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An optimistic view of European Embedded Intelligent Systems in a global market by Jean-Luc di Paola-Galloni

Khalil Rouhana about creating a bright future for Europe

FOREWORD

Dear participants in the ARTEMIS community.

At this moment the preparations for Horizon Europe (HEU), the successor of Horizon 2020, are in full flow. The European Commission made a proposal that is now being commented on by the European Parliament and the Council of the European Union. Next step is the trilogue negotiation between Parliament, Council and Commission, which should lead to agreement on compromise texts. It is unknown whether all decisions will be taken before the elections of the European Parliament take place in May 2019 and a new Commission is installed by the end of 2019.

Still Horizon 2020 is fully on, which means that ECSEL (which is funded by the EC under the umbrella of H2020) will organize its last two calls in 2019 and 2020, respectively. The expectation is that many Joint Undertakings will be continued under HEU, including ECSEL, although maybe under a different name and with an adapted scope.

We just had in November our second and very successful EFECS (European Forum for Electronic Components and Systems), this time in Lisbon with more than 600 participants. Our reporter Chris Horgan gives an impression from this EFECS in this Magazine. EFECS was organized by AENEAS, ARTEMIS-IA and EPoSS, together with ECSEL and the EC; Eureka was associated organizer; all logistics were done by ARTEMIS-IA. Very important that we had both the EC and Eureka as co-organizers, being the biggest funders on R&D&I in Europe, because the better we trans-nationally cooperate, the better for Europe.

Khalil Rouhana, the Deputy Director General of DG Connect of the EC plays a crucial role for the digitalization of Europe, the digital parts of H2020 and HEU, and the new Digital Europe programme. In this magazine he stresses the importance of lining up the strategies of the Member States and the Commission, as is done in the tri-partite model of ECSEL. Our president Jean-Luc di Paola Galloni held a very inspiring speech at the EFECS, based on a new report by Advancy commissioned by ARTEMIS-IA. The report is titled "Economic and technical outlook for Embedded Intelligence in the context of the ECS value chain". This report will be issued soon. With this report in mind Jean-Luc is interviewed on the position of ARTEMIS-IA in the ECS value chain to support Embedded Intelligence on an adequate level.

Invited speaker Olivier Ezratty gave a very good overview of all ins and outs of Artificial Intelligence at EFECS. He is also interviewed in this Magazine. Furthermore, I would like to highlight the contributions of Ronald Dekker on the Lighthouse Healt.E and Hossam Haick on a new device called "SniffPhone" for early medical diagnosis. Patrick Cogez will explain the update of the common ECS SRA (by AENEAS, ARTEMIS-IA and EPoSS) from its original 2018 version to the 2019 version.

I wish you an enjoyable read.

Jan Lohstroh
Secretary General of the Industry Association

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LISBON THE GATEWAY TO EXPLORATION

tens of inspirational speakers and presentations, hundreds of enthusiastic participants and visitors, and thousands of contact moments

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Lisbon breathes history – from the Romans to the Moors and the great explorations of the Age of Discovery between the end of the 15th century and the beginning of the 17th century, a period that defined Lisbon's golden era when the city was the European hub of intercontinental commerce. The successor to the first EFECS (2017) conference at the centre of European governance in Brussels, the modern Lisbon Congress Centre in the historic neighbourhood of Belém alongside the banks of the Tagus river provided the perfect venue for this second EFECS (2018) conference. Like Lisbon, with its constant urge to look beyond the horizon, this was all about looking beyond, about lighting the way for the Electronics and Components Systems into the future, one full of challenge and opportunity.

ECS 2018

Our digital future

Three days, tens of inspirational speakers and presentations, hundreds of enthusiastic participants and visitors, and thousands of contact moments – this was an event for sharing, for collaborating, for networking. During coffee breaks, cocktails and the dinner. All opportunities were seized to explore the possibilities.

AMBITIOUS GOALS

The Portuguese Minister of Science, Technology & Higher Education, Manuel Heitor opened proceedings with a keynote speech that underlined the importance of technological innovation in building a sustainable digital future and the vital role to be played by the ECSEL community in achieving the challenging targets being set. In fact, plenty was made of the need for Europe to rise up to the challenge, to exploit its strengths and to take the lead, and presenters varying from Khalil Rouhana, who painted a very positive picture of the European Commission's commitment to digitising European industry and supporting the ambitious goals of the ECS community and the ECSEL initiatives, to Jean-Luc di Paola-Galloni, President of ARTEMIS-IA, who talked about the opportunities and challenges for Europe in Embedded Intelligent Systems, and Olivier Ezratty, an independent business consultant who helps enterprises develop their innovation strategies and focused on artificial intelligence and hardware innovations. These were just a few of the pearls that adorned this very productive gathering.

ALL ABOUT IMPACT

Of course, while there was plenty of enriching fare for all to absorb in the auditoria, the exhibition of projects that covered a wide area of the concourse on the first floor displayed the real reasons for the investments being made, in terms of both money and effort, to put Europe on a front footing in the fiercely competitive global arena of the digital future. A range of projects stretching from industry and mobility to health and security projected how successful the collaborative context can be in driving breakthroughs and innovations into products and services that have a real impact on business, technology and society, making a real difference to people's lives.

SOMETHING FOR EVERYONE

Apart from the many ongoing and completed R&D&I projects, showing the innovation and progress achieved, there was a special area devoted to new project ideas that showed the technological challenges that are still to be faced, and offered networking opportunities with potential consortium partners. Furthermore, affiliated organisations were represented, including associations, alliances, ETPs and similar groupings that represent companies, institutes and universities with ECS R&D&I activities in Europe. The event's organisers also revealed many of their activities in the area of Embedded Components and Systems, and there was even a speakers corner that allowed selected organisations in the field to report on their activities. Something for everyone, then.

SOCIAL FLAVOUR

Anyone who knows Portugal knows how important the social side of life is, and EFECS 2018 took to the 'flavour' of its host country by organising both a cocktail networking hour as well as a networking dinner in a mix of business and pleasure. Even after a long 'day at the office', participants enthusiastically extended their day and lit up the early evening with conversation and laughter, cementing existing relationships and sparking new friendships. And prospective collaboration.

OPPORTUNITIES AND CHALLENGES

AN OPTIMISTIC VIEW OF EUROPEAN EMBEDDED INTELLIGENT SYSTEMS IN A GLOBAL MARKET

INTERVIEW WITH JEAN-LUC DI PAOLA-GALLONI *by* CHRIS HORGAN

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ECS Our digital future 2018

In the last issue of this magazine Jean-Luc di Paola-Galloni stated the importance of building strong actors in all application fields of cyber-physical and embedded systems. In Lisbon on 21 November last he took the opportunity to underline this view, with a focus on the value chain and how the ECSEL JU can help seize the opportunities this presents and tackle the challenges that have to be met.

"What is interesting," Jean-Luc begins, "and one of the reasons why a system house like Valeo (*the company where Jean-Luc is Group Corporate Vice-President of Sustainable Development and External Affairs – ed.*) is becoming more involved in ARTEMIS-IA affairs, is that an increasing degree of attention has to be given to the whole value-chain system. ECSEL was born, and has to grow, to safeguard the interests of the European semiconductor industry but it is clear that the value chain is moving from semiconductors – the hardware – to embedded systems or embedded software. This is the area in which ARTEMIS has its focus. Like my predecessors, who were also in systems houses and from industries that were hotspots at that time, like aviation and defence, we cannot deny the advances that have been made over the last five to ten years by the automotive industry, with its huge acceleration in the level of R&D. Consequently, the system houses in mobility have become extremely important. And what we see in the automotive industry is that the suppliers are investing twice as much in R&D as the OEMs. So it makes sense for companies like Valeo are taking a collaborative lead in this industry association and ensuring that where ECSEL goes, ARTEMIS goes, too. Together with the semiconductor industry and smart systems industry – so with our 'partners' AENEAS and EPoSS."

ECSEL was born, and has to grow, to safeguard the interests of the European semiconductor industry but it is clear that the value chain is moving from semiconductors – the hardware – to embedded systems or embedded software

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HARMONISING CAPACITIES AND STRENGTHS

As for the alignment of the associations, Jean-Luc has this to say (with a smile). "Well, I've not been on the end of any objections so far. Indeed, the new chair of the ECSEL JU, Sabine Herlitschka (*Chief Executive Officer of Infineon Technologies Austria AG – ed.*) is very much a technology partner, besides also being a customer and supplier, and we are co-defining what will be the future of ECSEL in which the whole value chain is represented." And looking at the intensified collaboration of the three associations within the ECSEL JU umbrella, Jean-Luc underlines how each association can galvanise its distinctive identity for the greater good. "We will show," he points out, "the Commission, the Member States, the Council and the European Parliament that we are able to work together in harmonising our capacities and strengths for the benefit of all the digital players in Europe. It is very important for us to reflect very careful on the forthcoming research that we share. This is what we are doing with the SRA. Additionally, ARTEMIS also has an agenda of its own, aligned of course to the general SRA agreed by the three associations. By ensuring that our points are very visibly highlighted, this will be reflected in the funding. As I showed in my presentation earlier on Opportunities and Challenges for Europe in Embedded Intelligent Systems, with the shift of the value chain, embedded software systems need significant amounts of funding. This is also a clear way of attracting new members to ARTEMIS. Perhaps even potentials that may otherwise not have considered participating in ECSEL. They will see that the priorities are shared not only by the ARTEMIS community but by other stakeholders throughout Europe, whether the Commission, the JU office itself or the partners."

