IGFS-based FoodSmartphone Early Stage Researchers share their opinions on future technologies for food safety analysis

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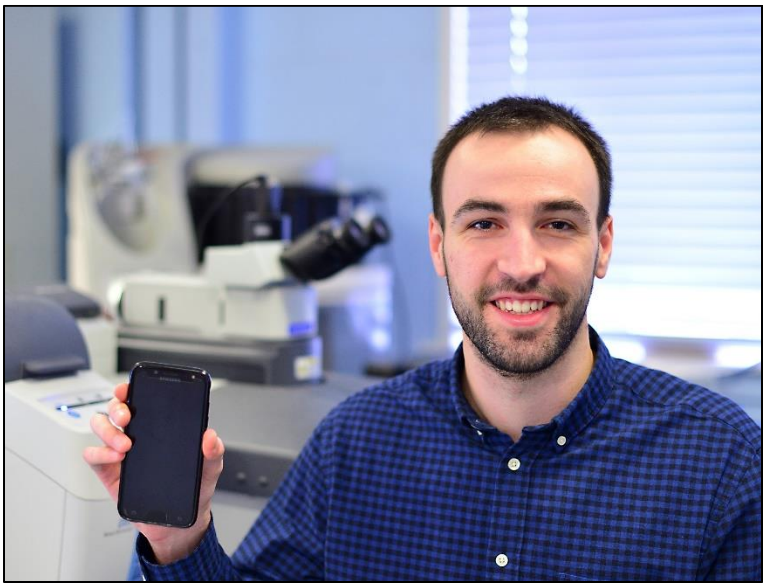

“What can’t be done with any of our smartphones these days?” That’s what we all wonder in light of the recent advances we all observe. That’s also what brought together a group of scientists who have embarked on a journey to combine smartphones and food safety analysis. As a member of the ambitious FoodSmartphone project team, our main aim is to develop smartphone based biosensors to detect multiple contaminants in food such as toxins, pesticides, microorganisms and allergens. The day when a smartphone can be used as a diagnostic tool by non-trained people is thus perhaps not so far away! It might look a futuristic idea, but this is a European research project that is now up and running, with QUB playing an important role. In total 11 early stage researchers have joined various teams in different European universities and companies to make this possible in a 3 year time period. The approaches being studied at the moment are as diverse as the team members’ backgrounds: enzymatic assays, plasmonic sensors, electrochemical sensors, etc., taking some of the advantages of gold, fluorescent or carbon nanoparticles to exploit their optical properties. Moreover, an early stage researcher from QUB focuses on image analysis and the computational aspect of the work, ensuring that the bioassays developed by other members of the group can be perfectly integrated into a smartphone.

With this project overview, one might wonder where we are now. It’s been one year since I joined the project so, with two years ahead, I feel confident to talk about what can be achieved within my particular project. The research I’m doing at the Institute for Global Food Security is split up in the same way as biosensors are: biorecognition element and signal transducer. My project aims to detect spoilage microorganisms in dairy products through a smartphone based sensor. These microbiological contaminations cause important economic losses, as any food batch contaminated will be quickly spoiled and must be discarded. In the event of finding pathogenic bacteria present in the food samples, the problem becomes even more serious, potentially threatening the consumer’s health if the contamination is not detected in time. For example, Mycobacterium bovis can spoil milk and dairy products made from raw milk, such as cheese and yogurt. More importantly, if the contaminated dairy products are consumed, consumers will be infected with Mycobacterium bovis which is also one of the causal agents of human tuberculosis.

So far I have been trying to optimize the signal transduction of the sensor, using gold nanostars. These nanoparticles show quite interesting properties, such as catalytic activity to oxidise substrates and generate a colour signal, or Raman enhancement to obtain a strong fingerprint of any molecule in the surroundings of the nanoparticles. These two phenomena have already been studied and optimized to be used in a sensor. Besides, any biomolecule can be easily attached to their surface, as if they were Lego pieces. In the case of the biorecognition elements, we are making use of isothermal amplification techniques, such as Recombinase Polymerase Amplification (RPA) or directly capturing the bacteria through specific antibodies and peptides. Both approaches are being studied and optimization is on-going to ensure specificity in the detection. You might have already noticed something: no temperature sensitive enzymes or standard PCR is proposed for this study. The rationale for this is simple, who would ever want a smartphone-based biosensor that needs to be used in the lab under controlled conditions? I plan to keep updated you all with my progress using blogs so please keep a lookout!

Yunfeng Zhao

Are you still hesitating whether or not to send suspect food sample to certified laboratory for analysis? This dilemma might be ended soon. As being aimed to decentralize food analysis procedure, The European Union Horizontal 2020 FoodSmartphone project is developing smartphone analysers to enable food analysis by normal end-user. Institute for Global Food Security (IGFS) at Queen's University Belfast is hosting 3 of the 11 Early Stage Researchers of the FoodSmartphone project to develop cutting-edge portable biosensing and data processing technologies to achieve this goal.

