Participatory Sensing for Urban Communities

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Abstract

Social Tapestries views participatory sensing as the principal supporting technology to enable grass-roots groups and communities to track and act on information about their local environment. In this article, we report on our experiences with a low-cost open source hardware and software platform, which we specifically developed for this task. We describe how we employed this platform to support community workshops and art, and highlight the lessons learnt through our involvement with urban communities in London, UK. We conclude by identifying the main ingredients for the development of a successful strategy for the use of this and other similar platforms in supporting environmental sustainability through sustainable communities.

I. Introduction

Public authoring is the mapping and sharing of local knowledge using pervasive computing technology to create and support relationships beyond established social and cultural boundaries and the development of new practices around place, identity and community. Social Tapestries (ST) is a programme of research into the potential costs and benefits of public authoring to communities and individuals [1, 5]. Within ST, several projects have focused specifically on how public authoring can support grassroots participatory sensing activities with a view to allow local urban communities to take action towards environmental sustainability. Here, we present three such projects, namely Feral Robotic Public Authoring, Snout and Everyday Archaeology, which explore complementary ways to achieve this aim. All projects share a commitment to the principal premise of ST that is, to contribute to an alternative experience commons where people are presented with the opportunity to be agents, actors and authors. They also make use the same open-source hardware and software participatory-sensing platform, which we specifically developed to support these activities. We describe the development of the platform in parallel to our discussion of our developing understanding of public authoring in this context.

II. Public Participation and Social Tapestries

Public authoring takes the view that true daily life is richer and more complex than consumption of services, products and media, relying as much on social networks, personal experiences and chance interactions and connections. Pervasive computing applications should attempt to reflect this richness and complexity. At the core of such diverse everyday activities lies social knowledge, a term used in ST to refer to the passing communications that are the glue of society and communities: the everyday and essential sharing of information, stories, knowledge and memories with friends, family, neighbours and strangers.

The practice of public authoring can offer opportunities to individuals and groups to intervene in situations that have previously been tightly controlled. For example, in the ST Eyes on the Street project, residents of the Havelock Estate in Ealing, London, are engaged in public authoring with a view to employ local knowledge to support the operation of a tenant organisation that aims to take over the management of their estate. In this case, we have found that public authoring may provide insights not otherwise available by creating a record of living that far exceeds what is possible through centralized estate-management services. Such activities should not necessarily be seen as threats to established authoritative sources of knowledge but rather as people's desire to participate.

This desire for participation in public life stemming from the grassroots is particularly attractive to ST. As a result, following on Eyes on the Street and a subsequent project with St Marks Housing Cooperative in West London, it became evident that an investigation was required into how participation by local communities in data collection through sensing in their immediate environment, can enable them to become actively involved in promoting sustainable environmental practices. Note that he concept of participatory sensing has been used elsewhere as a model for sensor networks [2]. In our work, we use the term giving emphasis on its social, rather that its technological meaning.

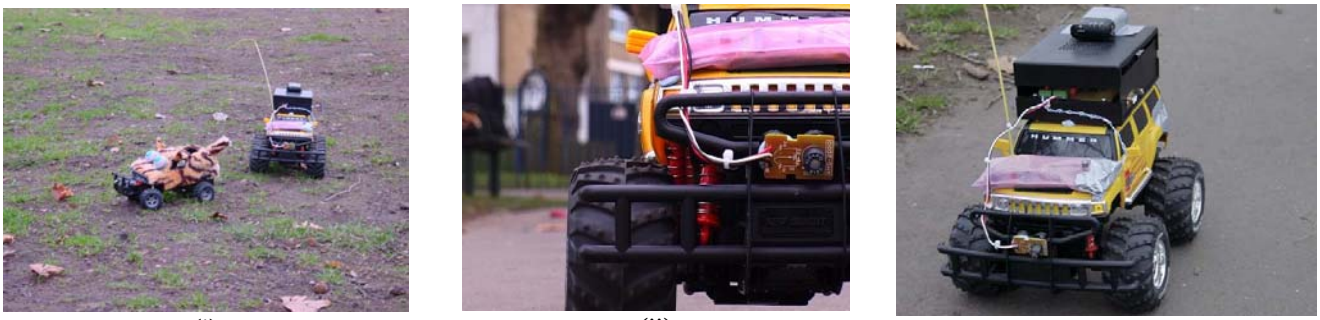
Many of the explorations within Social Tapestries are supported by the Urban Tapestries software platform [1], which has been specifically designed to enable public authoring. In UT, users as authors go about their everyday activities as they usually would, but whenever they wish to add new content they do so using their mobile phone. This task is facilitated by the UT client that allows them to annotate a place with media including text, sound, images or video. Authors can link such pockets of content together into threads with a specific theme. Threads and pockets published on UT weave together into an information tapestry overlaid on the urban structure. Users as consumers can search for, browse and access content published by other participants, also using the UT client application on their mobile phone. For our investigation of participatory sensing for environmental sustainability we extended UT with new information harvesting, management and visualization capabilities, and developed a new client platform specifically for sensing.

