Article

Participatory Sensing: Building Empowering Surveillance

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Abstract

Mobile phones could become the largest surveillance system on the planet. These ubiquitous, networked devices can currently sense and upload data such as images, sound, location, and motion using on-board cameras, microphones, GPS, and accelerometers. And they can be triggered and used by billions of individuals around the world. But the emergent, wide-scale sensing systems that phones support pose a number of questions. Who will control the necessary infrastructure for data storage, analysis, sharing, and retention? And to what purposes will such systems be deployed? This paper explores whether these questions can be answered in ways that promote *empowering* surveillance: large-scale data collection used by individuals and communities to improve their quality of life and increase their power relative to corporations and governments.

Researchers in academic and industry laboratories around the world are currently coordinating mobile phone networks for purposes that expand the definition of surveillance. Technology movements, variously called personal sensing, urban sensing or participatory sensing, have emerged within the areas of social computing and urban computing. These research programs endeavor to make ubiquitous devices such as phones a platform for coordinated investigation of human activity. Researchers are exploring ways to introduce these technologies into the public realm, a move that anticipates sensing by people across the world.

This paper uses ethnographic data collected in a sensing development laboratory to illuminate possibilities that participatory sensing holds for equitable use, meaningful community participation, and empowerment. Analyzing the motivations and values embedded within the design process and resulting technologies reveals ways in which participatory sensing builds tools for empowering surveillance and responds to the many ethical challenges these new technologies raise.

I. Introduction

Empowering surveillance, the question central to this special issue of *Surveillance & Society*, captures a thread running through a form of technology development emerging in academic and industrial computer science. Engineering labs are developing new software and architectures to retrofit tools of surveillance: embedded data gathering, sophisticated mash-ups and processing, and new kinds of data interpretation. The goal is to empower individuals and communities in a future where “evidence-based” and “data driven” knowledge production makes persuasive power increasingly reliant on data collection and use. These communities of researchers are developing tools designed for a new kind of surveillance – one in which records are produced and used by individuals or within informal communities, rather than by governments or corporations.

This article explores whether such research holds possibilities for *empowering surveillance*: large-scale data collection used by individuals and communities to improve their quality of life and increase their power relative to corporations and governments. It asks: what are the conditions under which surveillance tools can be repurposed for empowering goals? And what are the challenges to achieving those goals? I consider empirical data gathered during two years embedded as a researcher in an engineering laboratory

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dedicated to ubiquitous sensing technologies¹. Using interviews, document analysis, and participant observation, I consider conditions under which technologies produced within this setting might contribute to empowering, bottom-up data collection and exploration. After all, we already live among pervasive surveillance systems. As Lyon says, “Information societies are surveillance societies” (2001, 10). The question remains whether we can divert, subvert, or more equitably disperse some of that information power. I suggest that technology development to support self-documentation is perhaps one way.

The definition of empowerment as gathering data to improve individuals’ quality of life and increase their power relative to corporations and governments is rooted in the practice of *participatory research* (PR). PR is a set of research methodologies that position research subjects as co-investigators (Cargo and Mercer 2008). PR partnerships between academic researchers and co-investigators from partner communities are gaining prevalence in a diversity of fields, including health sciences (Horowitz, Robinson and Seifer 2009; Cargo and Mercer 2008), urban and environmental planning (Corburn 2003; Catalani and Minkler 2009), and information system design (Byrne and Alexander 2006; Rambaldi, Chambers, McCall and Fox 2006). It has previously incorporated primarily qualitative and survey-based social science data collection methods, but its values are newly relevant to questions of pervasive data collection, as well. Because its tenets focus on the ethics of collecting and analyzing data from individuals and communities, PR can be used as a model for large-scale or ubiquitous data collection. PR adopts the standpoint that data collection, sorting and use can be empowering, if it is conducted by the people most affected by the data collection – the research subjects themselves. The PR traditions develop their research questions with the cooperation of partner communities and engage community members in research design, implementation, analysis, and dissemination. Involvement with every stage of the research process allows participants to target local knowledge and benefit from the results of systematic investigations. PR successes in health and environmental research have improved the ability of marginalized or underserved groups to act on the results of the data they have helped collect and analyze (Horowitz et al. 2009). *Empowerment* in a data collection context means moving control of collection and analysis away from the hands of a privileged few and making the power associated with gathering data, interpreting those data, and drawing conclusions more distributed and diverse. This in turn gives the subjects of the data the power to answer back and make an alternate case to others (researchers, corporations, governments) who have engaged in data collection and inference-making about them.

Of course, empowerment will always be a slippery term. Different community and affinity groups may have contested notions of what counts as empowerment. Practices that empower some members of a community may disempower others. For clarity, this paper will focus on power relations between individuals or informal communities and established corporations or governments, because the balance of power between these two groups is more clearly disrupted by new forms of participatory data collection. How such data collection will affect power dynamics within communities is an open question.

Participatory sensing

Participatory sensing – using embedded devices to capture data about oneself and one’s community – could be called a subset of participatory research. Participatory sensing is simultaneously an emerging form of mass data collection, and is therefore an alternative form of surveillance. Participatory sensing captures kinds of data previously only available to corporations and governments. For example, mobile phone providers track the location of their subscribers for safety, billing, and marketing purposes (Curry, Phillips and Regan 2004). Governments survey commuting habits for city planning and collect health behaviors for public health initiatives. Data documenting individuals’ locations, routines and behaviors could be (and have been) used for control and discipline by the state and increasingly corporations (Green and Smith 2004). But captured and analyzed closer to individuals, these data also provide possibilities for self-exploration, community discovery, and new knowledge creation. This article asks: how does a turn

¹ See <http://urban.cens.ucla.edu/>

away from state or corporate surveillance, and towards individual tracking and records creation, encourage a kind of surveillance which is empowering, rather than repressive?

Participatory sensing data resist becoming traditional surveillance data through commitment to *local control, participation, transparency, and social justice*. Local control includes new tools and architectures to give people much more insight into, and power over, collected data. Participation includes a range of activities, from using broadly accessible tools to collect data, to engaging with, manipulating, and learning from the collected data. Participation encourages people to actively engage in sensing projects, rather than agreeing (or submitting) to passive surveillance. Transparency ensures that collected data are not secret or opaque. Instead each stage of the data life cycle, from collection through analysis through sharing, includes ways for individuals to review, understand, and even delete their data. And a commitment to social justice ensures that systems are built with goals of empowerment and change, rather than discipline and conformity. After describing each of these conditions in detail, I use the laboratory where I work and study as a case study in the possibilities, and challenges, for fulfilling these conditions during the technology design and deployment process.