MONEY WHERE IT'S NEEDED

The exhibition space at the conference in Lisbon featured many impressive projects but to what extent will the future also feature joint projects between the associations? Jean-Luc gives a very clear example. "Many system houses realise the need to include a higher level of upstream research that goes back to the hardware requirements needed for their own software applications. So more than ever we will see joint research projects where players from the three associations converge and align around one topic. It's very much in the European tradition. After all, Europe is quite a unique partnership in itself – a collective of highly diverse countries and cultures in which the actors compete increasingly on a collaborative basis. No-one can really go it alone anymore. And ECSEL is no different. In my presentation, as well as in the presentations of Sabine and Stefan Finkbeiner (*General Manager & CEO of Bosch Sensortec GmbH, chair of EPoSS – ed.*), I highlighted the situation regarding the competitiveness of Europe compared to other parts of the world where the level of funding is much higher. We have to accept that there is this imbalance and that the money that is available goes to the areas in which we need it, and not on projects of lower priority. This is also why we have been so prudent in establishing the SRA. And when we select projects, we will have to make sure that these mirror the dynamic shifts taking place in the landscape in which our associations and their projects, joint or otherwise, operate."

INDISPENSABLE

"I would describe myself as a grounded optimistic executive. Of course, we have to be realistic and realise that we cannot beat the US with its Googles or China with its Alibabas in the short term. However, there are still certain areas where our European digital players can be suppliers or customers to these global giants – working with them. There are pockets around big data, artificial intelligence, cybersecurity where business models have not yet been fixed. And we have certain expertise that is very much our own here in Europe, for instance in the relatively new Member States like Estonia or with associate nations like Israel. These are opportunities for ECSEL and for European technology. So, in that sense I am an optimist. It is an open battlefield, you could say. There are many applications that could 'accommodate' European technology. So it is not necessarily a manufacturing battle that will be fought but a digital one, through a solid value chain of different sizes of actors and companies - adding their value to products that may be either physical or cyber-physical or software solutions in such a way that make us indispensable in a global market."

ARTIFICIAL INTELLIGENCE

INTERVIEW WITH OLIVER EZRATTY *by* CHRIS HORGAN

THE FUTURE IS NOT WRITTEN IN ADVANCE, IT IS WRITTEN AS PEOPLES CREATE AND ADOPT IT

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Olivier Ezratty takes a fascinating look at Artificial Intelligence, the bricks and mortar of software solutions, during EFECS 2018 in Lisbon.

NEED FOR A BROADER DEFINITION

"AI can mean different things to different people. You have, on the one hand, the ultra-purists, who consider that we can only talk about AI if we are faced with a system that imitates human intelligence. Like a chatbot - a conversational agent. Which doesn't exist yet. For the moment, we can adopt a broader definition. Artificial intelligence includes all the techniques invented in this discipline since its inception in 1955: Bayesian systems, expert systems, multi-agents systems, machine learning, neural networks, deep learning or whatever is using it. The problem is," Olivier suggests, "that AI is often presented today in a more restricted sense: as an artificial intelligence system that must be able to learn by itself, and therefore process large volumes of unstructured data. Those who claim to have integrated AI into their solutions are not necessarily committing a crime of disinformation since they will indeed have AI bricks in their solution, in the broad sense of the meaning of AI, whether developed internally or acquired from the market, such as the large AI software components and development tools that are available in open source. There is also the impression that recent achievements are much more related to advances in hardware than in software and algorithms. Traditionally, the available raw processing power tends to make developers less astute in their approach to problems. But this impression probably comes from the difficulty in fully understanding the very nature of the advances made in AI algorithms and technical processes."

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There is hardly a market today that does not embed AI in one form or another – from healthcare and farming to finance and government, from defence and security to tourism and retail.

THE NEXT WAVE

However, despite the various pitfalls and the corresponding media bubble, AI is clearly making steady progress. "It is a wave that appears to be as important as previous technological waves," Olivier says, "such as the cloud, big data or connected objects or even blockchains. It is also regarded as part of this series of waves because it provides tools to improve performance and utilise value. And, of course, across the board, from captains of industry to world leaders and technology pioneers thirsty for knowledge and innovation, we are driven by the prospect of 'moonshots'."

RULE OF THUMB

When business leaders wonder if AI could do this or that, the first question they have to ask themselves is whether their company has or can get access to data that would help solve this problem. Generally speaking, if a data-based learning AI does not work well, it comes from the data that fed it. Has the universe of possibilities that the application would encounter been sufficiently represented in that training data set? This is the case with the most advanced techniques. We can explain the world around us using established rules and rules of thumb. The human brain works a lot on the basis of rules learned through experience or learning. A child learns to look left and right before crossing a street to make sure no cars are approaching. When the world is complicated, when we want to observe and understand consumer behaviour, we do not know how to describe it with mathematical or logical rules. So we try to deduce rules empirically, based on observational data. But here, we have to be wary of data bias. For example, if a system is trained to recognise cat images with a cat database, it will not recognise dogs. However, if the system was initially nourished with cats and dogs, it will recognise cats and dogs. Or a face recognition system powered only with faces of white people, without people of colour, will only recognise white faces. So, ideally, for an artificial intelligence system to be as effective as possible, it must have access to very large and diversified sets of data. This is something at which the Googles and Amazons of this world are good for consumer applications.

PERVASIVE

"However, what neither Google nor Amazon has is the databases that industry companies can create to implement a quickly profitable AI solution," Ezratty says. "Take audio signal processing, for instance. The noise of machines carries a lot of information: on the one hand, machine noise or sensor data and, on the other hand, 'tags' that indicate the types of failure or wear of parts that are related to these noises. This will enable preventive maintenance, whereby parts can be replaced or repaired on a given machine before it breaks. Furthermore, new advances in machine learning are enabling increasingly effective identification of the complex correlation factors that are inherent in data. Other major uses of AI in the workplace include image processing, such as video surveillance, maintenance and quality control. But AI is becoming pervasive – it's in our homes, in our cars, in our cities – all around us. There is hardly a market today that does not embed AI in one form or another – from healthcare and farming to finance and government, from defence and security to tourism and retail. You can see it as the 'glue' that links most technologies, and it will lubricate technology trends in the next decade like blockchain, IIoT (Industrial Internet of Things) and quantum computing."

DEEP LEARNING AND LANGUAGE PROCESSING

AI based on language processing allows you to know very precisely if you are saying good or bad things about a brand on social media. Companies commonly use language processing to analyse brand 'feelings', aka sentiment analysis. Language processing is used in sculpts - conversational agents - but also for data extraction, for the automatic generation of texts such as press releases from voting results, sports results, weather reports or stock prices. There are all kinds of uses possible, it all depends on what you want AI to do, the complexity of the algorithms, and the complexity of systems and data integration. To take the example of chatbots, you will find, on the one hand, very simple and inexpensive conversational agents that have just a 500-questions-answers database as their starting point and, on the other hand, sophisticated chatbots, powered by huge databases, internal, external, structured, unstructured, and capable of answering a much wider variety of questions and improving themselves by exploiting dialogues with users, like "I would like to book a plane and a hotel, in a month's time, in a nice place where the weather will be fine, preferably between 30 and 35°C and less than six hours away." Natural language processing technologies, NLP (natural-language processing), are now able to analyse very large unstructured text databases to derive rules that will then feed rule engines that can then be used in a chatbot.

MOONSHOTS

"There are many challenges ahead for AI, not least in terms of hardware – memory and processing speed as well as the energy footprint – but we have started our journey," Ezratty says. "A lot of software platform battles will have to be fought, as well as won and lost, but there is such a wealth of opportunity (Business Wire predicts the AI (chipsets) market to grow from USD7 billion in 2018 to USD69 billion by 2025 at a CAGR of 35.5%) that the race is well and truly on to get a piece of the pie." Exponential problems exist, from combinatory optimisations and molecular simulations to factorisation and machine/deep learning, and how to cryogenically cool quantum computers when they arrive but "just because it may be more difficult than before to move forward," Ezratty says, "doesn't mean it slows down the innovators and innovations that will be necessary.
On the contrary, the prospect of reaching 'moonshots' is the motivator. Man is insatiable in his quest for knowledge and innovation.
The march towards full or partial automation is already underway. We must prepare for it now, not resist it futilely, but adapt to it by modernising, by evolving our educational system and by producing competitive tools. Civilizations that have avoided technological progress and communication tools throughout history have systematically failed or, at best, declined. Like the Ottoman Empire, which took three centuries to adopt printing, or China, which brutally blocked its maritime trade in the 14th century. What Europe needs is moonshot projects, long-term bets and, in addition to R&D, product management skills, the targeting of volume markets, international collaboration from R&D to business and platform creation skills. The future is not written in advance, it is written as innovators→

CREATING A BRIGHT FUTURE FOR EUROPE

by **CHRIS HORGAN**

Khalil Rouhana is Deputy Director-General for Communications Networks, Content & Technology at the European Commission, and is responsible for coordinating the European digitisation of industry strategy and supporting R&D&I in key digital industrial technologies. In this respect, he oversees a number of Public Private Partnerships such as the ECSEL Joint Technology Initiative. At EFECS 2018 in Lisbon, he presented the latest developments at EU level relating to the Electronic Components and Systems arena.

INVESTMENT, RESEARCH ANDINNOVATION

Mr Rouhana began by emphasising the crucial role that the digital transformation will play in getting Europe to the forefront of the highly competitive global arena of electronics, an issue that had been highlighted in the European Commission's European Electronics Strategy presented four years ago. "We can't understate the need for investment, research and innovation in this sector." He then added "and the collaboration model that we have developed in the ECSEL JU is quite unique to Europe. We need to support this ambitious undertaking because its work will bring success on various levels for European industry, and will lead to job creation, societal wellbeing and economic prosperity and much more. I remember the scepticism there was fifteen years ago among the member states when we started this tripartite initiative. We had to work hard to gain the mutual trust that is so essential." Addressing the audience directly, Mr Rouhana paid tribute to their efforts. "The driver behind this was the partnership between industry along with the research community – so yourselves. It was your drive, your willingness to work together that has helped us get to where we are today. And what have we achieved? Well, we now have a proven framework in place that we can use as a model for other initiatives, for example in the fields of High Performance Computing and cybersecurity, where we have taken on similar kinds of goals and work methods envisioned all those years ago, and re-used them to tackle new societal challenges."

