Voices in the Noise: Crowdsourcing Public Opinion using Urban Pervasive Technologies

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Abstract

The civic potential of pervasive computing remains a relatively unexplored agenda. In our vision of communities and cities enriched with pervasive computing, citizens can leverage and appropriate the new technology and interfaces for their own purposes, and at the same time be empowered to be heard through the use of such technology. Here we report on our progress in creating public human interfaces for interacting with cities. We tackle an important societal issue, civic engagement, and present two longitudinal large-scale experiments for evaluating public interactive crowdsourcing technologies that promote civic engagement. The field trials we report involve public displays, together with mobile phones, Internet technologies, and social networking services to essentially crowdsource public opinion about contextually relevant and topical issues.

Introduction

Should pervasive technologies empower citizens to interact with their city and participate in its decision-making processes, and if so, how exactly? In our vision, citizens may leverage and appropriate the pervasive infrastructure for their own purposes and are empowered to consciously participate in forming the public opinion about topical local issues through the use of such technologies. Essentially, the public opinion can be formed using crowdsourcing mechanisms available to all. Here we report on our progress towards creating public interfaces for the interaction between citizens and city officials. Specifically we tackle an important societal issue, civic engagement, and present longitudinal large-scale experiments for evaluating interactive public technologies promoting civic engagement.

The civic potential of pervasive computing technologies deployed in current and future cities remains relatively unexplored, despite its increasing popularity within academic and urban planning communities. Different disciplines derive different visions of how this potential may be realized. Caragliu, Bo and Nijkamp (2009) note that in some cases the addition of pervasive computational resources in our urban environments highlights the growing importance of information & communication technologies (ICTs) in social & environmental capital of cities. Ishida (2000), on the other hand, argues it is a step towards a more technology-laden connected community that utilizes high-speed networks, flexible service-oriented computing infrastructure and new innovative services to provide added value to citizens and visitors alike.

In our work, we take the stance that pervasive computing technologies in cities are built primarily for human inhabitants, and therefore the humans and their contributions are the focus of our interest. In particular, our overarching goal is to develop a systematic understanding of how human inhabitants can -- or tend to -- interact with their everyday surroundings to provide value to the entire community, and in what ways will they appropriate the provided technology and service infrastructure. We recognize that this approach is in contrast to the perhaps more popular "engineering" approach, where intelligent infrastructure quietly churns away and collects data while inhabitants go about their everyday lives without a hassle. We see both approaches as necessary for progress.

A fundamental step in our work is to understand the possibilities afforded by the addition of new technological constructs built as integral and permanent additions to shared urban spaces. This article explores the potential role of pervasive technologies, namely public displays, in engaging the citizens to take part in local decision-making processes through crowdsourcing the public opinion.

Civic engagement with public displays

We present two longitudinal case studies conducted using interactive public displays in the northern city of Oulu, Finland. Hosio et al. (2012) describe the displays in question as a vivid visual element in the city, enabling direct dissemination of information, and that constitute a novel and appealing channel for dialogue and engagement with their users. The displays have been deployed for years, since 2009, and citizens and visitors can freely use them in a true 24/7 fashion. The 57" touch-capable displays are also multipurpose: at any given time they provide access to a variety of different applications. This is unlike several related deployments of public displays that feature a single application or service, usually for commercial or short-lived purposes. Multipurpose displays offer a variety of services to their users

including directory services, news and weather, image and video galleries, quizzes and polls, and games. During the studies, 10-16 functional screens were available for use at all times, both outdoors and indoors. Authentic in-situ depictions of the displays can be seen in Figure 1.

Figure 1. Public interactive displays in Oulu: two double-sided outdoor displays on the same streets that were under renovation and one single-sided indoor display in a local swimming hall.

The deployment forms the world's largest deployment solely built for research purposes, giving researchers a unique opportunity to experiment in a realistic testbed with thousands of un-coached users. For the studies presented here we developed two "civic" themed crowdsourcing applications. To keep the application deployments as authentic insertions to the already existing city fabric, our applications were not given any particular priority on the screens. They were simply deployed as one service among all the others on the displays' application directories. More details on the directory mechanism used on our displays can be found in Ojala et al. (2012). The displays have a fairly steady user base; During the deployment months, the total application launches on all displays was approximately 9000 per month, and particularly games have always been the most popular group of applications on our displays in the past. For an in-depth discussion about our infrastructure, its typical use, and social practices around the displays, we again refer the reader to the study by Ojala et al. (2012).

