Ambient Intelligence in the City
overview and new perspectives

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Abstract This text attempts to address deficits in the way ambient intelligence conceives of and designs for urban environments. It begins with an overview of issues surrounding ambient intelligence in the city, followed by critical voices and examples of alternative ambient intelligence systems. The text argues for the inclusion of pervasive sensing issues into urban planning, in particular to negotiate between private and public interests.

1 Overview and motivation and limitations

Ambient intelligence has the potential for improving urban life specifically and the commonwealth in general. As artists and architects working in and with ambient intelligence, our hopes and anxieties towards ambient intelligence are not primarily in the technical domain. Our interest lies in re-making urbanity with pervasive technologies as a means to invigorate urban life. For this we need to take a break, after almost two decades of ambient intelligence related research, and recalibrate all instruments.

We use the term ambient intelligence, coined by *Philips* to describe a future in which people are surrounded with networked sensors embedded in everyday objects that respond to their needs in a loose manner. We are not particularly concerned with the demarcation lines between ambient intelligence, ubiquitous computing, calm computing, pervasive computing and amateur computing. From our perspective efforts emanating from all of these fields modulate urban life and their effects overlap and reinforce one another.

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This text will weave its way through many topics, including contributions from political philosophy that are usually not included in debating merits and weaknesses of ambient intelligence systems in engineering publications. Some issues will remain untouched, others treated more lightly than they deserve to be. Our goal is to take stock of critical voices and expand the discussions around ambient sensing and control in the city to a conceptual kit for thinking about building livable cities for the 21st century.

2 Ambient intelligence and urbanism – a reality check

Ambient Intelligence (AmI) has been for the past years an ambitious project, one that includes the home, office, library, museum, department store, hospital, airport, as well as the infrastructures that support them [1]. AmI's scope covers all aspects of living, including work, leisure, healthcare and transportation. Many of the locations AmI has set its sights on are core components of the city as we know it and live it.

AmI in the city is in some ways the Situationists' dream come true [78], [27]. Constant's projects for *New Babylon* (1957-72), like all the utopian projects by Cedric Price, Archigram and Superstudio that it influenced, seem much less unrealistic today because it is now possible to design and build milieus that interact with their inhabitants directly and intimately. Doors to new urban activities are now open that allow people to share space like they share data on a network [62].

AmI in the city is a step further in the direction of ephemeralization: doing more with less as Buckminster Fuller described technical progress. As steel-and-glass has replaced brick-and-mortar, data flows change material objects, partially fulfilling prophesies of observers of the history of modernity such as Berman [10] who predicted that "all that is solid melts into air". Urbanity today is as much a function of transmitted data as it is of built houses, streets and monuments [65]. Social contacts can be easily made and selectively maintained with ubiquitous technologies [11], [65], [64], [32]. Even one's presence is altered via ambient micro blogging utilities that aggregate continuous streams of short sentences to new forms of presence some compare to Extra Sensory Perception [85], [86], [87].

AmI in the city is also the end of the virtual city. SimCity Societies [96], the sequel to the blockbuster city building simulation game SimCity [95] promised to simulate social forces and cultures at work in a city. But several players and reviewers were lukewarm about the result. "There is something not quite right with SimCity Societies", so VanOrd in the online game review site *Gamespot* [89]. Players design city societies by composing through the choice of buildings of various types and opposing forces. Need more stringent rules? Add a town hall. Need more authority? Add a police station. Thre is a disconnect between the elaborate visualization of urbanity and 'social forces' that are to be created from within the built structures.

Simulations have limits and materiality is bound to return with a vengeance. The increasingly popularity of locative utilities such as GPS for geotagged information and the rise of location based activities and services [72] mark parallel efforts to reintegrate the real world into databased abstractions. AmI is part of the next wave of systems defining a new shared reality.

AmI in the city also increases sustainability: The world's first 100 per cent carbon free community will be built in Masdar near Abu Dhabi by Foster and Partners [37]. Behind the mix of traditional (oriental) and modern (western) architecture, electronic networks control waste, water, traffic, and energy. Masdar (UAE, 2007 by Foster + Partners , Ras Al Khaimah (UAE. 2004-) and Waterfront City (UAE, 2008-) both by Rem Koolhaas with OMA, Dongtan (China, 2005-) by Arup, Logroño (Spain, 2008-) by MVRDV and others are perfect 'ecological solutions' that push all other urban issues aside. Sustainability cum AmI has formed a solid and successful coalition with the global economy. With advanced adaptive climate control, even the most uninhabitable places can put themselves on the global map. Who can question the merits of skiing in the desert if the artificially generated climate is CO2-neutral?

AmI in the city is a new form of production of space: Cities used to be functions of power, industrial production and commerce [58]. Now they are functions of consumerism, security and culture. AmI accelerates this trend. Consumption, security and culture are now the key issues organizing urban life. Each of them is related to the space of flows [15], altering the constraints of exchange across physical distance and the institutions that organize it. What the cathedrals were for the middle ages, the airport is today: the most extensive and complex built projects of your times [80]. In the case of the consumer world, a seamless transition from the global to the local stage is required. The fact that the infrastructure that makes the accompaning securitization efforts possible has slipped into the background [94] only proves how successfully and effectively pervasive sensing systems are operating.

Without a doubt AmI intensifies urban life. Some see the built city, qua city, as old fashioned [32] while urbanists make use of AmI technologies without considering the consequences for its inhabitants. As successful a marriage as AmI and urbanism should logically be, a second look reveals serious discord. AmI in the city has the potential of harming the very thing it should promote. People become data objects [50]. The interactive spaces provided by ambient systems are reduced to spectacle [24], and the ephemeralization itself increases junkspace [51]. Sustainability breads totalitarian immersion [23], [79]. What was elegantly delegated into the background returns to the forefront with a vengeance. AmI in the city is like *Sex in the City*. In both cases the public becomes a feeding ground for private needs. While the protagonists in the TV-show have to actively seek new opportunities, the AmI enabled city directly supports its customers, reducing the public to public access [76].

