INTELLIGENT SYSTEMS GROUP (ISG)

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Background and Mission

The Intelligent Systems Group's (ISG) mission is to carry out long-term research on novel technologies and applications of intelligent systems. The main objective is to develop enhanced adaptivity and context-awareness for smart environments. The research specifically focuses on the creation of dynamic models that enable monitoring, diagnostics, prediction and control of target systems (living and artificial) or operating environments. It is our aim to make the environment adapt to the users, instead of making the users adapt to an inflexible environment. We believe that by creating these novel components for smart environments, important enabling functionality will emerge that will multiply the versatility and applicability of such living environments.

We see behaviour modelling as a major challenge in developing truly intelligent and proactive environments. Human users of smart environments often behave in such a complex manner that it is hard to predefine and pre-program all of their behavioural patterns in the software. Models of user behaviour are required that are able to grasp the user's context at any moment and to enable adaptation of the functionality of the intelligent environment to the situation at hand. Further, it is essential to model the behaviour of the devices controlled by the intelligent environment, as this enables adaptation to environmental changes without reprogramming. Systems should eventually learn and adapt automatically, through these models, to perform their duties effectively.

Our research group combines a variety of key skills and technologies to aim at this goal. We have experience in the following key technologies: system architectures and implementation of context-aware systems; modelling and recognition of contexts from sensor signals; data mining algorithms; learning nomadic robots; embedded systems technologies; software security; and smart environment implementations. The key application areas are: smart living environments in homes and institutes; industrial automation; mobile robots; context-aware mobile devices; and wellness and medical applications. Each of these domains possesses special characteristics, but, from the point of view of developing algorithms for an intelligent system, they also possess remarkable similarities. They all produce a multitude of signals that represent the status of the system. The target system behaviour should be modelled and recognized based on the signals. The application service should then act accordingly. The availability of several application domains yields many advantages: a solution to a special problem in one domain may offer added-value functionality in some other domain; our solutions are deployed by many of our client industries; solutions to a wide range of real-world problems define a credible and versatile tool-box that has a major impact on our development-oriented sub-contractual projects.

The group co-operates with many international and domestic partners. In applied research, the group is active in European projects, and several joint projects funded by the Finnish Funding Agency for Technology and Innovation (Tekes) and industry.

The group and its members are active in the scientific community. For example, Prof. Juha Röning served as co-chair of the program committee of Intelligent Robots and Computer Vision XXV: Algorithms, Techniques, and Active Vision (9-12 September 2007, Boston, Massachusetts, USA). In the software security area, a European Intensive Programme on Information Security Management and Technology 8th Winter School was arranged in Saija March 26 – April 4 2007 and The Third Crisis Management Workshop (CRM 2007), Rovaniemi. Finland, September 20-21, 2007.

Prof. Riekki organised the Sendai-Oulu telepanel on medical ICT in the Second International Symposium on Medical Information and Communication Technologies 2007 (ISMICT'07), 11-13 December 2007, Oulu, Finland.

Prof. Seppänen was the leading figure in establishing the Oulu School of Biomedical Engineering, an umbrella organization of wellness and medical technology education at the University of Oulu and the Oulu University of Applied Sciences.

Our researchers also participated in organizing an International Workshop on Design and Integration Principles for Smart Objects held in conjunction with Ubicomp 2007. The ultimate goal of the workshop was to establish a community of researchers that study sentient artefacts. Other organizers came from Waseda University, Tokyo University of Agriculture and Technology, Osaka University and Keio University from Japan and Lancaster University from the UK. There were 12 high quality papers published in the workshop.

Several members of the group were also on the committees of international conferences. The group's expertise is recognized, for example, as several invited talks and lectures were given.

The activities of the ISG are led by professors Juha Röning (Director), Jukka Riekki and Tapio Seppänen.

Scientific Progress

In 2007, the research at ISG concentrated on prototyping smart environments, mobile and context-aware systems, data mining methods, signal analysis and secure programming. These were applied in context-aware mobile systems, intelligent service robots, quality control of steel plant and spot welding processes, and analysis of biomedical ECG and EEG signals.

Research on Prototyping: from a Smart Environment towards Remote Distributed Intelligence

Verification of the developed methods and models in prototypes will be an important part of the research. To support this activity, we will develop software and hardware architectures for smart environments. In addition to verification, prototypes speed up the commercialization of the research results. In prototyping, we have set and tackled the following objectives:

Developing software architectures for a smart environment. The aim is to create a software architecture supporting the development of context-aware applications for a smart environment. We have developed a Property Service Architecture, modular and scalable software concept that provides a possibility to connect resources to larger systems. The distributed system consists of device services that provide features and functionalities to systems, and control services that create smart functionalities for the whole system. Different kinds of devices can be tested on the system as they communicate similarly and even complex applications can be built rather easily using higher level control services. Dynamic capabilities of the general interface provide a possibility to expand and adapt the system to match the task and the environment's requirements.

