Nano-Tera 2015 Annual Plenary Meeting.

Where health, environment and energy meet.

This year the Nano-Tera Annual Plenary Meeting was held in Bern, on top of a hill offering a breath taking view on the Old Town and the Alps. Soon after the welcome message given by the President of Nano-Tera, *Professor Giovanni de Micheli*, people were invited to listen to the presentations given in the different rooms of the convention centre. The visitors had the choice between five main topics subdivided into three different presentations. With fifteen conferences planned in the next hour, a cornelian choice was left to the visitor on which conferences to give precedence. In this short window, a lot of things were possible to learn. Among them, that bio-robotic eels are taking care of our environment and that approximate computing will certainly save our cell-phones battery life. One of the presentations of this first session was about care for premature babies. For those who are lucky enough not to have interacted with incubators, premature care is made of interconnected tubes and cables that link the baby to electronic interfaces that are constantly beeping. NewbornCare drastically reduces the amount of attachments for the same vital result. We will come back to these three projects later.
After a short break, people were invited to discover another 20% of the proposed presentations. While speeches in the Smart Energy room were giving an interesting overview of the multiple energy saving possibilities, the UltraSoundToGo project was presented in the Medical Platforms room. Instead of the usual heavy equipment for ultrasonography, this project proposed an ultrasound device connectable on a cell phone and with an excellent resolution and a better frame rate than other state of the art devices.
In the second half of the afternoon PhD students were invited to present their research in order to prepare possible collaborations with industries. Among the most exciting projects was the Ezechiel project on stretchable electronics. Solstice, another interesting project was presenting “solar stickers”, or soft photovoltaic surfaces made of GaAs vertical nanowires that allow to create solar panels a thousand times lighter than today’s. These stickers could be used for battery charging of a great array of electronic equipment.

After this first approach, the second day of the symposium was holding a lot of surprises. Giovanni de Micheli opened the proceedings by insisting on the fact that 2015 Nano-Tera meeting was dedicated to PhD students. Nano-Tera presently involves 142 PhD students in its program. They are working in fields such as Health Monitoring, Smart Prosthetics, Medical Platforms, Environmental Monitoring and Smart Energy. University graduates are the best means of technology transfer with a great impact on economy and society, he insisted. De Micheli pointed out that in Switzerland there is an innovation gap, called the “Valley of Death”, where it is difficult for new and promising projects to find financial resources because of the fact that they sometimes lack expertise and solidity on the market. How could it be different ? Nano-Tera wants to bridge that gap by giving more communication opportunities between industries and academics, and already proposed, for example, co-teaching courses by teams involving industrial specialists.

Professor Jan Rabaey from the University of California Berkeley gave the keynote speech "On the Symbiotic Nature of Information Technology and Neuroscience".
Jan Rabaey started by warning us that Moore's law was going to reach its end in the next ten years. Until now Moore's law has been astonishingly successful in predicting the doubling of the number of transistors in a dense integrated circuit. This seems to be the end of it, but not a good enough reason to start getting depressed. The main challenge today, according to Jan Rabaey is data processing. How to make sense of massive amounts of data coming from more and more connected objects that are going to invade the electronic world ? The answer may reside in mimicking the human brain : "the most powerful computer that is 2 to 3 orders more efficient than today's silicon equivalent". A computational engine that reaches amazing performances with "mediocre" components, according to Jan Rabaey. Building computers on these premises, trying to imitate what our brain is capable of, to classify and index thanks to our associative memory. Tomorrow's computers would need to be able to couple random indexing with associative memory in a four-step process. The sensor part analyses data in a redundant mode and extracts the different features. The in-memory computing part transforms and classifies by associative memory. This random indexing/associative memory allows, for example, the creation of language identification programs with 98% accuracy. Approximate computing seems to become a major and promising resource as the IcySoC project (which stands for : Inexact Sub-Near Threshold Systems For Ultra-Low Power Devices) tends to demonstrate. Many applications, especially with the way we use them, do not need exact computing to give an acceptable result. Thinking about most videos we are watching on the internet or music that we play through our earphones, approximate or inexact mathematics could do the work without anybody noticing a difference, but nevertheless "saving six times the amount of dynamic power used today by reducing the supply voltage from 1.0 V. to 0.4 V."

After a brief presentation on posters where all participants had five minutes to introduce their theme of research to the audience, another round of lectures began with the Nano-Tera three main domains of predilection : health, environment and energy.

Martin Wolff, from the University Hospital Zurich said how glad he was that this year's Nano-Tera event was dedicated to PhD Students, they have the energy and the drive to go forward, seeing old problems with new eyes. Yet, Martin Wolff doesn't lack spirit in what he's doing, considering the many activities he is involved in. Focusing on the needs of all the human components of the medical chain, he emphasises that the three main groups of interrelated professionals, physicians, administrative regulators and scientists have different needs that are difficult to combine but essential to understand. Among the different on going researches that he presented, a particular example related to Nano-Tera, the "NewbornCare" project, was given as an illustration of the sometimes draining process researchers have to go through when confronted with the complexity of administrative approval. NewbornCare is a remote monitoring of premature babies in incubators through cameras. Today, several tubes and cables are connected to the new born causing a large amount of false alert, up to 87.5%, due to the interaction of the baby with the different attachments. This system, instead, captures all the vital data through visual signals only. This project needs to go through the same paperwork as, say, a chemical drug for the treatment of cancer. Martin Wolff almost launches a distress signal : too much paperwork may kill good ideas, or at least, delay the application of discoveries that do not need the same level of security checks before becoming public. It would be good to have a division of risks between invasive and non invasive devices such as cameras that could drastically change the comfort of the patients and the medical staff.

