July 2007 (vol. 8, no. 7), art. no. 0707-o7002

Published by the IEEE Computer Society

Works in Progress

Urban Computing and Mobile Devices

Editor's Intro

The July–Sept. Urban Computing special issue of *IEEE Pervasive Computing* features 12 Works in Progress on urban computing and mobile devices, and we've posted an additional seven WiPs here. The first two entries involve projects exploring interactions between urban participants and pervasive computing environments. The next three are projects that intend to leverage location and environmental information collected from mobile sensors such as wearable sensors, mobile phones, and RFID readers. The sixth entry is a project exploring how users can authenticate themselves to pervasive computing environments, and the final entry focuses on combining navigation in urban computing and physical urban environments.

—Anthony D. Joseph

Physical Computing/Art Projects

Piotr Adamczyk and Kevin Hamilton • University of Illinois at Urbana-Champaign

The University of Illinois at Urbana-Champaign offers a series of interdisciplinary courses for artists, engineers, architects, and computer scientists, focused on various physical computing projects. Students have deployed these projects throughout the campus and surrounding community to explore collective and individual social practices in cities.

Along with our collaborators, we've aligned the courses thematically rather than around a particular technology or technique because of the participants' radically different skills. We centered one course around the act of walking (http://www.art.uiuc.edu/projects/mobilemapping/), and how mapping and mobile technology mediate this act. Our current course (http://www.art.uiuc.edu/projects/memory/), explores how memory and history function to help create a shared space and how technology and design can help store new memories and retrieve old ones.

We've used numerous sensing and actuation technologies including Phidgets, mote wireless sensor networks, and hacked consumer electronics, each deployed in public-interaction projects (http://orchid.cs.uiuc.edu/people/adamczyk/pvss/). One such project explored the interaction between passersby and late-night bar patrons using an interactive video that was projected two stories high and related directly to the pedestrian traffic patterns. Other students used analog and digital technology to tag or bookmark their environment (see, for example, http://del.icio.us/) with both situated (audio-augmented graffiti-style markings) and mobile (GPS-aware music players) technology. Yet another project made ephemeral media authoring with Wi-Fi and camera phones more tangible by constructing new physical spaces for display and community interaction.

For more information, contact Kevin Hamilton at kham@uiuc.edu or Piotr Adamczyk at pdadamczyk@gmail.com.

Professor Tanda: Persuasive Pervasive Participation

Alan Chamberlain and Steve Benford • University of Nottingham
Nick Tandavanitj • Blast Theory
Amanda Oldroyd • BT Group Chief Technology Office

Professor Tanda is a mass-participation, pervasive mobile-phone-based game that engages the public and helps people see their behavior's environmental impact. Using both persuasive computing and pervasive computing, it encourages players to interact at different locations and times to build a picture of their lifestyle in relation to the environment.

Currently, players receive two content sessions per day. The sessions involve interacting with a character called Professor Tanda. He might

- ask a variety of environmentally based questions regarding the players' mode of transportation, energy and water consumption, and recycling habits,
- ask a player to take part in a practical activity,
- give advice regarding how to alter their behavior and reduce their environmental footprint, or
- try to guess the players' context.

A certain time, date, or location (based on cell mast IDs) can trigger the sessions, or users can trigger their own sessions (although the professor might be busy). Future developments focus on user-profile-based session triggering, the creation of operator tools, context-based visualizations, and full system automation. We also hope to further

- investigate how to develop and deploy large-scale, mass-participatory pervasive systems;
- evaluate where, when, and why people play;
- examine user behavior and attitudes toward such systems; and
- collect data relating to the users' understanding of place, activity, and time.

By participating in the game, we hope players will change their environmental behavior, using the information that the game provides, and have an engaging, enjoyable experience.

Professor Tanda is a joint project of the University of Nottingham's Mixed Reality Lab, Blast Theory, and BT, and it's part of the DTI/EPSRC (Department of Trade and Industry/Engineering and Physical Science Research Council)-funded Participate project (http://www.participateonline.co.uk/).

For more information, contact Alan Chamberlain at azc@cs.nott.ac.uk or Amanda Oldroyd at amanda.oldroyd@bt.com.

Urban Sonar

Kate Hartman, Kati London, and Sai Sriskandarajah • New York University

Urban Sonar (http://www.urbansonar.com/) is a personal space-monitoring system that senses an individual's experience as he or she moves through an urban environment, recording information that the individual can later retrieve and review.

The sensing system is integrated into a wearable device. Ultrasonic range finders mounted in the front, back, and shoulder areas of a jacket (see figure 1a) measure the wearer's proximity to solid forms on all sides of the body. Additionally, conductive fabric strips strapped around the fingers monitor the wearer's heart rate. The remaining electronic components are in a pocket inside the jacket. The sensing system feeds data into a microcontroller that interprets the values and transmits them serially via Bluetooth.

