

Sensors in Research

across disciplines and departments

Inter-Departmental Event

4 April 2017

Duke of Kent Building

Summary Report

Sensors in Research was organised by the HomeSense Team (CRESS & 5GIC) and attended by 34 persons from across the University. It was hard to say in advance how an informal get-together around sensors in research would be received, but the turnout was a pleasant surprise. Those who were in touch beforehand work in all three Faculties, including business, biosciences & medicine, electrical and electronic engineering, psychology, sociology, health sciences, communication systems, computer science, hospitality and tourism management, politics, law, civil and environmental engineering and veterinary medicine. Our email list includes 47 researchers.

The programme was loosely drafted around a few presentations, people introducing themselves and their interests in this area, and then sharing ideas on what to do next:

Inspirations, aims and purposes:

Nigel Gilbert (CRESS, Sociology)

Klaus Moessner (5G Innovation Centre)

Examples of using sensors in research:

Mark Cropley (Psychology)

Nick Palaghias (5G Innovation Centre)

Shujun Li (Surrey Centre for Cyber Security SCCS)

Robert Meadows (Sociology)

Group conversations:

Surrey's current work in this area: issues, concerns, questions (research focus, ethics, legal issues, security)
Future meetings? Funding opportunities?

Nigel Gilbert gave a historical account of new instruments and methods as major inventions in their time, changing the way we observe the world, ask questions and make sense of it. He named the natural sciences, Galileo's telescope and Newtonian physics. He named the survey method that radically changed how we do social research, and he spoke of purposely fitting digital sensors which is revolutionising how we observe human behaviour, collect data about everyday social life, the environment, and much more. These developments are not only calling for new analytic methods such as learning algorithms, but they also engender new research questions.

Klaus Moessner gave an account of network infrastructure issues associated with the Internet of Things (IoT) and 5G networks. Some of the technical complications turn on service provision, network resource scheduling and sharing. He reminded us that networks do not have infinite capacities, although, we acquire a perception of capacity, for example, by testing the transmission of data streams in organised ways. Sensors have a role in this research on network optimisation, but the data the 5G IC sensors can pick up on environmental variables are the basis for the HomeSense collaboration, i.e., to take a technology developed at the 5G IC into the real world of ordinary households and put them to use for social research purposes.

The introductions participants gave of themselves following these opening remarks, conveyed the diversity of scholarly backgrounds and interests in sensors. Researchers in communication systems are using sensors to understand human behaviour, not just to optimise networking protocols. Researchers in sociology are using sensors to aid their studies of ordinary household practices and sleep. Researchers in hospitality and tourism management are looking into automation in hospitality, the use of robots in hotels, placing sensors in hotel rooms to monitor and intercept energy consumption and other environmental variables. They are interested in visitor flows and eye-tracking technology to study customer orientations online. Researchers in health economics are interested in the ethical and health implications of using sensors to evaluate and intervene in health behaviour. Sensors are applied to study consumer behaviour and health behaviour change intervention. Sensors are also of interest in medical research to monitor for example, how interventions like patches and bandages are doing. Researchers in signal processing are using sensors in applications for smart homes, for example, using microphones in control designs. Veterinary researchers fit activity sensors similar to *Fitbit* on dogs and cows. Researchers in cyber security are interested in phones, cameras, trackers and other sensors that are widely in use. They study the security of devices, networks and systems, smart homes and more. They use sensors in forensic research and they rely on humans as sensors. Researchers in psychology use sensing of brain activity to study creativity. They use sensors to study occupational stress, health and well-being, if employee health can be improved using wearable sensing technologies, and how patients can be assisted.

This listing is not at all complete but it ought to give an idea of just how significant sensors are already in the methodological arsenal of many academic disciplines at Surrey, how powerful these technologies are in real-world applications as well as in refiguring the approach to research, to asking questions, and in raising ethical, legal and security concerns. Four examples were presented:

Mark Cropley (Psychology) presented an example of using sensors in research into occupational stress, more specifically, the relationship between work-related ruminations and heart-rate variability. He explained that high heart-rate variability is associated with good heart health, low variability with heart problems. He also explained that people who cannot switch off from work are more likely to suffer heart disease and heart attacks. While there might be an implication of poor dietary choices and other habits detrimental to heart health among those exhibiting high work-related ruminations, Mark explained that this research was more about testing the relationship (and interdependencies) between mental and physical functions. He used sensors to detect heart-rate variability in two groups, those reporting high work-related ruminations and those reporting low ruminations and did establish that higher heart-rate variability is associated with low ruminations and the other way around, low variability with high ruminations. Mark underscored a methodological issue. Sensors generate volumes of data and do not always respond correctly. To adequately address a particular research question, the momentary positioning of a sensor in the situated context of the wearer's body or mental state may matter the most, i.e., to hone in on the desired data.

