Ask the expert: The potential for location-based support in the fire service

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1. Introduction

Nottinghamshire Fire & Rescue services are a progressive division of the fire service and use a variety of location-based technology to respond to incidents. Mobile Data Terminals (MDT) are installed in fire-engine cabs, directing fire-service personnel to incidents and delivering other contextual information. Examples of this information include hydrant location, building plans, and the location of hazards on industrial estates.

This research elicits knowledge from an expert to establish the scope for incorporation of location-based services (LBS) into incident response. These services could be delivered on a hand-held computer or head-up display. Previous research includes examining spatial information in centralised control (Jiang et al., 2004) and transferring knowledge about building configuration using virtual reality (Bliss et al., 1997). The present study views current and future positioning technologies together with interoperable data sources capable of delivering the kinds of contextually relevant information that would generate useful, location-based support in this application domain.

The purpose of the research is to direct investigation into human factors aspects of representing spatial information. Representations should generate the best possible understanding of the information whilst maximising performance during response to an incident.

2. Method

The critical decision method or CDM (Klein et al., 1989) was adapted as a framework to elicit the ways in which spatial and geographical knowledge could influence decisions and actions on the fire-ground. The CDM technique is effective in eliciting knowledge about professions that cannot be observed directly for example the air force, or indeed, the fire service. The procedure involves interviewing an expert to develop a detailed description of an incident together with an incident time-line. Decision making and actions taken are then probed using the time-line as a framework. The expert is then encouraged to identify and expand on areas where critical decisions or actions are taken. What-if questions and different scenarios are presented to the expert on the basis of the timeline. In this way critical points where decisions are taken and information used to make those decisions can be identified.

Klein et al. (1997) use the CDM technique to elicit knowledge about decision making to inform the design of interfaces which improve decision making of military personnel. In the same way, this interview was used to explore the ways in which location-based, spatial information could be used to improve decision making on the fire ground. The timeline was developed around decision points where spatial information was used to inform a decision. Possible LBS applications were suggested at decision points and the expert was asked to comment on how these services might change or improve decision making.

The expert selected is an incident commander with over twenty-five years experience in the fire-service. The expert has wide ranging experience including operational and management. One author (JN) spent two days at the fire-service headquarters in Nottinghamshire to develop knowledge of the domain and the terminology employed by the fire service prior to the main interview.

The main interview lasted for two hours and forty-five minutes, during which time a scenario of an incident attended by the expert was developed and the potential for location-based support was explored.

3. Results

3.1 Incident

The incident described was a large fire at a warehouse under development in Beeston, Nottinghamshire. The fire took place at night, near to midnight, and took over seven hours to bring under control. The premises were in the process of being redeveloped into flats having previously been industrial premises built in the 19th Century. Original features had been retained and the building was five-storeys high. The fire had started on the fourth floor and was rapidly spreading to the fifth floor and the roof. The local area was surrounded by shops and homes.

The immediate consequences of these circumstances are:

- The layout of the building was unpredictable and unfamiliar since redevelopment was taking place.
- The building was once used for industrial purposes; many lift shafts and voids were still present.
- The building had many points of entry and access given its location near the town centre and its previous use as a factory.
- The building was close to shops and main roads in the area.

3.2 Analysis

The approach to assessing the potential for LBS is adapted from Klein et al. (1997). Decisions and actions taken, described in the interview, which have location as a critical element are listed. In addition, the reasons why those decision and actions are difficult are included. Current methods are described and finally, a hypothetical LBS is suggested in response to the action. Results are shown in Table 1.

4. Discussion

The CDM analysis has revealed a number of useful location-based services that could be developed to assist the fire service in responding to incidents. Some services identified would require improved positioning technologies (see Grejner-Brzezinsks, 2004, for review). General improvements in positioning technologies that allow seamless indoor and outdoor positioning, together with inertial technologies, could generate the reliability needed for such critical applications. Already 'smart buildings' are being developed where the use of ultra wideband or RFID technologies can locate individuals with high precision. Tapping these technologies could provide the data required to locate the individual and deliver appropriate location-based support.

