 | 95.14 |
| 0.80                 | 78.38 | 96.77 | 97.28 |
| 0.60                 | 83.94 | 98.42 | 98.62 |
| 0.41                 | 89.40 | 99.39 | 99.44 |
| 0.21                 | 94.69 | 99.86 | 99.86 |

Next, we compare the planar layout performance with the original Data Vortex network as shown in Figure 6(a) and 6(b), respectively. To see the small difference, the numerical results are also included in Table 2 for the latency and throughput performances. Here, all planar layouts use middle angles for injection angles to avoid unnecessary performance degradation, while \( A_{in}=5 \) case all angles including edge angles will be used for injection. The planar layout results are marked by solid shapes while regular layout results use hollow shapes for all three redundant operations. As shown, the routing performances in all cases are very close between the two layouts. We also notice that for \( A_{in}=1 \), the regular network achieves a little better throughput, while the planar layout achieves slight benefit over regular network in less redundant network conditions, such as \( A_{in}=3 \) and \( A_{in}=5 \). However, overall, there is very small
difference between the two layouts as long as the injections are carried out through the middle angles. We have also examined the performance under various network sizes, and very similar behaviors are confirmed.

**Table 2: Latency and Throughput performance comparison between the modified layout and the original layout under various load and redundant conditions**

<table>
<thead>
<tr>
<th>load</th>
<th>Latency (hops)</th>
<th>Throughput (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ain=1</td>
<td>Regular</td>
<td>Modified</td>
</tr>
<tr>
<td>0.99</td>
<td>13.77</td>
<td>13.68</td>
</tr>
<tr>
<td>0.80</td>
<td>13.06</td>
<td>13.08</td>
</tr>
<tr>
<td>0.60</td>
<td>12.52</td>
<td>12.57</td>
</tr>
<tr>
<td>0.41</td>
<td>12.12</td>
<td>12.15</td>
</tr>
<tr>
<td>0.21</td>
<td>11.79</td>
<td>11.81</td>
</tr>
</tbody>
</table>

**Figure 6: (a) Delay performance comparison (b) Throughput comparison for two layouts for different Ain with Ain=5, H=128**

Since a small difference exists between the modified planar layout and the original network, various bursty traffic conditions are also investigated in this study. Such conditions often reflect the nature of the traffic for packet-based communication, and they provide worse operation conditions in comparison to random traffic of the same load level. Therefore, performance under such condition is important to understand the behavior of the network architecture. We use the same model of bursty traffic model.
where a set of parameters ($A_{on}$, $A_{off}$) determines statistically how long each consecutive ON slots and OFF slots and the ON slots packets also target to the same destination (Yang, 2002). In comparison for random traffic, each ON slot’s packet is independent of each other even if there are multiple ON slots under heavy load conditions. The bursty traffic condition tends to create hot spot and cause congestions more easily within a routing network; therefore, performance measure under such conditions could reflect effectiveness in routing network design. As an example, three bursty conditions are compared, with case A ($A_{on}$=1.05, $A_{off}$=2.5), case B ($A_{on}$=1.5, $A_{off}$=2.5) and case C ($A_{on}$=5.0, $A_{off}$=5.0) that create load levels of 0.82, 0.65 and 0.5 respectively. Figure 7 (a), (b) and (c) show the consecutive slot length distribution in these cases to illustrate different nature of burstiness. The consecutive ON slots’ packets are also targeted to the same destination address.

Figure 7: Consecutive slots distribution pattern in bursty traffic (a) case A, (b) case B, (c) case C

Source: by the author

Similar to studies in random traffic, we investigated routing performance and its dependence on injection angle. A same network size with $A$=5, $H$=128, and a single injection angle $A_{in}$=1 is used. It is found that routing performances are slightly worse at edge angle injections (inject at $a$=0) in comparison to middle angles (inject at $a$=2 or $a$=1) under bursty conditions. This is shown in Figure 8(a) and (b) respectively. The difference is very similar to results shown in Figure 5 for random traffic conditions. Therefore, avoiding injecting traffic at edge angles if possible would optimize the routing performance of the planar layout network.
Table 3: Latency and Throughput performance under bursty traffic and their dependence on angle of injection in the planar network

<table>
<thead>
<tr>
<th>(Aon, Aoff)</th>
<th>Load</th>
<th>Latency (hops)</th>
<th>inject @ a=0</th>
<th>inject @ a=1</th>
<th>inject @ a=2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1.05, 2.5)</td>
<td></td>
<td>0.814602</td>
<td>12.835263</td>
<td>13.602769</td>
<td>14.007814</td>
</tr>
<tr>
<td>(1.5, 2.5)</td>
<td></td>
<td>0.654814</td>
<td>12.45464</td>
<td>12.843616</td>
<td>12.862699</td>
</tr>
<tr>
<td>(5,5)</td>
<td></td>
<td>0.500156</td>
<td>12.137842</td>
<td>12.321784</td>
<td>12.353967</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Aon, Aoff)</th>
<th>Load</th>
<th>Throughput (%)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1.05, 2.5)</td>
<td></td>
<td>0.814602</td>
<td>77.736682</td>
<td>95.879602</td>
<td>97.637188</td>
</tr>
<tr>
<td>(1.5, 2.5)</td>
<td></td>
<td>0.654814</td>
<td>82.535475</td>
<td>97.899508</td>
<td>99.490833</td>
</tr>
<tr>
<td>(5,5)</td>
<td></td>
<td>0.500156</td>
<td>86.89118</td>
<td>99.097604</td>
<td>99.943465</td>
</tr>
</tbody>
</table>

Figure 8: Injection angle dependence under bursty traffic for (a) delay (b) throughput performance comparison

Source: by the author

Figure 9 (a) and (b) show the delay and throughput performance comparison for different network sizes. Same cases of bursty condition A, B and C are considered in this study. The throughput shows close overlap between different network sizes, and the planar network slight outperforms the regular network, but it is the bursty condition and load condition that mainly determines the network performance. The average delay also overlaps almost exactly between the planar network and the regular network for all network sizes under these bursty cases. Larger networks require longer average delay as expected, and more bursty and higher load traffic conditions require longer delay as expected. The numerical results are also included in Table 4 to show the similarity in the performance between the regular and planar networks under the same bursty traffic conditions.
Table 4: Latency and Throughput comparison for different network sizes under bursty traffic condition. Three cases of bursty conditions are considered.

<table>
<thead>
<tr>
<th>(Aon, Aoff)</th>
<th>H=64</th>
<th>H=128</th>
<th>H=256</th>
</tr>
</thead>
<tbody>
<tr>
<td>load</td>
<td>Latency (hops)</td>
<td>Throughput (%)</td>
<td>Latency (hops)</td>
</tr>
<tr>
<td>(1.05, 2.5)</td>
<td>0.815351</td>
<td>49.610096</td>
<td>0.654524</td>
</tr>
<tr>
<td>(1.5, 2.5)</td>
<td>14.827003</td>
<td>48.118949</td>
<td>61.916435</td>
</tr>
<tr>
<td>(5, 5)</td>
<td>14.774362</td>
<td>17.522039</td>
<td>60.15549</td>
</tr>
</tbody>
</table>

Figure 9: Network size dependence under bursty traffic for (a) delay (b) throughput performance comparison

