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Technological Innovations for Future Healthcare Environments

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Technological Innovations for Future Healthcare

XOOTIC Magazine Committee

We are happy to present you the latest XOOTIC magazine. It serves as the proceedings of the XOOTIC Symposium 2011 with the theme *"Technological Innovations for Future Healthcare Environments"*. The goal of this symposium was to introduce to the XOOTIC members, as well as the broader audience from industry and the academic world, some of the technological innovations that are being developed in the healthcare domain and to bring insight on how they will help meet the demands posed by future healthcare environments.

The presenters of the Symposium were so generous to write a paper based on their presentations. As a result, this issue consists of a broad range of interesting healthcare-related papers. To summarize our article contributions:

- Hans Hofstraat (Philips Research) introduces us to Clinical Decision Support, incorporating the extensive experience at Philips Healthcare,
- Hans Kuppens (CCM, Centre for Concepts in Mechatronics) presents a machine to perform pathology (the study of diagnosis and disease) by digitization of slices of pathological tissue.
- Julien Penders (Holst Centre/IMEC) shows that the interesting subject of Body Sensor Networks is no science fiction at all anymore

From speakers from research institutes, available abstracts were included in this Magazine as well. Peter Hilbers (TU/e) writes about trends in Biomedical Engineering. Michiel Sprenger (The Netherlands National IT institute for Healthcare (Nictiz) and TU/e) presents the goals and challenges for the National infrastructure for patient information in the Netherlands. One day, there will be a nationwide electronic database in which hospital specialists find what your family doctor prescribed you once, to prevent risky errors and miscommunication. However, the Netherlands recently appeared not to be ready for it. Last but not least, Stefano Stramigioli (University of Twente) explains the impact of robotics for healthcare.

We are proud to present interesting articles from a fruitful Symposium that describe innovations that the industry and academia believe will solve many healthcare problems. Many achievements are being reported, but still many problems need to be solved. This symposium was the right avenue to bring the academics and industrial partners together to highlight some of the future challenges for the healthcare environment and share the technical innovations that will help improve the quality of future healthcare

We hope this XOOTIC Magazine issue will be of use as a reference for future healthcare-related innovations. Have a healthy and innovative 2012, everybody!

XOOTIC Magazine Committee
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Appropriate Solutions for Future Healthcare Needs

Hans Hofstraat, Philips Research

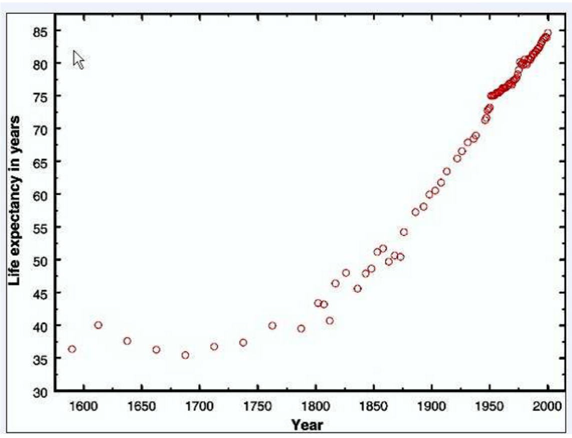
With contributions from: Sybo Dijkstra, Joerg Habetha, Richard Kemkers, Helko Lehmann, Harald Reiter, Joerg Sabczynski (Philips Research), and Patricia McGaffigan (Philips Healthcare)

By 2050, the worldwide number of people over 60 years of age will triple, from 600 million to two billion. In addition, 50% of people in the developed world is anticipated to suffer from chronic illness. Many health conditions, such as obesity, heart disease, and cancer, are strongly impacted by the way we live. There will simply not be enough nurses and doctors to cope with our growing (and aging) population. At the same time, we have higher expectations about care. Accelerated innovation introduces more promises and more choices, but also more complexity. Healthcare costs will become unsustainable; healthcare costs are expected to rise from 9% of the world-wide GDP to 15% by 2015. The only way to avoid this critical situation is to implement radical changes in the way we deliver healthcare [1] [3] [2].

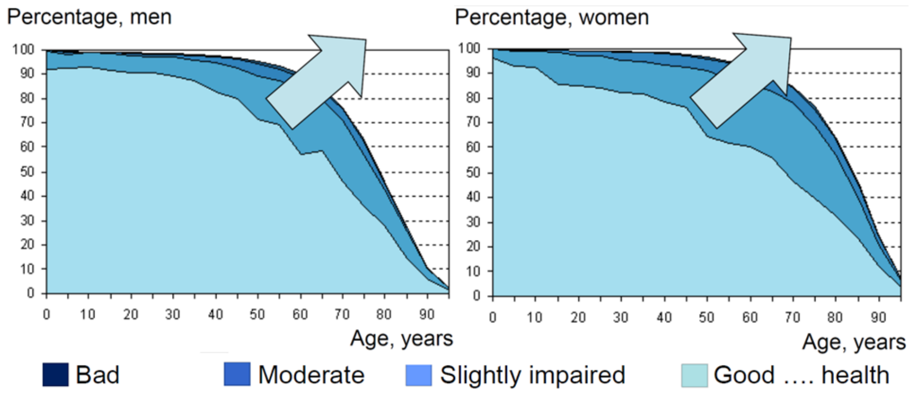
Introduction

Over the past 170 years, longevity in the Western world has increased by 6 hours per day. In 1630, the average life expectancy was 31. In the year 2002, this increased to 84. The increase has been linear since 1830, initially due to better hygiene and sanitation, later by improved drinking water. Starting around 1900, improved nutrition and reduced malnutrition started playing a major role. From the 1920s onwards, medical technologies took over as sources of improved life expectancy [6].

But, the world is ageing as well. In 1950, 6% of the world population was over 65 years of age. In the year 2000, 8% was over 65. By 2050, 15% of the world's population will be older than 65. The life expectancy curve in emerging markets follows the same trend. In 2000, the life expectancy in less developed regions was 65 for men and 68 for women (72 and 78 in developed regions). In 2050, the life expectancies in current day's less developed regions will have increased to 73 and 78, respectively (79 and 86 in developed regions) [4].



And the world population will increasingly suffer from chronic diseases. This will increase risks of dying of diseases such as cancer, ischemic heart failure, and stroke. Without action, the total number of these fatalities will rise from 23 million per year to 30 million per year. At the same time, as a result of better hygiene and more effective treatment, the number of deaths from infectious disease is expected to decrease, e.g. the number of HIV-related deaths is projected to decrease from 3 million per year to 1 million in 2030. Yet, without action, the total number of people dying from such diseases over the coming 10 years will be 400 million people [8].



In the Netherlands in 2025, 60% more personnel will be needed than today, in order to maintain the current standard of care. At the current rate, in 2025, there will be 470,000 job openings for medical personnel. The cost of care will have increased from 14.6% of GDP in 2009 to 24% of GDP in 2025. Financial issues can be solved. This is a matter of choice. But where will we find the people, particularly since the number of 'active' people is decreasing as a result of ageing?

Chronic illnesses are a consequence of ageing. Quality of life decreases in the last life years. In 2025, 4.5 million Dutch people will be over 65 years old. The challenge will be in promoting 'active and healthy ageing', in order to reduce the number of years lived in bad health and with low quality of life [5].

In order to enable long and healthy independent living, a paradigm shift in healthcare is required, addressing the needs across one's entire lifespan. Medical treatment of diseases always happens late in the cycle. Chronic disease management is much more about behavior change (a social model) than about late-stage medical treatment (a medical model). During one's life, we can distinguish a gradual rise in required medical service level. This rise in required service level at younger age generally has a few short bursts of sharply increased needs, such as during childbirth, as a result of (e.g. car) accidents or other injuries, and due to acute organ failure, in particular related to cardiovascular problems. In particular the latter types of acute incidents need to be reduced through changes in lifestyle, through health education, and by risk monitoring. In later life years, these episodes need to be avoided through decentralized support tools (e.g. at home). Behavior change plays a key role across the full life span, and is particularly related to prevention: primary prevention in the younger years, secondary and tertiary prevention (reducing risk of recurrence of exacerbations, the acute episodes of disease).

