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ERCIM NEWS

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Special theme:

Augmented Reality

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A Structured Approach to Defence Simulation Training

REVERIE – Real and Virtual Come Together in a Virtual Reality

ERCIM News is the magazine of ERCIM. Published quarterly, it reports on joint actions of the ERCIM partners, and aims to reflect the contribution made by ERCIM to the European Community in Information Technology and Applied Mathematics. Through short articles and news items, it provides a forum for the exchange of information between the institutes and also with the wider scientific community. This issue has a circulation of about 6,000 printed copies and is also available online.

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Next issue
January 2016, Special theme: Life Science

JOINT ERCIM ACTIONS

SPECIAL THEME

The special theme section "Augmented Reality" has been coordinated by Constantine Stephanidis, FORTH, and Eija Kaasinen, VTT.

RESEARCH AND INNOVATION

This section features news about research activities and innovative developments from European research institutes

EVENTS, IN BRIEF

ECSS 2015: Informatics in the Future – in the Year 2025

Vienna, Austria, 12-14 October 2015

ECSS 2015 is the 11th Summit of Informatics Europe. This major event, held in Vienna, Austria, 12-14 October 2015 is designed as the meeting place for anyone interested in issues of research, education, and policy in Informatics. The central topic of the 2015 Summit is "Informatics in the future – in the year 2025".

In view of closer cooperation between ERCIM and Informatics Europe, we present the keynotes of this event, of undoubted interest to the ERCIM community and the ERCIM News readership.

The background of ECCS 15 is the idea that informatics as the science behind Information Technology has two faces:

- informatics "in itself", e.g. algorithm, design, information presentation, programming languages, distribution aspects, complexity issues;
- informatics "for others" and "behind others", as a tool or methodological approach in other sciences and application fields. It is pervasive and changes the world, with its artifacts and also its vision.

Informatics is interdisciplinary quasi by nature, with engineering, formal methods (logics, maths) and natural science based approaches. The conference will discuss and reflect on research issues and methods, with a 10-year perspective.

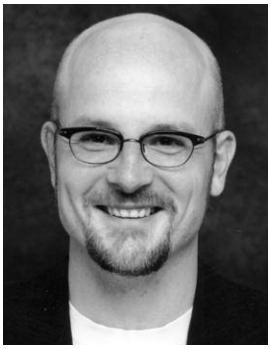
ECSS is a unique opportunity to meet some of the leading decision makers in informatics research and education, and discuss the critical issues of the discipline. The Summit is devoted to strategic issues and trends regarding all aspects of informatics: education, research, funding, entrepreneurship, management, career development, and policies.

Traditionally, ECSS conferences are organized by Informatics Europe in collaboration with a host institution, active member of the association. ECSS 2015 is hosted by the Faculty of Informatics, Vienna University of Technology (TU Wien).

ECSS 2015 is co-chaired by Carlo Ghezzi, President of Informatics Europe, and Gerald Steinhardt, Dean of Faculty of Informatics, TU Wien. The program chairs are Hannes Werthner, professor at the Faculty of Informatics, TU Wien and Frank van Harmelen, Department of Computer Science & The Network Institute, VU University Amsterdam.

More information:
http://www.informatics-europe.org/ecss/ecss-2015.html

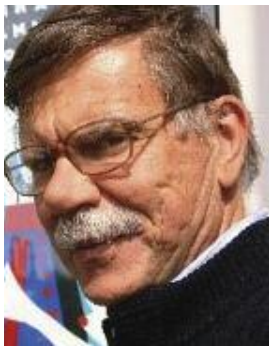
ECSS 2015 Keynotes



Dirk Brockmann:
Ebola, Pandemic Influenza, MERS & SARS – How Computational Models Reveal the Hidden Geometry of Global Contagion Phenomena

The last decade has witnessed the emergence and global spread of new, often highly contagious and virulent pathogens that spread across the globe in a matter of weeks or months. Emergent infectious diseases have not only become a key threat to global public health, but carry the potential of yielding major economic crises. Understanding and predicting the geographic spread of emergent infectious diseases has become a major challenge to epidemiologists, public health organizations and policy makers. Large-scale computer simulations that harbor methods from statistical physics, complex network theory and dynamical systems theory have become a key tool in this context.

Dirk Brockmann is professor at the Institute for Theoretical Biology at Humboldt Universität zu Berlin. He also leads the research group at the Robert Koch-Institut Berlin, Germany's federal Public Health institute.



Stefano Ceri:
On the Big Impact of Big Computer Science

Big science is bringing unprecedented progress in many fundamental fields, such as biology and medicine. While progress cannot be questioned, when looking at the foundations and models of big science, one wonders if this new approach is in contrast with critical thinking and model-driven scientific methods - which have shaped for decades higher education in science, including computer science. Computer Science education is changing due to the impact of big science, in some cases for better, in other cases for worse, and the question seems to be whether Academia is a good fit for data scientists. New models are needed for interdisciplinary education.

Stefano Ceri is Professor at Politecnico di Milano. He is currently leading the PRIN project GenData 2020 on genomic computing. He is the recipient of the ACM-SIGMOD "Edward T. Codd Innovation Award" (2013), an ACM Fellow and member of the Academia Europaea.

Jeroen van den Hoven:
Ethics and ICT: Learning to Design for Moral Values

ICT is a formidable shaping force in society. We need to treat it as such. This implies among other things that we need to shape it to express and accommodate our shared moral values and ethical considerations (e.g. regarding privacy, autonomy, responsibility, transparency, democracy, equality, social justice, safety, etc.). The more central big data, Internet (of everything), mobile and cloud computing, social media are becoming in our society, the more urgent the need is to educate the next generation of computer scientists to appreciate this and to help ourselves to the methodologies, tools and conceptual frameworks that support us in shaping our future and destiny by means of responsible innovations in ICT.

Jeroen van den Hoven is full professor of Ethics and Technology at Delft University of Technology, he is Founding Editor in Chief of Ethics and Information Technology (Springer). He won the World Technology Award for Ethics in 2009 and the IFIP prize for ICT and Society also in 2009 for his work in Ethics and ICT.

Maarja Kruusmaa:
Interdisciplinarity in Robotics and ICT

Robots are cyber physical systems interacting with the physical world through their sensors and actuators. Robotics is an inherently interdisciplinary area comprising engineering fields, such as mechanical and control engineering, as well as computer engineering and computer science but possibly also other disciplines, such as biology or cognitive science. There are challenges in education, research and development of robots in the context of current technology trends that predict further emergence of virtual and physical worlds, the drive towards large autonomy and the rise of consumer robotics.

Maarja Kruusmaa is a professor of Biorobotics and the head of the Centre for Biorobotics in Tallinn University of Technology. She is also a cofounder of a company Fits.me using robotics technology in a novel way and involved in policy making in ICT though several advisory bodies, such as EU DG Connect Advisory Board.

Bertrand Meyer:
Ethics of Computing

Recommending ethical principles is risky business: the basis for the recommendation should be universal, yet people differ in their assumptions; and the recommendations should be credible, but no one is beyond question. For prudence, the general ideas justifying the ethical advice are minimal but there are general ethical guidelines that can help progress in computing.

Bertrand Meyer is an entrepreneur, author and academic specializing in software engineering. He created the Eiffel programming language and the idea of design by contract. Since 2001 he is Professor of Software Engineering at ETH Zurich.

Dunja Mladenić:
Leadership and Balance in Research

Successful leadership of a large research group (approx. 50 people) requires clear philosophical alignment fundamentals shared between all the members of the team. This includes maintaining a common vision and high enthusiasm towards achieving results (no nonsense rule). In order to be sustainable in the long term, we have to maintain the flow of: (a) knowledge/experience, (b) social network of partners, and (c) constant funding. The organization of the team should be preferably flat (but not too flat) with well defined roles, but also as fluid as possible (no rigidness rule) facilitating personal and group progress. One of the fundamentals is to develop trust between people and maintain good human relationships within the team (no fighting rule).

Dunja Mladenić works as a researcher and project manager at J. Stefan Institute, the leading Artificial Intelligence Laboratory and teaching at the J. Stefan International Postgraduate School, University of Ljubljana and University of Primorska.

Reinhard Posch:
ICT-Innovation – How Digital Sovereignty and IT-Security Can Help to Push Europe Forward

With the Digital Single Market and the supporting programs H2020, CEF, ISA2 and others, Europe is making a big effort to shape up its ICT. This is also supported by legislation where IT-security plays an excelling role. Not only is the eIDaS regulation an example offering a seamless legal framework for all 28 member states, it is also a unique chance for Europe to show its ICT-strength. The open and innovative approach needs to attract European industry as a provider, and businesses as major enablers. IT-security and data protection need to enable digital sovereignty. These are fields where Europe has developed renowned expertise in the past and has the potential to develop further strength in the future.

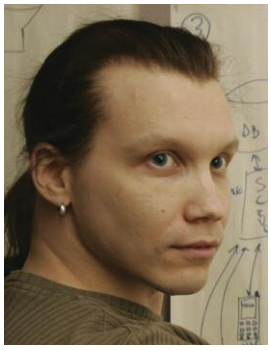
Reinhard Posch is professor at Graz University of Technology since 1984. As of 1999 he is also Scientific Director of the eSignature confirmation body "Austrian Secure Information Technology Center" (A-SIT) and Federal Chief Information Officer for the Austrian Government since 2001.

Britta Schinzel:
Ada Countess of Lovelace, a One-Person Opera, and The Role of Women in Computing

The first "programmer" of a mechanical computer, Charles Babbage's "Analytical Engine" comparable to today's programming procedures, was Ada, Countess of Lovelace. She was the daughter of Lord Byron and Lady Milbanke and, like her mother and her mentor Mary Somerville, she was very interested in science and mathematics. She welcomed all technical innovations of her age, the first railways and telegraphs, and the detection of the role of electromagnetism. She translated a French publication of a lecture held by Charles Babbage and extended his ideas to compute the Bernoulli numbers with a specification of the elementary operations of punched cards and the program structure of their ordering, one of today's flow diagrams. In the first part of this lecture, some of Ada's ideas are illustrated through in the presentation of a one person opera on her life. The second part of the talk goes on to highlight the role of women in general in the history of computing, programming and computer science. Currently, the number of women participating in computer science studies is gradually decreasing in western countries, while this is not so in the rest of the world. Reasons for these differences will be discussed.

Britta Schinzel was professor at RWTH Aachen in theoretical computer science, and worked within several areas of Artificial Intelligence, in interdisciplinary cooperation with medicine, biology, sociology etc. Since 1991 she is professor at the Institute for Computer Science and Social Research at University of Freiburg.

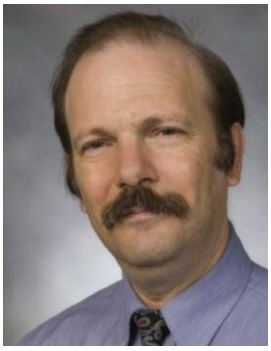
Matti Tedre:
A Computational Paradigm of Science and its Discontents



A number of theoretical and technical innovations in the 1930s and 1940s led to a new era of computing, and computing started to develop as an independent academic discipline. Some pioneers of computing emphasized the theoretical elements of science, advocating a mathematical view of computing as a discipline. Others distanced computing from natural sciences and championed for academic legitimacy of sciences of the artificial. At the time when experimental computer science debates emerged, many meta-studies compared research in computing with natural sciences and engineering, condemning computing as methodologically deficient. But in the new century, the success of computing in many scientific applications made computing, in the minds of many, a "paradigm" for other sciences: Computing can learn from nature, or it might be the best tool for studying natural phenomena, or it might actually be what nature does. The journey of computing is a nascent young field struggling for legitimacy of the vision that computing might not be only "a" science but "the" science.

Matti Tedre is the author of "The Science of Computing: Shaping a Discipline" (Taylor & Francis, 2014). He works as associate professor at Stockholm University, Department of Computer and Systems Sciences. Tedre was professor and head of IT program at Tumaini University, Tanzania, an adjunct professor of computer science at the University of Eastern Finland, and adjunct professor of Informatics and Design at Cape Peninsula University of Technology, South Africa.

Moshe Vardi:
From Model-Driven Computer Science to Data-Driven Computer Science and Back



Computer science seems to be undergoing a paradigm shift. Much of earlier research was conducted in the framework of well-understood formal models. In contrast, some of the hottest trends today shun formal models and rely on massive data sets and machine learning. A canonical example of this change is the shift in AI from logic programming to deep learning. Two examples of this trend are relational vs. graph databases and formal vs. dynamic verification. However, in each case the data-driven approach does not replace the formal-model approach; rather the data-driven approach is supported by the formal-model approach.

Moshe Vardi is the George Distinguished Service Professor in Computational Engineering and Director of the Ken Kennedy Institute for Information Technology at Rice University. He is a member of the US National Academy of Engineering and National Academy of Science, the American Academy of Arts and Science, the European Academy of Science, and Academia Europaea. He holds honorary doctorates from Saarland University in Germany and Orleans University in France. He is the Editor-in-Chief of the Communications of the ACM.

Zuzana Kúkelová Receives the 2015 Cor Baayen Award

Zuzana Kúkelová from Microsoft Research Cambridge, UK, is the winner of the 2015 Cor Baayen Award. Zuzana is a young scientist who delivered original scientific results on the border of applied mathematics and engineering, excelling in the discipline of applied and computational algebraic geometry and in geometry of computer vision.

Zuzana's work is building a bridge between highly abstract mathematical results, such as algebraic geometry, and engineering applications. This is highly relevant for all of society. Zuzana's work benefits engineering by offering many excellent mathematical solutions needed to develop computational techniques for applications such as Google's and Microsoft's 3D maps and image search.

In her thesis, defended in 2013 at the Czech Technical University in Prague, Faculty of Electrical Engineering, Zuzana worked on using algebraic techniques in computer vision. The main contribution of her work is the understanding and systematic use of algebraic tools for solving systems of polynomial equations in computer vision. She constructed a number of new minimal solvers in geometry of computer vision and also demonstrated how the algebraic techniques are interconnected and how they can be efficiently used to solve practical problems. An important result of her work was the development an automatic generator of specialized polynomial solvers. With the generator at hand, it becomes possible to test alternative formulations of a problem and to search for such formulations that provide useful specialized solvers. This was not possible before, since existing computer algebra systems were always primarily focused on providing completely general solvers and did not address the issues arising when special efficient solvers are needed. Her work was instrumental in solving a number of important practical problems in camera calibration and 3D reconstruction from images. With her PhD theses, Zuzana won the Antonin Svoboda award for best thesis of 2014 bestowed by The Czech Society for Cybernetics and Informatics.

In her short career, Zuzana has already presented and published an impressive number of papers at first quality scientific conferences and journals. She is also reviewer of a number of major computer vision journals and conferences.

Zuzana graduated in in Computer Science at the Comenius University, Faculty of Mathematics, Physics and Informatics, Bratislava, Slovakia. She received her doctoral degree in Mathematical Engineering (Computer Vision) at the Czech Technical University in Prague, Faculty of Electrical Engineering, Prague. She is currently postdoctoral researcher at Microsoft Research Cambridge, UK.

The Cor Baayen Award is given each year to a promising young researcher in computer science and applied mathematics. The award was created in 1995 to honour the first ERCIM President.

Nominees must have carried out their work in one of the 'ERCIM countries', in 2015 these included Austria, Belgium, Cyprus, Czech Republic, Finland, France, Germany, Greece, Hungary, Italy, Luxembourg, Norway, Poland, Portugal, Spain, Sweden, Switzerland, The Netherlands and the United Kingdom. The selection of the Cor Baayen award winner is the responsibility of the ERCIM Human Capital Task Group. The Call for nominations for the 2016 Cor Baayen Award is expected to be published in February 2016.

More information:
http://www.ercim.eu/activity/cor-baayen-award

2015 Cor Baayen Award

Winner:
- Zuzana Kúkelová, Microsoft Research Cambridge

Honorary mentions:
- Michele Coscia, CNR
- Marco Lorenzi, University College London

Other finalists:
- Pierre-Evariste Dagand, CNRS
- Natalia Diaz Rodriguez, Philips Research
- Julio Cesar Dos Reis, University of Campinas
- Bart de Keijzer, Sapienza University of Rome
- Henry Joutsijoki, University of Tampere
- Marco Lorenzi, University College London
- Dimitrios Schinianakis, Nokia
- Rebecca Steinert, SICS

The D-CENT Project: Decentralized Social Software for Political Autonomy

by Harry Halpin

D-CENT develops applications for the common good ranging from community-currency blockchains to collective legislation drafting.

D-CENT (Decentralised Citizen ENgagement Technologies) is a research project developing digital tools for political autonomy, and aiming at the particular concrete cases of direct democracy and economic empowerment. As an alternative to closed and centralised internet platforms whose business models crucially rely on monetising the identity and social lives of their users, D-CENT aims to create a uniquely European open and decentralised approach aimed at empowering ordinary citizens to take action for the common good. Given the vision of Europe itself as a federation that crosses linguistic and cultural barriers, the D-CENT project hypothesizes that such an federated approach may be more successful in the long-term than trying to naïvely replicate Silicon Valley in Europe.

Part of the Collective Awareness Platforms effort since October 2012, the goal of the project is to build this alternatives by bringing together hackers, academics, and policy makers with a large number of activists throughout Europe to tackle pressing social and ecological problems [1]. Indeed, the project consortium, co-ordinated by the British innovation policy think-tank Nesta, brings together some of the most exciting democracy activists and researchers in Europe, including both Forum Virium in Finland, International Modern Media Institute and Citizen's Foundation in Iceland, and the Open University of Catalunya and Barcelona Media in Spain, Open Knowledge Foundation and Thoughtworks in the United Kingdom, Centre d'economie de la Sorbonne (CNRS) and the World Wide Web Consortium (W3C)/ERCIM in France, and Dyne.org in the Netherlands.