Nick Palaghias (5G Innovation Centre) presented an example of how engineers seek out autonomic ways to learn about and understand human behaviour. Mobile applications play an important role already in this kind of research and the smart phone is the ideal methodological

device, although, they are still exploring the extent to which mobile phones can be used to study behaviour. Nick took an example of studying social interactions, utilising smart phones carried around in pockets to capture forward-facing orientations and the relative orientations between participants (indicators of trust), for detecting social interaction and the formation of social networks. Technically speaking, the mobile devices are collecting data and running inference engines, applying so-called sensing frameworks. He elaborated an experiment done in an office environment where five persons who did not previously know each other were asked to introduce themselves and interact. The formation of network and the interactions that were captured, were then compared with a trust map based on questioning the participants, with an outcome of roughly 80% accuracy. One problem Nick left us to think about is the stage of development and reliability of this kind of method, for example, what error rate is acceptable in different research scenarios.

Shujun Li (SCCS) spoke about ongoing research on cyber security and emphasised the difference between sensors as tools and sensors as threat. Research at the SCCS centres on security of communications, of privacy and authentication, of hardware and computing more generally. They are involved in forensics, using cyber security applications online to detect acts of crime. They are interdisciplinary, involving human factors researchers to study behaviours in and around IT, IoT and surveillance systems. They also seek to understand better *humans as sensors* and assisted by sensors that can capture what humans do, what humans say they do and think, and so on, which is eventually captured by software, not necessarily by digital sensors. As Shujun explained, we ought to be asking how we know (if at all) who is installing sensors, where they are installed, for what purposes, to whose benefit. There is always a trade-off between privacy and utility in studying, intervening in and changing behaviour. He mentioned that mobile phones are of great interest here because everyone has one, and so are cameras, eye trackers, and all sorts of sensors as tools to study behaviour and to detect various aspects of behavioural (bio)metrics in cyber systems. One of many problems Shujun foregrounded is knowing how networks and communication infrastructures can be expanded securely, and what we mean by the threat scenarios we are working with, for example, IoT security, medical devices security, smart homes, smart city, smart traffic security, and more.

Robert Meadows (Sociology) spoke of what is achieved in bringing sensors into social research settings. His research on sleeping couples some years back used activity monitoring based on gyroscopic variables and acceleration on three axes, to monitor sleep in the natural habitat, as opposed to the laboratory, and to explore this way different phases/patterns of sleep and sleeplessness (restless, restful, awake). Rob explained his interest in sleep as social practice, and one outcome was clear evidence of interdependency in the sleep patterns of couples which (by some misinterpretation) made him the academic who told couples not to sleep together. Rob spoke of the cost of the sensors in his collection (~£1,000), and that it took some wear and tear over the years before he used them to study recovering addicts. What has since transpired is an influx of relatively cheap activity monitors based on the same sensory principles and his current research is looking critically at this new era in which everyone can use sensors followed by a new ethics of sensors in use. For example, people bring their sensor data into the doctor's office, and we now talk about what is happening in sleep or in other daily practices on the basis of how sensors are designed. A key problematic Rob offered us was the rise of *algorithmic authority*, as he put it, and what we can now say about an everyday world full of all sorts of sensors.

At this point in the day, some participants were leaving and did not stay on for group conversations, but these four presentations had already engendered questioning and debate. They flagged up an assortment of interests, utility, usability and problems associated with the use of sensors in research and in real-life settings. The idea was to use the remaining time to cover questions of how a research group could be cultivated across university departments, what funding opportunities might lie ahead, and what future meetings could be organised. It appeared however, that we were all in great need for a '*social*' about sensors in our research, to talk about all sorts of problems and how different expertises are dealing with them. Most prominent here (to the rapporteur) were issues of

legality, ethics, security and public engagement about designing a future full of sensors for all sorts of assistive purposes in people's everyday lives.

Suggestions for future meetings:

1. Sandpit (one or more)

Everyone brings a research idea, and a subset are developed collaboratively. Sandpits will involve consultants from the Research and Enterprise Office.

2. Hosting external and internal speakers using sensors in research

If our ongoing research projects/budgets allow for seminars/lectures, let us be mindful of at least including those on the attached mailing list who have expressed interest. In some instances it might be ideal to advertise openly across all three faculties.

3. Show & Tell

Organise a show & tell event of hardware for this group, an occasion to get together for an afternoon of tinkering and demonstrations.

4. Support groups (one or more)

Organise event(s) to support legal, ethical and security aspects of sensor-based research.

Organise the development of a strategic research agenda for the future of sensors in research at Surrey.

The HomeSense Team would like to thank everyone who came, presented, asked questions and shared ideas. This was a useful and interesting event and it goes without saying, that we would be very happy to hear from any of you again about further meetings, also, if your ongoing research projects and budgets have resources to share that could be put to effective use in helping to cultivate an inclusive research environment centred on sensors and associated technologies.

With best wishes,
The HomeSense Team.