A Mobile Ecosystem for Citizen Social Sensing

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We plan to leverage Digital Footprint Data (DFD) through the development of a proof-of-concept, minimum viable citizen science ecosystem, which enables any individual to perform research that is in the public interest. Our first use case focuses on research related to tracking social interactions. Here, we develop a sensing device which incorporates aspects of group co-ordination, person mobility, citizen surveillance, and lifelogging. Measuring any of the above relies on mobile technologies for out-of-the-lab sensing, allowing researchers to track how specific variables change across different contexts and timeframes. Our plan is to extend the micro:bit (a pocket sized computer) to empower anyone to collect, interpret, understand, and share DFD with user-friendly interfaces and low-code tools. The outcome is wide-scale public engagement with digital footprints, fostering awareness, understanding, and skills for navigating a DFD driven world. It offers valuable opportunities to educate individuals about both the potential applications and the privacy implications of DFD.

I. Introduction / Background

In a world dominated by DFD, citizen-led research can significantly contribute to the public discourse and the responsible use of DFD, impacting policymakers and technologists. However, it is difficult for the public to engage in these conversations without sufficient digital literacy. To understand their DFD, a person needs to grasp basic concepts about what data is, where it comes from, and how it relates to their digital activities.

One pertinent DFD use case is studying the features of social networks and interactions to build up profiles about people and groups. This has far reaching privacy implications as sensitive information can be derived from this data, such as political affiliations, health conditions, or sexual orientation. This can cause harm if exploited by malicious actors or used to discriminate in employment and insurance settings. On the other hand, DFD related to sociability can be used to study wellbeing, group cohesion, and collaboration. By engaging citizen scientists in social interaction research, they can learn about both the benefits and privacy implications of DFD and contribute to conversations about their own digital futures.

Consequently, providing an ecosystem for citizen scientists to engage in social interaction research is the focus of this paper. This will be done without the need to access DFD from corporations. This is because DFD currently operates in a corporatocracy, whereby DFD is typically collected, used, and controlled by organisations for corporate interests. This provides barriers when utilising DFD for public good and educating citizens. Consequently, the design of the ecosystem incorporates values such as the creation of open-source resources, the use of low-cost hardware and the lack of prerequisite technical skills to ensure low barriers to entry.

II. Related Work

MIT's Sociometric Badge was a wearable device that measured social interactions in groups [1]. It contained a microprocessor with infrared, audio, accelerometer, and bluetooth sensors. It captured conversations and physical proximity of people in social situations. However, it was a commercial tool, that required a steep technical learning curve to use, and the associated software is now obsolete. Thus, it can no longer be used in research, and was never well-suited for citizen science studies.

Others have developed a "social mental health sensing" platform using MEM microphones [2]. To preserve privacy, the system extracted audio features automatically without saving raw audio. The inclusion of a microSD card and 2200mAH battery enabled long term data collection. Unlike the Sociometric Badge, proximity sensing between conversing people was not included in this platform. This is likely a result of the wrist-worn design and the emphasis on logging daily activities, as determining proximity would be challenging without others also having a compatible device.

Another consideration is sampling frequency. A device called "EAR" (electronically activated recorder), intermittently records ambient sound bites whilst a participant carries out their daily life [4]. EAR typically records only 5% of someone's day, sampling 30 seconds every 12 minutes. Embedded is a

privacy button which users can turn on if they wish for no recordings to take place during a certain time frame. Over time, it has evolved from a microcassette recorder to a smartphone app. It examines aspects of sociability, such as whether a conversation is happening, if there are any speech overlaps and if there is speech mimicry.

There are limitations with certain data sources when detecting social interactions. For example, when using microphone data, if a device is left in a person's bag it may miss conversations [3]. Also, if the device is close to a TV, it may incorrectly interpret the audio as part of a conversation [3]. This highlights the importance of adopting a multimodal approach when detecting social interactions and examining the validity of data derived from sensors.

