

2.2 Participatory Sensing (PART)

The vision of Participatory Sensing is of distributed data collection and analysis spanning the personal, urban, and global scale, often using “everyday” technologies like cell phones, in which participants make key decisions about what, where and when to sense. Previously called Urban Sensing, the area was renamed to emphasize its wide applicability and strong conceptual grounding in user participation.

The area targets technologies and applications that transform our capacity to help individuals, families, and communities monitor and improve their own health behaviors, adopt sustainable practices in resource consumption, and participate in civic processes. Each of these three touchstone topics—health (Figure 1), sustainability and civic engagement—is being explored in real-world deployments, such as AndWellness (Google and NIH-funded); the Personal Environmental Impact Report and What’s Invasive; and Mobilize in the Los Angeles Unified School District, Boyle Heights Neighborhood Collaborative and Remapping LA, respectively. In addition to these application-driven experimental deployments, the area has conducted technology-focused research around topics necessary for complete, robust participatory sensing systems, including: participant recruitment and reputation, task planning, and sensing campaign management; configurable triggers for experience sampling; human activity classification based on mobile phone sensors; integration with environmental monitoring assets; and data visualization. Privacy challenges are being addressed within a holistic ethics framework that emphasizes principles of participant primacy, data legibility, longitudinal engagement, and parsimony.



Figure 1. Diagram depicting general mHealth system use cases.

Since the introduction of the term by CENS in 2006, the area of participatory sensing (along with urban sensing) has generated a body of multidisciplinary work spanning many universities, including UCLA, Dartmouth, Columbia, MIT, CMU. It has also inspired work outside computer science in design, urban planning, and the arts, while becoming a driver application for other research topics, including a recent NSF Future Internet Architecture award to UCLA. The more technical aspects of our PS innovations are included in the research section of this report.

Application Drivers & Pilot Deployments

Ongoing collaborations target the three focus areas, including joint projects with the Semel Institute’s Global Center for Children and Families at the UCLA School of Medicine, the National Park Service, the Los Angeles Unified School District (LAUSD), UCLA REMAP, and others. The group continue to increase the scale of public use of these technologies. In Spring 2010, Google seeded a partnership with LAUSD to incorporate participatory sensing on Android phones into computer science and mathematics classrooms. That program, Mobilize, will now expand across the district through a new five-year NSF award (<http://mobilizingcs.org>). It builds on experience from community data collection, for example, a collaboration that began last year with the Boyle Heights Neighborhood Collaborative in Downtown Los Angeles mapped, recorded, and accumulated data on community member circulation and related condition. This was a unique, active and participatory approach that supported the Boyle Heights Planning for Place project in developing its plan for a healthy community. Now, Nokia and CENS are supporting the exploration of new approaches to community case-making and storytelling using this data as a case study, which will in turn impact architecture research. Work continues on an ARRA-funded NIH Challenge Grant to develop an innovative real-time assessment of behavioral exposures for cardiovascular disease (CVD) in young overweight mothers. Other health

science projects include exploratory work around supporting cancer survivorship research, HIV behavior survey with the Center for HIV Identification, Prevention, and Treatment Services, and a collaboration with UCSF on “mHealth” architecture.

Applications continue to take on a wider variety of diverse populations. While in the longer term scalability of any individual deployment/experiment will raise additional challenges, our experience to date has shown that the more important dimension for us to focus on is supporting a diverse mix of dynamic PS efforts, rather than any individual effort at very large scale. For the most part the latter more traditional notion of scaling is likely to be well addressed by mechanisms used in other areas of distributed systems and web applications (cloud solutions, schema-less data stores, etc.) Whereas a focus on an increase in the range of applications and projects is generating highly valuable feedback on system feature set, robustness requirements and optimization targets; participant pool coordination, planning and management needs; and the importance of careful user experience and interface design for successful deployment, and other issues that are more unique to this particular domain.

