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Intelligent and situation-aware pervasive system to support debris-flow disaster prediction and alerting in Taiwan

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Abstract

Effective information transmission through robust communications is critical to prevent and alert for natural disasters. However, disasters always destroy the wired communication environment. Moreover, effective information needs to reveal the real situations of the disaster, e.g., the accurate position and the real-time image/video of accident events. An accurate disaster prediction model is useful to reduce casualties and prevent disasters from occurring. An effective disaster prediction is based on the accurate disaster decision model, which can be achieved through the situation-aware information communications between the disaster area and the rescue-control center. This study proposes and designs an Intelligent and Situation-Aware Pervasive System (ISPS), which successfully alert people the occurrence of debris-flow disasters. ISPS is a three-tier architecture consisting of mobile appliances, intelligent situation-aware agents (ISA) and a decision support server based on the wireless/mobile Internet communications. Furthermore, the Location-aware Routing Prediction Method (LRPM) was developed to decrease the transmission traffic and latency of pictures pushing the maps of the disaster to mobile clients. Based on the database of the pre-analyzed 181 potential

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debris flows in Taiwan, accurate debris flow prediction models were built to prevent debris flow using case-based reasoning (CBR) in the decision support server.

Keywords: Situation-aware; Pervasive services; Decision and support mechanisms; Multimedia communications; Debris flows

1. Introduction

With the rapid progresses on consumer electronics and wireless/mobile communication technologies, handheld devices providing Internet and ubiquitous connections, such as personal digital assistants (PDAs) and Tablet PCs combining smart cellular phones have become popular for applications such as on pervasive entertainment, healthcare and disaster rescue (Joseph, 2004; Mohan et al., 1999; Varshney, 2003; Wei et al., 2003). The mobile communication and computing capabilities of the pervasive disaster system provide real-time and effective information about accidents and are very useful for disaster rescue (Kung and Ku, 2003; Satyanarayanan, 2001; Yu, 2003). The disaster rescue operations have three fundamental considerations (Lorincz et al., 2004):

(i) Real-time and effective information transmitted via robust communications is very important and critical for the disaster prevention and alert. However, the wired communication environment is always destroyed when a disaster occurs, particularly a debris-flow disaster.
(ii) Situation-aware information about the disaster area for the rescue-control center is very useful for making rescue decisions. The situation-aware information includes the location-based and some context-aware information, such as the mobile client's location and the real-time pictures/videos of accident events (Abowd et al., 2002; Banerjee et al., 2002; Lum and Lau, 2002; Patterson et al., 2003). However, owing to the narrow bandwidth in mobile networks and light computing capabilities in handheld devices, pervasive multimedia services are difficult to deliver (Hare, 2002).
(iii) An effective disaster prediction model is helpful for reducing the level of casualties and even preventing a disaster. The accurate occurrence probabilities of debris-flow hazards are based on effective prediction models, which can be derived from the well-analyzed knowledge of debris flows and intelligent reasoning engines (Tsai et al., 2002; Kawamura et al., 2003).

This study proposed and developed an Intelligent and Situation-Aware Pervasive System (ISPS) to provide real-time and effective information and to prevent and alter debris flows in Taiwan. The proposed ISPS is a three-tier architecture composed of the mobile clients, the intelligent situation-aware agents (ISA), and the Decision Support Server (DSS) based on the pervasive computing environment. Mobile clients use handheld devices, such as a PDA combined with a cellular phone, to transmit and receive multimedia debris-flow information including texts, pictures and audios based on real-time and interaction communications via GSM/GPRS networks. Mobile clients obtain customized information from ISA, which are located at the fronts of mobile networks. Eight intelligent agents are designed to achieve situation awareness. These agents are the user-interface,