The basic building blocks of D-CENT are open standards for a distributed identity management system that encourages autonomous control over social data. The foundation for this system is a privacy-aware OAuth-based system called "Stonecutter". This system is designed to be easy for community groups to set-up and host, allowing users to authorize access to their data for use in various applications from an easy-to-use dashboard without resorting to centralized platforms [2]. With support of D-CENT, the World Wide Web Consortium launched the W3C Social Web Working Group in order to build the standards necessary to allow decentralised applications to be able to easily share extensible status-updates, called "activity streams." Chaired by Tantek Çelik (Mozilla) from IndieWeb, Evan Prodromou (identi.ca and status.net), and Arnaud LeHors (IBM), the 46-person Working Group has already published a public Working Draft of the ActivityStreams 2.0 standard and in the future will produce a unified Social API. Tim Berners-Lee, the inventor of the Web and Director of W3C, has taken a personal interest and is currently focussed on his own design for re-decentralizing the Web called "CrossCloud."

This open-infrastructure is meant to enable various decentralized applications for the common good. For example, today there are no applications that allow people to self-organise online and draft their own proposals for everything from policy documents even to legislation, and then vote on the results. Using a decentralized architecture in D-CENT, proposals will be able to start from the bottom-up and then be modified and applied across different contexts, ranging from neighborhood assemblies to cities to nations, even at the European level. Another line of research of D-CENT investigates the use of community currencies and the possibility of using a blockchain-based architecture to create a Bitcoin for the social good.

While these projects may seem wildly ambitious, D-CENT has already attracted interest from a number of digitally-savvy political parties ranging from Spain's Podemos to the Icelandic Pirate Party – all of whom have seen spectacular leaps in popularity recently. D-CENT is committed to having its software open-source and available for any political party, government, or grassroots initiative. The stakes are high: Whether or not ordinary people can use these tools will spell the difference between a smart cities "controlled by a small elite group" or a "democratic city" based on a digital autonomy that allows meaningful political participation in the digital age [3].

Social Web Working Group meeting at INRIA in Paris

Links:

D-CENT Project website: http://dcentproject.eu

W3C Social Web Working Group: http://www.w3.org/Social/WG

References:

[1] F. Sestini: "Collective Awareness Platforms: Engines for Sustainability and Ethics," IEEE Technology and Society Magazine, vol.31, no.4, 2012.

[2] H. Halpin, B. Cook: "In Annual Privacy Forum Limassol, Cyprus, 2012, pp. 125-139.

[3] A. Pentland: "Social Physics", London, UK: Penguin Press, 2014.

Please contact:

Harry Halpin, W3C

E-mail: harry@w3.org

BlueBRIDGE - New Data Services for an Ecosystem Approach to Fisheries

BlueBRIDGE is the new European initiative funded under the H2020 framework to further develop and exploit the iMarine e-Infrastructure data services for an ecosystems approach to fisheries.

BlueBRIDGE's overall objective is to support capacity building in interdisciplinary research communities actively involved in increasing scientific knowledge about resource overexploitation, degraded environment and ecosystem with the aim of providing a more solid ground for informed advice to competent authorities and to enlarge the spectrum of growth opportunities as addressed by the Blue Growth Societal Challenge.

BlueBRIDGE capitalizes on past investments and uses the proven D4Science infrastructure that counts over 1500 users, integrates more than 50 repositories, executes around 13,000 models and algorithms per month and provides access to over a billion records in repositories worldwide, with 99,7% service availability.

BlueBRIDGE aims to develop innovative services in the following areas:

- Blue Assessment - services for stock assessment and for the generation of unique identifiers for global stocks;
- Blue Economy - services supporting the analysis of socio-economic performance in aquaculture;
- Blue Environment - spatial planning services to identify aquaculture and fisheries infrastructures from satellite imagery;
- Blue Skills - on-line training services and capacity building on existing training modules for fisheries scientists and other practitioners.

How to increase profits and minimize environmental impact with BlueBRIDGE aquafarming services for SMEs

Aquaculture is one of the pillars of the EU's Blue Growth Strategy and its development can contribute to the Europe 2020 Strategy. Although it represents a relatively small part of the EU economy, it has the potential to boost growth and jobs in EU coastal and inland areas.

In recent years aqua-farming companies have been competing in an extremely low profit margin environment, thus relying on high sales volume to create adequate profits. This landscape leaves little room for inefficient operations. Another major issue is the environmental impact and the environmental sustainability of the production. Aquaculture, in common with many other sectors, uses natural resources and interacts with the environment on issues of environmental protection. Efficient production management and the development of best practices respond to the above needs. It can dramatically help companies, most of which are SMEs, to improve profitability and minimize environmental impacts.

BlueBRIDGE will develop two new services addressing two relevant problems related to this challenge that build one upon the other:

- Performance evaluation, benchmarking and decision making in aquaculture service: providing capacities for companies to evaluate, benchmark and optimize their performance against best practices and the competition, and to extend the capacity of scientific research communities and policy makers to quantify and comprehend aqua-farming industry operation, ensuring sustainability and development of the sector.
- Strategic Investment Analysis and Scientific Planning and Alerting service: supporting investors and scientists in the efficient identification of strategic locations of interest that meet multifactor selection criteria.

The two new services will be put in practice initially in two domains:

- a group of aquafarming SMEs, that have been preselected and will be contributing to the benchmarking and evaluation of their production
- a group of individual stakeholders, not funded by the project, for evaluating potential investment scenarios.

The project is coordinated by ISTI-CNR, and the ERCIM Office provides administrative and financial support.

Links:
http://www.bluebridge-vres.eu
https://i-marine.d4science.org
https://www.d4science.org/

Please contact:
Donatella Castelli, CNR-ISTI
E-mail: donatella.castelli@isti.cnr.it

BlueBridge kick-off meeting participants.

Augmented Reality

by Constantine Stephanidis and Eija Kaasinen

Augmented Reality (AR) is a real-time direct or indirect view of a physical real-world environment that is enhanced or augmented by adding virtual computer-generated information to it. Accordingly, an AR system: (i) combines real and virtual objects in a real environment, (ii) aligns real and virtual objects with each other so that as the view to a real object changes, the augmented object connected to it changes accordingly, and (iii) runs interactively, in three dimensions, and in real time. AR technologies enhance human perception and help seeing, hearing, and feeling the surrounding environment in new and enriched ways. This is achieved by making people sense virtual objects, which appear to coexist in the real world. AR can also be used to hide visual elements of the real world to allow people to focus on specific aspects (Diminished Reality).

AR has been a very active research topic during the last decade, and its importance will increase in the future as the research focus is extending from enabling technologies to real-life applications. Long perceived as the technology for the future, AR is currently making its way in the market place. In consumer applications AR is spreading in domains such as advertising, entertainment, education, games, health, culture, tourism and design. In work applications AR is applied in maintenance, training, and in supporting different work tasks with contextual guidance. Today's smart devices, and especially products such as smart phones, tablets, and wearable devices, are rapidly bringing this new and exciting kind of human-computer interaction in everyday life. However, before AR becomes accepted as part of everyday life, besides technical limitations of existing technologies, HCI issues regarding intuitive and natural interaction, ergonomics and human factors, appearance and compatibility with social practices, as well as other issues such as cost, weight and power usage, must be systematically addressed.

This Special Theme of ERCIM News provides an overview of current research efforts in Europe in AR enabling technologies and applications, with focus in particular on the domains of cultural heritage as well as construction and industry. There is still a lot of research needed to develop enabling technologies that facilitate easy and natural access to augmented reality. This special issue includes an introduction and overview of AR browsers and an article about an "Interactive document" system that facilitates AR on printed documents. It also includes an article where the effects of rubber hand illusion are studied, i.e., how people perceive an augmented hand that they can control.

This special issue includes five articles that describe different cultural heritage applications of AR: a new and exciting multi venue scene for audio and visual experience in art centers, a new way to look at illustrations and sketchbooks in graphical design exhibitions, reconstruction of cultural heritage artifacts as well as an interactive system that facilitates versatile ways to explore augmented artifacts with multi-touch interaction.

In the domains of construction and industry, addressed applications include an AR system for city planners to experience virtual building models on site, as well as mobile AR systems for building maintenance. An article describes the potential of AR in industrial maintenance in gathering and sharing tacit knowledge. Finally, another article describes how AR can support learning complex physical phenomena, such as airstreams around objects and the resulting forces.

The results reported in these articles demonstrate that AR technologies are rapidly maturing and expanding, and cover application domains of high industrial but also public interest in Europe.

Please contact:
Constantine Stephanidis, ICS-FORTH, Greece, cs@ics.forth.gr
Eija Kaasinen, VTT Technical Research Centre of Finland Ltd., eija.kaasinen@vtt.fi

The Cliff - Performing Arts Centre on the Fjord

by Leif Arne Rønningen

The Cliff is a revolutionary concept for an arts centre on the fjord. It will create a new and exciting multi venue scene for audio and visual experience. The realization of The Cliff requires extremely low-delay networks between different venues, multi-view collaboration surfaces, and both internal and external multi-view video arts scenography.

Networked music collaboration, which is related to augmented reality (AR), has been carried out for decades, using available technology. In most cases, only 2D video is used, and unwanted long delays are often experienced. However, a number of successful productions, including the networked Thora paa Rimol opera [1], have applied the LOLA system. The LOLA (LOw LAtency audio visual streaming system) project aims to enable real time musical performances where musicians are physically located in remote sites, connected by advanced network services. [1].

The Cliff [2] represents a new concept in performing arts centres that can be transported to visit venues at the seaside, and is intended for networked collaborations via a digital network. Applications are typically music drama, theatre, concerts of all kinds, multimedia shows, and art exhibitions. Furthermore, The Cliff's exterior is a sculpture that can be changed dynamically by light, colour and water art.

The interior can be used in all weather, and the exterior when weather allows. In particular, on dark winter evenings when parts are covered by snow, spectacular sculptures can be created.

The surface of The Cliff will consist of many irregular multi-view surfaces, built of lens arrays that will be projected on by lasers from inside. The images generated will be visible from both inside and outside. A large number of miniature cameras, hidden in the surfaces, will provide the sufficient number of views to obtain near natural spatial feel. A networked processing system synchronizes all projections. Scenes can be built anywhere in the space, and projection walls, ceilings, floors and objects support the scenography and provide collaboration surfaces for networked collaboration.

A major advantage of video based scenography is the extreme dynamics of scene objects, which allow changes in milliseconds rather than seconds or minutes as with traditional scene technology. The marginal production cost is also much lower with video scenography and pre-recorded music.

Even if, in principle, the design and construction of The Cliff could start today, there remain both technical and artistic research challenges. The large, laser scan based multi-view displays needed, with views on back and front, are not yet available. And there is still a way to go before the perception of the virtual presentations can be near natural. Another challenge is to enhance the artistic value of the distributed or networked production of music drama compared with more traditional productions.

NTNU (Norwegian University of Science and Technology) and SINTEF (the largest independent research organisation in Scandinavia, and the natural contract R&D partner for the private and public sectors) have world-leading competence in ICT and ocean science and technology, strengthened by the 'oil age'. NTNU also have widely acknowledged activities in performing arts. Their combined expertise puts them in the ideal position to establish The Cliff as an extraordinary world-class performing arts centre.

Figure 1: The Cliff Performing Arts Centre at a molo in the Trondheim harbour. Size ca 300 x 200 x 100 meters.

Aida by Verdi as networked AR performance

For the opera Aida, the scene in The Cliff is planned to be a hill of stones, built as a promontory to a wall, with the

audience on three sides. The multi-view surfaces around the promontory are used for video scenography and collaboration surfaces for two additional venues. All other walls, ceilings and floors are also used as vision projection screens. The live performance is distributed and takes place at three venues each of which can accommodate over 1000 audience members. Most of the visualizations in The Cliff can be viewed externally from the city or the Trondheim fjord:

- The main soloists and characters play live in The Cliff. The performance is recorded, transported and shown on large, mobile, multi-view screens in the collaborating venues.
- Trondheim Symphony Orchestra plays live in Olavshallen (Trondheim) and is recorded and shown in The Cliff. When the orchestra plays overtures or the main role, video is presented on the periphery of The Cliff space, surrounding the audience entirely. An extract is shown in the Nidaros Cathedral on mobile screens. In all cases, superb 64 (or higher)-channel sound with extremely low delay is spread from the periphery both in The Cliff and Nidaros Cathedral.
- A large mixed choir (of priests, soldiers and others), performs live in Nidaros Cathedral (Trondheim). Both ensembles and their surroundings are recorded and shown in real time on the multi-view surfaces in The Cliff, and in Olavshallen.

To meet the hard delay sensitivity given by the distributed performing musicians, the technical delay requirements are visual (optical) end-to-end delays of less than 30 ms, and audio delays of less than 10 ms. To accommodate these requirements, a 100 Gbps IP/Ethernet fibre network with switches takes care of the transmission between the venues, including high performance image and sound processing equipment that needs to be optimized to support the low delays.

Links:

LOLA system :
http://www.conservatorio.trieste.it/artistica/ricerca/progetto-lola-low-latency

Nettmusikk2014 [In Norwegian]:
https://openwiki.uninett.no/_media/nettmus:nettmusikk2014-brukerstyre_2013-11-13.pdf

Thora paa Rimol [In Norwegian]:
https://openwiki.uninett.no/_media/nettmus:thorapr.pdf

Collaborative Surfaces and Spaces (ITEM@NTNU) :
http://www.ntnu.no/telematikk/people/personalpages/fac/leifarne/collaborationspaces

The DMP Architecture, Specification and Philosophy (ITEM@NTNU) :
http://www.ntnu.no/telematikk/people/personalpages/fac/leifarne/the_dmp_architecture_specification_and_philosophy

NTNU Faculty of Information Technology, Mathematics and Electrical Engineering :
http://www.ntnu.edu/ime

NTNU Oceans :
https://www.ntnu.edu/oceans/about-ntnu-oceans

References:

[1] Parts of the Thora paa Rimol opera as a neworked collaboration (augmented reality) version, were played between Dokkhuset Scene and Orgelsalen, Trondheim, 9th of December 2014, Project Nettmusikk2014, http://kwz.me/JJ.
[2] L.A. Rønningen: "The Cliff. Performing Arts Centre on the Fjord", Memo, NTNU/Item, May-June 2015.

Please contact:

Leif Arne Rønningen
NTNU, Norway
E-mail: leifarne@item.ntnu.no
http://www.ntnu.no/ansatte/leifarne

Virtual Reconstruction of Cultural Heritage Artifacts

by Michal Haindl, Matěj Sedláček and Radomír Vávra

Museums and other cultural heritage custodians are interested in digitizing their collections, not only for the sake of preserving cultural heritage, but also to make the information content accessible and affordable to researchers and the general public. Once an object's digital model is created it can be digitally reconstructed to its original uneroded or unbroken shape or realistically visualized using different historical materials. Some artifacts are so fragile that they cannot leave the carefully controlled light, humidity, and temperature of their storage facilities, thus they are already inaccessible to the public, and the viable alternative is their exhibition in the form of an augmented reality scene. Researchers at the Institute of Information Theory and Automation (UTIA) of the Czech Academy of Sciences in Prague have developed a sophisticated measurement and processing setup to enable the construction of physically correct virtual models.

While precise shape measurement can be achieved using advanced laser scanners and other commercially available shape measuring devices, an object's surface appearance is much more complicated. Virtual reality applications typically use oversimplified surface material and illumination models that only remotely approximate the appearance of real scenes, meaning human observers can easily differentiate between real and virtual or augmented reality scenes. Real surface material visual appearance is a highly complex physical phenomenon which intricately depends on incident and reflected spherical angles, time, light spectrum and several other physical variables. While recent advances in computer hardware and virtual modelling are finally allowing the view and illumination dependencies of natural surface materials to be taken into account in the form of bidirectional texture function models (BTF) [1], this occurs at the expense of an immense increase in the required number of material sample measurements and the visualization complexity.

Figure 1: Celtic druid head (300 BC, National Museum in Prague) precise BTF plaener model (left) and the reconstructed head using the same BTF model but another environmental lighting (right).

Figure 2: Reconstructed druid head using the linden wood BTF model.

Within the Pattern Recognition department of UTIA, we have built a high precision robotic gonioreflectometer [1,3]. The setup consists of independently controlled arms with camera and light. Its parameters, such as angular precision (to 0.03 degrees), spatial resolution (1000 DPI), and selective spatial measurement qualify this gonioreflectometer as a state-of-the-art device. The typical resolution of an area of interest is around 2000 x 2000 pixels, each of which is represented by at least 16-bit floating point values to achieve reasonable representation of high-dynamic-range visual information. The memory requirements for storage of a single material sample amount to 360 gigabytes per spectral channel but more precise spectral measurements with a moderate visible spectrum (400-700nm) sampling further increase the amount of data to five tera-bytes or more.

We applied this technique within the Czech Science Foundation project GAČR 14-10911S for the best known Celtic artifact from the European Iron Age period (450–50 B.C.) owned by the National Museum in Prague - the Celtic druid head. This plaener Celtic druid head (see Figure 1 - left) is so precious that it has only been exhibited three times since its discovery at a sandpit in Mšecké Žehrovice, Czechia in 1943, and each time only for a few days under tight security. Its exact digital model with ±0.1 mm accuracy created from our laser scanner measurements allows us not only to create a high quality copy for permanent exhibition, but art historians can study in detail its chiseling style by an ancient artist, its ritual smashing when Celts had to abandon their sanctuary, and even allows researchers to look for alternative materials (Figure 2) of that era. Visual techniques are non-invasive and thus ideal for documentation and assessment of cultural objects directly in their workroom computers. Unfortunately some parts of this precious sculpture were never recovered (see the right part of the head digital model on Figure 1 - left). These missing parts, as well as stone scars due to its ritual smashing and ploughing damage, can be reconstructed using prediction-based image processing methods. Figures 1 – right and 2 illustrate such shape reconstruction results in the original plaener and possible alternative wooden (Figure 2) materials. Once the accurate shape and material models are developed, we can insert such a model into an augmented reality scene (Figure 1 – right) in a way which respects physically correct illumination and viewing conditions derived from the real environment. For example, to insert this Celtic druid head into a true Celtic sanctuary if archaeologists were to find one.

References:
[1] M. Haindl, J. Filip: "Visual Texture", ISBN 978-1-4471-4901-9, London: Springer-Verlag, 2013.
[2] M. Haindl, J. Filip: "Advanced textural representation of materials appearance", Proc. SIGGRAPH Asia'11 (Courses), pp. 1:1 - 1:84, ACM .
[3] M. Haindl, J. Filip, R. Vávra: "Digital Material Appearance: The Curse of Tera-Bytes ", ERCIM News, 90, pp. 49-50, ISSN 0926-4981, 2012.