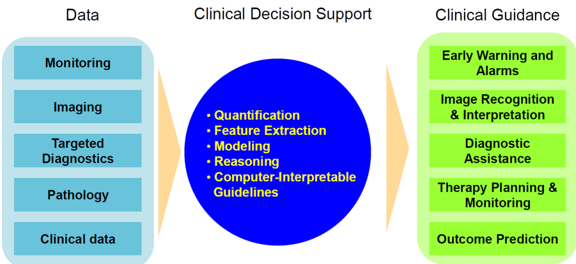
This requires a kind of holistic approach to healthcare delivery. The cycle of medical care revolves around six phases: prevention, screening, diagnosis, treatment, management, and surveillance. Each of the stakeholders acting in these phases needs to be involved. Many of these phases must be distributed over different settings, posing specific boundary conditions to effective care: ambulatory services, hospitals, out-patient services, and the home [7].

Clinical Decision Support

Medicine is transforming from an art to a science, creating a need for Clinical Decision Support (CDS) tools to help the clinician to deliver the best possible care tailored to a particular patient. A number of developments in medical decision making are currently taking place. The amount of knowledge on the origin of disease, and the best possible treatment for many medical conditions is sharply increasing (knowledge explosion). At the same time, also the amount of available medical data, such as images, diagnostic and pathological information, increases (data explosion). The increased availability of data enables information-based medicine and personalized medicine. Clinical Decision Support evolves from a drive for better outcomes towards solutions that enable decision taking based on objective and personalized information. CDS solutions integrate and interpret the universe of patient data, acquired from various sources, filter that data intelligently, and present the integrated outcome in an accessible and understandable way. The data is thus distilled into actionable, care- and patient-specific information.

The high-level goals of CDS are the following: improve outcomes (for a particular class of complaints, diagnoses or procedures), improve patient safety and reduce medical errors, foster evidence-based clinical practice, enhance patient education and empowerment, improve quality of care, foster compliance with clinical guidelines, and address clinician's information needs, while making sure that regulatory requirements for reporting and accreditation are being met [11].

CDS aims at providing clinical guidance, based on multiple data sources. These data sources originate from monitoring, imaging, targeted diagnostics, pathology, and clinical data. CDS comprises quantification (making information comparable longitudinally and spatially), feature extraction, modeling, reasoning, and (computer-interpretable) guidelines. Clinical guidance will be provided by early warning systems and intelligent alarms, image recognition and interpretation features, diagnostic assistance, therapy monitoring and planning, and outcome prediction.

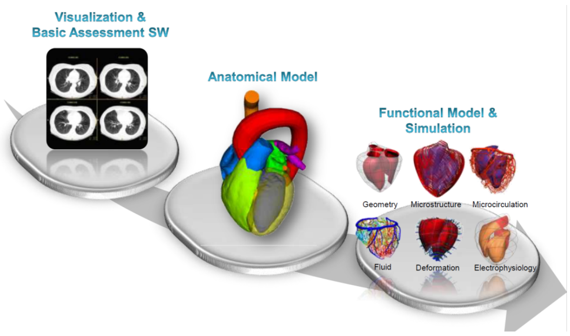


Novel CDS solutions will rely on computer simulation of biomedical and biomechanical processes. These simulations may allow patient-specific assessment and prediction of the development of diseases, and may simulate the impact of (different) treatments, enabling the choice of the best therapy for an individual patient. Forecasting treatment progress using computer simulations is also referred to as *In-silico* treatment.

Clinical Decision Support for Cardiac Interventions

CDS for cardiac interventions aims at more effective therapy planning and monitoring for minimally invasive therapy, adapted to the individual patient. Vast amounts of imaging data are generated for this purpose, which will be made suitable for therapy planning through the tools of quantification, feature extraction, and modeling. Proper modeling allows for planning of effective therapies and monitoring their outcomes. When this is then taken to clinical implementation, many tools and solutions need to be integrated into optimal workflows. The tools for minimally-invasive therapy can be placed in three categories: 'See' – recruiting the information for individual planning (comprising multi-modality imaging, image fusion and analysis, image guidance, procedure planning, and monitoring), 'Reach' – using the imaging information to get to the location of disease in a minimally invasive way (elements include instruments, navigation, robotics, localization), and 'Treat' – effectuating therapy (through diagnostics and staging, and employing therapeutic devices and systems). The logical consequence of the vast range of technologies that is becoming available is that image-guided interventions and therapy is gaining ground in enabling minimally invasive solutions and procedures. Examples of cardiovascular treatments which are being made less invasively are valve repair/replacement, Atrial and Ventricular Septal Defect repair, Coronary Artery Bypass Graft, and Electrophysiological treatments (e.g. to repair arrhythmias). Introduction of minimally invasive procedures results in reduction of patient trauma and improvement of quality of life, while at the same time reducing the length of stay in the hospital and reduction in cost of healthcare.

New software results in efficient inspection of huge data sets, originating from the latest medical scanning equipment. The software will derive quantitative information and produce images that can be used in creating anatomical models, which can be used in therapy. The tools are trained using sample images and can then be personalized using images from the actual patient. An example of how CDS currently is facilitated is through image-guided heart surgery. Using CT or MR scan images, a personalized heart model is generated, which is then used to create a 3D visualization of the patient's heart, during the surgery. The visualization allows accurate navigation of the catheter and very precise treatment, enabling even the most complicated minimally invasive surgeries.



In the future, these image-generated personalized anatomical models should evolve to functional models and simulation models of all aspects of organs, such as the human heart: geometry, microstructure, microcirculation, fluid dynamics, deformation, and electrophysiology. Philips cooperates with many partners, including clinical and academic groups, in the European FP7 euHeart project to create these anatomical models and simulations, and make them ready for application in practice.

Clinical Decision Support for Oncology

In this case, CDS has the ambition to assist choosing therapies with the best outcome, tailored to the individual patient. This involves accurate prediction of outcomes of therapies, based on patient data. In oncology it is very important that treatment is highly personalized, because cancer is a hyper-complex disease. Today, treatment decisions are based on a statistical approach, based on interpretation of treatment results across a wide set of patients, in many cases falling short in selecting the best approach for the individual patient. However, using CDS, cancer treatment aims to take into account the individual cancer biology.

In order to develop CDS in cancer treatment, models are needed that form mathematical representations of the biological reality. These models are able to translate available data into meaningful information. Multi-level models should take into account different kinds of treatments, such as surgery, radiotherapy, chemotherapy, new personalized medications, enabled by novel, targeted drugs, and interventional radiology. Personalization of the models in this case is not only provided by imaging data, but is further driven by inputs obtained from biopsy materials, enabling access to pathological characteristics and gene/protein expressions, and by radiobiological and pharmacodynamic parameter estimates. Also in CDS for Oncology, image processing plays an important role.

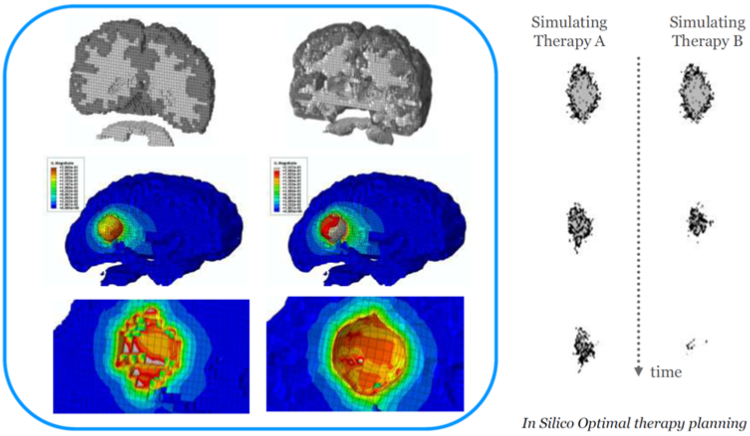
The personalized models should allow for simulation of the effects of different candidate treatments, which should result in accurate prediction and evaluation of the patient's reaction to those candidate treatments. Also, the simulation should result in construction of the optimal treatment schedule. This In-Silico treatment is referred to as 'multi-modal therapy optimization'.