III. PROTOTYPE ONE: ROBOTIC FERAL PUBLIC AUTHORING

Natalie Jeremijenko in her Feral Robotic Dogs project proposed ways to reconfigure toy robot-pets that became popular in the early 2000s, with a variety of low-cost chemical sensors that can sense, record and in some cases trace environmental pollution [3]. The aim of doing so is to create an opportunity for public discourse by providing the tools to construct open-ended interpretations of the evidence at hand. Such experiments open up new possibilities for exploring local environments to detect the presence of many kinds of emissions and map them using the UT toolset. A large variety of low-cost sensors are readily available including carbon monoxide and dioxide, solvent vapours, electro-magnetic emissions (for example, those coming from mobile phone masts, electricity generators and so forth), and light and noise pollution. Adding the sensor readings to UT makes evident the relationships between the physical environment and communal places. It enables people to feel they can learn about their environment and have the evidence to do something about it. By linking robot building and mapping workshops into traditional community events for example, fetes and local festivals, a wide range of people can become involved in gathering and sharing knowledge about their environment.

The Feral Robotic Public Authoring (RFPA) project takes exactly this point of view. To achieve this goal, we augmented the initial Feral Dog design with wireless networking, location and advanced environmental sensing capability, and linking it to the internet and the UT platform. Our priority is to develop a low-cost platform that can be built easily out of widely available commodity components and with very limited technological resources and skills. Out intention is that all software and designs would become available on the web for everyone to freely re-use, build or modify.

Our design implemented Gumstix, an open-source small and inexpensive computer running the Linux operating system. We extended the core design with cooling and power management sub-systems, which were critical for the consistent operation of the device, an external GPS receiver connected over Bluetooth, and customised its Analog-to-Digital Converter for use with a radio controlled car. And of course, we build in sensing capability using a variety of inexpensive sensors typically used in fire and carbon monoxide alarms, and home and car ventilation systems [6]. The full designs including bill of materials, assembly instructions for the enclosure and mounting, Gerber files for production of the printed circuit board, sensor calibration procedure and the software repository are available online via http://socialtapestries.net/feralrobots/



(i) (ii) (iii)

Fig. 1 (i.) The original Feral Robot (left) followed by the networked and location aware version developed for RFPA . (ii.) A close-up of the sensor modules at the front of the RFPA remotely controlled car. (iii.) The complete RFPA design with sensors, GPS, processing and networking unit assembled and operational during the London Fields trial.

IV. Community mapping workshops with RFPA

London Fields is a popular park in Hackney, East London, and an important resource for local communities in a built up area. The park is used by local people for a variety of activities: as a space to play and socialise in, for championship cricket and football games, dog walking, and as a popular walking and cycle route. In its relatively long history, London Fields and the area around it have adapted to accommodate the differing needs of the surrounding population.

Air quality in London is monitored on an hourly basis by the London Air Quality Network (LAQN), through an extensive network of observation stations in fixed locations across its Boroughs. LAQN is an important resource but considering that Hackney itself only has one station for the entire borough there is clearly ample opportunity to examine air quality at a more localized resolution. Yet, the collection of this kind of data by non-experts is not necessarily useful, and some would argue that such activities would lack scientific rigour and would thus not be comprehensive or authoritative. Data collected through the RFPA devices can provide a snapshot of pollution in a specific place at a specific time and is not designed to replace or replicate LAQN. Instead, it aims to trigger an open dialogue about how pollutant sensing technology placed at a grassroots level can function and its potential applications for community action and interaction.

Community pollution mapping workshops were organised in collaboration with SPACE Media Arts, a local arts and education charity, which allowed us to access their local community networks. We found is that grassroots pollution mapping is not necessarily about producing accurate scientific data. Instead, it is a tool to highlight concerns, to map knowledge, to enable involvement in the data collection process thus reinforcing perceptions of the area, and provide the focus for communities to come together. As one workshop participant remarked: “we have come to accept air pollution because we are culturally habituated in it -- that’s got to change and if this doesn’t happen at a grassroots level with tools that we can handle ourselves, governments will not shift because they are in with the big corporations.”

Nevertheless, not all workshop participants took the same view, and others expressed the opinion that ordinary people do not have any control over their local environment. For example, vehicle emissions are the major cause of air pollutants in London and in many cases they are due to pass-through traffic, about which local people have little power to intervene. This point of view can lead to passivity and resigned acceptance of the situation as expressed by one participant who said that “the more I think about it, the less I want to have any access to any data about air pollution in my locality, or information about this park. I don’t have a garden, I have a kid, and I’ll always use it.”

In addition to views of the here and now, community mapping workshops prompted participants to reminisce about the history of the Fields, highlighting past activities in the area which could have left an environmental footprint. This type of local knowledge is invaluable and can help locate pollution hotspots that would otherwise

require an extensive survey. An expert coming from the outside would not have access to this knowledge without considerable resources for research.

