A collaborative face-to-face design support system based on sketching and gesturing

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Abstract

Mobile and pervasive computing has seen a rapid development in the last years. Portable, handheld computing devices are getting more popular as their capabilities increase. Therefore, people having the need to work on-the-field have now the possibility to be supported by computer technology, for example, garden or building designers. Ad-hoc networking capabilities of handheld devices enable the development of supporting tools for collaborative work anywhere. This paper presents MCSketcher, a system that enables face-to-face collaborative design based on sketches using handheld devices equipped for spontaneous wireless peer-to-peer networking. It is especially targeted for supporting preliminary, in-the-field work, allowing designers to exchange ideas through sketches on empty sheets or over a recently taken photograph of the object being worked on, in a brainstorming-like working style. Pen-based designed human–computer interaction is the key to supporting collaborative work. The gestures-based command input results in a lightweight yet efficient and easy to use interface. Graph structured hierarchical documents help to overcome the problems of a small screen size.
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1. Introduction

The growing acceptance of handhelds enables users to take advantage of numerous facilities that mobile information systems can provide in environments that computer technology could not reach otherwise [1]. In addition to supporting individual tasks as note-taking, scheduling, address storage, etc., handhelds can build ad-hoc wireless peer-to-peer networks and support collaborative face-to-face applications anywhere [2,3]. Although peer-to-peer approaches to collaborative computing are still not common, according to [4], they are becoming increasingly interesting to developers and users, since they allow for new forms of cooperation that do not naturally fit in the client–server model, such as ad-hoc and opportunistic collaboration. From a technological point of view, peer-to-peer communication is well suited for sharing objects, because it allows different participants (peers) to maintain their own knowledge structures while exchanging information.

Increasingly centralized design and manufacturing systems are being found insufficient to respond to highly dynamic situations. With the advent of the Internet, product design and manufacturing is becoming increasingly distributed and new environments are required to develop and produce high quality products faster and cheaper [5]. Potential beneficiaries of systems implementing these features include users whose activities involve on-site collaborative design sketching. For example, a group of architects may need to jointly work on a construction site using sketches to exchange ideas about re-designing facilities [6]. Or a group of engineers conducting an on-site inspection might require high mobility and efficient communication to jointly work on possible deficiencies and

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improvements of the facilities exchanging graphic sketches while moving around the premises [7]. The construction industry presents particular opportunities for using mobile information systems to improve collaborative design practices on building sites.

A handheld's most natural data-entry mode is using the stylus (a.k.a. a pen-based or freehand-input-based system). This enables users to easily write down their ideas and/or draw design sketches imitating the use of pen and paper [8–10]. However, most currently available handheld applications implement interfaces following the approach used for applications running on desktop computers using widgets (buttons, menus, windows) instead of freehand-input-based paradigms (via touch screens) and/or sketching [6,11,12].

According to [8], graphics-editing applications running on handhelds do not require a mouse-and-palette-based interface, nor do they need to rely on such elements as colors, fonts or lines for creating sketches. They should rather implement interfaces using natural freehand-input stroke to interact with them. Applications implementing this approach have already been developed for scenarios such as sketching informal presentations [10] and military courses of action diagrams [13], and for being used as a non-technological method of idea generation in meetings. But no system using only interconnected handhelds in a wireless ad-hoc network with a pen-based system to create a sketch-based collaborative design-editing mechanism, has been proposed yet, as it was done for PC-based systems [14], but they do not share the advantages of mobile platforms.

The ability to draw design sketches on the fly, at any physical location and even while in movement, allows users to discover opportunities for substantial improvements at an early stage of the design process and thus enhance efficiency of productivity. Trough sketching the user can employ visual symbols, describe spatial relations [6], and/ or exchange opinions [15] using a fast and efficient way for sharing and discussing complex ideas [9,15]. All this, however, requires sketch diagramming support, allowing users to engage in face-to-face communication and explanation of their rough designs simultaneously [9,15,16]. The ability to handle graphic representations while engaging in a face-to-face communication is a natural mode of expression [9] crucial to knowledge creation and capture among a group of people [15].

In this work, we present MCSketcher: a Mobile collaborative sketching system using wirelessly interconnected handhelds in an ad-hoc network. It uses the pen-based paradigm, enabling users to draw sketches collaboratively and share their "graphic opinions" while maintaining at the same time a face-to-face communication to explain their designs. Two further fundamental aspects add value to the proposed application: the use of conceptual maps for organizing and structuring sketches [17], and the use of gestures as a simple way of implementing data-entry functions required by the user [12].

2. Related work

According to [8,12], sketching and gesturing with pen-based systems are natural modes for design–task-oriented interaction. In [9] it is noted that a sketch is a quick way of making designs that (a) facilitate the creator's idea generation process, (b) stimulate communication of ideas with others, and (c) stimulate the use of early ideas, thanks to the accessibility and interpretation they provide. It has been shown that the participation of various persons in the elaboration of a sketch using computer support improves the creativity of the group [16]. Various computer systems supporting sketch-based interaction have been developed in recent years. Desktop systems providing collaborative support include:

- Networked virtual environments (net-VEs). These are distributed graphical applications that allow multiple users to interact in real time, providing a shared workspace, as well as communication mechanisms [17].
- SKETCH [18] is a collaborative system based on a client–server model for supporting conceptual designs, that provides distributed users a cooperative workspace for sketching, as well as interactive design exploration and edition. However, it does not provide awareness of other users' presence. SKETCH includes an interface for creating and editing 3D sketches of scenes based on the use of simplified (2D) drawing commands interpreted as operations to be applied to objects in a 3D world. All objects are thus 3D and rendered in orthographic views.
- NetSketch [19], which is an application based on the SKETCH interface that supports distributed conceptual design, in which scene models are constrained to the relatively simple shapes that can be created and rendered. NetSketch uses a peer-to-peer network topology but cannot always guarantee model consistency among all users.
- A collaborative system for conceptual design is described in [14] allowing users located in geographically distant areas to cooperate by sketching, exploring and modifying their ideas interactively, with immediate visual feedback. The system can be used for urban and landscape design, rapid prototyping of virtual environments, animation, education and recreational activities.

Handheld-based note-taking and sketching systems have also been proposed:

- Citrin et al. [11], describe a software architecture that supports pen-based mobile applications through a client–proxy server organization, allowing many graphical applications designed with a mouse/palette-keyboard interface to be accessed through pen-based mobile devices offering shape, gesture, and handwriting recognition.