Rotuaari Renovation

The backdrop for the first case study is a large-scale renovation project that was executed at the very heart of Oulu. The project was an incremental effort to make the main pedestrian streets of downtown Oulu more pleasant through a complete overhaul and modernization of the streets. This included replacing the pavement and all street furniture, such as benches and light poles. Also an under-pavement heating system to keep the streets snow and ice free during the winter months was built. This project posed a major disruption to everyday life in our city center, as can be observed in Figure 2 (right).

Figure 2. Left: a conceptual image of one of the new streets (used with permission from Oulu Technical Centre). Right: a photo of the ongoing renovation.

The local officials managing the renovation project were the Technical Centre (TC), who typically use both print and online media to disseminate information about their ongoing activities. At the time their website featured feedback forms, but according to the TC these were not used at all by citizens. Local business owners frequently called or emailed the TC to discuss practical issues such as pedestrian flows to their stores. However, citizens typically did not

voice their opinions or concerns about the renovation to the officials at all. For this reason, the TC wanted to explore the potential of pervasive technology to address both the need for information dissemination and collection of feedback from citizens.

Our work towards enhancing civic engagement in this context consisted of designing a prototype system to distribute information about the renovation project and provide citizens with an easy-to-use feedback channel on the public displays. More specifically, our goal was to evaluate different mechanisms for citizens to provide feedback through the system. We adopted an iterative development cycle whereby the feedback application performance was assessed in terms of the quantity and quality of collected feedback at certain intervals. The analysis then led us to design alterations for the next deployment period. The feedback mechanisms we wanted to explore were mostly focused on text-based feedback.

We ended up deploying 4 incremental prototypes (P1-P4) over a period of two years. P1 was tested for three months during the summer 2011, which was the first summer that the renovation took place. Due to its high perceived value to the TC, we were able to continue the collaboration during the next phase of the renovation as well. Prototypes 2-4 were each deployed sequentially for one month during summer 2012 -- the second phase of the renovation. During the time between these periods the application was decommissioned from the displays, because the renovation only took place during summer months, and did not disturb the daily life in downtown during the time between. When launched on the multipurpose displays, the feedback interfaces shown in Figure 3 occupied the right half of the 57" screens (Figure 1). The purpose of each iteration was to collect empirical data on civic engagement and to generate recommendations for the next iteration of the prototype. Next we briefly describe the prototypes and the response they received.

Figure 3. The feedback interfaces of Rotuaari Renovation application. From left: P1, P2, P3, and P4.

Prototype 1: Situated feedback
The initial prototype (P1, Figure 3) enabled citizens to use the public displays to provide open-ended text feedback on the renovation project. We based our design on our earlier experience from other applications on the displays that successfully incorporated on-screen virtual keyboards for typing, as presented in the studies by Hosio et al. (2012) and Goncalves et al. (2014). The feedback messages collected by the displays were automatically sent to the TC without moderation.

P1 was launched 1406 times, and 35 feedback messages were dispatched to the TC. Two researchers categorized the feedback into "relevant" and "not relevant" messages, depending on whether they offer feedback of the renovation or consist of something else. In total 8 of the 35 items were found "relevant". The relatively high number of irrelevant messages (77.1%) suggested that the feedback collected by the prototype had high noise. Here, we define noise as messages that are not related to the renovation project.

Despite this, an interview with the TC revealed that they were, in fact, very satisfied with the results: for them, P1 was an original and novel channel that was perceived beneficial by citizens. It served as a nice addition to their public image as an innovative and technically advanced organization. Interviews with citizens during the final weeks of P1 deployment revealed that indeed it was seen as one of the most useful and interesting applications deployed on the displays at the time, thanks especially to its high relevance to a local and topical issue. The feedback channel was new to citizens and the idea was received positively, even if the prototype itself did not see as heavy usage as we would have expected. An issue that was frequently noted in the interviews was how difficult the virtual keyboard is to use: it is physically cumbersome, or even "painful", and users demanded more familiar input mechanisms such as using their personal computers and smartphones.