Platforms used by the group are becoming more mature and general. CENS is generalizing the codebase from AndWellness to also support the LAUSD Mobilize Program, as well as adding visual analytics capabilities using the popular statistics package R. AndWellness includes four system mechanisms to facilitate rapid prototyping of personal data collection. Specific systems contributions include survey authoring; a composable and extensible trigger framework that makes it easy to launch survey data collection based on time, place, or a user’s activity; a phone top ‘button’ that allows a participant to capture a quick emotion (such as a ‘stress button’ to document stress events)—and the time and location surrounding that event—without having to go through the burden of answering an entire survey; low-power data collection services (e.g. location, acceleration, mobility) to facilitate contextual and automated data collection without draining the battery and without interrupting the user; and a toolkit of generic visualizations that provide a quick snapshot of each user’s data.

Rapid campaign authoring, deployment and management tools, are enabling new data collection campaigns to be quickly created and deployed through the assembly and customization of a pre-existing web services and user interface components. Additionally, through collaboration with other institutions, CENS will integrate other emerging platforms and standards for data collection, such as Open Data Kit (ODK).

In addition to smartphone software, CENS is also developing SMS (text message) based systems on top of the UNICEF RapidSMS framework, to enable participation by the still large numbers of people who do not own smartphone or do not have a supported smartphone platform.

On the mobile devices themselves, research continues to better understand handset usage models as they inform resource management mechanisms; especially with respect to power consumption, where improved knowledge will support the goal of being able to continually run participatory sensing applications on everyday handsets. Additionally, we continue to explore embedding local processing to tighten the feedback loop with users. In general, as our deployments expand, we dedicate more effort to user interface improvements and usability study.

Privacy, Ethics, Law and Policy

Based on campaign deployment experience and ongoing consideration of privacy concerns, a major focus of research and implementation that emerged in 2009-2010 was the Personal Data Vault (PDV): a logically isolated secure repository for participatory sensing data that is controlled by the handset owner. Conceptual and technical work on this continues, including a version based on standard web protocols and another more experimental distributed version. In both cases, the PDV receives participatory sensing data as it is collected and selectively distributes it to third party applications according to a set of sharing rules created by the user. The groups collaboration with Prof. Jerry Kang of the UCLA School of Law has yielded a law review paper and initial legal approach that could provide additional protection for the data contained in the PDV. The implementation will be integrated into CENS applications in 2011.

The PDV is one of several examples of CENS participatory sensing research that is influenced through interaction with ethics education and research that aims to promote the participatory principles and user empowerment fundamental to this area. This work is in its third and final year of funding from the NSF Ethics Education in Science and Engineering, and is centered a participant-observer study of CENS research that aims to develop educational materials promoting ethics considerations in the development of participatory sensing systems, as well as original work in Information Studies on participatory practices in data collection. In addition to academic publications, reports, and popular articles in this area, a new interdisciplinary undergraduate course is being offered this spring that will explore the topics in depth. The project generated a second grant by the same team that will generate multimedia curriculum materials on a several different ethics topics.

Future Work

During the coming year we will continue to focus on expanded real-world deployments with a larger variety and number of users, higher stakes uses in real communities, and more robust, shared systems (such as the PDV and AndWellness core platform) to support data collection campaigns. These deployments will provide the systems scaffolding and practical opportunities to incorporate technology research in campaign deployment, management, recruitment, incentive, data processing and the other areas listed above. They will also provide opportunity for formal user studies and more concrete understanding of how to achieve maximum impact in the real world.

After an assessment of progress at a Summer 2010 “mini-retreat” the group has also started to focus on methodology for case-making and storytelling based on participatory sensing data. Acknowledging that data (and visualizations of that data) are often understood by stakeholders in participatory sensing through the articulation, sharing, and correction of narratives told using the data, the group is researching how to better support this in the collection and analysis process. Assistance in case-making and storytelling will help to motivate ongoing collection in communities and makes it easier for them to leverage the data that they have collected towards desired change. This work includes collaboration with visual and media arts students and faculty, and will culminate in automated data summary approaches that complement the work already being done in data visualization and analysis.