

The Faculty of Engineering and Science offers PhD courses and supervision in the following main areas:

- Artificial Intelligence and Its Industrial Applications
- Security Management
- Communication and Information Systems Security
- Mobile Radio Channels
- Formal Methods and Generative Programming
- Mobile Services and Wireless Networking Technologies

The main areas are described below.

Artificial Intelligence and Its Industrial Applications

Short Description of Main Research Area

Background: Over the past fifty years the field of Artificial Intelligence (AI) has grown from the efforts of a handful of computer engineers, exploring whether computers could play games intelligently, to a scientific discipline in its own right. Today, AI covers an enormous variety of subfields, from general topics such as perception and logical reasoning, to specific tasks such as speech recognition, playing chess, proving mathematical theorems, writing poetry, diagnosing diseases, bio-surveillance, and discovering hidden or latent regularities in the growing volumes of online data [1,2].

"Often, scientists in other fields move gradually into artificial intelligence, where they find the tools and vocabulary to systematize and automate the intellectual tasks on which they have been working all their lives. Similarly, workers in AI can choose to apply their methods to any area of human intellectual endeavor. In this sense, it is truly a universal field [1]."

Industrial relevance: Presently, AI is playing an important role in many industrial applications. Indeed, companies in the Agder region are already applying AI in their products and services. Even more companies, though, pinpoint that they see a potential for increasing their competitiveness by introducing AI capabilities into their systems and solutions.

Research area: This research area will have a particular focus on the use of AI in industrial applications. Recently, there has been an increasing focus on how AI-based technologies can have a systemic impact on various sectors of the economy and of society, and how AI and ICT can help in providing a basis for sustainable development. For instance, the transport sectors of the economy account for 14 percent of total greenhouse emissions, and consequently, for example, the development of AI-based Intelligent Transport Systems (ITS) can, in addition to improving safety and efficiency of transport systems, also reduce their environmental impact [3]. As a regional example from Agder, the aim of making supply chains incorporating shipping and rail a competitive and a preferred choice for intra-continental transportation is emphasized [4]. AI-based scheduling and planning systems that can support alternative route/transport planning for the latter purposes is under investigation.

Academic Staff

This research area will be housed in the Learning Automata (LA) laboratory of UiA, which provides general learning algorithms and uses them for pattern recognition, clustering and machine learning. The students will be supervised by Ole-Christoffer Granmo, B. John Oommen, and Nouredine Bouhmala. Their brief biographies follow.

One PhD student and two assistant professors are also working in the area.

Associate Professor Ole-Christoffer Granmo: Ole-Christoffer Granmo was born in Porsgrunn, Norway. He obtained his M.Sc. in 1999 and the PhD degree in 2004, both from the University of Oslo, Norway. He is currently an Associate Professor in the Department of ICT, University of Agder,

Norway. His research interests include Intelligent Systems, Stochastic Modelling and Inference, Machine Learning, Pattern Recognition, Learning Automata, Distributed Computing, and Surveillance and Monitoring. He is the author of more than 31 refereed journal and conference publications.

Professor II B. John Oommen: John Oommen was born in Coonoor, India. He obtained his B.Tech. degree from the Indian Institute of Technology, Madras, India in 1975. He obtained his M.E. from the Indian Institute of Science in Bangalore, India in 1977. He then went on for his M.S. and Ph. D. which he obtained from Purdue University, in West Lafayette, Indiana in 1979 and 1982 respectively. He joined the School of Computer Science at Carleton University in Ottawa, Canada, in the 1981-82 academic year. He is still at Carleton and holds the rank of a Full Professor. Since July 2006, he has been awarded the honorary rank of Chancellor's Professor, which is a lifetime award from Carleton University. He is also a Professor II in the Department of ICT, University of Agder, Norway.

His research interests include Automata Learning, Adaptive Data Structures, Statistical and Syntactic Pattern Recognition, Stochastic Algorithms and Partitioning Algorithms. He is the author of more than 295 refereed journal and conference publications, and is a *Fellow of the IEEE* and a *Fellow of the IAPR*. Dr. Oommen is on the Editorial Board of the *IEEE Transactions on Systems, Man and Cybernetics*, and *Pattern Recognition*.