CRUCIAL TRIPARTITE MODEL

Looking at the investment figures emerging in China and the US, for example, Mr Rouhana pointed out that such levels were unattainable in Europe without the tripartite cooperation that has endowed this PPP with a significant budget of €5 billion from 2014-2020. This budget is made up roughly of 25% by the EU and 25% by participating states and the remaining 50% from industry. Along with the annual calls, he cited the underlying factors of success: industry drive and commitment; member state involvement in funding and governance; leveraging more substantial resources; avoidance of fragmentation and duplication; strategic alignment and long-term planning. "And yes, even on the political front, things are becoming clear," Mr Rouhana continued, "about where our priorities must lie. That's good news indeed because it means we have gained a real focus that is also aligned with what industry is calling for. This – here and now – is where it's happening and we have to master these key technologies that are present here."

REGAIN THE INITIATIVE

At the turn of the millennium Europe had been the first mover in technology, also in terms of its deployment. This created the right framework for both public and investment. "But we're not in that situation today," Rouhana pointed out. "We seem to →

be adopting a wait-and-see approach, only moving after the others have moved. This cannot continue. This simply does not help us. We have to re-establish ourselves as first movers. Take the lead in research, science and technology. And in deploying them. But it is vital that we back up our ambitions with the necessary budgets otherwise we won't be able to maintain our industrial competitiveness and scientific excellence in the future. This is why the Commission has prioritised Digital in its proposal for the next EU Multiannual Financial Framework. In addition to the more than 13 B€ for Digital technologies in Horizon Europe (the next Research and Innovation Programme), the new Digital Europe Programme with 9.2 B€ will provide the means for Europe to be a first mover in deploying the technology and reinforcing its capacities in Computing and Data, Artificial Intelligence and cybersecurity. So that's how to address the challenge, one that will take place in the new value chains that have emerged and will continue to emerge in the light of the digital transformation." Looking at the current picture, especially on the components front, it is clear that the EU has a strong position in emerging, rapidly growing areas like the smart car, Industry 4.0 and personalised healthcare. All areas that will increasingly require very advanced components to address sophisticated artificial intelligence and include communication functionalities. However, Mr Rouhana warned, the EU is practically absent in key components for Computer, Consumer, Communication markets, and pointed out that this is a not sustainable situation. There is still much work to be done to regain the initiative.

THE DIGITAL TRANSFORMATION – ALL-INCLUSIVE

"Going forward, then, we can learn lessons, and it is certainly the case that we have learned very good lessons from the ECSEL JU – it is the approach we are using today across the board, and it's founded on cooperation and collaboration. This will help us in our very ambitious goal of bringing digitisation to every business and industry across Europe and to every citizen. We will do this by taking advantage of our leading position in areas like high-performance computing and artificial intelligence. How? By boosting the EU's technological and industrial capacity and AI uptake across the whole economy, by stepping up investments, strengthening research from lab to market, supporting AI research excellence throughout Europe and by bringing AI to all small businesses and potential users."

MAXIMISING BENEFITS

Mr Rouhana stated that the Commission's objective is to ensure that Europe drives the digital transformation of society and economy, bringing benefits to all citizens and businesses. More specifically this involves reinforcing the EU's digital capacities, for instance in computing, data, cybersecurity and AI, ensuring the widest possible roll out and maximising the benefits of digitisation along with preparing for and leading the development of next generation technologies so that a world-leading connectivity infrastructure can be built. Importantly, it is essential to support the creators and ensure the widespread distribution of their work. In respect of the Digital and Industry objectives, the focus lies on manufacturing technologies, key digital technologies, advanced materials, artificial intelligence and robotics, space, advanced computing and Big Data as well as circular industries and next generation internet. All this with a proposed €15 billion budget.

TARGETING IMPACT

The coordinated public investments at EU level will target areas where EU investment has clear added value. Given that the investment levels are high, no Member State can do this or go it alone so there will be areas where a need exists to aggregate resources and areas where scale matters for wide diffusion across the EU. Complementarity and synergies will be key. Rouhana provided several examples of where Europe had identified targets and their impact, including:

HPC (high performance computing)

+ Two exascale machines by 2022/2023 (at least one with European technology)
+ At least one post-exascale machine by 2027
+ Hybrid HPC-Quantum infrastructure by 2027

Cybersecurity

+ By 2025: self-healing cybersecurity systems in major critical infrastructures and public administrations
+ By 2025: post quantum cryptography systems

Artificial Intelligence

+ By 2022: world class reference sites for real scale testing of AI in health, mobility, smart cities, etc.
+ By 2023: 5-10 % of public sector data easily available for innovators and researchers across the EU

Advanced Digital Skills

+ Increase ICT specialist employment from 8.2 million in 2016 to 12 million in 2027
+ Increase growth rate/per year of ICT specialists from 3.3% (2007-16) to 4.3% (2016-27)

Digital health

+ By 2022: 1 million sequenced genomes
+ By 2027: 450 million citizens have access to health records,
+ 100 million citizens have personalised health systems
+ Data from 10 million citizens available for new discoveries

Digital Innovation Hubs

+ 250 Hubs across the EU
+ 90 experiments per hub
+ Reaching ~42000 SMEs

SEIZE THE OPPORTUNITIES

"Our ambitions are high, and we now have to make sure that we can deliver. With the means from the public side and from the private side. We have to recognise and understand where our strengths lie and work together so that we can match these other regions of the world. We have to be able to seize the opportunities that exist in the global marketplace and, by doing so, create a bright future for Europe, safeguard our values and ensure that we can sustain, and even improve, our wellbeing."

"Open platforms have clear advantages for developing technology faster and getting it to market"

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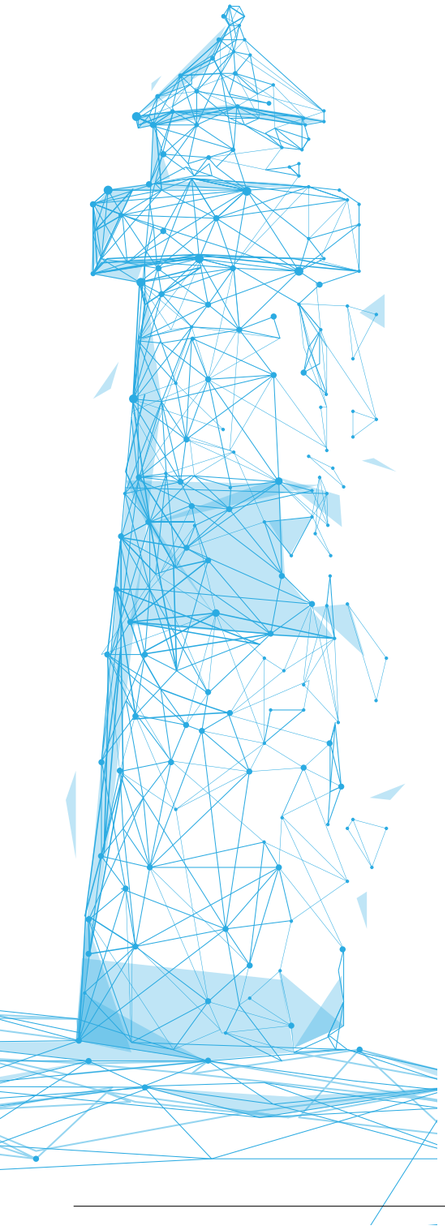
ECSEL JU LIGHTHOUSE INITIATIVES

HEALTH.E LIGHTHOUSE

"MOORE FOR MEDICAL": ACCELERATING INNOVATION IN MEDICAL DEVICES

INTERVIEW WITH RONALD DEKKER *by* CHRIS HORGAN

Following on from the launch of the Industry.E and Mobility.E Lighthouse initiatives, a third beam of light is shining onto the healthcare domain: Health.E. Its aim is to enable affordable healthcare in an ageing society as healthcare moves relentlessly from centralised symptomatic treatment towards preventive, predictive and participatory care. Researchers in academia and industry are developing technologies and systems that will keep people healthy for longer and allow patients to remain independent as long as possible in their own home environment. Leading the 'construction' of this Lighthouse is Ronald Dekker of Philips Research, whose work focuses on the integration of complex electronic sensor functionality on the tip of the smallest minimally invasive instruments. This part-time professor in flexible and stretchable electronics at TU Delft explains some of the principles that underlie this third member of the Lighthouse family and the challenges it faces.



PROPELLING INNOVATION

"Our aim, first and foremost," Dekker begins, "is to make the ECS community aware of the existing and arising opportunities in Heath by collecting and defining roadmaps for these arising opportunities. The second goal is to stimulate the development of open technology platforms. The shift towards open technology platforms, supported by roadmaps, will generate the production volumes needed for sustained technology development, which will result in new and better solutions in the healthcare domain. And if we can achieve these two goals, this will help to propel innovation along the whole medical instrument supply chain and provide solutions for a wide range of health-related societal challenges. It will keep track of a person's health or the response to medicines by continuous monitoring with smart body patches, which will reduce the need for hospitalisation. Miniaturised smart catheters and laparoscopic instruments will further facilitate keyhole surgery. Implantable neuromodulation devices will control specific organs, avoiding the side-effects of conventional medication while organs-on-chips will combine the latest developments in stem cell research with micro-fluidic devices for the development of new precision medicines. Finally, the data collected with these systems and other diagnostic equipment will be used to create digital representations of persons that can be used to predict in-silico the effectiveness of medicines and therapies."

GETTING TO MARKET

Industrial innovation in medical devices and systems is lagging behind in comparison to the innovation speed in the consumer electronics industry. This is not only caused by strict quality regulations, but also by the fact that the volumes are often small compared to consumer products, which requires significant investments in non-standard manufacturing technologies. Many breakthrough innovations therefore simply do not make it to the market and end up in the "valley of death."