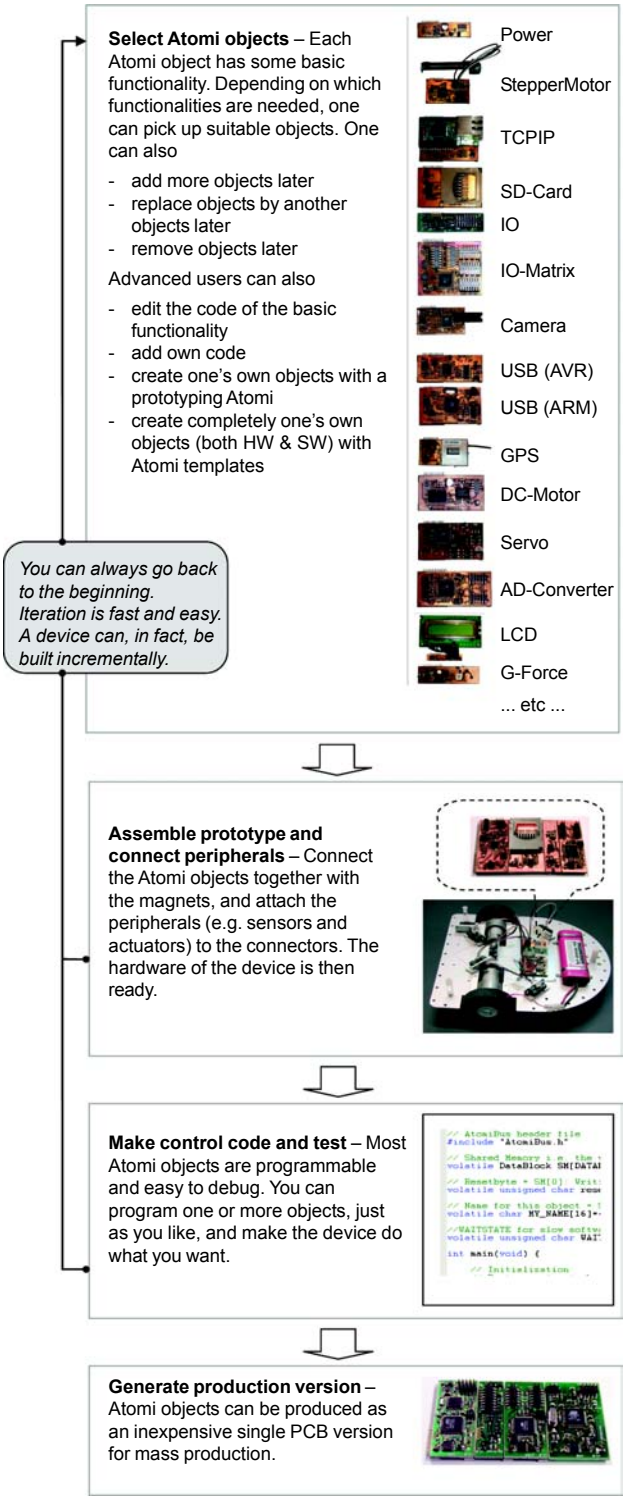
The other main objective here is to develop an architecture that provides a software library that integrates all our research work to rich set of tools. These methods and solutions are therefore easily usable on forthcoming projects, which speeds up and develops our research work and capabilities.

Developing hardware architecture for a smart environment. The aim is to develop a basis for devices operating in a smart environment. Modular technologies have been the subject of our research for some years now. Modularity has been achieved using a modular electronic concept, the Embedded Object Concept (EOC) Atomi and a modular software architecture - Property Service, which provides an interface for these resources and an opportunity to control different robots and other devices of a smart environment.

EOC is a concept that utilizes common object-oriented methods used in software by applying them to combined Lego-like software-hardware entities. These modular entities represent objects in object-oriented design methods, and they function as the building blocks of embedded systems.

This concept enables one to build new embedded systems from electronic Lego-like building blocks. The goal of the EOC is to make designing of embedded systems faster and easier while preserving the commercial applicability of the resulting device. The EOC enables people without comprehensive knowledge in electronics design to create new embedded systems. For experts, it shortens the design time of new embedded systems.

Implementing the conceptual idea of embedded objects has been successfully implemented with the Atomi II framework. It is a technical specification for implementing the



Using embedded objects.

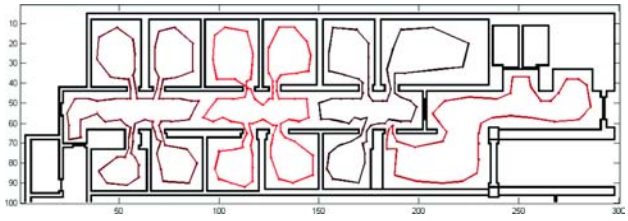
EOC and ensuring universal physical, electrical, and functional compatibility between embedded objects. Most importantly, the framework specifies a scalable and inexpensive bus system including arbitration, addressing, and a flow-controlled data transfer method. It also includes physical dimensions, rules for expansion, PCB specification, electrical properties, default protocols, default software structures, and much more. The research on the EOC is still ongoing.

Building a testing environment. In addition to software and hardware architectures, a test environment will be needed. We are building a prototype of a smart living room in our laboratory. This living room will be a large, proactive system. The technology and computation will be hidden as far as possible; the goal is to provide the user with a natural environment that offers advanced services. The hardware for the first version of the prototype has been installed. The implementation of the basic software and the development of the computational methods will continue.

Remote Distributed Intelligence. The aim is to develop a prototype for testing and verifying Remote Distributed Intelligence. This is realized by implementing a multi-agent system composed of state-of-art miniature mobile robots equipped with sensors and communication devices, which support a wide range of applications including guarding, inspection, and environment monitoring, for example. This research will give us valuable knowledge about the possibilities of a multi-robot team in real world applications.

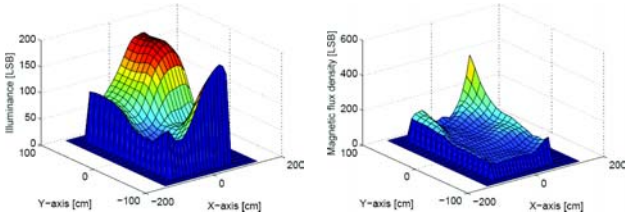
Miniature mobile robots form a multi-robot team to investigate Remote Distributed Intelligence.