AmI in the city is not an isolated phenomenon. The dialectics between private interests and public domain are to be found in many aspects of our lives. Economic privatization and the wish for and perceived need of one's own home creates in its wake a retreat from public life. AmI home automation systems partake in the "rhetorics of privatization" by promising to deliver technologies that are so effective one need not leave the house anymore. However, being networked with the world is not equivalent to participating in it. The advantage of having your shopping done automatically and never having to stand in line at the store will result in not meeting anyone standing in line at the store, or anywhere else for that matter.

Many academics, when describing the impact of AmI refer to sociologists like Henri Lefebvre and Michel de Certeau. [32]. Guided by these authors, they describe the new urban reality predominantly as a multiplication and intensification of social dynamics. But in the view of political philosophy the public has a different meaning. Here, the public is characterized by antagonism instead of by shared interests. Martin Heidegger, for example, interpreted the *res* of the *res publica* as a thing that has the power to bring together what it separates [45]. In this tradition Bruno Latour wrote: "We don't assemble because we agree, look alike, feel good, are socially compatible or wish to fuse together but because we are brought by divisive matters of concern into some neutral, isolated place in order to come to some sort of provisional makeshift (dis)agreement" [56].

3 Ambient intelligence and philosophies of technology

Social scientists, political philosophers and historians of technology have a long history of reflecting on the many ways in which technologies impinge on daily life. Mumford [68], Giedion [43], Ellul [28], Feenberg [33] and others have formulated selective accounts of how automation technologies change the fabric of human life on individual, group and public levels. While some of the details of these texts are no longer relevant, many of the general observations remain valid. Ellul in particular retains a following (in addition to some critics) precisely because his concern is more focused on the 'big picture'. For example, Ellul used the term *convergence* of technologies to describe the multiplicative effect of adding several technical components into a single, larger system. Indeed, the ease of living through interwoven technical systems that is at the core of AmI is a form of Ellulian convergence. Smart kitchens in sync with energy management systems function quietly while people relax in the living room watching movies on demand. Convergence however can cut two ways. It produces an effect more powerful than the sum of its individual parts, but also increases the opacity of the system. Convergence creates a kind of background discomfort, even when everything seems to be working just fine. Ellul also reminds us that no technology can really liberate us (from other technologies). AmI rests on the unarticulated assumption that 'smart' technology is inherently better that 'dumb' (old) technology, and that our lives will be better with new smart

systems. Ellul points out that the only basis for this belief is the lack of tested alternatives.

Ellul's observations on the dynamics between the public and private domains under the influence of technologies retain validity in the context of AmI in the city. When technology enters the public domain, it receives new mandates for which it is not properly prepared. Technologies change in the hands of corporations and states. They change because the state is charged not only with maintaining law and order, but also with establishing just relations amongst its citizens. It therefore imposes limitations on pure technique (in the Ellulian sense) of private persons, such as forbidding the free manufacture of explosives and drugs while maintaining the right to do so itself. Ellul reminds us to differentiate between the making of technique and the politics of technique, between technique as a domain specific solution and its embedding in the world. The problems of the second act are not part of the design process of the first one. How technologies are applied defines how we come to live with them [3], [4]. Furthermore, failing to consider the dynamics of this second act tends to upset the balance of private and public responsibilities, and AmI in the city is subject to these same dynamics.

In *Medienkultur*, Flusser asks how politics change under the impact of technology, such as artificial intelligence [36]. Flusser understands that the most important changes made to public space through technology are not those changes directly intended, but the (long term) side effects that alter the way one thinks about public and urban space. While Flusser claims that the information revolution diminishes public space, he understands that this is really a function of how the revolution occurs, how the networks are built and who controls them. The ability to understand and modify the way the system works is dependent, so Flusser, on technological literacy: "Die grundlegende Frage ist ... die des Schaltplans der Kanäle". Flusser calls for something like Agre's critical technical practice [2], [4] but a public one. What is needed, according to Flusser, is a dialog-based circuit for information transmission. Andrew Feenberg [33] pushes the call for dialog in technical design even further. Feenberg rejects Ellul's essentialist and reductivist theories of technology and sees technology as a contested field where individuals and social groups can struggle to influence and change technological design, uses, and meanings. Feenberg advocates for democratic debate in situating, limiting and controlling technical systems such as (some) environmental advocacy groups already demand. This grass roots based opportunity for the *reconstruction* of technologies is at the core of Feenberg's line of argumentation.

The question of interest here is how AmI might be (re)constructed – who draws up the plans and how this might occur in the context of the city. Without a clearer notion of this we can hardly hope to design and build socially robust ambient systems. In particular the traditional delimitations of private versus public interests seem at risk. Ubiquitous technologies open public domains more and more to private corporations, while private living rooms and desktops become public market

places. Ubiquitous technologies at their worst favor individual interests over those of the commonwealth in ways older systems never could. Hanna Arendt compared the public sphere to a table, something that connects us as we sit around it. In *The Human Condition*, Arendt formulated two theses on the public that receive new significance under AmI. [7]. The first one states that technical progress increases the sphere of influence of individuals while that of the public domain recedes. The second one states that the private sphere and the public sphere are interdependent, and that the two domains require a balancing act in order to remain in equilibrium. Bruno Latour [55] suggests we build a *parliament of things*, open to all and everything, including humans beings, animals, plants, insects and inanimate objects to balance our new situation. Indeed, in such a parliament of things, AmI could play a very important role because it could help to articulate the intelligence, the rights and the agency of the ambient. Decried by some as naiv, by others as visionary, Latour's *parliament of things* retains radical appeal. And radical are the changes we need, we believe, for today we are no where close to balancing out the dynamics emanating from AmI in the city.

4 Out of balance

With a history of suspicions towards large scale technical systems in public spaces, AmI and the humanities seem predestined to clash. Sure enough, even a cursory search through some ambitious ambient and ubiquitous intelligence projects launched in the last few years stokes this fire. The final report of the European Union's Information Society Directorate in 2001 [49] is verbose on usage scenarios but mostly silent on qualitative content of ambient systems of the future. While this important document does acknowledge the need for building AmI upon a "humanist foundation", it erects the foundation at the wrong spot: the user interface. But the roots of long term perspective this text seeks to address run much deeper.