The Health.E lighthouse will accelerate the innovation in medical electronic systems by:

+ Serving the needs of medtech and pharma by ECS (electronic components and
+ systems) solutions;
+ Stimulating the open technology platform model;
+ Collecting and defining roadmaps for arising opportunities in the Health domain;
+ Reducing fragmentation and duplication by creating a sustainable ecosystem that covers the complete value chain, consisting of technology suppliers, device manufacturers and end-users, transcending project boundaries
+ Reaching out to other European initiatives and communities.

LACK OF TANGIBLE PRODUCTIVITY

There is a very noticeable 'elephant in the room' anyone involved in miniaturised, or smart health technology innovation will understand. The problem is that the huge amount of technological innovation that is possible, is not appearing in our homes and hospitals. Too often, innovation remains a concept on paper and doesn't make it past the first challenges toward a useable, beneficial technology. Whilst there is no shortage of ideas and research for this new pedigree of medical technology, there is a realisation that manufacturing it can fast become impractical and overly expensive. This is one of the biggest challenges Dekker has identified. "At the moment, every university and every research institute is investing a lot of effort into research into advanced technological medical devices because it's assumed everyone will see the necessity of that. However, if you comprehend the sheer amount of money that is going into smart healthcare and then you see what is reaching the market, in reality it is very, very little. There are significant challenges that need to be tackled for this vision of our healthcare future to take shape."

PLAYING THE NUMBERS

Whilst smart healthcare technology is feasible, for it to become a reality depends on combining standard semiconductor manufacturing with materials like polymers, uncommon metals and sometimes even

proteins. These devices will use new packaging techniques involving advanced moulding, micro-fluidics and heterogeneous integration. Therefore, to make these devices requires specialist knowledge and adherence to strict regulations. Manufacturing such devices can also be prohibitively expensive when starting from scratch, which is offputting for start-ups, innovators and entrepreneurs. "Where microfabrication is involved, developing the basic underlying technology becomes very expensive, very quickly, and you can only afford to do it if you have enough turnover to justify those developments," Dekker explains. "In consumer markets there are those high volumes needed – for example, making microphones for mobile phones or accelerometer sensors. In markets with high consumer demand, those high volumes make it justifiable and if you have a good business plan it is not so difficult to get the money to do that innovation but if you compare that with the medical domain, the volumes for applications are relatively small. That's why there is this challenge in the sector." A significant problem is justifying relatively small volumes with a disproportionately expensive and technical production line. A new approach is needed.

SHARING PLATFORMS, SAVING COSTS

If a stumbling block for progress is the 'how to' with manufacturing and the large expense of creating a specialist pilot line, what's needed is a pre-existing pilot line open for third parties, with the express purpose to help develop these kinds of innovations and to manufacture technologies that can be shared for different applications. It was while working in the InForMed project aimed at developing a new kind of smart catheter for better treatment of heart arrhythmias, one that could measure the depth of ablation, that the team involved had a 'lightbulb' moment about how the nature of innovation in the medical device sector needed to change.

Dekker: "We developed smart catheters but we thought about it and realised that the way to go forward was to open up these technologies and offer them to other companies for use with their products. This would generate volumes, making it feasible to do sustainable, continuous innovation. It had not been part of our original plan and this kind of offer is actually something very new among medical device manufacturers. It is certainly not customary in the medical domain. It can be hard to persuade people that this really is an open technology, a way to bring innovation to the market."

As one of the biggest issues with development is generating volume to justify the cost of creating the pilot line, a good way to tackle this is to create open platforms, to share the technology – meaning the pilot line will continue to be in use with various innovative projects able to use the same initial technology, as a standard requirement. This will shift the uniqueness of a device from the technology inside it to the application of it and the design of the device around it. This is another way for innovation to speed up, to be more efficient with the processes toward a product launch. For example, advanced devices for electrophysiology that make advanced drug safety testing available at earlier stages in a drug's development, deep brain stimulation via minimally invasive neurosurgical therapy or a nano-electronic platform for detecting bacterial infections and smart body patches. An example of the success and far-reaching potential in this approach can be demonstrated when we look at a project that is developing body patches that conform to and monitor the body. Whilst we are used to seeing technology that can sense things that are on the surface of the body, like a pulse, the arrival of affordable ultrasound devices means that we can create devices that can look inside the body.

A DIFFERENT APPROACH TO INNOVATION

A series of European projects grouped in the Health.E Lighthouse initiatives is now beginning, led by the POSITION (ECSEL) project that is developing the TRL8 platform technologies for the next generation of smart catheters and implants. It is much more the 'open platform' that was envisaged. The same applies for the ULIMPIA (PENTA) project where an open technology platform will be developed for ultra-sound body patches. A supporting Lighthouse project is ORCHID (H2020) where a European roadmap for Organ-on-Chip is being defined, and in the future, other projects will be added to the Lighthouse initiatives. Key to success for progress in the sector is that the projects provide a way to accelerate innovation, facilitating methods that work, pull designs off the drawing board and pushing them into production.

LIGHTING THE WAY

"Open platforms have clear advantages for developing technology faster and getting it to market" Dekker stresses, "and what the Health.E Lighthouse initiative can do is to provide the means to advance and refine the methodologies, thereby stimulating the development of open technology platforms for medical devices and systems. There is no better way to justify the value of research into new technologies than by bringing innovation to market. This is what makes the Health.E Lighthouse so crucial – it champions a coordinated approach to produce new technologies more consistently and also ensures there is a broad scope of innovations that can benefit from standardisation of underlying technologies."

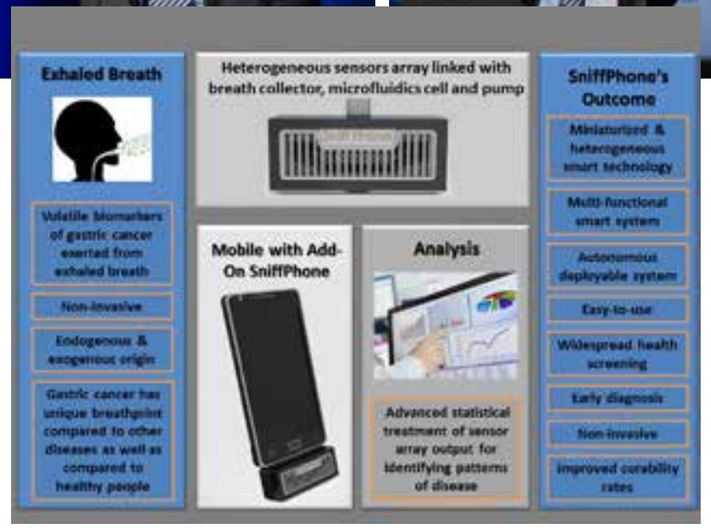
ARTEMIS Magazine 25 *December 2018*

A NOSE FOR DIAGNOSING DISEASE

FROM HIPPOCRATES TO HAICK

INTERVIEW WITH HOSSAM HAIC *by* CHRIS HORGAN

Hossam Haick, the developer of the Na-Nose breathalyser technology and the innovative Sniff-Phone, admits that this very modern technological innovation has roots that go all the way back to the ancient Greeks. “It was during my studies that I became fascinated by what Hippocrates, the father of medicine, had been doing nearly two and a half thousand years ago. Hippocrates had told his students to "smell your patients’ breath" to search for clues about diseases, such as kidney disease and Halitosis. So, I admit a debt to him for being a real inspiration to the development of this modern and ingenious device for sniffing out, or detecting, the presence and stage of certain diseases and disorders in exhaled breath.”



NANOSCALE SENSORS AND AI

Exhaled breath contains nitrogen, carbon dioxide and oxygen, as well as a small amount of more than 100 other volatile chemical components. The relative amounts of these substances vary depending on the state of a person's health. In more recent times, teams of scientists have developed experimental breath analysers, but most of these instruments focus on a single type of disease, such as cancer, and/or the instruments were expensive, heavy and time-consuming. In his work, however, Hossam Haick and his team of collaborators in 14 clinical departments worldwide wanted to create a breathalyser that could distinguish among multiple diseases.

To this end, they developed an array of nanoscale sensors to detect the component profiles of the disease and have examined their development in thousands of breath samples from patients who were either healthy or had one of 17 different diseases, such as kidney cancer or Parkinson's disease. By analysing the results with artificial intelligence techniques, the team was able to use the array to classify and diagnose the conditions, which were based on mass spectrometry to identify the breath components associated with the diseases. "What we found," Hossam explains, "is that each disease produces a unique volatile chemical breathprint, based on differing amounts of 13 components. They also showed that the presence of one disease would not prevent the detection of others, which is essential in developing a practical device to screen and diagnose various diseases in a non-invasive, inexpensive and portable way."

A PHONE THAT SNIFFS OUT CANCER

The SniffPhone is the latest low-cost nanotech diagnostic tool proposed by Professor Hossam Haick of the Technion-Israel Institute of Technology. It links the Na-Nose breathalyser technology to a smartphone whereby embedded micro- and nano-sensors 'read' the exhaled breath and then transfer the information through mobile phone to an information-processing system for interpretation and assessment.

AWARD-WINNING LIFE-SAVER

A research consortium headed by Haick recently received a EUR 6 million European Commission grant to develop the product, described by Haick as "tinier and cheaper than the disease-detection solutions currently available. Not only will it consume little power but, most importantly, it will enable immediate and early diagnosis that is both accurate and non-invasive. Early diagnosis can save lives, particularly in life-threatening diseases such as cancer." The consortium members include Siemens Healtineers (Germany), University of Riga (Latvia), University of Innsbruck (Asutria), NanoVation-SG. (Israel), JLM Innovation (Germany), Cellix Microfluidics (Ireland), ChipShop Microfluidics (Germany), and VTT (Finland). At EFECS 2018 in Lisbon, Haick presented the award-winning project and its very impressive results in a very tangible form, the latest prototype version 2 (see photo above).