A second series of RFPA workshops was run in collaboration with the Jenny Hammond School in Waltham Forest, also in East London. In July 2006, a week-long workshop with 30 students aged between nine and 10 years old involved several activities including extensive use of the RFPA platform to gather evidence about the world around them. These activities were linked to specific modules within the Key Stage 2 national curriculum, in particular transport, architecture and climate, and allowed the students to gradually develop associations and connections between these areas and how they all fit within the environmental sustainability agenda.

V. Developing the platform

RFPA allowed us to experiment with participatory sensing and gain experience in what works both from a technical and a community perspective:

Embedded interaction. The RFPA cars, although appealing (especially to younger and male users) provided limited opportunities for interaction beside the remote control. While running, they collect data silently and relay it to the UT server for further processing without any perceptible indication that this has occurred. Their operators are only able to tell if the different system components function correctly due to several LED indicators, but are unable to get feedback about the current detected levels of air pollution for example.

Media scavenging. UT was designed as a stand-alone software system well before the emergence of Web 2.0 and due to our resource limitations in supporting the software development process over an extended period of time, it lacked features that users identified as important. As a result, we adopted an approach based on scavenging functionality that could be mashed up with UT to provide the missing features, such as social networking as implemented by Ning.com.

Everyday archaeology. Since we formulated the participatory sensing approach, we have seen its emphasis shift from pollution mapping to what we now describe as everyday archaeology. In doing this, we shifted our focus away from the specifics of data collection and focus on the process of excavating information about the local environment and its relationship to communities.

VI. Prototype Two: Snout

Our next investigation of participatory sensing was through the development of a community art project in partnership with the International Institute of Visual Arts (inIVA). We consider community art to be an appropriate approach for community development because it reflects the main principles of participatory sensing: it is rooted in a shared sense of place, tradition and spirit; it is as much about the process of involving people in the making of the work as the finished object itself; and it is situated in public, accessible and resonant places, geared to a specific audience and a specific time. It seems that this point of view can offer new opportunities for the development of a community around environmental sustainability by providing both the practical and the conceptual framework required. Indeed, community art and grassroots activism are about knowledge and building social capital in the form of the grassroots networks that enable people to move information and ideas to a broader audience and make change happen.

The specific performance developed for Snout explored relationships between the body, community and the environment. The concept of the performance was developed around the Carnival with two typical costumes build and instrumented with participatory sensing capabilities. The reason for this choice was that carnival is a time of suspension of the normal activities of everyday life – a time when social hierarchies are inverted and when everyone is equal. This view is highly compatible with the Snout objective to invite participation. The characters selected were Mr Punch and the Plague Doctor (Figure 2).

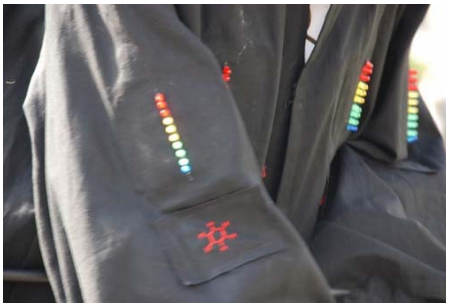
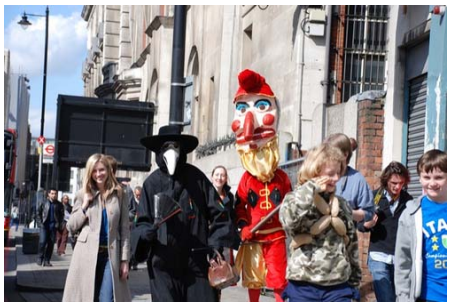



Fig. 2 Snapshots from the Snout performance.

VII. Lessons learnt through Snout

Snout enabled us to take further our ideas about participatory sensing, especially in identifying effective ways to facilitate the development of grassroots communities.

Inspiration rather than prescription. We initially considered our open-source platform as the main ingredient of any community project around participatory sensing. However, it turned out that the complexity of the hardware construction aspect in particular caused significant difficulties to the general user, despite the fact that is considerably more accessible than any other alternative available.

Multiple ways to access information. A single web interface as the only means to interact with the captured data appeared to be far too limiting and unable to address the needs and concerns of all the users involved. Instead, it was necessary to provide alternatives that could address the specifics of the situation in which access to the data is required as well as the skills of the particular user.

Access also via low-tech materials. Within the context of multiple modalities of access to the captured data, it is especially important to note approaches that do not employing information or communication technology. For example, fabrication of physical artefacts can be particularly effective in interpreting and communicating the data. We specifically experimented with Story Cube and Diffusion electronic notebooks.

VIII. Conclusions

We believe that this work has demonstrated that it is possible, using cheap electronics and publicly accessible mapping software, to create an engaging form of environmental sensing at a micro-local level. Although our prototypes require a level of electronics and engineering skill above that of most people, they are well within the realm of the hobbyist and we believe it is possible to further reduce its complexity as new platforms and products become more readily available and cheaper. We also hope that we have shown how artists and engineers can collaborate to bridge the gulf between pragmatic technical solutions to social problems and the cultural interventions that artists bring to their communities.

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