The intelligence revolution

Prof. Jinhua Ma of the Muse Lab in Japan explains how the probable boom in the development and deployment of smart objects and environments will help humans overcome some of their physical and perceptual limitations

Professor Jianhua Ma
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by Victor March

Numerous tools and machines, from ancient times to the present, have been developed with the aim of extending human capabilities and overcoming human limitations. Computers, originally created to enhance our computational and information processing capabilities, are one example. The revolutionary changes brought about by these devices are now under the eyes of everyone. From stationary supercomputers/grids, clusters, workstations, servers and PCs to portable laptops, PDAs, handhelds, computers have become ever more popular and more powerful. However, the power and popularity of these relatively isolated devices is not ubiquitous intelligence.

On the other hand, as computers become ever smaller and become embedded within all types of ordinary objects, and as ubiquitous IT networks emerge, the objects around us become capable of computing and communicating, connecting to each other and acting rationally with some degree of intelligence. Such objects can be called smart, and the same can be said of an environment. When an environment is broadly pervaded with smart objects, that is what we call ubiquitous intelligence.

It may not be enough to describe the profound changes brought about by ubiquitous intelligence as the information revolution. It would be more appropriate to refer to them as the intelligence revolution. A benefit of the intelligence revolution is that both work and everyday life are becoming more convenient, comfortable and efficient.

In terms of applications, where do you foresee the vastest deployment of ubiquitous intelligence and emerging and disruptive technologies?

In the long run, with the continuing miniaturization of IC chips and wireless communication devices, ubiquitous intelligence can, at least theoretically, be deployed anywhere. In practice, however, many factors affect the deployment of smart objects in real application environments. One of them is the cost/performance concern of embeddable computers. Relatively small and cheap devices, such as some RFID (radio frequency identification) tags and sensors, usually have limited computational power, memory capacity and communication distance. The better performing devices cost much more and come in larger sizes. This factor makes the applications of ubiquitous intelligence fall into two main categories for the time being. Those using cheap devices offering limited, specific but cost effective services, such as RFID-based cards, supply chain management applications and sensing appliances. And those using high performance devices in applications that require relatively greater accuracy, for example childcare, car safety, healthcare and so on.

Another issue regarding ubiquitous intelligence applications is the privacy concern and related laws and legal matters. Ubiquitous intelligence can certainly make our lives more convenient but it can also be used to take away our privacy and control us. Therefore, the potential applications of ubiquitous intelligence will at first be deployed where privacy is not a serious or sensitive issue or can be kept under control.

Will advanced identification technologies like RFID play a major role in the construction of intelligent environments?

Absolutely, RFID will play an essential role in intelligent environments. Consider modern society: it is organized around personal ID codes, including citizen number, insurance number, telephone number, credit card number, bank account number, driving license number, passport number and many more identification codes. It would be difficult or even impossible to effectively manage contemporary society if we did not have these personal ID numbers.

Now consider an environment full of objects embedded with computers and software "agents" (Prof. M. Minsky, "Society of Mind" - 1985) which make them "intelligent." An environment characterized by ubiquitous intelligence is a collection of such smart objects which form an object society. Like human society, unique and universal object identification will play a fundamental role in managing the object society. Without such identification, it would be impossible to properly organize and manage the smart objects. Due to the great number and diversity of real objects, the associated methods, mechanisms, standards and technologies related to object identification, including RFID, are much more complex than for human identification.

Meet Jianhua Ma

Professor Jianhua Ma has been a professor of Computer and Information Sciences at Hosei University since 2000. Previously, he worked for 7 years at NUDT, 3 years at Xidian University and 5 years at the University of Aizu. From 1984 until 2000, his research covered a variety of areas including coding technology for mobile communications, secure systems, speech processing, multimedia networking, QoS modeling, groupware, graphics ASIC, virtual reality, hyper-world management, etc. His current research interests are ubiquitous/pervasive computing, mobile multimedia, P2P networks, proactive and autonomic multi-agents, integrations of digital cyber world and physical real world, etc. For the last two years, he has been greatly devoted to research towards what he calls the smart world, mainly characterized by ubiquitous intelligence and fulfilled with smart things ranging from smart objects and smart spaces to smart systems. A ubiquitous smart hyperspace for childcare, called UbicKids, is under research and development by his laboratory in collaboration with several other research groups.

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When do you think we will start living in a world where we are surrounded by smart objects?

To be honest, it is a difficult question to answer. The terms "surrounded" and "intelligence" are a bit subtle and vague. Some objects already have a certain level of intelligence. Let's take a look at some homes, in Japan for instance, where we can find lamps with sensors and ovens capable of automatically cooking food according to instructions downloaded from the Internet, or cars with embedded computers for smart functions. This is the beginning. It will be an evolutionary process over a long period, perhaps decades, from the current world with very few smart objects to a truly smart world filled with intelligent objects. But that that is where we are going.

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What is a "hyperworld" and how is it related to ubiquitous intelligence?

About 10 years ago, Prof. Tosiyasu Kunii, Prof. Runhe Huang and I realized the importance of integrating the multiple real and virtual environments, called the hyperworld, so that we not only get passive multimedia information but also actively sense and control the real worlds directly. This hyperworld vision was a natural extension based on our previous research on active devices and media, tele-presence, multimedia networks, augmented reality and mathematical visualization modeling. In a word, a hyperworld is an integrated world environment of multiple interconnected real and virtual environments possibly mediated or synthesized with the involvement of many computers. The basic characteristic of the hyperworld is the direct mapping between virtual worlds and real worlds via active devices including sensors, actuators, micro-machines, robots, etc.

Later, we realized that it would be too early to study the integration of the virtual and real worlds, as the virtual world itself was unclear yet. Thus we shifted our research focus to the study on cyber worlds and developed various cyber applications related to virtual university, e-commence context-aware groupware, mobile multi-agent system, etc. The cyber world's emphasis is more or less on virtual objects and environments. As the hyperworld is the integration of real and cyber worlds, it is still necessary to study real objects and environments which have embedded computers. To be balanced, therefore, we proposed smart worlds, which are based on digital cyberspaces but with emphasis on real world applications. These are mainly characterized by ubiquitous intelligence or computational intelligence pervasiveness in the physical world pervaded with smart objects, ranging from man-made items to natural objects, from everyday appliances to sophisticated embedded systems, from small rooms to large buildings, from enclosed sites to open areas, and from stationary places to mobile vehicles. That is to say, the cyber worlds focus on the ubiquitous intelligence of the virtual "e-things" while the smart worlds are aimed at the ubiquitous intelligence of the real "u-things". The further integration of the two types of ubiquitous intelligence brings us towards the hyperworld.