What we found is that each disease produces a unique volatile chemical breathprint, based on differing amounts of 13 components.

NEW DESIGN WITH NEW FEATURES

"The SniffPhone has evolved a lot since the project started," says Haick. The first prototype was built and a first round of clinical trials was carried out by the team at the University of Latvia in Riga. These clinical trials included 48 gastric cancer patients and 150 patients with pre-cancerous lesions of different severity while additional samples of more than 300 people from the general population were taken for diagnostic model validation. Extensive real-life usability tests were conducted and feedback was collected from researchers as well as end users, such as medical personnel and patients. "The insights we gained from the clinical studies have been applied in new technologies that we have implemented in the upgraded version 2 of the SniffPhone prototype," Haick explains. "It has been completely redesigned and now has many new features." This new version of the SinffPhone also features autonomous operation, is battery operated, with charging required only once a day, and there is a Bluetooth smartphone connection.

PHILANTHROPY AND SCIENCE: TACKLING DISEASE WORLDWIDE

The interest generated by this innovative technological solution is evident in some of the high-profile philanthropists that have been attracted to Haick's work and have committed funding to the development, such as Bill Gates, with whom he met in South Africa where Gates was keen to learn about the innovative artificially intelligent nanoarray technology he was developing to detect diseases non-invasively. Such was the impression Haick created that Technion, the Israel Institute of Technology, was awarded a grant as part of the Bill and Melinda Gates Foundation Grand Challenges Exploration programme launched in 2008 that commits USD 100 million to encourage scientists worldwide to expand the pipeline of ideas to fight the world's greatest health challenges by fostering innovation in global health research.

"With the help of the Bill and Melinda Gates Foundation," Haick says, "we are developing an accurate, fast and inexpensive adhesive electronic patch that can diagnose tuberculosis." The diagnosis, which uses a skin sample, would take up to five minutes, and it would be less expensive and more accessible than the current diagnostic tools. "In this way we aim to increase the survival rate among tuberculosis sufferers and to stave off the spread of the disease. We hope that such measures will improve the democratisation and accessibility of health services around the world."

ECS SRA UPDATE

2019 VERSION

INTERVIEW WITH PATRICK COGEZ *by* CHRIS HORGAN

ARTEMIS Magazine 25 *December 2018*

The Electronics Components and Systems Strategic Research Agenda forms the basis for the calls for projects of Research and Innovation Programmes such as ECSEL and EUREKA/ PENTA and EURIPIDES². Almost a year on from its first publication, the ECS SRA has been updated. As a living document, this SRA is responsive and alert to the often rapidly changing environment in which it provides strategic guidelines. Patrick Cogez, Technical Programme Manager at AENEAS, one of the three partner associations (with ARTEMIS-IA and EPoSS) of ECSEL, is Chair of the ECS SRA and responsible for coordinating the production of this document. He took a little time out in Lisbon to outline some of the main changes of this latest version that was presented during the EFECS 2018 event.

CONSTANT EVOLUTION IN HIGHLY DYNAMIC LANDSCAPE

"Our mission as industry associations is to ensure that Europe can maintain and strengthen its leadership in the relevant fields in terms of both current and foreseeable technology capabilities, so the goal of the ECS SRA is to identify the key focal points for pertinent research and innovation in Europe. But as we know," Patrick explains, "our industry is highly dynamic. Technology is changing rapidly and becoming more advanced year by year, and new applications are emerging at an ever increasing pace. This has to be reflected in an SRA document that is able to evolve constantly through annual reviews. We plan a major update every three years. Our three associations have the essential responsibility to provide guidance to all ECS stakeholders so that they can keep abreast of new emerging technologies, potential game-changers and the evolving long-term vision. Furthermore, in preparing such an SRA, we can scout for new participants and communities. The more people we can involve, the more comprehensive our reach can be and the more impact we can have."

ARTIFICIAL INTELLIGENCE

This is the first minor update the ECS SRA has undergone. It represents a range of changes to the chapters in the 2018 edition, particularly in respect of the timelines that have been adjusted to cover the period 2019-2028. Furthermore, the importance of the ongoing and future breakthroughs of Artificial Intelligence, the technology developments they require and their impact across all application domains are evident throughout the document. In addition, an entirely new chapter has been added: Chapter 11, Long Term Vision.

LONG TERM VISION

"There was clear need to have a separate chapter on the long-term vision of the SRA," Patrick says, "to give more space and scope to survey the emerging technologies that have a significant potential impact on the European ECS landscape over the next ten years and beyond. We have avoided trying to make specific predictions – there is always the possibility that these can be disputed. So what we have done with this chapter is to highlight the challenges that need to be solved in the light of likely long-term trends such as fossil fuel availability, requirements for personalised medicine or zero-emission environmental norms. We then go on to identify which technologies or applications could be the most promising, or still need to be developed, to provide the solutions to the expected societal needs that have to be met. In particular, Chapter 11 focuses on the expected future requirements that the predicted evolution of current technologies will not be able to fulfil."

By highlighting key research and innovation topics required to maintain the competitiveness of the European ECS industry in the long run, this Long-Term Vision chapter is an essential element of the ECS SRA mission to generate growth, create value, jobs and prosperity, and safeguard Europe's competitiveness and sovereignty. For a brief summary of the other main changes and updates. On the next page a brief summary of the other main changes and updates →

THE MAIN CHANGES IN THE ECS SRA IN BRIEF:

0. **Introductory and Overview Chapter**
   The section on new technological paradigms was reshuffled to bring the advent of Artificial Intelligence and data analytics more prominently among the game changers while the long-term vision section has been replaced by an introduction to the new Long-Term Vision chapter.
1. **Transport and Smart Mobility**
   The chapter has been expanded to more explicitly include all transportation modes with maritime transport covered more extensively, and the railroad and multimodal transportation challenges addressed in more detail.
2. **Health and Wellbeing**
   The text has been aligned with the ECSEL Lighthouse HEALTH.E, resulting in minor updates.
3. **Energy**
   Addition of sub-chapter: Digitalisation & Energy along with Artificial Intelligence/Machine Learning approaches.
4. **Digital Industry**
   Given the vast economic scale of agricultural industry and current deployment of IoT devices for precision farming, digital farming has been included in chapter 4.
5. **Digital Life**
   The only change is a minor update of the timeframe diagrams.
6. Systems and Components: Architecture, Design and Integration
   The complete text of the chapter has been streamlined, repetitions eliminated and passages with similar meaning combined, resulting in a much more concise version without loss of content. Important topics have been emphasised/extended (e.g. AI and Software) and high priority areas have been revised.
7. **Connectivity and Interoperability**
   The only change is a minor update of the timeframe diagrams.
8. **Safety, Security and Reliability**
   Additions include disruptive threats linked to cloud, big data and quantum cryptography, new patterns of processor architecture and new priorities around architecture & design related to security along with the impact of Artificial Intelligence.
9. **Computing and Storage**
   Challenges related to energy consumption are also discussed at system and infrastructure level, Artificial intelligence developments, software challenges for growing complexity plus the need for methodologies and tools for application and system design. Open Hardware initiatives are addressed in this new edition of the SRA
10. **Process Technology, Equipment, Materials and Manufacturing for Electronic Components & Systems**
    The title has been reworded, the first paragraph of the executive summary adapted to strengthen link to applications, most importantly Artificial Intelligence, and the impact section revised to improve readability, with links to other chapters like Digital Industry and Computing & Storage more apparent. The text regarding the major challenges has undergone significant revisions.
11. **Long-Term Vision**
    New chapter.

HIGH-LEVEL CONFERENCE

EU RESEARCH AND INNOVATION IN OUR DAILY LIFE

Improving Europeans' daily life with research and innovation – success stories

by **LUCIANO GAUDIO**

On Tuesday 27 November 2018, the President of the European Parliament, Antonio Tajani, and the Commissioner for Research, Science and Innovation, Carlos Moedas, convincingly introduced and identified the importance of the High-Level Conference on "EU research and innovation in your daily life", which took place at the European Parliament in Brussels. The conference brought together more than 1000 participants, including key personalities, researchers, and politicians, who had a chance to see the real-world impact of some of the most life changing projects supported under the Horizon-2020 programme-. The ECSEL Joint Undertaking was honoured to be part of this high-level meeting, proudly represented by the "InForMed" project and the ECSEL JU Lighthouse Initiative "Health.E".

The conference produced a great deal of inspiring comment and discussion. President Tajani said: "All sectors have benefitted from European research: medicine, pharmaceuticals, environmental sustainability, energy, combatting ageing, nanotechnology, artificial intelligence, food safety, transport, space, defence, security and cyber security, to name a few. This conference will present some of the many success stories of European research. And it is essential that EU citizens know about them."

Moreover, Commissioner Moedas emphasized the importance of bringing the cutting-edge innovation developed by European scientists and researchers closer to the rest of European citizens: "Breakthroughs make our lives healthier, more efficient, more prosperous. Thousands of brilliant scientists and innovators across Europe and the rest of the world have been supported by EU funding, and thanks to them we know that science and innovation are not confined to the lab. Instead, they bring real, tangible benefits to our daily lives and they make Europe and the world a better place for us all."

The ECSEL JU funded project "InForMed" was selected to showcase just in front of the plenary room of the European Parliament. (Prior to the event, a selection committee had set up to identify the most representative projects among a few hundred proposals submitted by the European Commission DGs, Executive Agencies and Joint Undertakings).

InForMed developed – among other things - smart catheters incorporating a range of sensors such as miniaturised ultrasound probes. For a physician dealing, for example, with a blocked artery, this can provide vital information. Knowing the size and shape of the occlusion can help tailor the treatment required, making the life of surgeons and patients easier and the cost of the intervention a lot lower.