4.1 Hydra's new heads

The University of Notre Dam's *Hydra* project [16] is an example of the kind of 'smart' system designed for public spaces hat would make any critical observer shudder. Hydra, funded in part by the US Department of Defense, is a military and urban surveillance system that attempts to combine a number of uncoordinated video surveillance camera views of scenes from different locations in order to deduce a "global threat". From the project website we read the following:

"Uncertain scene recognition from any single view is checked and validated with potential captures from another angle in order to improve the recognition accuracy. Our infrastructure widely deploys a number of high fidelity video sensors and stores

all the captured streams for certain well defined durations. These sensors are deployed as necessary in an ad hoc fashion. Smarter sensors and computer hubs can then analyze these stored streams to detect and review emerging threats, or potentially capture events that are easily missed by simpler and real time algorithms."

Like the mythical Hydra, this system is designed with robustness against the loss of one of its parts. E-hydra can operate even when the video sensing or the processing components are compromised. The system designers were creative in their expansion of surveillance methods, coining the terms *retrospective surveillance* and *telepostsence*. Retrospective surveillance attempts to review captured scenes from several sites in order to validate whether a hint of threat detected at one site is part of a larger pattern. Telepostsence is defined as the selective combining and rejecting of small video segments from a larger stream to create a unique multimedia experience (a summary video). Technically impressive as these preemptive surveillance schemes appear, they assume that the early elements of threat can be clearly defined. What would constitute such a threat primitive in a busy city, and how would one be able to filter false positive results from the final elegantly composed summary video stream, particularly when the original footage is discarded? This E-hydra monster may grow additional heads even without having its current ones chopped off.

4.2 Information cities

'Information cities' has been used by software architecture researchers [34] to describe cities not limited by physical boundaries. Information cities facilitate the access and exchange of information related to services usually provided by cities through web services. The concept imagines the city on servers becoming a full scale urban institution replacing, eventually, all public services and expanding into commerce, emergency services, health care as well as cultural and social activities. This changes buildings and by extension the city because they now function not only as material but also as data carriers as Mitchell mentions in *City of Bits* [65]. Ebay, Yahoo and similar portals are prototype information cities that have no shells but house and entertain millions of inhabitants 24 hours a day all over the world.

But not all of what is built is melting into air. Public life is imploding into the private living room. From the comfort of your home you can perform your duties as citizen, your needs as consumer as well as your dreams as a tourist. Because the information city is where your living room is, your living room can be anywhere. People who stay at home during their vacation and enjoy a staycation might opt to travel with utilities such as *Easier-Travel.com* and live off other peoples' vacation memories [13]. Energy price increases have discouraged some, but not all mobile McMansion RV owners from taking their Italian marble-floored, high-tech controlled, window-size flat-screen high-definition television enabled and satellite connected systems on the road [77].

An architectonic consequence of applied information displays applied to buildings is that facades have become fashion statements. Buildings, however ambitious the initial project, tend to fall out of favor after 25 years as is now the case in Frankfurt's Museum für Moderne Kunst [93]. In this vein one can imagine future cities to be designed with durable infrastructures for transportation, water, electricity, waste management, communication and surveillance while the visible architecture skins change as frequently as the society of spectacle desires [24]. Architecture then becomes media-production, encouraged and defined by the fad of the day. Facades become billboards rather than interfaces. If information is piped in only one direction from the emitter to the consumer, then cities "could support an as yet unimaginable form of totalitarism" [35].

The impact of intelligent information systems on architecture can also be observed in the development of Computer Aided Design (CAD). While CAD was first used for designing the appearance of a building, it is now used for organization and environmental control in buildings [46]. Evolutionary design approaches, gleaned from adaptive systems control and data analysis, have been integrated into architectural design [39]. Fuller and Haque's proposal [40] to consider the design dynamics in open source software as a model for architectural design and urban planning belongs to the same genealogy. Inspired by the FLOSS (Free, Libre or Open Source Software) movement, the authors suggest the equivalent of an open source license for the construction of cities. This includes altering the role of the architect from an 'idealizer' of form to a 'facilitator' of design processes. Architecture should begin immediately with building and construction. In urban planning the notion of plan completeness does not exist. The same quality characterizes Cedric Price in his famous, never built but highly influential project *Fun Palace* [73]. For Fuller and Haque incompleteness is operational. They understand building and city regulations as a kind of generating algorithm for the design of neighborhoods, assuming that one can compute the opposing tensions of all given constraints. Systems built under the proposed *Urban Versioning System* license (UVS, UVS 1.0) would remain unfinished and evoke modularity and granularity of participation; allowing people of various levels of expertise and commitment to participate in the design process.
However, the rules for participation in large programming tasks are not really as gentle and accommodating as Fuller implies. Jonathan Corbet recently wrote a comprehensive guide to contributing to the Linux Kernel [18], a show case of collaborative open software development. He describes in detail the review process that all changes and additions (patches) must adhere to. The cyclical process is hierarchical and ordered along a predefined time line of review steps performed by many different people. There is exactly one person who can merge patches into the mainline kernel repository if previous groups fail to agree: Linus Torvalds. Furthermore, code standards and patch formatting are well defined and strongly enforced. It is the quality of the code that ensures its inclusion into future releases (mainline tree). This quality control is enforced by an equally elaborate system of reviews, the duration of which is highly variable. Contributors who fail to respond to the community's inquiries and comments can see their code removed from the mainline tree. Even after

inclusion in the tree, developers are encouraged, required even, to be responsive to questions, comments and suggestions for further improvement. Still, the kernel development community can teach everyone interested in harnessing the added value in group dynamics a lesson. If work occurs only behind closed doors, many problems remain hidden longer than they should be, with adverse effects for the overall outcome of the endeavor. But openness and participation are not the only essentials for public life. Dissent, argumentation and conflict need to be supported. Models based on maximizing efficiency filter disruptive elements out of the system. Models that facilitate ordering concert tickets, buying groceries and paying taxes can hardly become models for improved public life that thrives with antagonism and debate.