II. Conditions for democratizing data collections

Participatory sensing imagines a world where individuals and loosely affiliated groups can use familiar tools such as mobile phones to gather significant amounts of data on themselves and their environment. This is an expansion on the idea of self-surveillance put forward by Vaz and Bruno (2003), employing specialized technology with specific abilities and limits to consider the self as subject. Off-the-shelf technologies currently available can gather images, sound, location, and motion using phone cameras, microphones, GPS, and accelerometers. For example, the project Your Flowing Data² asks users to send short SMS messages recording data points (e.g. weight, exercise accomplished, mood, or food eaten) throughout the day. The project then provides users with creative visualizations to explore patterns among data points and learn from their data. A different example is the Personal Environmental Impact Report (PEIR)³, a participatory sensing application that uses participants' mobile phones to record their location every thirty seconds. PEIR takes this time-location series and infers how much a participant drives each day, and whether she spends time near polluted highways. It uses this information to give participants a daily profile of their carbon footprint and exposure to air pollutants.

But such data-intensive self-surveillance can have unintended consequences. Projects such as Your Flowing Data and PEIR gather, store and process large amounts of personal information, creating massive databases of individuals' locations, movements, images, sound clips, text annotations, and even health data. Habits and mood are both socially sensitive (would you want such information shared with a boss or friend?) and may be linked with, or have an impact on, legally protected medical information. Location information is equally revealing of habits and routines. Location data shared with an acquaintance might reveal minor indiscretions, exposing little white lies about plans or social obligations. Surveillance disrupts information privacy, allowing data to flow outside of expected contexts and social norms (Nissenbaum 2009). It produces conformity by creating chilling effects on legal, but socially marginalized, activities (Cohen 2008). And databases of locations and routines allow for segmentation and sorting of consumers, enabling ever more forms of structural discrimination based on new demographic categories (Phillips 2005; Curry et al. 2004).

These possibilities highlight social control enabled through data collection. Surveillance has been defined as: "any collection and processing of personal data ... *for the purposes of influencing or managing those whose data have been garnered*" (Lyon 2001, 2). This definition points to the often pernicious effects of

² See <http://yourflowingdata.com/>

³ See <http://peir.cens.ucla.edu/>

surveillance: a focus on social conformity and homogenization at the expense of deviance, disobedience and even creativity (Foucault 2002). As scholars from Foucault (1979) to Vaz and Bruno (2003) have explained, surveillance is an instrument for normalizing and disciplining individuals. Foucault's influential work on surveillance and the panopticon point to the tendency of the surveilled to supervise and discipline themselves – a goal embraced by self-surveillance applications focused on health interventions or worker productivity.⁴ Vaz and Bruno explicitly explore self-surveillance, which often involves identifying something wrong with the self, something that has strayed from the 'correct' path. Similar disciplinary effects are seen when communities organize to collect data, as well. Many community-focused data gathering projects report and discipline perceived social problems such as crime or blight.⁵ Data collection, as an accepted avenue to empirical knowledge production, is one tool for gaining power over others and using this power to control. Collecting data allows the surveilling party to sort populations, draw conclusions, or track individuals.

Participatory sensing, however, challenges some of the attributes that make traditional surveillance practices particularly damaging. Participatory sensing provides a new (and I argue, mostly positive) wrinkle in what Lyon refers to as "postmodern surveillance" (Lyon, 2001). Such surveillance is large-scale data collection conducted by corporations and organizations in addition to traditional government actors. Both Agre (1994) and Marx (2002) indicate that surveillance is increasingly embedded and invisible. Marx also finds that surveillance is progressively involuntary, as giving up one's data is now required to gain many services. A final pernicious effect of surveillance is its increasingly uneven application, directed at marginalized and disenfranchised groups. Monahan writes that the social relations produced by surveillance systems are "part of larger trends toward sociospatial segregation in modern society" (2006, 14). Broad-scale data collection about purchase habits, location and movements enables data sorting and subsequent social profiling, by governments and corporations (Curry et al. 2004). As Monahan describes it:

...what is being secured are social relations, institutional structures, and cultural dispositions that—more often than not—aggravate existing social inequalities and establish rationales for increased, invasive surveillance of marginalized groups (2006 ix).

If surveillance is to be empowering, a tool to improve individuals' quality of life and increase their power relative to corporations and governments, disrupting the social control agenda of surveillance by corporations or governments is a critical goal. Monahan describes this as "democratizing surveillance practices" (2006, 17). New tools and data flow architectures for participatory sensing can foster local and individual, rather than centralized, control over data. Participatory sensing can upend invisible and involuntary surveillance by placing both collection devices and data control in the hands of participants, and it can also foster social justice projects because it is accessible and usable by multiple communities. Self-surveillance, like all surveillance, invokes disciplinary effects. But whether self-discipline is *empowering* depends upon the degree to which subjects identify with or view as desirable the disciplinary goals. It depends also upon whether collected data can provide not only a tool for discipline, but a simultaneous avenue for individuals to examine, question, or upend disciplinary goals. Lyon (2001) suggests that decentralizing data surveillance could lead to "productive chaos." Participatory sensing can use a focus on local control, participation, transparency, and social justice to harness this productive chaos. What might these democratized, empowering data gathering practices look like?

⁴ See for example RescueTime <http://www.rescuetime.com/>, which, while not a mobile application, is explicitly targeted at self-surveillance for increased productivity.

⁵ See for example CitySourced <http://www.citysourced.com/>, in which predefined categories of community problems include such designations as "homeless nuisance."

Local control

Traditional surveillance practices benefit one powerful organization, or a small set of organizations, by gathering consumer or citizen data so that individuals can be sorted, grouped, and predicted. As Lyon writes:

The classically oriented theories [of surveillance] have in common a search for the social – and especially the institutional – roots of surveillance processes... Each emphasizes aspects of surveillance that can readily be understood as magnifying the power of the institution employing the relevant practices to the relative disadvantage of individuals who are thus located, recorded, observed, monitored, classified and processed (2001, 118-119).

To resist magnifying the power of single institutions, new systems of ubiquitous data collection can allow for a much more distributed, diverse model of data collection. A combination of cheap, readily available sensing tools connected through architectures responsive to individual data collectors can allow individuals to collect and manipulate their own data of interest. While corporations will surely continue to collect huge amounts of data, individuals will have their own resources to analyze and act upon.

To progress individual or local control over participatory sensing data, a number of research groups are working on data management tools that would sit between a user's phone or other data collection device and third party applications. A Stanford research team envisions a personal server that would reside in the home and host and aggregate data before they are shared with third parties (Lam 2009). AT&T Lab's virtual individual servers (Cáceres, Cox, Lim, Shakimov and Varshavsky 2009) are another set of architecture innovations designed to help users control personal data sharing. The team I work with at UCLA is focusing on a Personal Data Vault (PDV), protected cloud storage that would be controlled by the individual data collector (Shilton et al. 2009). These alternative architectures would also encourage selective sharing by helping individuals broker data sharing arrangements with multiple service providers. Vaults could also work together or within a social network to allow data sharing and joint analysis among informal groups.