Other applications are feasible with current technology; the data is present but not in a usable or intuitive form. Delivering building plan or site data from a database, directly to the individual is a possibility using wireless technology and hand-held devices or ruggedised laptops. Conflating this data with , for example, current wind-speed or thermal imaging provides further possibilities for support. Currently, much data is gathered on the fire ground itself. Thermal imaging data is delivered to the in-cab data system and the incident commander makes inferences concerning wind speed and fire spread. Truly interoperable data sources and structures would allow this data to be processed and then delivered to a handheld device. In the same way, an algorithm that dynamically computed routes out of a building could be developed and the information delivered directly to the appropriate individual. Interoperable data sources are the key to developing these services.

Understanding the human factors requirements when delivering this kind of information are critical if LBS are to be used in this context. Users must be able to understand and act on information quickly if the services are to be used and not discarded for more traditional methods of working. The CDM technique is a valuable tool for rapid elicitation of user knowledge or user requirements, in this instance the fire-service and location-based support. The detailed understanding of user requirements developed by using the CDM technique can then drive system design. Interface design or interaction with a device are two examples in which understanding user requirements are critical.

Table 1

Abstraction of decisions and actions with suggested LBS applications

Action	Why Difficult?	How decisions are made	LBS
Fight Fire	Dynamic situation that requires continuous updating. Requires dynamic assessment of risk with many variables. Choices dictate whether to commit crews into building.	Risk to crew is the key variable. Relies on prior experience of situation and location. Relies on spatially distributed data sources: reports, data gathering crews, MDT information, thermal imaging, knowledge of building structure and type.	Display all information in one place. Predicted movement of fire through building, access points and location of any known hazards or casualties within structure.
Fight Fire – Positioning of jets	The need to co-ordinate many resources in the correct locations. Access to and knowledge about fire ground and appropriate water supplies is key.	Prior knowledge about local water mains and fire ground. Walking around fire ground. Taking into account future movement of fire within structure.	Represent fire ground and jets. Ability to create what-if scenarios. Visualising spread of water jets or cooling effects on spread of fire. Show location and size of water mains. Infer resource requirements.
Find safe routes into and out of building	High risk operational environment. Dynamic environment. Limited time due to physical demands and oxygen requirements of crews.	Overall impression of fire. Type of structure. Location of hazards or casualties. Sometimes, static 3D CAD models available. Guidelines laid on way into building.	Interactive model of building layout with data representing distance and time. LBS directing firefighter to specific points in the building.
Protect Public	Balancing risk with the need to keep roads, shops etc open. Knowledge of peripheral hazards required which may not be obvious.	Prior knowledge of environment. Macro view of area showing key access routes or hazards, e.g. petrol stations. Places where many people congregate – pubs, halls, shops. Appraisal of fire behaviour leads decisions.	Macro level view of area indicating specific public risks given particular movement of fire. Conflation of weather and thermal data to predict movement of fires.
Protect surrounding structures	Requires prediction of fire spread and knowledge of the structure and contents of nearby buildings.	Visual search and local knowledge. Walk – around. MDT data if available. Some integration of thermal data if available.	Representation of surrounding structures and distance to seat of fire. Data about fire loadings of surrounding buildings
Search & Rescue	High risk operational environment. Sometimes risk to crew outweighs the benefit of rescue. Limited time due to oxygen requirements.	Dependent on state of fire. Size of building is critical. Potential knowledge from MDT data.	Planning aid to direct search attempts or segment building into areas. Fastest search route planning. Fastest exit if necessary. Device to direct individual crew members to a location.

Future research in this area will examine the human sciences aspects of understanding and acting on spatial data in this application. The research will focus on delivering simplified map information to firefighters using handheld computers in order to navigate around an incident. For example different representations may generate differences in memory, performance or mental workload. Understanding these factors will lead to services that are both useful to, and usable by the individual.

5. References

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7. Biography

Jim Nixon

Jim Nixon is a research student examining human factors issues surrounding the perception and communication of different geospatial representations over mobile communications. Jim holds an undergraduate degree in psychology and a masters degree in human factors. He is a graduate member of both the Ergonomics Society and the British Psychological Society and is working towards professional registration.