5 Ambient agoras

As part of the *Disappearing Computer* EU research initiative [25], Streitz and collaborators [82] have formulated novel ways of addressing the problem of computer-based support for collaboration between local and remote distributed teams. The authors stress the fact that the *Ambient Agoras* project goal goes "beyond traditional support for productivity oriented tasks in the office" and focuses also on designing experiences. According to the authors, the specific development was guided by three objectives. First, awareness devices should help members of a distributed team communicate in a natural way. Second, the interfaces should be adapted to the changing requirements of emerging office concepts as well as to the increased mobility of employees. Third, a privacy concept should give people control of determining if they are being monitored and allow them to select different roles in the sensor-augmented smart environment.
The third point is of interest for AmI in the city. The project authors went to great lengths to personalize activity monitoring technologies, including the integration of a 'privacy manifesto' compiled by the researchers Lahlou and Jegou as part of the same EU initiative [60]. The text lists nine key concepts that ambient system designs are urged to consider: *think before doing, re-visit classic solutions, openness, privacy razor, third-party guarantee, make risky operations expensive, avoid surprise, consider time, good privacy is not enough*. The more important ones are quoted from the guidelines document here.

Openness: "Systems should give human users access to what they do, do it, and do nothing else. Help human users construct a valid and simple mental model of what the system does. Goals, ownership and state of system should be explicit, true, and easily accessible to human users, in a simple format."
Privacy razor: "Human user characteristics seen by the system should contain only elements which are necessary for the explicit goal of the activity performed with the system. No data should be copied without necessity."
Expensive risky operations: "No system is 100 per cent privacy safe. Human users should be made aware of which operations are privacy-sensitive. Operations identi-

fied as privacy-sensitive should be made costly for the system, the human user, the third party."
Avoid surprises: "Human users should be made aware when their activity has an effect on the system. Acknowledgement should be explicit for irreversible major changes. Cancellation should be an option as much as possible, not only in the interface, but in the whole interaction with the system."
Consider time: "An expiry date should be the default option for all data."

Compared to the current unregulated world of privacy (mis)management, this document is truly noteworthy. While these concepts are a real contribution to advancement in the construction of socially robust ambient sensing systems, they are not sufficient. Some researchers have proposed improving privacy design through every more stringent methods of data access control [57]. However, we believe that the problem lies in a different corner. We believe that trustable systems are more important than precise systems. How can people rely on these concepts if they can not see them in action and check them at will? Without trust, none of the nine concepts can be effective. Trust is paramount, but difficult to generate and not to be confused with the promotional slogan of 'trusted computing' [67] that focuses on access restrictions and secure internal operation instead of enabling external control and allowing users to verify and 'trust' their computing systems.
Furthermore, the implementation details of the nine point privacy manifesto are critical. Good intentions can become ineffective in compromised implementation details. For example, *Ambient Agoras* proposes to free people from indiscriminate observation by ambient sensing technologies. This is achieved by a custom designed two part mobile device (ID stick and reader) called the *personal aura* that enables users to control their appearance in a smart environment by deciding whether they want to be visible for remote colleagues, and if so, in which social role they want to appear. However, the 'opting out' through the privacy mode does not guarantee privacy from other sensing modalities. Lounge cameras persistently watch the workers as they enjoy their break, independent of their personal privacy aura choice.
The concept of an ambient experience space as opposed to an ambient observation space is somewhat misleading, offering 'designer surveillance' to placate any pesky opposition. Aesthetically pleasing intrusive surveillance is no better than poorly styled and color mismatched surveillance. In this regard the observations from Mitsubishi Electric Research Laboratories [74] on the advantages of low-resolution occupancy sensing over high-resolution video surveillance are important (albeit intuitively obvious). Video cameras are usually ceiling mounted and watch bodies and faces while infra red sensors are wall mounted and sense motion. Infra red sensors that detect only thermal infra red emissions are blind to the kind of data most people are sensitive about. Indeed, infra red presence sensors were strongly preferred by a sample user group over video cameras as they generated a more relaxing experience of being perceived but not being watched.
The advantage of the experience metaphor used by the authors of *Ambient Agoras* is that it actively acknowledges the pervasiveness inherent in smart networked sensing systems and implicitly stipulates that people should be able to feel comfortable

in its vicinity. But experience culture and leisure culture are rheoric devices that discourage dissent. If 'fun' is to be had, who will want to argue? In this sense the experience metaphor is a distractor. It distracts from the fact that the experience created is geared to work flow improvement only. Even in lounge spaces people remain tentatively available for work related conversations while having their coffee break, effectively compromising the very idea of a break from work.

5.1 Combat zones

In *Ambient Intelligence and the Politics of Urban Space*, Crang and Graham [22] identify three emerging dynamics in the "politics of visibility": commercialization, militarization and the artistic endeavors to re-enchant and contest the urban informational landscape. Quoting McCue [63] the authors see in AmI the enabler of robust identity dominance "to provide battle space awareness necessary to identify, track and target lurking insurgents, terrorists and other targets". The militarization and commercialization of public space through ambient systems finds a counterweight in the work of activists and artists, who, according to the authors, attempt to make visible what the other two forces make invisible. Since the majority of civilian life occurs in cities, the holy grail of surveillance within the war on terror and asymmetric warfare is the technological unveiling of cities and urban life. To achieve this, say the authors, biometric sensors will need to verify and code people's identities, as they flow through national or other borders, through finger prints, iris scans, DNA, face and voice/accent recognition as well as gait and odor recognition. The authors join others [21] in fearing the forward looking nature of military-like surveillance that replaces the act of observing and watching with that of 'identifying', and transforms urban space into *combat zones that see*.

Few ambient sensing paradigms are attracting more critical attention than RFID technologies [81], [54]. Some authors such as Kranenburg foresee a complete interweaving of urban infrastructure and traceable objects [53]. He points out that the making of the new networked cities is happening behind closed doors, with little public knowledge, discussion or consent. He also points out that the call for trust in such systems can not be created as long as there is no transparency in data management: who really knows what and who will be checking all the data recorded by the continuously growing network of tagged objects. While the data emanates from the public domain, it resides largely with private parties reducing the public to an unknowing bystander. Kranenburg currently sees the only recourse to connecting to the public in, well, scandals: RFID in passports leaking data, patents by industry to scan your garbage, a secret plot to chip all old people preventing them from wandering off on their own. Kranenburg proposes ways of acting against the trend. A new interpretation of life style management might create specifically tailored privacies instead of a single personal privacy allowing one to choose the kinds of traces one leaves in a sensor network, not unlike the personal aura of the *Ambient Agoras*

project.