Source: by the author

GLOBAL LAYOUT CONSIDERATION

The proposed layout design allows each cylinder level to stay on the same plane instead of a cylindrical structure, so it provides a flexible global network layout while maintaining the synchronization requirement. Consider the simplicity of routing path arrangement in physical systems, we presented two different approaches.
In the first approach, the physical layout follows the same pattern as the logical layout, so multiple parallel planes are used in the system implementation, as shown in Fig. 10. If I/O ports $(A_{in} \times H)$ that connects the first cylinder and the last cylinder need to be in the same physical location, which is often the case, then a loop-back arrangement in the middle cylinders can be designed as shown in Fig. 11. Whether the number of routing cylinders is even or odd, we can put these levels along with I/O plane in one of the parallel planes. This allows for very simple synchronization between stages, and all the routing paths between the cylinders are parallel links, and can be maintained uniform rather easily. The intra-cylinder paths are fabricated on the cylinder plane, and they follow a fixed routing pattern as designed. As network expands or scales to larger sizes, such as doubled, these modules can be stacked up along the height dimension in the same planar fashion. We recommend providing connector banks at the interfaces of each cylindrical plane because such arrangement allows for simple subsystem replacement in the case of failure of a particular plane or inter-cylinder routing paths. This also allows for easy modification in case path lengths or packet lengths are upgraded in future systems.
In the second approach, all routing nodes are laid on the same plane as shown in Fig. 12. The intra-cylinder paths are fabricated on the routing node plane as that in the first approach. To provide interconnection between the neighboring cylinders, we provide a sandwich structure between the plane of routing nodes and plane for input and output connector bank. This can be visualized in Fig. 13. These connectors allow for parallel routing path between the neighboring cylinders to go to the third dimension as shown in Fig. 13. Such modular design allows for easy scaling to larger network sizes as well as easy system maintenance if components or subsystems need to be replaced.
In addition to the scaling in the network height, it is also possible to expand the network along the angle dimension if extra redundancy in the network is desired. To make the existing modules useful for such expansion, sub-modules can be added in the following fashion so that network resources are evenly distributed and shared. As an example, Fig. 14 shows the alternate arrangement of expansion module and existing module in neighboring levels. Such arrangement allows the I/O ports from the expansion module to equally share the available routing resource at different levels.

**CONCLUSION**

To summarize, an alternative planar layout of the Data Vortex architecture was proposed to facilitate the three dimensional integration of the network nodes. This is accomplished by dividing routing paths along the cylinder to two different directions, while adding same
angle paths in the first and last angle to form similar routing loops. As a result, all nodes on the same routing level can be implemented on a plane, and overall architecture appears to be multiple planes interconnected. The optical paths and control links between routing levels along the same angle can further be put on a plane perpendicular to the routing level planes, and easily form a three dimensional structure that facilitates the modular design and synchronization of the overall network. The routing performance is specifically evaluated and in comparison to the original network performance under various network conditions and network sizes. Both random traffic and bursty traffic conditions are examined for such comparison study. The detailed analysis has shown that the new planar layout achieves very similar routing performance as that of original Data Vortex network, and, in general, edge angle should be avoided for packet injection for optimum routing performance. Overall network layout must consider simplicity, scalability and flexibility so that rearrangement can be accomplished in the case of maintenance and upgrade. The proposed solutions provide easy-to-implement systems, and they are ideal for large scale system integration.
REFERENCES LIST


Kash, J. (2008) “IntraChip Optical Networks for a Future Supercomputer-on-a-Chip”, IntraChic Optical Networks, URL:


Parallel Interference Cancellation in DS-OCDMA System Using Novel Multilevel Periodic Codes: Performance Analysis

Besma Hammami
Université de Tunis El Manar, Ecole Nationale d'Ingénieurs de Tunis, LR-99-ES21 Laboratoire des Systèmes de Communication, 1002, Tunis, Tunisie

Habib Fathallah
King Saud University of Riyadh, Saudi Arabia

Houria Rezig
Université de Tunis El Manar, Ecole Nationale d'Ingénieurs de Tunis, LR-99-ES21 Laboratoire des Systèmes de Communication, 1002, Tunis, Tunisie

Abstract

This paper aims to explore an introduction of the optimization of Bit Error Rate (BER) in parallel cancellation of multiple access interference (PIC) using a novel periodic optical encoder applied to fiber-to-the-X (FTTX) passive optical network (PONs) with a direct sequence optical code division multiple access (DS-OCDMA) system. The performance of our system is analysed in a synchronous network using multilevel periodic codes (ML-PC) and the results are compared with those for different receivers. We investigate the performances in terms of signal to noise ratio (SNR) and bit error rate (BER) in the presence of multiple access interference (MAI) and an additive white Gaussian noise (AWGN). Three groups of parameters were considered in this work: the number of users, the parameters related to the encoder and the parameters of the receiver.

Keywords: Fiber-to-the-X passive optical network (FTTX-PON), parallel interference cancellation (PIC), direct sequence optical code division multiple access (DS-OCDMA), multilevel periodic codes (ML-PC), signal to noise ratio (SNR), additive white Gaussian noise (AWGN), multiple access interference (MAI).

INTRODUCTION

Direct-sequence code division multiple access (DS-CDMA) (Goursaud et al., 2004a) is currently the subject of much research. It is a promising multiple access capability for third and fourth generations mobile communication systems.

In Direct Sequence transmission, the user data signal is multiplied by a code sequence. Mostly, binary sequences are used. To obtain better performance than those obtained by the detection single-user, multiuser detection has been investigated for links optical code division multiple access (OCDMA) (Zouine et al., 2004b) (Goursaud et al., 2004c).

Indeed, this type of detection, already used for the radio CDMA has proven its efficacy in reducing the impact of interference on performance (Moshavi, 1996, p. 124).
The advantage of the multiuser detection over single-user detection is the knowledge of codes of undesired users that evaluates more precisely the interference present in the received signal. Consequently, the data are better detected (Goursaud et al., 2004a).

**Figure 1: Direct Sequence OCDMA System**

![Diagram of Direct Sequence OCDMA System](image)

**Source:** by authors

In this paper, we present a parallel cancellation method (called PIC) developed for radiofrequency systems, applied to the direct sequence optical CDMA system, the spreading codes considered here are achieved with a new periodic coding scheme (Esmail et al., 2011, p.677), that has been previously proposed for fiber-to-the-X (FTTX) monitoring, and to the best of our knowledge never explored for data coding/decoding. The receiver studied here is constituted by a limiter optical device placed in front of a PIC structure.

Our study is done when the direction of data transmission is the uplink direction, from Optical Network Unit (ONU), to Optical Line Termination (OLT). Using the DS-OCDMA technique for the upstream, would provide necessary bit rate, dispensing of synchronization for this track (Hammami et al., 2012, p.21). The bit error rate (BER) performances were reported in the case of an optical synchronous incoherent DS-OCDMA system using multilevel periodic codes (ML-PC).

In this paper we compared the efficacy of the receptor PIC with the conventional correlation receiver (CCR), and then with their amelioration which is the parallel interference cancellation with an optical limiter (called HL+PIC), we deduce the superiority of HL+PIC structure not only in performance but also in regards to feasibility. In the work reported here, we focus our attention on the signal to noise ratio (SNR) and bit error rate (BER) performances of the DS-OCDMA system, whereas we studied the effect of the parameters of the receivers used and the size of the network, on the system performance when applied to the fiber-to-the-x passive optical network (FTTX-PON) architecture.

This paper is organized as follows: In the first section, we present the description of the DS-OCDMA system. We introduce in the second section, the principle of the conventional correlation and the parallel interference cancellation receivers and their improvement. In the third section we introduce the multilevel periodic codes and their properties. In the fourth section we evaluate the performance of the proposed system through the signal to noise ratio (SNR) and the bit error rate (BER), assuming additive white Gaussian noise (AWGN) channel.
SYSTEM MODEL

In a DS-OCDMA system, users transmit binary data equiprobable and independently in an optical fiber. Differentiation of users is done by multiplying the data by a code (Figure1). This code should be specific to each user, so that we can extract the data by comparing the received signal with the desired user code.

The codes studied in this paper are the multilevel periodic codes (ML-PC) (Esmail et al., 2011, p.677), which are determined by the length of the silent intervals separating the multilevel pulses, i.e., its period. The codes length of the \( i^{th} \) customers \( (l_i) \) is related by the silent period between the subpulses and is given as:

\[
l_{ci} = p_i w T_s c
\]

where \( c \) is the speed of light, \( p_i = l_i / c T_s \) is an integer number that determines the length of the \( i^{th} \) encoders ring \( l_i \), \( T_s \) is the transmitted pulse duration and \( w \) is the weight of the code \( (c_i) \).