In this context, the Philips Research participates in the European FP7 ContraCancrum project, again with clinical and academic partners, focusing on molecular-level simulations, biochemical modeling, and molecular statistical models of response to therapy. This results in a cellular and higher biocomplexity level simulator, which is based on a discrete event cytokinetic model of cancer. The simulator also contains medical image analysis modules. At the biomechanical level, the simulator provides interaction between cellular simulation and biomechanics, predicting tumor growth and its effects on normal tissue. Through a combination of cellular-level, molecular level, tissue level and tumor-level models, the multi-level simulator aspires to predict the influence of therapies on cancer growth and thereby allows selecting the optimal therapies.

Clinical Decision Support for Early Warnings and Alarms

Two kinds of medical uses of early warning systems will be described: monitoring development of complications during patients' stay in intensive care units, focusing on avoiding the development of sepsis, and home monitoring of patients with congestive heart failure.

Sepsis is the second leading cause of death in intensive care units (ICUs). Sepsis is a serious medical condition that is characterized by a systemic inflammatory state, and the presence of a known or suspected infection. Currently, the identification of septic patients is based on known signs and symptoms (e.g. fever, chills, heart rate) and clinician's intuition. However, currently available clinical and laboratory parameters are insufficient. Early diagnosis is important for patient outcome. Over the first six hours after the onset of recurrent or persistent hypotension, each hour of delay in initiation of antimicrobial therapy is associated with a mean decrease in survival of 7.6% [9]. It is therefore extremely important to early identify onset of sepsis, and start effective treatment. The Philips product ProtocolWatch allows for intelligent monitoring of patients in the ICU particularly focusing on early detection of sepsis. ProtocolWatch has shown to increase compliance with the Surviving Sepsis Campaign's resuscitation bundle ($p = 0.003$) and a significantly reduced time (over 1 hour) to antibiotic administration ($p = 0.02$) [10].



In Silico Optimal therapy planning

Models of sepsis and other complications in ICUs are based on biomarkers, clinical information and measurements of vital signs. The models can improve monitoring and treatment of patients by providing new clinical decision support features for complications such as pneumonia, sepsis, and acute lung injury (ALI). These models also lead to a better understanding of physiological processes that play a role in the development of such complicated and not yet fully understood systemic complications.

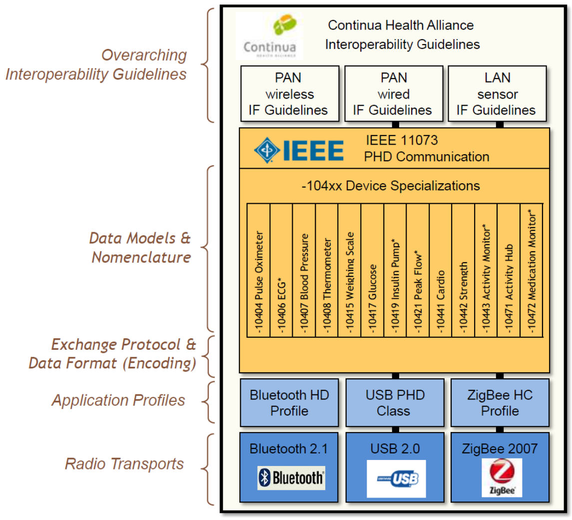
In the USA, 500,000 new cases of Congestive Heart Failure (CHF) are diagnosed annually. This makes CHF the first-listed diagnosis among hospitalized patients. 18% of CHF patients are re-admitted to hospital within 30 days. Using home monitoring systems, 72% reduction in re-admissions was observed in the SPAN-CHF study. In total the cost of avoidable re-admissions after cardiac incidents is $12 billion.

In the future, connected care from hospital to home should be broadly implemented to avoid re-admissions. However, implementation of this paradigm shift impacts the customary clinical workflow, and therefore needs innovation in clinical workflow and business models. Technologies that enable hospital-to-home care comprise: user interaction technology, patient/user interfaces, miniaturization and energy management, wireless communication, approaches that enable life style modifications, e.g. through web and social networks. Heart failure management systems integrate these technologies in the shape of wearable bio-impedance monitors, connected weight scales, connected blood pressure meters, ICD (Implantable Carioverter Defibrillator), and other monitoring systems, and ICT solutions such as PDAs and special web portals.

Philips leads two major European integrated projects: MyHeart (FP6) and HeartCycle (FP7), that have as ambition to define the next generation of tele-monitoring systems. The goal of these projects is to improve patient-centric disease management, and demonstrate its impact on integrated solutions to cardiovascular disease.

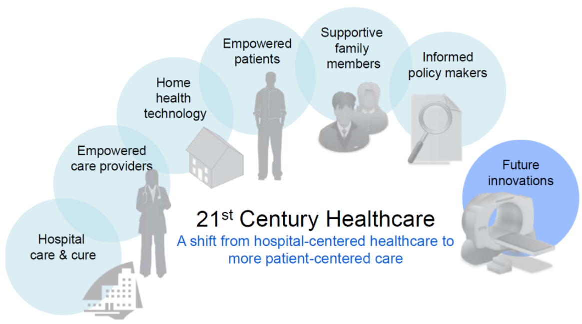
The MyHeart project, now completed, worked on easy-to-use sensors for patents' self-measurement. The developed system analyzed signs of upcoming de-compensation, aiming to allow timely intervention. The project took overarching interoperability guidelines into account from the Continua Health Alliance. Communication with other devices uses standardized interfaces, such as Bluetooth, USB 2.0, and ZigBee 2007. Standardization of technologies and communication protocols is essential for widespread use of telemonitoring approaches.

During the period of the MyHeart observational study (2008 to 2010), 150 patients were involved, at 6 clinical sites in Europe. Patients were followed for 12 months. The project resulted in special textiles with wearable and washable electronics, integrating Electro-Cardiogram (ECG) measurement devices, acceleration sensors, and equipped with an RF link to a base station for recording and storing the data.



mally invasive and personalized treatments, and integrated and remote patient management and follow-up. Other projects focus on monitoring in such different situations as intensive care units and home health management, providing early warning and avoidance of deteriorations . At the same time, modeling efforts will result in better understanding of disease development. This in turn will facilitate better monitoring and yet earlier detection and warning. Eventually clinical data integration will facilitate integrated medical decision taking, improved efficiency, and reduction of medical errors.

In addition, the HeartCycle project aims to provide clinical proof of the advantages of efficient workflows for professionals and patient empowerment. The idea is to have the patients manage their own illness with 'light' medical support. Associated technologies are: management and decision support algorithms, smart clothes and on-body electronics, innovative sensors and patient devices, again linked to a professional platform. The project is following 120 patients from up to four clinical sites in Europe, for 12 months. All patients were recently discharged from hospital after an episode of worsening heart failure. The expected outcomes of the project are: clinical experience in use of clinical algorithms, training packages for patients and health professionals, system deployment, improved diuretic management on symptoms, blood pressure, and renal function, better understanding of impact on daily life of patients, improved outcome compared to traditional control mechanisms. The two large European projects should provide the basis for broad implementation in the healthcare system of integrated solutions with proven clinical outcomes.



All these developments Philips focuses on are people-centered, tailored to patients and health workers, and their needs. in order to implement these solutions, the present clinical systems need to change. In some cases, also clinical workflow and business models need to change requiring input from many disciplines, involving all stakeholders. Healthcare in the 21^{st} century to stay sustainable will need to shift from hospital-centered care to patient-centered integrated care solutions, with proven and measurable outcomes.

Conclusions

Clinical Decision Support can enable smart and effective solutions that impact the whole clinical care cycle, through improved disease understanding, reduction of medical errors, and improved efficiency. Many projects are currently focusing on building and providing clinical evidence of such effective solutions. These projects provide technologies for diverse solutions, ranging from in-silico planning of individualized treatment of cancer, selection and guidance of mini-

Acknowledgements

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Hans Hofstraat completed his thesis (Free University, Amsterdam; awarded by Royal Dutch Shell prize) and post-doctoral work (Eidgenossische Technische Hochschule, Zurich, Switzerland) on low-temperature high-resolution luminescence spectroscopy. Subsequently he turned to marine environmental research, focusing on phytoplankton and eutrophication, and on organic trace contaminants, in the laboratory of the Dutch Public Works Department in Rijswijk, The Netherlands.