Prototype 2: Situated polling and off-screen feedback
The second prototype (P2, Figure 3) was used to evaluate the effect of providing multiple feedback channels utilizing both the public displays as well as personal mobile devices carried by the citizens. As requested in the previous

interviews, the feedback mechanism on the displays was simplified by removing the on-screen keyboard, and we also added an emoticon-like interface where "smiley faces" to rank personal agreement on two statements defined by the TC:

- Statement 1: *"The large renovation project is topical and necessary for Oulu!"*
- Statement 2: *"The City officials are informing citizens sufficiently about the renovation project!"*

The smileys were captioned using standard 5-point Likert-scale statements from "strongly disagree" to "strongly agree", from left to right. Citizens had to rate both statements and touch a "send button" to register their ratings. The displays encouraged citizens this time to submit more detailed feedback through their personal mobile devices using either text messages (SMS), email, or by sending a message with a certain hashtag to Twitter. SMS and Twitter have been used successfully in conjunction with public displays for feedback before, e.g. in studies by Ananny and Strohecker (2009) or Munson, Rosengren and Resnick (2011), and several participants interviewed about the previous prototype had suggested using something quicker and more effortless than virtual keyboard on the public display.

During the 1-month deployment of P2 it was launched 381 times, disappointingly leading to zero feedback via email, SMS, or Twitter. A total of 20 smiley submissions were made with an average rating of 3.8 (SD: 1.5) and 3.4 (SD: 1.6) for statements 1 and 2, respectively. Interviews with citizens revealed that smileys were preferred to the text based feedback mechanisms. Interviewees claimed that email would be their favorite choice, but also claimed that leaving feedback later, e.g. at home and out of context, was seen as very unlikely. Ironically, the majority of respondents expressed the need for a virtual keyboard because they felt it would be the most straightforward way to submit feedback instantly. In summary, we found that citizens were reluctant to devote effort to use any of the three offered text based feedback mechanisms, all of which required the use of personal devices. The interviews highlighted, once more, the need for effortless, in-situ feedback mechanisms.

Prototype 3: Real-time stream with off-screen feedback

In this prototype (P3, Figure 3) we attempted to test a motivational approach to increase the use of the smartphone-based feedback mechanisms. For this reason we added a "stream" of the ten latest messages received through all of the text-based channels (SMS, email, Twitter) to the interface to allow for discussions to take place. This is a practice suggested for enhancing communication between community members on public displays by Redhead and Brereton (2006). We hypothesized this would motivate feedback submission by letting users observe others' messages, which in turn enhances sense of community, a motivator for participation in urban settings, as also discussed by Chavis and Watersman (1990). The stream of messages on the public displays was moderated by the researchers to remove offending and irrelevant comments.

During the 1-month deployment of P3, the application was launched 444 times, resulting in 6 text based feedback messages, all via SMS, and 46 smiley responses. Similar to the data from P1, text messages were categorized into "relevant" and "not relevant" by two researchers, and all 6 were labeled unanimously relevant. The average agreement ratings given by the emoticon-like on-screen mechanism were 4.4 (SD: 1.2) and 4.3 (SD: 1.1) for each statement. Overall, we observed that the introduction of the message stream clearly encouraged users to leave textual feedback and use the smiley mechanism more.

Prototype 4: Real-time stream with situated feedback

In the final prototype (P4, Figure 3) we removed the smiley mechanism because we felt it was limited in richness of feedback. We also removed the SMS/email/Twitter channels and instead deployed the virtual keyboard mechanism from P1. This time, however, we complemented it with the messages stream from P3, as we anticipated it would enhance both participation and quality if used in conjunction with the virtual keyboard.

During the 1-month deployment P4 launched 433 times, and we received 40 feedback messages originating from the virtual keyboard. Two researchers again categorized the new messages into "relevant" and "not relevant", resulting in 13 relevant comments and 27 irrelevant ones (unanimously). Thus, the percentage of noise was approximately the same as in P1: 67.5%.

Aftermath

To summarize the statistics, the application was launched 2664 times in total. This resulted in 81 textual feedback items (27 relevant) and 66 smiley rankings. The final interview with the TC revealed that they were still satisfied with the positive exposure they were getting through our deployments, and that the prototypes were valued especially in building public relations and the image of their activities in general. The TC also regarded the grid of public displays as a promising medium to better connect with citizens, keeping in mind the fact that their previous channels had resulted in

practically no feedback from citizens at all. Our deployments were the sole channel citizens used to voice out their opinions and feedback to the TC about the renovation project.