Distributed multi-robot systems can be utilized in various real-world applications such as mapping, cleaning, monitoring, and distributed sensing. Our research is focused on distributed sensing, mapping and exploration of real-world environments. A novel ANT based method called the Team Ant Colony Optimization algorithm (TACO) was developed for optimizing the paths of individual robots in order to explore the given environment in the minimum time. The novel idea was to replace every ant in an ant colony optimization algorithm with a team of ants and letting those teams construct solutions to the multiple travelling salesman problem. The simulation results show that the proposed algorithm outperforms existing neural network based approaches in solution quality. Furthermore, the experiments presented demonstrate the feasibility of the proposed approach in multi-robot path planning.

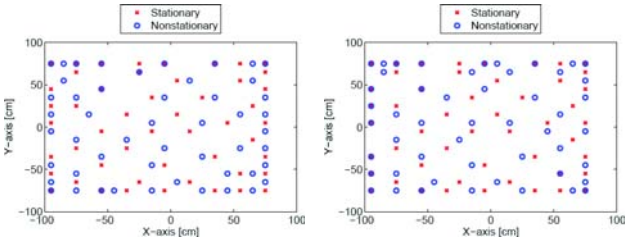


Sample routes produced by the TACO algorithm for four robots in a hospital environment.

Gaussian processes have a long history in geostatistics in the context of interpolation. In the field of robotics, Gaussian processes have recently attracted attention, for example,, in terrain modelling, since they allow prior knowledge of the environment to be taken into account in the model. Gaussian processes are also useful in distributed sensing scenarios where humidity, temperature, or carbon dioxide concentration may require regular monitoring with a restricted number of sensors. In our research, we are concerned with sensing the environment using mobile robots, i.e., multi-robot systems. This enables selection of optimal sampling locations in order to produce maximum information about the environment.



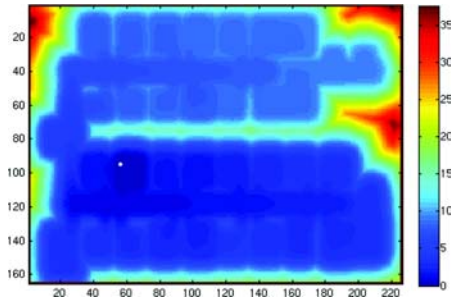
Non-stationary interpolation of ambient light (left) and magnetic flux density (right) in an indoor environment.



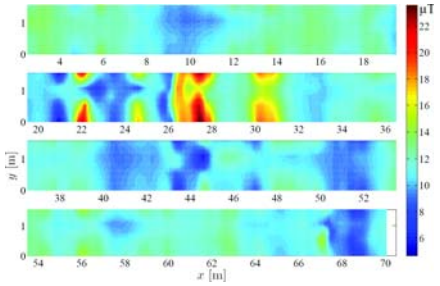
Optimal sampling locations for ambient light (left) and magnetic flux density (right).

Exploration of initially unknown environments in one of the key elements of almost all multi-robot systems. We have studied methods for coordinating multiple robots while they explore an unknown environment. The methods take simultaneously into account the cost of reaching a target point in the environment, and its utility. The aim of the venture is to explore the unknown environment in a coordinated manner in a minimum time.

As part of our distributed sensing research, measurement techniques were developed to map the magnetic field of the environment. The magnetic fields of modern buildings with reinforced concrete structures are extremely non-uniform. Our research concentrates on mapping magnetic anomalies, and analysing the properties of the fields.



Cost of reaching various locations in a hospital environment (the São Francisco Xavier Paediatric Hospital's). This cost map is computed for a robot in location (55, 95).



The two-dimensional magnetic field measured from a hallway of an office building. The hallway was approx. 70 m long and 1.5 m width.

Research on Context-Aware Services

A growing variety of services are nowadays available for users. We are approaching a situation where the sheer number of services hinders their utilization. Our hypothesis is that this service overload can be managed by utilizing the user's context. To develop context-aware services, we have set and tackled the following objectives:

Recognizing the user's context. The aim is to find and develop methods for recognizing the user's context from sensor data using signal processing, pattern recognition and machine learning methods. Context can be used to identify the services that are relevant in the situation at hand - and to adapt these services. In earlier research, our focus has been on wlan position data, data produced by our pressure-sensitive EMFI floor and heart rate measurements.

During autumn 2007 co-operation with Japanese partners continued when a researcher from our group visited for a three months period the Tokyo University of Agriculture and Technology in the Daily Life Computing Research Group led by Associate Professor K. Fujinami. The aim of this research visit was to study novel and state-of-the-art sensor technologies to model human motion, and more specifically how to recognize identity, location, and activity of persons, based on motion information from environmental and wearable sensors. As a comparison to earlier work on our pressure-sensitive Emfi floor, we have now used simple 10x10 cm binary switches installed on to a floor surface (see below). In addition, we have examined a single sensor board attached to person's body, consisting of 3D acceleration and gyroscope sensors. Large data sets, including data from multiple persons, were collected to study person identification and tracking using these two different sensor modalities. During the visit, a preliminary study on feature extraction and recognition were experimented on using statistical machine learning methods such as Bayesian kernel methods (i.e., Gaussian Processes) for classification and for the fusion of different sensor modalities, as well as sequential Monte Carlo for dynamic modelling and tracking. Additionally, a real-time prototype was build which uses a person identity and location information from the floor sensors to provide context-aware services,. The preliminary results were encouraging and the research will continue during 2008.

The installation of the binary switch floor sensor to be used to study person identification and tracking for the context-aware systems.

Our work on user activity recognition has continued as we have developed new machine learning algorithms for different applications. The user's activity can be recognized via wearable sensors by utilizing a novel sequential learning method that combines discriminative learning of individual input-output mappings using support vector machines with generative learning to smooth temporal time-dependent activity sequences with a trained hidden Markov model type transition probability matrix.

Furthermore, the activity of the user can be utilized in identifying the user of a sentient artefact. When the user's activity is linked to a certain artefact, for example, drinking activity linked to a cup etc., we can determine the user of the cup easily. In a case of multiple users in a same activity, correlation analysis can be done between the measurements produced by the artefact and the measurements produced by the user.