Local control architectures allow for three key differences from traditional surveillance. First, individuals gain a private store of information that would otherwise be unavailable (e.g. collections of mood, sleep habits, and so forth). A private store that contains unique data could give individuals new ways to understand their lives and their communities. This is in direct opposition to a major tenet of surveillance – using personal data about *others* to understand and control them. In her explanation of the dangers of surveillance, Los (2006) invokes the concept of the 'file,' and its modern replacement, the 'data double' – the secret, centralized document or dataset kept on an individual. The file is the ultimate tool of surveillance, both allowing governments to keep careful tabs on their citizens, and encouraging citizens to self-regulate their behavior out of fear of the unseen file. Los worries that incomplete and dehumanized datasets are increasingly gaining authority over daily experience and narrative. To create conditions where ubiquitous data collection tools can be empowering, movements like participatory sensing can balance the concept of the file or the inaccessible data double. What if your data double was a personal documentation (of you), rather than monitoring (about you)? Giving individuals read, write, and share access to their files can balance the dynamic of surveillance towards one of empowerment. As scholars of personal recordkeeping have documented, self-documentation is a powerful tool for self-actualization (McKemmish 1996; Srinivasan 2006b, 2006a). Personal documentation helps people make connections between events and tell new stories about the self. Theorists of international development have discussed how personal documentation can help individuals and communities work towards goals and aspirations (Appadurai 2003). More concretely, it can also allow individuals to create correlations between and learn from habits and routines (Roberts 2004). Participatory sensing is also related to, but not identical to, practices like life logging (Bell and Gemmell 2007), which attempt to record the entirety of one's personal

experience. Participatory sensing rejects that everything can or should be captured, and instead focuses on targeted data collection that might be useful to oneself or one's community. Keeping ubiquitous data collection technologies on the side of personal documentation, and away from others' monitoring, is one important aspect of empowering surveillance. Local control technologies such as personal data vaults can foster the personal archive, giving individuals a place to view their data, tools to interpret those data, and maps of when and where the data have been shared.

Second, local control through a vault provides an alternative vision to current data flow architectures: data stores owned and operated by the same entities that build applications and provide data services (Google is just one relevant example). Local control architectures can slow the proliferation of such vertically integrated personal data sets, keeping data control separate from companies or governments with interest in mining that data. Current sensing architectures upload data directly to third party applications. These third party applications therefore hold multiple, sometimes redundant sets of personal data. These applications are quite diverse, created by large corporations such as Google and Microsoft as well as small companies and interested amateurs.⁶ While all of these applications need to analyze personal data to perform their services, some do not rely on those data as a source of revenue (e.g. Your Flowing Data has a very different business model than Facebook). Many of these applications could benefit from processing performed inside a personal data store, importing only aggregate data to run through their analysis services.

Third, and perhaps most importantly, local control of data can provide the capacity to "answer back" to ongoing forms of corporate and government surveillance. A concentration on local data control can resist the conditions of totalitarianism often associated with surveillance. Los(2006), for example, writes that surveillance often entails "...monistic centralization of control" (2006, 69). Local control of participatory sensing data creates conditions under which the individual holds and has access to many of the same kinds of data as those collected by centralized authorities. A patient with a personal record of eating, sleeping and exercise habits goes into a hospital setting with an understanding of data that may affect their diagnosis and treatment. An individual who can see her location traces can game the system, switching her routine to confuse tracking algorithms and invalidate a system's sorting inferences. A shopper who can visualize his own purchasing habits can decide when he needs to switch stores, sign up for loyalty cards under a new identity, or swap cards with a friend to obfuscate the data. A community that has been reassured that a local factory is not harmful to their health can create a map of pollution incidences and health complaints, and use this to negotiate with legislators or factory management (Ryder 2006).

Participation

Collecting and holding data locally is only one piece of moving data gathering away from surveillance and towards personal and community empowerment. The ability to draw meaning and conclusions from those data, and then use the data to make a case to oneself or others, is critical to distributing the power of ubiquitous data collection. Enabling communities to understand the nature of data collection systems, as well as the data flowing through those systems, is an important tenet of participatory research (Cargo and Mercer 2008), and has been proposed as critical to emerging electronic, pervasive data collection such as mobile-phone-based sensing (Cuff, Hansen and Kang 2008).

Participation in sensing begins with using accessible, familiar tools for data collection. Unique among potential tools for sensing is the mobile phone. Phones are globally available. The estimated 4 billion mobile phones in the world are more widely available than personal computers, credit cards, or televisions (Kinkade and Verclas 2008). They are also devices accessible to diverse communities. Recent research by the Pew Internet & American Life project has found that adoption of mobile phone technologies and data use on mobile devices is increasingly prevalent among African American and Latino communities in the

⁶ For examples, see: My Tracks, <http://mytracks.appspot.com/>, Ecorio, <http://www.ecorio.org/>, Daytum, <http://daytum.com/>, Myrocasm, <http://mycro.media.mit.edu/>, and Moodstats, <http://www.moodstats.com/>.

United States, and is in fact higher among communities of color than white Americans (Smith 2010). Mobile phones are networked, allowing data to be not just recorded but sent via SMS or uploaded to cloud storage. Phones also have a number of data collection features. They can record text input from users. And increasingly, they can take photographs, record sounds, and sense their location using GPS or cell-tower triangulation. Some have accelerometers, which can measure data about movement to infer precise activities such as sitting, walking and running. And many can connect to other kinds of sensors (physiological sensors, etc) or sense other phones around them using Bluetooth. These features make mobile phones unique among surveillance technologies, and make phones a viable tool for widespread participation in data collection.

Participation in data collection is not the only “participatory” part of “participatory sensing.” Techniques from the engineering tradition of participatory design - a distinct but politically sympathetic tradition to participatory research - might be another way to involve people in the goals and design of participatory sensing and mitigate the surveillant nature of pervasive mobile phone data collection. Traditionally formulated to help factory workers take control of the technologies entering their workplaces (Gregory 2003), participatory design has been adopted in everything from hospital databases to government e-services (Dearden, Lauener, Slack, Roast and Cassidy 2006; Pilemalm and Timpka 2008). Participant design methods emphasize enabling system end users to decide on the goals and functions of a set of technologies. Participation in sensing system design would let users shape the systems to collect data of interest to them.