In DS-OCDMA system the data of active users are spread by multiplication with the code sequence, and at the output of the encoder the \( k^{th} \) user signal is obtained as:

\[
e_k(t) = a_k b_k(t) c_k(t)
\]

\( a_k \) is the power level at the output of encoder and \( b_k \) is the data transmitted by the \( k^{th} \) user. In the case of multilevel periodic codes (ML-PC), the total power for any code with weight \( w \) (Esmail et al., 2011, p.677), is:

\[
P_t = \sum_{j=1}^w \rho_j
\]

\( \rho_j \) is the \( j^{th} \) subpulse power level generated by the encoder. The first subpulse power level \( \rho_1 \) is equal to \( \rho_1 = s^2 \). For \( j = 2, \ldots, w \) the level of \( \rho_j \) can be derived as:

\[
\rho_j = (1 - s)^2 s^{j-1} + (1 - s) \rho_{j-1}
\]

\( s \) is the power coupling ratio which determines the amount of power coupled to the ring encoder proposed in (Esmail et al., 2011, p.677). It was shown in (Esmail et al., 2011, p.677) that the interval of \( s \) between 0.5 and 0.6 gives good distribution for the power between the subpulses with cumulative power that depends on the weight \( w \). Finally, at the input of the receiver, the signal \( e(t) \) is the superposition of signals transmitted by the \( N \) users:

\[
e(t) = \sum_{k=1}^N e_k(t - \tau_k)
\]
Figure 2: Conventional Correlation Receiver for User 1

Figure 3: Schematic of the PIC Receiver

A) Principle of Conventional Correlation Receiver

The conventional correlation receiver (CCR) is the simplest receiver in a DS-OCDMA system, the principle of this receiver is the estimation of the power contained in the chips unit code, to compare thereafter to the decision threshold. It provides three functions:

- Multiplying the received signal by the code of the desired user. This step, equivalent to the realization of a mask between the received signal and the code sequence, can retain only the power present in the chip unit code,
- Integration of the signal obtained on the bit time: This step evaluates the total power present on the signal previously obtained during the interval of a bit time. This step provides the value of the decision variable.
- Decision making by comparison to a threshold: comparing the decision variable with the decision threshold used to obtain the estimated data.

Assuming that the user # 1 is the desired user, the decoding part of the DS-OCDMA system is performed by correlation (Figure 2).

B) Principle of Parallel Interference Cancellation Receiver

In a structure with parallel cancellation, all undesired users are detected at the same time using the conventional receiving systems. The parallel interference cancellation receiver has the principle of the reproduction interference from undesired users, to remove it from the total received signal (Figure 3). The PIC requires several steps:

- The detection of data sent by each undesired user is done by the conventional correlation receiver (CCR) with a detection threshold “$S_t$”, at the output of each receiver, we obtain the estimation $\hat{b}_i^{(k)}$ of the data sent by the undesired user # $k$,
- The second step is to reconstruct the signals transmitted by undesired users by multiplying the estimated data $\hat{b}_i^{(k)}$ by the corresponding code $c_k(t)$.
- In the third step, we obtain the interference term $r_i(t)$ which is actually the sum of the reconstructed signals, then it is subtracted from the received signal $r(t)$:

$$S(t) = r(t) - \eta_i(t)$$

where $\eta_i(t) = \sum_{k=2}^{N} \hat{b}_i^{(k)} c_k(t)$, then:

$$S(t) = r(t) - \sum_{k=2}^{N} \hat{b}_i^{(k)} c_k(t)$$

(6)
• The last step is the detection of the desired user data #1 from the signal "cleaned" from the interference $S(t)$. This detection is done through a CCR with a decision threshold $S_f$.

C) Amelioration

1) Principle of Hard Limiter (HL)

The ideal function of the component called "Hard Limiter" (HL) is defined by:

$$g(x) = \begin{cases} 
1 & x \geq 1 \\
0 & 0 \leq x < 1
\end{cases}$$  \hfill (7)

In practice, this component removes a part of the received power to get at the end a signal which each chip contains a power equal 0 or 1. For example, in Figure 4, we observe that the HL removed a part of the power contained in the first chip, and left unchanged the rest of the signal. Indeed, the power contained in the first chip of the received signal has a value of 2, while the one in the same chip after the action of HL is 1.

Thus, the HL has eliminated a part of the interference contained in the first chip. On the other side, the chips containing a power equal to 1 before the HL remain unchanged, and those for which the power was zero. As a result, levels 0 and 1 will be unchanged, and levels greater than 1 will be reduced to one. This limitation of the power in each chip reduces the interference, and removes some interference patterns leading to an error.

2) HL+PIC

To improve the performance of the PIC, the detection of undesired users can be achieved by a HL + CCR receiver. Thanks to the limiters placed before the receivers of the undesired users, the data are therefore better estimated so the contribution of these users in the received signal is better evaluated.

D) Impact of the AWGN on the Performance

We will study the impact of noise on the performance of a DS-OCDMA system using periodic codes by analyzing our receivers studied here in absence of noise and then in the presence of this imperfection.

1st case: In the synchronous case ($\tau_k = 0$) and ignoring the noise term, the only limitation for both structure either CCR or PIC, is the multiple access interference (MAI). In this case the received signal $r(t)$ is given by the following relationship:

$$r(t) = e(t) = \sum_{k=1}^{N} a_k b_k(t) c_k(t)$$  \hfill (8)

$r(t)$ is the received signal, $e(t)$ is the transmitted signal, $b_k(t)$ is the data transmitted by user #k and $c_k(t)$ is the code related to the user #k.

Mathematically, the successive operations of the CCR receivers translate into the following expressions:


- multiplying the received signal by the code of the desired user gives $r_{\text{corr}}$ which is the correlated signal:

$$r_{\text{corr}}(t) = \left( \sum_{k=1}^{N} a_k b_k(t).c_k(t) \right).c_1(t)$$

$$r_{\text{corr}}(t) = b_1(t).c_1(t) + \sum_{k=2}^{N} a_k b_k(t).c_k(t).c_1(t)$$  \hspace{1cm} (9)

- the integration of the obtained signal provides the decision variable $Z_i^{(1)}$ of the $i^{th}$ data of user #1 is written as follows:

$$Z_i^{(1)} = \int_{0}^{T_b} b_i^{(1)} . c_1 dt + \sum_{k=2}^{N} b_i^{(k)} \int_{0}^{T_b} a_k c_k(t) . c_1(t) dt$$  \hspace{1cm} (10)

$b_i^{(1)}$ is the $i^{th}$ data of user #1.

- decision making by comparison with a threshold $S$ respected the decoding rule follows:

$$\begin{cases} 
\text{si} & Z_i^{(1)} \geq S \rightarrow \hat{b}_i^{(1)} = 1 \\
\text{si} & Z_i^{(1)} < S \rightarrow \hat{b}_i^{(1)} = 0 
\end{cases}$$  \hspace{1cm} (11)

2\textsuperscript{nd case: In this case, we} consider that the noises can be assimilated to an additive Gaussian noise. We consider a DS-OCDMA system in the presence of additive white Gaussian noise (AWGN) with variance $\sigma_p^2$. In this case the received signal at the input of the receiver is the sum of contributions of all users (MAI) and noise (AWGN):

$$r(t) = e(t) + b(t) = \sum_{k=1}^{N} a_k b_k(t)c_k(t) + b(t)$$  \hspace{1cm} (12)

Considering that the desired user is the user # 1, we deduce the decision variable:

$$Z_i^{(1)} = \sum_{k=1}^{N} b_i^{(k)} \int_{0}^{T_b} a_k c_k(t) . c_1(t) dt + \int_{0}^{T_b} b(t). c_1(t)$$  \hspace{1cm} (13)

For the decision making we will follow the same rule as in Equation (11).
ML-PC CODE PROPERTIES

The values of auto and cross-correlation of the codes are key parameters for system performance in the presence of multiple users. To calculate this parameters we consider a truncated version of an ML-PC codes as shown in Figure 5(a) (dark bars) with a weight \( w = 4 \).
For comparison with the ML-PC code (dark bars) we also consider a flat periodic code with weight $w=4$ (gray bars). Figure 5(b) shows the autocorrelation function for code having a period $p_1=7$ for both ML-PC and flat periodic codes. In order to simplify, we always normalize the autocorrelation main peak to one. In this case we observe a main lobe of one for flat and ML-PC codes. We can also note that similar to the well-known prime codes, high out-of-phase sidelobes appear with maximum equal to $(w-1)$ pulses (Fathallah et al., 2008, p.1). For flat periodic codes $\frac{(w-1)}{w} = \frac{3}{4} = 0.75$, however, for ML-PC this is 0.61 (the sum of its highest three pulses). High autocorrelation sidelobes are not problematic as pulses are separated by more than sidelobe duration (Fathallah et al., 2008, p.1). The cross-correlation function is illustrated in Figure 5(c) considering codes with periods $p_1 = 7$ and $p_2 = 15$. We obtain unitary cross-correlation for flat codes which is $\frac{1}{w} = \frac{1}{4} = 0.25$, and 0.48 for ML-PC codes.

