COMPUTER SCIENCE

How Smart is Your City?

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From art galleries to our cities' streets, ambient intelligence can help to make the human environment safer and more responsive to the needs of individuals.

The idea of Ambient Intelligence (AmI) implies an intrinsic link between individuals and their environment, enabling individuals to access and interact with computing artifacts in ways that are intuitive and do not disrupt everyday activities. Given the many different environments encountered as part of everyday life—within the home (*1*) as well as beyond it—enabling such interaction is a formidable technological challenge. The reward may be an environment that is safer, uses less energy, and responds to the needs of all individuals. Recent advances in embedded systems, robotics, and sensor technology suggest that AmI may indeed be realized, particularly if crucial privacy and security concerns are addressed.

AmI has been demonstrated in many domains, including offices, industry, transport, gaming, and e-commerce. To illustrate its potential and ubiquity, three exemplar scenarios are now briefly considered. These demonstrate 1) information filtering and personalization - a practical and eminently achievable vision of AmI; 2) autonomous mobile robotic services - a development that may radically challenge perception, trust and acceptance of AmI; and 3) how a simple AmI smartphone service may radically improve the quality of-life those afflicted with dementia.

Museums and art galleries comprise many exhibits, yet tend to offer broad generalized information, usually in the form of visitors' or audio guides. AmI challenges this "one-size-fits-all" approach, envisaging a digital information space that enables the personalisation of information to meet diverse user needs (*2*). This may include generating recommendations for visiting other exhibits, based on, perhaps, what the visitor has already seen and what their cultural interests are. Typically, a conventional smartphone is sufficient to enable this kind of interaction, acting as a lens into the information space. In sharing positional and personal information, multimedia content may be personalized and presented via the visitor's smartphone, thus resulting in a more satisfactory experience. However, a prerequisite is the deployment of a suitable AmI technological infrastructure, for example using RFID, and the construction of an information space for all the exhibits. This later issue is of prime importance, demanding that the curator possess a deep understanding of their exhibits and the visitors they hope to attract.

Ubiquitous robotics (*3*) represents an area of significant potential for AmI in the longer term. Interestingly, many of the technologies to successfully deploy suites of mobile robots exist; however, cost remains excessive. Until this is addressed, such robots cannot be deployed in a widespread fashion, and the key issues of Human Robot Interaction (HRI) and social acceptance cannot be researched thoroughly. Dustbot (*4*) has demonstrated robots collecting waste in an urban environment without direct human oversight, demanding obstacle (stationary and mobile) avoidance on the part of the robot, as well as interaction with householders. Computational intelligence, embedded both on the robot and in the environment, is essential for enabling this behaviour.

Ultimately, AmI is about people and improving their quality of life. Consider the case of people with dementia - an issue that will have increasing implications for society in the coming years. Elopement is characteristic of many with dementia and is a major factor contributing to institutionalization (*5*). Tracking is one solution, but raises ethical and privacy concerns (*6*). In equipping the person with a GPS unit, embedded on their smartphone perhaps, models of their behavior can be constructed, deviations from which can lead to alarm generation. Crucially, the decision to activate an alarm can be made on the smartphone, thus removing the need for a centralized tracking approach. Hence, it is possible to balance the privacy of the person with dementia, their autonomy to make their own decisions, their own welfare, and the needs of their carers.

As of today, the potential of AmI has been demonstrated in a wide range of domains and proof-of-concept services. The challenge is to translate this potential into a coherent vision and practical implementations, marked by scalability, robustness and intelligence. One key enabling technology is that of the Sensor Web (*7*); this envisages a network of sensors spatially distributed and embedded within the environment. However, a standardized approach to achieving interoperability between physical sensor networks and the web itself requires further research.

As embedded technologies evolve, their support for more sophisticated software increases, thus enabling the deployment of the complex software algorithms necessary to realize AmI. Such software, as well as being inherently distributed, must encapsulate robustness, scalability and interoperability amongst others. Distributed Artificial Intelligence, specifically Intelligent Agents (8), represents one mature software paradigm for delivering AmI.

How people will experience AmI over time is open to speculation. Indeed, increased awareness of energy issues suggest that the smart grid and energy efficiency (9) may become pioneering AmI services. In the longer term, AmI may be experienced as part of the "smart city" (*10*) concept. This concept is one vision of how cities may evolve as technologies such as AmI permeate all aspects of urban life. In many domains, such as those alluded to previously, this will emerge organically, though it terms of governance and administration, a top-down approach may be anticipated.

As AmI becomes mainstream, there is an urgent need for issues of security, privacy, and ethics to be brought to the public's attention. One interesting legal proposal is that of

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Ambient Law (*11*). This argues that the freedoms that underpin constitutional democracy may be radically altered as AmI permeates everyday life. Such freedoms may be reinforced in some circumstances; in others, they may be destroyed. Avoiding the latter situation demands greater communication between lawyers and computer scientists such that appropriate legal norms can be constructed and incorporated into the design and use of AmI.

References and notes

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