

# Sensors 2016

## Wearable Smart Sensors and Technologies

Conference with Exhibition and Posters

Tuesday, 21st June 2016

held at the Royal Society of Chemistry Lecture Theatre  
Burlington House, Piccadilly, London W1J 0BA

### A Conference Report by Timothy O'Brien – University of Lincoln

The conference was held in two sessions with six presentations each, and its topic was **Wearable Smart Sensors and Technologies**, and these varied considerably in the sensing platform as well as in the intended use. The presenters were from universities across the UK and the Republic of Ireland, with conference attendees from the UK, Republic of Ireland, Greece and Switzerland.

#### Session 1:

The opening presentation was by Dr Daniel Roggen's (University of Sussex), an overview of the state of so-called wearables, which have multiple applications and definitions. General descriptors in wearable technologies often include a seamless design, personalisation, invisibility (or unobtrusiveness) and intuition. The examples of the applications ranged from assistance with Parkinsonian gait by way of motion sensing and audio cues to potential lifestyle or diet changes with a hypothetical wearable able to understand the context of an environment rather than simply measuring particular metrics.



Dr Stephen Morgan (University of Nottingham) presentation was on the use of photonic and conductive textiles in applications ranging from reflectance-based sensing (e.g. traditional pulse oximeter), capillary refill times (automated sensing) and monitoring foot conditions to identify conditions likely to lead to foot ulcers in diabetic patients. A functionalised optical fiber—one modified with either functional layers or a grating structure can operate as a number of different sensors including

measuring temperature, humidity or pH. These sensors could be applied to wound dressings for which information regarding the conditions of the wound can be determined without removing the dressing and therefore will leave the wound environment undisturbed.

Dr Niko Münzenrieder (University of Sussex) presented the development of flexible circuits intended to eventually be used in flexible and stretchable everyday items, such as textiles, or even on the skin. The flexibility of the thinnest circuit described (on 1  $\mu\text{m}$  thin parylene membrane) is able to bend around a human hair. Additionally, the circuit is largely transparent, and Dr Münzenrieder gave an example of a smart contact lens using the circuit for glaucoma monitoring.

Dr Elizabeth Rendon-Morales (University of Sussex) highlighted the lack of sensing technologies to monitor the electrocardiogram (ECG) of living organisms during their early development in a non-invasive and non-destructive manner. Dr Rendon-Morales described a sensor based on Electric Potential Sensing (developed and patented by the University of Sussex) that demonstrates ECG



activity of zebrafish embryos (used as model organisms for this process) as early as three days post-fertilization without the need for an invasive process. Dr Rendon-Morales indicated this could provide a pathway to monitoring the ECGs of other embryonic organisms remotely.

Dr Emer Duffy (Dublin City University) presented a wearable device designed to capture volatiles released through human skin. Monitoring of these volatiles provides a non-invasive method to communicate information regarding the health of the subject (including disease detection, wound healing and more). The wearable consisted of a solid-phase micro extraction fibre attached in a housing which provided a pre-concentration step, which is necessary due to the low concentrations of the liberated volatiles. Dr Duffy stated that searches for relevant biomarkers present in the volatiles were currently underway.

Desiree Acha (Middlesex University) described the current challenges in the medical diagnosis of dementia—specifically Alzheimer’s disease as it is the most prevalent. She described a biosensor using electrochemical impedance spectroscopy with exceptionally high sensitivity for existing biomarkers related to Alzheimer’s. The intent for the biosensor is for use in affordable early detection and diagnosis of dementia.

### **Session 2:**

Dr Michael Lones (Heriot-Watt University) spoke about the use of smart sensors for the management of dyskinesia—involuntary movements as a side effect of a common treatment of Parkinson’s. Unlike many of the previous presentations, the measurement methods were not the focus. Motion sensors were used to gather the data, but rather the emphasis was on the interpretation of this complex data. Evolutionary algorithms were used to distinguish movements due to dyskinesia from other sources, with the results connected wirelessly to a mobile phone. The intent is to provide valuable information to clinicians regarding patient data that was previously unavailable in order to adjust treatment dosages for specific patients.



