Materials science at your fingertips

Professor Eva Campo discusses the production of a revolutionary tactile display, capable of rendering Braille in easily readable format and with reliable refresh rates

What is the underlying ethos of the 'Nano-optical mechanical systems' (NOMS) project and the services it provides?

The main goal of NOMS is to provide a demonstrator of a tactile display for the visually impaired. The subjacent technology features novel materials that change shape upon light irradiation – these are smart materials that consist of a chemically-engineered blend of polymers, liquid crystals, and carbon nanotubes. By integrating smart materials into microsystem technologies, it will be possible to produce refreshable tactile displays with enough resolution to display not only Braille text, but also graphs and images, and eventually facilitate navigation through an online environment.

Which key tools are the members of NOMS using in order to gain knowledge about visual impairments linked with brain analysis?

Neurophyschology studies at NOMS are crucial for assuring the adequate development of a demonstrator. Common tools of the trade involve techniques such as Event Related Potentials (ERP). In this context, ERP attempts to answer whether or not the perception of an 'on' and 'off' blister in the NOMS tablet is registered in the brain. This is critical for the development of a product, as well as understanding the impact of such a device.

Are there any longstanding issues with Braille and graphic representation for those with visual impairments?

Representation of information through tactile stimuli is a complex problem in both the cognitive and technological realms. Cognitively speaking, it is unclear how to best convey information to the visually impaired on a two-dimensional representation. The visually capable can relate to this problem by comparing the ease of reading certain maps or navigating certain websites. Meanwhile, the lack of suitable technologies that would enable the placement of two closely-spaced blisters to allow a 'continuous line' to be 'read' has hindered the development of refreshable systems to display graphs or images. Most of the available technology relies on mechanical components and their miniaturisation is problematic, often leading to unreasonable electrical consumption, weight and cost.

Could you elaborate on the main features of the NOMS tactile tablet prototype?

The demonstrator created at NOMS is a 2x3 cell, following the directives of a Braille cell. It features an innovative demonstrator using smart composites activated by light. Although efforts exist in using smart composites activated by thermal and electrical means, we feel the NOMS prototype is a step forward in achieving higher resolution, lower consumption and a faster response. Along with higher microtechnology integrability, the NOMS prototype serves as a proof-of-concept for this emergent field to be deployed in assistive technologies. When used with the NOMS-developed driving electronics as well as a 'simplifying software', performance of the NOMS demonstrator has been identified by neuropsychologists as highly flexible and usable. The presented novel interface seems to outperform commercially available stimulation devices for haptic research, mostly based on piezoelectric technology.

What challenges or obstacles have you encountered so far?

The technical level of the NOMS project is high. Pushing the conventional boundaries of synthesis/microprocessing/

performance has been an arduous task, especially because microprocessing embeds some of the synthesis processes that are crucial for adequate performance. In addition, the team had to bridge the need for a multidisciplinary approach. NOMS embodies the nano-bio-info-cogni paradigm and, currently, few researchers are comfortable speaking the vocabulary across such a broad spectrum.

Could you outline the next stages of development for the tactile tablet and other opto-smart technologies being developed by NOMS? When do you foresee the project reaching maturation?

Several scientific and technological advances need to surge to facilitate the full development of a NOMS tactile tablet. For example, an improved understanding of the synthesis/properties in the materials space will be crucial to producing composites to comply with performance requests, such as actuation response times. These are fundamental questions that possibly hold the key to unlocking the full potential of smart behaviour. This understanding will be highly useful in terms of designing ways to integrate composites into microtechnologies, further paving the way to commercialisation.

Light **touches**

Through the development of light-actuated Braille displays, the **NOMS** project could provide revolutionary technologies for the visually impaired, while also answering fundamental questions related to materials science and its associated disciplines

THE PRODUCTION OF refreshable tactile displays that can produce both Braille and graphic representations has been an ongoing challenge, and existing mechanical technologies are inadequate. Given the archaic nature of interfaces for the visually impaired, a technological divide has developed, with no good solutions to date. However, this now looks all set to change.