Participation techniques should encompass not just system design (a first step) and data collection (the second), but data analysis. Tools to help individuals and groups analyze and learn from their own data will be critical to participatory sensing. The participatory research literature emphasizes the importance of cooperative data analysis so that even granular quantitative data can be understood by community co-investigators (Cargo and Mercer, 2008). Cooperative analysis strengthens the conclusions that can be drawn (academic experts may see some patterns; local knowledge experts may see others) and encourages co-learning between academic and community partners. Participatory sensing projects might incorporate creative visualizations to help people understand their data. For example, Your Flowing Data experiments with new visualizations and explanations: as the site says: “your.flowingdata was designed by a statistician, but you don’t have to be one to play with your data” (Yau 2010). Systems might provide natural language explanations of quantitative data to help people understand what their data say about them. A more advanced way to help users interpret their data would be to build a set of inference agents within the analysis software for a given project. Agents might keep track of who had access to what data, and give users reports about what each friend or third party application learns. Such devices to improve individuals’ *data literacy* – the knowledge needed to interact with and draw conclusions from quantitative data – can help people feel that their data are accessible, and will help them answer back to data collection authorities by understanding the meaning of their data.

Another important influence of data literacy will be an increased understanding of the limits of data. Pervasive sensing data are profuse, messy, and sometimes inaccurate. They describe a relatively narrow set of phenomena, and participants (or anyone else) can draw a limited number of statistically valid conclusions from those data. Moreover, sensing data are thoroughly constructed. Sensing systems portray their data as accurate and meaningful by design; however, data sets are often limited by the technological capabilities of the tools in use. For example, mobile phones can collect location but not actions within a location. An action, such as driving, or a meaning, such as tendency to overeat, must be inferred. Participatory analysis strengthens the tie between understanding the messiness and vagaries of data and resisting surveillance. As Ball (2006) writes, data surveillance can be politicized and resisted by problematizing the boundaries of what data can describe, and how data are coded. Error, bias, and category construction are important concepts in understanding quantitative sensing data. Participants with their hands in their own data will be faced with the limits of what data can describe, the difficult decisions

and political impacts of constructing categories, and the problems with taking data for truth (Bowker and Star 2000). Cultivating a public that understands not just the meaning of, but the problems with, quantitative data is part of what Ball (2006) describes as a politics of resistance.

Of course, there is a warning note about participation running through the surveillance literature. Encouraging participation in data collection does not always result in community documentation projects or citizen science initiatives. In fact, today's popular forms of "participatory" surveillance are broadcasting ourselves, enjoying the broadcasts of others, monitoring and holding accountable those around us (Green 2002) and reporting on neighbors (Andrejevic 2005; 2007). These examples suggest that participatory sensing could become another form of social surveillance emphasizing conformity and discipline. Perhaps participatory sensing would come to resemble a vigilante network, like China's "human flesh" search engines (Downey 2010). Several more conditions, including transparency and explicit social justice goals, are needed to form data collection projects which are truly empowering.

Transparency

Giving people local control over their data, and a participatory role in collection and analysis, are not complete steps towards democratizing data collections. Lyon posits that surveillance dangers lie in factors beyond centralized power, including invisible data collection frameworks and leaky data containers. To further defang their pernicious possibilities, ubiquitous data collection systems will need visible frameworks for collection, processing and analysis. They must also provide legible interfaces that illustrate data sharing and withholding decisions. And they must provide secure containers for the data they collect.

Visibility of data collection and sharing can be assisted by accountability and audit mechanisms to help users interpret where their data are flowing and who might have access. Auditing techniques can also provide participants with accountability for how their data are used (Weitzner et al. 2008). Audit mechanisms could be as simple as logs that reflect what data a phone or vault has sent to third party applications. A more complete form of feedback could take the form of a "TraceAudit": a trail of data use outside the vault, modeled after an internet traceroute ("Traceroute" 2009).⁷ Such a mechanism could begin to address individuals' lack of control once their data have left their phone or vault. This would require third party applications to log sharing or transformation of data back to the vault, according to terms agreed upon when an individual (or the vault on her behalf) contracts with the application. Audit mechanisms like the TraceAudit might go so far as to require accountability for data use from third party applications. A third party auditor or periodic certification of third parties might serve as an even stricter implementation of accountability (Shilton et al. 2009).

Social justice

Another distinction between participatory sensing and surveillance are the possibilities for projects that engage, and perhaps even lessen, social inequality. Participatory sensing can document phenomena previously too expensive or time consuming to research. It can be employed by anyone with a mobile phone, making it more accessible than even some of the most common methods used in community mapping and community organizing. An appeal to social justice goals such as community building and personal documentation set participatory sensing apart from traditional forms of surveillance, as well as explicitly anti-surveillance movements.

Participatory sensing has roots in previous movements to use surveillance to empower the disenfranchised, particularly movements like sousveillance (Mann, Fung and Lo 2006) and cop-watching (Huey, Walby and Doyle 2006). Unlike these movements, however, participatory sensing does not directly interfere with government and corporate surveillance. Instead, like participatory research movements,

⁷ The traceroute is a tool used to map the path of packets as they move through a network.

participatory sensing focuses on documentation of the self and community in order to answer back to powerful authorities. The concept of answering back highlights another important distinction: intention. Forms of social or interpersonal surveillance meant to entertain, scintillate, or report or inform on neighbors, for example, do not have explicit social justice goals (Andrejevic, 2007). These different intentions are reflected in different surveillance practices. Instead of focusing sensors on others, participants focus them on themselves. Instead of collecting and broadcasting video, participants might collect and analyze self-reports and share these with only a limited group. The next section explores how the social goals of participatory sensing affect concrete surveillance practices.

III. Building empowering surveillance at CENS

The Center for Embedded Networked Sensing (CENS) is one of a number of academic and industrial research labs focused on designing and implementing systems for participatory sensing and pervasive data collection. Based at UCLA, CENS has a team of roughly thirty students, staff and faculty working on system design and implementation. A majority of the team members are computer scientists and electrical engineers. But because mobile sensing questions intersect with human and social science concerns, the team has recruited researchers from outside of engineering, as well. CENS partners with health scientists, urban planners, and ecologists to design sensing projects. CENS has included social scientists since the Center's founding (Borgman, Wallis and Enyedy 2007). My research is made possible by this openness to interdisciplinary work. I have a position as a researcher within the participatory sensing team. I was hired three years ago to help deal with privacy challenges raised by team members and external advisors. As a team member, I have been able to closely observe and participate in CENS system design.