The tagged and bookmarked world of RFID is the inverse of another imagined scenario: RFID-lessness and falling off the information grid. If an object or a person is not encoded and available to search engines once everything is assumed to be tagged and searchable, it effectively, informationally, ceases to exit. Already, pets entering the European Union must have a transponder implanted [31]. Untagged pets will be confiscated. It might not be long before untagged creatures, including human beings, constitute a new class of lost and disenfranchised beings, unable to find help or be found by others [6]. In the future, no one will be allowed to exist outside searchable databases, and those who do, do so at their own peril.

6 Amateur ambient intelligence

Several impulses on how ambient sensing can make city life richer come not from the ambient intelligence professionals nor architects and city planners, but from, hobbyists, dilettantes, and early technology adapters. Amateurs lack expertise but also the bias and occasional 'group think' that often accompanies expertise. In the realm of interaction design, artists have conceived of usage scenarios human computer interaction designers generally do not consider [14]. In *Help from Strangers – Media Arts and Ambient Intelligence* we described the selective decoupling of utility form technical invention to generate alternative forms of experiencing automation systems. The following paragraphs will weave through projects chosen for their contributions to inventing new ways of combining people with networked sensing particular to urban contexts.

6.1 Slow space design

Sociality, spatialization and temporality refer to the readings between the lines of urban culture, a concept notably formalized by de Certeau [23]. This is a form of urban context awareness where the context is soft, fuzzy and not computable. Wait a moment, look at that tree. There is no reason to hurry. Such events are not to be found on a city map; they are generated at random by people wandering through the streets, going about their daily chores.

Temporality is a key component of urban experience. The *Amble Time Project* designed by the Media Lab Europe [26] and described by Galloway in *Ubiquitous computing in the city* [41] utilizes the fact that city maps generally do not include temporal information. *Amble Time* adds an element of time to a PDA-based tourist map. With a GPS system and an assumed average walking speed, it creates a bubble that indicates the possible place one might reach within an hour on foot. Alterna-

tively, given a final destination, it can show where a pedestrian could roam along the way and still arrive in a timely manner. *Amble Time* is an interesting example of a project that does not, but easily could be modified to suit commercial interests. The project would be experienced in a completely different manner if the ambling were designed to lead people to stores in lieu of parks. Since businesses will probably pay to have themselves included in these temporal walk maps, this might be unavoidable. It will be all the more important that AmI practioners take particular care in making sure people can add their own paths, place signs and notices for friends, and easily remove all preset entries, including those of paying patrons.

6.1.1 Ritornell

Sonic complexity is a hallmark of urban experience. *Sonic City* [42] contributes to the many sounds that pulsate through the urban landscape. It enables people to create sound tracks while walking through the city. The installation allows people to leave at hidden places in public spaces pre-recorded messages that are then whispered to by-passers as they lean towards a sensor. These audio tags create a novel and sometimes unscripted way for people to interact with their physical and social surroundings.

Cities are full of underspecified spaces, spaces that do not seem to belong to anybody, but are used by everyone. Taking a cue from Marc Augé's seminal text on non-places [9], *Texting Glances*, a collaborative project at the University of Dublin, activates urban waiting spaces such as bus stops, doctors' offices, airports and similar places where people gather, usually with no interest in the location itself, and wait for something not related to the place itself to occur. *Texting Glances* is a mobile phone based collaborative game that generates a story. As people wait, they text (with their mobiles) into a system which in turn responds with an image. As more people participate, a multi-authored story is generated and shared with the public through large displays in a train station.

Ambient technologies often seem to counter the urban qualities of event, flow and temporality. Technologies create an almost contradictory sense of consistency and coherency while the urban world that is experienced is one of change, flow and surprise. Part of this, so Galloway, stems from the tendency to imagine new technologies as representational artifacts rather than temporal performative practices. Galloway suggests that ubiquitous technologies should begin to understand themselves more as diverse procedures and performances as opposed to stable (networked) artifacts. How engineers should actually 'perform' such work however, is not discussed at all. The heavy lifting is graciously left to others.

6.2 Unusual encounters

The Cornell Lab of Ornithology's citizen science projects, such as NestWatch [19] offer lay people the opportunity of contributing to bona fide research as bird watchers. Bird watching is an activity that relies on patient people in the field dedicated to the task. Cornell is making use of the widespread interest in bird watching by offering lay people the chance of participating in the lab's well respected research and engaging them as free lab assistants. Precisely formulated templates, when properly filled out, provide the data that the researchers seek. Observations can be input from any internet enabled computer. A program aggregates and analyzes the volunteers' inputs. The eyes and ears of Cornell's Ornithology Lab are expanded far beyond its campus by this human computer network, and as a result, many people identify with the work.

SETI's (Search for Extraterrestrial Intelligence) goal is to detect intelligent life outside Earth [5]. Radio SETI uses radio telescopes to listen for narrow bandwidth radio signals from space. Such signals are not known to occur naturally, so detection might provide evidence of extraterrestrial technology. The terabytes of data collected by the system are distributed to idling computers all over the world that work on small data chunks and return their results to a central server. Anyone can sign up and donate their computer's idle cycles to the SETI project. This citizen computing schema makes clever use of the internet's non-centralized infrastructure and of computers idling online. For the participants, the allure of the project resides in contributing in a modest but personally perceptible and community appreciated manner to a grand and unique challenge. In return for free computing cycles, SETI@home delivers the satisfaction of contributing to an unsolved universal riddle.

6.3 Mobile devices everywhere

Mobile device communication habits are forming new ways of experiencing and suffering from the city. Jan Chipchase of Nokia's Mobile HCI Group describes his group's experiences studying mobile TV use in South Korea. Chipchase asked a survey group why they used the mobile TV devices [17]. Answers included the desire for immediate knowledge, the desire to kill boredom and the wish to stay up to date with popular events. The times and places device use occurred include bars (waiting for friends), traffic lights or during the commute, which often exceeds one hour, one-way, in Seoul. The city is an obstacle course that demands patience from its inhabitants while the newest communication technology distracts from the fundamental traffic congestion problems. The city as built environment is most noticed when device reception fails due to intermittent signal strength.

In an other study, Tamminen and co-authors describe the mobile phone habits of a study group navigating their ways through Helsinki via public transportation [84].