Ubinion

The second discussed deployment on the display grid, Ubinion, was designed to allow users to give feedback to the local authorities and to allow further discussions about municipal issues using a combination of public displays and social networking services (Facebook). The first series of case studies of the service were conducted in semi-public environments: local school during breaks, a sports fair, and university open days. The three deployments were regarded highly successful in collecting feedback from and reaching out to a vast number of otherwise unreachable local residents. The setup and findings from the first case studies are reported in detail by Hosio et al. (2012). The design choices were made in collaboration with the authorities and with emphasis especially on their shortcoming in their existing communication practices. No changes to the design or user interfaces of the service were made to the six-month long (181 days) field trial presented here. The original design requirements for the system were:

1) Exploit public displays' attractiveness: Peltonen et al. (2008) note that the use of public displays is social by nature, and Hosio et al. (2010) suggest that supporting sociality may increase the adoption of public display applications. They also contribute to a "cutting-edge" image that can attract users. Furthermore, the "honeypot" effect, described by Brignull and Rogers (2003), often leads to increased exposure of a service and thus its use.

2) Design for playfulness: Peltonen et al. (2008) as well as Brignull and Rogers (2003) note that interactions and interfaces on public displays need to be simple and effortless. Previous research by Schönböck et al. (2008) has shown that the 'mirror' metaphoris an efficient way of playfully enticing users to approach a display, and become active participants. Also, Hosio et al. (2012) has shown that enabling groups of users to create and interact together using a large public display is fun and social, thus lowering the barrier of interacting with a public display. Previous research by Kukka et al. (2012) has also shown that while users tend not to perceive playful applications as useful or important prior to using such displays, data collected from actual longitudinal studies shows that the opposite is in fact the case.

3) Extend the interaction through social media: Social media has rapidly become one of the de facto tools for communities to discuss topical issues. The local authorities already had a presence in the most important social networking services, and utilizing them was seen as a highly potential means to connect better with citizens. In addition, social media services can ease content creation, storing, and delivery, all key challenges in public pervasive systems, as identified by Storz et al. (2006).

The Service Features

Ubinion allowed users to take a snapshot using a camera embedded in a large public display, add a caption, and submit the photographs to the authorities. The submitted photos could not be viewed on the public display itself. The service operated in four phases (Figure 4). Users were able to browse between the phases by touching large buttons in the lower part of the screen. First, users were shown general usage instructions and info on how the service functions. This screen introduced a topic on what to give feedback about. In this trial also the topic was kept the same as it was in the earlier study by Hosio et al. (2012)]: "what is wrong in Oulu, what could be developed in Oulu?" The second screen presented imaginary examples on what kind of photos the service produces. These were not user-generated photos, but were created by researchers and authorities when designing the service. Then, users could take a snapshot (after a 10 second countdown) using a camera embedded in the top of the display. This photo could be retaken as many times as necessary. Finally, the caption, or a thought, was typed into a "speech bubble" or a "protest sign" embedded in the picture using a virtual on-screen keyboard. When users clicked the submit button, the picture and caption were submitted and added to a public photo album in a dedicated Facebook page. The page was then moderated and frequented by the City officials, and used for further civic discussions and responding to the given feedback.

Figure 4. The screens of Ubinion application. From left: initial instruction screen, example opinions and feedback, webcam image and choice between "speech bubble" or "protest sign" as the augmenting element, and a screen with virtual keyboard to enter text in the chosen graphical element and a submit button.

Ubinion usage statistics

During the field trial, the service was launched 1582 times (averaging 8.8 launches per day), resulting in 425 unique photos submitted to the online gallery of the service. Thus, 27% of the launches led to a photo submission. The daily service use and the amount of submitted photographs varied strongly between different hours of the day, with minimum amount of photos (N = 0) taken between 05:00 and 07:00 am and maximum (N = 45) between 18:00 and 19:00.

The use of the public display application was not at all reflected in the online gallery. The gallery received just 33 online visitors during the study. Of these, some are attributed to our own team, suggesting that practically others did not visit it. Since the traffic of the online gallery was steadily low, so was the interaction there with the photographs. Only 23 submissions out of the 425 were "liked" during the 181-day trial, and 16 comments were added to the photos online. The comments were without exception people joking around after recognizing themselves or their friends in the photograph or people leaving their own nickname or smileys as a comment.