Please contact:
Michal Haindl
CRCIM (UTIA), Czech Republic
Tel: +420 266052350
E-mail: haindl@utia.cas.cz

An Augmented Reality Application for Art Exhibitions

by Nuria Rodríguez-Calatayud, Jordi Linares-Pellicer and David Heras-Evangelio

The exhibition "Think with Your Hands" offers a new way to look at illustrations and sketchbooks. It breaks the mould of a traditional show, thanks to an augmented reality project developed by 'UNIT experimental' at Universitat Politècnica de València. This project centres on the work of Pep Carrió and Isidro Ferrer, two of Spain's most prestigious graphic designers, whose sketchbooks, objects and collages come to life when interacting with the mobile devices and augmented reality.

Some years ago, a group of researchers from the Universitat Politècnica de València (UNIT experimental) began focusing on a new line of work that would foster communication between art centres and their visitors. Its main goal was to explore the interactivity offered by mobile devices, and to develop highly intuitive software, which, through augmented reality techniques, would allow a clever, direct relationship between the work of art and the public. Right from the start, researchers' work has benefited from the synergy that comes from fusing art and technology: the use of technology in full awareness, to widen the creative limits of artists. "Think with Your Hands" was one of the first products the research group created with this purpose.

The exhibition "Think with Your Hands: Pep Carrió & Isidro Ferrer" was launched in the ABC Museum of Madrid. The exhibition then travelled to the USA (sponsored by The Spanish Ministry of Education, Culture and Sports), and was displayed at: the Centro Cultural Español de Cooperación Iberoamericana (Spanish Cultural Center for Ibero-American Cooperation), Miami; then the arts centre 'Artisphere', Washington, in September 2014; and the Instituto Cervantes, Chicago in February 2015.

This interactive project proposes a combination that balances the real and the virtual through augmented reality. It inserts objects or virtual graphics into a real environment in what is called augmented reality art [1]. The viewer can simultaneously see the virtual objects in motion and the real one with which he or she is interacting in the context of the exhibition. We have found that this overlapping of 3D registers turns the imaginative world of the viewer on, while it expands the meanings proposed in the exhibition projects.

The exhibition "Think with Your Hands" exemplifies the use of new technologies in "augmenting" the aesthetic experience within an exhibition, thereby encouraging other experiences. The application "Los cuadernos" (downloadable from Google Play and AppStore) is required to achieve this goal. Once installed in the mobile phone or tablet, the exhibition visitor discovers multimedia information that is hidden to the naked eye, such as animations, 3D elements, video interviews with the artists, image galleries, and interactive sketchbooks. These "augmented" contents bring together knowledge and entertainment.

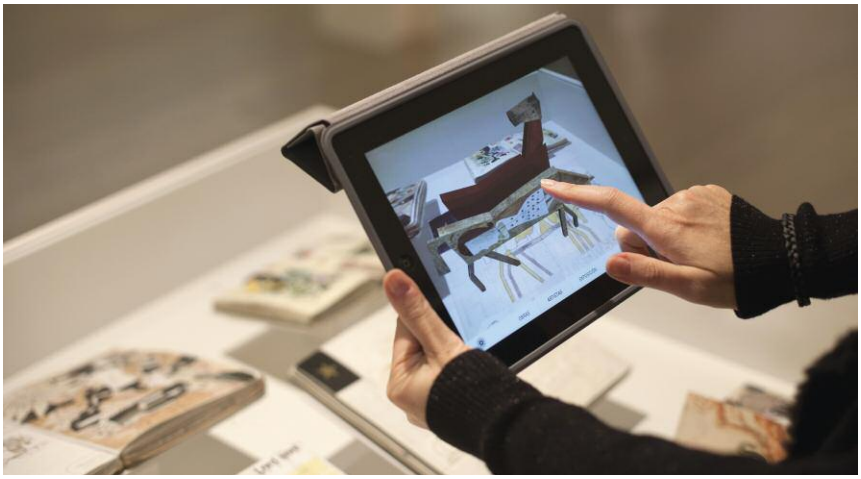


Figure 1: The AR application in the exhibition.

The project comprises more than one hundred pieces by the two creators, including: drawings, sketchbooks, collages and objects, which, when seen through the touch screen of a mobile device, are virtually activated and their contents appear multiplied, branching out, sometimes in a playful fashion through 3D animations, other times in an informative, documenting way through sound and video.

The exhibition also showcases a different result of a "UNIT experimental" research project: an interactive publication compiling the sketchbooks of the authors as part of their work process. The book, entitled "Open All Day - The Sketchbooks of Isidro Ferrer & Pep Carrió", demonstrates how traditionally printed books can exist alongside new technologies and serve as a support for innovative ways of acquiring knowledge. In its nearly 300 pages, readers can create their own routes, activating videos, animations and interactive contents through its mobile device screen.

Links:

The results of this work can be seen visiting the videos in 'Projects' section in http://unitexperimental.com.
A direct link to one of the videos can be found at
https://vimeo.com/68120456

Reference:

[1] V. Geroimenko: "Augmented Reality Technology and Art: The Analysis and Visualization of Evolving Conceptual Models", in Proc. of 16th International Conference on Information Visualization (IV), 2012

Please contact:

Nuria Rodríguez-Calatayud, Jordi Linares-Pellicer, David Heras-Evangelio
Universitat Politècnica de València, Spain
E-mail: nurodca@pin.upv.es, jlinares@dsic.upv.es, dherase@dib.upv.es

360^2: Turning an Ordinary Rotating Metal Disk into a Unique Interactive Exhibit

by Dimitris Grammenos, Xenophon Zabulis and Panayiotis Koutlemanis

360^2 is an interactive system that allows exploration of digital representations of real artifacts through physical and multi-touch interaction with a double rotating gimbal (i.e., a disk that the user can freely rotate around two axes). While the user manipulates the disk, the system uses a projector to augment a display upon it. User input is supported both through fingertip contact (i.e., multi-touch) and disk rotation in both axes. In addition to the disk, a secondary projection surface is provided for additional information, upon which multi-touch gestures are supported.

A key innovation of the 360^2 system [1] is the fact that both the metal disk and the secondary projection surface do not integrate any technological element. This is achieved by a computer vision system that employs a depth camera that is hidden above the installation. Using the depth images, the system estimates the disk's orientation, and detects and localizes fingertip contact with the disk [2]. This information is employed for supporting user interaction, but also for appropriately warping the projected visual content so that it appears undistorted on the disk's surface. The 360^2 system was developed in the context of the "Ambient Intelligence Programme" of the Institute of Computer Science of the Foundation for Research and Technology – Hellas (FORTH-ICS).

Figure 1: Installation of Stater 360^2 at the Archaeological Museum of Thessaloniki, Greece.

Three different applications of the system are currently available:

1. Stater 360^2

This application allows users to "take into their hands" coins at a large scale. Whilst in an idle state, a collection of coins is presented on the disk's surface. If a user rotates the disk, the coins slide and collide following the disk's motion and tilt, as if they were real objects. When a coin is selected it grows until it covers the whole surface of the disk (Figure 1). The user can access the other side of the coin simply by rotating it. Furthermore, by touching the coin's surface, a menu offering four choices becomes available: a) access a magnifying glass that can be freely dragged over the coin's surface; b) see a map on which the coin's place of origin is highlighted; c) read textual information about the current side of the coin; d) shrink the coin back to its original size, revealing the whole collection again. On the secondary projection surface detailed information about the coin's place of origin is offered, along with buttons for language selection. Stater 360^2 is currently being exhibited

Figure 2: Installation of Phaistos Disk 360^2 at the information office of the Municipality of Heraklion in Crete, Greece.

Figure 3: Installation of Artefact 360^2 at the premises of ICS-FORTH.

as part of the exhibition entitled "The Europe of Greece - Colonies and Coins from the Alpha Bank Collection" at the Archaeological Museum of Thessaloniki.

2. Phaistos Disk 360²

This version of the system (Figure 2) was developed for, and is installed at, the information office of the Municipality of Heraklion in Crete. City visitors can interact with a large-scale digital recreation of the Phaistos Disc, one of the most famous archaeological findings in Crete. The original clay disc, dating back to c. 1700 BC., is 16 cm in diameter and its two sides bear a total of 242 enigmatic signs in an unknown language. The system installation comprises a metal disk manufactured to offer a feeling of clay. Users can flip the disk to see its back side or rotate its surface to have a better view of the symbols which are arranged in spiral format. A touch on the disk can provide information about each side. Furthermore, a magnifying glass is available and a study tool, allowing to access information about individual or groups of symbols. Except for language selection, the secondary projection surface provides access to alternative rendering of the disk's surface.

3. Artifact 360²

Artifact 360² supports the exploration of artifacts in 360 degrees (Figure 3). By rotating the disk around the vertical axis, the user can see 360 different views of the artifact, as if the actual object was placed behind the disk's surface, thus creating a 3D visualization effect. By tilting the disk surface, the user can access alternative lighting settings, revealing different details of the artifact. When the user touches the metal surface, hotspot areas of the current view are presented. Upon touching a hotspot, related information is presented. Additionally, using two fingers, the user can magnify different parts of the presented image.

This work was supported by the FORTH-ICS internal RTD Programme "Ambient Intelligence and Smart Environments".

References:

[1] P. Koutlemanis, et al.: "A Steerable Multitouch Display for Surface Computing and its Evaluation", Int. Journal on Artificial Intelligence Tools, Vol. 22, No. 6, 1360016, World Scientific Publishing Company, 2013.

[2] X. Zabulis, P. Koutlemanis, D. Grammenos: "Augmented multitouch interaction upon a 2-DOF rotating disk", in Advances in Visual Computing, Springer, LNCS Vol. 7431, pp. 642-653, 2012.

Links:

[1] http://www.ics.forth.gr/ami

[2] Youtube video: http://youtu.be/ltobJ-RBgao

Please contact:

Dimitris Grammenos

ICS-FORTH, Greece

E-mail: gramenos@ics.forth.gr

LecceAR: An Augmented Reality App for Cultural Heritage

by Francesco Banterle, Franco Alberto Cardillo, and Luigi Malomo

Augmented Reality (AR) - the augmentation of a physical world's view with digital media - has recently gained popularity thanks to the increasing computational power and diffusion of mobile devices such as tablets, and smartphones. These developments allow many practical applications of AR technology, especially in the cultural heritage domain. LecceAR is an advanced app that allows tourists to view rich 3D reconstructions of cultural heritage sites within the city of Lecce in Italy.

LecceAR is an iOS app for markerless AR that will be exhibited at the MUST museum in Lecce, Italy. The app shows a rich 3D reconstruction of the Lecce Roman amphitheatre, which is only partially unearthed (see Figure 1). The use of state-of-the-art algorithms in computer graphics and computer vision allows an ancient theatre to be viewed and explored in real-time.

LecceAR is the result of a joint collaboration between different institutes of the Italian National Research Council (CNR). In fact, it was developed by the Visual Computing Laboratory (ISTI-CNR), NeMIS (ISTI-CNR), and IBAM-CNR, as a deliverable for the Italian project "DiCeT: Living Lab di Cultura e Tecnologia" (PON04a2_D). This project began in early 2013 and has been showcased, including LecceAR, at the MUST museum in Lecce during an exhibition in September 2015.

Although commercial AR frameworks exist and provide compelling prices, they usually have low quality rendering engines. For example, they may have limits in the number of triangles to be rendered for a 3D object, and on customization of the final visualization. These are key issues especially in the cultural heritage domain, which requires large 3D models that are typically the output of a 3D scanning campaign. Therefore, we opted to develop a from-scratch app to have enough flexibility and the capability to render large and complex 3D models.

LecceAR was developed using standard computer vision and graphics libraries; i.e. OpenCV and OpenGL. The app comprises two modules: a matching and tracking module, and a renderer.

The first module, 'MaTrack', processes frames coming from the device's camera in order to establish whether or not they contain a known target image. If a frame contains a target, the module computes a geometric transformation mapping the target onto the video

frame, and initializes the tracker which stabilises the transformation. Furthermore, the tracker is able to keep the alignment between the virtual and the physical worlds even when the target becomes only partially visible. Many AR apps recognize only synthetic images, but our app will be part of a museum exhibition, where "aesthetics" constraints are crucial for the target image used in the exhibition. Therefore, the target used in the current implementation, shown in Figure 2, is a standard picture.

The second module, a renderer, is a proprietary component for rendering virtual objects, called Viewer3D. This is an OpenGL|ES 2.0 real-time renderer which was developed for the iOS platform using the VCG library. The renderer, whose setup requires only a few lines of code, can be encapsulated inside a UIView. In this way, the renderer is very handy, because a UIView is the basic iOS widget for visualizing graphics on a screen. Once the renderer is initialized, 3D models can be rendered by loading them, assigning a shader, and automatically converting the transformation of the previous module into an OpenGL matrix. Viewer3D supports different file formats, including the PLY and OBJ formats that are the de-facto standards for 3D scanned models and 3D modelling packages used in the CH domain. Moreover, our renderer allows different attributes to be defined over the vertices of a 3D model, to encode normals, texture coordinates, colours, ambient occlusion, etc. This increases the flexibility of the system in coping with different rendering and shading needs. In terms of performance, our renderer can achieve up to 60 fps while rendering a 3D model composed of 2M triangles, with a texture and using a Phong lighting shader on an iPad Air 1st generation and an iPhone 5S. This is achieved without the need of streaming from the flash memory. An example of the rendering in action for the visualization of the Lecce Roman amphitheatre is shown in Figure 3.

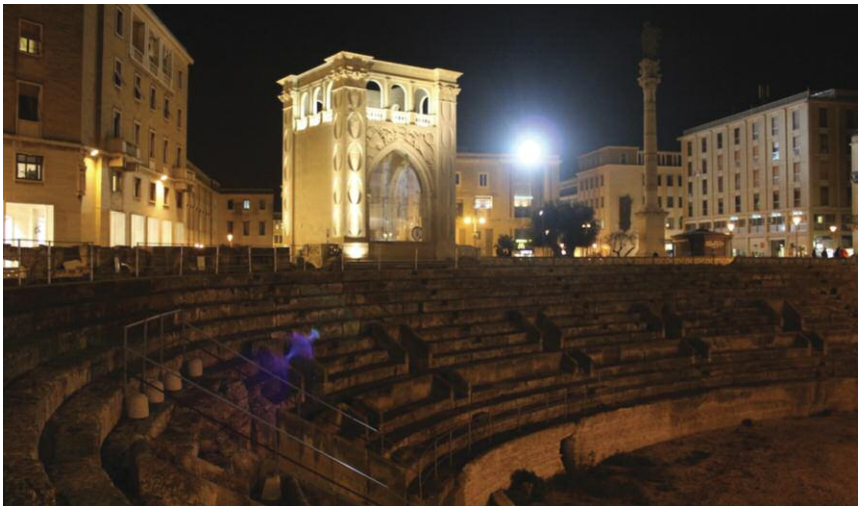


Figure 1: The amphitheatre's current state.

The next iteration of LecceAR will be focused on enabling the app to recognize and track thousands of images by improving the similarity search. Moreover, we would like to extend the system to work on non-planar scenes, i.e using the 3D metric of the physical world directly.

We hope that LecceAR provides tourists with a useful app for visualizing cultural heritage sites as they were at the peak of their magnificence, such as the Lecce Roman amphitheatre in the 2nd century AD.

Links:
LecceAR Official website:
http://vcg.isti.cnr.it/LecceAR/
NeMIS-MIR:
http://nemis.isti.cnr.it/groups/multimedia-information-retrieval
Visual Computing Laboratory:
http://vcg.isti.cnr.it/
IBAM: http://www.ibam.cnr.it/en/
VCG Library: http://vcg.isti.cnr.it/vcglib/

Reference:
[1] F. Banterle, F.A. Cardillo, L. Malomo, F. Gabellone, G. Amato, R. Scopigno. "LecceAR: An Augmented Reality App", in Digital Presentation and Preservation of Cultural and Scientific Heritage (DiPP), September 2015, Veliko Tarnovo, Bulgaria.

Please contact:
Giuseppe Amato, Roberto Scopigno
ISTI-CNR, Italy
E-mail: giuseppe.amato@isti.cnr.it, r.scopigno@isti.cnr.it

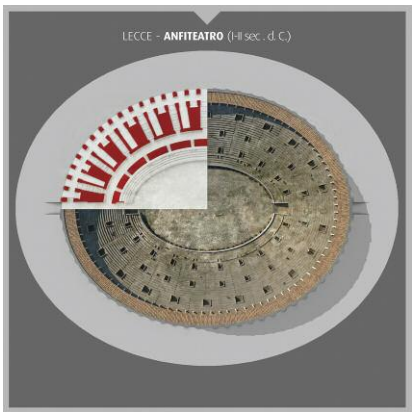


Figure 2: The used target in the app.

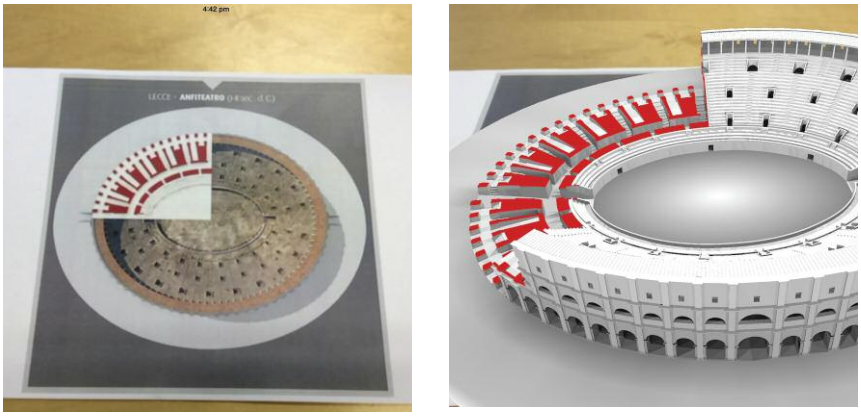


Figure 3: Screenshots of the app running: left: The app just before augmentation of the viewed target image. Right: the app with the 3D reconstructed model on top of the target image.