Led by the Spanish Research Council (CSIC-Spain), the 'Nano-optical mechanical systems' (NOMS) collaboration has been making inroads into this separation, which has also opened up a number of broader research questions. Through the use of smart composite materials, they have been able to create polymer-like systems that can easily be integrated into microsystem technologies. In fact, the technology is being pursued in biomedicine and robotics, moving towards the creation of artificial muscles, or smart valves and channels. The team has created optically actuated technology, which is incredibly appealing for a range of applications, with integration into existing technologies an easy step. The work has demonstrated the potential for producing mass-scale consumer electronics with tactile representation, and such products could be targeted at both the visually impaired and the public at large.

The NOMS project has generated numerous innovations, and this success is driving the team to further cutting-edge work. Material development has been handled by groups at the Cavendish Laboratory at the University of Cambridge, and the Slovak Academy of Sciences. Assisted by pre-established material properties, their efforts have provided new information in the realm of smart composite synthesis. The move towards industrialisation has been significantly helped by the work of a team from the Spanish Research Council, which has produced an operating tactile blister through microtechnologies. Quantifying important parameters on performance and fast cycling – including power consumption and response – are important steps. Furthermore, the development of 'simplifying software', along with the driving electronics executed by the Autonomous University of Barcelona, are set to help investigate the fundamentals of cognition behind tactile perception, conducted by neuropsychologists at Hamburg University.

Added to this, the groups have been educating graduate students in their highly multidisciplinary environment, comprising exposure to physics, chemistry, engineering and neuropsychology. With training also provided in intellectual property and commercialisation, NOMS is contributing to educating graduates with both technical and commercial skills to promote lab-to-market.

USER INVOLVEMENT

The direction of the study has remained on course not least due to the inclusion of end users within the work. The involvement of the Slovak Blind Union, and their director Dr Branislow Mamojka, has been crucial to such innovation. Similarly, Professor Jordi Roig, leader of the Electronic Engineering team for NOMS, is both a user and experienced product developer of technology for the visually impaired. These stakeholders are indispensable in the development of nanotechnology products for market. Professor Eva Campo, now at Bangor University (UK), is co-leading the team, and is aware of the importance of an integrated approach: "It has been illustrated that this inclusion increases the likelihood that the product would be taken up by the end user, and assistive technologies also seem to fall in this purview, with the NOMS consortium being purposefully assembled to meet this criterion". One application these technology-literate end users have been able to identify is single blister applications. These would work as an addition to commonly-used electronic equipment, and would function much the same way as the green or red LEDs on such equipment. Such a small innovation would have the potential of easing the lives of visually impaired users of these products.

SMART MATERIALS

The research is not only focused on the production of new technologies; the consortium is also trying to understand the materials at a more fundamental level. Such an understanding will facilitate development from the biological to enhanced tactile surfaces. Bangor University has recently funded the Laboratory for Matter Dynamics, which is trying to uncover the basic features of smart behaviour. Utilising spectroscopies that unveil molecular

INTELLIGENCE

NOMS

NANO-OPTICAL MECHANICAL SYSTEMS

OBJECTIVES

NOMS aims at providing tactile screens to enable the visually impaired to read complex representations such as mathematical equations and graphical images, incorporating these devices into ATMs, personal computers, mobile phones etc.

KEY COLLABORATORS

Eva Campo, Bangor University • **Jaume Esteve**; **Núria Torras**; **Kirill Zinoviev**, CNM-IMB CSIC • **Eugene Terentjev**; **Jean Marshall**, University of Cambridge • **Maria Omastova**; **Klaudia Czanikova**; **Igor Krupa**, Slovak Academy of Science • **Brigitte Roeder**; **Patrick Burns**, University of Hamburg • **Jordi Roig**; **Marc Valvidiera**; **Vicens Soler**, Universitat Autonoma de Barcelona • **Wiebe Wagemans**; **Floris Crompvoets**, Philips • **Branislav Mamojka**; **Peter Teplicky**, UNSS • **Nicholas Walker**; **Rifat Iqbal**, Microsharp • **David Wenn**, IxScient

