‘Do you smell rotten eggs?’ Evaluating interactions with mobile agents in crisis response situations

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ABSTRACT
In this paper, we present ongoing research concerning the interaction between users and autonomous mobile agents in the environmental monitoring domain. The overarching project, DIADEM, deals with developing a system that detects potentially hazardous situations in populated industrial areas using input from both a distributed sensor network and humans through mobile devices. We propose a model of interaction with the gas detection system where concerned citizens communicate with a mobile agent to inform the gas monitoring system about unusual smells via their mobile phones. Next, we present a preliminary user requirements analysis based on 40 phone calls from members of the public to an environmental monitoring agency. Finally, we introduce measures to study the delicate long-term social relationship between users and the gas monitoring system.

Categories and Subject Descriptors
H.5.m [**INFORMATION INTERFACES AND PRESENTATION**]: Miscellaneous.

General Terms
Design, Experimentation, Human Factors.

Keywords
Trust, sensor networks, evaluation, adaptivity, social aspects.

1. INTRODUCTION
The DIADEM project deals with human interaction with distributed intelligent networks through mobile phones. The domain is detection of chemicals in urban industrialised areas. We will specifically focus on a distributed gas-detection network and human users living in a heavily populated and industrialized area that requires environmental monitoring to quickly detect potentially hazardous situations. Thus far, environmental monitoring agencies are in charge of collecting data about air quality and gas emissions. In addition, the area’s population can call the agency in case they notice an unusual smell or other pollution, to file a complaint or to receive advice on the nature and severity of the pollution. However, there are only a limited number of operators working in the agency’s control room at any given time. In case of a crisis event, if many people try to call simultaneously, the call centre’s capacities are quickly exhausted. The goal of the EC project DIADEM is to develop an (semi-) autonomous system that in case of unusual sensor readings deploys a Bayesian reasoning system to reduce the number of possible events (e.g., which gas has been detected and whether it poses a threat). If a potential hazard is detected or reported, the system will call upon human observation in and around the affected area to gather more information. For this purpose, participating users will be requested by a mobile agent (e.g., application on their phone or remote mobile phone service) to self-report their observations, which are then communicated to the central system. If necessary, the system provides location-based warnings and safety instructions. The pollution detection context makes the relationship between humans and agent delicate. On the one hand, the system requires information from users to determine the likelihood and location of an incident. On the other hand, users would like to express concerns, complain about unfavourable smells, or receive instructions in the (unlikely) event of a hazardous incident. To inform the design of the agent that will interact with members of the general public via mobile phones, a series of controlled experiments will be carried out. In the following, we first present related work we consider relevant for studying human-mobile agent interaction in the crisis response domain. Second, we present results of a preliminary analysis of 40 phone calls to the environmental monitoring agency and, finally, we propose a research model for this particular domain.

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2. RELATED WORK
Autonomous and adaptive mobile agents that accompany users wherever they go and provide a connection to distant systems are an intriguing area for research into human interaction with mobile applications. Various research projects have highlighted the potential of context-aware and user-adaptive applications for potentially high-risk and high-stress applications (e.g., disaster prediction and alerting [5]). Frequently, user-adaptive systems make decisions on behalf of the user, thus potentially leading to situations where users’ perceive they are not in fact in control of the system [8]. An overview of user-adaptivity issues, such as controllability, privacy, and transparency is provided by [4]. Trust is considered to be one of the important affective elements that play a role in human interaction with technology (e.g., [6]), and is crucially important in the crisis response domain tackled by this project. In addition, systems that display autonomous behaviour will not simply be treated as tools; instead, users will interact with such systems as if they were social actors following social conventions, comparable to human-human interactions [7]. As illustrated by research into mobile persuasion [3], social and affective processes also play a role when interacting with mobile

agents. Aspects such as perceived empathy with the user, actively acknowledging the user's (affective) experience, and acting accordingly could be key in achieving trust [1]. In a research project concerned with human-mobile agent interaction in contexts where the information communicated is potentially of vital importance establishing and maintaining a close social relationship between agent and user is crucial. Dialogues with such agents present challenges beyond dealing with limited screen real estate and designing for a wide array of different devices.

3. PRELIMINARY CALL ANALYSIS

A preliminary analysis was carried out based on 40 phone calls to the environmental service call centre responsible for gathering and documenting complaints, and locating environmental incidents. The calls were recorded after a minor chemical spill during a transshipment that resulted in unfavorable smells. Evaluating the calls, we deduced a number of motivations for people to call, including 1) worry or irritation about the smell, 2) desiring advice regarding what to do (e.g., send kids home, close doors/shops etc), 3) a sense of 'civic duty' to report the incident and provide information. The agency aimed at identifying the location and cause for the smell. To determine the precise gas type, call centre agents first asked for a description of the smell. Since callers usually cannot identify the specific chemical responsible for the smell, agents motivate callers to further specify the smell ("Does [the smell] remind you of something?"), and sometimes ask comparison questions to ease the caller's task ("Does it smell sweet/like a chemical/like rubber?"). We found that agents and callers sometimes seemed to have contradictory goals. Frequently, callers wanted to provide as much information as possible, whereas agents, in order to manage the sheer number of calls, had to quickly gather exclusively information required for further investigation and documentation. Moreover, it became clear that callers were expecting different feedback than the agents were prepared to offer. Agents are trained to gather unbiased information. Callers, however, were often hoping to receive additional advice indicating a trade-off between user expectations and designing mobile agents that gather and provide unbiased, reliable information. This analysis demonstrated the role and relevance of agents' social behaviour.

4. PROPOSED RESEARCH MODEL

Based on a review of relevant literature, the call analysis, and [2], we propose a research model to address those factors relevant to evaluating human interaction with mobile interfaces (Figure 1).

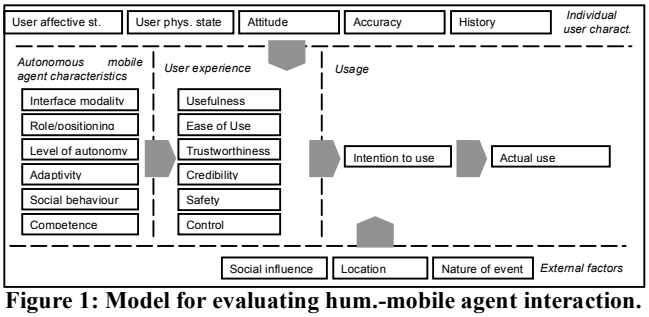

Figure 1: Model for evaluating hum.-mobile agent interaction.

First, we identified a number of **individual user characteristics**, such as users' affective/physical state, attitude towards mobile technology in general and the specific mobile device in particular, and individual user history.

Second, we also anticipate certain **characteristics of the autonomous, mobile agent** to play a key role: e.g., its level of autonomy, interface modality, and social behaviour. Third, both user and agent characteristics impact the **user experience**. To enhance the general user experience, factors such as credibility, ease of use, and usefulness are crucial. Forth, there are **external factors** that may influence gathering and supplying of accurate information (e.g., the nature of the event, its cause, and location). Finally, the user experience plus external factors determine whether users intend to make **use of the mobile agent**.

5. CONCLUSION

In the DIADEM project, we study the interaction between users and autonomous, mobile agents in the emergency management domain. A number of factors make this research unique and challenging: The need for human 'sensors' to inform an autonomous decision system; the potentially hazardous and stressful context; the need to interrupt users in their daily activities; the need to elicit information from and inform members of the general public. In this paper, we have identified variables we deem important for successful interaction with a mobile agent representing a distributed gas sensor network in a research model that will be validated by a series of controlled laboratory and real-world experiments to study.

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