Auto AR – In Situ Visualization for Building Information Modelling

by Leif Oppermann

Being able to explore vast outdoor scenery, cityscapes, or the interior of virtual buildings is the state of the art for video gamers. But city planners and building owners usually still have to settle with blueprints, rendered movies, and miniature models. Fraunhofer FIT's innovative "Auto AR" system allows the user to experience virtual building models on site, almost as if they were already built.

Workflows in architecture, engineering and construction are currently undergoing the second major renewal in the past 20 years. After the significant move from ink-based drawings to Computer Aided Design (CAD) came the move to full 3D building models. Those models are now continuously linked with additional meta-data and regarded as the central digital model of the whole building process. The resulting digital collaboration process is also known as Building Information Modelling (BIM). It is considered to be a game changer to successful building in the future, and is described in government strategy plans of several countries, including the UK [1] and Germany [2]. The underlying assumption is that digitally facilitated collaboration will enable better teamwork and thus greater efficiency and better outcomes for all stakeholders.

Auto AR uses these digital building models and allows visualization of them live on site via a head-mounted display, and also records data for later use in the office. We employ a 360° panoramic camera that is attached to the roof-top of a car and connected to a laptop workstation in the car. Together with the high quality position and orientation sensors this provides the basis for a real-time and centimetre precision visual overlay of building plans onto the camera capture of the real environment. This car-based setup can easily be driven to any construction site or development area to quickly capture views of the planned construction project.

The co-driver of the car wears a head-mounted display which shows the live-view of the panoramic camera according to the user's head movement, thus effectively showing the existing built-up environment of the neighbourhood. But once the car gets near to the construction ground, the display allows for a virtual time warp. Instead of just seeing the empty site, the co-driver now sees erect virtual buildings in perfect 3D perspective superimposed on top of the background video. The 3D-models are placed exactly where planned and show all the details that the architect put into them. Even variations are possible, maybe showing different entrances or facades that could not be agreed on without seeing them in the context of the surrounding area. This allows for more targeted discussions and better decisions on site, and also remotely later while replaying the recorded data.

Figure 1: Auto AR system allows the user to experience virtual building models on site. Photo: Fraunhofer FIT, VWFS, Oltmanns und Partner, DhochN, Büro Gaudlitz.

The system uses proven technology from the engineering and game domains and combines them into one compelling solution. Examples for this are the industry-grade panoramic camera and survey equipment, as well as the virtual reality head-mounted display and the commercial-grade 3D engine. The camera image is combined with a high frequency, real-time kinematic system to provide for a high precision GPS-coordinate. The viewing direction of the user is continuously measured via the head-mounted display and merged with the position and orientation of the car.

The live-experience of architectural planning could for example be applied to the presentation of alternative designs to committees and decision makers, or be integrated into public participation processes to support the much demanded improved communication of plans. And if building plans have to be changed again, the previously recorded panoramic video footage can be easily recycled, because the visualization is separated from the background video. Video and 3D visualization are only ever merged live during real-time playback, which saves recording and rendering costs. Moreover, viewpoints of special interest can be quickly accessed like chapters on a DVD, so users such as developers and real estate agents could easily use it for their sales communication.

In addition to the exterior view of the building from the panoramic camera perspective, it is also possible to leave

the pre-defined track and walk into the buildings. Thus, stakeholders including architects, BIM managers, building owners, investors, and future tenants benefit from a much improved spatial understanding of the three-dimensional plans and can also quickly try out different designs and variations for the interior plans.

The use of AR for BIM has been suggested previously [3], but no one has really applied it to the process so far. Auto AR system is the result of a Fraunhofer internal strategic investment project. Such projects are awarded to innovative ideas whose results could then be further explored in future research and development projects. We are at this stage now and thus currently looking for new opportunities to apply this unique AR-technology to future automotive and building information modelling projects.

Link:
http://www.fit.fraunhofer.de/mars

References:
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[2] BMVI - Pressemitteilungen-Abschlussbericht der Reformkommission Großprojekte, [online], http://www.bmvi.de/SharedDocs/DE/Pressemitteilungen/2015/060-dobrindt-reformkommission.html, consulted Aug. 2015.
[3] X. Wang, P. E. Love: "BIM + AR: Onsite information sharing and communication via advanced visualization", in 2012 IEEE 16th International Conference on Computer Supported Cooperative Work in Design (CSCWD), p. 850–855, 2012.

Please contact:
Leif Oppermann
Fraunhofer FIT, Germany
Tel: +49 2241 14 27 24
E-mail:
leif.oppermann@fit.fraunhofer.de

Mobile Augmented Reality for Building Maintenance

by Charles Woodward, Mika Hakkarainen and Timo Kuula

Augmented Reality (AR) can help mobile workers to obtain timely and accurate information related to maintenance targets. We implemented a mobile AR system based on the BIM representation of a building, combined with FMS and other data sources. Technical challenges included indoors locationing and 3D tracking of the mobile device. User evaluations were conducted in two phases, first providing valuable input for system design, and finally showing very positive results on technology acceptance.

Building maintenance workers have a number of locations to visit and they are constantly on the move, thus their tools should support mobile work. Also, the workers frequently meet with new locations and unknown equipment, requiring tools to provide them with up-to-date information at the site. Mobile Augmented Reality can be used to visualize alerts and operating instructions directly on the target, thus helping mobile workers with improved situational awareness, also reducing the workers' need to shift their attention from the work target to external devices or manuals.

VTT was among the first in the world to implement a mobile AR system for building maintenance workers. The work was conducted in the national project DigiSpaces 2011-2013, with support from Tekes (the Finnish Funding Agency for Innovation) and involving industrial partners Granlund (building services), Pöyry (engineering), Skanska (construction), Tekla (BIM design), Solibri (BIM verification), and Nokia (mobile devices and location based services).

The implementation was based on participatory design (PD) and user centric (UCD) principles, involving several users and experts from a group of industrial partners. The users in the group interviews provided a large number of good quality ideas and generally saw that a mobile tablet application would be easily utilized in their work. Among the most important findings in the first round of user tests, it was concluded that in addition to Building Information Models (BIM), other data sources such as Facility Management System (FMS) should also be integrated into the system. Other features that were proposed by the users included Virtual Reality (VR) view for remote inspections.

These and several other ideas from the user studies were taken into account in the final system implementation. The system allows the user to view the BIM with maintenance targets and alarms in a real time video view on a Windows tablet. The BIM is partly transparent when visualized in the right position and orientation, giving an illusion that the BIM is merged with the real building, enabling the user to "see behind walls" etc. The user may freeze the view, investigate the problem in more detail, and select parts for additional information. The user is able to add feedback on the part, e.g. mark a maintenance procedure being done or pending for further action.

Locationing and orientation tracking with the system is based on hybrid markerless tracking. The final solution provides very good accuracy, speed and robustness, combining elements of VTT's point cloud based computer vision tools (ALVAR Tracker), orientation sensors (IMU) and indoors locationing (Nokia's HAIP). Furthermore, an autonomous mapping robot was implemented to automatically acquire

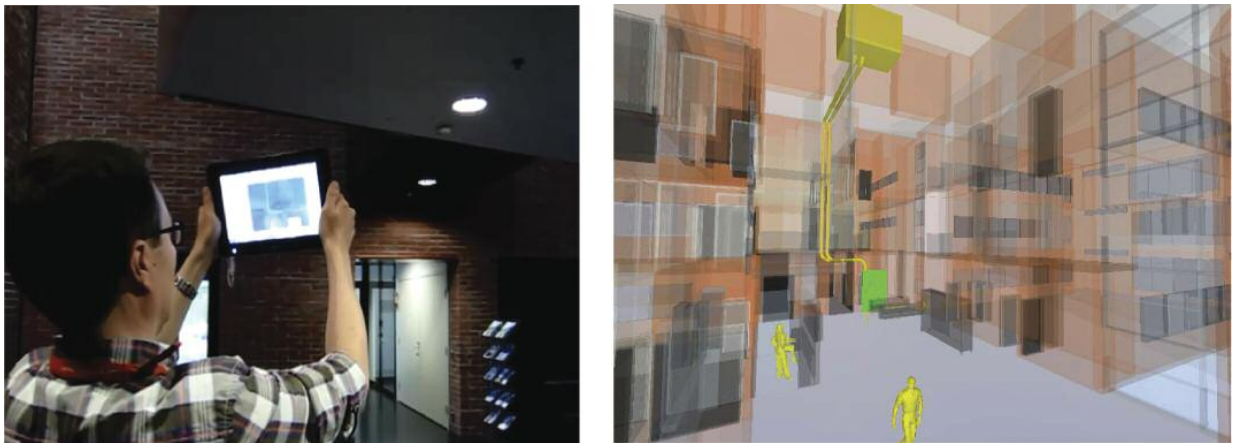

Figure 1: Mobile user browsing the air conditioning problem in AR view (left). BIM with malfunctioning devices highlighted (right).

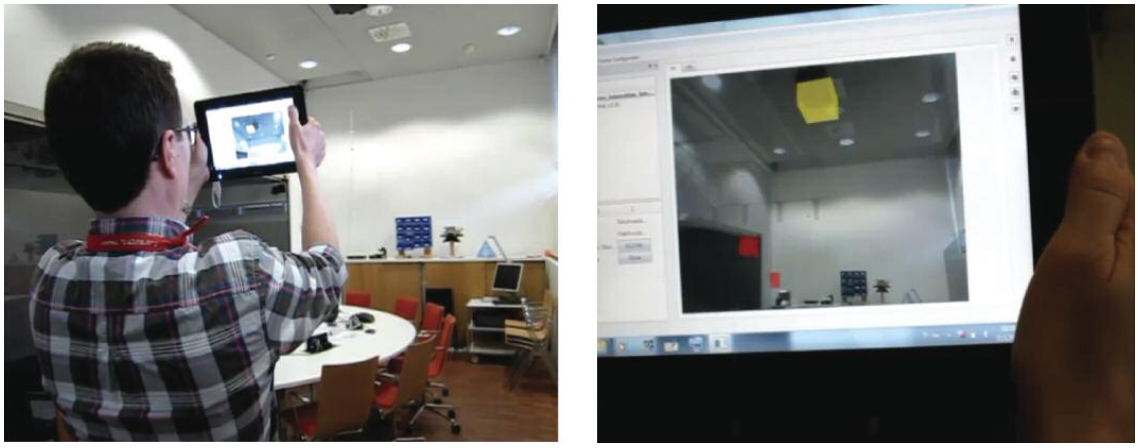

Figure 2: Mobile user finding warnings and alarms in a room (left). Alerts highlighted in mobile AR view (right).

and update the point cloud data for tracking.

With the system implementation ready, we implemented a second round of user tests with a real world pilot case. Figures 1 and 2 show two use case scenarios; a video of the pilot is provided in YouTube (see Links). The results indicate very good user acceptance and strong potential for utilizing BIM data and mobile AR solutions in building maintenance work. On a scale of 1 to 7 (1 = completely disagree, 7 = completely agree), some of the average user ratings were:

- The tablet system would be useful maintenance work – 6,50
- AR visualization of the targets would help maintenance work – 6,00
- BIM contents of the building on a mobile device would help in maintenance work – 6,38
- Use of the current version of the tablet system was easy – 4,75
- It is worthwhile to develop the system further into a completed product – 6,63.

In conclusion, we hope that BIM practices will be developed to better serve the whole building life cycle, besides their current use for planning and construction. Much of the current BIM information is actually not required after the construction phase, and it should be made easy to extract the relevant components and level-of-detail for having BIMs serve as a living document and data repository for building life cycle management.

Links:
VTT Augmented Reality / 3D Tracking website: http://www.vtt.fi/multimedia

http://youtu.be/uYFtYbqvoq0

References:
[1] T. Kuula et al.: "User requirements for mobile AR and BIM utilization in building life cycle management", Proc. CONVR2012, Taipei, Taiwan, 1-2 November, 2012, pp. 203-211.
[2] C. Woodward et al.: "Implementation and evaluation of a mobile augmented reality system for building maintenance", Proc. CONVR2014, Sharjah, UAE, 16-18 November, 2014, pp. 306-315.

Please contact:
Charles Woodward
VTT, Finland
E-mail: charles.woodward@vtt.fi

Augmented Reality Based Knowledge Sharing Solutions for Field Service Personnel

by Eija Kaasinen, Susanna Aromaa and Ville Rauhala

One particularly promising application field for augmented reality (AR) is maintenance work. AR can provide field service personnel with easy access to situationally relevant information that supports their work. Several demos and proofs of concept have previously been presented. We propose that AR has a lot of potential, especially in gathering and sharing tacit knowledge. Successful solutions are based on a thorough understanding of the maintenance work and the associated knowledge sharing requirements.

The FIMECC S-STEP programme by Finnish Metals and Engineering Competence Cluster (FIMECC) is developing smart technologies for life-cycle performance, utilizing the possibilities of industrial internet and service business. One of the four projects of the programme focuses on knowledge sharing solutions for field personnel. In global service business, tacit knowledge, communicated person-to-person, is becoming less accessible owing to multivendor global services, employee turnover and age structure. Our project will utilize Augmented Reality (AR) based interaction tools to gather and to provide easy access to situationally relevant knowledge. This will radically improve service quality, work satisfaction, productivity and risk reduction. The planned outcomes of the project include work practices, user interaction solutions and data management solutions with which knowledge can be easily gathered, interpreted, built, stored, retrieved, shared and utilized in service operations.

The project involves FIMECC companies with their own business cases: Bronto Skylift, KONE, Konecranes and Wärtsilä, companies providing enabling technologies: 3D Studio Blomberg, Ixonos and Mevea as well as research organizations: VTT Technical Research Centre of Finland Ltd (leader), Aalto University, University of Tampere, Technical University of Tampere, Lapland University of Applied Science and Lappeenranta University of Technology.

Various Internet of Things (IoT) solutions provide real-time information from the maintenance targets. A lot of knowledge that supports service operations exists as tacit knowledge of the most experienced senior personnel. The work of maintenance personnel, assisted by AR solutions, can be supported by both IoT information and human tacit knowledge. Successful solutions provide situationally relevant information with appropriate modalities. Recent advances in both hardware quality and pricing enable the adoption of powerful AR and multimodal technologies on lightweight yet powerful mobile and wearable devices. Also, the related 3D tracking technologies, sensors and depth cameras allow implementation of multimodal AR even in challenging industrial environments. These solutions enable effortless or even automatic gathering of knowledge while expert maintenance persons are working, utilizing video and audio recordings complemented with text or speech. Mobile devices and AR glasses provide easy access to situationally relevant knowledge to support ongoing

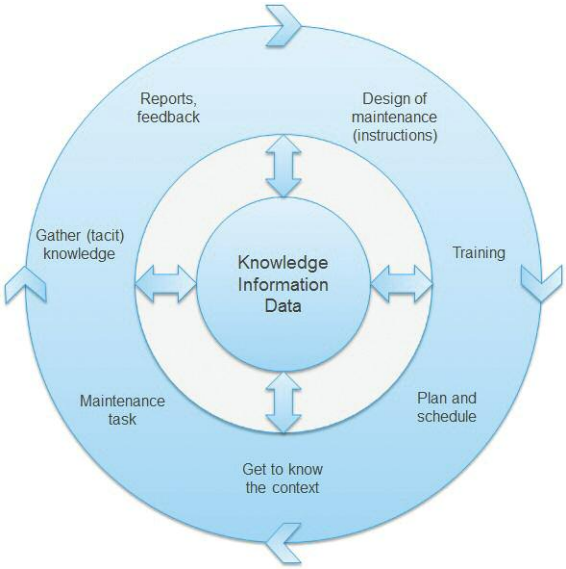

Figure 1: Most sub tasks of maintenance work will benefit from access to situationally relevant knowledge.

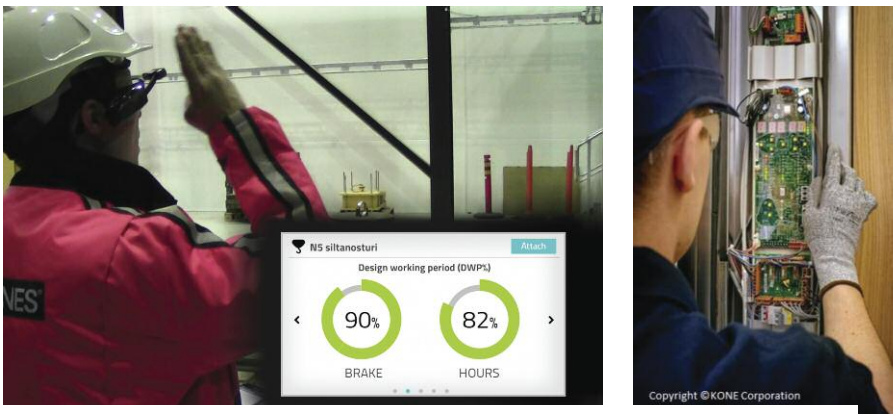

Figure 2: Examples of our first case studies: augmented reality gives information about the maintenance service object and instructions. The solutions are based on AR-glasses and gesture recognition. (Company cases from Konecranes and KONE).

maintenance tasks of novice maintenance persons.

In the near future maintenance work will undergo a major transition because AR will affect most sub tasks of maintenance work as illustrated in Figure 1. Ideally, all required information will be available for the maintenance worker at any time, reporting will be automatic and the work will become more technology-mediated and digital [1]. Maintenance work places high demands on the interaction tools, which help to gather and provide information without disturbing the maintenance task at hand.

Figure 2 illustrates some of our company cases of AR solutions for maintenance where AR is utilized to give information about the maintenance service object and instructions. With AR solutions the reporting and gathering of tacit knowledge will be done automatically during the maintenance work. This information can again be applied to improve maintenance activities and processes.

Figure 3 shows our project's roadmap of the foreseen changes in maintenance work through the use of AR solutions and other technology. Work and technology changes are described from the current situation to 3-4 years into the future.

Our future plans include implementing company specific AR solutions and evaluating them with field service personnel. The parallel company cases facilitate learning from one case to another. Based on user feedback from all the company cases we will then design second generation use cases that will already be mature enough for actual field use.