PERFORMANCE EVALUATION

A) Signal to Noise Ratio (SNR)

We consider the signal to noise ratio of the spread signal received at the input of CCR. Thus, with an additive noise $n$ normally distributed with zero mean and variance equal $\sigma^2$, and a total power for any code $P_t$ (in the case of multilevel periodic codes, ML-PC), the SNR is:

$$SNR = 10 \log_{10} \left( \frac{P_t}{\sigma^2} \right)$$

(14)

And with a power normalized to 1 (in the case of flat periodic codes, flat-PC) the SNR becomes:

$$SNR = 10 \log_{10} \left( \frac{1}{\sigma^2} \right)$$

(15)

We will present in this section the algorithm used in our simulation and we will analyze the results.

B) Numerical Simulation

At the transmitter of the DS-OCDMA channel, we begin by the generation of periodic codes and then the random generation of bits sent by each user and random selection of $N$ active users among users of the family, afterwards the step of the spreading is done by multiplying the data of the desired user by the corresponding code, subsequently the spreading of data of the undesired users and adding their contribution to the signal of the desired user. Finally, we sum the encoded data and transmit it over a channel assumed to be ideal.

At the receiver, we consider both scenarios: interference only and interference plus AWGN, and we will follow the different stages of the parallel interference cancellation structure described in Section II, and to analyze the performance of this structure multi-user, we will compare it with another receiver such as, the conventional correlation receiver (CCR), and the CCR improved by adding an optical limiter (known as Hard Limiter), and then the improved of PIC (HL+PIC).
C) Analysis of Results

The simulation has been carried out in MATLAB to evaluate the BER performance for the parallel interference cancellation (PIC) and compared it with other receivers (CCR, HL+CCR, HL+PIC).

Figure 6: BER versus Decision Threshold of the desired users $S_f$ using ML-PC, $N=6$ Users

Figure 7: BER versus Decision Threshold of the undesired users $S_t$ using ML-PC, $N=6$ Users

Figure 8: BER versus decision threshold for different SNR using CCR receiver, $N=6$ Users

Figure 9: BER versus decision threshold for different SNR using PIC receiver, $N=6$ User
So we must first determine the optimal thresholds ($S_t$: optimal threshold of the undesired user, $S_f$: optimal threshold of the desired users) of the PIC receiver.

In Figure 6, we plotted the evolution of the BER of the PIC receivers with ML-PC codes with period $p_i$, weight $w=5$, $s=0.4$ and $N=6$ users. This performance was evaluated as a function of the $S_t$ and varying $S_f$ between 0.12 and 0.2. From this presentation, we can observe that the best performance is obtained for a decision threshold $S_f = 0.1$ whatever the value of $S_t$.

Now, we will fix the value of $S_f$ at 0.1 and we will present in Figure 7, the variation of BER as a function of $S_t$ with the same ML-PC code and $N=6$ users. So we can look that the best performance is achieved when $S_t = 0.2$.

We can conclude that the two optimal thresholds are:

- The optimal threshold of the undesired user: $S_t=0.2$,
- The optimal threshold of the desired users: $S_f=0.1$,

As usual, we will also identify also the optimal threshold by plotting the evolution of the BER of the CCR receiver in the presence of noise as a function of decision threshold for ML-PC codes with period $p_i$, weight $w=5$, $s=0.5$ and $N = 6$ (Figure 8), using Equation (14). We can also see that the optimal threshold $S_{opt}$ is the same whatever the value of SNR, we can define the optimal threshold as follows:

$$S_{opt} = P_t \cdot w = w \cdot \sum_{j=1}^{w} (1-s)^2 s^{i-1} + (1-s) \rho_{j-1}$$

As in our case, we have $s=0.5$, then $P_t = 0.0238$

Here: $S_{opt} = 0.0238 \times 5 = 0.119$ approximately

$$S_{opt} = 0.12$$

(as shown in Figure 8).
We worked with the different values of the optimal threshold estimated in the previous figures, and we plotted the variation of the BER as a function of the network size $N$ (Figure 10), with the same ML-PC code. First, we can see that the performance of the four receivers degrade when the number of users increases, but does not exceed $2 \times 10^{-2}$ and that thanks to the use of periodic codes.

Furthermore, we observe that for a given code, the PIC allows a number of active users more important than the CCR or HL+CCR. Indeed, for a ML-PC code (with period $p_i$, $w = 5$ and $s = 0.4$) and $BER = 5.5 \times 10^{-2}$, the PIC allows 64 simultaneous users to communicate, while the CCR and HL+CCR allow only 20 users at most, to be active on the network.

By comparing the four receivers, one can conclude that the best performances are obtained when we work with a HL+PIC receiver and here the BER can achieve $3.125 \times 10^{-5}$ for $N = 6$ users.

In Figure 11, we plotted the variation of the BER as a function of the network size to identify the impact of the additive white Gaussian noise on the performance of the DS-OCDMA system using ML-PC code when the structure of the multi-user detection is the parallel interference cancellation receiver. So we can observe that the impact of AWGN on the performance of system is more clearly in this figure, i.e. the performance degrades when integrating the AWGN and especially in the case of CCR receiver.

It should be noted that although we worked with encoders with low cost manufacturing, installation and operation, we can maintain good performance and a significant in terms of number of users. Then with this type of codes (ML periodic code) we can achieve a BER = $3.125 \times 10^{-5}$.

**CONCLUSION**

In this paper, we investigated the multi-users detection with the parallel interference cancellation (PIC) structure by comparing it with their amelioration constituted by a limiter optical device placed in front of a PIC structure (HL+PIC) and other receivers (like the Conventional Correlation Receiver and HL+CCR), using a novel coding scheme so called multilevel periodic coding (ML-PC) for the direct sequence optical code division multiple access system. We studied the characteristics of these codes and investigated their performance in bit error rate and additive white Gaussian noise. We derived the values for different values of optimum threshold that minimizes the bit error rate when we use the PIC receiver and also the CCR receivers. We can also investigated that the best performance was obtained when the SNR = 25 dB in the case of the CCR receiver and is equal to 30 dB in the case of PIC structure. In our system, we can achieve almost a BER = $3.125 \times 10^{-5}$ for $N = 6$ users in the ideal case and close to $10^{-3}$ for 10 users in the presence of noise.
Reference List


Categorization of User Behavior using Scoring

Komalavalli.B
M.A.M College of Engineering, Trichy, India

Abstract

This paper aims to explore Comparing the Relevancy between the search engines using intended scoring. Search engine is designed to search for information on the World Wide Web. The problem with search relevance ranking is to estimate relevance of a query. Ranking is essential for any information retrieval system. The rapid growth of web base led to the research in search engine optimization. Ranking is an integral component of any information retrieval system. The top results returned by the search engine reflects the quality of the search engine. The existing practice for ranking is by comparison based methodology. In this paper, a score comparison method is used for finding the relevance. Kendall distance methodology is used to rank the webpage’s relevance. A top k version of the score comparison methodology is also provided for comparing the top result of the web page. The proposed system converges the results helpful for determining the number of iterations necessary to achieve a useful Page Rank assignment. The stopping criteria for rank comparison are to be identified. Fusion is to be done from specific distribution. The maximum and minimum value for Kendall distance and the method for speeding up the computation are to be identified.