Associate Professor II Nouredine Bouhmala: Nouredine Bouhmala was born in Casablanca, Morocco. He obtained his MSc degree from the Swiss Federal Institute of Technology at Lausanne in 1994 and his PhD in Computer Science from the University of Neuchatel, Switzerland, in 1998. He is presently an Associate Professor at Vestfold University College and Associate Professor II at the University of Agder. His research interests include Meta-Heuristic Algorithms for Combinatorial Optimization, Parallel Computing, and Data Mining. He is also an Associate Professor II in the Department of ICT, University of Agder, Norway.

Relevant Courses

Basic course

- IKT623 *Principles of Artificial Intelligence (AI)* (5 credits)

Advanced courses

- IKT710 *Learning in Random Environments* (5 credits)
- IKT711 *Principles of Pattern Recognition* (5 credits)

References

- [1] S. Russel and P. Norvig. *Artificial Intelligence: A modern approach*. 2nd Edition. Prentice Hall, 2003.
- [2] T. M. Mitchell. *The Discipline of Machine Learning*. Machine Learning Department technical report CMU-ML-06-108, Carnegie Mellon University, July 2006.
- [3] Shaheen, Susan A. and Timothy E. Lipman. *Reducing Greenhouse Emissions and Fuel Consumption*. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RP-07-14
- [4] LogIT Systems. <http://www.logit-systems.com/>

Security Management

Short Description of Main Research Area

Management of security as a system is involving people, organizations, technology and their interactions. The perspective can be on organizational security and or security of critical infrastructure.

The emphasis of this area is on the *temporal* aspect of change in security management. This is a much neglected aspect that will become increasingly important.

The main reference guide for security managers "The Information Security Standard (ISO/IEC 27000 family of standards)" has not been designed as a guidebook but instead to help identify information security requirements. Hence, the standard lacks practical recommendations about how to manage, monitor and measure the effectiveness of security controls. Further, the standard is descriptive rather than prescriptive. Applying the standard is a subjective process, depending on the interpretation of the security manager. In particular, the ISO 27002 standard strongly recommends that information security be a continuous improvement process – but such quality improvement processes are extremely difficult to implement and the standard does not provide guidance in such respect.

Mastering the dynamics of security management provides several bonuses:

- You will learn important reasons why many managers fail to achieve a satisfactory state of security.
- You will discover that some important security failures occur as unintended side-effects of management actions.
- You will appreciate the importance of managing security as a continuous improvement process, preferably as an integral part of the organization's total quality improvement process.
- You will understand the reasons for common implementation failures in quality improvement processes – both in security and in general (i.e. implementations failures of most enterprise quality improvement processes).
- You will see the connection between good security management, organizational learning from incidents, continuous quality improvement and security culture.
- You will understand the main reasons why many continuous quality improvement processes fail and be in a good position to avoid mistakes and make better decisions.

To study the dynamics of security management we use the methodology of *system dynamics* in this manner:

- Qualitative system dynamics, mainly through the so-called system archetypes
- An introduction to system dynamics modelling with Vensim

Academic Staff

Professor Jose J. Gonzalez: Jose J. Gonzalez was born in Spain. He received a M.Sc. in Physics (Dipl. Phys.) and a PhD in Natural Sciences/Physics (Dr. rer. nat.) from the University of Kiel, Germany in 1970 and a PhD in Technology (dr. techn.) from the Norwegian University of Science and Technology in 1978. He is currently a Professor of Information Security and System Dynamics at the University of Agder.

His main research interests are security management, security as continuous improvement, security and quality improvement, incident reporting and management systems, learning from incidents, insider threat, crisis management in critical infrastructure and system dynamics modelling of security systems. He has published in, among other journals, *Computers in Human Behaviour*, *Journal of Structural Learning and Intelligence*, and *Technology, Instruction, Cognition and Learning*. Gonzalez is co-leader of the Security SIG in the System Dynamics Society and has led efforts to establish an international System Dynamics Network.

Professor Gonzalez supervises three PhD students working in his research group.

Further staff: The area of security management is quite successful in getting external funding, including funding from the EU. As a consequence, we have postdoctoral fellows that can assist in teaching PhD courses and supervising project work. In 2009-2010 it is expected that we will have a 2-3 postdoctoral fellows funded by the EU.