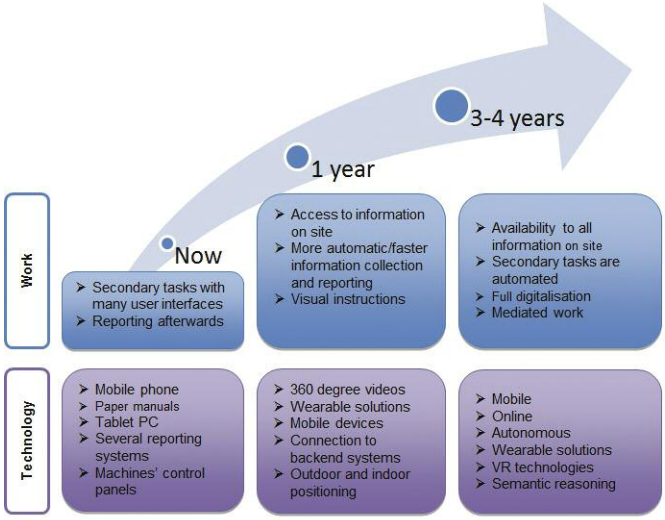

Figure 3 Roadmap for maintenance work and enabling technologies.

Link:
FIMECC S-STEP Programme:
http://www.fimecc.com/content/s-step-smart-technologies-lifecycle-performance-0

Reference:
[1] S. Aromaa, A. Väätänen, I. Aaltonen, T. Heimonen: "A model for gathering and sharing knowledge in maintenance work", in proc. of the 33rd Annual Conference of the European Association of Cognitive Ergonomics.

Please contact:
Eija Kaasinen
VTT Technical Research Centre of Finland Ltd.
Tel: +358405571005
E-mail: eija.kaasinen@vtt.fi

Susanna Aromaa,
VTT Technical Research Centre of Finland Ltd.
E-mail: susanna.aromaa@vtt.fi

Ville Rauhala,
Lapland University of Applied Sciences, Finland
E-mail: ville.rauhala@lapinamk.fi

Augmented Reality Supported Learning

by Constantin Brosda and Leif Oppermann

Complex physical phenomena, such as airstreams around objects and the resulting forces, can be very difficult to understand. Our Augmented Reality Supported Learning (ARL) app uses Augmented Reality (AR) to visualize the effects occurring upon a tangible object and to develop a set of experiments to be used in a learning environment.

Physics experiments, which often involve phenomena and concepts that are invisible, can sometimes be difficult to understand: for example, airstreams around objects and the resulting forces. We use Augmented Reality (AR) as an extended view on experiments to show additional information and thereby explain the phenomena while still allowing direct hands-on physical manipulation.

Previous EU projects, such as CONNECT and EXPLOAR, which were implemented at science centres, indicated that using AR in this way can be helpful for learners [1]. One major drawback of these science centers is they are only easily accessible for local schools. Why not, instead, bring the science centre into the classroom? Together with our pedagogical partners in the "Science Center To Go" EU project, we have created a suitcase prototype using a dedicated notebook [2] in which we present miniaturized versions of the exhibits. Powerful and widely spread smartphones now also allow us at Fraunhofer FIT to deploy such sophisticated applications on mobile devices using our Augmented Reality Supported Learning App (ARL). This allows us to reach a larger number of users and schools in which

smartphones are more common than computers.

We had to use miniaturized versions of science centre exhibits in order to provide a quality of visualization of effects and phenomena that was equivalent to the real thing. We also needed to preserve the degrees of freedom in the interaction so as to avoid a rigid simulation. Therefore following the idea of tangible interfaces [3], the miniatures were printed with a 3D printer and equipped with markers for identification. The ARL App [L1] uses the camera stream to detect and calculate position and rotation of the objects and uses this information for the simulation. Based on the live data the virtual content is updated giving the users the impression of a seamless connection between real objects and virtual content.

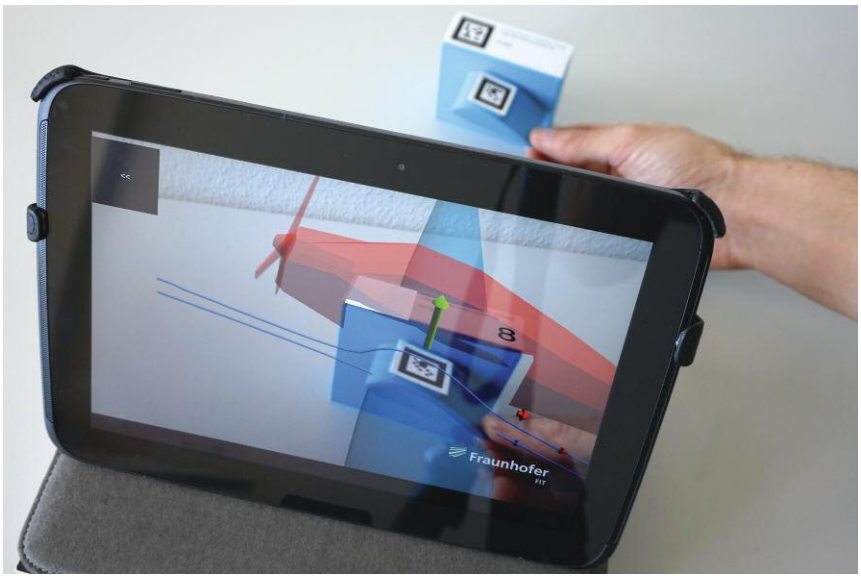

Figure 1: Visualizing forces and airstreams around a miniaturized wing using Augmented Reality.

One of the scenarios is the Bernoulli Effect, which tries to provide an answer to the question "Why do airplanes fly?" This exhibit consists of a model of a wing as shown in Figure 1. The wing is mounted on an axle to change its angle of attack. The air stream is visualized in the AR view. Forces of lift and drag are indicated through arrows at the wing model. The virtual content of the augmented view is instantly adapted for new angles of attack. Learners might change the airstream by changing the position of the fan as well as try out differently shaped wing models. This allows the user's own hypothesis to be tested and the user to experience the Bernoulli Effect first hand. The information visualized in AR is intended to increase the user's acceptance of otherwise more abstract content.

Another example is the Doppler Effect. The Doppler Effect exhibit allows users to move a sound source relative to a listener. The sound source is represented by a fire truck and its sound is captured by a virtual microphone. The user hears a change of pitch in the microphone input when either of the objects is moved. This miniaturized setup allows the simulation of the Doppler Effect, since, owing to the reduced scale, even small movements have a remarkable effect. Additionally visualized sound wave fronts further improve the understanding of wave propagation of relatively moving objects.

In the ongoing EU project Inspiring Science Education [L2] the ARL App featuring the Science Center To Go exhibits is currently used at schools in Europe. To lower the barrier of integrating interactive tools with the lessons, the ISE platform provides demonstrators for each tool. The teachers can then adapt and deploy their own interactive lesson.

In addition to the classical physical experiments outlined above, we - in cooperation with the ITA Institute of Textile Technology at RWTH Aachen - have also extended the ARL App to be used for mechanical engineering courses. This enables students to learn the mechanics of the machine in situ. By pointing a tablet towards the point of interest, the mechanics and gears become visible even while the machine is running.

We believe that the ARL App represents a further step towards turning concepts that have been developed and evaluated over years into reality for a broader group of users using smartphones and tablets, and helping students to understand and develop an interest in STEM (science, technology, engineering and mathematics) fields. The ongoing development of hardware will allow us to run more complex simulations bringing the virtual overlay and the real object even closer together to create a seamless augmented reality supported learning experience.

Links:
[L1] http://arl.fit.fraunhofer.de
[L2] http://inspiring-science-education.org

References:
[1] M. Wittkämper et al.; "A Distributed System for Augmented Reality Experiences in Science Centres and Museums"; Technologies for E-Learning and Digital Entertainment, pp. 936-946, 2007.

[2] H. Buchholz, C. Brosda, R. Wetzel: "Science Center To Go – A Mixed Reality Learning Environment of Miniature Exhibits", in A. Lazoudis, S. Sotiriou, (Eds) Proc. of the "Learning with ATLAS@CERN" Workshops Inspiring Science Learning EPINOIA, 2010, pp. 85-96, 2011.

[3] H. Ishii, B. Ullmer: "Tangible bits: towards seamless interfaces between people, bits and atoms", Proc. of CHI '97; Conference on Human Factors in Computing Systems, pp. 234-241.

Please contact:
Constantin Brosda, Leif Oppermann
Fraunhofer FIT, Germany
Tel +49 2241 14-2643
{constantin.brosda,
leif.oppermann}@fit.fraunhofer.de

Augmenting Printed Documents

by Xenophon Zabulis, George Margetis, Panagiotis Koutlemanis and Constantine Stephanidis

The "Interactive Documents" system augments documents, books, and leaflets on the surfaces on which they are read. The augmented content complements that of the printed document interactively; the user can touch regions of interest both within the printed matter and the augmented content.

The "Interactive Documents" system augments printed documents that are placed upon a planar surface (e.g., a desk or a table) with multimedia content and interactive applications. Using a projector above the surface, augmented content is dynamically displayed around and upon the printed document, aligned in real-time with its 2D location and posture. The system was developed in the context of the Ambient Intelligence and Smart Environments Programme of the Institute of Computer Science of the Foundation for Research and Technology – Hellas (FORTH-ICS).

As soon as they are placed on the surface, printed documents become interactive. Users can select any of the interactive hot-spot areas of the document in order to view related multimedia content (e.g., images, videos) or deploy interactive applications. The system employs an RGBD sensor (a conventional and a depth camera combined) as a sensing modality to identify documents and user fingertip contact with them.

The RGB component of the signal allows recognition and localization of documents on the surface. This is achieved by retaining a database of known documents, which stores the visual appearance of each printed page, in terms of visual features in each. When running, the system matches database features with features imaged by the camera to recognize the document pages. The spatial arrangement of these features in the database enables the estimation of location and orientation of the document on the surface. As features are local, recognition is robust to document occlusions by user hands. The depth component of the signal is employed in tangible interaction with documents, multimedia content, and applications. Tangible interaction avails detection and localization of fingertips upon the surface or document. Using the location and posture estimates of the document, touch is localized upon the printed page. This way, touch is inter-

Figure 1: User interaction with augmented printed documents. Main: the system highlights regions of potential user interest; upon user touch, relevant content is augmented, juxtaposed to the document. Thumbnails: multimedia augmentation in a music and poetry book (left), map augmentation providing city tour information on the printed map (middle) and visitor information (right).

preted with respect to the page, to find which word or figure in the document, or application, the user interacts with. By knowing the page location touched, underlined, or encircled by the user, the system can provide content and context-based information and assistance, as page contents are associated in the database with their semantics.

Augmentation is enabled by common calibration of the projector and camera. The system translates the location and posture of the document to the projector reference frame. This way, not only content is presented aligned and upon the document, but documents can be moved and rotated along the surface at user convenience, with the augmented content being "dragged along" in real time.

"Interactive documents" is a versatile system that can accommodate applications from different domains. It has been employed as an educational tool, to augment books with context-based multimedia information, and provide interactive exercises related to the content of each book page. Another use is to provide information to the visitors of a city upon a map; this use is installed at the Tourism Office of the Municipality of Heraklion, where tourists can place their own copy of a printed map, upon which the system highlights places of interest. The visitors can touch on the highlighted areas and see videos and images related to the selected place, as well as guidance information. The system finds use in expos and marketing, where printed leaflets are enhanced with multimedia information and interactive applications about the featured product.

Link:
http://www.ics.forth.gr/ami/projects/view/All/Interactive_Documents

References:
[1] G. Margetis, X. Zabulis, S. Ntoa, P. Koutlemanis, E. Papadaki, M. Antona, C. Stephanidis: "Enhancing education through natural interaction with physical paper", Universal Access in the Information Society, Special Issue on "User Experience and Access using Augmented and Multimedia Technologies", pp. 1-24, 2014, DOI: http://dx.doi.org/10.1007/s10209-014-0365-0
[2] G. Margetis, X. Zabulis, P. Koutlemanis, M. Antona, C. Stephanidis: "Augmented interaction with physical books in an Ambient Intelligence learning environment", Multimedia Tools and Applications. Published on-line: 10 January 2012 DOI: http://link.springer.com/article/10.1007/s11042-011-0976-x
[3] G. Margetis, P.Koutlemanis, X. Zabulis, M. Antona, C. Stephanidis: "A Smart Environment for Augmented Learning through Physical Books, in Proc. of the IEEE International Conf. on Multimedia and Expo (ICME 2011), Barcelona, Spain, 2011.

Please contact:
Constantine Stephanidis
ICS-FORTH, Greece
Tel: +30 2810 391741
E-mail: cs@ics.forth.gr

Augmenting the Rubber Hand Illusion

by Filip Škola, Szymon Fiałek and Fotis Liarokapis

Augmented reality (AR) is a technology that merges real and virtual information in real-time performance. AR introduces new opportunities in a number of application domains, one of the least explored to date being perception and psychology. Researchers from the HCI Lab developed a novel AR experiment in order to test the effects of the well known rubber hand illusion.

The traditional rubber hand illusion is an old psychological experiment where participants are under the illusion that a rubber hand is part of their own body. During the experiment, the rubber hand is positioned in front of the participant while their real hand is kept hidden from their view. Synchronous touches are then applied to both their real hand and the rubber hand and within minutes participants get the illusion that the rubber hand is part of their body [1]. This experiment has been previously exploited in immersive virtual reality (VR) environments [2]. The purpose of this study is to investigate whether AR can be used as a medium to provide a similar level of ownership.

Compared to the aforementioned experiment where a plastic rubber hand was used, a virtual 3D representation was chosen to create the same illusion this time in an immersive AR environment. The 3D rubber hand was made out of photogrammetric techniques and belongs to one of the lectures of Masaryk University. In particular, 15 high definition images were taken and then they were processed using medical imaging software to produce the 3D mesh. Textures were also taken from the high definition images and the resulted 3D model consists of 46611 vertices and 93218 triangles offering a very realistic model of a human hand.

For the visualization, a state-of-the-art head-mounted display (HMD) was used for presenting the augmented rubber hand illusion to the participants. The device used was the lightweight Vuzix Wrap 1200DXAR. The whole scene was then ported into the ARToolkit software tool. The AR application displays an animation of the hand being stroked by a virtual brush. Moreover, an EEG 32-sensor device called Enobio-32 was used and the electrodes were located at the extended 10-20 system. The raw EEG has usually been described in terms of frequency bands: gamma (greater than 30 Hz) beta (13-30 Hz), alpha (8-12 Hz), theta (4-8 Hz), and delta (less than 4 Hz). The setup of the electrodes takes approximately 30 minutes and the AR experience approximately three minutes.

Experiments were performed on 21 healthy volunteers (six females and 15 males), aged 20-35 years old. Participants were asked to complete two different questionnaires, one measuring their cognitive workload (based on the standard NASA TLX questionnaire)

Figure 1: A participant experiencing the AR rubber hand illusion.

and another one regarding their experience with the rubber hand illusion. In addition, EEG signals of the individuals were recorded and stored for further processing. Figure 1 illustrates a participant experiencing the AR rubber hand illusion.

In the analysis of the questionnaire data, four questions were found to be correlated with the recorded EEG data. These were (a) I felt as if the rubber hand was controlling my will; (b) I felt as if the rubber hand was controlling my movements; (c) I could sense the movement from somewhere between my real hand and the rubber hand; (d) It seems as if the rubber hand has a will of its own. The questionnaire results are presented in Table 1.

Results indicate that agency control, understood as the subjective awareness that one is initiating, executing, and controlling one's own volitional actions in the world, correlated positively with Theta frequency ($r = 0.54$, $n = 21$, $p < 0.02$). Theta frequency is believed to be associated with the intention of movement [3]. Agency control also correlated positively with Alpha frequency ($r= 0.55$, $n = 21$, $p < 0.01$). Brain activity resulting in increased alpha frequency is believed to be connected with higher state of relaxation. Frustration measured by NASA TLX correlates positively with Delta frequency ($r = 0.44$, $n = 21$, $p = 0.04$).

Variable	SD	Mean
Ownership	1.52	4.37
Ownership control	1.11	2.26
Agency	1.38	2.39
Agency control	1.40	2.14
Mental Demand	3.29	3.19
Physical Demand	1.33	1.71
Temporal Demand	1.25	1.81
Performance	1.90	2.62
Effort	2.12	2.00
Frustration	2.28	1.86

Table 1: Questionnaire results.

Concluding, this prototype experiment demonstrated that the AR medium seems to be providing a similar level of ownership as reported in the original rubber hand illusion experiment. In the future, a comparative analysis between the original rubber hand and the AR representation will be performed with more participants to measure more accurately the level of ownership.

Links:

Medical Imaging software: http://www.canfieldsci.com/imaging-systems/mirror/
Vuzix Wrap 1200DXAR: http://www.vuzix.com/augmented-reality/products_wrap1200dxar/
ARToolkit: http://www.artoolkit.org/
Enobio-32: http://www.neuroelectrics.com/products/enobio/enobio-32/
HCI Lab: http://decibel.fi.muni.cz/wiki/index.php/
Personal Web Page: http://www.fi.muni.cz/~liarokap/

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Please contact:

Fotis Liarokapis, Masaryk University, Faculty of Informatics, HCI Lab, Czech Republic
Tel: +420 549493948
E-mail: liarokap@fi.muni.cz

An Introduction to AR Browsers

by Howard Ogden

This article is an introduction to Augmented Reality (AR) Browsers, market analysis and challenges to overcome (barriers to adoption).

In 2008 IT and Technology research firm Gartner released their annual report "Hype Cycle of Emerging Technologies". This was the first year that the report mentioned Augmented Reality (AR). In it, Gartner estimated that AR was "more than 10 years" from mainstream adoption [1].

In 2009, Wikitude (AT), Sekai Camera (JP), Layar (NL) and Junaio (DE) were released to the general public on Android & iOS smartphones and categorised as Mobile Augmented Reality Browsers. Collectively, they heralded a new way for consumers to view geotagged data; using the camera view of a smartphone to graphically display spatially distributed data points.