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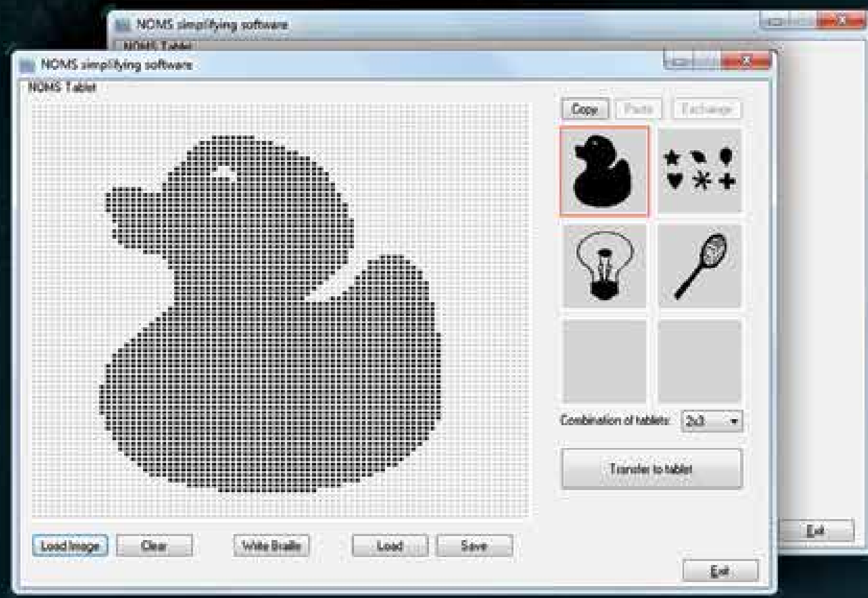
EVA CAMPO is a faculty member at Bangor University, having funded the Laboratory for Matter Dynamics to study atomistic phenomena behind smart composites. She has served as Assistant Education Director at the University of Pennsylvania and Assistant Professor at CNM-IMB-CSIC, where she was the leading PI soliciting NOMS. She currently acts as PI's assistant.



EXAMPLE OF NOMS SIMPLIFYING SOFTWARE WHICH CONVERTS COMPLEX IMAGES INTO SIMPLE, HAPTIC-READY PATTERNS

configurations, the hope is that they will soon be able to better uncover the way in which these materials function. Such advances will feed back into the synthesis of these materials to enhance performance. Furthermore, it will provide a strong focus for the labs at Bangor, providing Campo's students with cutting-edge material as a part of their course. The hope is that the innovations made as part of NOMS will be translated into excellence in education.

MATERIAL EXPLORATION

There are other ways that the study ofnew materials is impacting research within the wider community. The Materials Genome Initiative was first proposed by Professor Cedar at the Massachusetts Institute of Technology (MIT) in the context of developing materials for batteries. Rather than every project working on trial-and-error before choosing suitable syntheses for a given project, the Materials Genome is a databank of properties which allows researchers to begin creating materials by design. The creation of information on the synthesis to properties map allows researchers to make good hypotheses about the ways in which specific combinations of materials will behave. The Initiative was created in order to expand such an approach to materials science more broadly, and the group's work is able to feed into this understanding of the interactions within composites. The method is projected to accelerate the lab-to-market trajectory, which is frequently slowed down by experimental material design, which is both expensive and time-consuming. Using computational approaches, it will be possible to begin designing materials on demand, and it is hoped that this will have a significant impact on materials science, as well as related disciplines. By reducing the lengthy process of design, commercial pathways are created which will bring innovative products swiftly to market, an exciting prospect for NOMS.

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NEW CURRICULUM

This research is having an impact within Bangor which is stretching beyond the installation of their new laboratory. Campo explains the link between cutting-edge research and the teaching environment: "Echoing the lab-to-market paradigm, I recently proposed a lab-to-classroom initiative to kick-start the education dimension of the Materials Genome Initiative". Within this, the team is able to consider whether their research is filtering into class teaching at the correct pace, balancing the difficulty of such curriculum development against the current division between scientific discoveries and what is learned by students. The researchers are also questioning whether they place enough of their work in the curriculum to comply with the Initiative. This benchmarking allows the scientists to bring their work to the student body, and the process will be a central point of discussion at the Education Symposium at the Materials Research Society meeting in spring 2013. Through these means, the NOMS project is set to continue having an impact at Bangor well after the funding period, feeding into teaching and ongoing research projects at the University.