The mobile phone, as the newspaper earlier, has become a personal space claiming mechanism. Sitting in a bus or train, travelers engaged in all kinds of useful and useless mobile applications during their transits and mark a desire for privacy when concentrated on mobile information delivery. Temporarily and situationally, the public bus seat morphs to a personal space.

Not all usage of phones and TVs is rational. The desire to be wirelessly connected varies from querying bus schedules to feigning phone calls in response to peer pressure [44]. Fake phoning, as this activity has been coined, shows how communication technologies, the most ubiquitous of ambient information systems, are capable of supporting some of the least rational behaviors of modern urbanites. Pathologies are to be expected in global mobile information device proliferation, and not all kinds of user generated content are equally desirable. When camera enabled mobile phones are used indiscriminately by mobs that are not always smart [75] urbanity suffers by its own design and creates its very own participatory panopticon [52].

7 Ambient intelligence for the people

AmI systems usually function autonomously, with high level control removed from those who experience it. This could be countered by making public participation in the design of AmI systems should become a requirement. Interestingly, computer science has precedents in this regard. The Participatory Design tradition formulated in Scandinavia [12] was originally built upon the desire to include the needs of IT professionals into the design of the workplace. Several projects expanded the initial results to include experience based design methods that took the practical knowledge of workers such as nurses into the design of health care facilities. For AmI it might be necessary to expand the Participatory Design principles to include (lay) people's input. How might this happen?

7.1 Knowledge from many minds

In the future, AmI will become part of the infrastructure of cities such as water, gas and electricity have in the past. One important challenge is finding out what people on the street really think and feel about ambient control systems and to use the knowledge of many minds as feedback for the design of these systems. Most assessments of AmI systems, such as *Ambient Agoras*, survey only a few people on too few issues. It is not possible to generalize from such limited and biased data. Given the ubiquity of the internet, querying large numbers of people seems to have become easy. *Infotopia* [**?**] delivers a good framework for discussion on what to expect from gathering data from many people through online deliberation, blogging, wikis and similar venues. Deliberation is often heralded as a democratic feature of the web.

Sustein describes how, contrary to intuition, deliberating groups do not do well at aggregating information objectively and fall prey to group think. However, prediction methods, such as prediction markets with incentives, can achieve, according to Sunstein, the kind of knowledge isolated minds can not. To make use of this in our case would require however, that one defines the experience of an AmI system according to market mechanisms and bids on its success or failure. How much are you willing to bet that people do not want to be watched entering the office building in the morning? No information market can make judgments of value, but they can aggregate private judgments of individuals where there is an incentive to share them. For AmI systems, the incentive might not be directly monetary but emotional (fear of surveillance, loss of opportunity). Interestingly, the scope of prediction markets is constantly expanding. Recently, one successfully predicted the acquittal of pop star Michael Jackson. The Hollywood Stock Exchange [47] regularly anticipates box office successes and failures.

8 Remaking public space, with and in spite of ambient intelligence

As mentioned above, AmI systems in the city do not act in full view of the public. They do not define representative facades of buildings. Rather, they form a network of possibilities and obstructed opportunities that modulate life in the city. The next section of this text seeks to describe a few ambient intelligence like projects that seek to find new ways of augmenting urbanity and renegotiating the limits of private and public domains with the current state of sensing technologies and computational infrastructure.

8.1 Paths of surveillance

The Institute of Applied Autonomy [48] created a special service for anyone wishing to avoid ubiquitous surveillance. I-See is a web-based application charting the locations of closed-circuit television (CCTV) surveillance cameras in urban environments. With i-See, users can find routes devoid of these cameras through *paths of least surveillance* [Fig. 1] that allow them to walk around their cities without fear of being caught on tape by unregulated security monitors. The program takes starting and destination points as inputs and maps the shortest distance with the least number of security cameras. The program relies on a list of camera locations as a reference for the path generation. Several cities, including Manhattan and Ljubljana, have already been mapped out and readied for i-See, now in its third generation. Unfortunately, the army of surveillance cameras grows faster than the small group of activists can work, making the impressive system less effective than it has the potential to be.

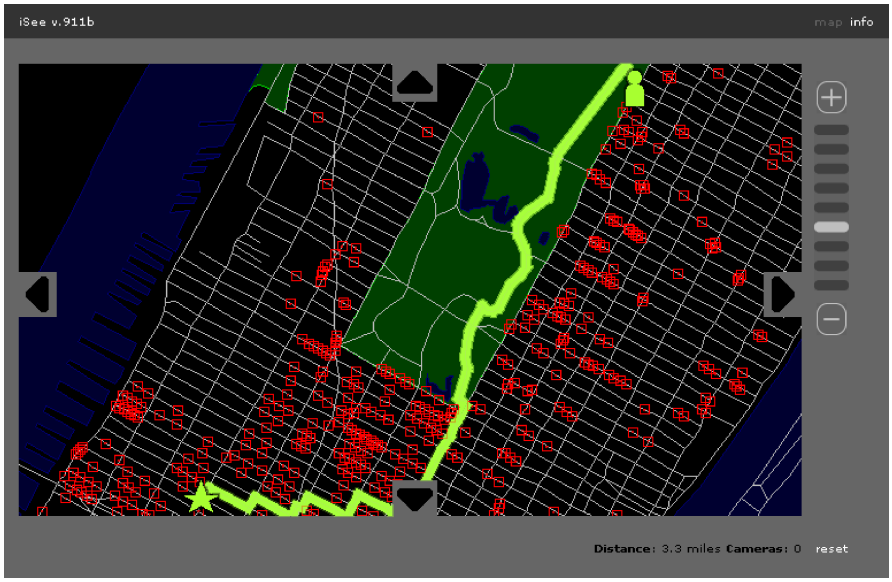

Fig. 1 A path of least surveillance traced in Manhattan (courtesy of the Institute of Applied Autonomy).