He then moved to industry, conducting research in the areas of optical spectroscopy, photonic polymers and in-vitro diagnostics at Akzo Nobel Central Research in Arnhem, the Netherlands. From 1998-2008 he was part-time professor in the Institute of Molecular Chemistry at the University of Amsterdam. In 1998 he was also appointed department head at Philips Research in Eindhoven (the Netherlands), at first of the Department Polymers and Organic Chemistry, and subsequently of the Department BioMolecular Engineering.

In 2003 he was appointed Vice President Philips Research. In 2005 he became Sector Head Molecular Medicine in Philips Research Europe, and globally responsible for the Focal Area Molecular Medicine in Philips Research. Since 2007 he is responsible for Healthcare Strategic Partnerships in Philips Research worldwide, actively driving the Open Innovation approach to Philips Healthcare research program.

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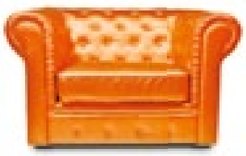


BIJ SIOUX ZIT JE GOED

Hoe jij ook het liefste zit, bij Sioux hebben we een stoel die bij jou past. Tenminste, als jij een softwaretalent bent met minstens zoveel energie als ideeën. Wij bepalen samen de projecten en de rol die het beste in jou naar boven halen. Met een persoonlijk opleidingsbudget van € 6.000,- per jaar werk je verder aan je vermogen om telkens weer grensverleggende oplossingen te ontwikkelen.

We zijn erg blij met de OOTI's die ons helpen de wereld een stuk slimmer te maken. Dat dit gevoel wederzijds is, wordt bevestigd door het grote aantal OOTI's al werkzaam bij Sioux. Als je wilt weten hoe het precies zit, kom dan binnenkort Proefzitten.

SIOUX

www.sioux.eu/proefzitten

System and Software Architecture in Medical Application of Pathology

Hans Kuppens, CCM

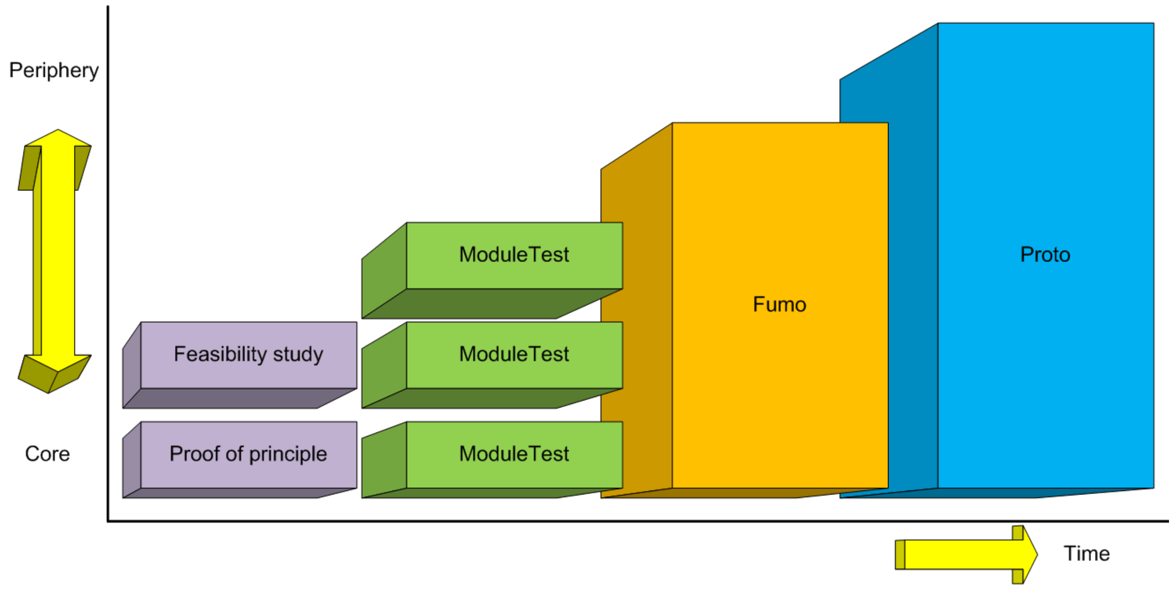
It is commonly known that Brainport Eindhoven has recently been designated as the smartest region of the world. One of the key factors of this success is the way that co-development is embedded in this region. With large and innovative companies like Philips and ASML in the lead, a coherent group of many small business companies are working together on revolutionary and state-of-the-art technological solutions. An illustrative example is the development of the Ultra Fast Scanner (UFS), a high-speed device for automated digitization of slides containing pathological tissue. Philips Digital Pathology (DP) is marketing and servicing this device as part of a total medical application for digital pathology, but also provides and owns the essential core knowledge in this technology area; Prodrive has developed and is supplying the electronics of the UFS, while Frencken accounts to the production and qualification of the sold devices. CCM (Centre for Concepts in Mechatronics) is responsible for system architecture and system integration. Each of the aforementioned companies have an indispensable contribution to the total UFS project.

Co-development

The opportunities that co-development has to offer are speaking for themselves. The specialisms, human resources and facilities of each participating company are deployed in a flexible and effective way. Because CCM was hosting a development room, where all project members worked closely together (the so-called one-room approach), the pitfall of insufficient communication due to physical distances was effectively suppressed. Moreover, the project was organized and managed in such a way that there was no mutual competition; instead, all participants had the same goals and interests, because of a risk-reward involvement, and there was no parochialism or whatsoever in the project team. By consciously creating these conditions, the 'organizational' pillar of the successful co-development has been established.

Risks

But there are more conditions necessary for realizing a successful project. Although all participating companies are organized as a single team, each company still has its own dedicated 'deliverable'. And all these contributed deliverables need to seamlessly match with each other.



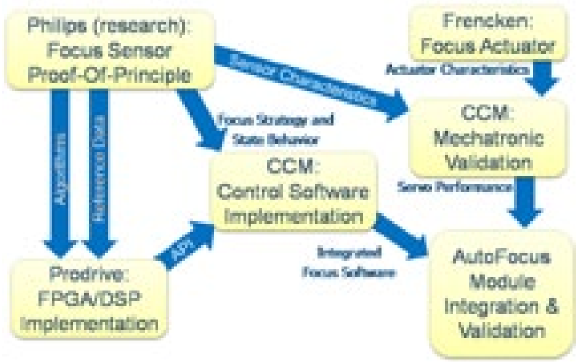
This does not only comprise the 'technical' interfaces (mechanical, electrical, optical, software). At first sight, these interfaces might be well specified in the project definition phase, somewhere at the beginning of the project timeline. But in reality, this is generally not possible due to existing uncertainties. Moreover, matching interfaces between the deliverables do not guarantee that also the composed solution performs as required. Mutual influencing and joint behavior extend across the individual deliverable boundaries, and are hard to predict in the early design phase. These technical problems conflict with generic business requirements: exceeding available financial budgets and time-to-market constraints can turn a technologically advanced solution into a commercial fiasco (specifically for the UFS, there was a demonstration required on an important pathologist's annual meeting, where the competition had to be defeated). The solutions for managing these technical project risks come from the system architects.

Decomposition and phasing

One of the primary tasks of the system architects is to adequately divide the project development activities into smaller workpackages, in such a way that all technical and non-technical project targets are met on time of course. Two approaches, decomposition and phasing, can be combined into an effective development strategy. With decomposition, the development is split up into more or less independent activities. A first separation is logically based on the competences of the participating companies, and each company can split up further and distribute over smaller project teams. The purpose is to do as much as possible in parallel, thus reducing the total lead time. The architect team deals with all issues that go beyond the scope of the individual activities. But that is only part of the story. For challenging projects (such as the UFS), it is important to identify and mitigate all technical risks in an early stage, thereby giving other activities less priority. This is what is accomplished by phasing: define feasibility and 'proof-of-principle' studies for the critical risk items, followed by module development and test for isolated modules. Interaction between modules can be tested in a FuMo (functional model) before finally the first prototype is built and tested. Needless to say is that each phase focuses on the performance to be achieved, without being distracted or delayed by low-risk peripheral components.