CENS provides a complex case study in the challenges of deploying empowering surveillance. CENS leaders regularly engage in deep and deliberate discussion of ethical issues. Data privacy and expanding participation in sensing are major personal concerns held by lab leaders. The team often debates thorny social issues such as consent, data retention limits, use of sensing systems by children, and even the relationship between participatory sensing and surveillance.⁸As a result, CENS has taken design and development positions which reflect possibilities for empowered surveillance. These include encouraging various forms of community participation, reshaping the architecture undergirding participatory sensing to distribute the power of data aggregation, and pursuing projects with explicit social justice goals.

A range of participation

At CENS, empowering surveillance begins with an emphasis on designing data collection systems that utilize the widely available and accessible mobile phone. Widely available devices cross race and income lines and help to address the digital divide both in the U.S. and abroad; while a relatively small percentage of the world has internet access, a much larger percentage has access to mobile phones (Kinkade and Verclas 2008; Smith 2010). Unlike traditional tools of surveillance (cameras, card readers or specialized data collection software) phones are cheap, easy to find, and easy to use, providing a foundation from which anyone can theoretically participate in a sensing project. CENS has undertaken a commitment to realistic and accessible participatory sensing by endeavoring to create sensing projects for all types of mobile phones. Although smartphones (with GPS capabilities and increasingly user-friendly touch screens) provide both attractive programming interfaces and data collection abilities, CENS projects also incorporate simple data collection (such as SMS messaging) which can be accomplished on less expensive devices. CENS has also committed to stretching the limits of what is possible with off-the-shelf devices, instead of adding expensive external sensors to phones. The center director parodies notorious surveillance advocate Donald Rumsfeld with the quote: "If you can't go to the field with the sensor you need, go with the sensor you have."

⁸ For example, a very lively hour-long discussion about the social impacts of our technologies occurred when I workshopped this paper with the participatory sensing team.

In addition to using accessible collection technologies, most lab projects explicitly focus on “human in the loop” sensing, giving individuals some measure of control over data collection and analysis processes. The project, titled What’sInvasive⁹, for instance, uses human recognition of plant species to target and locate invasive species in national parks. What’sInvasive partners with expert consultants from the National Park Service to design a system for use by park visitors. Visitors to California’s Channel Islands use their mobile phones to identify and photograph invasive plant species as they hike through the national park. These photos are automatically geo-tagged and uploaded to a park map, giving rangers a real-time picture of invasive plants in the islands. Hikers can find and “sense” invasive species much more accurately and cheaply than automated sensor networks.

AndWellness, another system under design at CENS, gives a different picture of the ways individuals can be kept in the sensing loop. AndWellness is a mobile service to improve personal health and wellness. CENS is designing the system in partnership with community health researchers and practitioners. The system helps clients work with a doctor, community health worker, therapist or dietician to document and interpret behavior patterns and indicators of health or disease. CENS is adapting AndWellness for a variety of pilot projects. One project uses a combination of activity patterns (walking, running, sitting, driving) and user-input “experience samples” (Csikszentmihalyi and Hunter 2003; Csikszentmihalyi and Larson 1987) to monitor cardiovascular risk factors among young mothers. Experience samples ask users to answer survey questions which record behaviors, such as their diet, stress, or exercise. Another pilot asks a population of users at high risk for contracting HIV to document risk behaviors such as sexual activity and drug use. After short periods of tracking and data analysis, users can see correlations between places, activities, and behaviors. With their doctors, study participants can use this data to plan interventions that target places and times where users routinely engage in unwanted behaviors. To encourage behavior change, AndWellness not only engages participants in data entry, but also in reviewing those data and learning from them over time.

The meaning of “participatory” in “participatory sensing” has been a topic of ongoing debate at CENS. As these projects illustrate, participation implies a range of behaviors, and a range of involvement in each project. In almost all CENS projects, a basic level of user participation requires user input (whether turning sensing on and off, taking a picture, or entering text) to target and restrain data collection. In projects such as AndWellness, users are involved not only with data collection, but in reviewing and reflecting on their data with guidance from a clinician.

Other CENS projects take a more expansive definition of “participation,” involving users throughout the design, sensing, and data analysis process. The Biketastic project was developed in cooperation with local bike advocates. Biketastic helps bikers plan safe routes and collect data to improve those routes. BikeTastic cyclists carry a GPS-enabled mobile phone during their commute. The phone also uses its accelerometer to document the roughness of the road, and takes audio samples to analyze noise along the route. Participants can also use the system to share information about their routes with other riders through a public website. The BikeTastic project began with a series of focus groups with area bike advocates to brainstorm system features. These advocates also volunteered as early pilot testers and gave feedback on the usefulness of system features (Reddy et al. 2010).

Two new projects, the Boyle Heights Participatory Sensing project and the Mobilize project, are perhaps the most participatory CENS undertakings to date. The Boyle Heights Participatory Sensing project goals are defined by community organizers from the mixed-income Los Angeles community of Boyle Heights. Residents use CENS technologies to document routes to school and work, the availability of health eating options, and gathering places for youth, as well as less desirable aspects of the community like safety hazards and poor housing conditions. At the end of the data collection period, Boyle Heights Planning for

⁹ <http://whatsinvasive.com/>

Place will use the data to create a healthy community plan. Residents and organizers, rather than CENS designers, have defined what to sense, when to collect data, and what will be done with that data.

Participation in data analysis is another important challenge for empowering surveillance. Techniques for participatory analysis remain among the difficult challenges in CENS development, focusing as they do on fostering data literacy among diverse user populations. The Mobilize deployment targets this question directly. Mobilize works with Los Angeles public high school teachers to integrate participatory sensing projects into computer science and math curricula. Students undertaking new sensing projects are engaged in defining data collection goals, building the tools necessary to reach those goals, and analyzing project outcomes. Mobilize targets data learning as part of a broader math and science curriculum among high school students. By introducing kids to mobile phone technologies, the Mobilize project helps to foster understanding of a new kind of research, and new kinds of data, among high school students from predominantly underprivileged communities. As the project organizers wrote in their proposal:

At its heart, participatory sensing is about data collection and interpretation—with the type of information collected, how it is organized, and how it is ultimately used determined by the participants themselves.

Architectures for local control and transparency

The availability and range of data collection enabled by mobile phones provides a unique base for participatory, rather than surveillant, data collection. In an attempt to enable empowering surveillance by further democratizing data collections, CENS is working on alternatives for increasing participant control of storage, processing and analysis.