While it would be worthy to analyze the number of submissions per each of the displays, we see this in our case as unjustified. Many displays were relocated or offline for weeks during the trial due to ongoing renovations in the City. We also suffered from technical difficulties, such as broken touch panels or web cameras, preventing the use of this service on certain screens for varying periods of time. We acknowledge this as a limitation in our study. Despite this, it was evident that displays deployed in "casual" locations produced more output. These are locations such as a popular swimming hall's lobby, a market square, or a walking street hosting a selection of shops, cafes and pubs. It also became apparent that, again and unfortunately, very few of the submissions and their captions were related to the purpose of the service, which aimed to elicit meaningful civic feedback for the city officials. This was not entirely surprising, however, as we expected some degree of appropriation because our study was conducted outside the safety of a laboratory or controlled environment.

Examples of the obtained output

It is important to illustrate what kind of input did our deployments receive from the public. As for the first discussed deployment, Rotuaari Renovation, both negative and positive aspects were highlighted by the audience. Comments such as "More employees are needed, this needs to be done faster", "Looking good, also the new stage looks nice!", or "It's great to see the City developing!" were voiced by citizens. Also, when the stream was deployed, in P4, discussions started to take place: "Wasting years because of this small renovation is way too long", "Also, please add more working hours, it is taking too long", and "Yea, I also really agree on that" were posted sequentially to the stream. This suggests that adding the comment stream led to further engagement with other citizens. However, throughout the study strong appropriation of the used technology led to high noise in the received feedback. Comments, such as "It's fun in Oulu", "hello everyone", "I like beer at nights", random character strings, nicknames (probably the nicknames of the commenters themselves), swearwords, and other profanities were often submitted using the prototypes.

The Ubinion deployment, having a far more visual and playful approach to obtaining feedback, was also used in several different ways by the public. The visual element introduced rich options for users to express themselves in ways that were impossible for us to predict before the deployment. We observed a lot of self-expression, gesturing to the camera (with the archetypical middle-finger being quite popular), and other, even acrobatic, poses by groups of users. Figure 5 below depicts four authentic output examples from the Ubinion deployment.

Figure 5. Example output submitted using Ubinion. From left: "I am Nadia", "Streetfighters Teemu and Mika", "More bicycle parking areas", "More roller skating opportunities for the young".

The strong appropriation in both discussed cases illustrates that citizens are highly prone to use new pervasive infrastructure for their own needs, in a way that goes far beyond the intentions of the technology designers. This in term increases the required effort to moderate and filter the input of the citizens, but is also at the same time promising: it indicates their willingness to adopt and use the new deployed technology instead of seeing it as an oddity to avoid. And this, if anything, is an integral prerequisite for crowdsourcing the public opinion via new, more effective and open civic engagement channels.

Discussion

First we would like note a principle we follow in our deployments in the public space; Our experimental approach is not to develop systems and services in our testbed and then claim that they are applicable everywhere, in all contexts and cultures. Instead, our approach is to identify concepts and ideas that can be used in developing pervasive technologies, and subsequently validate them in our own testbed. We agree with Brown, Reeves and Sherwood (2011) who noted that the inevitable variability of completely public trials makes them difficult to reproduce even with the best efforts of researchers. However, many ideas from our work carry over well into other environments. Here we discuss the overarching findings that surfaced from the case studies.

Feedback in the city: everywhere or situated?

Pervasive technology can enable citizens to provide feedback anywhere and anytime. Interestingly, our results suggest that feedback should be, on the contrary, highly situated. Especially our interviews suggest that for a feedback channel to be effective it needs t o be made available at the right time, in the right context. This is in line with previous research by Ananny and Stroehecker (2009), suggesting that feedback mechanisms -- whether for an online community, a service, or presumably a city -- can be more effective when they are situated. Battino, Vande Moere and Barsotti (2011) describe public displays a highly situated technology by their very nature, and how they are perceived as an integral part of a place's identity and character. Thus, utilizing them as a channel for instant contextual feedback is a compelling use case. During our interviews several respondents voiced preference for fast, situated feedback mechanisms that are easily available at the right time -- the time when they are actually at downtown and can see the renovation first hand -- instead of having to go online once they get back home and recall the feedback they wanted to give.