Augmented Reality academics and researchers were quick to dismiss the browsers; to them it wasn't AR, as none of the browsers utilised Computer Vision techniques, simply GPS coordinates. Nevertheless, it felt like the future had arrived. By the turn of the decade AR Browsers had become tech media darlings and they began to receive multi-million dollar investments. These investments allowed the AR Browsers to invest heavily in R&D. This, alongside advancements in the underlying smartphone technology, enabled the first steps towards true mobile augmented reality: the software began to understand what it could see. Initially the browsers could recognize set patterns: barcodes, QR codes and fiducial AR markers. The vision capability quickly evolved and by the end of 2011, image recognition and natural feature tracking (NFT) were possible using AR Browsers on mobile devices. It was around this time that Blippar (UK), Zappar (UK) and Aurasma (US) joined the AR Browser market. These notable newcomers benefitted from not having to make the transition from GPS based AR to image recognition and gained traction in the marketplace quickly.

Fast-forward a few years and in many respects Gartner's 2008 prediction has held true. Certainly AR Browsers have yet failed to have an impact on the day-to-day life of even hardcore enthusiasts, let alone everyday people.

Meanwhile AR has, at least in one case, achieved high-growth adoption. In 2010 a startup called Quest Visual created a translation app called "Word Lens". This ingenious tool would use optical character recognition on any foreign language and augmented reality to overlay a translation on it. In 2014 Google acquired Quest Visual for an undisclosed sum and, as you may know, the augmented reality feature has been incorporated into Google Translate. Today the most widely used augmented reality application in the world is: Google Translate.

Aurasma, Blippar, Layar and Zappar are well-funded companies, with bright minds working on an exciting technology. That said there isn't much to differentiate them. To achieve their goal of ubiquity they are all targeting the same low-hanging fruit: print and packaging for marketing purposes, with relatively similar solutions and relatively similar levels of success.

Given the similarities though, AR Browsers are 'walled-gardens': No standards exist to allow for AR content to be interchangeable. If this were the World Wide Web, it would be the equivalent of the search engine Bing only being accessible via Internet Explorer and Google only on Chrome. If they were popular it wouldn't be a problem of course; most markets have space for several companies with a similar offer, but the user review scores on the various app stores indicate they are less popular now than ever before; so it seems there's a complete disconnect between AR Browsers and the people who actually use their product.

However, when AR Browser spokespeople appear on TV news or at industry events they all claim traction, measuring their success by the brands they have attracted to their platform. They also mention they've had x-million downloads, and quote statistics such as "average dwell times of x-seconds", but real success relies on going beyond the easily won deals and massaged metrics.

It's fair to say that a large percentage of consumer brands have now experimented with augmented reality in some form, the majority using AR Browsers. All gold rushes have a life cycle and perhaps as evidence to the potential end of the craze in existing markets, AR Browsers are currently aggressively expanding their product to newly equipped, emerging markets; where they can employ the same old tactics with expectations of yielding the same results.

By this reasoning it's not a technology issue holding AR back from mainstream adoption; it's a governance issue by ARs' biggest players.

Unless the focus shifts from attracting the Next Big Brand to adding value to the everyday lives of their end-users, the AR Browsers - who are in the best position to be taking the augmented reality industry forward - are actually holding it back. If they fail to improve, the brands and businesses they depend upon will become cautious of entrusting their content with a 3rd party and their legion of unimpressed end-users.

Reference:

[1] Gartner Research, http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp

Please contact:

Howard Ogden
Chief Evangelist, Kudan
https://www.kudan.eu
E-mail: howard@kudan.eu

European Research and Innovation

A Structured Approach to Defence Simulation Training

by Peter Kieseberg

The Austrian SCUDO project is developing a training kit enabling an easy-to-use setup simulation environment for training personnel in the defence of critical infrastructures against IT security incidents.

Modern IT systems are heavily integrated into critical infrastructures and attached to vital parts of operative core components. Many organizations have contingency plans in case of attacks on their critical systems. Post-mortem reviews of the contingency plans indicate that the plans are often outdated or even completely unknown to key players [1]. Problems are further compounded when the contingency plan of an organization relies on establishing communication with parties outside the administrative boundaries of the organization under attack. The lack of updates in the partners' structure results in loss of vital information, outdated assumptions, and an inability to establish appropriate paths of communication and information exchange in the case of an attack.

Regular training focusing on different attack scenarios can facilitate detection of weaknesses, and thus help to overcome them. While table-top exercises are quite popular within some industries, we still lack standardized training methods. In particular, we need to work on developing: efficient setup of training; metrics for measuring readiness and progress; and the availability of tools for preparing and developing the exercises, including an appropriate environment for their execution and analysis.

The SCUDO research project addresses the following research questions:

- The development of an iterative training process yielding quantifiable results, including the required metrics (see Figure 1).
- The construction of different classes of scenarios with respective training environments.
- The development of a training kit that allows the further development of practical scenarios based on the iterative training process.
- Providing tool and visualization support for training execution.

The main aim of the SCUDO project was to generate a training kit that facilitates the straightforward tailoring of predefined basic scenarios into suitable and diverse training scenarios by non-experts in the field of simulation training or table-top exercises. To this end, it included:

- A set of practical basic scenarios, based on three different incident classes.
- A repertoire of easy to deploy inline events.
- Guidelines for the adaption and tailoring of scenarios to fit the training partners and environment.
- Guidelines for efficient execution and operation of training, including recommendations for observers.

Figure 1: Iterative training process.

Figure 2: Tool support.

- Metrics for the measurement of the readiness level.
- Templates for the documentation of readiness and progress.

An emphasis was placed on generating exercises that involved several related institutions (e.g. supplier-customer) or competing companies, since conflicting contingency plans were identified as a major obstacle [1]. In order to enable the trainers to select the right exercise environment from the basic scenarios and the set of inline events, three fundamental incident classes were defined. The first class (IC1) is concerned with a local disruption of vital IT service business operations (e.g. DNS), while IC2 deals with attacks against the availability and integrity of data transfer and (secured) IT-based communications. Finally, IC3 covers the worldwide disruption of integral IT services that are vital for business continuity, e.g. zero day exploits in the backbone router infrastructure. For each incident class different responses are required from the trainee response team, for example: in regard to communication obligations with governmental departments and the general public, down to liabilities and other legal and regulatory issues.

The SCUDO project has developed support tools for training execution, including support for the players, operators, and observers of an exercise. This set of tools is based on open source technologies and features on-site training for the players, in case of several different companies, as well as the automated collection of training data for the calculation of different metrics in the course of a subsequent analysis.

SCUDO also delivered preliminary results on developing a Situational Awareness Centre [2], monitoring data streams that can lead to the detection of the attacks. This functionality may be added transparently to the exercise scenarios. Thus, the same exercise can serve both the traditional training setup and for identifying the needs and gaps in a potential Situational Awareness Centre.

The SCUDO tools were evaluated in practical exercises attended by major players in Austria with emphasis on important providers for critical infrastructures and the respective governmental partners and ministries [3]. The simulated scenarios within training sessions helped to dramatically increase the readiness of all participants, leading to a better response by their response teams, as well as updates to their contingency plans. Furthermore, the project has raised the collective situational awareness of these issues to a higher level. This direction will be further pursued in a follow-up project regarding the development of Situational Awareness Centres.

The SCUDO project, which was supported by the KIRAS programme of the Austrian Research Promotion Agency (FFG), concluded in February 2015. The project consortium was led by Thales Austria and was carried out by a team of ten partners, ranging from (governmental) stakeholders to scientific and industrial partners.

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Links:

The official SCUDO project homepage:
http://www.sba-research.org/scudo

Please contact:

Peter Kieseberg
SBA Research, Austria
E-mail: pkieseberg@sba-research.org

Reducing the IoT - PbD Dilemma by Enriching Authorization with Reputation Mechanisms

by Darío Ruiz López

The RERUM framework is designed to be both secure and private, whilst maintaining the open nature of the Internet of Things (IoT) by empowering users by allowing them to define dynamic access criteria based on user reputation.

One of the main obstacles currently hindering the adoption of IoT is the lack of trust in the security and privacy provided by IoT frameworks. By offering a framework designed to be both secure and private, RERUM aims to foster the adoption of IoT, specifically in the scope of Smart Cities.

However, there is a very serious issue when trying to apply the Privacy by Design (PbD) techniques to the IoT [1]: A common perception of the IoT is that its sole purpose is to connect everything to the Internet, but the IoT is more than this: the IoT will allow devices connected to the IoT to connect to each other for any purpose, including purposes that we cannot foresee. Hence, IoT is conceptually aiming to achieve an open world. This is one of the biggest strengths of the IoT because it potentially offers an almost infinite world of data to data mining engines. At the same time, however, it makes it incompatible with the Privacy by Design concept.

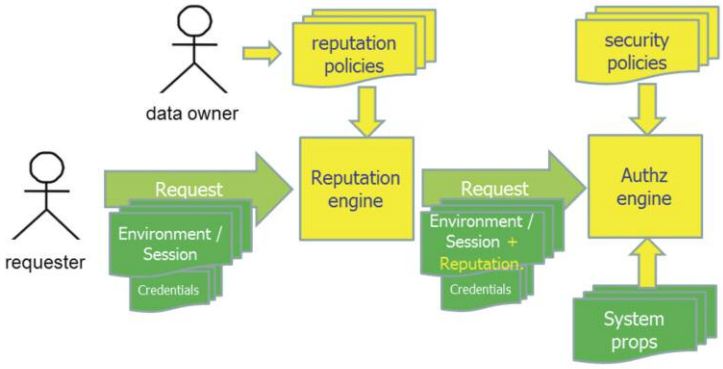

Figure 1: RERUM approach to reduce the IoT-PbD dilemma.

In contrast to the openness of the IoT, in Privacy by Design, access to data is meant to be granted only to those people or applications previously agreed to by the owner of the data, and only for purposes stipulated by the owner [2]. That is, Privacy by Design conceptually aims at a closed world by default, rendering it necessary to define in advance who can access the data and for what purpose.

Moreover, even if the user wanted to grant access to any IoT device in the world and for any purpose (as is intended by the IoT), there is no way this could be achieved, since the user would have no way to know in advance who will be wanting to access the data and, even worse, the purpose of this access may not even exist yet, since the concept of IoT implies new purposes may appear with time as new devices and applications are developed.

Thus, there exists a dilemma between fully supporting IoT and PbD that makes it necessary to come to a compromise between them. Though RERUM has mainly opted for PbD, it has also studied the nature of this dilemma and tried to reduce it by analyzing the objectives of both the IoT and PbD with the goal of attaining as many objectives as possible - even if this means adapting the way the concepts were written.

IoT is not about violating privacy, but providing technical means for devices to connect to each other throughout the internet, and PbD is not about impeding connectivity, but empowering users to control how their data are used. Hence, the way to approach IoT and PbD should be to find ways to let users grant access to their data to IoT devices while maintaining control of how this access is granted. However, since the nature of IoT means that the number of consumers and purposes of the requests is near to infinite, this control must be accompanied by automatic processing that allows the access decision to be made based on criteria defined by the user. In this way we allow the user to define access criteria that will let IoT devices access data according to those criteria, even for unknown applications and devices, and even for unknown purposes.

RERUM proposes a reputation engine configurable with rules defined by the user to enrich the authorization process with the result of this evaluation, so the data owner has the option of defining access criteria that allow data access by unknown users, even for unknown purposes if the data owner wishes.

The RERUM project is a research project subsidized by the European Commission through the Seventh Framework Programme. RERUM aims to create an IoT framework for Smart Cities based on the concepts of Security and Privacy by Design.

RERUM started its work in September 2013 and is currently being executed by the RERUM consortium, formed by the following companies and institutions throughout the European Union: Eurescom, Atos, Siemens, Zolertia, Forth, Cyta, the universities of Bristol, Linköping and Passau, and the municipalities of Heraklion and Tarragona.

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Please contact:

Darío Ruiz López, Atos, Spain
E-mail: Dario.ruiz@atos.net

Verifying Systems-of-Systems with Statistical Model Checking

by Axel Legay, Jean Quilbeuf, Flavio Oquendo

Verifying the correctness of systems-of-systems (SoS) is a key challenge, largely because SoSs are evolutionarily developed by combining autonomous systems to fulfill a mission that could not be performed by one of the constituent systems alone. In the trade-off of correctness vs. scalability, model checking does not scale up to address the trustworthiness of SoSs, owing to the state explosion problem. A recent technique, however, has overcome this shortcoming: 'Statistical Model Checking' is based on sampling traces of the system-of-interest until adequate statistical evidence has been established.

DANSE, one of the first European projects dedicated to SoS engineering, has defined a new methodology for the rigorous design of SoSs (Figure 1).

The behaviour of an SoS emerges from the interaction among its constituent systems. The DANSE methodology (co-designed by world-leaders in the SoS industry, such as THALES, EADS, and IBM) recommends that an SoS's behaviour (in terms of trustworthiness) be verified whenever a new SoS is being designed or when an existing SoS is undergoing a new evolution.

Clearly, DANSE advocates verification procedures to guarantee that an SoS accomplishes its missions in a trustworthy manner. These missions include performing a given service, which is the main reason for the SoS to exist, but also guaranteeing the quality of service, in particular in terms of safety, security and other extra-functional properties, e.g. ensuring the privacy of consumers connected to a smart grid.

Desired SoS behaviours and quality are often abstract and not verifiable, which further accentuates the difference in the DANSE methodology from systems engineering: requirements are difficult to verify and evolve with the SoS. The DANSE methodology primarily describes SoS requirements in the form of goals and contracts. Goals are quantifiable characteristics to be optimized toward an objective value. Contracts are statements that must be true for the SoS to have acceptable behaviour. Goals and contracts can be identified at both SoS and constituent system levels.

Testing will often not work in this context. Indeed, the interaction between the constituent systems is highly unpredictable, which makes it difficult to derive test cases with high coverage. Moreover, testing makes it hard to cast complex quantitative properties.

Model checking is a widely recognized verification technique to guarantee the correctness of a system-of-interest, relying on algorithms that check whether all executions of the modeled system satisfy properties stated in a specification logic. Its use to support formal verification of SoS models is impractical, however, for several reasons. First, as an SoS is obtained by the combination of several systems, the combinatorial blow up of the state-space, commonly known as the state explosion problem, prohibits this technique from being applied to most real-world applications of SoS. Second, model checking tools typically require models to be specified in a particular language. Unfortunately, in an SoS each constituent system is usually designed using a specific modelling language (e.g. Modelica, Simulink), relying on a specific computational model. Therefore, it would be necessary to translate all constituent system models into a common formal language understandable by a model checker. But overcoming this technological issue is unlikely to solve the problem, because the state space of an SoS is too large to be handled by a model checker.

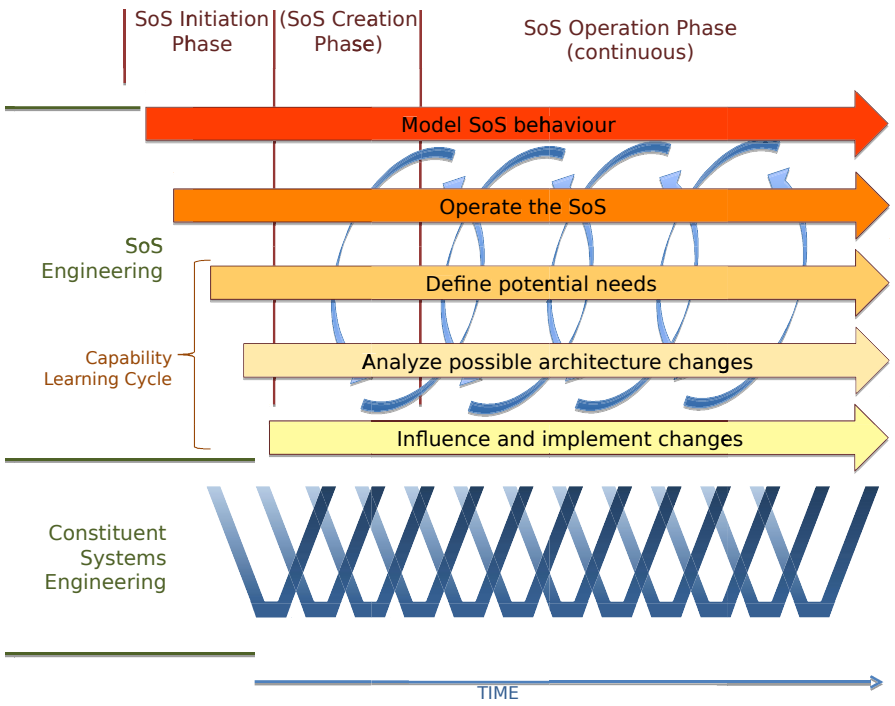

Figure 1: DANSE SoS Lifecycle.

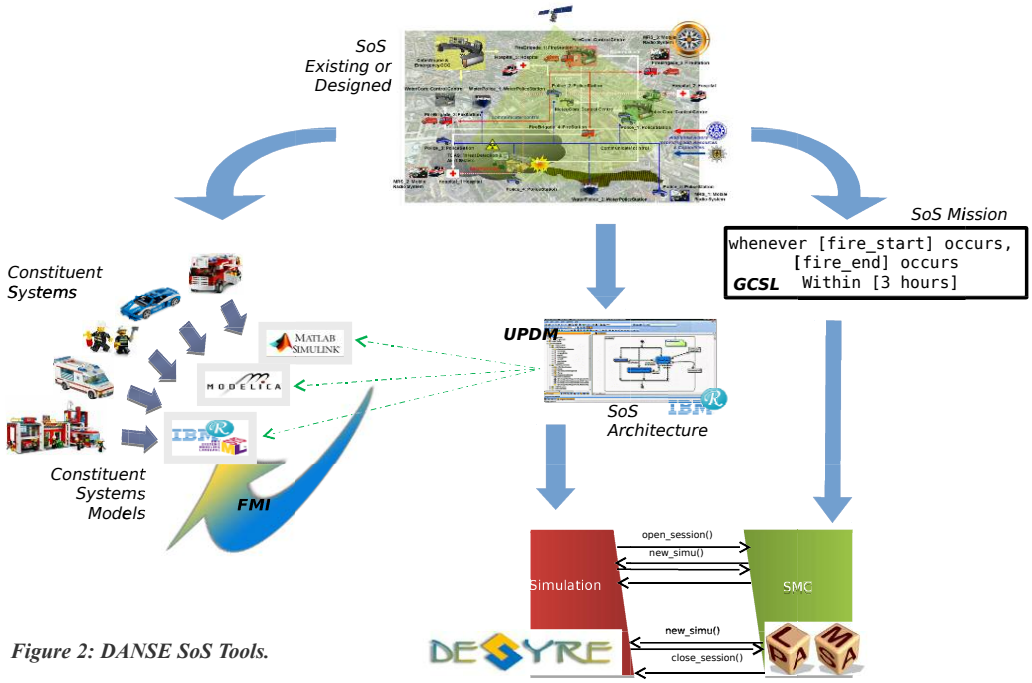

Figure 2: DANSE SoS Tools.