Keywords: Score comparison, rank comparison, NDCG, Kendall distance, top k lists, Latent Semantic Index

INTRODUCTION

Measuring effectiveness of information retrieval (IR) systems is essential for research and development and for monitoring search quality in dynamic environments. We hypothesize that the selection of systems that would return documents different from the majority could eliminate the ordinary systems from data fusion and provide better discrimination among the documents and systems. However, due to the size and dynamic nature of document collections and users, evaluating or comparing the retrieval performance of search engines in regular intervals is difficult (Neelam & Simple, 2012: 2012: 443). Another difficulty in creating relevance judgments is that people usually disagree about the relevance judgments. The problem of rank fusion is the problem of computing a “consensus” Ranking, given individual Ranking preferences (a Ranking is a linear ordering of a set of items) of several judges (Maksims et. Al., 2012). The Ranking fusion problem is encountered in many situations and a prominent one is meta search: it deals with the problem of combining the result lists returned by multiple search engines in response to a given query, where each item in a result list is ordered with respect to a search engine and a relevance score.

While search engines certainly help users in locating information relevant to the user’s information need, they still have a number of deficiencies: (i) indexing Web data is a time
and space consuming task. As the content of the web changes rapidly, each search engine has to set up a tradeoff between the coverage, that is, the number of Web documents indexed with respect to the whole Web and the update frequency, that is, the time that occurs between the subsequent re-indexing of the complete database (Venkat et al., 1997: 62)

However large the indexes are, still a search engine (re) indexes only a small subset of all available documents on the WWW; (ii) many information sources, for example proprietary information sources like the Digital Libraries of Editors are not indexible as they do not admit the gathering of their document (Sherman, 2003: 289). These are essentially databases that cannot be indexed by search engines. The only way to search for information within these Digital Libraries is to rely on the search services provided by them; (iii) for some search engines the more advertisers pay, the higher they will rank in the search results, called pay-for-placement, with a consequently average loss in precision; (iv) search engines are subject to spamming(R. Fagin, R. Kumar, and D. Sivakumar, 2003, p. 147), that is, a search engine has been spammed by a page in its index, on a given query, if it ranks the page “too highly”.

Several Ranking fusion methods have been proposed in the literature (Nuray & Can, 2006: 602). A major distinction between the methods is that they can be classified based on whether: (i) they rely on the rank; (ii) they rely on the score; and (iii) they require training data or not. Preliminary experimental results seem to indicate that score based methods outperform rank based methods, while methods based on training data perform better than those without training data.

Searching is a major activity on the Web, and the major search engines are the most frequently used tools for accessing information. Because of the vast amounts of information, the number of results for most queries is usually in the thousands, sometimes even in the millions. On the other hand, user studies have shown that users browse through the first few results only.

A top 10 list, for example, is typically associated with the “first page” of results from a search engine. While there are several standard ways for measuring the “top k quality” of an information-retrieval system (Bar-Ilan, Mat-Hassan & Levene, 2006:1454) (For Example precision and recall at various values of k), it shows that there is no well-known and well defined method for comparing two top k lists for similarity or dissimilarity of web pages from two different search engine. Methods based on precision and recall yield a way to compare two top k lists by comparing them both to “ground truth.” However, there are two limitations of such approaches: first, these methods typically give absolute (unary) ratings of top k lists, rather than give a relative, binary measure of distance. Second, for IR in the context of the world-wide web, there is often no clear notion of what ground truth is, so precision and recall are harder to use.

LITERATURE REVIEW

Automatic Ranking of Information Retrieval Systems using Data Fusion

Automatic ranking deals about measuring effectiveness of information retrieval (IR) systems are essential for research and development and for monitoring search quality in dynamic environments. In this system, a new methods for automatic ranking of retrieval
systems is employed. In this method, merging of the retrieved results of multiple systems using various data fusion algorithms occurs, use the top-ranked documents in the merged result as the “(pseudo) relevant documents,” and employ these documents to evaluate and rank the system (Crestani, 2003: 90). Experiments using Text Retrieval Conference (TREC) data provide statistically significant strong correlations with human-based assessments of the same systems.

The system hypothesizes that the selection of systems that would return documents different from the majority could eliminate the ordinary systems from data fusion and provide better discrimination among the documents and systems. This could improve the effectiveness of automatic ranking. Based on this intuition, a new method for the selection of systems to be used for data fusion is introduced.

For this purpose, the bias concept that measures the deviation of a system from the norm or majority and employ the systems with higher bias in the data fusion process is used. This approach provides even higher correlations with the human based results. Assessing IR effectiveness normally requires a test collection, a set of queries, and relevance information about each document with respect to each query. Text REtrieval Conference (TREC) uses the pooling approach to overcome such difficulties. Pooling is the selection of a fraction of documents with high similarity to the query for assessment, assuming that the pooled documents are a representative sample of the relevant portion of the whole collection. Zobel examined the effect of pooling on the effectiveness assessment in very large databases and showed its reliability. To reduce the manual effort involved in pooling, Cormack, Lhotak, and Palmer proposed an algorithm that compared them with the TREC pooling method. They found that it is possible to build an effective pool with fewer human judgments.

In this system, the application of three different data fusion methods (Rank Position, Borda Count, and Condorcet—defined later) in ranking retrieval systems in terms of their effectiveness without using human relevance judgments is presented and assessed. Combining different rankings using data fusion, or selecting documents based on multiple criteria is also referred to as rank aggregation. In IR, data fusion merges the retrieval results of multiple systems and aims at achieving a performance better than all systems involved in the process.

Data fusion in automatic evaluation determines the (pseudo) relevant documents for evaluating the relative performance of a set of retrieval systems. For this purpose, the retrieval results of the systems to be ranked are merged following various techniques and the top-ranked documents in the merged result are considered as “PSEUDO RELevantdocuments” (Pseudorels) and used to evaluate the relative effectiveness of retrieval systems.

In this system, a novel method for the selection of the retrieval systems to be used in data fusion is also introduced. This method is based on the bias concept. The experiments show that the use of bias in the selection of systems to be used in determining the Pseudorels improves the effectiveness of automatic ranking. In the experiments, four TREC collections (TREC-3, -5, -6, and -7) is used. The correlations between actual methods and the actual TREC rankings are strong and statistically significant in all of the variations of our methods. Also, the effectiveness of actual methods with the results of Soboroff et al. and Wu and Crestani is compared, and show that it outperform their best cases.
In the system, a new method for automatic ranking of retrieval systems without relevance judgments using three different data fusion techniques, is proposed, the Rank Position, Borda count, and Condorcet methods. It compares the effectiveness of these three methods in automatic ranking. It considers the effectiveness of ranking by using all of the systems for determining Pseudorels and by using some of the systems that behave differently from the norm. The norm and being different from the norm are defined by using the bias concept.

**Web Metasearch: Rank vs. Score Based Rank Aggregation Methods**

Given a set of rankings, the task of ranking fusion is the problem of combining these lists in such a way to optimize the performance of the combination. The ranking fusion problem is encountered in many situations and, For Example, meta search is a prominent one. It deals with the problem of combining the result lists returned by multiple search engines in response to a given query, where each item in a result list is ordered with respect to a search engine and a relevance score (Nuray & Can, 2006: 606). Several ranking fusion methods have been proposed in the literature. They can be classified based on whether:

(i) they rely on the rank;
(ii) they rely on the score; and
(iii) they require training data or not.

The system will make the following contributions:

(i) It will report experimental results for the Markov chain rank based methods, for which no large experimental tests have yet been made;
(ii) While it is believed that the rank based method, named Borda Count, is competitive with score based methods, it will show that this is not true for meta search; and
(iii) It will show that Markov chain based methods compete with score based methods.