Relevant Courses

Basic course

- IKT624 *ISO/IEC 27000 Family of Security Standards* (5 credits)

Advanced course

- IKT701 *Dynamics of Computer Security Incident Response Teams* (5 credits)

Communication and Information Systems Security

Short Description of Main Research Area

We focus on design, specification and implementation of secure and privacy preserving solutions for emerging communication technologies and systems. In particular, we are interested on designing solutions that give adequate protection both security and privacy in context of such communication systems and services. Current research interests include: wireless and mobile network and system security; secure and privacy-preserving solutions for ad-hoc and peer-to-peer networks; security, privacy and trust in wireless sensor networks; formal methods for description, modeling and analysis of security, privacy and trust; context-aware access control models; trusted computing; security and privacy in m-healthcare information systems; knowledge management with application to security and privacy; new cryptographic primitives for emerging technologies.

Academic Staff

Professor Vladimir Oleshchuk: Vladimir Oleshchuk was born in Ukraine. He received his MSc in Applied Mathematics (1981) and PhD in Computer Science (1988), both from the Taras Shevchenko University in Kiev, Ukraine, and MSc in Innovations and Entrepreneurship (2007) from the Norwegian University of Science and Technology (NTNU). From 1987 to 1991 he was Assistant Professor and then Associate Professor at the Taras Shevchenko University. He is employed at University of Agder since 1992 first as an Associate Professor and then as a Full Professor.

His current research interests include formal methods and their application to improve security, privacy and trust with special focus on communication systems. He has served as a program committee chair, program committee member and reviewer for many international conferences. He was a guest co-editor for special issues of International Journal of Computing and Teletronikk. He has been visit researcher at University of Oslo, University of Pittsburgh (USA) and University of Aizu (Japan).

Associate Professor Rune Fensli: Rune Fensli was born in Arendal, Norway. He is employed at the University of Agder since 2000, first as an Assistant Professor and from 2008 as an Associate Professor. He obtained his PhD in Computer Science from the University of Aalborg, Denmark in 2008. Involvement in developing a wireless sensor for vital signs monitoring has been the main area of his PhD work carried out during the years 2003-2007. The main focus area of research activity is within Tele-Home-Care sector.

Further staff: Professor Oleshchuk supervises four PhD students working in his research group. Also one assistant professor belongs to the group.

Relevant Courses

Basic course

- IKT626 *Main Results and Research Topics in Security* (5 credits)

Advanced course

- IKT702 *Selected Topics in Security for Mobile Systems* (5 credits)

Mobile Radio Channels

Short Description of Main Research Area

We handle all aspects of mobile communication, starting from communication channels up to mobile applications. Our mobile communication group develops methods to model physical channels between mobile devices. In this area we handle MIMO (multiple input - multiple output) systems that are used to have better communications characteristics. An example of such systems is WiFi routers with several antennas. Our models can be used to simulate the channels and to derive error statistics.

Academic Staff

Professor Matthias Pätzold: Matthias Pätzold was born in Engelsbach, Germany. He received the Dipl.-Ing. and Dr.-Ing. degrees in electrical engineering from Ruhr-University Bochum, Bochum, Germany, in 1985 and 1989, respectively, and the habil. degree in communications engineering from the Technical University of Hamburg-Harburg, Hamburg, Germany, in 1998.

From 1990 to 1992, he was with ANT Nachrichtentechnik GmbH, Backnang, Germany, where he was engaged in digital satellite communications. From 1992 to 2001, he was with the Department of Digital Networks at the Technical University Hamburg-Harburg. Since 2001, he has been a full professor of mobile communications with the University of Agder, Grimstad, Norway. He is author of the books "Mobile Radio Channels - Modelling, Analysis, and Simulation" (in German) (Wiesbaden, Germany: Vieweg, 1999) and "Mobile Fading Channels" (Chichester, U.K.: Wiley & Sons, 2002). His current research interests include mobile radio communications, especially multipath fading channel modelling, multi-input multi-output (MIMO) systems, channel parameter estimation, and coded-modulation techniques for fading channels.

Professor Pätzold is recipient of several best paper awards.