In early CENS systems, data flowed from a participant's phone directly to a sensing application provider (in this case, CENS servers). This positions application developers as powerful data aggregators. That model struck the team working on privacy issues as backward. We began work on the Personal Data Vault (PDV), discussed above, explicitly intending to democratize the process. The vault is built to sustain the values (local control, participation and transparency) discussed here, translated as design principles. We hope that a vault architecture will help individuals foster as sense of ownership over their data, treating the data as resources to be collected, monitored, and shared judiciously (Shilton et al. 2009). We also intend that the vault provide a place for individuals to reflect on their data double, transforming data collection from an outside gaze into a process of self reflection, awareness and identity building. The PDV can provide an interface to data collected in both AndWellness *and* Mobilize, for example. Observing how your eating habits are affected by your commute, or considering the health effects of air pollution and exercise, could both be data double contemplations enabled by the PDV. Future vault applications could include an inference engine, which might help users understand which data the vault had shared, and what might be inferred about them by others from those shared data. In this way, the vault can serve not just a data diary, but as a tool to track and peer into the data others may be holding about an individual.

Another trajectory at CENS has been the endeavor to match engineering research challenges to issues of local control. At least one graduate student is writing a computer science dissertation on advanced privacy filters that would allow data vault users to better match sharing preferences to their daily lives and realities. The leadership team has also brainstormed systems that would allow vault users to negotiate with third parties to reveal less granular data, and even vault mechanisms that would allow users to send machine-generated data for time periods in which they wished not to reveal real location data (Mun et al. 2009). Building the ability to “lie” with machine-generated data also points users toward the construction of definitions of accurate or “true” data by the system, further encouraging participants to understand the limits of self-surveillance data.

Addressing social justice

CENS writings, grant proposals, and selection of projects have undertaken a broad social justice agenda. The center director has described health applications as the “killer apps” for participatory sensing, and projects that specifically address health disparities (among low-income mothers and HIV positive young men, for example) are among the first health studies targeted by CENS projects. Other projects envision public interest initiatives, envisioning potential for technological platforms for advocacy—“making a case” through distributed documentation of some need. Biketastic, for example, aims to create better maps of bike routes in the famously car-centric city of Los Angeles. The project is a low-cost, real time way to documents areas where city planners could improve existing conditions or increase access through new routes. The Mobilize project aims to put participatory sensing technologies to work in under-resourced computer science and math classrooms in L.A.’s public schools. Finally, the Boyle Heights Participatory Sensing project directly engages questions of race, class, and accessibility while targeting goals of community participation and improvement.

IV. Challenges

CENS lab goals highlight social justice and empowerment, and concrete work on sensing tools and architectures has broadened the spectrum of who can participate in sensing. But the risks of pervasive data collection are made more complicated by a variety of factors. A number of structural challenges complicate the project of empowering surveillance. Some of the techniques for empowerment, such as participatory design, are ideal goals that are difficult to fully implement in practice. The design lab must also weigh values of efficiency and production and early-stage design focus on systems rather than data, all of which compete with a focus on empowerment. Serious challenges to empowerment come from the complex network outside of the CENS lab involved in collecting and transporting participatory sensing data. And finally, sensing projects raise questions of the thin line between self-surveillance, discipline, and empowerment.

Working with users

Motivating student designers to work within participatory frameworks has its challenges. This is no surprise. There is a large literature on the difficulties of participatory design. These range from the logistic—how to describe systems to users, how to translate user ideas into features—to the cultural (Hornecker et al. 2006; Kensing and Blomberg 1998; Pilemalm and Timpka 2008). Such design practices are often slow and involve many rounds of sometimes frustrating iteration. These practices are perhaps least suited to the quick pace and technical pressures of emerging technologies (Shilton et al., 2008). Finding well-suited partner organizations, and the funding to support long-term collaborations, is an ongoing challenge. More than one project idea has been abandoned due to lack of fit between designers and community organizers, or lack of resources to continue a partnership.

These tensions were illustrated in my observations of Biketastic, which was designed in partnership with Los Angeles bicycle advocates. Biketastic was fueled by the personal and work interests of a small team of CENS developers. The developers had some experience as cyclists, and an interest in applying their work to bike transit challenges. As the project received no outside funding, the designers were only able to give it full-time design attention for a few months. Biketastic developers liked the idea of seeking advice from bike advocates, and found several sets of expert Los Angeles bikers with whom to consult. But time constraints and the demands of other projects made them reluctant to undertake the considerable logistical effort required to organize design meetings, focus groups, and pilot trials. Community members, who were volunteering their time as well, proved equally difficult to corral for meetings and advice.

While meetings with bike advocates produced a number of useful and creative ideas, technical limitations circumscribed the feature set that the design team was able to produce. For example, bikers prioritized a mash-up of routes with real-time traffic information. But because designers could not find a compatible

source of traffic data, this feature remained outside the realm of possibility. Designers instead tried to meet biker wishes by approximating traffic along a route using noise readings taken with the phone microphone. This was a creative use of the available tools, but received mixed reviews from pilot testers (Reddy et al., 2010). This was one of several examples of bikers holding expectations for sensing capabilities difficult to meet with available technologies.

Feedback sessions between bikers and developers could also be tense. Developers felt the need to defend each design decision challenged by the bikers. A designer explained his defensive reactions, indicating that he believed it important to educate the pilot testers on the design team's reasoning and the limitations of the technology.

Finally, Biketastic has reached stasis due to a lack of external funding. Funding guarantees graduate students to work on a project, full-time staff to concentrate on duties unwanted by, or unsuited to, graduate students, and resources such as phones and server space to devote to a project. Funding also facilitates interaction with clients and community members, as clients may need to be reimbursed for time spent organizing support, attending meetings, or pilot testing. Though the developers feel satisfied by the system they have built, there is no ongoing support for updates, improvements, or continuing work with cyclist communities.

CENS is fortunate to have an organizational culture which values client collaboration and user input. Leaders emphasize and approve projects with committed outside partners, and encourage students to work with those partners. However, the time and motivational pressures that make participatory design challenging for students indicate that such design practices will continue to be a hurdle. If a focus on user-centered or participatory design is critical to empowering surveillance, more accessible methods that appeal to both designers and user groups will be necessary. Designers must work hard to find a match with users who have the time and interest to invest in a participatory design process. At the same time, users must be open to quirky interfaces, occasional bugs, and technical limitations. And project leaders (as well as administrators and funders) must reduce time pressure on students and accept participatory design as a generator of innovation and not a chore. Funders must also recognize the importance of long-term community-researcher partnerships – a problem in much of participatory research and participatory design (Horowitz et al., 2009; Cargo and Mercer, 2008).

Competing values in design

The mixed success of participatory design practices points to a problem of competing values in the CENS design space. CENS designers truly value participation, transparency, and social justice goals. But they also face significant competing values that sometimes outweigh ethical principles. There are technical limitations on the projects and system features that designers can pursue. The team works with a limited number of phones to distribute to pilot testers, and those off-the-shelf phones have restricted features. Team members face pressures to move their design process along quickly, and sometimes values-based design is seen as an impediment to quick progress. Students eager for success as academics face stringent deadlines and pressure to publish their ideas before anyone else does. These features of the constant pressures of technical innovation often combine to make a slower, stickier, values-oriented design process unattractive.