Dr Toby Jenkins (University of Bath) described two medical devices with potential theranostic (therapeutic and/or diagnostic) effects. One device functions as an indicator when a wound has become infected with common bacteria. The device autonomously prompts a visual cue on the bandage when the wound condition reaches a certain infection level. The trigger takes advantage of cytolytic enzyme secretion from the bacteria, and a self-quenching effect is observed in carboxyfluorescein. The second device functions as a warning system for patients infected with a bacteria responsible for the majority of nosocomial urinary tract infections. Similarly, a visible event takes place when a trigger occurs—in this case the pH of the urine increases as a result of the bacteria.

Professor Liudi Jiang (University of Southampton) presented on the disparity between the lower limb development and amputee satisfaction over the past few decades. This gap is primarily due to the lack of significant development in the body-socket interface. The morphology of the amputated limbs is inconsistent between individuals, and therefore a customized socket fitting is important for the overall comfort of the prosthetic limb user. Prof. Jiang described pressure sensors placed in a tri-axial arrangement to assist in identifying susceptible areas and to improve the fit of lower limb prosthetics.



Professor Ahmad Al-Shamma'a (Liverpool John Moores University) highlighted the increase in popularity of wearables that do not provide detailed health information to their users. He explained that existing biosensors can provide a multitude of practical information but are currently not available in a wearable format. Prof Al-Shamma'a also described the use of electromagnetic waves in the microwave region for a wide variety of real-time

monitoring applications. At the conclusion of the presentation, he discussed the development of Sensor City, a planned site of innovation for academics and industry (<https://www.ljmu.ac.uk/about-us/sensor-city>) please copy the link and paste in to your browser.

Dr Sally Gowers (Imperial College London) presented the issues stemming from a lack of donor organs, specifically kidneys, compared with the need for these organs. Dr Gowers described a portable system that can travel with the donor organ to continuously monitor tissue health on the basis of metabolic markers. The system uses modified electrodes and micro dialysis and connects wirelessly to a tablet computer for data transfer.

Dr Aoife Morrin (Dublin City University) closed the afternoon session with her presentation on the use of a conductive 'smart tattoo' produced from a silver ink to form a concentric electrode. Using AC impedance yields information regarding the moisture content of the skin, which is applicable for sufferers of conditions such as atopic dermatitis which causes chronic dehydration.

Two posters were also displayed at the conference. One focused on comparing a number of low-cost sensors to determine exposure to environmental hazards, specifically for mothers with young children. The second poster was related to the presentation given by Dr Gowers regarding the portable system to monitor organ viability in real time.

The exhibitor presentations at the conference, held in Session 1, were by Hamamatsu Photonics UK Ltd and NanoFlex. Hamamatsu is a photonics-based company producing a range of light-detecting sensors including mini-spectrometers, image sensors (CCD, CMOS, NMOS, etc.) and photomultiplier tubes. A number of other light



emitting products such as lamps, LEDs and light sources are produced by the company as well. NanoFlex produces electrodes that are 100—1000 times more sensitive than traditional electrodes (100 $\mu$ m disc electrodes). These electrodes are functionally similar to traditional electrodes, although flexible options are also available. While NanoFlex does not develop products containing the electrodes, they are intended to be used as components in the developments of biosensors and other products using electrochemistry.

Additionally there was a demonstration of a device developed by the University of York (presented by Amir Dehsarvi), which was a LID-Monitor that offers a safe, simple and unobtrusive way of monitoring dyskinesia in the home environment. The device utilises six small wireless sensors placed on the arms, legs, head and trunk that continually monitors patient's movements associated with dyskinesia and symptoms of Parkinson's disease are recognized. The information from the sensors are automatically uploaded via a smart phone to a remote secure server to interpret the data presented in the form a graphical report.

In summary, the Wearable Smart Sensors and Technologies Conference contained a variety of different sensing platforms with a wide range of applications. The recent developments in sensors research hold exciting prospects for the medical industry. Conference attendees engaged with presenters in relevant discussions regarding the topic of the presentation. The meeting provided ample opportunity for all concerned to hold informal discussions and the participation of many of the leading UK research groups in the field initiated a number of new collaborations.

Photos by John Trigg