8.2 Staging city life

OptionalTimes [59] is an interactive movie controlled by movements and moods of city dwellers that plays itself out on a public stage in the middle of the town of Almere. People's motions within the public space act as triggers for interactive domino effects. Activities sensed by the motion detectors become input for an evolving narrative. The affordances of the sensing system are translated into narrative opportunities, playing themselves out differently based on the activity level of pedestrians moving into and out of the scene. For example, a man walks with great haste through the square, the installation senses his pace and releases images of a reality speeded up. Then one of the fictive characters enters the square in a rush. The authors see the work as a new way to relate to one's surroundings and translate these relations into a public space and a stage for all to see. The movie is viewed at the same location where it is made and builds tension between the ideal and the real. The system works with multiple time frames: events are recorded and periodically projected back into the square. OptionalTimes mediates the constant change in public culture with an architectural backdrop that remains static. People walk into and out of the stage that is the city, temporarily participating in a fictive event only to disappear back into their own reality. The project is succinctly location specific. The town square of Almere, reflected in the various characters, projections and re-projections that dive in and out of it, has its kinetic portrait taken.

8.3 Paths of production

MILK [71] is a narrative GPS visualization system. The project tracks one of the dairy transportation lines from Latvia to the Netherlands, through the complete trade network between the source of the raw material and the destination of the final processed, packaged and consumed product; all the way from the cows' utters to the mouths of the consumers. The collected data was augmented with audio recordings and photos of the places and people that make the transportation possible. Minutiae of their daily lives and routines were added to the database of geographic coordinates cross Latvia and into the Netherlands. The composite dataset was edited into a visual story, played at exhibition venues in 'cartographic' order from the east to the west, following the path of the milk. Different parts of this path can be viewed through a website. Portraits of the farmers, closeup shots of hands of workers and truck drivers are complemented to the paths they created while casual and sometimes insightful comments scroll across the bottom of the screen. Images of objects, buildings and maps add informational dimensions to the intelligently designed shots of the participants. The artist group intended and succeeded in building a new landscape like representation [88] of economic transactions of an anonymous life staple surrounded with subjective events a single media carrier, audio, image or locational data capturing system alone can not create.

8.4 Personal pollution control

The participatory urbanism project [69], [70] aims to promote new styles and methods for individual citizens to become proactive in their involvement with the city, neighborhood and, says the project author Paulos, 'urban self reflexivity'. Mobile phones double as measurement instruments for some environmental descriptors (carbon monoxide, sulfur dioxide, and nitrogen dioxide). According to Paulos this allows data usually collected and monitored by government agencies to be expanded and differentiated by location. It also allows lay people to contribute data with their own mobile devices. One scenario from the project website imagines Mary suffering from asthma as she is gardening in her yard. She checks her particulate matter sensor on her mobile phone and finds that it reports dangerous levels of exposure, mostly likely from wood burning pollutants. The city's centralized system has no knowledge of the problem, so Mary checks sensor data from people in her neighborhood. She sees that the problem is concentrated around a single cul-de-sac near her. She also notices that several homes in that area are using fireplaces and generating excessive airborne pollutants, forbidden by local ordinance. Mary forwards the measurement collection to her local air quality measurement district where action is taken to enforce the clean air policy.
Here, networked information devices allow lay people to augment government services where they fail to operate properly. As opposed to the scenarios described in the EU Report on Ambient Intelligence in 2010 [49], participatory urbanism advo-

cates a bottom up approach to environmental protection and enforcement. Measuring pollutants, even when it is performed properly, is only one part of environmental control, and not the most challenging one. Still, the project succeeds in mapping out a way in which networked citizen surveillance might help individuals assert their personal concerns vis-à-vis complacent government agencies.

8.5 Full body ambient intelligence

AmI in the city expands to ambient urban recreation. City waterfronts are coveted areas of public leisure removed from hectic city life but well within information delivery infrastructures. The Glass Bottom Float project (GBF) is a practical example of critical ambient intelligence applied to environmental monitoring, real time responsiveness and long term observation [8]. GBF is a beach robot [Fig. 2] that floats in lakes on public beaches and informs beach visitors of the water quality and, at a later stage, on the expected pleasure of swimming in the waters.

Fig. 2 GBF at Woodlawn Beach State Park, NY (courtesy of realtechsupport).

More often than not, people are informed by anonymous government agencies about water and air quality via occasional official news releases, often after critical thresholds have been exceeded. Furthermore, most official sources of environmental information are updated too infrequently [Francy2006] and the data are usually not collected where people experience their environment. Identification with water quality is often unintuitive for lay people due to abstract measures used by the scientific community. In order to address this, the GBF project has devised an additional measure of water quality related to people's immediate uses of recreational waters.

The authors refer to this as the *swimming pleasure measure* (SPM). SPM is based on several inputs [Fig. 3], including water temperature, pH, conductivity, chlorophyll, turbidity, salinity, dissolved oxygen and total dissolved solids. A local weather station delivers real time data on air temperature, relative humidity, air pressure, wind speed and direction. A commercial fish finder is reconfigured to deliver water depth, wave motion, positional information as well as the presence of fish large and small. A hydrophone listens for speed boats passing by, people playing on the float and underwater marine life.

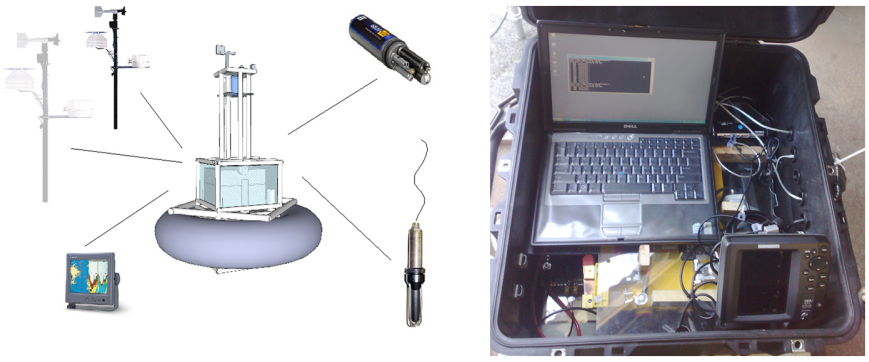

Fig. 3 GBF sensor suit and the water proof box (courtesy of realtechsupport).