With a budget of 48.1 M€, this project - coordinated by Philips - involved 39 participants from 10 countries from 1 June 2015 to 31 September 2018. InForMed project proves the added-value of the ECSEL JU programme in bringing together key industrial and academic players in a manufacturing ecosystem, ensuring that technologies and competencies are available in Europe.

But involving new actors is a key capability of ECSEL JU. Our stand proudly hosted the founders of "BIOND Solutions B.V, a Delft University of Technology spin-off, born under the flag of the InForMed project, BI/OND is an innovative Dutch biotech start-up company specialised in developing artificial human organs using advanced hardware solutions. These avatars, called "organs-on-chip", can replace standard, static methods and reduce the use of animals for testing new pharmaceuticals. During the InForMed project, BI/OND engineers designed, fabricated, tested and patented several prototypes.

The eye-catching stand was enthusiastically visited by Members of the European Parliament, the Director General of the DG RTD, journalist and many other participants.

Moreover, ECSEL JU, the InForMed project coordinator and representatives of the "Health.E" Lighthouse Initiative had the opportunity to talk and illustrate the programme and project results to the President of the European Parliament and the Commissioner for Research, Science and Innovation.

With €200 billion invested over the last 30 years, the EU R&I Framework Programmes have shaped the way research is done in Europe and have evolved from supporting cross-border collaboration in research and technology to contributing to the EU's overarching jobs and growth strategy. The Framework Programmes have been growing progressively in scale, scope, and ambition with the aim to make Europe more competitive in key technologies.

ECSEL JU plays a crucial role in this respect and contributes maintaining the European leadership in the key sector that is Electronic Components and Systems (ECS). Aligning EU and National strategies and leveraging additional research, development and innovation funding from industry is the strength of our programme.

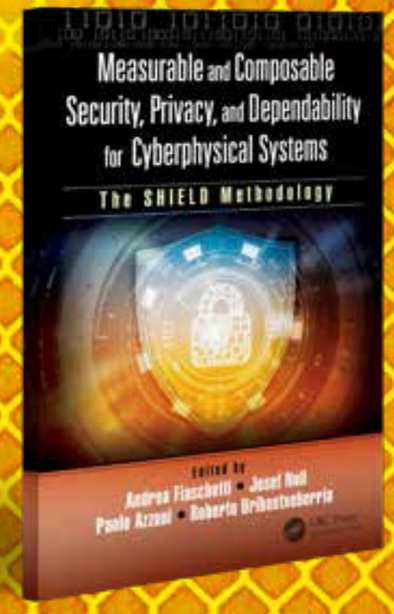
Ahead of the European elections in May 2019, the time is now ripe to look back at what EU research and innovation has achieved over these last 30 years. This high-level Conference was also an opportunity for policy makers to reflect on the benefits for all EU citizens of EU research and innovation through continued dialogue amongst EU institutions, Member States, Universities and Research centres, stakeholders, and citizens.

Many of the projects that the EU has funded over the years have compelling stories to tell, but reaching out to a large non-specialist audience is not always that easy. ECSEL JU was proud to overcome this challenge and deliver an important message to citizens and policy-makers by using a concrete example – EU research and innovation is delivering excellent science for the benefit of EU citizens.

nSHIELD BOOK RELEASE

"MEASURABLE AND COMPOSABLE SECURITY, PRIVACY, AND DEPENDABILITY FOR CYBERPHYSICAL SYSTEMS - THE SHIELD METHODOLOGY": A MUST-READ IN THE AGE OF MASSIVE DIGITALISATION

INTERVIEW WITH PAOLO AZZONI *by* CHRIS HORGAN



"We are at the beginning of a new age where the active and dynamic interaction between the physical and digital worlds represents one of the strongest driving forces that will shape the digital innovation and will influence the evolution of future markets, potentially in every vertical domain. We probably cannot stop or slow down the inclusion of CPS in everyday life, therefore the impact of this dynamic interaction must be kept under control, to ensure security, privacy and dependability."

PARADIGM SHIFT

In outlining this inevitability, Paolo Azzoni points to the requirement for a paradigm shift in handling this interaction, one that addresses the need for securing information instead of securing infrastructures, identifying a security methodology and defining the concept of security measurability. Increasing security, privacy, and dependability (SPD) introduce new challenges in emerging CPS, Internet of Things and Machine to Machine scenarios, where heterogeneous systems are massively deployed to pervasively collect, store, process, and transmit data of a sensitive nature.

"Industry demands solutions to these challenges," he says, "solutions that have to provide *risk assessment of security critical products*, measurable *security*, *privacy*, and *dependability*, and *configurable/composable security*. Security is frequently misconstrued as just the hardware or software implementation of cryptographic algorithms and security protocols: on the contrary, SPD represent a new and challenging set of requirements that should be considered *in the design process*, along with cost, performance, power, etc." Recently, a book on these topics was published, providing concrete answers to ensure SPD of CPS and IoT. In this edition, we interview Paolo Azzoni, the Research Programme Manager at Eurotech Group. Paolo has been an active part of the Artemis community since the very beginning and is one of the book's editors.

NEW CHALLENGE, NEW METHODOLOGY

In the new digital age, based on interconnected, inter-dependent, collaborative, and smart systems, security represents a major concern and the book proposes a new methodology to address composable security, privacy, and dependability in CPS and IoT. "Security represents a new challenge and its complexity requires us to consider it from the early stages of the design process, so we decided to identify concrete answers based on *built-in*, rather than *add-on*, SPD functionalities," Paolo explains. "The book is not a collection of scientific papers, rather the description from both a theoretical and practical perspective of a new methodology to address SPD, called SHIELD, and it provides examples based on real use cases that allows to adopt SHIELD in different vertical domains."

The book's main objective is to provide a modular, composable, expandable and highly-dependable architectural framework conceived and designed with the SHIELD methodology. "This framework," Paolo explains, "allows the desired SPD level to be achieved in the context of integrated and interoperating heterogeneous services, applications, systems and devices. It allows the development of concrete solutions capable of achieving this objective in specific application scenarios with minimum engineering effort."
The book is the result of a long-lasting research programme led by the editors, Paolo Azzoni, Andrea Fiaschetti, Josef Noll and Roberto Uribeetxeberria, and is based on the joint effort of an international team of forty highly professional researchers and engineers, over more than six years, starting from pSHIELD and nSHIELD Artemis projects. The participation by major European industry players in security, privacy and dependability also made it possible to commercially exploit the results developed in these projects.

How secure are Cyber-Physical Systems?
"A huge effort has to be spent to secure CPS and IoT," Paolo says. "If we consider the large number of attacks that have occurred in the last few years, involving a heterogeneous set of CPS (from printers, web- cams, residential gateways, baby monitors, to more complex vehicle control units, and even a process control system of a nuclear power plant), it is clear that the SPD level currently available in CPS and IoT must be significantly improved. →

It is, and it will be a delicate balancing act between technical aspects and costs. CPS and IoT manufacturers are experiencing enormous difficulties in managing the complexity of this new generation of connected devices: something unprecedented if we compare it with the security issues faced and managed by the manufacturers in the personal computer era. Unfortunately, once a product is on the market, no one in the value chain currently has enough incentives, motivations or even the complete expertise to manage SPD vulnerabilities. Moreover, the complexity of identifying and managing a vulnerability doesn't help to this regard. If we further consider the legacy systems, the situation gets worse: the ageing process of a device, which tends to lack maintenance, makes it more vulnerable and dangerous. The result? Hundreds of millions of potentially vulnerable and insecure devices that are connected to the Internet, a communication media that dramatically increases the overflow speed of SPD vulnerabilities: in the personal computer era, the limited connectivity confined security issues mainly to the domain of slow spreading viruses. The entire CPS and IoT community will be asked to acquire a high level of technical expertise to tackle current and future SPD challenges, a live knowledge base that evolves as quickly as technologies and threats evolve. Maintaining adequate professional expertise, identifying new SPD solutions and paying the costs of better CPS *up front* is certainly much cleverer and cheaper than being forced to suddenly face security disasters and having to pay the subsequent enormous costs."

A PLAYGROUND FOR HACKERS

The complexity of CPS and IoT provides a rich and inspiring playground for hackers: the ubiquity and pervasiveness of CPS/IoT, the heterogeneity of devices and their capabilities expose both industrial and consumer domains to a huge set of SPD risks. SPD vulnerabilities in the digital world affects also the physical world, and they have both a global technological and geographical impact. "There is a plethora of threats that can be classified into four main categories," Paolo explains, "based on the final goal of the attack: cloning, theft-of-service, spoofing or feature unlocking. Considering the functional objective of the attack, we can further distinguish between attacks against privacy (the goal of these attacks will be to gain knowledge of sensitive information); attacks against integrity (these attacks will try to change data or code within a CPS); attacks against availability (a.k.a. "denial of service", these attacks disrupt the normal operation of the system). Eventually, attacks can be classified by considering the method used to execute them: physical attacks, side-channel attacks and software attacks. Hackers have and will have unprecedented opportunities."

THE SYSTEM LEVEL IS THE NEW CHALLENGE

The effects of poorly designed CPS can potentially affect every aspects of our daily life, including the home and work environments, the city context, transportation, industrial settlements, power plants, etc., impacting both their physical and digital dimensions. "CPS and IoT are and will be almost everywhere, in consumer devices, vehicles, aircrafts, trains, medical devices, industrial plants, etc. and attacks on any of these systems can potentially have terrible consequences, including the loss of human lives. The concept of *system* is the real new challenge of SPD issues," Paolo says, "because the high level of connectivity of CPS propagates the potential effect of exploiting vulnerabilities to the entire system (or system of systems) that comprises the hacked CPS. This becomes the entry point for a massive attack, a sort of chain reaction, that could even extend to an entire vertical domain. The market will put pressure on CPS vendors to design their systems better and, if this is not taken into consideration," Paolo warns, "business and society will certainly be affected."