Naturally, we were disappointed about the low amount of feedback we received, and especially about the lack of actionable, non-noisy feedback. In deployments like these we must however consider the context more carefully. The applications were not deployed standalone as disruptive interfaces that are designed from the beginning to gain the immediate attention of passersby, which is the case in much of the related literature about situated technology interventions. Comparing our approach to such mechanisms is unjust, as further explained by Hosio, Goncalves and Kostakos (2013). Our public crowdsourcing deployments rely on already built city canvas, and aims for interaction with citizens through establishing a situated, purposeful channel that people can rely on reaching those that would otherwise not have their voices heard. Also, while the feedback from such deployments as our Ubinion is not perhaps directly actionable in regards to the original issue, a lot about the current ethos in the city can be inferred from the obtained results through thematic analysis by experts.

So, while the two deployments discussed here did not perhaps yield the results we originally wanted, public displays as a platform are promising in terms of providing feedback opportunities, as users still interacted with them. Thus, the effectiveness of the actual feedback mechanisms becomes crucial. In our particular case it was important for the TC to offer text-based solutions. Virtual keyboard, SMS, Twitter, and email were all evaluated for this purpose, and their differences turned out to be drastic, as we discuss next.

The channel still matters

The first discussed case study focused on comparing different input mechanisms in otherwise identical environment. In P2 when SMS, Twitter, and email channels were deployed to facilitate easier typing and to lessen noise, the amount of feedback dropped to zero. This highlights the need for effortless, in-situ interaction mechanisms for crowdsourcing that requires the least amount of effort from the participants (Goncalves et al., 2013). In Finland, Twitter is scarcely used and while smartphone penetration is rapidly growing, it is still far from everyone to have email capabilities in their mobile phones here. What was unexpected in the use of SMS, compared to the use of virtual keyboard, is the quality of feedback it produced. All the messages submitted through SMS (during P3) were relevant to the renovation project. We attribute this to the cost of SMS, which in Finland is approximately 0.07EUR per message. This price may seem low, but Shampanier, Mazar and Ariely (2007) note that there is a substantial difference in perception between zero cost and anything above that. As our results suggest that only people who were serious in voicing their feedback were willing to pay for it, we believe that requiring even a minimal payment from citizens is effective in filtering out much of the noise from their feedback. At the same time, our findings highlight an important tradeoff in developing our environments: should the infrastructure be free at the point of use or not? Our study suggests that this tradeoff is manifested in terms of quality of citizen contribution and participation levels when considering civic engagement in a modern city.

Furthermore, the message stream in P3 and P4, which allowed people to review others' contributions, substantially enhanced civic engagement. The stream also enabled discussions around the renovation project to occur on public displays. Displaying previous feedback comments is analogous to online message boards, which can be conceived as democratic meeting places, virtual agoras. The underlying value of such boards comes from anonymous, fairly unstructured discussion that allows users to post what they want instead of what the officials want to hear. This shift in power has a liberating effect, as topics and concerns that people are interested in arise, but the officials are not

necessarily aware of. The egalitarian nature of our public displays, which allow anyone to walk up to them and use them to contribute to the ongoing discussion, acted as a catalyst to civic engagement. Furthermore, rather than the infrastructure hiding away events and actions taking place, the stream revealed these to citizens and as a result engaged with these citizens.

The Ubinion deployment had a different approach to collecting feedback, and therefore a direct comparison between the mechanisms used in the deployments is not fair. However, it was clear that the playful interface encouraged people to express themselves in rich ways and use the deployment as a stage for engaging in public play in the public space. Before the case study described in this article, Ubinion was deployed in semi-public settings, as reported by Hosio et al. (2012). In the earlier case, it performed much better in terms of feedback quality, but when deployed in the heart of the city, unsupervised, citizens appropriated the application much more to their own purposes. Unfortunately, this also caused the Youth Affairs Department to quickly lose interest in the deployment. While there is nothing new in this -- it is indeed well known that users tend to appropriate technologies that are deployed "out there" -- we feel that the magnitude of the effect is still generally underestimated in the research community. We should be more careful when making claims about a prototype's performance in authentic and longitudinal use scenarios. It takes months to really start seeing the true user behaviour patterns. Our studies once again highlight the challenges in transferring technologies trialed in controlled settings to real cities. Far too often it is taken for granted that the challenge of transferring a prototype to everyday environments is merely a technical one. It certainly is not, it is a much more complex issue with several human factors and new stakeholders to deal with.