This is especially important in the context of meta search as scores are usually not available from the search engines. The problem of rank fusion is the problem of computing a "consensus" ranking, given individual ranking preferences (a ranking is a linear ordering of a set of items) of several judges (Bar-Ilan, Mat-Hassan, & Levene, 2006: 1458). The ranking fusion problem is encountered in many situations and a prominent one is meta search: it deals with the problem of combining the result lists returned by multiple search engines in response to a given query, where each item in a result list is ordered with respect to (with respect to) a search engine and a relevance score. While search engines certainly help users in locating information relevant to the user's information need, they still have a number of deficiencies:

i. Indexing web data is a time and space consuming task. As the content of the Web changes rapidly, each search engine has to set up a tradeoff between the coverage, i.e., the number of Web documents indexed with respect to the whole Web and the update frequency, i.e., the time that occurs between the subsequent re-indexing of the complete database. However large the indexes
are, still a search engine (re) indexes only a small subset of all available documents on the WWW;

ii. Many information sources, For Example, proprietary information sources like the Digital Libraries of Editors1, are not indexible as they do not admit the gathering of their documents. These are essentially databases that cannot be indexed by search engines. The only way to search for information within these Digital Libraries is to rely on the search services provided by them;

iii. For some search engines2, the more advertisers pay, the higher they will rank in the search results, called pay-for-placement, with a consequently average loss in precision;

iv. Search engines are subject to spamming, i.e., a search engine has been spammed by a page in its index, on a given query, if it ranks the page “too highly”.

Limitations, as such listed above, have led to the introduction of meta search engines3 with the aim of both alleviating user’s work and to improve the retrieval effectiveness. The ideal scenario for ranking fusion is when each judge (search engine) gives a complete ordering of all the alternative items in the universe of alternatives. Unfortunately, in meta search this is far too unrealistic for two reasons:

i. the coverage of search engines is different; and

ii. search engines limit access to the top 100 or 1000 ranked items of their ordering.

There were some directions for future research, which are currently investigating;

(i) To verify whether Markov chain based methods perform well also in other context(M. Montague and J.A. Aslam, 2001, p. 429). For Example, testing them also with respect to other TREC results;

(ii) To investigate the performance of the methods when training data is available.

Rank Aggregation Methods for the Web

The problem of combining ranking results from various sources is considered. In the context of the Web, the main applications include building meta-search engines, combining ranking functions, selecting documents based on multiple criteria, and improving search precision through word associations (Renda & Straccia, 2003: 843). A set of techniques for the rank aggregation problem and compare their performance to that of well-known methods is developed. A primary goal of the work is to design rank aggregation techniques that can effectively combat/spam, a serious problem in Web searches. Experiments show that the methods are simple, efficient, and effective.

The task of ranking a list of several alternatives based on one or more criteria is encountered in many situations. One of the underlying goals of this endeavor is to identify the best alternatives, either to simply declare them to be the best (For Example, in sports) or to employ them for some purpose. When there is just a single criterion (or “judge”) for ranking, the task is relatively easy, and is simply a reaction of the judge's opinions and biases. (If simplicity were the only desideratum, dictatorship would prevail over democracy.)
In contrast, this system addresses the problem of computing a “consensus” ranking of the alternatives, given the individual ranking preferences of several judges. It calls for the rank aggregation problem. Specifically, the rank aggregation problem in the context of the Web, where it is complicated by a plethora of issues is studied. The method begins by underscoring the importance of rank aggregation for Web applications and clarifying the various characteristics of this problem in the context of the Web.

The theoretical underpinnings for stating criteria for “good” rank aggregation techniques and evaluating specific proposals is provided, and novel algorithmic solutions are offered. The experiments provide initial evidence for the success of our methods, which will significantly improve a variety of search applications on the Web. A mathematical setting in which to study the rank aggregation problem, and propose several algorithms is provided. By drawing on the literature from social choice theory, statistics, and combinatorial optimization, the system formulates precisely what it means to compute a good consensus ordering of the alternatives, given several (partial) rankings of the alternatives.

Specifically, the method of Kemeny, originally proposed in the context of social choice theory, as an especially desirable approach, is identified, since it minimizes the total disagreement (formalized below) between the several input rankings and their aggregation. Unfortunately, the system shows that computing optimal solutions based on Kemeny’s approach is NP-hard, even when the number of rankings to be aggregated is only 4. Therefore, several heuristic algorithms are needed for rank aggregation and evaluate them in the context of Web applications.

Besides the heuristics, a crucial property of Kemeny optimal solutions that is particularly useful in combatting spam, and provide an efficient algorithm for minimally modifying any initial aggregation so as to enjoy this property is identified. This property is called the “extended Condorcet criterion,” and it call the efficient process that is guaranteed to achieve it “local Kemenization.” The algorithms for initial aggregation are based on two broad principles. The first principle is to achieve optimality not with respect to the Kemeny guidelines, but with respect to a different, closely related, measure, for which it is possible to fund an efficient solution.

The second principle is through the use of Markov chains as a means of combining partial comparison information derived from the individual ranking into a total ordering. While there is no guarantee on the quality of the output, the latter methods are extremely efficient, and usually match or outperform the first method (Lee, 1995: 270). Experiments and quantitative measures of quality for the meta-search problem, and give several illustrations of our methods applied for the problems of spam resistance and word association queries is reported.

The theoretical groundwork for describing and evaluating rank aggregation methods is developed. Several rank aggregation techniques is proposed and tested. These methods have the advantage of being applicable in a variety of contexts and try to use as much information as available. The methods are also simple to implement, do not have any computational overhead, and out-perform popular classical methods like Borda’s method. The value of the extended Condorcet criterion in the context of meta-search, and have described a simple process, local Kemenization, for ensuring satisfaction of this criterion is established. Further work involves trying to obtain a qualitative understanding of why the Markov chain methods perform very well. Also, interestingness
to measure the efficacy of the methods on a document base with several competing ranking functions.

**RESEARCH OBJECTIVES**

The ideal scenario for rank aggregation is when each judge (search engine in the case of meta-search, individual criterion for multi-criteria selection, and subsets of queries in the case of word association queries) gives a complete ordering of all the alternatives in the universe of alternatives. This, however, is far too unrealistic for two main reasons. The first reason is a particularly acute problem in doing meta-search: the coverage of various search engines is different; it is unlikely that all search engines will (eventually) be capable of ranking the entire collection of pages on the Web, which is growing at a very high rate. Secondly, search engines routinely limit access to about the first few hundreds of pages in their rank-ordering. This is done both to ensure the confidentiality of their Ranking algorithm, and in the interest of efficiency.

The issue of efficiency is also a serious bottleneck in performing rank aggregation for multi-criteria selection and word association queries. Therefore, any method for rank aggregation for Web applications must be capable of dealing with the fact that only the top few hundred entries of each Ranking are available. Of course, if there is absolutely no overlap among these entries, there isn't much any algorithm can do; the challenge is to design rank aggregation algorithms that work when there is limited but non-trivial overlap among the top few hundreds or thousands of entries in each Ranking (Jayanthi & Jayakumar, 2011: 2). Finally, in light of the amount of data, it is implicit that any rank aggregation method has to be computationally efficient.

**Background on Rank Comparison**

A link analysis ranking algorithm starts with a set of Web pages. Depending on how this set of pages is obtained, we distinguish between query independent algorithms, and query dependent algorithms. In the former case, the algorithm ranks the whole Web. The PAGE RANK algorithm by Brin and Page (Borodin, Roberts, Rosenthal & Tsaparas, 2005: 273) was proposed as a query independent algorithm that produces a Page Rank value for all Web pages. In the latter case, the algorithm ranks a subset of Web pages that is associated with the query at hand (Page, 1998).

Kleinberg (1999: 625) describes how to obtain such a query dependent subset. Using a text-based Web search engine, a Root Set is retrieved consisting of a short list of Web pages relevant to a given query. Then, the Root Set is augmented by pages which point to pages in the Root Set, and also pages which are pointed to by pages in the Root Set, to obtain a larger Base Set of Web pages. This is the query dependent subset of Web pages on which the algorithm operates (Satokar & Gawali, 2010: 31).

Comparison of rankings is a fairly well-studied problem, and we mention the most popular rank comparison methods here. Comparing two different rankings has been studied in various fields. In each case, a measure has been provided that takes into account how much the positions of each item differ in the two ordered lists. The measure is zero when the two rankings are exactly the same, whereas it is maximum when the rankings are completely opposite to each other. Some very useful and widely used
measures for comparing two rankings are Spearman’s foot rule, Spearman’s rank correlation, and Kendall tau.