He was local organizer of the conference "Kommunikation in Verteilten Systemen (KiVS) 2001" and organizer of the 2nd Int. Workshop on "Research Directions in Mobile Communications and Services 2002". He served as a member of the Technical Program Committee (TPC) for IST'05, VTC'05-Fall, WPMC'05, WPMC'06, ISWCS'06, and WPMC'07. He also served as session chair for several reputed international conferences (VTC'04-Spring, NRS'04, PIMRC'04, IST'05, WPMC'05, WPMC'06, IST'07, and WPMC'07).

Further staff: Professor Pätzold supervises six PhD students, and one assistant professor is also working in the area.

Relevant Courses

Basic course

- IKT622 *Introduction to Mobile Fading Channels* (5 credits)

Advanced course

- IKT703 *Mobile Fading Channels* (5 credits)

Formal Methods and Generative Programming

Short Description of Main Research Area

Formal methods are mathematically-based techniques for the specification, development and verification of software and hardware systems in order to contribute to the reliability and robustness of a design. We are specifically working on formal language semantics and related tools as well as on correctness for security and safety related aspects of systems. We use formal specifications together with code generation out of these specifications and proofs in terms of model-checkers and property checkers.

This is all geared towards a lightweight use of formal methods, where a high level of abstraction is combined with an automated check of properties. We use domain specific languages to let the users express the relevant properties of their systems.

We work actively in the SDL and ASM communities as well as in the work on more formality for UML.

Academic Staff

Professor Andreas Prinz: Andreas Prinz was born in Torgau, Germany. Having studied mathematics and computer science at Humboldt-University in Berlin, Germany, he received his M.Sc. in mathematics (1988) and PhD (1990) in computer science there. He was employed at Humboldt-University as post-doctoral fellow from 1990 until 1993. From 1993 to 1994 he worked at the Software Verification Research Centre (SVRC) in Brisbane, Australia. Returning to Germany in 1994, he continued his work at Humboldt-University. From 1997 to 2003 he worked with DRResearch GmbH, a company in Berlin.

Andreas Prinz was appointed Professor for Systems Development at the University of Agder in 2003. His research interests include formal methods and their application and use in tools. In addition, he has a strong interest in software technology and compiler construction. He has participated in several projects dealing with the development of modern telecommunication systems using advanced technology.

Professor II Christian S. Jensen: Christian Søndergaard Jensen was born in Denmark. He is currently a Professor at the Department of Computer Science, Faculties of Engineering, Science and Medicine, Aalborg University, Denmark, where he is a member of the research group that covers the area of database and programming technologies. Since 2001 Christian S. Jensen has been employed as professor II at the University of Agder.

His professional interests include a variety of aspects of data management. Since the late 80's, much of his research has been concerned with aspects of temporal, spatial, and spatiotemporal databases, including data modelling, database design, data models and query languages, efficient query processing, and systems architectures. In recent years, his research has also covered aspects of ubiquitous data management and data management for mobile computing and services. He is the author of about 300 refereed journal and conference publications.

Further staff: Professor Andreas Prinz supervises four PhD students, and four assisting professors are also working in the area.

Relevant Courses

Basic course

- IKT617 *Formal Descriptions and Related Tools* (5 credits)

Advanced course

- IKT706 *Using Semantics to Generate Code* (5 credits)

Mobile Services and Wireless Networking Technologies

Short Description of Main Research Area

Background: Mobile and wireless communications can be presented by the standard OSI protocol stack which covers issues from physical layer up to application layer. While layer 2 and layer 3 deal with how to construct a network and transfer traffic flows in an efficient and robust way, how to manage existing and create innovative services and applications which meet user satisfaction is dealt with at upper layers. These topics are covered by this research group with focus on wireless networking technologies and emerging mobile services in next generation IP networks and mobile/wireless systems.

Industrial relevance: The research topics covered within this area are of great importance for industry, from network operators, ISPs, terminal manufactures, to SMEs which foresee new business opportunities in the world of wireless communications. Indeed, while emphasizing the quality of our research work in this area, many of our research activities are in cooperation with industrial collaborators.

Research areas

Mobile Services

Our ambition is to innovate in the area of mobile networks and services for mobile devices, and to combine short-range communications with support by operators, e.g., for reachability, identity management, and provisioning.