An example of the tensions between deadlines and values-based design occurred during construction of the PEIR system. PEIR tracked an enormous amount of personal data, recording latitude and longitude readings every thirty seconds and translating these data points into activities (walking, driving, staying still, etc). The team agreed early in system development that it should enforce data retention policies, keeping raw data for only six months at a time. But the PEIR team suffered from staff turnover, strict paper deadlines, and a frenzied push to get the system running before a national technology exhibition. The data retention plan was continually moved to the back burner, and in the end, was never implemented.

Features for restricting data sharing and use, or obscuring or falsifying data, are typically implemented in real systems much less quickly than features needed for acquiring data.

Early stage design

Design values that compete with local control, participation, transparency and social justice are amplified by a structural feature of the CENS design space: the nature of the experimental, early-stage design process. The realities of early-stage design lead to an important disconnect between focus on building software, and focus on the *data* that are the heart of participatory sensing. Most of the issues that intersect ethics, surveillance and empowerment revolve around what data are collected, and who aggregates and interprets those data. Data lie at the base of privacy concerns and each of the empowerment mechanisms I have discussed. However, in interviews and meetings with CENS student designers, it became apparent that the realities of early-stage design make data a secondary concern. CENS graduate students are responsible for building new systems, and as a result focus largely on the algorithms and storage undergirding and surrounding the data.¹⁰ Their research posits how to build these algorithms and database structures more elegantly, quickly, and efficiently. In each of my interviews with graduate student designers, I asked who was in charge of the data collected during a given project. The answers were often quite murky, with responsibility distributed between several designers or ignored altogether. This focus on systems, and resulting de-emphasis on data, reflects the early stage of CENS participatory sensing design. This is consistent with findings of previous studies of CENS development, in which early attention to systems for scientific data gathering gave way to attention to scientific data as the development process matured (Borgman, Wallis, Mayernik, and Pepe 2007).

The problem with focusing on algorithms, rather than data, is that the algorithms are often seen as ethically neutral, while data are more obviously problematic. As Los writes:

The technicistic approach that prevails in global surveillance culture and likely affects programmers, managers and users of surveillance systems removes these systems' codes and scripts from the scope of moral reflection. These truncated, de-humanized and de-socialized scripts appear as 'given' and acquire a very positivistic air (2006, 89).

By focusing on code, and considering ethical issues as a problem of data, developers risk neglecting ethical inquiry by placing such inquiry out of the scope of their design practice. A CENS example illustrates this relationship between focusing on data and realizing surveillance problems. After participating in a data collection pilot for AndWellness, a developer, previously blasé about issues of privacy and surveillance, wrote: "Just browsing the survey questions, I now understand how critical privacy is for such an application." The kinds of data under request (including location as well as questions about eating, sleeping and exercise habits) made the surveillance and privacy concerns concrete for the designer in a way that constructing algorithms had not.

Resources and funding also make a difference in attention to data and the larger ethical concerns engendered in that data. Larger, better funded participatory sensing projects like AndWellness have correspondingly large development teams. Because the teams are large, they require formal weekly planning meetings and fairly clear lines of communication. Ethics issues tend to come up in these meetings, due to a variety of factors. CENS leaders are often in these meetings, as am I. In addition, the discussions fostered by a larger group of people tend to reveal worries and opinions, which then become design concerns. The design of larger systems contrasts to projects like WhatsInvasive and Biketastic, which have little or no initial funding and only two or three developers. Design meetings for these projects are informal and often spur-of-the-moment. Leaders and team members communicate about these projects largely over email. The less complex systems (which harbor less obviously sensitive data) are perceived to

¹⁰ As a lab leader explained to me: "Understand that there would *be* no data without first having a system."

need less planning in advance. And fewer ethical concerns surface in the discussions of the small working team. As participatory sensing progresses to more mature design and projects, some of these issues will be addressed. However, developers working on small-scale and amateur projects may be challenged to rethink the design process and put equal emphasis on data and systems.

Challenges to social justice goals

Harder to discuss, but important to recognize, are challenges created by the laudable goals of using participatory sensing to benefit underserved or marginalized populations. This focus creates an uncomfortable question. Is the CENS emphasis on using participatory sensing tools with marginalized or at-risk populations (such as HIV positive young men or urban high school students) actually increasing the surveillance of these populations? Could sensing projects compound instead of address structural inequalities? If empowering goals falter – or if police or immigration authorities subpoena CENS data – has the social experiment actually increased the vulnerability of these populations to control and discipline? Increased data gathering among marginalized communities could risk increasing what Gandy (1993) refers to as the ‘panoptic sort’ – segmenting people according to their social address. I witnessed a stark illustration of this issue when I presented to Communities for a Better Environment (CBE), an environmental justice advocacy group in East Los Angeles. The advocates around the table included youth leaders from a predominantly Latino neighborhood. The youth reaction to CENS sensing technologies was firm: “No way.” When they realized the phones would track their location, they became convinced that police or immigration authorities would demand the data. A second project with a demographically similar community in the Boyle Heights neighborhood of Los Angeles raised similar concerns. This project was able to move forward, but only after CENS helped allay participant concerns through measures to protect anonymity. The project used loaned phones instead of participants’ own phones, and shared those phones widely without tracking who borrowed which phone. These two communities of color, targeted by authorities in a way UCLA researchers rarely are, immediately sensed the concerns of equity, power, and surveillance that participatory sensing can raise. Although these reactions are anecdotal, they are worth considering, as they point to potential pernicious effects of undertaking data collection projects in the name of social justice.

CENS’ focus on participatory projects attempts to mitigate concerns about power and equity, but it is also important to note that participatory projects do not have an unblemished social history. As Cooke and Kothari (2001) write in *Participation: The New Tyranny?* participatory methods are sometimes used by governments or corporate interests to validate development projects which serve to control, rather than empower, marginalized populations. Cooke and Kothari use their edited collection to document economic development projects in which ritualistic notions of “participation” became a cynical means to justify manipulation of marginalized populations. Similar critiques have arisen of the practice of incorporating participatory methods into the design of geographic information systems (Elwood, 2006). In addition, participatory processes add work – sometimes lots of work – for participants. Participants once protected by features such as confidentiality under IRB-approved traditional research projects must now be actively involved in managing and organizing their own data. Participation demands volunteer effort, and therefore may privilege those with time and resources to spare. Constant self-reflection on the motivations behind participatory sensing, and honest appraisal of who benefits from sensing, will be necessary to ensure that participation is not a puppet, and that participatory sensing continues to serve social justice interests.