SPM combines quantitative and qualitative data. It is a complex measure that includes subjective ways of knowing. In order to capture this, swimmers at the beach are interviewed for their opinion on the water conditions. They are asked for either a word (awful to excellent) or a number (1 to 10) that matches their experience. This input is sent to the remote database and aggregated with the sensor data to see when and how the two different 'views' on the water overlap or differ, leading to the possible prediction of people's opinions not unlike Von Ahn performs in his harnessing of human input to automate image annotation [91], [92]. Furthermore, the park manager enters his daily water bacteria measurements into the system. In the US, the Environmental Protection Agency stipulates that public swimming waters contain no more than 235 cfu (coliform forming units)[30]. This input serves as a control for the internal assessment and ensures that the calculated measure of the swimming pleasure does not blatantly contradict government regulations. This is important as GBF collects data that is not traditionally part of water quality assessment protocol. GBF does not attempt to replace current procedures, inadequate as they may be. GBF is an addition to ongoing efforts, and places them in a new context. The multi-pronged and collaborative approach improves the quality of the data as well as the technical and social robustness of the project. It also ensures that the government controlled beach operator actively supports the system, a prerequisite for project success.

The SPM is shared with the public in multiple ways. Beach visitors are encouraged to spend the afternoon daydreaming on the float as it bobs about in the water and maps out paths of least contamination. Depending on the water quality a light flashes an beach side practices conform colored quality code (red: danger, blue: caution, green: good). The latest sensor data is available on mobile phones so people can check the local conditions before they drive off to the beach (and waste time in traffic) [Fig. 4]. Recordings from the hydrophone give visitors samples of the underwater audio landscape and remind them that humans share the water with many other species as well as motorboats.

Fig. 4 GBF output modalities: mobile, resting spot, micro-blog (courtesy of realtechsupport).

GBF also sends short text messages to a micro blog *Twitter*. The twittering connects the fickle but rough watery environment with fickle online communities removed from the outdoors. It brings things that concern us all into the private domain through personal communication media.

9 AmI in the city, revitalized

We conclude with a scenario informed by the discussions above.

Sal awakens. It is a bright and sunny day.
Sal looks out of the window of her condominium. Several flocks of birds are displayed on the networked active window. The city airport has been tracing geese living close to the airport to warm them of approaching aircraft. Warining the geese prevents collisions between planes and birds. Preventing even one plane from colliding with geese offsets the costs of collecting this information for decades, and allows the system to be freely shared at no cost. When air traffic is low at night, the system tracks urban bats and makes the bat sightings available to networked active windows. Sal knows now that many bats frequent her neighborhood in June, that some stay into July and that all disappear after August. Sal's phobia of bats has vanished once she began to follow the bats' trajectories.
Sal gets her jogging gear on. Not the new one with the body sensors. It was damaged

in the dryer a few days ago. While slipping on some old unwired jogging pants, she reminds herself that it makes no sense to check body vitals every time you go outdoors. There is just too much data around these days.
It is a warm morning as Sal jogs over to the neighborhood MicroPublicPark. Sal sees a crowd of people over at the far end of the park. Someone is gesticulating towards the large water tower *Water-IS-us* recently installed in the park. Curious, she jogs along for a closer look. She spots Joe and inquires about the commotion. Joe, a member of *Water-IS-us*, tells Sal that the MicroPublicPark's water tower control room seemed to be working just fine, at last.

MicroPublicPark is open to all. It is a surveillance-free space that symbolizes and performs public maintenance of shared water resources. It operates in full view of the public. Anyone can watch the system as it analyzes the city's water supply and informs on the state of events. Not only does the system analyze the water and warn of compromised water quality, it monitors the sources from which the water is collected. An upstart company specializing in sensor networks donated the system and volunteers keep it working. The city offers research and development grants to people who propose and implement improvements to the PublicMicroPark. Considerable expertise in designing state of the art environmental control has been collected as a result. University students get course credits for helping out. The system is networked with other MicroPublicPlaces throughout the city. Direct links with MicroPublicPlaces across the globe are in progress. Anyone can stop by the water bar at anytime and get a cup of water to taste the results of the system.

Sal takes a cup of fresh MicroPublicPark water. "Hmm. Tastes like water from a glacier stream. I am surprised!" Joe adds that the MicroPublicPark has a state of the art water analysis and augmentation system that combines the most advanced technologies with old technologies. Like the Romans the MicroPublicPark stores the water in vast underground cisterns lined with lime stone from an old local quarry. The ambient water flow monitoring system can keep track of the water from the small streams outside of the city all the way to the glass of water in your hand. Furthermore, the system keeps the public abreast of water related commerce. The stock prices of the main players in the global water business are displayed on the large data screen together with the water analysis results. Company video conferences are streamed to the display and announced in the park so everyone can see how they present themselves. Media reports and scandals are made public. Recently a company in Bolivia, *GreenWater*, tried to buy the water rights to large parts of South America. They argued that by privatizing the water resources they would ensure that they are put to efficient use, that they maximize share holder profit and, as a consequence, save the earth from wasting precious water. Sal is not sure if she believes the story.
Joe points to the control room display where nasty electronic comments are being posted next to the *GreenWater's* company logo. *GreenWater* has climbed to the top of the chart of bad companies, an honor no company can take lightly due to the wide appeal this popular chart holds with globally networked consumers. "In Shenzhen",

Joe notes, “products from GreenWater have been pulled from the shelves due to massive consumer protest”. Sal is not sure if Joe is getting carried away. “Gotta go, see you later”, she says as she jogs off through the park.
At home under the shower Sal realizes that she is drinking the water she is showering in. Only a small part of the world’s population has that luxury, she reminds herself. Sal checks MicroPublicPark’s URL she committed to memory, scrolls past the list of events and planned activities and finds many more references to water mismanagement in the US and reported water rights theft in Africa. The list seemed endless. Sal is confused but determined to revisit the MicroPublicPark again the next morning.

10 Outlook

The model of the Greek polis, the European city, and the American suburb no longer suffice as models of urbanity in the age of ambient intelligence. We need new models, models that have more Africa [29] and Mars in them. The public changes under ambient intelligence. Information cities inspired exclusively by economic and technical infrastructure models can not scale to urban satisfaction. City planning is already a multi-disciplinary domain where professionals and non-professionals of all kinds collaborate to balance contradicting interests and needs. Ambient systems design needs to come out from the bunker and move into full view such that it becomes a public affair. Knowledge from other domains must help AmI expand its current practice. In the end, the (AmI) engineers, managers and politicians will build the new ambient cities. But we all need to come together and work together, even though we do not get along that well.

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