

When the World Talks Back: Exploring the Future of Interactive Products

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Technology Creeps In

At the Computer Human Interaction Congress in The Hague in 2000, John Thackara, the director of Doors of Perception, the international conference and knowledge network for information and communication technologies, opened his keynote address with what then appeared to be a very speculative series of questions:

“What happens to society when there are hundreds of microchips for every man, woman, and child on the planet? What cultural consequences follow when every object around us is ‘smart’ and connected? And what happens psychologically when you step into the garden to look at the flowers— and the flowers look at you?” John Thackara, 2000

Much has transpired over the past three years to move us surprisingly close to this vision. New innovations in networked wireless technology have created a host of exciting new developments in the field of interactive product design. The following list that was reported in the June 25, 2003, edition of the *Vancouver Sun* is indicative of the extent wireless has crept into our lives:

- ?? Point-of-sales devices like wireless credit card readers now allow business transactions anywhere
- ?? Location-based services like Bell’s nearest restaurant finder cost 25 cents a call while Rodgers even more accurate GPS-enabled phones allow you to pay your parking meter fee on your cell
- ?? Office services allow your office information like e-mail, customer orders, and forms to be available wherever your travel.
- ?? Digital cameras built into cell phones let you shoot and send travel and business photos to other phones or computers.

The real surprise, however, is how prevalent these technologies have become in so short a period of time. How many of us would have guessed that 16 million camera phones were sold worldwide in 2002 while projections indicate this will rise to 147 million by 2007... and perhaps even more surprising, how many of us are aware that on-line gaming now takes up more than 50 percent of all wireless data traffic.

Another good indicator of the relevance of Thackara’s questions can be found in work underway at Philips. In the article, “Experience Counts,” Irene McWilliam provides insight into the ideas behind what Philips is calling their Ambient Intelligence initiative. According to McWilliam, Philips has been working with the concept of ambient intelligence for some

time now. Originally known as ubiquitous computing, its aim was to disperse the inherent intelligence available in the PC throughout the user environment. More recent growth of the Internet, coupled with the advent of wireless technologies like Bluetooth, has brought the possibility of truly distributed intelligence closer than ever. This notion of distributing technology into the users' environment takes full advantage of networked wireless capabilities and along with these developments comes the necessity to explore more natural modes of interaction... including speech, touch, gesture, as well as changes in light and temperature.

In the publication *Ambient Intelligence in HomeLab*, Stefano Marzano, the CEO of Philips design, sheds some light on the effect this might have on the way we live our day-to-day lives. He follows up on the ideas forwarded by McWilliam, by pointing out that the intelligent technologies emerging today are miniaturized and, therefore, becoming increasingly invisible. He goes on to point out that as a result these technologies can merge seamlessly into our environments— be that our homes, offices, cars, streets, or even our clothing. Marzano's forecast for the future is that, "... the home of tomorrow will look more like the home of yesterday than the home of today. The bulky boxes containing today's ageing technologies will disappear, and the function we need will be hidden in timeless objects such as furniture, containers, ornaments, walls, floors, and roofs." (p. 7) "Our environment will come alive with intelligence," he says, and "[o]bjects that were formerly inanimate, passive spectators will become animate 'subjects', interacting with us and other objects in animate and highly personalized relationships." (p. 7)

Wicked Problems

So what does all this mean for us? Technology is changing the way we live; technology is changing the way we interact with other people; and technology is changing life as we know it in more significant ways than we have seen in the past. As smaller, faster, networked, wireless computing reshapes human experience, new questions need to be asked about the role these products and systems will play in our lives. How will the convergence of telecommunications, robotics, affective computing, and artificial intelligence manifest itself? What are the social and cultural implications of products and systems that are aware of their environment and can express personality, and articulate emotion in responding to stimulation? "Which objects should host these new intelligent systems? How will these new objects behave in relation to us and each other, and what communicative codes will they need to use." (Marzano, 2002) What are the benefits of building autonomous devices that respond to and interact with us on a daily basis, and where does the balance lie between utility, usability and desirability.