Kendall (Tau) distance, Kemeny distance, or bubble sort distance between \( R_1 \) and \( R_2 \) when interpreted as the number of pair wise adjacent transpositions needed to transform from one ranked list to the other. More recently, Bar-Iran Mat-Hassan, and Levene(2006) proposed that differences in ranking in the initial part of the lists should be given more weight than those toward the end of the lists.

**Background on Fusion**

Fusion is the process of combining multiple sets of ranks or scores available for the given items. Rank fusion also known as rank aggregation obtains a consensus ranking from the available ranked lists. These lists need not be full lists, making rank fusion a very challenging problem (Kumar & Shekhar, 2011: 745). Score fusion, on the other hand, combines the scores directly, in order to produce a consensus score vector, on which the final ranking may be based upon. Such fusion may be performed by taking an average of the scores assigned to an item.

Two of the standard score fusion techniques are Comb SUM (a simple average) and Comb MNZ(a weighted average) (Renda & Straccia, 2003). Several studies have compared the effectiveness of rank and score fusion. Scores contain more information than ranks but may be prone to noise. It is suggested in that only the induced ranks should be considered for fusion, whereas it is found that score fusion is advantageous, provided that normalization is performed properly. A detailed discussion on ranks versus scores is available.

**RESEARCH METHODOLOGY**

**Comparing Scores Directly**

The objective in the present investigation is to discern between two scoring functions directly without performing the additional task of computing the induced ranks. Taking an Example, we propose the concept of a degree of discordance for a pair of items, which subsumes the usual definition of discordance as a special case. The dissimilarity of two scoring functions with respect to a pair. It may be inferred from the differences in the separation of \( i \) and \( j \) by the scoring functions. Thus, a measure of dissimilarity between \( S_1 \) and \( S_2 \) may be based on the separations

**Comparing Top K Scores**

A top \( k \) list is the set of items with the largest scores. Top \( k \) lists differ from full lists because two lists need not have the same set of items. To compute the degree of discordance of a pair \( f_i \), We extend our procedure to comparing the top \( k \) scores of two scoring functions by mimicking compared the top \( k \) lists obtained by two different rankings. When dealing with items that appear in only one list, the definitions of ranks and discordance are appropriately modified, resulting in, among many others, a Kendall distance for top \( k \) lists.
Comparing Top k Lists

For generalizing the definition of discordance to the case of top k lists. We reproduce the text from and, simultaneously, make a note of how the same extension for computing the degree of discordance would differ in each case. The generalized discordance between i and j, with respect to two lists. Here, there is no confusion regarding what the discordance should be as it is clear that i is ahead of j. However, the degree of discordance needs the information regarding the separation between i and j.

Limitation

Rank comparison of two identical search engine is to done by comparing the intended scores. The stopping criteria for converging the comparison is to be identified. The fusion is to be done from specific distribution for both the search engine. The maximum and minimum values for kendall distance is to be calculated. Methodology for speeding up the iteration is to be identified.

CONCLUSIONS AND FUTURE WORK

Comparing Scores Directly

The objective in the present investigation is to discern between two scoring functions directly without performing the additional task of computing the induced ranks. Taking an Example, we propose the concept of a degree of discordance for a pair of items, which subsumes the usual definition of discordance as a special case. The dissimilarity of two scoring functions with respect to a pair. It may be inferred from the differences in the separation of i and j by the scoring functions. Thus, a measure of dissimilarity between S1 and S2 may be based on the separations.

Comparing Top K Scores

A top k list is the set of items with the largest scores. Top k lists differ from full lists because two lists need not have the same set of items. To compute the degree of discordance of a pair fi, We extend our procedure to comparing the top k scores of two scoring functions by mimicking compared the top k lists obtained by two different rankings. When dealing with items that appear in only one list, the definitions of ranks and discordance are appropriately modified, resulting in, among many others, a Kendall distance for top k lists.

Comparing Top k Lists

For generalizing the definition of discordance to the case of top k lists. We reproduce the text from and, simultaneously, make a note of how the same extension for computing the degree of discordance would differ in each case. The generalized discordance between i and j, with respect to two lists. Here, there is no confusion regarding what the discordance should be as it is clear that i is ahead of j. However, the degree of discordance needs the information regarding the separation between i and j.
Limitation

Rank comparison of two identical search engine is to done by comparing the intended scores. The stopping criteria for converging the comparison is to be identified. The fusion is to be done from specific distribution for both the search engine. The maximum and minimum values for Kendall distance is to be calculated. Methodology for speeding up the iteration is to be identified.
Reference List


BOOK REVIEW

Letting Go of Your Bananas
How to Become More Successful by Getting Rid of Everything Rotten in Your Life

Ng Choon Lai
TMC Academy, Singapore


This is a motivational book by a businessman turned motivational expert, Dr Drubin D.T, who shows you how to use his 12 keys to dump unhealthy habits, relationships , jobs and beliefs that are standing between you and your success. Learn how to take advantages of opportunities at your doorstep, make your fears work for you, increase your resourcefulness and be more responsible as you stay happy, purposeful, passionate, and persuasive.

Each of the keys represents an important area and Dr Drubin wants his readers to know and follow to achieve their goals. The structure of the contents is very systematic and easy to follow. Some of the keys are related to each other to a certain extent. At the end of each key, there is a special to-do list titled “What you can do” that gives readers an opportunity to apply and practice the learning.

Introductory pages -“Everyone Has a Story.” Dr Drubin clearly explained the meaning of bananas that existed in our life. He advocated us to get rid of the rotten banana and keep the positive one. The rotten banana represented an area in our life where we are limited, settling or just plain stuck. He cited his own story to let the readers know how he came to this world and the mission set for him. He explained a lot of reasons why you must read his book in order to understand the 12 keys he has come up with. He used numerous arguments to convince readers to read his book further after the introduction.

Key #1- “Letting Go of Your Bananas.” In this key, Dr Drubin discussed and explained why we should get rid of bad bananas that existed in our lives. He cited the method used in Africa to catch monkeys and the greatest base stealer, Rickey Henderson, to show the consequences of not letting go of your bad bananas and letting go of it respectively. He assumed that people are not willing to let go of things, people, habits, and beliefs that keep them where they are instead of where they want to be because of upholding the status quo, not taking control of your own destiny, no courage and confidence in facing the changes, not taking responsibilities for one’s life and not knowing the truth about yourself. But, in reality, there are many factors that disallow you to do just whatever things and also there are a lot of pros and cons for not doing the things you wanted to. He encouraged us to seek all opportunities available to get rid of rotten bananas, embrace changes and live a better life. He also recognised that not all
the rotten bananas could be easily gotten rid of especially big and stinky ones which required professional help.

**Key #2 - “The Dash of Life.”** Dr Drubin defined what he meant by the dash of life especially the dash that he referred to as the hyphen between the date of birth and date of death. He said “the dash between the dates signifies all of the events of your entire life. Your dash is what truly defines how you have lived, how you have served others, and the impact you have had on the people who matter most to you and the world in general.” (p.13). He advocated us to get rid of life challenges or rotten bananas and don’t let this get into our way to a fulfilling life. He used his own examples to illustrate his points. He also told us how to improve our dash of life (quality of life) by watching our diet, exercising regularly, reading self-help books and taking vacations to recharge our mental and physical batteries. The way Dr Drubin explained his points with examples was clear, logical, understandable and inspiring. But, the downside is that Dr Drubin did not explain with any real life examples the consequences of not getting rid of rotten bananas and how miserable our lives will be as a result.

**Key #3 -“Increase Your Resourcefulness.”** By increasing your resourcefulness, you will increase your chance of achieving your goals, according to Dr Drubin. He characterised the quality of a resourceful person should have – passionate, able to look beyond the obvious, creative and resourceful, take change as friend, take barrier as minor inconvenience, hardworking and with total dedication. But he elaborated very little on how to get these qualities. He recommended to us the five steps: 1) Be 100 percent crystal clear about what you want. 2) Focus all of your mental energy on what you want. 3) See yourself as already having whatever you desire. 4) Take the assumptive approach. 5) Adopt his definition of true personal power. You may try out these five steps when it comes to getting things you want in your life. These five steps are very useful and empowering.