In project Ubilife, we have developed novel algorithms to recognize the gestures of users based also on acceleration signals. The algorithms combine machine vision and speech processing research in utilizing

User activity measurement with wearable 3D acceleration sensors (on the right wrist and thigh, triaxial accelation signals).

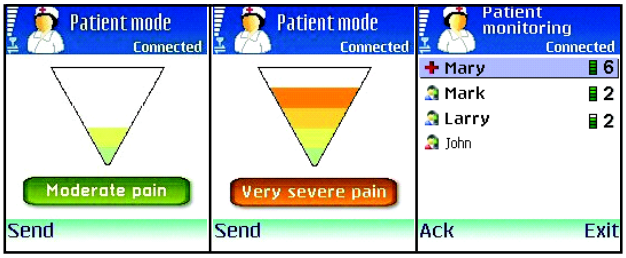
both ballistic features and hidden Markov models for the recognition. Gestural controlling can be used in many different application areas where alternative user interfaces are needed.

Modelling user's behaviour. The aim is to find models that can be used to predict users' behaviour. User models will enable services to be adapted automatically based on users' personal preferences and they will also enable proactiveness. Objectives will create the necessary basis for this work; the model will be created by observing the user's context changes and actions over time. In earlier research, we have created rule-based models of user behaviour by utilizing data mining algorithms to associate different contexts in order to better serve the user. In the future, adaptive machine learning models based on neural networks, kernel methods, and sequential modelling will be applied along with the study of novel sensor measurements recorded from the different wearable and environmental sensing devices. We have continued this work, co-operating with Waseda University, and also co-operation with the Tokyo University of Agriculture and Technology is planned.

Labelling personal information with context. The aim is to develop methods that could help the management and utilization of the growing quantities of digital information related to our lives. The hypothesis is that context is an intuitive way of organizing personal information, as it allows users to relate information to their experiences. We especially aim to produce a methodology for collecting and storing an extensive set of digitally available, context-labelled data from a person's everyday actions and activities, and to outline data mining and learning methods for accessing, visualising and utilising such data in useful ways.

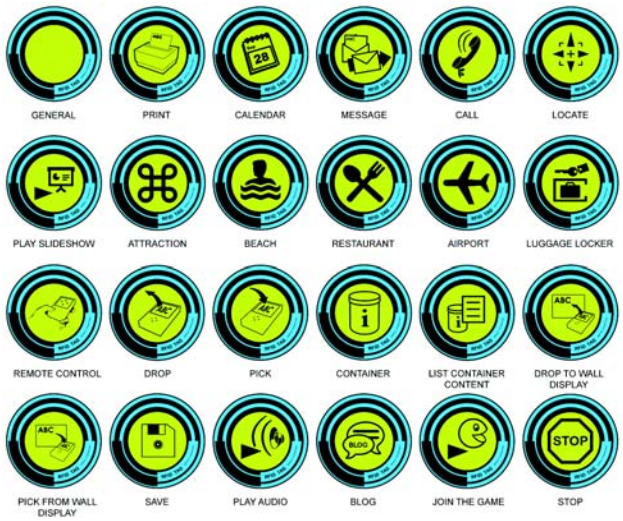
Wireless hospital. We implemented in 2007 a novel system for patients to report the level of pain they are experiencing and for nurses to monitor the patients' pain reports. The patients use either a mobile phone application or a special pain meter device, completely built by us and designed by the University of Lapland's designers. The next figures show the special device and some screenshots from the patient's and nurse's applications. The system was tested with genuine patients and nurses in 7 field trials in Northern Finland during 2007. The system was found to be easy to use and useful.

Three pain meters.



Mobile phone applications for patients to report the level of pain they are experiencing and for nurses to monitor the patients' pain reports.

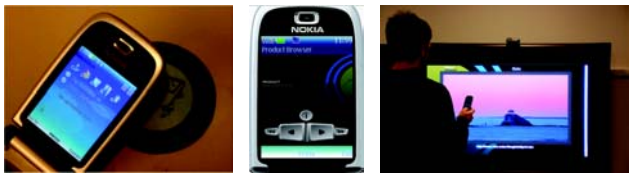
Physical user interfaces. We developed further our RFID-based physical user interface. The figure below presents the latest set of RFID icons that advertise the objects in the environment that can be touched, and the services that are activated when these object are touched. This set was developed together with the University of Lapland. Each icon is equipped with an RFID tag that contains data determining the service. When an icon is touched with an NFC-equipped mobile phone, the phone reads the data from the tag and delivers it to the system serving the user. The aim is to have a common visual vocabulary that will be widely known by the users and widely utilized by service providers.



The icon set.

We developed in 2007 the REACHeS platform for controlling Internet services with NFC-equipped mobile phones. When a user touches an RFID tag with a mobile phone, the corresponding service in the Internet is informed. This service then creates a user interface on the mobile phone's display. The commands given by the user are mediated to the service and the service's responses are mediated back to the mobile phone. The services can also control a wall display. The developed simple and versatile interfaces allow a large number of services to be activated by a simple touch and controlled remotely by a mobile phone. Several prototypes have already been implemented on top of this platform, including a photo album and a video player; they both utilize a large wall display and are controlled with a mobile phone. The next figure illustrates the Product Browser pro-

totype that allows a user to browse product advertisements on a large wall display. The user touches an RFID tag with a mobile phone in the leftmost figure. The user interface that the Product Browser service creates on the mobile phone's display is shown in the middle and an example of the content of the wall display in the rightmost figure.



The Product Browser prototype.