AutoFocus

An illustrative example of such a combined decomposition and phasing work breakdown is the development of the autofocus system of the UFS. Without going into technical details, the autofocus system is specifically designed and optimized for good focusing performance on tissue, and consists of a focus sensor with some optics, combined with an actuator that moves the imaging lens to the correct height. The focus sensor produces a data stream that needs to be processed by software before it can be passed through as a setpoint for the focus actuator. The focus sensor including the processing algorithms were identified as a critical risk items. Hence, a proof-of-principle test setup was realized in the very beginning of the project. This yielded essential information for the developers who were assigned with the implementation of the algorithms. In parallel, the focus actuator was developed and validated with the correct mechatronic properties. This all resulted in a short lead time and limited effort needed for integration and validation of the complete module.



Software integration

Another hurdle to overcome are the software risks. With multidisciplinary projects, it is commonly observed that most software errors are introduced during the coding phase, but are detected and repaired during the integration & testing phase. In fact, many errors are caused by the definition of imprecise and incomplete interface specifications, a process which is done even before the coding phase has started at all. Generally, this late error detection and fixing implies lots of rework in a critical phase of the project, with the ultimate deadline nearby. This risk can be mitigated by doing early simulation testing and code reviews, but that will also slow down the overall software development progress; this is always a trade off. Beyond that, 'traditional' software simulation with code running on different platforms that are still under development is not trivial, even when not taking the different participating companies into account. Therefore, a fundamental and revolutionary choice has been made for the UFS project: use a tool for formal model verification, ASD:Suite®[1] . With ASD:Suite®, large parts of the software can be verified mathematically, instead of defining and running tests and testing all possible scenarios, which can be very tedious. Of course, the software still needs to be validated, but that is something which has to be done anyway.

[1] Product of Verum Software Technologies BV

Modeling software interfaces

With the help of ASD:Suite®, all internal and external software interfaces are modeled. This modeling extends the traditional static API definition with dynamic behavioral characteristics. By verifying the software designs against these interfaces, all possible execution scenarios are checked still in the design phase to be precise. So at the start of the hardware-software integration, the majority of the software code was already guaranteed to be free of common defects, such as unspecified behavior, deadlocks, unhandled race conditions, etcetera. The consequences? After a development phase of only one year, the complete system integration phase took no more than 2 months, which is unprecedented for a complex and multidisciplinary device such as the UFS.

The success

Needless to say, the demonstration of the UFS at the USCAP meeting was a great success, prominent pathologists were very impressed, and the competition was defeated with a substantial lead. Thanks to the smartest region in the world, where the competences of the smartest companies in the world are brought together, resulting in the smartest products of the world.

Hans Kuppens is a Principle System Architect at CCM Centre for Concepts in Mechatronics BV. After his study Technical Physics at the Eindhoven Technical University, he started his career at CCM as a system designer. Over the years, he became experienced in the field of optical design, illumination design, vision and image processing, but he also gained expertise in the role as a software architect in complex mechatronic systems. He was deeply involved in the establishment of various projects with a strong physical character, such as the development of illumination systems (ASML), photo-electric measurement equipment (Oce), wafer dicing platform (ALSI), laser beam recorder for Blu-ray mastering (Singulus Mastering). Today, in his most recent project, he has the role of software architect in the development of the Philips Ultra Fast Scanner.

Shaping the Future of Health with Body Sensor Networks

Julien Penders, Harmke de Groot, Chris Van Hoof
Holst Centre/imec, Eindhoven, The Netherlands

The healthcare landscape is changing, driven by societal and demographic pressures. Future health systems will be focused on prevention, on effective provision of continuous treatment, on integrating lifestyle parameters, and will be customized to the individual needs of each patient. Body sensor networks, wireless body-worn sensors monitoring health and bodily functions, stand up to revolutionize the way health services are provided. This article discusses early applications of body sensor networks: a wearable miniaturized necklace for 24/7 cardiac activity monitoring, a headset for brain wave monitoring, and a network of sensors enabling stress monitoring. Remaining technology challenges are highlighted. Overcoming them will lead to the realization of disappearing body-worn sensors, shaping the future generation of health systems.

The New Wave of Healthcare: Wearable, Digital, Wireless

Raising healthcare costs and new demographic, societal and health trends are pressing for a change in healthcare systems. The Continua Health Alliance [1] identifies three major trends calling for a radical change in healthcare systems. The first is a change in lifestyle, shifting towards busier time schedules with little motivation and time left for fitness and health management. As a result, the number of overweight people worldwide is growing, and is now estimated to 1 billion, out of which 300 million of those are clinically obese. Without action, more than 1.5 billion people are expected to be overweight by 2015. Second is the epidemiologic transition from episodic to chronic healthcare needs. Over 600 million people worldwide have chronic diseases. In the US alone, spending is expected to increase from $500 billion a year to $685 billion by 2020. The last, demographic, trend is an ageing society. Globally, the number of persons 60 and older was 600 million in 2000, and is expected to double to 1.2 billion by 2025. This calls for radical changes in how health services are provided, targeting increased efficiency, productivity and usability while controlling cost.

The supporting role of an adequate technology platform is critical. E-health technology, enabling wireless and mobile based healthcare services, is increasingly coined as the revolutionizing enabler for the next decades to come. E-health is claimed to offer the potential to reduce costs and better addresses the requirements of this new wave of healthcare. It holds the potential to enable personalized healthcare, deliver remote health services and increase the delivery efficiency in real-time.

An Enabling Technology: Body Sensor Networks

One key component of e-health is the Body Sensor Network (BSN), consisting of a network of wireless sensor devices centered around an individual person's life and work space, and monitoring health and bodily functions. A personal BSN comprises a series of miniature sensor/actuator nodes each of which has its own energy supply, consisting of storage and energy scavenging devices. Each node has enough intelligence to carry out its task. Each node is able to communicate with other sensor nodes or with a central node worn on the body. The central node communicates with the outside world using a standard telecommunication infrastructure such as a wireless local area or cellular phone network. Experts might then provide services to the individual wearing the BSN, such as management of chronic disease, medical diagnostic, home monitoring, biometrics, and sport and fitness tracking. BSN may also include feedback loops for disease management or drug and treatment delivery within so-called closed-loop systems. BSN provides feedback to the individual about her lifestyle and health status, facilitating behavioral changes towards a healthier lifestyle. The vision for Body Area Networks is illustrated on Figure 1. In this article, we discuss the use of BSN for three applications in the area of cardiovascular, neurophysiological and stress monitoring.

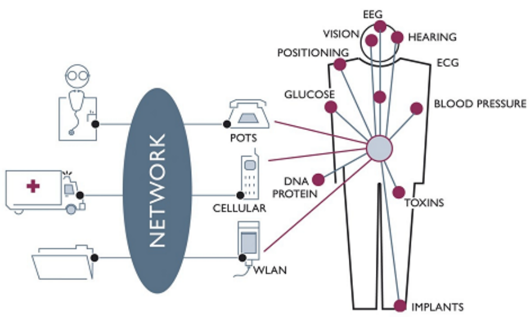


Figure 1: Vision for the year 2015: people will be carrying their personal body sensor network and be connected with service providers regarding medical, lifestyle, assisted living, sports and entertainment functions.

Cardio: ECG 'on-the-move'

Recent advances in low-power micro-electronics have enabled miniaturizing ECG monitoring devices, leading to the multiplication of ECG patches [2] [3]. These patches differ in size, functionality, and use-cases, but all suffer from the same limitation in terms of power consumption. In 2010, our group has developed a low-power wireless ECG platform targeted to ambulatory monitoring [4].

Figure 2: Low-power ECG necklace for 7-day ECG recording on-the-move. Design of the enclosure was realized in collaboration with Koen & Co (Utrecht, The Netherlands).

The low-power ECG necklace (Figure 2) monitors 1-lead ECG (bipolar) and 3D-accelerometer. The core component of the system is an ultra-low-power Application Specific Integrated Circuit (ASIC) for bio-potential readout [3]. The ASIC only consumes 21uA, has a CMRR higher than 120dB (at 50Hz), and an input referred noise of 60nV/vHz. The necklace integrates a low-power microprocessor from Texas Instruments (MSP430), a low-power radio from Nordic Semiconductor (nRF24L01), a 3D accelerometer from Analog Devices (ADXL330), and an on-board SD card. The system is powered by a rechargeable Li-ion battery. Data is transmitted wirelessly to a PC or a mobile phone via a wireless receiver connected to the device (Figure 3). Alternatively, the data can be stored locally for further post-processing. All electronics and battery are packaged in a pendent that can be worn around the neck, or attached to an arm using an elastic band. The size of the packaged necklace is 60mm x 40mm x 10mm, and total weight is about 20 grams.

