
IGI PUBLISHING **ITB15277**
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This paper appears in the publication, **Advances in Ubiquitous Computing: Future Paradigms and Directions** edited by S. Mostefaoui, Z. Maamar, and G. Giaglis © 2008, IGI Global

Chapter I

Mobile Phone and Visual Tags:
Linking the Physical World to the Digital Domain

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Abstract

The growing ubiquity and usability of smart mobile phones can be exploited to develop popular and realistic pervasive computing applications. Adding image processing capabilities to a mobile phone equipped with a built-in camera makes it an easy-to-use device for linking physical objects to a networked computing environment. This chapter describes an extensible and portable programming platform that, using bi-dimensional visual tags, turns mass-market camera-phones into a system able to capture digital information from real objects, use such information to download specific application code, and act as a GUI for interacting with object-dependent computational services. The system includes a module for on-phone extraction of visual coded information and supports the dynamic download of mobile applications.

Introduction

Despite the significant progress in both hardware and software technologies, Weiser's vision (1991) of an almost invisible computing and communication infrastructure able to augment the physical world with human-centric, seamless services is still not completely realizable or economically convenient. However, the deployment of ubiquitous computing applications can be significantly eased if a personal device is included as the access medium. The most obvious candidates are mobile phones, as they are in constant reach of their users, have wireless connectivity capabilities, and are provided with increasing computing power (Abowd, 2005). Moreover, an always growing number of commercially available devices are equipped with an integrated camera; according to recent studies, over 175 million camera phones were shipped in 2004 and, by the end of the decade, the global population of camera-phones is expected to surpass 1 billion.

Camera-phones enable a very natural and intuitive model of interaction between humans and the surrounding environment. Instead of manually getting information or editing service configurations, one can just point at a physical object to express one's will to use it; taking a picture of the object would suffice to set up the link with the offered services. The locality, spontaneousness and ubiquity of such an interaction perfectly fit with the pervasive computing paradigm, allowing us to access *context-dependent* services anywhere, anytime.

Capturing digital information from images is not a trivial task, especially when resource-constrained devices are used. To ease the acquisition process, objects can be labeled with visual tags, that is, bi-dimensional barcodes that encode context data. A programmable camera-phone can execute an image processing routine to read and decode the visual tag, without the need for additional hardware. Extracted data directly can provide information about the resource or, if the amount of information is too large, the visual tag can encode a resource identifier that can be used to gather information from the network.

Research in this area has contributed to the design of several barcode recognition algorithms and to envisage new interactive applications. The growing interest in this topic is also demonstrated by the release of commercial systems, which mainly focus on exploiting visual tags to link products or services to specific Web pages on the mobile Internet. However, we observe that currently available systems either lack in flexibility, as the software must be already installed onto the mobile device and cannot be dynamically extended in order to interact with new classes of resources, or run on specific hw/sw platforms (e.g., Symbian OS), thus preventing the deployment of services on most of the camera-phones already shipped or in production in the near future. Finally, architecture insights of commercial systems are rarely documented.