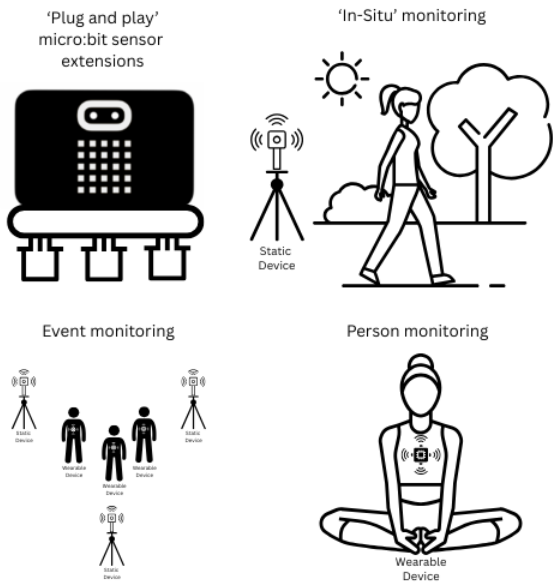
III. Imagined or existing prototype sketches/drawings/photos

We will explore which sensors can be attached to the micro:bit for the purpose of collecting data on social interactions. In particular, we will focus on the MIKROE clickboards [5] and JacDac [6] ecosystems due to a wide range of existing sensors and ease of compatibility. Both support the instant connection of sensors and microprocessors without the need of soldering parts together, allowing the developed ecosystem to remain modular and user friendly.

Some sensors we plan to explore beyond those in the social interaction research noted above are:

- GPS - where interactions are/are not happening.
- Voice/ Face Recognition – How many speakers?
- Time of Flight – 3D social environment mapping
- 24GHz mmWave – Human presence detection

We aim to create two prototype devices: one static device that can be mounted 'in-situ' and one wearable device with a smaller form factor. Both will use the same ecosystem, but will contain different peripherals. The ecosystem will outline any hardware and software needed to attach additional sensors to the micro:bit (e.g. MakeCode extensions), and will be shared open source. Its proposed modularity will allow for customisability, so the research tool is fit-for-purpose for any given project and will only collect data that is needed.



We are not starting technological development from scratch and our partnership with the Micro:bit Educational Foundation and Microsoft Research offers notable advantages. At the heart of the ecosystem, we will leverage the micro:bit - a pocket-sized, user-friendly, reprogrammable computer, which has been adopted globally in classrooms by over 38 million children [7]. Using a block programming platform called Microsoft MakeCode [8], users can customise what data to collect and when, by dragging and dropping blocks together, like jigsaw pieces. Any subsequent collected data is stored only on the portable devices. Then, after data collection, the devices can be connected to a computer, data visualisations viewed, and the data exported as a .csv file using Microsoft MakeCode's Data Viewer. All the above requires no prerequisite technical skills from a citizen researcher. As the underpinning technology is supported by Microsoft and a growing global community of MakeCode and micro:bit users, the ecosystem promises longevity and sustained engagement, standing out from other commercial setups that quickly become obsolete without ongoing funding and technical personnel (e.g. MIT's Sociometric Badge [1]).

IV. Responsible innovation

When exploring add on sensors, we will build a sensor dictionary that 1) describes a sensor, 2) its ethical/security considerations, 3) its capabilities and limitations for citizen science research, and 4) some proposed best practices. The purpose is twofold. It will inform the design of a final list of sensors to incorporate in the ecosystem. It will also help both citizen researchers and ethics committees to review projects using the ecosystem by outlining concerns and potential ways to mitigate these. As a bi-product, this also ensures the ecosystem meets the ethical standards and data security requirements of universities and other public organisations.

The ecosystem will be designed so that its parts can be reused in many studies. In particular the modular design of the ecosystem allows for the swapping in and out of different sensors depending on the project of interest, without having to purchase entirely new kit. This in turn increases the sustainability of the ecosystem, by reducing lab waste. Furthermore, the hardware will be robust to drops, scratches and bumps, and designed with longevity in mind. All of this minimises the environmental impact of the ecosystem.

V. Author bio(s) / experiences

Heather, Richard, and John are working to improve research culture across three domains in a Wellcome Trust-funded project titled "Reimagining Research Practices: Towards a Sustainable, Ethical, and Inclusive Future." The proposed device aims to be the catalyst of this change, offering a tangible example of how the intersection of these three areas can enhance research quality. It will also support our research practices, due to our expertise and work in social psychology, digital ethics and embedded technology for education. Barrie, Liam and Peter are technicians in the Psychology Department. They work to improve research technologies, with expertise in electronics, fabrication, and experimental software/programming. This ecosystem will speed up the development time of experimental set ups by

providing existing infrastructure for connecting different hardware together and logging data.

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VII. Refernces

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