Research on Data Mining

Biosignal Processing

Sudden cardiac arrest is the most common cause of death in western countries. It accounts for approximately 50% of cardiovascular deaths and apparently has a highly variable pathophysiological etiology. The risk of sudden cardiac arrest is high in certain subgroups of patients with a history of myocardial infarction and depressed left ventricular function. The key question in research is why do some subjects develop ventricular fibrillation during acute coronary occlusion, while others survive this episode without fatal arrhythmia. The challenge for research is to develop approaches or techniques that will allow the screening of the specific risk for fatal ventricular arrhythmias as a predictor of the first event in patient populations that have a low cumulative risk, but generate a large number of victims. In addition, the predictive value of many known risk factors of sudden cardiac arrest among patients with known heart disease has not been definitively established.

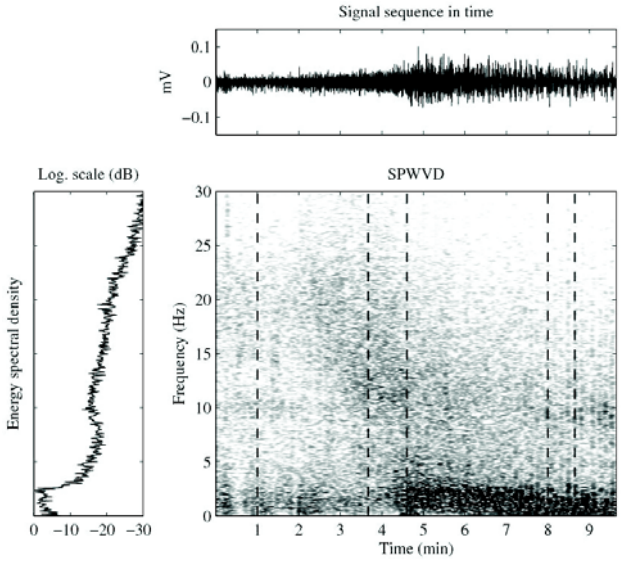
Computation of risk markers from ECG characteristics. The aim is to develop new methods and algorithms for the analysis and interpretation of electrophysiological signals and the autonomic regulation of the cardiovascular system. The digital 12-lead ECG was decomposed into multi-dimensional dipolar and non-dipolar components in the depolarization and repolarization phases in order to derive new risk markers of heart diseases. 12-dimensional principal components analysis was performed to extract dipolar (vector cardiographic) and non-dipolar components from the measurement signal. The depolarization and repolarization phases were analysed separately, and various parameters (e.g., VCG loop descriptors and singular value-based descriptors) were developed that describe the electrical functioning of the heart during one beat or in continuous ECG.

An EDL based (Equivalent Double Layer) simulation environment was utilized to model myocyte-level action potential changes of infarcted heart ventricle tissue. The infarct locations, sizes and severities were varied and it was shown that these parameters affect significantly some ECG indices, like the recently developed TCRT. It was shown that the location of the infarcted heart tissue must be known in order to correctly interpret the TCRT parameter value with different patients.

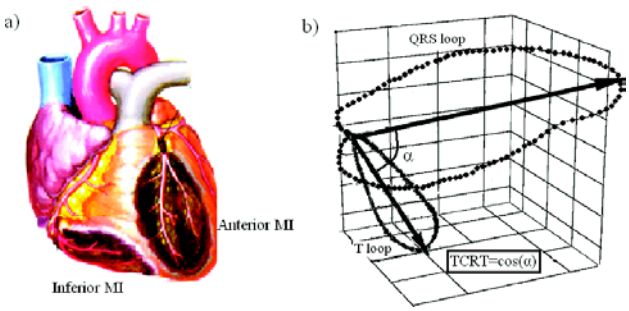
Modelling of physical fitness. A new model was developed for estimating the endurance fitness level of a runner from the physiological signals and contextual information related to the runner. The new method can estimate the endurance fitness within 5% inaccuracy as compared to a running ergometer.

Estimation methods of anaesthesia depth. The aim of this task is to develop new methods and algorithms for estimating the depth of anaesthesia from a multi-channel EEG. A new concept of relative induction time was recently developed, which enables a significant improvement in the depth estimation from EEG. The new method produces a time-continuous value for the depth estimate and accurately predicts the instant of loss of consciousness. The method was extended such that it can model the depth of anaesthesia to such a depth that burst-suppression of EEG starts to evolve.

Modelling of human text writing. New techniques for predicting text production of a keyboard user were developed. The solution includes advanced statistical models of word combinations and word-class combinations that effectively enhance text production.



Spectral contents in deep anaesthesia through smoothed pseudo Wigner-Ville distribution.



The influence of the size and the location of the myocardial infarction (a) on electrocardiographic morphology parameters (b). A computer simulation study, 2007.

Data Mining Systems

The goal of this research is to create an holistic approach to data mining systems. The development efforts are divided into three categories; algorithms with independent updating properties, software methods for fast and reliable implementation of the systems, and methods for coping with ever expanding amounts of data. The technologies to be developed are collectively known as the *Smart Archive*.

The aim of the Smart Archive is to develop a framework for the modelling of phenomena that continuously produce new measurement data. The focus area of the technology under development is intelligent on-line data processing for the purpose of on-line modelling. Development is currently in progress of a software framework that enables the rapid realisation of new models as software applications. By using the framework, the implementation and set-up times of models can be significantly reduced and their operational reliability improved. A specific issue to be addressed is the selective storage and effective utilisation of accumulating data that eventually comes to represent the full spectrum of the phenomenon being modelled. An advanced prototype version is being used to create a series of data mining solutions for diverse industrial application domains, and based on the resulting experience the design of the framework will be further refined. The ultimate goal is a truly generic data mining meta-application with a graphical user interface that allows application instances to be constructed parametrically with the minimum quantity of application-specific code.

