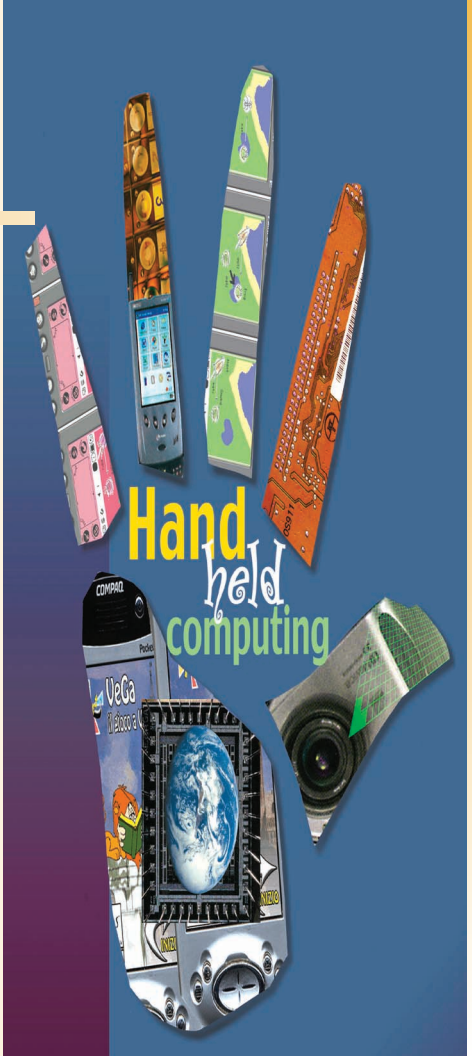
Handheld Computing



The increasing consumer use of handhelds has paralleled an increase in research addressing technology issues related to these devices and their potential use in novel applications.

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Mobile computing, now a mature and established field, appears destined to become the dominant computing paradigm. Appearing in many forms and with increasingly diverse functions, mobile devices now include personal digital assistants such as the PalmOS and Pocket PC, handheld games like GameBoy, mobile phones, digital audio players, smart cameras, and many more.

Developers are augmenting these handheld devices with ever-increasing functions that cross boundaries, such as GPS-enhanced PDAs and games or cameras on phones. Communication technologies such as Bluetooth, WiFi, and G3 will make it easier for these devices to communicate with other handhelds, appliances, and computers. Concurrent with the evolution of applications and middleware, the use of PDA-class devices is reaching a critical mass in schools, hospitals, and other venues beyond traditional business uses.

UBIQUITOUS ACCESS

Handhelds are rapidly becoming ubiquitously accessible companions that support activities of daily living. Faster processing, increased storage, and improved interconnectivity make these devices useful as universal entertainment machines, electronic map and guidance systems, and access devices for information retrieval from the Web or specific information systems such as tourist guides.

Because handhelds are inexpensive compared to other types of computers, users can possess more than one of these devices, each having a specialized user interface. Although handhelds can be used in isolation, they also can interoperate with other devices through wireless networks including WiFi and Bluetooth. Further, by using inexpensive components, developers can integrate different technologies into one device, leading to one of the fastest-growing markets for handhelds.

Worldwide, about 30 million PDAs are in use, but this pales in comparison to the 1.3 billion mobile phone devices currently being used (www.cellular.co.za/stats/stats-main.htm). Increasingly, these mobile *smart phones* offer PDA-like capabilities. Analysts predict that in 2003 smart phone sales will reach 4 million units in Europe, for the first time outpacing sales of PDAs (http://search.internet.com/www.rimroad.com). In the US, predictions indicate that the smart phone segment of the phone market will increase from 8.5 percent in 2003 to 35 percent in 2007, while PDA sales will increase from 6.9 million to 17.1 million in the same period (www.wirelessdevnet.com/news/2003/169/news7.html).

In an environment in which the circumstances make using a laptop inappropriate, a handheld device offers a convenient alternative. For example, using a laptop isn't feasible when standing or walk-

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ing around while working in a hospital or when touring a museum, but these settings offer an ideal environment for handheld computers. In circumstances requiring hands-free operation, wearable devices offer an appropriate option. However, even users who are not familiar with complex technical computer systems can manipulate handhelds in many novel, nontechnology-centric application domains.

The increasing consumer use of handhelds has paralleled an increase in research addressing technology issues related to these devices and their potential use in novel applications. These issues range from determining the kinds of applications best suited to handhelds to fundamental user interface concerns such as how to overcome size, form factor, weight, energy consumption, and input limitations. Determining how to implement systems that span multiple heterogeneous devices presents another concern.

