Towards a Mission-Critical Ambient Intelligent Fire Victims Assistance System

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ABSTRACT

While various ambient computing and intelligence techniques have been used to assist human beings in different aspects of their daily lives and work, this paper investigates potential ambient intelligence support in mission-critical scenarios such as firefighting. The paper reviews state-of-the-art ubiquitous techniques and tools assisting firefighting. Based upon these great research results, the authors then report the design and implementation of an ambient intelligent fire victims assistance application. By sensing the physical environment and occupants in a fire building, the system suggests the safest and fastest route along which the building occupants could evacuate; and when escaping from the building is not possible, the system tries to calm down and inform the trapped ones an action list. The channels to convey the guide assistance include traditional lights, speakers, and occupants’ mobile phones (if existing). The empirical experiments show that ambient intelligence in such a fire response guide can help improve the egress time performance of building occupants. The presented ambient smart fire victims’ assistance system is supposed to work at an early stage of fire in a building. As a complement of existing firefighting techniques, it still faces a number of open questions to be resolved in the future.

Keywords: Ambient Computing, Ambient Intelligence, Context, Evacuation Route, Firefighting Technologies, Victim Assistance System

INTRODUCTION

In the past, fire hazards have caused many injuries and casualties. According to the statistics done by Brushlinsky et al. (2006), each year there are around 7-8 million fire disasters all over the world, which killed 70-80 thousand people and injured 500-800 thousand more. In 2008 in China, the number of fire disasters was 133 thousand (excluding forest, grassland, army, and underground mine fire). In total, 1385 people were killed and 684 people were injured. The direct loss estimate was about 1.5 billion RMB Yuans (CMPS, 2009).

In fire disasters, many people lost lives due to bad judgment. Poor decisions are likely
made in life-critical urgent situations. Let us take a close look at two recent fire disasters. One happened in a college dormitory, and the other in a club.

**Case 1:** On September 20, 2008, a fire occurred at Wuwang Club at Long Gang Street, Shenzhen, China. According to the police, the fire originated from the fireworks being set off on the stage. The disaster killed 44 people with 88 people being injured (Wang et al., 2008). At the beginning of the fire, people in the club mistook it for a show. The fire quickly led to lots of smoke, and many people were smothered. As the customers were not familiar with the back door where the emergency exit is located, hundreds of people rushed to the front door through which they entered, causing many people being stumbled to the ground. In contrast, as the employees of the club knew the emergency exit, the majority of them succeeded in escaping from the fire via this exit gate. The death rate for the total 150 employees is far less than that for the club customers.

**Case 2:** On November 14, 2008, at the Shanghai Business College in China, a dormitory room on the sixth floor caught fire at 6:10 am in the morning. The fire expanded very quickly and gave off a lot of smoke. The door was incidentally closed. The four trapped girls fell back to try to keep away from the fire. Eventually, the fire flame spread to the balcony. The girls jumped from the balcony before the firefighters arrived. They may have thought it was safer to do so, yet none of them could survive. The police received the fire report at 6:12 am. The firefighters soon arrived, and the fire was put out at 6:30 am (Liu, 2009).

A critical lesson we learn from these tragedies is that on-site occupants’ assistance in an unexpected and urgent fire situation is very much desirable. While lots of great efforts have been made to deliver tour guide or museum guide, we ask ourselves: “**can we design a mission critical fire response guide to calm and assist on-site victims in a fire building to survive?**” If there had been such an assistance system, which could point nervous and chaotic people to the right emergency exits along with the proper escape path (in case 1); or which could adaptively advise the four trapped girls to use the sheets in the dormitory and tie them to their bodies and climb down to the lower floors, e.g., the fifth floor, rather than directly jump down to the ground (in case 2), their lives might have been saved.

According to the physiological, psychological, and social behavioral studies (Song, 2002), at times of urgency, people tend to make unsound situational judgments and take wrong actions and, at times, even lose consciousness. Shouting loudly, losing confidence, disregarding exhortations, running in all directions, etc. are typical behaviors of people confronted with emergency situations. Even worse, poisonous smoke from the fire, e.g., CO, HCL, HCN, etc., can easily cause physiological disorders, such as impairment in the sense of smell, breathing difficulty, blurred vision, damage to the visceral and cranial nerve system, etc., which soon lead to mental confusion, behavior disorders, dizziness, coma, and suffocation (Song, 2002). There is no doubt that prompting ambient intelligent ubiquitous computing support to occupants is in demand. However, common human behavior makes the problem particularly challenging.

The aim of this study is to investigate ambient smart context-aware techniques for assisting fire victims to react properly when confronted with an emergent fire disaster from a technical perspective. Such an assisting system is not meant to substitute existing firefighting facilities and systems, but as a complementary user-centric technology to calm and help some people in a fire building. The system is mainly used before firefighters come. We have the following assumptions in this study.

- The layout of the fire building is available beforehand.
- Fire locations can be detected by smoke and temperature sensors.
- IDs of frequent occupants and number of occupants in each cell unit (room or cor-