During the last year, research was carried out in two projects, SAMURAI and XPRESS. In the SAMURAI-project new methods for utilizing measurements from wearable electronics and the metal industry were development. As an example, the figure below presents a method for visualizing numeric and audiovisual information simultaneously, which makes it easier for the user to understand the numeric measurements. The EU-funded XPRESS-project kicked off last year, and is by far the largest research project of the group. In the project, 17 participating organizations are developing methods for making the production of goods more efficient, and the results are then applied, for example in the European automotive and aeronautic industries.

A visualization method for simultaneous observation of numeric and audiovisual signals. Developed for data mining research.

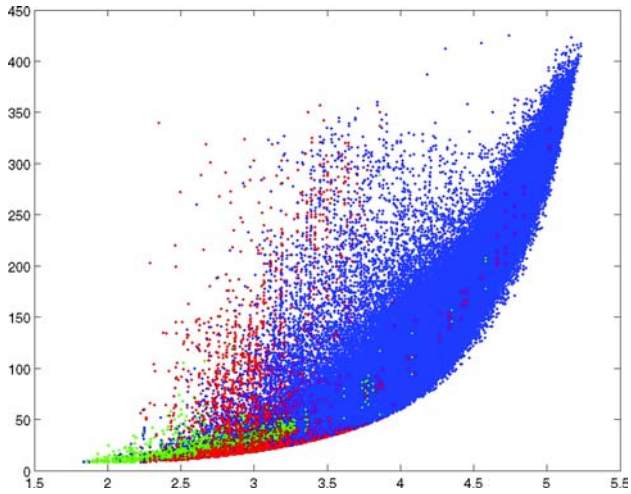
During autumn 2007 a researcher visited the University of Applied Sciences in Karlsruhe, Germany for three months. The aims of the visit were to improve research collaboration and achieve a better understanding of tasks to be done for welding experton in the Xpress project. In the previous collaboration project (Sioux -project 10/2002-10/2004), methods were developed to control the quality of welding spots and to reduce the set-up times of new welding processes. The methods developed during the project were based on data gathered from real welding experiments from different welding machine manufacturers. The problem, however, with these methods is that the data set used only cover a small portion of the spot welding data space. On the other hand, there are simulation tools which estimate the signal curves and the quality using a physical model of spot welding. The simulation tools cover the data space more widely but the estimates do not react to extraordinary changes during different welding events. In addition, the simulations take too much time to be used online, so it cannot be used as it is. Thus there is a need to integrate these two models. The research started in Germany, where the first results revealed a need to improve the simulation tool. The research will continue after the improvements are developed.

Utilization of process data in the optimization of production processes: The research focuses on methodology for more efficient utilization of measurement data to improve efficiency and product properties in manufacturing industries. The data mining group has long experience in researching data mining and statistical modelling methodology for the purposes of improving product properties, especially in the steel industry. Emphasis is paid to the applicability of research results: the active implementation of advanced data analysis methods to industrial applications ensure the efficient transfer of the latest data mining technologies to industrial practice. The data mining group also belongs to the Centre of Advanced Steel Research, which was founded to gather together the steel research at the University of Oulu.

During the last year the most important research goals have been the development of methodology for semi-automatic maintenance of industrial prediction models, and the development of prediction model for the risk of rejection probability in a Charpy-V test. The research has been conducted with close co-operation with local steel industries.

The Charpy-V test measures the impact toughness of steel and its statistical distribution depends on the steel composition and process treatments in such a complex way that the reliable prediction of the rejection risk has not succeeded earlier. The introduction of LIB-transformation has proven to be a step ahead in this challenging application.

Manufacturing industries commonly employ statistical prediction models for example in their production planning. A common problem is that changes in products and processes often cause the models to drift out-of-date. The research in semi-automatic model maintenance has resulted in promising methods and practices which may lead to significant economic benefits by making it easy to keep the models up-to-date by means of the on-line processing of daily production data.



Dependence between Charpy-V measurements and their LIB transformation (measurements on the y-axis and the LIB on the x-axis).

Research on Software Security

Within the Intelligent Systems Group, the Oulu University Secure Programming Group (OUSPG) has continued research in the field of implementation level security issues and software security testing. Software implementation may introduce potential for unanticipated and undesired program behaviour, e.g. an intruder can exploit the vulnerability to compromise of the computer system.