Moreover, the semantics of all the constituent systems and their interactions may not be known.

To solve those issues, DANSE proposes a novel approach based on Statistical Model Checking (SMC). SMC consists of observing several executions of the system-of-interest, monitoring them with respect to a given property, and then using an algorithm from the statistics (e.g. Monte Carlo, hypothesis testing, etc.) to derive the overall probability to satisfy the property.

SMC is a compromise between testing and classical model checking techniques. Simulation-based methods are known to be far less memory- and time-intensive than exhaustive ones, and are often the only feasible possibility in the case of SoS. This method does not require extra modelling or specification effort, but simply an operational model of the SoS that can be simulated and checked against state-based properties.

Within this framework, it is assumed that the next state of the SoS depends on some probability distribution. This is not a major restriction since probabilities are naturally used to model user requests and environmental states (e.g. weather conditions, traffic, human knowledge). Results from statistics provide bounds on the approximation error depending on the number of simulations, which allows fine tuning of the analysis depending on the requested precision.

SMC algorithms are implemented in the Plasma-Lab tool. This tool has been used to enable verification of SoSs in the DANSE project as depicted in Figure 2. In DANSE, the co-simulation of heterogeneous constituent systems in an SoS is obtained by relying on the FMI/FMU standard. Each constituent system model is compiled to a Functional Mockup Unit (FMU) that complies with the Functional Mockup Interface (FMI). The simulation is handled by the DESYRE simulator which orchestrates the execution of the FMUs according to the defined SoS architecture. The missions are specified as GCSL patterns that are then translated to BLTL, one of the property languages understood by Plasma-Lab. During the analysis, Plasma-Lab interacts with DESYRE to launch new simulations and control execution of the current one.

In the DANSE project, SMC has been applied to verify several complex industrial case studies. In particular, it was used to verify a water treatment and distribution system on a national scale. The mission verified that the system trustworthily provides enough water for the customer. The DANSE approach was also used to assess the reliability of an air traffic management system. In this case, SMC was used to check that the system remain operational more than 99% of the time, on a scale of 25 years.

Future work on the verification of SoSs is mainly focused on the specification and verification of emergent behaviour by tightly integrating a formal ADL for describing SoS architectures, i.e. SosADL and an enhanced Plasma-Lab.

Links:

http://danse-ip.eu/
http://project.inria.fr/plasma-lab/
https://team.inria.fr/estasys/
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Please contact:

Axel Legay, Jean Quilbeuf, Inria and IRISA, France
E-mail: axel.legay@inria.fr

Flavio Oquendo, IRISA (UMR CNRS, Inria & Universities of Rennes and South-Brittany), France
E-mail: flavio.oquendo@irisa.fr

A Bottom-up Strategy for Clustering Complex Datasets with Application to Language and Script Discrimination

by Alessia Amelio

A bottom-up clustering algorithm can be used to extend a state-of-the-art method to partition datasets in groups of complex data. The algorithm has been applied to discriminate between documents in different languages and scripts.

Given a set of images included in a database, image clustering has the aim of grouping the images in homogeneous classes, for which images in the same class exhibit a similar informative content. Grouping depends on the image representation by descriptors capturing the informative content and on the similarity measure applied on the descriptors.

Genetic Algorithms Image Clustering (GA-IC) [1] is an evolutionary algorithm, for clustering a database of images by co-occurrence and colour centile features, representing the texture and colour image contents. A weighted graph G = <V, E, W> is retrieved from the database, where nodes V represent images of the database and edges E connect each node to the other most similar nodes. Node similarity is evaluated between the images associated with the nodes. For a given node v, the other most similar graph nodes define the h-neighbourhood of v, where h is a parameter related to the neighbourhood size. The weights W on the edges express the similarity degree among the nodes. An evolutionary strategy on the graph G finds groups of nodes representing image clusters.

Here I propose a bottom-up clustering method which is an extension of the state-of-the-art GA-IC approach. Two main modifications have been introduced, which improve performance and enable the algorithm to be used in a wider scenario of complex data. The algorithm has been applied to discriminate between documents in different languages and scripts.

The first novelty reduces the number of 'noisy' edges connecting the graph nodes whose corresponding objects are not particularly similar to each other. Such edges are usual in a context of complex objects for which the h-neighbourhood definition is not sufficient to capture the real similarity. Consequently, I modify the neighbourhood of a graph node v by considering only the most similar nodes which are also 'spatially' near to v, based on a given node ordering. In particular, I introduce a concept derived from the Matrix Bandwidth definition in the G graph construction. Let f be a node ordering, mapping the graph nodes V to integers f : V → {1, 2, ...n}, where n is the number of graph nodes. For each node v with corresponding label f(v), I compute the difference between f(v) and the labels F of the nodes in the h-neighbourhood of v. Then, I connect v with the only nodes in the h-neighbourhood whose label difference is less than or equal to a threshold value T. Figure 1 illustrates the main steps of the procedure for graph construction.

The second novelty introduces a bottom-up refinement strategy at the end of the GA-IC procedure, very important for improving the final solution by 'correcting' the local optima. Specifically, considering the clusters detected from the GA-IC evolutionary procedure, the distance for each pair of clusters is computed. The cluster pair with the minimum associated distance is then merged into a single cluster. The procedure is repeated until a fixed number of clusters is reached. The distance between two clusters is the distance between the two farthest objects, one for each cluster. Figure 2 shows the main steps of the strategy.

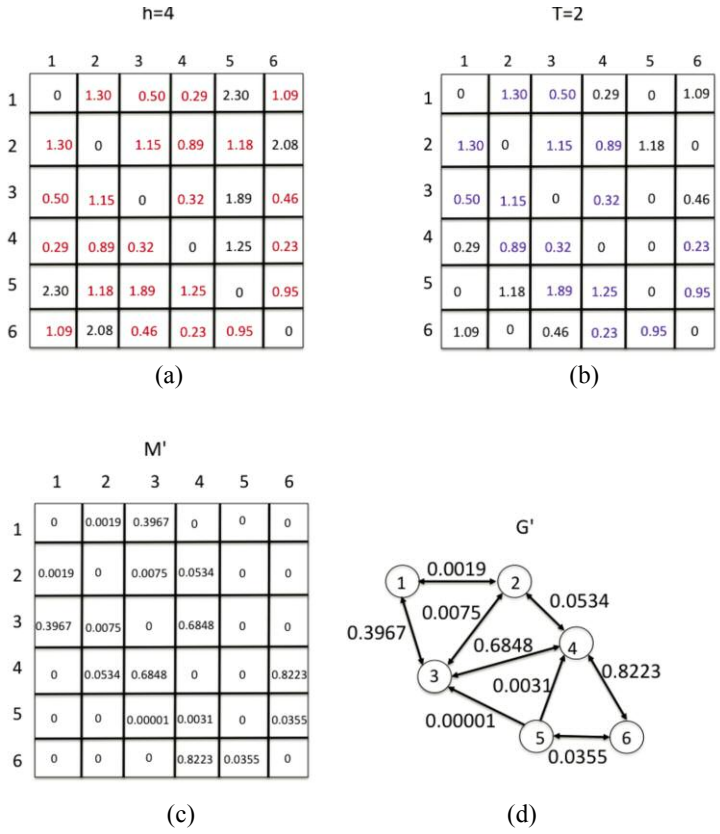

Figure 1: Example of graph construction. (a) Creation of the distance matrix, obtained by computing the distance for each pair of objects in the database (six objects). For each node (row) in the distance matrix, detection of the 4-nearest neighbors (in red). (b) For each node (row), detection of the neighbors with label difference smaller or equal to T=2 with respect to the label of that node (in blue). (c) Computation of the similarity values from the corresponding distance values. It defines the graph adjacency matrix M'. (d) Creation of the graph G' from M'.

The bottom-up algorithm has been extensively evaluated by using well-known performance indexes on large databases of complex text documents, given in multiple languages and scripts and using different kinds of features for document image representation [2],[3], where it enlarges previous approaches by adding automatic classification.

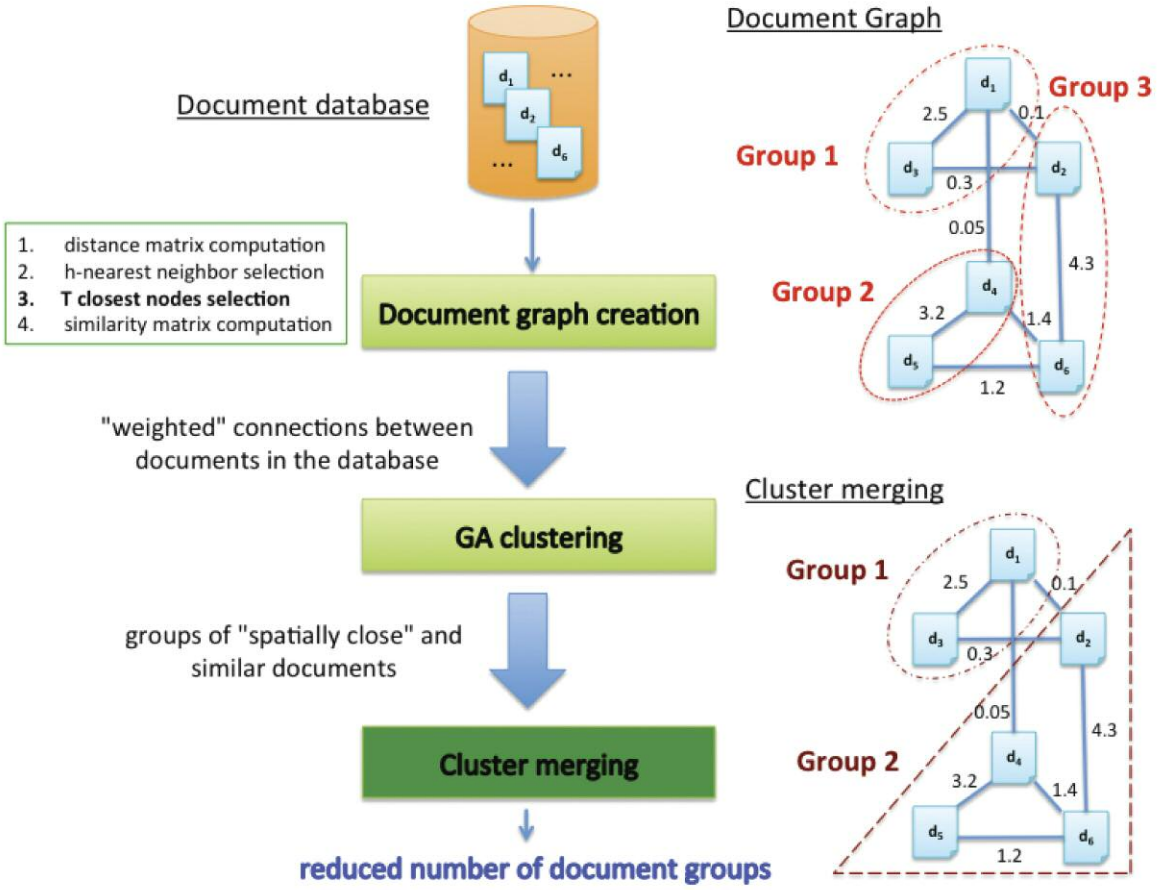

Figure 2. Diagram of the algorithm applied on a document database. Starting from the database, the first step creates the document graph (top right). It has the documents as nodes and the connections between documents as links. Weights on links represent the similarity among documents. Each node is connected to the most similar and "spatially" close other nodes. Clustering is the second step, dividing the documents in groups. Finally, a merging procedure is performed (third step) reducing the number of groups to only the most meaningful ones (bottom right). The two proposed modifications of the base approach are reported in bold (phase 3 of selection of links connecting only "spatially" near nodes) and in dark green (Cluster merging).

The new strategy has been used for the discrimination of text documents in English, French, Spanish, Portuguese and Slovakian languages. Another experiment has been performed for the discrimination of documents in closely related South-Slavic languages [2], such as Serbian, Croatian, Macedonian and Slovenian. The algorithm has been also adopted for the clustering of documents written in different kinds of scripts. In particular, the approach has been tested on datasets of documents written in German scripts, such as Antiqua and Fraktur, and in South-Slavic scripts, such as Latin and Cyrillic, and Latin, Cyrillic and Glagolitic. Another much more complex experiment consisted in the differentiation of Medieval South-Slavic labels hand-engraved in stone and hand-printed in paper in the old Cyrillic, angular and round Glagolitic scripts, a real challenge for a clustering approach [3].

In these experiments, the bottom-up algorithm has been compared with a wide range of well-known classification algorithms, including the GA-IC base algorithm. In all the experiments, the new approach demonstrated its superiority with respect to the other classifiers in terms of the performance indexes, by perfectly clustering the proposed document databases.

Future work will investigate the discrimination of documents in Italian and Latin languages and will provide a useful tool for the classification of the documents in 'old Italian', which is important for cultural heritage preservation.

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Please contact:

Alessia Amelio
ICAR-CNR, Italy
E-mail: amelio@icar.cnr.it

REVERIE – Real and Virtual Come Together in a Virtual Reality

by Fons Kuijk, Rufael Mekuria and Pablo Cesar

REVERIE is a general-purpose tele-immersion system that enables individuals to interact in a shared 3D synthesized environment. It is a meeting place for virtual characters representing real participants and receptive virtual agents (autonomous humanoids). Participants observe this virtual reality from the dynamically changing point of view of their virtual embodiment (an avatar or a replicant) and 3D spatial audio completes the impression of being immersed.

Tele-immersion enables individuals that are geographically apart to interact naturally with each other in a shared 3D synthesized environment in which each of the participants can be represented by a virtual character. Since tele-immersion systems are not restricted to the recordings of static cameras, they enable participants to see the virtual environment from the dynamically changing point of view of their virtual representation. REVERIE's virtual environment is one example of such an ambient, content-centric Internet-based environment where people can work, meet, participate in live events, socialize and share experiences as they do in real life, but without time, space and economic limitations. Users are represented either by an avatar (a geometrical model of a human that can be animated by means of parameters) or by a replicant (a surface model of the user captured with multiple cameras and reconstructed as photorealistic 3D meshes or point clouds that are transmitted in real-time). In this environment we may also find agents, fully autonomous virtual humanoids that do not represent a human user in the real world, but act like one.

The REVERIE system [1] is a distributed architecture of web-connected clients that can be configured to run the modules needed for a particular application. Modules of the REVERIE system analyse captured data from the real human user and model the interaction between virtual and real, including facial expressions, gaze and gestures, as they are essential aspects of non-verbal communication. The components can be deployed on user computers, as they do not require a heavy setup (Kinect, webcam and microphone) and therefore are well suited for a web-based communication system.

Non-intrusive real-time recognition processes enable the speech, the gestures, the emotions and the facial expressions of users to be recognized by the system in a dynamic and natural fashion. This way, real-time puppeting of avatars is made possible along with mouse-keyboard-triggered actions such as navigation or requesting to speak. Depending on the activity of the users, the avatars produce rich human-like behaviour that is visually understood by other users and virtual agents.

Using similar control structures augmented by reasoning components, the REVERIE system manages autonomous

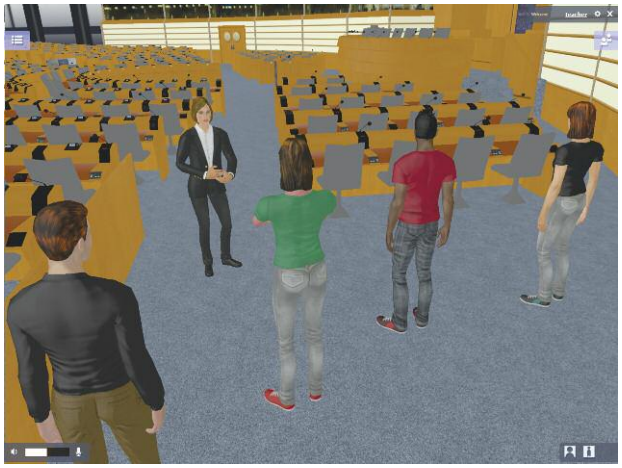

Figure 1: A fully autonomous agent acting as tour guide for a group of students being represented by avatars.

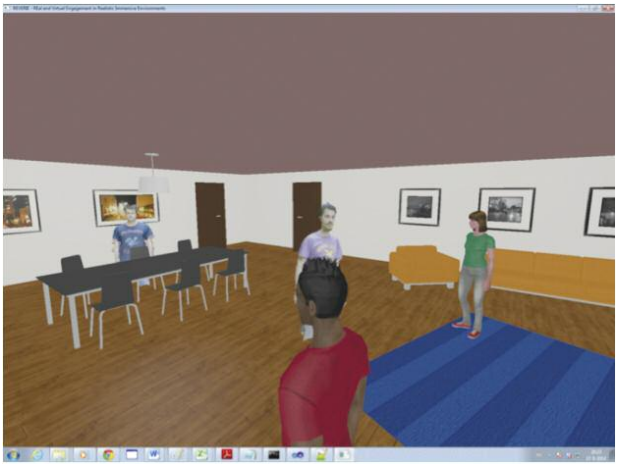

Figure 2: REVERIE scene with four participants, two of them represented by replicants and two represented by avatars.

virtual agents that may act as tour guide or lead a game [2]. Moreover, agents are capable of reacting autonomously to the users' activity in various ways, detecting when a user is losing engagement or participating in the interactions and showing appropriate behaviour (gestures, gaze, speech) in response.

