A pervasive assistive environment for visually impaired people using wireless sensor network infrastructure

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ABSTRACT

Wireless sensor networks (WSNs) have been identified as a promising technology for supporting assistive environments. This article introduces PROTECT, a system that employs autonomous software objects referred to as mobile agents (MAs) able of locating and informing visually impaired persons for potential risks. PROTECT utilizes a 3-tier architecture where the first tier comprises a base station (BS), the second tier mobile sinks (MS) (carried by blind people on their sticks) and the third tier stationary sensor nodes. This WSN is deployed in an urban environment. In the event of an alarm issued by a sensor node, the BS launches a number of MAs supplied with a near-optimal itineraries that visit the nodes in the alarm's surrounding area and notifies, through Wi-Fi (IEEE 802.11), visually impaired people for potential hazards in their proximity. In the event of communication problems (e.g. failure of some sensor nodes) PROTECT modifies the itineraries of the MAs to bypass the problematic areas avoiding disruption of the data collection process from working sensors. Simulation results confirm the high effectiveness of our proposed scheme in WSNs used in assistive environments and its performance gain over alternative MA-based approaches proposed for data fusion tasks.

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1. Introduction

Assistive environments use technology to improve the functional capabilities of individuals with disabilities. Such environments also enable a cost-effective self-care to users and provide them independence along with a better quality of life. In this work we introduce an assistive environment architecture based on sensor networks technology used for monitoring potential hazards on behalf of visually impaired people, while also ensuring network stability and operation even when a percentage of sensor nodes (SNs) fail.

Wireless sensor networks (WSNs) have come into prominence recently and many researchers focus on the numerous possibilities this kind of networks enable. A WSN is an infrastructureless network, comprising a large number of SNs spread within an area of interest (Akyildiz et al., 2002). Sensor networks have various applications such as environmental monitoring (e.g. traffic, habitat), industrial sensing and diagnostics (e.g. appliances, supply chains), infrastructure protection (e.g. water distribution), battlefield awareness (e.g. multitarget tracking), context-aware computing (e.g. intelligent home, responsive environment) and assisted navigation (Zhao and Guibas, 2004).

Mobile agents (MAs) represent a distributed computing technology with many advantages in WSN environments compared to the traditional client/server model (Pham and Karmouch, 1998). Some of them are improved performance in data fusion,[1] lower energy consumption of the constraint energy nodes, minimum bandwidth usage, and advanced reliability of the network. For those that are still skeptic about the utilization of agents in WSNs, Rogers et al. (2009) describe three examples (implemented on real SNs and deployed in real, harsh environments) where WSNs and agents managed to collaborate with great success. These examples depict some of the advantages that agent technology (including MAs) can offer to WSNs. The term MA (Pham and Karmouch, 1998) refers to an autonomous application program able to migrate from node to node to complete specific tasks assigned from network users. An MA can be programmed to perform local data processing on each SN depending on the data it already carries. The processed data are then carried by the MA to the next SN where the same procedure is applied.

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[1] Data fusion is the process of combining data from different complementary sources to maximize the useful information content. It has two main advantages: (a) improved reliability, (b) possibility to minimize the retained data.