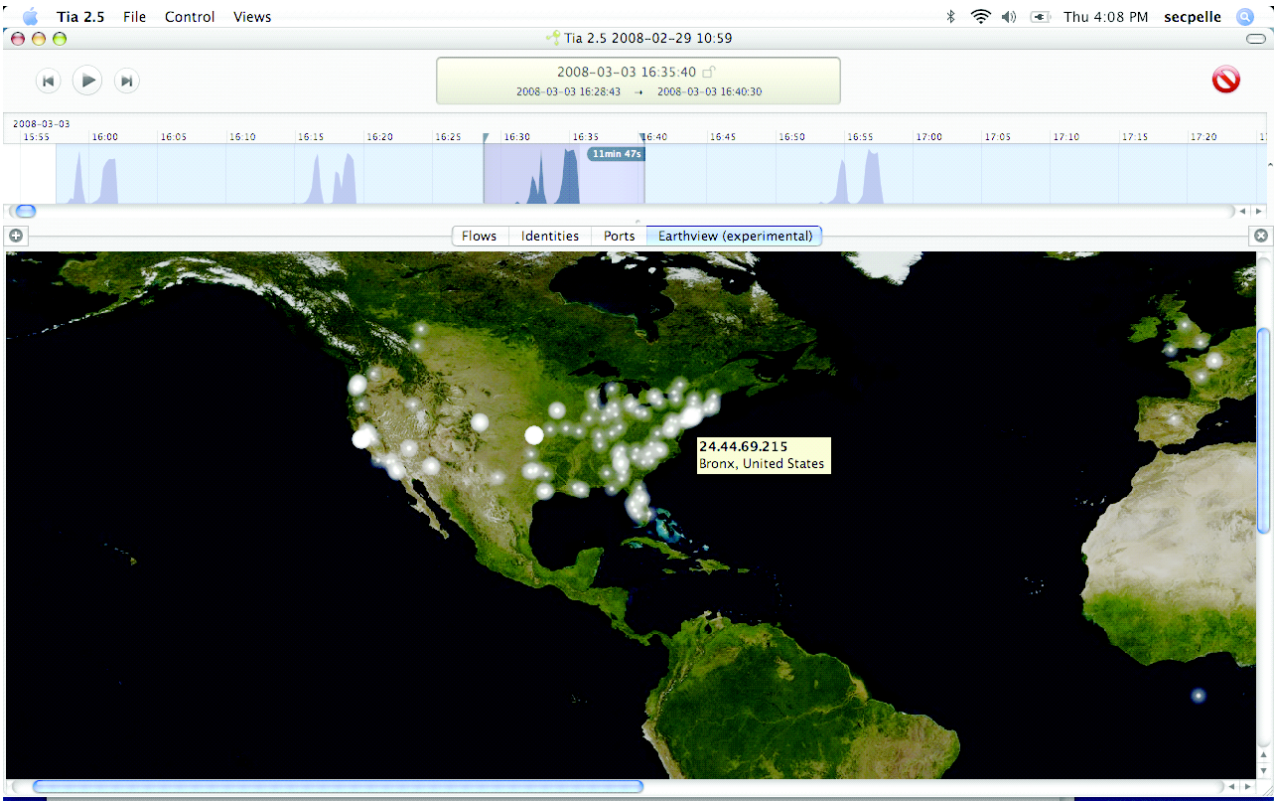
In 2007, the research focus at OUSPG remained on black-box methodology for improving software security. OUSPG approaches the problem from three different directions, namely, network traffic data-mining and visualization, protocol genes and protocol dependence.

Causal relationships. The aim is to develop methods for inferring causal relationships in complex systems. The research applied data mining to network traffic to find data relevant to the system being analysed. Applications of the method include getting an overall view of the communication patterns of complex systems, diagnostics and security risk assessment.

Information network environments are more complex than ever before, and the complexity will increase in the future. One important factor affecting the increase of the complexity is the convergence of information networks. One seemingly simple event may generate a number of small actions in different parts of the network. Additionally, different components may use varying protocols. Thus the secure development, deployment and management of complex networks is laborious and requires in-depth understanding of different fields.

Network traffic data-mining research applies black-box methodology in understanding the behaviour of different components in computer networks. Examples of systems where this work has been applied are operator WLANs, firewalls and malware.

Operator WLANs are a good example of complexity due to the large amount of infrastructure involved (e.g. integration with traditional phone network authentication infrastructure). Firewalls may have unintentional information leaks due to misconfiguration or implementation problems. Malware is software that is purposefully obfuscated to make reverse-engineering and removal difficult. By monitoring the external behaviour of malware, it is possible to understand how it functions.



A single piece of malware communicates with several hosts around the world.

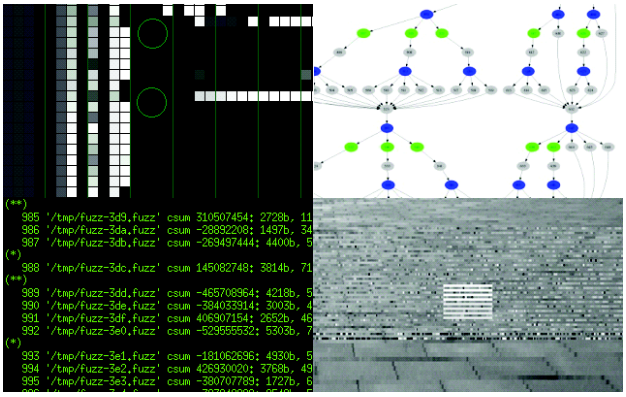
Within this context, a three-month research visit to Dartmouth College was made during spring 2007 to apply this work to usage patterns of large-scale wireless networks.

Identification of protocol genes. This research, PROTOS-GENOME, approaches the problem of complexity from the other direction by developing tools and techniques for reverse-engineering and identification of protocols based on using protocol genes - the basic building blocks of protocols. The approach is to use techniques developed for bioinformatics and artificial intelligence. Samples of protocols and file formats are used to infer structure from the data. This structural information can then be used to effectively create large numbers of test cases for this protocol

The PROTOS-GENOME project produced test suites for several archive file formats that are typically implemented, for example, in anti-virus products. The test suites have been distributed to vendors in cooperation with FICORA and NISCC. A number of vulnerabilities was found in widely used antivirus software products.

Vulnerability management of the information infrastructure contributes to protocol dependence: Another angle of battling complexity is through technology dependencies. This activity studies the impact factor of different technologies on CNI, and develops a visual model for understanding dependencies related to protocols. This was accomplished by extending traditional Wikis, which are effective mass collaborative authoring services with graphing extensions. Graphingwiki enables the deepened analysis of the Wiki data by augmenting it with semantic data in a simple, practical and easy-to-use manner. Visualisation tools are used to clarify the resulting body of knowledge so that only the data essential for a usage scenario is displayed. Logic inference rules can be applied to the data to perform automated reasoning based on the data. Perceiving dependencies among network protocols presents an example use case of the framework.

A newly established area of research in OUSPG is computer-assisted teaching. This work originated in 2005 with RAIPPA, software for automated software for programming laboratory pre-exercises. The system has improved learning results significantly, and its use has expanded to other programming courses taught in the department. Work on RAIPPA continues in 2008 with funding from Campus Futurus, an organization within the university that promotes the use of ICT in teaching. The system will be expanded with pilot courses from throughout the university.