TO THE HEART OF THE MATTER

Security has become a major concern because it is often misinterpreted just as a good risk analysis and it has not been fully integrated from the earliest stages of products design and development. "Currently, there is no comprehensive methodology to assist developers of security sensitive systems. We wanted to go to the heart of the problem, proposing a methodology

for *building and maintaining* secure CPS and IoT solutions, across the entire product lifecycle," Paolo says. "The methodology addresses measurable security and, instead of assessing it 'monolithically', it focuses on different and correlated aspects of security in CPS, introducing countable values for the Security (S), Privacy (P) and Dependability (D) of the system and of its components. The approach works toward measuring SPD in terms of cardinal numbers, representing the application of specific SPD methods as required by a specific threat scenario." The process is based on the semantic description of the potential attack scenario, of the security-related aspects of systems, and of the security policies that should be applied irrespective of the scenario. "The SHIELD methodology addresses also scalability," he continues, "by using composition techniques that are able to build a security representation of the composed system (and system of systems) based on the individual SPD representations of each single component. This simplifies the process of measuring the SPD of the composed system and opens up for the opportunity to *build* the system in an incremental way."

The architecture built with SHIELD allows to be coherent, measurable, composable and modular, ensuring a flexible distribution of SPD information and functionalities between different CPS while supporting security and dependability characteristics. The architecture is adaptable to many different application scenarios and cover most of their SPD requirements. It is also interoperable, providing standard interfaces for easy adoption and simple deployment of the SHIELD solution, even in legacy systems. Security interoperability extends also among heterogeneous systems, the same way as standardised communication architectures (TCP/IP, OSI, etc.) aim at making communications among heterogeneous systems possible.

LAYERS

A SHIELD system is organised in four different layers. A *node layer* constitutes the physical part of the system and is composed of stand-alone and/or connected elements like sensors, actuators, or more sophisticated devices, which may perform smart communications. A *network layer* provides the common set of protocols, procedures, algorithms, and connectivity technologies that allow the communication between two or more devices, as well as with the external world. A *middleware layer* runs on specific SHIELD nodes and includes all the software functionalities required to manage SPD. Finally, an *overlay layer* collects the semantic information from the entire system and drives the composition of the SHIELD components in order to meet the desired SPD level.

INDUSTRIAL APPLICATIONS

"An entire part of the book is devoted to application scenarios, vertical domains and potential perspectives," Paolo says. "It covers the adoption of SHIELD in four different domains, proving how generic and flexible the approach is: airborne, railway, biometric security, and smart environments security (smart grid, smart vehicles, smart cities, etc.). It also describes how we developed, implemented, and tested more than forty security-enhancing prototypes in response to specific industrial requests. Finally, this part of the book provides an overview of the industrial perspectives of SPD and illustrates the results obtained by adopting the SHIELD methodology in other European research projects."

WIDE AUDIENCE

The book intends to raise the awareness on the security, privacy and dependability challenges that come with the massive digitalisation introduced by IoT and cyber-physical systems. It reveals the shortcomings of current approaches, addresses the state of the art of SPD and proposes a new concrete solution for various market segments. Touching several scientific and engineering disciplines, the book's audience ranges from system integrators, software engineers, security engineers and electronics engineers to managers and policy makers that, in industry and public administration, will be directly or indirectly involved in future massive digitalisation.

THE TULIPP PROJECT

POWERFUL IMAGE PROCESSING IN A COMPACT PACKAGE

by **PHILIPPE MILLET, THALES, DIANA GÖHRINGER, TU DRESDEN, MICHAEL GRINBERG, IGOR TCHOUCHENKOV** (FRAUNHOFER IOSB), **MAGNUS JAHRE** (NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY), **MAGNUS PETERSON** (SYNECTIVE LABS AB), **BEN RODRIGUEZ** (HIPPEROS SA), **FLEMMING CHRISTENSEN** (SUNDANCE MULTIPROCESSOR TECHNOLOGY LTD) AND **FABIEN MARTY (EFFICIENT INNOVATION)**

At first glance, advanced driver-assistance systems (ADAS), unmanned aircraft vehicles (UAVs) and medical X-ray imaging have little in common. That's if you're looking at them from the user's point of view. However, take a closer look at these systems from the developer's point of view, and you will notice that they all need high-performance image processing and they all have the so-called SWaP (size, weight and power) constraints that are common for every embedded computing system.

That's how the Tulipp project started. We took a range of application domains as a basis for the design of a common reference processing platform (i.e. the hardware, the operating system and its programming environment) that captures the real-time requirements, high-performance image processing and vision applications common to all of them. We created a set of guidelines to help select combinations of computing and communication resources to be instantiated in the platform while minimising energy resources and reducing development costs and time-to-market. These are based on existing standards, combined to optimise the performance / energy-consumption ratio.

DESIGNING THE TULIPP REFERENCE PLATFORM

The key insight of the Tulipp project is that industrial embedded image processing application development can be captured by an abstraction known as the generic development process (GDP). The input to GDP is a functionally correct implementation of the image processing system that runs on a desktop computer; the application is then moved onto the embedded platform. The first step is to partition the application to leverage the accelerators — such as graphics processing units (GPUs) — or reconfigurable fabrics — such as field programmable gate arrays (FPGAs) — commonly available on high-performance embedded systems-on-chip (SoCs).

Second, the implementations of the parts of the application designated for each accelerator are adapted to meet the accelerator's requirements and characteristics (for example, adapt a new programming model to expose parallelism). Third, the accelerated components are integrated and functional correctness is verified. Finally, the key performance indicators of interest — such as frame rate, power consumption or energy consumption — are retrieved and assessed. If the system requirements are not met, development is restarted at the partitioning or accelerator implementation steps. In summary, GDP is an iterative process where each iteration (hopefully) brings the image processing system closer to meeting system requirements.

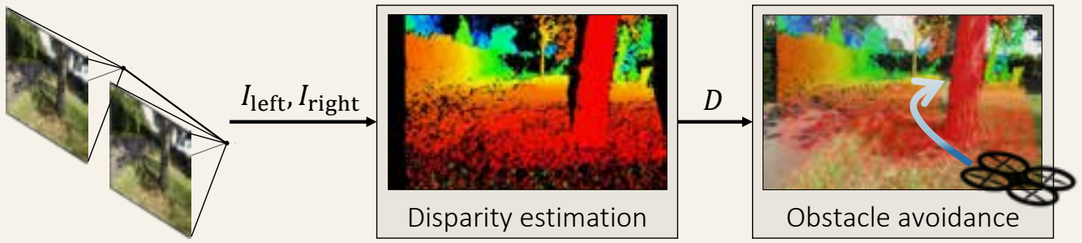
The major goal of the developments within the Tulipp project is to minimise the number of iterations through the GDP, and our approach was to design a reference platform consisting of high-performance, low-power hardware, a real-time operating system, and productivity-enhancing utilities — a framework that efficiently supports the developer when carrying out the GDP.

To achieve this, a consortium of eight partners (Thales, Sundance, HIPPEROS, NTNU, Fraunhofer, Synective Labs, TUD and Efficient Innovation) joined forces to develop the Tulipp reference platform and make it publicly available. We decided to focus on three industrially relevant use cases covering three different domains: pedestrian detection (ADAS), depth map computation using stereo cameras (UAV), and medical X-ray image enhancement (medical).

However, it would not be sufficient to simply design a platform in 2018 and to call it a reference platform, given the rapid pace at which technology improves. It is crucial that the reference platform is created at a level of abstraction where it can accommodate technology improvements. We've achieved this by documenting the process of designing the platform within a book that will form the basis for future standardisation efforts. In addition, the insights of our experts have been captured in a set of publicly available guidelines, consisting of practical advices, best practice approaches and recommended implementation methods that help developers select the optimal implementation strategy for their own applications.

In accordance with the GDP and our Tulipp guidelines, we've also produced a development kit consisting of:

+ a Tulipp hardware platform developed by Sundance, our hardware platform provider, which is based on the Xilinx Zynq multi-processor systems on chip (MPSoCs) Ultrascale+™
+ the Tulipp operating system, based on the HIPPEROS multi-core operating system
+ STHEM, the Tulipp toolchain, which was designed by NTNU and TUD



This development kit is available as a bundle and can be purchased from Sundance. It will also be provided for free to attendees of the tutorial session organised as part of a workshop on low-power, high-performance embedded solutions at the HiPEAC conference in January 2019 in Valencia.

Along with the FinFET+ FPGA, the Xilinx Zynq Ultrascale+™ MPSoC contains an Arm Cortex™-A53 quad-core CPU, an Arm Mali™-400 MP2 Graphics Processing Unit (GPU), and a real-time processing unit (RPU) containing a dual-core Arm Cortex™-R5 (32-bit real-time processor based on Arm-v7R architecture). The MPSoC implements many different interfaces, some of which can be used both externally and internally. The versatility of such components helps the system adapt to legacy interfaces and allows the user to select the most suitable chip for their application. However, SoCs and MPSoCs based on FPGAs are often available with different sizes of the reconfigurable matrix. This forces the board manufacturers to build as many board types as the number of available chips, which is extremely expensive.

The solution to this problem is often to solder such chips on a smaller board called a module with standardised interfaces. This allows the board manufacturer to develop carrier boards with different kinds of input and output interface while keeping the same interfaces with the processing module. When developing a new application, system developers can create their own configuration by selecting the carrier board that covers their application needs and the processing element that copes with the processing requirements. This approach is also good for compatibility and standardisation because it allows the processor to evolve while keeping the same interface with the carrier board. In addition, this approach also allows control of the components around the processor and helps ensure that the whole system is more stable.

The Tulipp hardware platform follows the embedded computer standards PC/104. They are intended for specialised environments where a small, rugged computer system is required and define both form factors and computer buses. The standard allows customers to build a modular customised embedded system by stacking together boards from a variety of commercial off-the-shelf (COTS) manufacturers.

