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Ubiquitous Multimedia: Bridging the Digital Divide

Sethuraman Panchanathan
Arizona State Univeristy

The rapid emergence of multimedia technology and standards is resulting in an explosion of media-rich applications. However, the state-of-the art multimedia solutions still require user interaction and intervention, which in turn place limits on the proliferation of media in everyday situations. I believe that technology illiteracy and/or fear of change is accentuating the multimedia (digital) divide—namely, the disparity between the have's (technogeeks) and the have-not's (the common man).

Early attempts to address this problem were conceived many years ago under the umbrella of user interfaces. Many researchers felt that these interfaces (although eventually developed by engineers) would be created by a team of nonengineers and human-factors specialists including sociologists, psychologists, and artists. This has resulted in interesting outcomes ranging from appealing mouse designs to palm devices with graffiti. The question remains where we are with all of this. A significant percentage of the population is still technology averse, and many are comfortable at best with just switching on the computer, browsing, and using email. Yet the push to have every little application enriched with media continues—we're moving from text to images to video to 3D to virtual worlds. A lot of talk focuses on the next killer-app, but there's little effort spent on how we can bridge the multimedia divide.

One of the key requirements in bridging this divide is to address media-related challenges in everyday problems, keeping in mind not only the technological advances, but more importantly, the social implications and societal impact. The answer lies in taking a problem-centric view rather than the typical technology-centric view of developing solutions. The challenge then is to explore solutions that use media ubiquitously. Killer-apps don't emerge unless users seek applications that aren't just rich in commercial impact but have the potential to generate and foster innovative concepts that can result in a much larger and broader impact. To generate a user-centric or problem-centric view as opposed to a technology-centric view, we must undertake a step-by-step approach toward solving a real problem similar to any design process.

Approaching ubiquity

The concept of ubiquity reflects the trend where computing devices become increasingly embedded, intelligent, and deployed in a variety of settings such as the home, office, vehicle, and in other environs to augment human capabilities. These devices must be invisible or transparent and embedded anywhere and everywhere. As the late Marc Weiser envisioned it, ubiquitous computing will usher in the age of calm technology, replacing explicit interactions with computing devices by implicit exchanges.

I'm convinced that ubiquitous multimedia has enormous potential and can influence the way we operate and interact with the external world. Examples of this include the proliferation of media technologies in smart spaces such as homes, offices, and cars. This promulgation is brought about by a convergence of many different enabling technologies such as intelligent agents, distributed computing and databases, embedded hardware and software, as well as ubiquitous media. The success of the proliferation of these concepts to a large extent depends on research advances on numerous issues, including perception and cognition of media and the interplay between the different media in various applications.

Ubiquitous multimedia applications

At the Center for Ubiquitous Computing (Cubic) at Arizona State University, we're investigating an application targeted for the visual and hearing impaired that challenges the concept of ubiquity. This application illustrates the power of

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ubiquitous media by responding to the needs of a population or consumer base that currently doesn't have access to visual media. Hence, this community can most certainly benefit from seamless multiple media capture, processing, transformations, and delivery.

To understand the consumers' real rather than perceived needs, it's important to first engage in user-centric discussions with the target population. This requires assembling focus groups of consumers and listening to their needs as well as conversing with them about how technology could augment or enhance their lives. It's also important to engage other related specialists to complete the requirements analysis. For instance, in the case of our target application for the visual and hearing impaired, the focus groups should consist of

- blind and deaf–blind individuals of different age groups and educational levels,
- mobility instructors and educators of blind and deaf–blind children,
- researchers involved in disability studies, and
- companies that manufacture existing assistive devices and adaptive-technology products.

(By assistive device, I mean high-tech navigational devices used by the blind or deaf and blind. A long white cane, seeing-eye dog, or sighted guide aren't assistive devices but are standard means of mobility. Adaptive technologies are computer-based hardware and software that make existing commercially available computers and applications accessible to the blind or deaf and blind.) The outcome of this consultative process serves as the foundation for understanding the consumers' needs, which we have chosen to represent as a collection of scenarios or stories that bring out the technological challenges and requirements. Although the instinctive approach is to take on the complex scenarios in our eagerness to generate technological innovations, it's more important to first focus on simple scenarios and see how we can adapt, augment, and perfect the existing solutions, specifically focusing on the ubiquitous capture and delivery of media.

The focus groups we interviewed at Cubic identified many scenarios that would have a significant social impact. Here is just a sampling of the simple scenarios: helping a blind child read a book (scenario 1) and helping a deaf–blind individual confidently pick up a newspaper and read it (scenario 2). It would greatly impact a blind child or deaf–blind individual if they could experience reading with no barriers. The first task at hand is to investigate what prevents this from happening. The focus in solving this problem should remain not in just identifying and putting together a collection of media technologies but instead on how to do it in a ubiquitous manner that delivers the richness of the experience as well as having a broader impact.

Figure 1. Laura reads a book using a pair of glasses consisting of an integrated video camera and speakers wirelessly connected to a palm-size processing unit.

In scenario 1, Laura is nine years old and has been blind since birth. She has, thus far, only been able to experience books with book readers but has always wanted to do it on her own. We plan to introduce her to a technology that will let her read regular print (see Figure 1). Her version of the technology will consist of a pair of glasses with an integrated video camera and speakers wirelessly connected to a palm-size processing unit. The glasses will be light and the camera and speakers hardly noticeable. The device will be unobtrusive and won't make her look like an alien.