IN THIS ISSUE

The call for papers for this special issue elicited an overwhelming response covering a wide variety of topics. The five papers we selected from among 87 submissions specifically focus on handhelds rather than on more general mobile devices and technologies or networking issues that also apply to laptops. Further, we aimed for a mix of application and technology papers.

Three of the papers we selected describe novel applications for using handhelds in a classroom, in a hospital setting, and for sightseeing. In addition to helping shape the next generation of applications, these user-centric approaches also reveal interesting alternatives for evaluating the applications and determining user requirements.

Two papers focus on handheld technologies. One discusses usage scenarios for handhelds and the other addresses software engineering issues. Their analysis and experience will help researchers better understand problems and develop some candidate solutions.

In "Handhelds Go to School: Lessons Learned," Deborah Tatar and colleagues discuss a series of educational projects in which SRI International has been designing prototypes and performing classroom-based research in conjunction with teachers. This work explores the use of wireless handheld devices to enhance instruction in kindergarten through twelfth-grade classrooms. Using wireless handhelds in an educational setting offers new opportunities for innovative user interaction, communication, and connection with sensors—both in the classroom and on field trips. Lessons learned from this experience include the observation that using handhelds helps teachers use technology with more students in a wider range of circumstances. This, in turn, leads to increased student participation and fewer disruptions.

"Context-Aware Mobile Communication in Hospitals" by Miguel A. Muñoz, Marcela Rodríguez, and Jesus Favela describes their experience with developing a collaborative handheld system for use in a hospital setting. The authors first conducted an extensive user analysis to discover the hospital staff's information needs and communication patterns so that the system would support the real tasks required by the intensive and distributed nature of information management in this environment. The resulting system extends the instant-messaging paradigm by adding context-awareness based on location; the timing of an exchange; the location of a worker, device, or artifact; and the person's role, not just his or her identity.

In "VeGame: Exploring Art and History in Venice," Francesco Bellotti and colleagues describe a mobile device that uses a handheld platform and educational software to leverage video game techniques and make exploring a locale's heritage a challenging and compelling experience. The device architecture includes microgames incorporated into a game structure that closely resembles a treasure hunt. The hunt encourages either individuals or collaborative teams to look more closely at artifacts located around the city. Although the authors also point out some drawbacks of current technology, such as the limited user interface and computational power, their VeGame demonstrates how a handheld device offers advantages over other media—including paper or larger computers such as laptops—for applications that require users to be active and mobile while exploring their environment.

In "Fostering a Symbiotic Handheld Environment," Mandayam Raghunath, Chandra Narayanaswami, and Claudio Pinhanez propose symbiotic applications in which handhelds work with the larger set of devices in the user's environment as a way to overcome some of the problems with using small devices. The authors analyze issues in handheld computing by sketching several usage scenarios to identify technological problems such as display capabilities, input capabilities and modalities, control capabilities, authentication, security, privacy, ways to exchange data, and wireless information access.

Developers of handheld applications—especially those running in a collaborative setting—require support for design, implementation, and evaluation. Nenad Medvidovic and colleagues introduce a system that supports *programming in the small and many*. Prism provides software development for dynamic, mobile computation on large numbers of small, resource-constrained platforms in complex scenarios. In "Software Architectural Support for Handheld Computing," they use a sample application to describe how their support system assists in the development of complex, distributed systems that integrate traditional desktop platforms, PalmOS and Windows CE devices, and digital cameras.

These systems, along with our own work[1] and that of many others, highlight both the breadth of applications and the user interface and development challenges that a world filled with handheld devices will bring.

Handhelds will increasingly serve as a personalized, single point of access for controlling electronic equipment and devices in the environment.[2] Game applications—already proven and popular commercial handheld products—are now the focus of increasing research.[3] Handhelds also demonstrate a growing potential for use as an entertainment appliance for showing videos or playing music.

Developers are working on technologies that address some handheld device limitations, such as sophisticated energy management, to allow longer usage. New display types are beginning to appear as well, such as OLED,[4] e-ink (www.e-ink.com), and digital paper (www.gyriconmedia.com). Novel input devices such as projection keyboards[5] have been introduced as well.

The use of handhelds to gain access to information services, both online and offline, requires further research. Advances in this area must take into account the small screen size and other output restrictions that limit data presentation.[6] Input restrictions also apply to these mobile devices, requiring either multimodal input as addressed in the W3C's Multimodal Interaction Activity standards (www.w3.org/2002/mmi) or special adapted ways to use a pen or stylus.[7,8]

Although many challenges lie ahead, overall we are excited by the continued growth in the research and commercial development of handheld devices. ■

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