Unlike avatars and agents, the replicant representation is a real-time captured model of the user for which transmission of 3D geometry poses a large challenge in compression. Therefore, the REVERIE system contains a framework for geometry compression to address the challenge of immersive communications. The framework includes three different codecs that have different properties and can be used in different situations depending on the need of the application [3]. As spin-off we have contributed a base reference software platform for MPEG (where CWI leads an activity of the 3D Graphics group) that can be used for collaborative development of technologies for compression of time varying point clouds that includes colour and prediction schemes. This work led to an update of the MPEG-4 requirements for including time varying point clouds for supporting 3D tele-immersion scenarios and will allow industries to rapidly develop and integrate these technologies in their industrial systems.

The user experience of the REVERIE system has been evaluated in a field trial including avatar and replicant representations. In this study, participants in groups of four (two being represented as replicants and two as avatars) interact in a virtual room to complete a collaborative task. We learned that a replicant representation has some advantages: the user represented is instantly recognized, the representation demonstrates what the user does and where s/he is looking, and one can see the user's emotional state. Because of this, participants recognized the usefulness of the replicant representation in the successful completion of a collaborative task. On the other hand, an avatar representation, which uses less bandwidth, is preferred when limited facilities leads to low-quality replicants (e.g., having artefacts or missing user body parts), which degrade the user experience. Completing tasks with low-quality replicants would require users to rely solely upon verbal channels. Avatar representations are also useful to enable users to hide from view and still have a virtual embodiment that mimics their actions in a "natural" way by pose, gesture and emotion recognition.

The results of these field trials highlight the potential of the replicant representation in virtual worlds, and the relevance of design, implementation and evaluation of geometry codecs to support this representation.

This work has received funding from the European Union's Seventh Framework Programme FP7/2007-2013 under grant agreement no. ICT-2011-7-287723 (01/09/2011 - 31/05/2015). In this project fifteen renowned research institutions and industrial players with balanced expertise covered all the technical aspects needed to achieve the challenging project goals: STMicroelectronics, Queen Mary College, CTVC Ltd, Blitz Games Studios, Alcatel-Lucent, Disney Research, HHI (Fraunhofer), TP Vision, CWI, Telecom ParisTech, DCU CLARITY, Synelixis Ltd, ITI (CERTH), Microsoft Innovation Center Torino and WooX Innovations Belgium.

Link:
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Please contact:
Fons Kuijk
CWI, The Netherlands
E-mail Fons.Kuijk@cwi.nl

A Knowledge Based Solution for Intelligent Verification and Validation of Interlocking Railway Systems

by Pierfrancesco Bellini, Paolo Nesi and Imad Zaza

Although modern secure railway transportation management systems are employing more 'intelligent', highly computerized technology, they are still strictly dependent on the site-specific configuration of track layout, which follows different rules for different nations. An expert system model, which independently formalizes a railway network, focusing on railway terminals (stations) and including topological and functional aspects of track elements, enables verification and validation.

An interlocking system is an arrangement of signalling devices at track crossings or junctions that displays a stop signal unless the route is clear and safe, thus preventing conflicting movements of trains. The control table - a matrix composed of a row for each route and a column for each relevant track side device for that route [1] - rules the interlocking decisions process.

European railway standards are being established to facilitate interoperability and high speed trains. Loosely coupled systems – a consequence of different interlocking systems being used in different regions - lead to high maintenance costs, thus it is necessary to find a well-established shared configuration and operational system. Multiple solutions may be proposed to model a railway station, and the resources needed to validate and verify any solution or changes can be time-consuming and unaffordable for single teams.

To tackle this problem, we have developed a new approach based on a knowledge base (KB) system. The overall system architecture (shown in Figure 1) is composed of three parts: a KB model, an input station (signal principles, specific track elements field, and track layout), and device specifications (track device status and commands configuration).

The KB model is based on an ontology which formalizes the relevant concepts of a track layout, e.g. track elements network and their related properties, such as train detector, signals etc.

The tasks of the KB interlocking model are: verification and validation; route request processing, validation of a track layout (and eventually suggesting missing elements); control tables generation.

To give an example, we could compile a station layout in the KB. Then, we could query the model to gain information about completeness and consistency of whole specification and of the elements adopted to configure the solution,

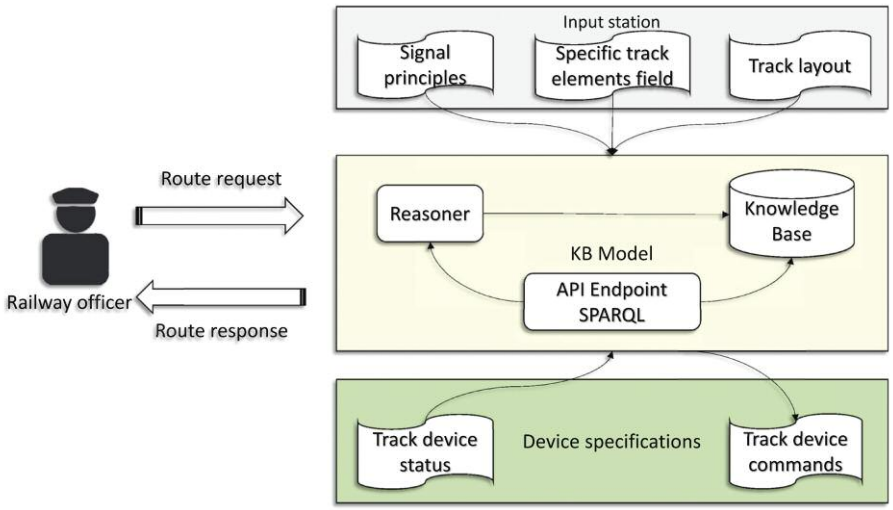

Figure 1: Knowledge based solution macro components.

exploiting routes or investigating which changes are needed to satisfy a specific interlocking principle, e.g. certifications. Using conventional procedures, the same actions would require considerably more effort, e.g. changing a safety rule means recompiling the entire control table including the related verification phases.

To build our ontology, we started by mapping the RailML infrastructure sub schema as a well-established domain of interest, identifying elements and their characteristics [2]. The RailML [2], an XML schema related to the railway domain, is composed of three subschemas: Infrastructure, Rolling Stock and Timetable. The infrastructure schema describes track positions according to nodes and branches modelling.

The initial prototype was unsatisfactory because the ontology was derived by simply mapping XML to OWL (Web Ontology Language) thus obtaining a taxonomy i.e. no significant inferences would be possible. Therefore, the early model has been enriched by using the OTN Open Transport Networks (OTN) for the topological aspects and Semantic Sensor Network (SSN) for modelling observations of events related to devices. OTN is a general purpose ontology oriented to transportation networks based on Graphic Data Format (GDF) which is a widely used binary data format for storing geographic data. The SSN ontology enables expressive representation of sensors, sensor observations, and knowledge of the environment. Despite the large coverage, the ontological model was not satisfactory and complete, thus other classes were added to improve the hierarchy of track elements, thus enabling inference and reasoning.

In order to validate the proposed ontology, data related to different railway stations formalized according to the rules of different countries (Netherlands, Germany and Italy) were loaded into the KB and tested.

The formalized semantics of our proposed approach have several advantages over state of the art formal specifications such as z-notation. For instance, they can be used to infer new facts (e.g. use of a specific track device) or to prove safety properties (by means of the execution of semantic queries checking several kinds of verification and validation properties for completeness and consistencies).

We chose OWL as the modelling language, and adopted Stardog as RDF-store and SPARQL end point for testing. Clark and Parsia's RDF-store was chosen because of its reasoner that implements integrity constraint checking - an essential feature for validating track layout. Stardog was used because it enables a Close World Assumption for integrity constraints checking.

This activity was developed in the context of the RAISSS project partially supported by POR CReO FESR (European Fund for Regional Development) (2007 – 2013), and cofounded by the Tuscany Region, in collaboration with ECM S.p.A., a company producing solutions and technologies for the safety and control of railway infrastructures; and TESYSRAIL (national technological cluster on transportation 2020, technique and tool for railway transportation), supported the National Technological Cluster "Transport Italy 2020". The work reported here was conducted at the DISIT Lab, Dept. of Information Engineering, Florence University. DIST is involved in the development of ontologies and knowledge bases for various smart city models and tools.

Links:

RAISSS project: http://www.disit.org/5481
TESYSRAIL project: http://tesysrail.it/en/
http://www.disit.dinfo.unifi.it

References:

[1] J. Glover: "Principles of Railway Operation", Ian Allan Publishing, 2013.
[2] A. Nash et al.: "RailML-a standard data interface for railroad applications" Publication of: WIT Press, 2004.

Please contact:

Pierfrancesco Bellini, Paolo Nesi or Imad Zaza
University of Florence, Italy
E-mail: pierfrancesco.bellini@unifi.it, paolo.nesi@unifi.it, imad.zaza@unifi.it

PaaSage First Product Release

PaaSage, a large scale European research project for developing an open and integrated platform to support model based lifecycle management of Cloud applications for software and service providers is proud to announce the official public release of the first version of the PaaSage product.

The PaaSage product and the source code will be available through the OW2 AppHub European Open Source Market Place on 30 September.

As of today, Cloud solutions are still insufficient and in particular require from developers, operators and providers a high level of expertise to properly exploit the capabilities offered by Cloud technologies. Cloud infrastructures are not standardised and porting an existing application to a Cloud platform is still a very challenging task, leading to strong dependencies between the client application and the Cloud platform. Developing once and deploying on many Cloud Platforms is what the PaaSage development environment enables.

PaaSage is an integrated open source development environment to support both design and deployment of Cloud applications, together with an accompanying methodology that allows model-based development, configuration, optimisation and deployment of existing and new applications independently of the existing underlying Cloud infrastructures.

Launched in October 2012, PaaSage is a research project carried out by 19 European partners, and led by ERCIM. The PaaSage technology will also be showcased at the upcoming Paris Open Source Summit 18-19 November 2015).

More information:
Passage software at OW2
http://www.ow2.org/bin/view/ActivitiesDashboard/PaaSage
http://www.paasage.eu/
Paris Open Source Summit
http://www.opensourcesummit.paris/

W3Cx Re-opens course to Learn HTML5 from W3C

After a successful first run of the course that had over 77K enrollees, W3Cx re-opens registration for the HTML5 Part-1 MOOC course, to start on 5 October 2015. The course lasts 6 weeks, and is taught by Michel Buffa, Professor at the University of Côte d'Azur.

This HTML5 Part-1 course focuses on Web design fundamentals at an intermediate level, and allows Web developers and designers to test their new skills through numerous interactive exercises and practical assignments.

HTML5 represents the set of features that entrepreneurs and organizations will rely on for years to come.

More information:
W3Cx:
https://www.edx.org/school/w3cx
Learn HTML5 from W3C:
https://www.edx.org/course/learn-html5-w3c-w3cx-html5-1x-0

8th International Conference of the ERCIM Working Group on Computational and Methodological Statistics

London, UK, 12-14 December 2015

The 8th International Conference of the ERCIM WG on Computational and Methodological Statistics (CMStatistics 2015) will take place at the Senate House, University of London, UK, 12-14 December 2015. Tutorials will be given on Friday 11 December 2015 and the CRoNoS Winter Course on Robust methods and multivariate extremes will take place on 9-10 December 2015.

Topics include, but are not limited to: robust methods, statistical algorithms and software, high-dimensional data analysis, statistics for imprecise data, extreme value modeling, quantile regression and semiparametric methods, model validation, functional data analysis, Bayesian methods, optimization heuristics in estimation and modelling, computational econometrics, quantitative finance, statistical signal extraction and filtering, small area estimation, latent variable and structural equation models, mixture models, matrix computations in statistics, time series modeling and computation, optimal design algorithms and computational statistics for clinical research.

This conference is organized by the ERCIM Working Group on Computational and Methodological Statistics (CMStatistics), Queen Mary University of London, Birkbeck University of London and Imperial College London. It will take place jointly with the 9th International Conference on Computational and Financial Econometrics (CFE 2015). This conference has a high reputation of quality presentations. The last editions of the joint conference CFE-ERCIM gathered over 1250 participants.

More information:
http://www.cmstatistics.org/CMStatistics2015/

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Xavier Leroy, Royal Society Milner Award 2016

Xavier Leroy from Inria has been awarded the Royal Society Milner Award 2016 in recognition of his research on the OCaml functional programming language and on the formal verification of compilers. This prize, created in homage to Professor Robin Milner, rewards a European researcher for his or her exceptional contribution to computer science. "The fact that it bears Milner's name is particularly close to my heart", says Xavier Leroy. "Robin Milner was a pioneer in fundamental computer science who founded whole areas of research on programming languages, machine-assisted proofs, and process computing. My work on the OCaml functional programming language and on the formal verification of compilers, as well as that of our Inria colleagues on the Coq proof assistant, are part of this legacy. It is very moving to see how far we have come, from Milner's great ideas of the 1970s to tools as powerful and as widely used as OCaml and Coq."
https://royalsociety.org/grants-schemes-awards/awards/milner-award/

New Journal: Econometrics and Statistics

The ERCIM Working Group on Computational and Methodological Statistics announces the publication of a new journal: "Econometrics and Statistics", the official journal of the networks Computational and Financial Econometrics and Computational and Methodological Statistics. It will consist of two sections: Econometrics and Statistics. In the Econometrics section emphasis will be given to methodological and theoretical papers containing substantial econometrics derivations or showing a potential of a significant impact in the broad area of econometrics. The Statistics section will publish papers providing important original contributions to methodological statistics inspired in applications. The journal is published by Elsevier.
http://www.cmstatistics.org/EcoSta.php

Source: CWI

Lex Schrijver wearing the EURO Gold medal.

Lex Schrijver Receives EURO Gold Medal 2015

Researcher Lex Schrijver (CWI) has been awarded the EURO Gold Medal 2015. This prize is considered the highest European distinction in Operational Research (OR) and is awarded by the Association of European Operational Research Societies (EURO). Schrijver received the prize in July at the 27th European Conference on Operational Research in Glasgow. Schrijver is CWI Fellow in the Networks & Optimization group at CWI and professor at the University of Amsterdam. He is a world-renowned authority in the field of discrete mathematics and optimization. He is best known to the general public for his work on the optimization of the Dutch railway timetable. Schrijver has received numerous awards and honours, including the NWO Spinoza Prize, Fulkerson Prize (twice), Dantzig Prize, Frederick W. Lanchester Prize (twice), John von Neumann Theory Prize, and the Franz Edelman Award. He is Fellow of the American Mathematical Society and a SIAM Fellow, has honorary doctorates from the University of Waterloo and the Loránd Eötvös University and is a Knight in the Order of the Netherlands Lion.

ERCIM "Alain Bensoussan" Fellowship Programme

ERCIM offers fellowships for PhD holders from all over the world. Topics cover most disciplines in Computer Science, Information Technology, and Applied Mathematics. Fellowships are of 12-month duration, spent in one ERCIM member institute. Fellowships are proposed according to the needs of the member institutes and the available funding.

Application deadlines: 30 April and 30 September.

More information: http://fellowship.ercim.eu/

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ERCIM is the European Host of the World Wide Web Consortium.

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http://www.iit.cnr.it/

Norwegian University of Science and Technology
Faculty of Information Technology, Mathematics and Electrical Engineering, N 7491 Trondheim, Norway
http://www.ntnu.no/

Czech Research Consortium
for Informatics and Mathematics
FI MU, Botanicka 68a, CZ-602 00 Brno, Czech Republic
http://www.utia.cas.cz/CRCIM/home.html

SBA Research gGmbH
Favoritenstraße 16, 1040 Wien
http://www.sba-research.org

Centrum Wiskunde & Informatica
Science Park 123,
NL-1098 XG Amsterdam, The Netherlands
http://www.cwi.nl/

SICS Swedish ICT
Box 1263,
SE-164 29 Kista, Sweden
http://www.sics.se/

Spanish Research Consortium for Informatics and Mathematics
D3301, Facultad de Informática, Universidad Politécnica de Madrid
28660 Boadilla del Monte, Madrid, Spain,
http://www.sparcim.es/

Fonds National de la Recherche
6, rue Antoine de Saint-Exupéry, B.P. 1777
L-1017 Luxembourg-Kirchberg
http://www.fnr.lu/

Science and Technology Facilities Council
Rutherford Appleton Laboratory
Chilton, Didcot, Oxfordshire OX11 0QX, United Kingdom
http://www.scitech.ac.uk/

FWO
Egmontstraat 5
B-1000 Brussels, Belgium
http://www.fwo.be/

F.R.S.-FNRS
rue d'Egmont 5
B-1000 Brussels, Belgium
http://www.fnrs.be/

Magyar Tudományos Akadémia
Számítástechnikai és Automatizálási Kutató Intézet
P.O. Box 63, H-1518 Budapest, Hungary
http://www.sztaki.hu/

Foundation for Research and Technology - Hellas
Institute of Computer Science
P.O. Box 1385, GR-71110 Heraklion, Crete, Greece
http://www.ics.forth.gr/

University of Cyprus
P.O. Box 20537
1678 Nicosia, Cyprus
http://www.cs.ucy.ac.cy/

University of Geneva
Centre Universitaire d'Informatique
Battelle Bat. A, 7 rte de Drize, CH-1227 Carouge
http://cui.unige.ch

Fraunhofer ICT Group
Anna-Louisa-Karsch-Str. 2
10178 Berlin, Germany
http://www.iuk.fraunhofer.de/

University of Southampton
University Road
Southampton SO17 1BJ, United Kingdom
http://www.southampton.ac.uk/

INESC
c/o INESC Porto, Campus da FEUP,
Rua Dr. Roberto Frias, nº 378,
4200-465 Porto, Portugal

Universty of Warsaw
Faculty of Mathematics, Informatics and Mechanics
Banacha 2, 02-097 Warsaw, Poland
http://www.mimuw.edu.pl/

Institut National de Recherche en Informatique
et en Automatique
B.P. 105, F-78153 Le Chesnay, France
http://www.inria.fr/

Universty of Wroclaw
Institute of Computer Science
Joliot-Curie 15, 50–383 Wroclaw, Poland
http://www.ii.uni.wroc.pl/

I.S.I. - Industrial Systems Institute
Patras Science Park building
Platani, Patras, Greece, GR-26504
http://www.isi.gr/

VTT Technical Research Centre of Finland Ltd
PO Box 1000
FIN-02044 VTT, Finland
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