Fashion, Night Clubs, and Connected Things

Thomas Röggla
t.roggla@cwi.nl

David A. Shamma
aymans@acm.org

Pablo Cesar
p.s.cesar@cwi.nl

Centrum Wiskunde & Informatica
Science Park 123, Amsterdam,
Netherlands

Abstract
This article discusses findings that we gathered in an experiment where 900 people attending an exclusive dance event during the *Amsterdam Dance Event* wore Bluetooth-LE enabled wristbands which would perform activity recognition and localisation. The data was then used to drive a live visualisation and control a light and audio system. This way, each party guest wearing one of the wristbands actively contributed to the overall experience with their movement and location patterns. We will discuss this further as part of a case study and try to highlight the privacy implications that we happened upon and offer some points for critical reflection.

Author Keywords
Sensors; cultural experiences; Bluetooth LE; design; activity recognition; shared experiences, ubiquitous computing

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction
As technology starts to seamlessly blend into our daily lives more and more and as chipsets are becoming ever lighter, smaller and more efficient, they start to become an integral part of our most private personal space in the form

Figure 1: One of the wristbands that each guest received as part of their invitation, which would measure their activity level throughout the event. (CC BY Ayman on Flickr)

of wearables. Such battery-powered wearable devices often gather data about their user's physical state from a series of sensors and also tend to employ wireless technologies such as Bluetooth to communicate this data to a central hub with more processing power or storage capability. This of course, raises a few privacy concerns about the proper use and storage of the data, as well as identifiability of specific users when an individual's data is used as part of an aggregate measure. This is especially important when dealing with devices which can be used for getting a user's location or track their behaviour.

As a case study, we would like to discuss an experiment that we ran in collaboration with the Dutch fashion designer ByBorre in the context of a two-day event during the Amsterdam Dance Event held in Amsterdam in October 2016. In this, we created custom-designed wristbands, fitted with Bluetooth-LE enabled circuit boards. The boards collect information about the wearer's movement patterns, temperature and approximate location in relation to our base stations. These wristbands were given to the 900 attendants of an exclusive clubbing event and the data would drive a live visualisation and control a light and sound installation.

More specifically, what we want to discuss in this are the privacy concerns raised by the use of wearables as they could be employed to track the user's location within the venue as well as their activity. Moreover, we want to highlight the way in which we used the technology to set up and create a unique social environment for users to gather and together create an enhanced clubbing experience.

Background

Club culture has always been about getting together and enjoying multisensory experiences with other people. These experiences are curated by the event organizers [1] and each individual average club goer typically has little impact on the experience as a whole. Our goal with this experiment was it to find out how we could make the club itself be able react to the amount of activity within it by means of technology and how to integrate this technology with the environment as seamlessly and unobtrusive as possible.

This system came into existence as part of a collaboration on wearable technology with *ByBorre*[1], a Dutch fashion designer. For a two-day club-event within the context of the annual *Amsterdam Dance Event*[2] held in October in Amsterdam, we wanted to explore what the club of the future might look like. The core idea of this event was it to find ways to learn about the guests' behaviour and try to communicate with the environment. The goal being to bring people together and design an experience which would stimulate all the senses at once: Specially created dinner menus, drinks and perfumes, an adaptive sound system and light show with technology playing the role of connecting all the senses into an all-encompassing experience.

Over the course of two days, a total of 900 people were invited to attend the experience and each one of them would receive one of the sensors after they had registered at the entrance with their name and specified their favourite drink. With this, users also gave consent that their movement data and location would be collected and that their name and favourite drink may be featured on a big screen as part of the real-time visualisation. Moreover, users also agreed that they may be filmed during the course of the evening.

Discussion

During the two days that the event was taking place, we collected a total of about 40 million unique data points. In-

[1] http://www.byborre.com
[2] https://www.amsterdam-dance-event.nl

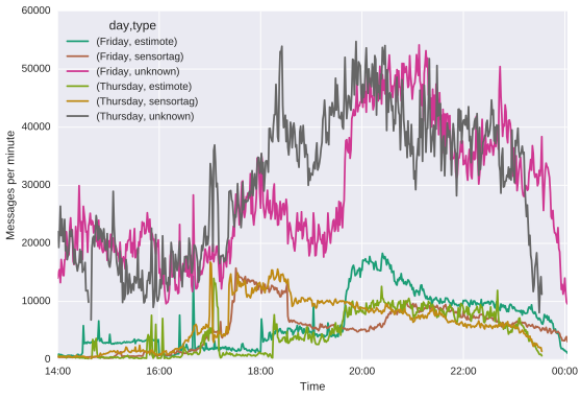

Figure 2: Number of packets from the wristbands and from other, unknown devices (purple and gray) for each point in time during the two days