**Key #4 - “Finding your Bananas.”** Dr Drubin divided the bananas into five varieties namely physical bananas, mental bananas, emotional bananas, economic bananas, and social bananas. He explained each of these bananas and how they could cause a barrier to us and hold us back. He also explained how to overcome each of these bananas. He stressed that it was not easy to identify and work to overcome our barriers. However, if you have personal tenacity and your desire to persevere regardless of the challenges, you can alter your destiny. This key is very helpful in understanding the different kinds of barrier placed in our paths that prevent us from getting where we want to be and the solution offered to overcome them. Clearing away our rotten bananas with our resourcefulness will lead you to the life you want without regret. Although the author recognised the fact that identifying and working to overcome barriers is not easy, he ignored other factors such as the situation you are in and the impact of the change.

**Key #5 - “Win the Blame Game.”** I like the way Dr Drubin defined the blame game in this key. He said “the blame game is an ego defence mechanism that we employ to keep us feeling good about ourselves.” (p.44). He advised us that to win the blame game, you must take responsibility of things that went wrong and not to take the easy way out by blaming others. He further stressed that the past was supposed to be a place of reference but not a place for residence. When you live in the past, you are holding on to the rotten bananas and are not looking where you are going to than where you have been. He believed in decision and action but not so much in planning but he forgot the old saying “failing to plan is planning to fail.” However, the key gives us some reasons to
forget the past and how we should handle our past events and encourages us to have courage to move forward by clearing whatever rotten bananas placed along our path.

**Key #6 -“Your Bananas Are in Your Head.** The whole key revolved around how powerful and useful our minds are. Dr Drubin informed us that our mind could be used to bust our barriers. He said “change your mind and your change your life. Change your mind and you reshape your destiny.” (p.55). I fully agreed with what Dr Drubin said about the use of our minds and impact on us. The saying “You are what you think” fits in nicely to this key. This key will be useful to those people who want to change their lives for the better. Dr Drubin believed in willpower more than motivation. Willpower does play an important role in our life but you must have good techniques in order to sustain your willpower. Dr Drubin seemed to neglect this point.

**Key #7 -“Essential to Banana-Free Living.** Dr Drubin used the three essentials to explain how each of them could help us to achieve a banana-free living. Maintain a willingness to be coached; develop a consistent powerful work ethic; and always be crystal clear about the direction of your life. In each of these three essentials, Dr Drubin explained how each of these essentials could be used to get rid of your rotten bananas. He even cited his own work experience to illustrate the effect of developing a consistently powerful work ethic.

**Key #8 -Fearlessness.** Dr Drubin advised us to interpret the fear as “False Evidence Appearing Real” instead of looking at it as the actual meaning. He went on further to describe how the fear could have impact on us. He said that “in life, when it comes to your fears, you can allow those fears either to dictate your life or to serve as the catalyst for personal growth. As long as your fears do not prevent you from advancing your life, you will always experience the richness that life brings with it.” (P.72). He broadly categorised the fears as fear of rejection and fear of consequence and explained how each of these two fears came from and what were the measures could be used to overcome them. Dr Drubin described the fears in that manner that give readers a very general understanding of them and details were lacking. However, the description was very straightforward and easy to understand.

**Key #9 -Make Greatness Your Destiny.** How to make greatness your destiny was the area discussed in this key. Dr Drubin told us that if you wanted to achieve greatest in your life, you should have your strong belief in yourself and the willingness and ability to visualise a better future. He cited his life experience to explain how to find greatness in your life by finding and acting on opportunities and preparing to take outrageous action. He advocated that we needed to think big, be bold and find your passion and miracle could occur in your life. He recognised that achieving your greatest was never always fast, easy, or convenient. Thus, this shows that he is a down-to-earth person and has gained a lot of life experiences.

**Key #10 -“Future Vision.”** This key discussed how your mind could help you to achieve future things you wanted. Thinking, thought, visualisation and imagination were the key elements coupled with resourcefulness, focusing and faith could change your future life for the better. The author seemed to emphasise so much on how powerful these elements were and ignoring other factors that exist in our real life that could prevent us from achieving what we wanted. He even used his own real life example to illustrate that you could get the thing you wanted if you used those elements correctly.
Key #11 -“The Habits of Heroes.” Follow your models or heroes and emulate their action in achieving their personal or professional success in their lives was the advice given by Dr Drubin in this key. He cited Mr Lance Armstrong as an example to illustrate what the heroes meant but he was not able to know at that time that Armstrong was lately stripped off his title due to his admittance of doping. He told us that there were eight habits he believed that would be able to support us in our quest for the best that life had to offer. The eight habits are: 1). A high sense of priorities. 2). Clarity of vision. 3). Personal resilience. 4). The habit of doing more. 5). A strong feeling of self. 6). Renegade thoughts and behaviour. 7). Dream unrealistic dreams. 8). An attitude invincibility. This key is useful to us when we are looking for the directions that will lead us to a better life and free from negative bananas.

Key #12 -“Building a Better Bunch.” This key told us that we would always have some bananas in our lives. The key was to identify rapidly the ones worth-keeping and the ones that were rotten. Dr Durbin suggested to us that we should assume the role of a CEO of a company taking charge of your own life. He explained that we are empowered to govern our thoughts and actions because they take total and complete control of our future. He gave nine guidelines to his readers to consider. These nine guidelines were: 1) Think one step ahead and always have a backup plan. 2) Understand and effectively utilise the power of your personal affirmation and self-talk. 3) Be childlike in your unwillingness to accept no as an answer. 4) Live the principles of TELL (teaching, earning, laughing and learning). 5) Always deliver more than you promise. 6) When given the choice regarding how to think and behave, always choose limitless over limited. 7) With a dramatic need for speed. 8) Become more purposeful in your thoughts, actions, and attitudes. 9) Eliminate the eighth day of the week. To follow these guidelines and stick to it may not be easy for everyone but take them into account and implement them and they may help us in achieving our goals.

Conclusion pages – Final Reminders About Banana-Free Living. Having explained and discussed with examples for the 12 keys, Dr Drubin linked all the keys together and summarised the important points for easy recall by his readers. The important message he wanted to get across to his readers was to stay totally committed to getting the very most out of life as you let go of your bananas and enjoy a life without limits.

The gist of this book is the 12 inspiring and empowering keys. The author illustrated the keys with his own life experiences one by one. You may already know some of the keys but it is good to revisit them because that will give you the courage and motivation to use them. The 12 keys are not miraculous and perfect and some of which may not be applicable to you. However, knowing them will improve your life and may be able to help you one way or other in your future endeavours. This is the book which we need when we are at the crossroads and need directions.
CALL FOR PAPERS

Thank you very much for your overwhelming response to the call for papers for the issue in February/March 2013.

The next issue of TMC Academic Journal will be published in August/September 2013. We invite contributors to submit your original and unpublished research articles, book reviews and reflections in any fields of Business, Mass Communication, Hospitality and Tourism, Psychology and Information Technology for publication in TMC Academic Journal by the due date. All submissions are subjected to a stringent double-blind peer review process.

Important dates for Volume 8, Issue 1, Aug/Sep 2013:
- Open for submission: 15/03/2013
- Last day of submission: 15/05/2013
- Notification of acceptance/rejection: 15/07/2013
- Submission of final version: 10/08/2013

Authors of accepted papers will be invited to submit their bio data for inclusion in the journal. Authors are also required to sign the Transfer of Copyright Agreement as stated in TMC Publication Guidelines.

We also invite colleagues who are interested in being a reviewer to join our Review Committee. Your thoroughness, detailed and constructive feedback in the review process will both assist the author(s) in improving their manuscripts and the publication in attaining the highest quality. Your contributions are highly appreciated and they will certainly enrich your academic career.

Kindly send your manuscripts via email as attachment in Microsoft Word to <journal@tmc.edu.sg>. The instructions for authors can be found at <http://www.tmc.edu.sg/index.php/tmc-academic-journal>. Please do not hesitate to contact us for further information on paper submission.

We look forward to receiving your manuscripts.

Dr. Huong Ha
Co-Editor in Chief