What issue is the FoodSmartphone project trying to solve? Current food analysis procedure requires sending tremendous amount of suspect food samples to centralized laboratory for analysis. In these laboratories, professional personnel and elaborate lab equipment are required to process the food analysis. However, the facts that an increasing number of food sample is needed to be analysed and lots of resource limited regions still suffering from a lack of resource restraint the tenor of food quality control. At IGFS and FoodSmartphone project, we are developing user-friendly and easy-to-use smartphone analysers for food analysis. These devices will enable screening of suspect food samples at the user end. A small portion of food sample that fails to pass this screen process will then be sent to centralized laboratory for confirmatory tests.

My job here at IGFS is mainly focusing on developing signal processing and secured data transmission solutions for the FoodSmartphone project. There are many ways to achieve such smartphone-based biosensing for food analysis nowadays, including but not limited to optical, bioelectrical, and mass-based methods. Our research starts with optical methods. That is, the biosensing methods that use light as their sensing media. What advantages do optical methods have in general? The first one that comes into my mind is their non-destructiveness and rapidness. To make an analogy, we can diagnose our health condition by simply taking an X-ray image of our body without doing a surgery. Similarly, food quality can be assessed using near-inferred or inferred light scanning without the necessity to open or destroy the food sample. Another advantage of optical method is its simplicity. Light is one of the most fundamental elements of our universe, and its characteristics are well studied. And almost every smartphone today has an optical camera integrated, making them ideal platforms for optical biosensing. Moreover, we can not only analyse what chemicals exist in the food, but also where they are located through advanced optical imaging by taking advantage of the fine resolution bought by the high-quality smartphone cameras today. When optical analysis is combined with bio-chemical essays, a much higher specificity and sensitivity can be achieved for the detection of contaminants in food samples. For example, optical markers can be coupled with immuno-assays to amplify the light signal so that contaminants even with very low concentration can be detected in food sample.

I believe that no one wants to spend weeks to learn how to analyse the data on a smartphone. Therefore, development of a user-friendly smartphone App becomes essential to handle user interactions in order to realize easy-to-use devices even for normal end-users. By integrating the smartphone App with biosensing and signal processing techniques, an accurate and straightforward smartphone device for the detection of contaminants in food sample will be possible.

Last but not least, please check out our blog to follow our newest experience as an early stage researcher working at IGFS and discover our latest progress on pursuing the goal of the FoodSmartphone project!

Jordi Nelis

The market for foodstuffs is increasingly globalised and food production and processing is often conducted in a highly industrialised fashion while transport networks are becoming ever more complex. This can undermine product traceability and prevents rapid action to contain possible threats due to a lag in time caused by the centralised, laboratory based, quality control system that is currently in place. This is especially true for the shellfish industry. Shellfish are often produced in remote areas spread out over scores of little bays. However, quality control of these products is done in centralised laboratories using time consuming and costly equipment. As a result only a small portion of the marketed shellfish actually gets tested. Moreover, products can already be dispensed before test results come back. This situation can lead to big economic losses due to product recalls.   An interesting option to counteract this is to apply user-friendly, decentralised, screening strategies. Indeed, shellfish farmers and even consumers could test the products themselves if a simple point of site (POS) system could be developed for the detection of these marine toxins. The development of such a POS system is my current job as a Marie Curie early stage researcher (ESR) working for the FoodSmartphone consortium here at the institute of global food security (IGFS). FoodSmartphone, as the name suggests, aims to develop smartphone based sensing technology for a variety of food contaminants of which marine toxins in shellfish is one. Evidently, use of smartphone technology can be adventurous in several ways. For example: 1) smartphones are compact and fitted with many sophisticated sensors (such as the camera and video sensors) which can be piggybacked for contaminant detection. 2) the connectivity of smartphones can be used to send and store information which can create big data sets providing scores of information regarding our marine waters which is currently unavailable. 3) geolocalisation and secure data transmission can be used to pinpoint problematic areas analysed while limiting the options for food fraud. The development of such a smartphone based device (SBD) is currently underway!

I am now a bit over a year into my 3 year project and have made some interesting progress in the development of such a system. First of I started with developing several nanoparticles which I wanted to use for the signal enhancement properties. To this end gold nanoparticles, (spheres, rods and stars) were synthesized. Next these particles were used to investigate their use both in optical and electrochemical based sensing. More specifically, plasmonic ELISA, darkfield microscopy and use of screen printed electrodes was investigated. Especially the electrochemical approach has shown much promise for sensitive toxin detection for one specific toxin in shellfish and is currently being further developed into a multiplex system. Apart from this, a study is also being performed on the application of a smartphone app (developed by a fellow ESR from QUB who focuses on image analysis and machine learning) for the quantification of results obtained with lateral flow assays (LFA). This work is equally interesting since it potentially opens the doors to a more universal approach for LFA quantification.

In summary, we have obtained interesting results by hyphenating smartphones with biochemical assays for the detection of marine toxins in shellfish. The progress of this work, and the work done by fellow ESRs in the foodsmartphone project is expected to have a substantial impact on the way we screen for food contaminants. More information regarding the progress of this project can be found on http://www.foodsmartphone.eu/ and also on our blogs which are often a fun combination of travel stories, puns and science and I invite anyone interested to check them out on https://foodsmartphone.blog/

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