The capabilities and potential of networked wireless technologies are not all obvious... in fact many are not visible. A good example is the growing phenomenon of Wi-Fi networks. Many of us are familiar with Wi-Fi and understand the concept of wireless networks but the implementation and range of the service is not obvious— and we have no precedents for visualizing the invisible boundaries of a wireless network. There is also a growing social concern regarding corporate control of the airwaves. As a result believers in free Wi-Fi have put chalk markings on buildings— called "war chalking"— to indicate Wi-Fi hotspots that

people can tap with a laptop. In an alternate but perfectly legal scenario, the Boston-based company NewburyOpen.net who preach that Wi-Fi should be free, use their own homemade network that comprises a mobile Wi-Fi transmitter built into a car to offer free broadband access to people who would otherwise have to pay for it. As the company is quick to point out, "The car is an incredible way of showing that wireless has no boundaries." (Melville, 2003)

The Wi-Fi example is a relatively simple scenario. On many other fronts our world is becoming much more complicated and technology has opened doors to a level of interaction with our environment that will be difficult for many people to understand. Sony's Aibo is perhaps the tip of the iceberg. The robot dog is an amazing autonomous device. It is aware of its environment and it can respond... as it sees fit. It is no accident that Sony chose the metaphor of 'man's best friend' to implement such a sophisticated technology. Aibo looks like a dog and Aibo moves like a dog. The metaphor is successful... and we assume Aibo will react like a dog and we are able to accept Aibo as a novel hybrid toy pet. But what happens when we take Aibo's sensors and actuators and embed them in our environment. What happens when, as Stefano Marzano suggests, you talk and the walls talk back? Who are you talking to? What are the protocols? How do you address a wall? How do you tell if the wall understands you? How do you know how the wall feels and whether this is a good time to talk or whether the wall is busy talking to another widget or phidget (Greenberg, 2002) and that it would be inappropriate of us to interrupt? By building on a recognizable precedent, Sony cleverly sidestepped the 'wicked problems' we now face.

It is important to recognize that these are not exclusively technological problems... many of the more critical issues are social and cultural in nature and they won't be solved through technical analysis. Technology alone does not hold the answer. But that's not all... so far we have only touched on the issues as they pertain to a stand-alone device. The concerns and complexity increase exponentially when you realize wireless technologies are networked by definition... in other words these devices can talk to one another... And what does that mean? There have been many peculiar and disconcerting stories surrounding Aibo for instance. One such tale suggested that Sony was using the camera in Aibo's nose to conduct (underhanded) market research. In another development, the Australian engineer and designer, Natalie Jeremijenko, now the Director of the Experimental Product Design Initiative in the Department of Mechanical Engineering at Yale University has published work on feral robot dogs and has been able to demonstrate the pack behaviour of robotic dogs by hacking the operating system of low cost robotic dogs and converting them to sniff out toxic waste. (Jeremijenko, 2003; *Feral Robots: Dog Report*, 2003) These issues have far-reaching social significance with respect to personal privacy, security and safety... and we will have to contend with these concerns as well.

Trying to Find a Balance

One of the keys to solving these wicked problems appears to be a balanced understanding of both the technical (utilitarian and performance) issues and human (social and cultural) considerations. For the past four years we have been building the infrastructure of a new school to address a new generation of students equipped to tackle the requirements of a new

generation of interactive products... designed from the outset to address the needs of real people in everyday situations. The program is heavily research oriented at both the undergraduate and graduate levels to foster a better understanding of the need to develop integrated solutions to the individual social, cultural, environmental and technical issues surrounding the potential offered by advanced technologies. This year, we graduated our first undergraduate class along with our first extensive sequence of graduate course offerings.

At the undergraduate level, we have created streams in performance and media art, interaction design, and information technology. All streams have significant computing course content in addition to core requirements for each stream supplemented with interdisciplinary courses ranging from social and cultural studies to business management. The capstone course brings together all students in these three streams in a collaborative interdisciplinary team-based studio-type course taught in an on-line environment. Through a comprehensive sequence of six modules, students from the three different disciplines pool their knowledge, skills and personal interests to design and develop new ways to use technology to respond to people's everyday needs. The course, which runs for a full academic year, requires each team to develop and prototype concepts, assess the viability of the idea, conduct extensive user testing and further refine the idea based on real-user input. The results of our first class exceeded our initial expectations with all twelve teams successfully producing and field testing advanced operational prototypes of new product concepts. Of particular note, two of the twelve teams entered a province wide entrepreneurship competition and as of this date one of the two teams has advanced to the semifinals— Voracity is a new concept for interactive game play based on 3-G cell phone technology.