In scenario 2, Will is a university student who became deaf and blind when he was two. He likes to navigate himself through campus, pick up the campus newspaper, and read it while enjoying his lunch at his favorite spot at the university cafeteria. His version of the technology will consist of a pair of glasses with an integrated video camera wirelessly connected to a palm-size processing unit that features an integrated refreshable Braille device (see Figure 2). Using the refreshable Braille device, Will can switch into document-navigation mode. The system will try to interpret the newspaper layout and provide Will with information such as headings, runners, number of columns, and page numbers. Will can then choose his favorite sports column, and switch into reading mode, and begin reading using the refreshable Braille device. We'll

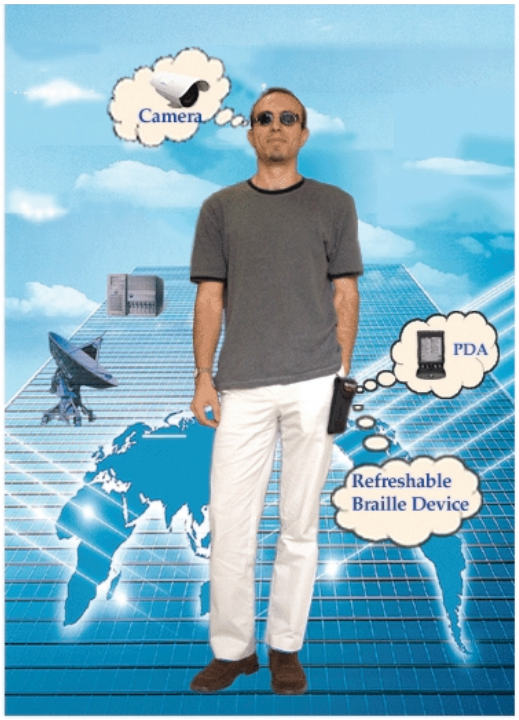

Figure 2. Will sporting a pair of glasses consisting of an integrated video camera wirelessly connected to a palm-size processing unit that also features an integrated refreshable Braille device to help him confidently read a newpaper.

design the system to pick up the selected article so Will can begin reading using his refreshable Braille device.

A sighted child can learn, understand, and appreciate pictures from a young age while blind children don't have the same exposure to translating 3D objects into flat symbols. Sighted people are exposed to so many pictures that they take them for granted. Typically, an illustrated book for young blind children is homemade by parents and teachers, and there's a clear frustration brought on by the lack of available material. The opportunities for ubiquitous multimedia in this area are enormous. For example, we can unleash multimedia's power to present visual information through tactile tools, thus introducing preschool children to shapes, sizes, colors, counting, and geometry.

Technical challenges

Here are some basic research and technical challenges in tackling our sample scenarios:

- real-time optical character recognition (OCR) from the camera input;
- compensation for different lighting conditions, orientations, and skew;
- interpretation of page format and layout;
- navigation within a document and within a page;
- integration of OCR, camera, audio-output device (speakers), and refreshable Braille devices.

Although the scenarios seem to be limited to processing visual media, we must address various other important research issues. For example, Laura uses her sense of hearing in many different ways to understand and interact with her environment. Using a speaker to present her with the output from the book reader, though intuitive, interferes with her normal abilities rather than augmenting her capabilities. This points to fundamental research challenges that we must tackle, such as

- How do blind people use their hearing?
- Where should we place the speakers so that the sound output augments their audio perception rather than interfere with it?
- What should be the type and characteristics of the audio device?

As you can see, simple scenarios that seem straightforward possess a number of research and technical challenges that need attention. Complex scenarios such as navigation and interaction with the environment involving the target population present more sophisticated challenges we must address. For example,

- How do we communicate information gathered through one media (such as visual) through other media (such as audio or tactile)?
- What's the best way to transform the acquired multiple media data and partition the processed output for best delivery of information?
- How we do we detect, describe, and recognize visual scenes, people, and so on?

Although these complex scenarios have the potential to unravel significant innovations, we must first tackle simple scenarios by identifying complex technical challenges inherent in them and developing a framework that's extensible to complex scenarios. At Cubic, we've created layered scenarios for our target application, each bringing out the technical challenges at various levels of complexity. The

complex scenarios build on the core technologies that will be constructed at the lower layers.

The target application I describe here not only demonstrates the lack of ubiquitous media solutions and limitations of existing technologies, but more importantly, points to new dimensions of research that make media ubiquitous. Although at the outset, it may seem that the solutions that emerge may only impact blind and deaf–blind individuals, it's quite the contrary. The technical innovations can potentially impact the general population much more than even the target population. For example, the problems of detecting, describing, and recognizing content and events in the realm of media ubiquity have direct relevance to the security issues that have become of particular interest in light of the recent terrorist attacks in the US.

I can cite many such examples, but the general rule of thumb to remember is that when we acquire, process, and present media for people who are in some way perceptually challenged, the creativity that's born is likely to have a strong impact on all people. A specific example of this is the invention of the typewriter. The first commercially successful typewriter, The Hansen Writing Ball, was produced in Denmark in 1870. It was originally designed to help the blind and its inventor reasoned that a ball-shaped arrangement of keys would allow touch-typing. The impact of the typewriter and its derivative (namely, the keyboard) is a testimony to the translation of the real benefits of such innovations originally intended for a smaller audience penetrating the general community at large.

Conclusions

Bridging the divide between technology-savvy individuals and the common man requires not only exploring opportunities for penetration of multimedia technologies in everyday applications, but more importantly, a conscious effort to identify consumers' media needs, followed by ubiquitously capturing, processing, and delivering media. This challenge offers numerous opportunities to engage multimedia researchers in the foreseeable future. **MM**

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Readers may contact Sethuraman Panchanathan at the Center for Ubiquitous Computing (Cubic) in the Dept. of Computer Science and Eng. at Arizona State Univ., Tempe, AZ 85287-5406, email panch@asu.edu.