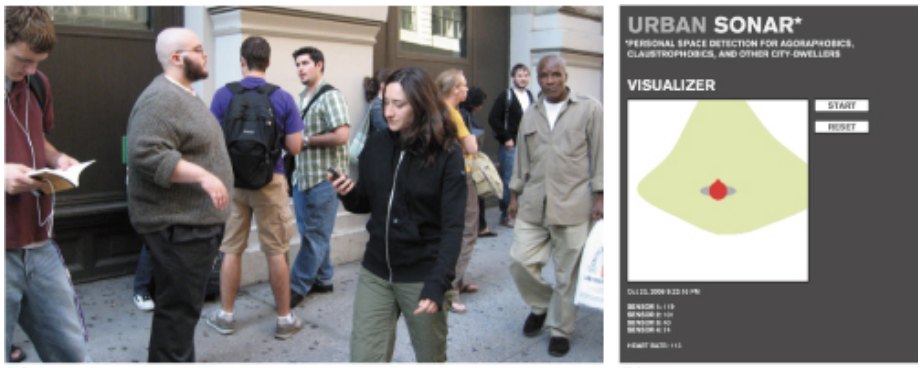

Figure 1. The Urban Sonar space monitoring system: (a) a user wears the black Urban Sonar jacket, which contains ultrasonic range finders and other electronic components; (b) the system visualizes the ebb and flow and the user's personal space and heart rate.

The system receives and records the data using a Bluetooth-enabled mobile phone. Once the session is complete, the mobile phone uploads the log file to a server that then presents the data as a time-based visualization. This visualization displays an accelerated, bird's-eye view that simulates the ebb and flow of the user's personal space and heart rate as the values fluctuate during the period of data logging (see figure 1b).

Urban Sonar thus turns its gaze both outward and inward, using an individual's personal space and heart rate to visualize a lived experience through quantitative data.

For more information, email info@urbansonar.com.

Mobile Phones to Monitor Pollution

Eiman Kanjo and Peter Lanshoff • University of Cambridge

At the University of Cambridge, we're exploring the sensing capabilities of built-in devices in modern mobile phones, which can give ordinary people the ability to affordably monitor their local environments. To achieve this, we're developing accurate and miniaturized pollution-monitoring sensors to communicate with mobile phones and GPS receivers over Bluetooth. Mobile phones will act as data-collection points for processing and mapping surrounding pollution levels (see figure 2).

Figure 2. A screenshot of a mobile phone shows carbon monoxide data and GPS locations on Google map.

We're also developing a noise sensor using the phone's microphone, where the phone can analyze an incoming sound signal and present it graphically on its screen. This will indicate the sound level generated by local traffic.

Furthermore, by using mobile phones' communication capabilities (such as General Packet Radio Service and Wi-Fi), we'll be able to send this data to a remote server in real time. The server could then deliver the processed data to users who subscribe to the service. This service will provide information about peak periods of air pollution localized for the user's part of the city.

For more information, contact Eiman Kanjo at ek315@cam.ac.uk or see www.escience.cam.ac.uk/mobiledata.

Urban Computing Using RFID Location Markers

Kaoru Sezaki and Shin'ichi Konomi ● University of Tokyo

Our group at the University of Tokyo's Center for Spatial Information Science is currently developing a positioning system using numerous RFID location markers and mobile devices. It's a part of three-year national project called RFID-based Positioning Systems for Enhancing Safety and Sense of Security.

Existing positioning technologies such as GPS, cell-tower triangulation, and RFID badges are problematic in terms of accuracy, coverage, and privacy. Our system uses the data captured from RFID location markers, sensors, and nearby peer devices so that pedestrians' mobile devices can accurately compute their positions. Each device uses its position and time as its spatiotemporal address (STA)—that is, its network address—thereby preventing privacy-violating location tracking. Mobile devices are often equipped with various sensors, so the pedestrians carrying them work as mobile sensors. The devices can then use the STAs to gather real-time urban environmental information such as noise level and CO_2 density.

We built prototypes using notebook PCs and recently tested them with 18 users simultaneously walking around in a 75 m × 25 m space. We also plan to develop mechanisms for location-based information dissemination and exchange and to create a more realistic testbed in a real urban area.

For more information, contact Kaoru Sezaki at sezaki@iis.u-tokyo.ac.jp.