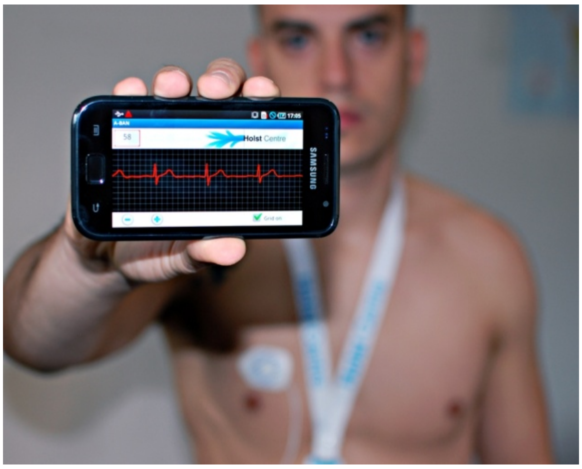


Figure 3: Low-power ECG necklace interface to Android phone, provides 24/7 connectivity to mobile phone services.

The ECG necklace can be operated in continuous streaming mode, in which the data is continuously transmitted to the receiver; or in data logging mode, in which data is stored directly on the SD card. The necklace features two embedded algorithms for local analysis of the ECG signals. Instantaneous Heart Rate (iHR) is computed in real-time from the ECG signal [6], and respiration frequency is estimated from changes in the QRS amplitude. The average power consumption of the entire system is 1.2mA (at 3.3V) when raw ECG (256Hz) and accelerometer (10Hz) data is streamed, 2.3mA (at 3.3V) when the same data is stored on SD card, and 1.8mA (at 3.3V) when the iHR is computed locally and sent wirelessly with the accelerometer data. Depending on the mode of operation, the ECG necklace runs from 3 to 6 days on a 175mAh Li-ion battery.

The ECG necklace provides a generic platform that can be used for different applications. In a pilot study currently on-going, the necklace is used to detect epileptic seizures based on heart rate changes [7]. Tests are run overnight, and standard epilepsy monitoring equipment is used as reference. The system is worn at the arm. An ECG-based seizure detection algorithm is implemented in the system to detect epileptic events in real-time. Events are then transmitted wirelessly to a computer synchronized with the reference system. Three patients have been included in the study so far, and results suggest that major seizures can be detected by the system [7]. In another study, the necklace is used to monitor patients diagnosed with Atrial Fibrillation. Patients wear the system around the neck for a period of 7 days. Data is stored locally for further analysis. Preliminary results (on 1 patient) confirm the good signal quality in daily life activities.

Neuro: EEG brought to home

EEG monitoring is common practice in neurophysiology, and is usually performed in clinical environment, where patients are equipped with gel-based electrodes. Recently the use of EEG has been extended to non-clinical use, mainly for gaming applications [8]. Last year our group reported a new wireless EEG headset that improves reliability and portability of EEG monitoring, illustrated on Figure 4.

Figure 4: Wireless EEG headset takes EEG monitoring out of the hospital environment. The system relies on an ultra-low-power bio-potential read-out ASIC developed by imec, and achieve up to 3 days of autonomy.

The core of the system is a low-power wireless 8-channel EEG monitoring electronics. It allows monitoring of up to 8 EEG signals in a referential configuration, with the reference usually placed at the mastoid. The system relies on an ultra-low-power ASIC for the acquisition of the EEG signal [9], characterized by a high CMRR (120 dB) and low noise (60nV/sqrt(Hz)) . The ASIC features an on-chip low power ADC (11 bits), calibration and electrode impedance measurement nodes, and consumes only 200μW. In addition, the integrated EEG monitoring system includes a low-power micro-controller (TI MSP430) and radio (Nordic nRF24L01) providing local processing and wireless communication functionalities. The overall size of the system is 25 x 35 x 5 mm3. Average power consumption is less than 10 mW when sampling and streaming the 8 EEG channels continuously at 1kHz. For a configuration with one EEG channel sampled at 256Hz, power consumption is down to 3.5mW.

Headset integration is crucial in achieving ease of use, hence enabling EEG monitoring in non-controlled environments. The EEG headset allows monitoring of 4 EEG channels (P3, Pz, P4, Cz) with reference at the mastoid. Commercial EL120 re-useable dry electrodes are used, for their special contact posts designed for use through hair. These electrodes are Ag/AgCl coated resistive electrodes. These electrodes are embedded into specially designed electrode housing, connecting the electrode to the headset, providing mechanical adjustment and tilt, and ensuring signal transmission. The wireless EEG headset has been evaluated for different applications. It shows very good performance in monitoring different frequency bands when compared with reference systems. Odd-ball tests have also demonstrated the possibility to capture the P300 complex, suggesting its applicability for brain computer interface applications.

Emo: managing your stress

Stress has been shown to be a precursor for severe health problems such as hypertension, cardiovascular diseases, and depression. Early detection of stress symptoms, combined with timely therapeutic action achieved through feedback to the individual, has the potential to prevent stress related health problems. Stress is known to activate the Sympathetic Nervous System, and is reflected on physiological signals such as heart rate, respiration, perspiration and skin temperature. By allowing measurement of these signals in daily-life situations, body sensor networks provide a new opportunity towards stress management. In 2009 we have developed a low-power wireless body area network for monitoring Sympathetic Nervous System responses, namely: ECG, respiration, skin conductance and skin temperature [9]. The system consists of a chest belt and a wrist-based device, and is illustrated on Figure 5.

Figure 5: Wireless Body Sensor Network for monitoring physiological signals regulated by the Sympathetic Nervous System. The chest belt measures ECG and respiration; the wrist device measures skin conductance and skin temperature.

The system has been evaluated as a potential tool to measure stress in patients with stress-related psychiatric disorders. The study involved 15 patients and 15 controls, and led to the conclusion that a response to a social stressor can be detected using the system. The data also suggested that there are some differences in features extracted from patients and controls signal. Although additional data would be needed to statistically validate these conclusions, this opens a new perspective towards wearable stress monitoring in daily-life situations.

Summary and challenges

Health services are urged to change due to demographic, societal and epidemiologic pressures. Body Sensor Networks stand up to revolutionize healthcare systems, leading to personalized, delocalized, predictive and more efficient care delivery. A wearable ECG necklace monitors cardiac activity 24/7 for over a week, allowing early detection of cardiovascular disorders. A wireless EEG headset allows monitoring brain activity from home, and may soon provide the means to directly control a computer using brain waves. A network of wearable sensors, distributed on the body, measures physiological responses and may provide indication about the stress level of an individual.

Challenges remain. Today's solutions still consume too much power, which compromises their wearability and miniaturization. Ultra-low-power sensors, sensor interfaces, digital signal processors and radios are needed to drastically reduce power consumption, and thus size, of body-worn sensors. We go on with our lives: health should be mobile. In addition to the power consumption constraints, analog and digital circuits need to deal with the artifact and noise inherently associated to ambulatory environments. This requires innovative signal conditioning and processing approaches to filter or reduce motion artifacts. Algorithms are also required to analyze the data on-the-go. Algorithms shall be distributed over the body sensor network, and each node needs the capability to process data in a power efficient way. Health should be connected. Low-power radio technologies that are interoperable, but do not interfere, with mobile phones or other connectivity devices are needed.

Addressing these challenges will contribute to enabling novel e-Health solutions. What if almost invisible wearable sensors could tell you how you sleep, how you feel, when you are stressed, or how healthy is your lifestyle? The new era of healthcare is near: personal, wearable and digital.

Julien Penders is Program Manager at the Holst Centre / IMEC, where he leads the activities on Body Area Networks. He is responsible for the development of ultra-low-power wearable health monitoring systems and their evaluation in field studies. He has (co-) authored over 30 papers in the field of body area networks and autonomous wireless sensor networks, and is the author of two book chapters on the topic. He serves as a reviewer for IEEE EMBS conference and several journals. Julien holds a M.Sc. degree in Systems Engineering from University of Liege, Belgium (2004), and a M.Sc. degree in Biomedical Engineering from Boston University, MA (2006).