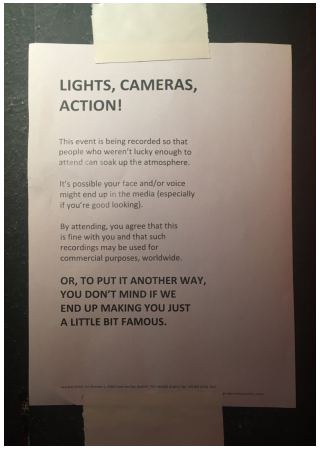

Figure 3: Notice to guests that they may be filmed during the course of the evening

terestingly, only roughly 13 million of which were packets transmitted by our wristbands (see Figure 2). All other traffic stemmed from other Bluetooth devices. Presumably phones in people's pockets, little trackers such as smart key rings or bigger, stationary devices such as laptops or printers.

What is interesting here is that even though we had the user's consent to gather the data from their wristbands, purely by accident the system also captured all other Bluetooth traffic from devices, which openly advertised themselves. In order to drive the interactive part of the event experience, the packets sent out by the wristbands, while being standard Bluetooth-LE packets, were carefully crafted and needed be parsed by our system to extract activity data. Consequently, all the other packets contain data of unknown shape. However, with little amount of scripting, one could also parse these packets and if nothing else extract a UUID (*Universally Unique Identifier*) from them and get a coarse location for the owner of the device (provided the user carries it with them). The accuracy should then only be slightly worse than the location data provided by our wristband, since we also use the UUID field for localisation. The only difference being that our wristbands likely have a shorter advertising interval, which makes accurate location tracking easier. One could argue however, that localisation is the whole point of Bluetooth LE beacons like those detected by our system [3, 2] and users of these are aware of this. What falls into this category and what we think users are actually less aware of of are mobile phones with Bluetooth antenna turned on.

The data gathered from the wristbands on the other hand was parsed by our system and subsequently analysed in real time. We trained a convolutional neural network in our office by performing activities that we thought people might be doing during the event, such as dancing, standing or walking. During the event we were then able to get a fairly decent estimate of how active people were.

Pairing this with the localisation functionality of the system, one can gather a good estimate of what people are doing and coarsely where they are located. Interesting to note here is that while we only trained the network to recognise three very specific activities, it should not be that difficult to train the network to recognise many more different activities, thus possibly even increasing the overall accuracy of the algorithm. This however, may obviously not be in the user's best interest, but could potentially actually be useful in healthcare applications. Different from the rather serious privacy concern raised by open broadcast of UUIDs being used for localisation, this concern only affects devices which actually broadcast acceleration values from a gyroscope as part of their advertisement packets.

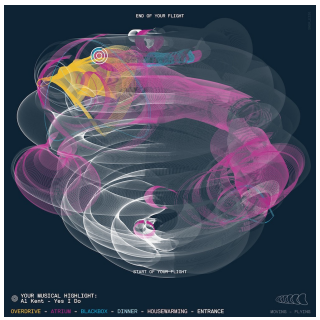

Figure 4: Post-event graphic which was sent to each guest, representing a summary of their experience.

During the event we took utmost care that the privacy of the guests be protected and made sure every participant was aware of what was going to happen during the evening. In the welcome area users could have their name, e-mail address and their favourite drink registered to their wristband. Their drink choice would then be displayed on a display visible to the bartender, should the wearer of the wristband approach the bar counter.

While we did store the sensor data itself in a database for later processing, no names of guests were stored in this database, only the UUIDs of the Bluetooth beacons. The association of UUID and names and e-mail addresses were stored separately. After the event, UUIDs were matched to guest names and e-mail addresses to compile a graphic as in Figure 4 representing this individual's experience during the event, and their favourite song identified by the highest point of their activity level. These graphics were then sent to the special guests as a high-quality print alongside a custom-knit scarf. All other attendees received their individual graphic via e-mail a few days after the event. It is easy to imagine that this data can also be used to identify users which frequently stood close together or showed a similar activity pattern during the same songs, thus adding another social component and a novel way to meet new people to the experience.

Conclusion

In conclusion, in this paper we outlined an event in which a large number of people were using Bluetooth LE-enabled wristbands to take part in a social clubbing experience enhanced by technology. We discussed the privacy implications that we encountered during the development and the setup of the system at the venue and offered some initial reflections upon them. We also briefly touched on how this technology can be used to enhance social and group interaction or create novel ways for people to interact with their environment.

All summed up, we believe it is important to respect users' privacy at all costs, especially when it comes to devices which may reveal details of a user's physiology or their current state of being, e.g. heart rate or level of activity or may cause uninvited invasion of their personal space. Thus we think it is of great importance that the user shall always be made aware which kind of data their wearable devices are capable of generating and where and how they are being used.

References

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