Towards open civic engagement

Advocating civic engagement with pervasive technologies may at first sound like an oxymoron. An important driver behind civic engagement is the need to solve problems -- which is something that pervasive technologies can be argued to do. So do we even need to concern ourselves with civic engagement in an environment where problems can be solved with technology and engineering? We argue yes, because civic engagement is also about collective decision making and dialogue. However, there are certain obstacles we face in the process.

Despite the low volume of feedback in our study, we argue that as pervasive technology matures from concepts into reality it will become increasingly important to harness the power of the crowd, to crowdsource public challenges. In previous studies with similar technology, but tailored to a younger clientele and deployed in more controlled settings, Hosio et al. (2012) showed that our systems were successful in eliciting high numbers of relevant feedback in a much shorter period of time. Because it is typically the young who are most aggressive in adopting the new technology, perhaps they feel most comfortable being vocal citizens, the pioneers of open civic engagement. Therefore, as Clary and Snyder explained (2002), a major ongoing challenge is to also attract adults to participate and break their deeply-grained habits remaining inactive in community-driven participation.

Deployments in controlled settings and with narrow demographics, such as only young people, are highly effective in quickly testing a new technology concept. However, in order to make a long-lasting impact the technology to connect with citizens has to be available "out there", in our everyday surroundings. Open civic engagement can only happen when equal opportunities for participation are provided; Age, gender or any other factors must not limit the access to the new technologies. Therefore, we advocate deployments in the urban space around us. Also noted by Müller et al. (2010), this space is a rich yet challenging environment to deploy infrastructure and applications in. Several considerations, including the intertwined social practices of the space, robustness of the technology, vandalism, differing stakeholder interests, and even weather conditions cause constraints when deploying technology in such authentic settings. These are all details that we had to confront during our long-term experiments. However, these challenges turned out to be critical to shaping our understanding of citizen's use of our technology. This insight has been voiced before, with e.g. Sharp and Rehman (2005) arguing that to gain an understanding of how new, openly accessible technology is received and especially appropriated by the general public, deployment in such environments, or living laboratories, is needed.

A key factor in obtaining reliable results in open environments is understanding users' intentions, or their seriousness. Müller et al. (2010) explain that particularly public display users often lack a clear motive when starting to use it. Also, Hosio, Goncalves and Kostakos (2013) showed that the vast majority of service launches on multipurpose displays may well originate from pure curiosity rather than intention to actually use the service. In our vision it is clear that computational resources such as public displays can and will be appropriated for several different use cases. This naturally has implications also for civic deployments in public, as all services compete for popularity against other services. When users are offered a myriad of options, it becomes more important than ever to be able to offer interesting and appealing services. In our environment it seems to be games that are most attractive to the general public, and we have indeed set to explore gamification as one of the design elements in our later, currently ongoing experiments.

Conclusions

Creating public human interfaces for interacting with our surroundings is challenging but worthwhile. In this paper we focus on an important societal issue, civic engagement, and present a series of longitudinal large-scale experiments for evaluating interactive public technologies that crowdsource the public opinion. Our experiments demonstrate that the choice of feedback mechanisms leads to variations in feedback quantity and quality, as well as to different reactions and appropriation by citizens. While we do not argue our findings lead to universal solutions for permanently enhancing the connection between citizens and officials, we remain carefully optimistic about our work. The system we deployed was the sole channel chosen by citizens for giving feedback about the renovation project affecting their daily lives, and we gained valuable insights into how different feedback mechanisms really work, or often do not work, "out there", in authentic settings and outside the safety of laboratory environments.

We conclude by noting that a city does not just magically become open and offer sustainable solutions for civic engagement overnight. For this reason we emphasize conducting longitudinal experiments in collaboration with authorities and citizens. Particularly the case of civic engagement calls for sustained participation and hence for longitudinal action. We believe that permanent and situated installations, such as our public interactive displays, can be harnessed to provide sustained interaction opportunities for the future city and its citizens. Indeed, the study presented here is by no means a one-off endeavour, but a part of a greater effort of connecting citizens to different authorities and municipal actors in our city. At the time of writing this article we have several other civic services deployed on top of our public display infrastructure, and the lessons from the trials presented in this article have been a great help in designing the ongoing experiments.

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