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Abstract: Trends in Biomedical engineering

Peter A.J. Hilbers

Peter Hilbers *is a Professor large-scale Computer Simulations at the Department of Computing Science and Professor BioModeling and bioInformatics at the BioMedical Engineering Department both at the Technische Universiteit Eindhoven. He studied Mathematics at the University of Groningen, where he also completed his PhD study on 'Mapping of algorithms on processor networks' in 1989. From 1989 untill 1996, he worked at the Shell Laboratory in Amsterdam. He was appointed part-time Professor at the Eindhoven University in 1993, and full-time Professor in 1996. His main research interest is on the application of computer science in the areas of biomedical technology, catalysis, and polymer chemistry.*

The goal of the research at the department of Biomedical Engineering of the Technische Universiteit Eindhoven is to further and apply engineering principles and tools to unravel the pathophysiology of diseases and to enhance diagnostics, intervention and treatment. To that end we design new and integrate technological methods from physics, chemistry, electrical engineering, mechanical engineering and computer science to solve (bio)medical problems.

In this presentation we discuss several recent developments in biomedical engineering and in particular we emphasize the role and the challenges of computer science in these developments. We show examples of how molecular modeling methods, systems biology, and parameter estimation techniques are used to construct computational models. With these models biomedical processes and structures such as biomembranes, protein interactions, vesicles and complex biochemical networks and diseases like metabolic syndrome and diabetes mellitus are studied. Results of these studies are presented.

Abstract: National infrastructure for patient information in the Netherlands: goals and challenges

Michiel Sprenger, PhD

The Netherlands National IT institute for Healthcare (Nictiz) & Eindhoven University of Technology, School of Medical Physics & Engineering (SMPE/e)

Michiel Sprenger *was educated in physics at the University of Amsterdam. He did a PhD in solid state physics at the same university. He subsequently worked for many years at the Vrije Universiteit Medical Center (VUmc) in Amsterdam, starting in the physics aspects of clinical magnetic resonance imaging, and subsequently as the leader of the Department of Clinical Physics and Informatics. In 1988 he joined the National Institute for IT in HealthCare (Nictiz) as a senior strategic adviser. In 2010 he joined Eindhoven University of Technology on a part-time basis, being active in the post-graduate educational program for Qualified Medical IT specialists, QMI.*

The creation, in the Netherlands, of a safe and reliable infrastructure for the exchange of patient information is described. It has shown to be a major interoperability challenge, in which solutions have to be found simultaneously on organizational, semantic, and technological levels. The goal is to support safe, reliable and selective exchange of information between healthcare professionals and institutions. A second goal, of which the importance is rapidly growing, is to facilitate patients to be more active in their own health management by granting them access to their information and facilitating applications to be developed for them.

An overview is given of the process of the last 7 years, the recent developments, the current status and the plans for the future.

Abstract: Robotics 4 Healthcare

Jorn Bakker, Chilo van Best
XOOTIC MAGAZINE

This abstract is written based upon the presentation of Stefano Stramigioli (University of Twente) on the Xootic Symposium of 18 March 2011.

The number of people above 65 in the West is increasing and will remain to increase over the coming decades. This rise is due to the fact that we are living longer and our birthrate is relatively low. In 20 years from now, 25 percent of the Western population will be above 65. This means that demand for care will increase even further. Developments in robotics have taken flight during the last decades and will continue to do so in the coming time. Both the amount of technology available and the number of applications are abundant. Where robotics traditionally used to be applied in industry only, there is (will be) a shift in market size from industry to all kind of service robotics applications like home, healthcare, agriculture, and more.

It seems like a natural solution to employ robotics in elderly care. Due to these developments, the European Commission announced a policy to boost European robotics. The European Union doubled its investments between 2007 and 2010 with almost 400 million to support European robotics research. The application of robotics in healthcare will require a paradigm shift in robotics. Where robots in industry are designed to execute specific tasks as fast and efficiently as possible, in healthcare the operational requirements are very different. The environment in which robots operate is more complex. The speed at which the robot should operate and interact is slower. Most importantly, robots will interact with human users, and therefore safety is one of the major concerns. A lot of activities are being carried in order to develop standards and guidelines to ensure safe operation of robots in an environment where humans are present.

In order for the paradigm shift to happen these challenges need to be solved. This, in turn, means that the coming time in robotics will be very exciting. and there will be plenty of scientific and engineering challenges to be solved. For example, to cope with safety, novel actuator technologies have to be developed. This is for example happening in the EU-FP7 FET project VIACTOR: http://www.viactors.org/objectives.htm

Stefano Stramigioli received the M.Sc. with honors (cum laude) in 1992 and the Ph.D with honors (cum laude) in 1998. He is currently full professor in Advanced Robotics at the University of Twente. He is an officer and Senior Member of IEEE. He has more than 160 publications including 4 books, book chapters, journal and conferences contributions. He is currently leading a growing group of about 40 people among which 15-25 Ph.D. students. He has been Editor in chief of the IEEE Robotics and Automation Magazine, which he brought from the seventh to the first place in the ranking of the Impact Factor among all journals on Robotics. He is member of the Editorial Board of the Springer Journal of Intelligent Service Robotics. He has been an AdCom member of the IEEE Robotics and Automation Society, he is currently chair of the Electronic Products and Services of the IEEE Robotics and Automation Society and he is the Vice President for Membership of the same society. Nationally, he is a member of the Management team of the graduate school DISC, the chair of RoboNED, the national platform coordinating all academic, industrial and governmental institutions on Robotics and responsible for producing a Strategic Research Agenda for Robotics for the Netherlands and he is one of the initiator of the LEO (www.leo-robotics.eu) robotics center. He has been the 2009 recipient of the IEEE-RAS distinguish service award and he is a member of the 3TU Center of Excellence on Intelligent Mechatronics Systems.

Results of the 2009 XOOTIC Survey

Chilo van Best
Roxana Frunza, Panagiotis Georgiadis, Harold Weffers

In this article we present you the results of the 2009 Xootic Survey. The Survey gives a great insight into the lives of our OOTIs and fellow XOOTIC's (ex-OOTIs). You will enjoy this article particularly if you have a passion for numbers. Many, many numbers.

Introduction

Every two years, the XOOTIC Survey Committee carries out a survey with the following goals:

- Give insight to current OOTIs and XOOTIC's on potential future careers
- Give insight to XOOTIC's on what their XOOTIC-colleagues are currently doing
- Give insight to OOTI-management on how skills taught at OOTI are used in practice and what practical skills need to be taught at OOTI
- Give feedback to the Xootic board and members on our alumni organization

The 2009 Xootic Survey was a special one. For the first time, the survey was carried out online using the SurveyGizmo[1] web site with no additional cost. Not only did this way of working save a lot of time (and money!) for sending around all the paper surveys (only to those XOOTIC's whose addresses were available), it also saved an awful lot of time: processing the paper results manually, a tedious task, was replaced by (the still a bit tedious) task of copy-pasting from one Excel sheet to another. This also reduced the human factor (less copying errors). A bonus was that survey results were now arriving from distant countries like the United States and Australia as shown in Figure 1. It was a true global survey.

Probably thanks to the results from other continents and the ease of filling in an online survey, the response was higher than ever: in the previous record year 2000, 88 filled-in surveys were received, but in the last survey, this record was broken with 93 surveys! 44% of the 210 “sent surveys"' (or in this case: e-mails with an invitation) were returned (led to results). This was the highest response rate since 2000 (47%).

[1] http://www.surveygizmo.com/

The OOTI Population

The OOTI population is gradually changing from mostly Dutch to non-Dutch. Only 2/3 of the respondents still had their professional education in the Netherlands. There is not much difference between bachelor and master education: 61% had their bachelor in the Netherlands, 10% in Romania , and 3% in other countries; 67% had their master in the Netherlands, 10% in Romania, and 4% in other countries. As in the previous survey, 60% of the latest generations had their master outside the Netherlands.

More and more people joining the OOTI program already have a few years of work experience (since 2001, more than 50% had a job before joining OOTI).