Authentication in Urban Computing Environments

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Hafiz F. Ahmad ● Comtec, Japan
Fauzan Mirza and Arshad Ali ● National University of Science & Technology Institute of IT, Pakistan

Our work focuses on using machine-learning techniques in conjunction with standard cryptographic techniques to provide a comprehensive security system fulfilling the two main requirements of an ambient intelligent environment: security and usability.

In this framework, the workflow begins when a person enrolls by answering self-chosen, truly private questions. The answers are then converted to hashes (http://www.rsa.com/rsalabs/node.asp?id=3109), to form positive training data as opposed to negative training data, which is derived from an algorithm based on the dictionary attack. (In this algorithm, typically used in offline attacks, the attacker creates a dictionary of possible keywords to try various passwords. We use this system to make our system more robust against such expected attacks.) Finally, a multiagent system is formed in which a cluster of agents train a single agent to be a true representative of the single user. The agent thus securely stores that user's answers to his or her self-chosen, private questions. After the agent completes the training, the system transfers the agent to a wearable device.

At runtime, the user first authenticates himself or herself to the agent using traditional techniques such as biometric and basic password-based authentication. However, from this point on, the agent authenticates the user in the ambient intelligent environment using standard security protocols but using knowledge-based authentication as long as the agent can detect that it was never detached from the user. An example is a sensor attached to a device's strap. When the strap opens, the sensor sends an event to the software agent, resulting in an internal state transition. The agent then knows it might no longer be with the actual user, so it requests reauthentication.

Among some of the innovations we're working on are coupling knowledge-based authentication with the hash-generated approach, a multiagent-learning paradigm, a comprehensive architecture for authentication in an ambient intelligent environment, and a technique for generating training data for machine-learning techniques used in security.

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A Navigation Engine for Ambient Wayfinding

George Roussos, Dikaios Papadogkonas, and Mark Levene • University of London

Wireless networks are becoming increasingly pervasive in urban spaces, thereby embedding semantic spaces in physical locations and vice versa. So, material and information spaces cohabit in a single environment, which consequently possesses both spatial and information characteristics. The vast size of such meta-urban spaces poses unique navigation challenges, and overcoming them will require new tools and skills. Although human navigation and wayfinding abilities have been refined over millions of years, on the basis of our ever-changing material world, our tools in searching for unstructured information are relatively recent. For most people, practical experience in this area largely involves a Web search engine.

In this project, we explore providing navigational assistance in urban pervasive computing environments. First, we propose a conceptual framework for constructing automated cognitive representations of ubiquitous computing spaces. Second, we investigate how to use this framework in practical situations to develop tools that support recall and reflection in the context of a personal experience. A critical element of this work is our exploration of how the aggregate record of social experience can support the exploration of unfamiliar environments. We evaluate the performance of these techniques by applying them to a variety of data sets collected using different wireless networks including metropolitan Wi-Fi, Bluetooth, and cellular.

For more information, contact George Roussos at g.roussos@dcs.bbk.ac.uk.

Related URLs

- Conversion to hashes: www.rsa.com/rsalabs/node.asp?id=3109
- Participate project: www.participateonline.co.uk
- Pollution-monitoring sensors: www.escience.cam.ac.uk/mobiledata
- Tagged environment example: http://del.icio.us
- University of Illinois at Urbana-Champaign course related to memory: www.art.uiuc.edu/projects/memory
- University of Illinois at Urbana-Champaign course related to the practice of walking: www.art.uiuc.edu/projects/mobilemapping
- University of Illinois at Urbana-Champaign student projects: http://orchid.cs.uiuc.edu/people/adamczyk/pvss
- University of Illinois at Urbana-Champaign student projects, related contact information: Kevin Hamilton (www.kevinhamilton.org) and Piotr Adamczyk (http://pdadamczyk.googlepages.com)
- Urban Sonar: www.urbansonar.com

Related Links

- DS Online's Mobile and Pervasive Community (http://dsonline.computer.org/portal/site/dsonline/)
- "Guest Editors' Introduction: Urban Computing--Navigating Space and Context," *Computer* (http://doi.ieeecomputersociety.org/10.1109/MC.2006.308)

Cite this article:
Piotr Adamczyk, Kevin Hamilton, Alan Chamberlain, Steve Benford, Nick Tandavanitj, Amanda Oldroyd, Kate Hartman, Kati London, Sai Sriskandarajah, Eiman Kanjo, Peter Lanshoff, Kaoru Sezaki, Shin'ichi Konomi, Muaz A. Niazi, Hafiz F. Ahmad, Fauzan Mirza, Arshad Ali, George Roussos, Dikaios Papadogkonas, and Mark Levene, "Urban Computing and Mobile Devices," IEEE Distributed Systems Online, vol. 8, no. 7, 2007, art. no. 0707-o7002.