Areas of interest:

- Mobile network architectures and protocols
- Short Range Communications
- Resource Awareness and Discovery
- Wireless Residential Networking and Services
- Mobile terminal evolution
- SIP/IMS
- IP independent mobile routing (future area)

Wireless Networking Technologies

Medium access mechanisms and routing protocols in wireless networks and mobile systems, especially in 3G and beyond, ad hoc and mesh networks; QoS and resource management, traffic engineering and cross-layer design in wireless systems and IP networks; Analysis, simulation and performance evaluation of various communication protocols and networks; Networking aspects of cooperative communications, cognitive radio networks, and hybrid cellular/ad hoc architecture.

Academic Staff

The research activities in this area are hosted in the Agder Mobility Lab (AML) at UiA, with tight cooperation with international and national collaborators including both academic and industrial partners, typically in the form of research projects. Professor Reichert and Associate Professor Li serve as the main supervisors for the students working in these areas, and the co-supervisor for a student could be one of our collaborating partners.

Currently Professor Reichert and Associate Professor Li supervise eight PhD students, and five assistant professors are working in the area.

Professor Frank Reichert: Frank Reichert was born in Germany. He holds a PhD degree in Electrical Engineering from Aachen University of Technology, Germany and has been working for over 20 years on technology and strategies for fixed and wireless communication systems both on national and international level.

From 1995 he was with Ericsson Sweden, guiding investigations on, e.g., Future Service Layer Architectures, Wireless Internet technologies, and 3G applications and terminals. Assignments included creating and managing European Research projects (e.g. EUREKA Subproject PRO-COM, ACTS OnTheMove).

Frank Reichert established Ericsson Cyberlab Singapore in 1999, focusing on user centric, ethnographic application and terminal design, as well as rapid prototyping of new HW/SW products exhibited at fairs like CeBIT 2001 and COMDEX (e.g. Ericsson Cordless WebScreen, Delhipad, Nanorouter). He was board member for Singapore CWS (Centre for Wireless Communications). He

has been working as an expert, evaluator and auditor for the European Commission in industrial R&D frameworks such as RACE, ACTS, 5FP, 6FP, and Celtic Calls 1-3.

Since July 2005 he is with the University of Agder, undertaking research in wireless communication networks and services. Current cooperation includes a project with Ericsson on wireless residential communications. He has published about 50 papers at international conferences on the mobile technologies.

Associate Professor Frank Li: Frank Li was born in China. He holds a PhD degree from the Department of Telematics, Norwegian University of Science and Technology (NTNU) in 2003. He worked at UniK – University Graduate Center in Oslo as a senior researcher before he joined the University of Agder in August 2007.

He is mainly interested in wireless networks and mobile systems, especially ad hoc and mesh networks, including routing protocols, MAC mechanisms, IP and transport layer issues, cross-layer design, QoS, traffic engineering, and performance evaluation of various communication networks.

During the past few years, he has been a team leader or a main participant for several Norwegian and European research projects including IST FP6 project, ADHOCSYS, which is financed by the European Commission under the strategic objective "Broadband for All". He is listed as a Lead Scientist by the European Commission in November 2007.

He has served as a reviewer for various international journals and conferences, including IEEE Transactions on Communications, IEEE Communications Magazine, IEEE Transactions on Vehicular Technology, The Handbook of Computer Networks (John Wiley & Sons), Elsevier International Journal Simulation Practice and Theory (SIMPRA), IEEE GLOBECOM, IEEE ICC, IEEE VTC, IEEE WCNC, IEEE ISWCS, IST Mobile & Wireless Summit, European Conference on Parallel Computing (Euro-Par), International Conference on Communications in Computing (CIC), EuroNGI Conference on Next Generation Internet Networks, etc.

He is also interested in standardization activities within IETF MANET, W-OSPF, IEEE 802.11s etc.

Relevant Courses

Basic course

- IKT625 *Simulation and Performance Evaluation of Computer and Communication Networks* (5 credits)

Recommended course

- UNIK9290/4290 *Mobility in the Internet* (10 credits, UiO/UniK course)

Advanced courses

- IKT700 *Advanced Mobile Network and Service Architectures* (5 credits)
- IKT709 *Advanced Protocols for Mobile Communications* (5 credits)