Unfortunately, it is not sufficient to choose the best possible high-performance embedded vision hardware, along with a dedicated and optimised real-time operating system. In order to fully exploit a heterogeneous platform such as the Zynq Ultrascale+, application functions have to be mapped and scheduled on the available resources and accelerators. To help application designers understand the impact of their mapping choices, the Tulipp reference platform has been extended with performance analysis and power measurement features. Specifically, NTNU and TUD developed the STHEM toolchain, consisting of the following generic functions that complement and refine the capabilities of existing platforms for embedded vision applications:

+ a novel power measurement and analysis function
+ a platform-optimised image processing library
+ a dynamic partial reconfiguration function
+ a function providing support for using the real-time OS HIPPEROS within the Xilinx software development environment SDSoC™

The main feature of STHEM is the ability to non-intrusively profile power consumption and processor program counter values and thereby directly attribute energy consumption to source code constructs (e.g. for loops and procedures). This is enabled by our custom Lynsyn power measurement unit, which uses the JTAG hardware debug interface to concurrently sample platform power consumption and program counter values. STHEM supports a variety of ways of visualising these profiles, which aid application developers in identifying power consumption and performance issues.

In addition, STHEM contains a number of other utilities — such as a high-level FPGA library for image processing. This library is highly optimised, parametrisable and includes 28 vision functions, which are based on the OpenVX specification. Due to its implemented structure, the library is straightforward to use, while it is also easily portable as it has no dependencies to other libraries. It uses SDSoC and Vivado high-level synthesis (HLS) directives, which can easily be changed for any other HLS tool. Furthermore, the library is not restricted to any SDSoC version. Most functions support additional data types for higher precision and more flexibility and auto-vectorisation for easy-to-use performance optimisation. Collectively, these functions facilitate the efficient development of image processing applications on the Tulipp hardware platform.

As stated above, we had three use cases in different application domains in mind when developing our reference platform. The first use case adds a computing board to a medical X-ray sensor, helping to reduce radiation by reducing noise in the images. The second use case equips a UAV with real-time obstacle detection and avoidance capabilities based on a lightweight and low-cost stereo camera setup. The third use case enables the implementation of pedestrian detection algorithms running at real time on a small, energy-efficient, embedded platform.

ADVANCE IMAGE ENHANCEMENT ALGORITHMS FOR X-RAY IMAGES, RUNNING AT HIGH FRAME RATES

The TULIPP medical use case centres on mobile C-arms, a medical system that displays X-ray views from inside a patient's body during an operation, greatly enhancing the surgeon's ability to perform surgery. The system allows the surgeon to target the region much more precisely and to make small incisions rather than large cuts. This leads to faster patient recovery and lower risks of hospital-acquired infection. The drawback of this technique is the radiation dose, which is 30 times higher than we receive from our natural surroundings each day. These high doses of radiation are received not only by the patient but also by the medical staff doing such interventions all day long, several days a week.

Since the sensitivity of the sensor is very high, one could try to reduce the dose of radiation. However, this also increases the noise level on the images, making them almost unreadable. Fortunately, this effect can be corrected with proper image processing. Due to the high resolution of X-ray images, this procedure needs a lot of computing resources and, to complicate matters, the system has to meet strong real-time constraints due to the live display function. With specific noise reduction algorithms running on high-end PCs, it is possible to lower the radiation dose and restore the original quality of the picture. Unfortunately, in a confined environment such as an operating room, crowded with staff and equipment, size and mobility are of key importance, making the use of high-end PCs impractical. By bringing the computing power of a PC to hardware with the size of a smart-phone, Tulipp makes it possible to use a quarter of the radiation while maintaining the picture quality.

REAL-TIME OBSTACLE AVOIDANCE SYSTEM FOR UAVS BASED ON A STEREO CAMERA

Despite all the publicity about autonomous drones, most current systems are still remotely piloted by humans. A human on the ground has to constantly monitor both the payload of the drone in order to successfully accomplish the mission (e.g. to capture the desired data) and the drone's flight in order to avoid collisions with obstacles. The simultaneous operation of the UAV and of the sensor payload is a challenging task. Mistakes can threaten either the success of the mission or — much worse — human safety. Moreover, the UAV's area of operation may be limited due to the need for a constantly available communication link between the UAV and the remote control station.

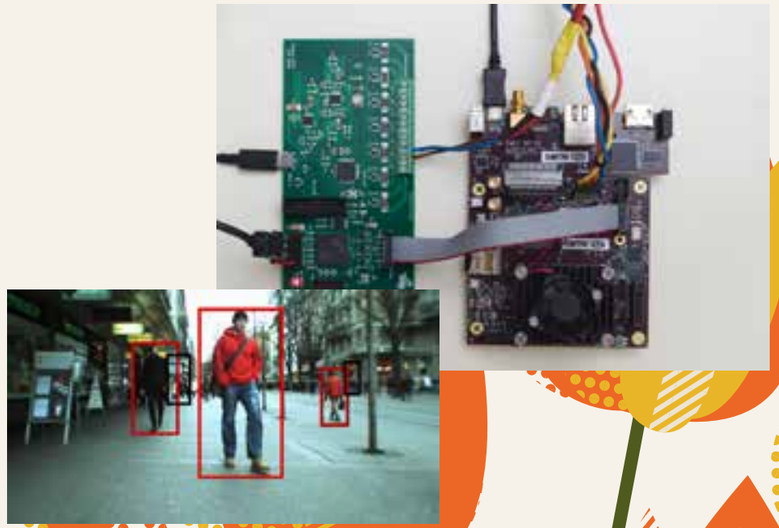
A major improvement could be made if UAVs were capable of autonomous navigation, or at least if they had an obstacle detection and avoidance capability. This capability can be achieved by means of additional sensors, such as ultrasonic sensors, radars, laser scanners, or video cameras monitoring the UAV surroundings. However, ultrasonic sensors have a very limited range, radar sensors might "overlook" non-metal objects, while laser scanners are heavy and energy-intensive and thus not suitable for applications with UAVs, which have tight weight and power constraints. Hence, our work within Tulipp focused on obstacle avoidance based on a lightweight stereo camera setup with cameras orientated in the direction of flight.

We use disparity maps, computed from the camera images, to locate obstacles in the flight path and to automatically steer the UAV around them. We used high-level synthesis (HLS) to port the semi-global matching (SGM) disparity estimation algorithm, written in C/C++, to the embedded FPGA, and achieved a frame rate of 29Hz and a processing latency of 28.5ms for images sized 640×360 pixels. The disparity maps are then converted into simpler representations, so-called U-/V-Maps, which are used for obstacle detection. Obstacle avoidance is based on a reactive approach that finds the shortest path around the obstacles as soon as they are within critical distance of the UAV.

PEDESTRIAN RECOGNITION IN REAL TIME

Nowadays, most advanced driver assistance systems (ADAS) rely on vision systems or on combinations of vision and radar. Modern image processing algorithms are capable of extracting almost all the information required about the vehicle's surroundings. However, there is often quite a big step between the first prototypical implementation on a desktop PC and the integration into a small and energy-efficient electronic control unit (ECU). In Tulipp we focused on the pedestrian detection application based on Viola-Jones classifiers.

To implement the application on the Tulipp hardware we used SDSoC, which offers a smooth optimisation path from the "C" version of the code running on the Arm processors of the Zynq towards FPGA-optimized parts. →



An ADAS algorithm must of course run at real time, which means it should be able to process a video image stream at full rate (30Hz), or at least at half rate. This algorithm, however, took roughly 10 seconds per frame on an ordinary PC, and almost 30 seconds per frame on the ARM platform, so the required speed-up was significant. The frame size used here is 640x480.

One of the "classical" problems with the Viola-Jones algorithm is its non-sequential memory access pattern of the integral images, and — especially for the FPGA platform — the limited memory space embedded in the FPGA logic. By totally restructuring the computational order, a more efficient access pattern could be used without changing the results. The classifier data, which is different for each scale, is then streamed through the FPGA, and the on-chip memory can then hold all data needed for running one scale at a time.

After these optimisations, the final implementation that uses the FPGA logic in combination with the ARM cores, reached roughly 15Hz, i.e., 66ms processing time per frame. This means that the algorithm may run on every second image if the camera runs at 30Hz.

So what's next for TULIPP? We'll be working on bringing even more intelligence to the platform by adding new accelerated technology dedicated to artificial neural network.

TULIPP has been named as a runner-up in the European Commission ECS Innovation Award, presented at the European Forum for Electronic Components and Systems 2018

Interested in finding out more about TULIPP's work? Don't miss the workshop at the HiPEAC Conference:
TULIPP: Energy Efficient Embedded Image Processing: Architectures, Tools and Operating Systems

https://www.hipeac.net/2019/valencia/schedule

CALENDAR

ECS BROKERAGE EVENT 2019
15-16 January 2019
BRUSSELS, BELGIUM

HIPEAC 2019 CONFERENCE
21-23 January 2019
VALENCIA, SPAIN

HORIZON EUROPE AND THE WORLD
5 February 2019 Brussels
VALENCIA, SPAIN

EMBEDDED WORLD
26-28 February 2019
NUREMBERG

DATE 2019
25-29 March 2019
FLORENCE, ITALY

SSI INTERNATIONAL CONFERENCE
10-11 April 2019
BARCELONA, SPAIN

ARTEMIS TECHNOLOGY CONFERENCE
16-17 April 2019
AMSTERDAM, THE NETHERLANDS

ENABLE-S3 FINAL EVENT
16-17 May 2019

ITS EUROPEAN CONGRESS 2019
03-06 June 2019
EINDHOVEN, THE NETHERLANDS

IOT WEEK
17-21 June 2019
AARHUS, DENMARK

ECSEL-JU SYMPOSIUM
17-18 June 2019
BUCHAREST

EFECS 2019
19-21 NOVEMBER
HELSINKI

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