At the graduate level, we complement this initiative with a focus on more specific methodologies to support the development of interactive products and systems. Our first course offering in Robots and Interactive Products concentrated on the evolution of the stereotypical robot. Our initial research was based on an examination the world of toys, where for the last two decades a steady evolution in emotionally meaningful interactive products had been unfolding. Some of the key examples from the world of toys include: Teddy Ruxpin, Tamagotchi, Giga Pets, and Furby. Similarly some of the key examples from the academic and commercial research labs we looked at include: Cynthia Breazeal's emotional robot, Kismet, at MIT; Mitch Resnik's 'programmable brick' at MIT which was the prototype for the Lego Mindstorms Robotics Kit; Sony's robot dog, AIBO, NEC's personal robot, Papero; and Honda's dexterous biped, Asimo, who can navigate stairs.

Once again, for the project development, we created interdisciplinary teams comprising students from interactive arts and students from information technologies. We then challenged the students to design and prototype a scenario for an 'intelligent' interactive product/system that could demonstrate autonomous behavior during the execution of a 'meaningful' task. The students organized themselves into three teams and divided work responsibilities around the design concept, the development of the mechanical components, and the necessary software programming. Each team was provided one complete Lego

Mindstorms Robotics Invention System 2.0 kit to get started, although there was no restriction on the technology they could use to carry out their project.

Each team was encouraged to develop a plan for an iterative rapid prototyping strategy (Shrage 1999, 2000; Kelley, 2001) to guide them through a series of iterations ranging from preprogrammed demonstration models to a final fully autonomous prototype. To help get everyone started, the initial assignment was to build one of the robots depicted in the Mindstorms tutorials reference. This exercise served as a catalyst to bring the students together and the task was sufficiently complex that the students were able to discover each other's technical skills, and knowledge. The 'building block' format of the Lego Robotics System proved to be an excellent experimental platform for the less technical students. Lego has implemented a similar format for software programming. RCX Code is an application that runs on a PC with a modular graphical interface for plugging together customized software applications to download to your robotic device. You can buy third-party extensions to the Robotics system and for the ambitious you can even design and build your own sensors. There is also a very large on-line user community. Similarly, on the software side there is a high degree of flexibility including the potential to use more powerful software applications. All this means students can focus on the 'real issues' with out getting bogged down in the complexities of engineering and software design.

Working from an original concept, each team was able to demonstrate autonomous behaviour with their prototypes. Each team's robot was capable of interacting with people and each team's robot had begun to develop its own personality:

Embley is a robot that explores the simple but challenging task of identifying human presence. When Embley encounters an obstacle it references its heat sensors to determine whether it has come across an entity that radiates heat. Upon recognizing a heat source the robot adjusts its frame of reference by maneuvering its onboard camera upward, then running a sequence of video reference algorithms to determine whether the warm object it has encountered is, in fact, a human.

Smarti merges a number different technologies— wireless network architectures, robotics, and artificial intelligence— to create a system of hockey puck sized interactive robots that engage the user in a socially meaningful and emotionally engaging fashion. Each Smarti system contains five bots that distribute themselves throughout the home and engage users in a range of environments.

Johnny 6 is an exploration into the mechanics of personality-based communication and emotional interaction between humans and robots. Johnny 6 has the capacity to handle voice-based interaction, and the ability to articulate basic emotion (happy, sad, angry) using movement and sound. Johnny 6 also has the capacity to operate in a semiautonomous fashion. (A more detailed discussion of this project can be found in Budd and Evernden, 2003.)

Prototyping Methodologies

The importance of prototyping tends to be well understood in the field of industrial design. And as you can see from our brief overview the requirement for prototyping is a key component in both our undergraduate and graduate course offerings. In fact, we believe prototyping should be considered an intrinsic part of development process for interactive products and systems. Perhaps our concerns in this regard can be understood in this brief anecdotal tale presented by Lars Erik Holmquist, the leader of the Future Applications Lab at the Viktoria Institute in Goteborg, Sweden, at the Doors 7 Conference in October 2002, as he described how he was once shown a prototype of an intelligent flower stick.