Ethics in a network: constraints beyond the lab

Though ethics of participation, local control, and transparency regularly intersect with design, participatory sensing engineers do not have unlimited agency to “solve” these challenges. Several networks and infrastructures surrounding participatory sensing affect the degrees of freedom that designers have to resolve ethical issues and embed their own values. While values decisions remain critically important to the project of participatory sensing, the agency of designers is necessarily constrained by a number of social, infrastructural, and technical factors.

One factor affecting participatory sensing design is the fact that mobile phone manufacturers control hardware and phone operating systems, creating potential barriers for designers. Operating systems may pose technical limits on how users may collect data (for example, the iPhone's prohibition on running programs in the background, limiting when and where data can be collected). Hardware controls what types of data can be collected (geotagged images, accelerometer, GPS vs. cell-tower, etc) and therefore what projects are undertaken. Mobile phone manufacturers also provide software for phones, including data collection software (e.g. Nokia's Nokoscope). Participatory sensing designers who adopt such software to facilitate data collection will inherit defaults such as resolution of data collected, how data are stored and with whom they are shared.

Another factor that limits the ethical agency of participatory sensing designers is a lack of control over the infrastructure on which participatory sensing rests. Wireless carriers provide the networks on which sensing data travel, and in many cases, collect data similar or identical to those collected in participatory sensing. While common carrier law, as well as security measures like encryption, prevent access to the content of messages flowing through these channels, telemetry (like location) falls outside of this protection, even though location is in itself useful and sensitive data (Waldo, Lin and Millett 2007). Similarly, function creep, such as when data gathered for emergency services are sold to advertisers, is an ongoing worry for such sensitive data (Curry et al. 2004). Protections for data collected about and over the mobile network are still in flux, but the legal landscape does not look promising for data protections and individual control (Green and Smith 2004; Waldo et al. 2007). The U.S. Department of Justice is currently appealing a court ruling that prohibits law enforcement from compelling providers to release user location data without a warrant (Freiwald and Swire 2009).

Finally, even where intentions are good, the granular data collected during participatory sensing projects are easily shared, subpoenaed, or stolen. It is also incredibly difficult to delete data once they have reached "the cloud" (Bannon 2006). Emerging, experimental techniques to make data "disappear" (Perlman 2005) are both complicated to implement and do not delete data shared with servers beyond a user or single application's control. Good faith efforts to pursue democratized data collection and empowering surveillance may be stymied by the nature of data sharing in a complex network of government regulations, carriers, application providers, and individual users.

Self-discipline and empowerment

As Vaz and Bruno write, "there is no neat line distinguishing power from care" (2003, 273). Empowering surveillance is also self-surveillance, which often focuses upon deviance in the body or the community that social pressures dictate must be rectified. CENS projects such as AndWellness assume an agenda of healthier eating or better adherence to wellness practices; projects such as Mobilize (or the more obviously punitive CitySourced) seek to document community blight alongside positive attributes. Though there are few studies of data-intensive self-tracking, there are signs that such practices can become obsessive forms of self-discipline. Entries on self-quantification blogs such as "The Quantified Self" discuss not only the joys and discovery of self-tracking, but also obsessive behaviors surrounding weight and exercise that self-tracking can feed (Carmichael 2010). In this light, participatory sensing can be seen as an heir to Foucault's vision of surveillance over individuals. In *Discipline and Punish* (1979), Foucault describes the historical transition from exiling the mad or the sick to "institutions for measuring, supervising and correcting the abnormal... to brand [the individual] and to alter him..." (1979, 199-200). This new form of power, enforced through surveillance, continues to this day. Foucault's concern for techniques and institutions for measuring and supervising necessarily extends to participatory sensing, no matter how distributed the architecture or deep the community participation.

But though it has undeniable disciplinary effects, participatory sensing does more than just brand and alter the individual. Data collection for and by the self targets social norms to which the subject agrees or even desires. Though these desires may be socially constructed and enforced, this does avoid the totalitarianism

that occurs in a panoptic scenario, when subjects under surveillance feel the need to conform to norms with which they do not identify and would not choose (Vaz and Bruno 2003). Indeed, participatory sensing has the potential to do more than simply help individuals comply with consensual social norms. Its focus on participation in defining data collection and understanding the meaning of sorting and analysis could enable individuals to identify that they are in fact the subject of such social pressures. This is where participatory sensing diverges from Foucault's disciplinary visions: it recognizes the agency of individuals within the mechanisms of surveillance. Participatory sensing does not deny that social forces press on deviant bodies or construct the homeless as a 'nuisance.' But through a focus on participation, it proposes that individuals can learn to recognize such pressures through ongoing interactions with the realities and limits of data collection. By becoming directly involved in the very real messiness of surveillance, individuals have much more agency to stop and start surveillance, and to believe, ignore, or even challenge the resulting branding.

V. Conclusion: An ethics of empowerment

Surveillance has moved into spheres beyond government and state power. In *Surveillance Society*, Lyon (2001) writes:

Surveillance is diffusing decisively into society at large, although it should be noted that this does not mean that the capacity to answer back has now exceeded the power of state surveillance upon its citizens (33).

This suggests that, one day, "the capacity to answer back" could be realized. We have not reached that point in 2010, but the emergence of participatory sensing brings us closer to such a possibility.

Participatory sensing will coexist with broad data surveillance by corporations and governments, and may also be used towards pernicious ends. But, with its emphasis on participation and targeted collection, participatory sensing may simultaneously give people their own way to use tools and platforms of surveillance. Participatory sensing, when developed with a focus on local control, participation, transparency, and social justice, emphasizes learning, messiness, and experimentation rather than rigid categories and conformity. This is why empowering surveillance is not just possible, but desirable.

As CENS has matured, new projects suggest that such goals are possible. The Boyle Heights Participatory Sensing project is one of the first in which these ideals are approached. Funding from a progressive foundation enables community organizers with explicit social justice goals to manage and run the project, and control project resources. Designers and organizers are working together and using sufficiently mature technologies to ensure local control of the data, participation by affected community members, and transparency of the sensing process. Such values, when translated into design and engagement practices, can create an ethics of empowerment for surveillance technologies.

This paper doesn't ask whether an outcome of empowering surveillance will be prevalent, or even likely. It only asks if it is possible, and if possible, valuable. The challenges I present here point to how difficult it will be. Nevertheless, reappropriating surveillance tools for empowerment is both feasible and desirable. CENS provides an incredibly particular instance, joining specific personalities, politics, design goals, funding and purpose. But their efforts illustrate an interest in empowering surveillance at the design level, and a willingness to address the conditions that might foster empowering surveillance. If system designers can raise ethics of empowerment, including focus on local control, participation, transparency and social justice, to top priorities in design, we can build systems which meet the requirements for empowering surveillance.

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