The “environment part” lecture was given by the aptly named, Jan Van der Meer, from the Department of Fundamental Microbiology UNIL who is working on sensors and bio-sensors projects, called Envirobot and Bravoo, specialised in the detection of pollutants in lakes, rivers and seas.
Envirobot is a robotic eel composed of seven modules connected together with actuated hinge joints. When put in motion, the anguilliform robot goes wavy in a very natural fashion swimming like an eel. Each of its modules is being packed with an array of physical, chemical or biological sensors that constantly feed a data base with information on, for example, water temperature, oxygen, salinity or on the presence of pollutants such as lead, copper or mercury. One of Envirobot’s bio-sensors is composed of a chamber where the alteration of movement of five to six daphnia individuals upon contact to a water sample can be followed. Daphnia, or water fleas, are small crustaceans the size of one to five millimetres, which are very sensitive to chemical variations in the water. Modifications in the frequency of their movement within the chamber are automatically analysed and compared to calibrated non-polluted controls. The advantage of a swimming robot is its ability to move without creating disturbance in the water, which is not the case for a robot with propellers. By adding or removing modules, the robot is reconfigurable for the type of pollutant to study. The final goal of the project is to produce a new Envirobot, which is going to be able to find pollution on its own, on the basis of input given by its sensors. Bravoo is the static version of the robotic eel. It is a buoy packed with all sorts of sensors with a much longer autonomy, since this buoy can stay an entire month collecting data versus only one day for Envirobot. Bravoo creates no disturbance at all and is more suitable for marine water monitoring on extended areas where it is maybe not possible to replace sensors every day.

The Smart Energy part was presented by David Atienza, Professor at the Embedded Systems Laboratory, EPFL, and like Jan Rabaey, David Atienza warns us about the end of Moore’s law and the enormous quantity of data that will need processing. If in 2013, data collection and processing was evaluated at 4.4 ZB, this number will grow to 44 ZB in 2020.
Today, data centres are essential to society, they are used in all our activities : health, science, services, information, commerce or personal life. Each data centre consists of thousands of computing servers that store and process on our behalf. We are now facing a threshold, performance growth has stopped, we will always need more energy to get higher power density for the same server size. Today, the energy cost is as high as the investment needed into servers on a three-year replacement policy. Power is becoming the most expensive aspect of a data centre.
David Atienza reminds us that brains are the most efficient computing systems, and brains do approximate computing. They are accurate only when it is really necessary and they have optimal power management. “YINS”, a Nano-Tera project, is an energy and thermal aware design of future data centre based on energy recovery where all levels or parts of a big data centre would participate in enhancing energy awareness. Better chip design together with inexact arithmetic and smart grid science with a real time monitoring based on local power optimisation can save power on a large scale.

Projects like “SHINE”, a new generation of hydrogen production using sunlight, aims at mimicking natural photosynthesis in a next-generation device able to exploit efficiently incoming sunlight in order to direct it into Photo-ElectroChemical (PEC) components designed to split water into hydrogen and oxygen.
The self-tracking solar concentrator intends to reduce the tracking energy needs using an innovative strategy to follow the sun-path across the seasons. It will be able to fully cover the seasonal-tracking requirements. It is constituted by focusing lenses, an optical waveguide, a dichroic membrane and a honeycombed actuator filled with paraffin wax. The natural sunlight crosses two stages of lenses and is focused onto a particular membrane separating visible light and infrared light. The infrared light is then absorbed by the underlying paraffin wax, which melts and expands upwards pushing the membrane towards the waveguide and realizing the actual optical coupling. Therefore, concentrated light is able to be extracted at the waveguide facet. As concentrated sunlight will be directed towards small PEC components, SHINE is focusing efforts towards the fabrication of miniaturised solar water-splitting units that can be incorporated within the concentrator waveguide. The microstructured systems being developed exploit the advantages of microfluidic technologies and use fluid mechanics approaches to improve the water electrolysis processes.

2015 Nano-Tera Annual Plenary Meeting ended with the Best Poster and Video Award. First place for the poster award was attributed to the project UltraSoundToGo, headed by Giovanni de Micheli. A project that will allow remote hospitals in developing countries to have access to high quality ultrasound imagery with a device that can be connected to any smartphone. The data would then be sent to a well-equipped hospital for processing in only three minutes.

The film made by the research group “Shine”, on hydrogen production using sunlight, was awarded with the shooting of a professional film to present their work to a larger audience.

This year, Nano-Tera focused on green and renewable energies and warned us about the overwhelming quantity of data that will need processing in the years to come. Seeing the incredible energy and constant flow of ideas that goes around in a gathering like this year’s, there is hope that solutions will certainly find their way through the future PhD synapses and finally to the general public.

Sources :

Nano-Tera information sheets
Nano-Tera website
Nano-Tera posters

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addendum :

Projects like “Shine”, a new generation of hydrogen production using sunlight. “Shine” innovates by proposing two layers of focusing lenses that could work in conjunction with materials mimicking natural photosynthesis, like Photo Electro Chemical (PEC). With this system, a perfect exposition to the sun is not reduced to the only moment of the day when the sun is at the best angle with the photovoltaic panel. The lenses authorise a 16° difference with the optimal angle for the same result. The focused light goes through two layers, a waveguide and a prism membrane that separates infrared from visible light before hitting the actuator layer. The actuator has a honeycombed structure, each hole of a diameter of 510 micrometres wide is filled up with a paraffin wax that allows the collection of infrared light. When the heated paraffin expands, it pushes up the prism membrane that redistributes the light in the waveguide membrane for minimum loss.