“This was a stick that you would put in your flower pot, just like an ordinary flower stick, but it would do all kinds of things. It would start monitoring the plant’s well being, so it would know if I was watering it, if I was talking to it, it could communicate the plant’s feeling(s) to me, it could communicate with other plants, it would run forever by getting its energy from the sun and the soil, like the flower did and so on.”

It turned out the student’s magic plant stick was purely conjecture. As educators we have probably all seen this scenario. In world of computing science and software development it affectionately became known as vaporware in the late 1980s and early 1990s. The same syndrome potentially holds true for the development of interactive products. Holmquist used this example to underscore the fact that “ubiquitous computing is hard... (and that) because ubiquitous computing is really hard, there are a lot of really deep technical problems that you really need to solve before you have a chance of getting anywhere near this vision.” (Holmquist, 2002)

The value of prototyping is well documented in both design and management circles (Schrage 1999, 2000; Kelley 2001) but perhaps not as well understood as an active development methodology as we might like. As we have previously identified, the development of effective intelligent interactive products and systems is a complex process with significant social implications. Without prototypes to support new concepts ideas will remain highly questionable.

We have also identified the complexity of the technical aspects of prototyping interactive products and systems. Our experience indicates the ‘building block’ format for both the software and hardware components of the Lego Robotics System is a viable vehicle—particularly when you take advantage of third party add-ons supported by an active on-line user community. And we are working towards building a repository of tools and techniques to support our endeavors. Interestingly we have discovered several other groups who are charting a similar course. Saul Greenberg’s Groupware team at the University of Calgary has recently spun off a commercial enterprise, Phidgets, Inc. The company packages phidgets, a 3-D version of the widgets that have simplified software development in interface design with. Phidgets allow designers (in this case programmers) the ability to plug together hardware components and focus on the programming aspects of interactive product development. (Greenberg, 2002) In another ambitious development, experience designer, Irene Mavrommati and computer scientist Achilles Kameas lead a team under the auspices of the European Union IST/FET project of the Disappearing Computer Initiative called e-

Gadgets. The e-Gadgets team is in the process of prototyping a series of wireless networked 'extroverted gadgets' that add smart networked capabilities to existing objects— like tables, lamps, and ... allowing users to create and specify interactive relationships throughout their personal work or living environment.

Our Next Step

So where are we headed? On reviewing the robots developed by the three graduate teams it became readily apparent that consolidating the collective capabilities of the three projects would represent a major step forward and provide a springboard for a more sophisticated level of man-machine interaction. We have already learned a great deal. We also recognize a major limitation in our initial approach. There is no reason, whatsoever, to think in terms of self-contained products or systems— wireless networking has changed all that. It's time to take the sensors and the actuators 'off the dog'.

In response, this fall we will be offering a revised version of our graduate course called "Ambient Technology— Smart robots and other interactive products and systems" to reflect our shift in focus from self-contained to distributed interactive systems. We are also currently working on a new interactive system to help us probe social response to smart systems. Wireless Walter is a robot and research platform for exploring a users' acceptance of different media-based interaction. Walter utilizes a wireless video feed to facilitate operator awareness and robot control (including movement, sound, video, and voice) from a remote location... As Walter navigates and interacts with people in a space, the absence of a visible operator suggests that he is doing so in an autonomous manner. In this capacity Walter becomes a viable platform for assessing man/machine interaction.

And what of our opening quote from John Thackara, "... and what happens psychologically when you step into the garden to look at the flowers— and the flowers look at you?" Still sound far-fetched? Not at all! One of our more ambitious student teams recently produced a fully operational prototype they called Plantera. Plantera explores the potential for using technology to enhance emotionally meaningful relationships between people and plants. From a research perspective the Plantera project serves as an interesting platform for investigating personality based interaction mechanics between a user and a living organic life form. Plantera pots reference sensor data related to light intake, hydration, and owner interaction and then communicate the plant's health, happiness and vitality to the owner through sound and light— in effect Plantera can actually 'talk' to you. Welcome to the future of interactive products.

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