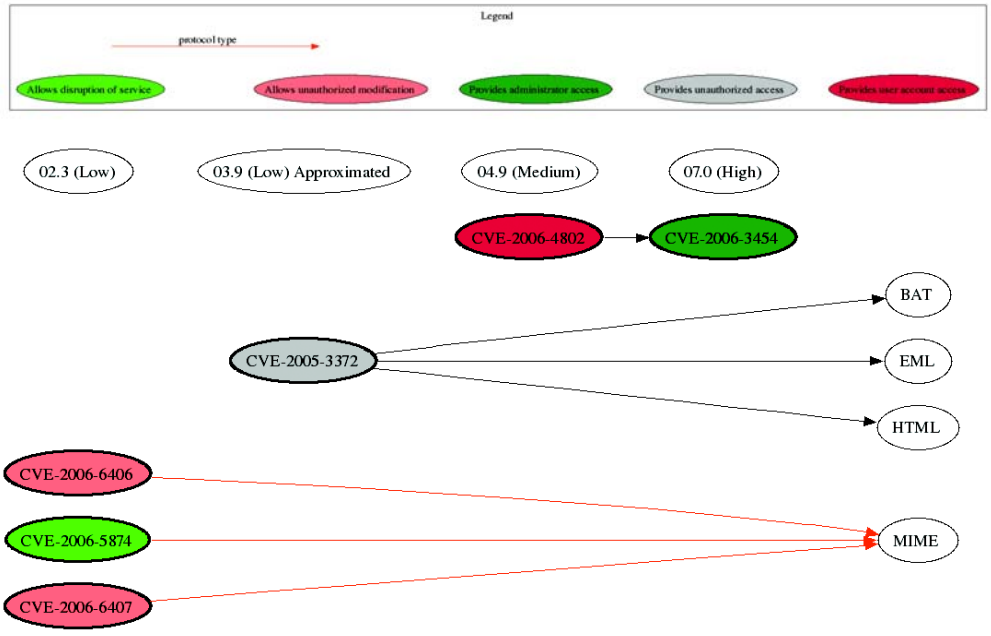


Visualisations of file format analysis and fuzzing.

Exploitation of Results

The results of our research were applied to real-world problems in many projects, often in collaboration with industrial and other partners. Some examples of exploitation are described below. Especially during the reported year, outdoor robotics was a new area for exploitation of our research results.

The Intelligent Systems Group utilizes a robotics laboratory and pressure-sensitive floor (EMFi material) installed in our laboratory as part of a smart living room. Other equipment includes a home theatre, two degree-of-freedom ac-



Impact of several vulnerabilities.

tive cameras, four mobile robots and one manipulator, a WLAN network, and various mobile devices (PDAs, a tablet PC, Symbian mobile phones). WLAN positioning covers a large part of the campus (including the laboratory), and a home automation network is being installed. Our aim is to gradually build a versatile infrastructure that offers various generic services for pervasive applications. Naturally, this kind of environment enables realistic experiments that lead to a better understanding of such applications.

The embedded objects implemented according to the Atomi II Framework specification are called *Atomi* objects. Several different Atomi objects have been created for real life tests (see Figure "Using embedded objects"). The Atomi objects have been used in several projects, and they have proved to be very usable.

Recently, the Atomi objects have been used both in pure research projects and in projects that aim at commercial products in the end. The Atomi objects have been applied to telepresence robots, nano scale manipulation and measurement technology, a hand held medical device, and several robot applications.

The results of the multi-robot and distributed sensing research will be utilized in a real world application scenario as a part of the ROBOSWARM project, which is a sixth framework EU project launched on November 2006. The end demonstration of the project will be arranged in the São Francisco Xavier Paediatric Hospital in Lisbon, Portugal. Furthermore, modelling spatial distributions of physical quantities such as temperature, illumination, humidity, gas concentrations, or magnetic flux provides an opportunity to observe how these distributions change in time, how to utilize the information captured by the distributions, and to reason how to adjust the distributions by modifying the environment. The information provided by the models could be useful in numerous applications such as in dynamic optimization of the heating system of a building for saving energy, in monitoring the air quality in various parts of hospitals, and in monitoring the water quality of lakes and rivers (e.g. pH and oxygen levels).

During the reporting year, the group started to utilize robots also outdoors. The group participated in the first European-Landrobot trial, C-Elrob 2007, for civilian participants arranged in Monte Ceneri, Switzerland. Two robots, Maahinen and Ilmarinen, were prepared for the event. C-Elrob 2007 included four different scenarios: Urban- and Non-Urban scenarios, Autonomous reconnaissance and Combined trial for testing the co-operation between the aerial and the ground unit. As an only team, ISG was the only team to succesfully take part in all the four scenarios.

In addition to the core research, OUSPG also maintains a test network infrastructure for research groups such as OUSPG, ISG and MediaTeam. Test networks are required for the safety of both our own researchers and innocent bystanders, and one was constructed for internal use in the laboratory. The network provides a fully functional infrastructure with services such as storage, backups, DNS and mail.

Future Goals

We will continue to strengthen our long term research and researcher training. We will also continuously seek opportunities for the exploitation of our research results by collaborating with partners from industry and other research institutions in national and international research programs and projects. The group is a founding member of the European Robotic Network of Excellence (EURON). The group is a contract member of EURON II which was approved for the EU's 6th framework as a Network of Excellence.

We will strengthen our international research co-operation. We have arranged research visits to Professor Tatsuo Nakajima's research group at Waseda University. This co-operation will continue. Shorter research visits to European partners of EC funded projects are also planned.

Personnel

professors & doctors	8
graduate students	20
others	51
total	**79**
person years	55

External Funding

Source	**EUR**
Academy of Finland	33 000
Ministry of Education	298 000
Tekes	591 000
domestic private	294 000
EU + other international	540 000
total	**1 756 000**

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