Employers and Employment

Having a job as an XOOTIC is still easy: only 1% of the XOOTIC's is unemployed. 98% has either an (in)definite contract or a freelance contract (2%). Over 3% checked the 'other' category, which includes finite contracts over some months. By far the most XOOTIC's have an indefinite contract (82.6%).

Our most important employers are flexible staff companies (27.17%), although their importance seems to be decreasing. Younger people work at smaller companies.

XOOTIC's do not like job hopping: 89.2% had between 1-3 employers. 61% of the XOOTIC's who

Figure 1: Worldwide Xootic survey responses

are currently not working part-time want to work part-time. It seems in contrast with the popularity of flexible staffing companies, where it is relatively hard to work part-time. Only 11.8% of the respondents are already working part time.

When looking for jobs, XOOTIC's select them with a focus on job activities and carreer perspective. The way XOOTIC's get a job is changing rapidly: only 13% found their job using open applications (2006:27.7%), while 23.9% found their job using a job advertisement (2006:12.3%).

Job Function and Ambition

The job functions XOOTIC's have are as follows: 44.5% of the XOOTIC's are now software engineers, 15.2% are software architects, 6.5% are researchers/scientists, 6.5% are system architects, 4.3% are heads of department and 4.3% are project leaders.

Note that Figure 2 does not show all the categories and therefore the percentages do not sum to 100%. The functions are ordered in percentages of 2009.

Comparing this to the results of 2006, it is interesting to note that the percentage of software engineers was then only 26% as illustrated in Figure 2. This means the share of software engineers has almost doubled. This is in great contrast with the ambition of XOOTIC's: only 5% wants to work as a software engineer in 5-10 years. System architect/analyst and management jobs are desired but not yet attained functions.

XOOTIC's are involved in all phases of software engineering process, no matter what their functions are.

The technical contents of XOOTIC jobs have not changed much since 2006. The majority are still using XML, C, and C++ (each is used by about 65% of XOOTIC's). XML and C++ both grew about 10% in popularity.

The technical skills not used in the OOTI program have changed considerably since 2006. Agile development went from 32% to 67%, rapid development from 23% to 43%, and web technology from 21% to 42%.

The popularity of working abroad (outside the Netherlands) is increasing: in 2006, 45.0% wanted to work and live abroad; in the 2009 survey, this number had increased to 49.4% and the part of XOOTIC's already working abroad had risen from 0 to 4.3%. This means the people who did not want to work or live abroad dropped with about 10%.

XOOTIC's are less sure about their career path: the percentage worrying about it went from 26.0% to 34.4%.

The OOTI Program

The OOTI program is known in the industry according to 80% of the answers and is rewarded according to 44% of the respondents.

XOOTIC's think that OOTI program provided them with better technical skills; the non-technical courses are much appreciated and used (technical writing 92% and meeting techniques 88%).

XOOTIC's, considering what they know now,

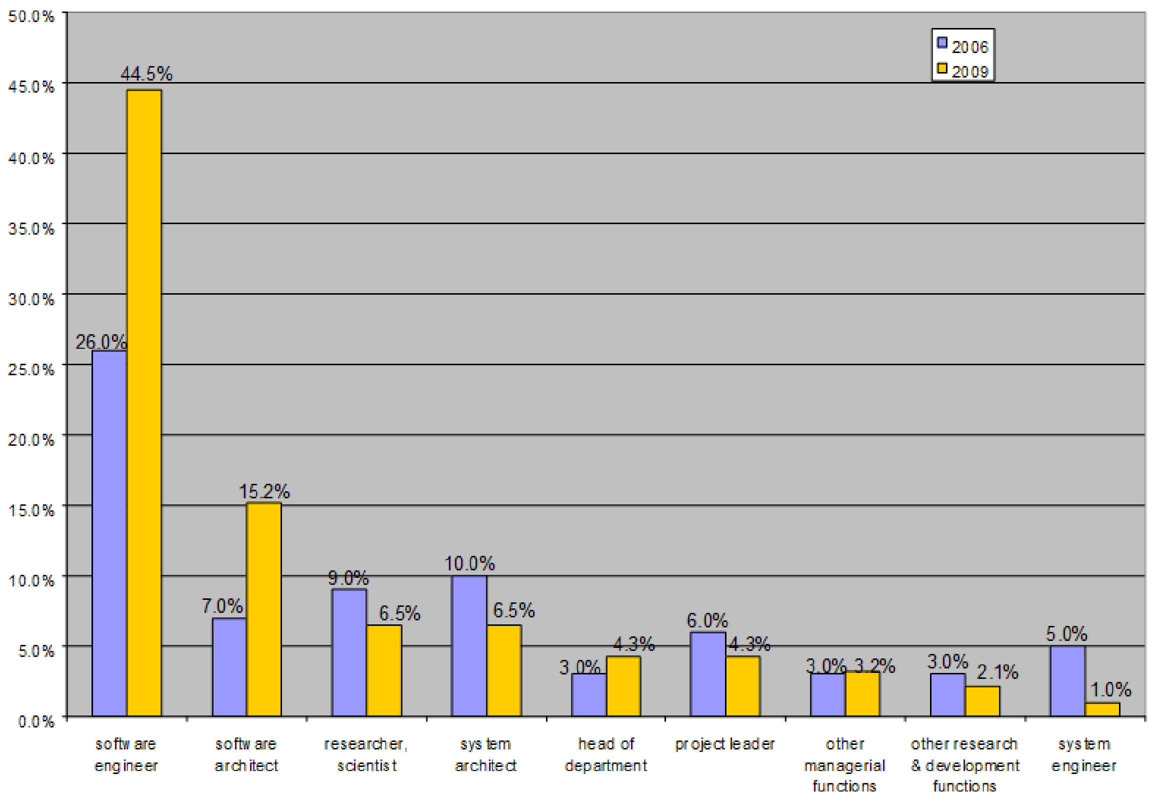

Figure 2: Distribution of job functions

would still do the OOTI program (96.7%). They do not use their PDEng title (47.8%) or they use it only sometimes (31.5%).

These numbers are not much different from 2006.

Our Association

The Xootic website slowly becomes more popular. New techniques are carefully appreciated. Of the respondents, 37.6% would subscribe to Xootic RSS feed (40.8% would not).

Younger people visit Xootic events more often. About 80% of the XOOTIC's since 2001 visited Xootic events in the last two years (2008 and 2009), significantly more than the 35% of the XOOTIC's until 1991.

Suggestions for future magazines or lectures are:

- Agile development
- Model-driven design
- Virtual worlds and gaming
- Robotics/artificial intelligence
- Processing on GPUs and Cell processors
- VMWARE and virtualization techniques

Suggestions for Xootic and its activities:

- Get more senior XOOTIC's active
- Have "lunch meetings" at places like High Tech Campus where lot of XOOTIC's work

OOTI 20 Years: Comparison with 1998

As OOTI exists for 20 years, it is nice to compare old surveys with the latest survey. The oldest survey we could get was from 1998 (it mentions surveys from 1993). From the article we could discover some interesting numbers from 1998:

- Top-3 jobs: software engineer 26%, researcher 17%, project leader 15%
- Top-3 disciplines at work: Electronics, information technology, and telecommunication (48%, 40%, and 38% respectively; these numbers are now 40%, 75%, and 25%).
- Top-3 programming languages: C++, C, and Java

The article further mentions a jealous-making 77% response rate in 1993.

Conclusions and Future Work

Comparing the data with 2006, there are not many differences. The only remarkable difference is that many more people are software engineers. We can enthusiastically conclude that bringing the survey online was successful. Not only did it save a lot of work, it also enabled XOOTIC's from other continents to join the survey, thereby improving the quality of the results. The response was very high.

We hope that a next Survey Committee would improve automatic processing of the survey results. This will increase the ease and accuracy of making the Survey. Using infographics will make future reports visually attractive. Adding a time estimate might convince people to fill in the survey. We envision that later Survey Committees may not be needed: a board member can then push a button to send the Survey, wait a month for the results, and write a short article for the Xootic Magazine.

We would like to thank all XOOTIC members who returned their questionnaire for their cooperation and their time.

The Xootic Survey 2009 Committee:
Chilo van Best
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Harold Weffers