A MVC prototype for the landmarke firefighter navigation system

Markus Scholz, Leonardo Ramirez, Sebastian Denef, Matthias Betz, Tobias Dyrks, Philipp Scholl, Mathias Busse, Matthias Stoetzer, Matthias Berning, Matthias Budde, Dimana Shishkova, Till Riedel and Michael Beigl

I. Introduction

Firefighters operate in a highly dangerous, obstructed and instable environment in which the loss of orientation means a direct threat of life. Providing these users with navigational support is therefore not a new idea. However, looking at the problems of delivering such information especially in harsh indoor environments leads to open questions in todays localization research. Hence, one of the tasks of the WearIT@Work project was to search for alternative approaches to support firefighters. From their work with firefighters in this project Ramirez et al.[1] discovered that it may be sufficient to integrate information from their surroundings into the actual work practices of firefighters. They argue that the combination of such information with the skills of the firefighters may compensate the missing exact localization. Further on [2] suggest that especially information of how to find a previously established path is essential.

Both authors describe an ad hoc wireless sensor network (WSN) which is build of nodes that are either automatically deployed [2] or by the firefighters themselves [1]. Building up on the work of Ramirez et al. the landmarke project [3] was initiated.

In landmarke we are building a navigational support tool for firefighters on the basis of manually deployed sensor nodes together with firefighters, firefighter instructors, industrial and academic partners. Apart from the attempt to realize such a tool the project also aims to investigate if this system might even improve established firefighter tactics.

II. The landmarke vision

The landmarke vision describes a system which does not focus on precise locationing but on providing navigational support which builds on the existing skills of firefighters. During the mission the firefighters themselves deploy the nodes of an ad hoc self organizing WSN as they find it the most useful. This system provides navigational support by using the deployed nodes, also known as landmarken, as way points to navigate to important places and to track firefighters moving along the nodes. Landmarken further allow the storage of tactical information. They mark special places and can indicate which spaces have already been searched or which haven't been explored yet. While exploring the fire field firefighters further collect knowledge about their environment and synchronize their knowledge with fellow comrades to complement their view of the scene.

Although various approaches have evolved around the question on how to support firefighting in the last years e.g. [4], [5], providing a system which will give an additional benefit for these highly trained, well equipped users which can be transferred into their daily practice is a highly complex matter. Therefore ensuring usability and practicability of the system is an important part of the landmarke research project. Hence, a participatory design approach was established which ensures that the development of the system concentrates on the real needs and possibilities of the users. An essential part of this approach are periodic user workshops in which landmarke system prototypes are repeatedly evaluated in a wide range of test scenarios. In these workshops firefighters frequently try out the system and give feedback on its attributes like usability, practicability, overall value and other system characteristics. A thorough description of this design process is given in [6], while tests conducted to ensure feasibility regarding sensor integration in this specific domain may be found in [7].

Hence, during the course of the research project several prototypes from simple and bulky to more complex and integrated were build and given to the firefighters in order to further optimize functionality and design. This process eventually led to a first complex system demonstrator which may be used to realize the landmarke vision.

III. Complex system prototype

Implementing the described vision requires a system design which supports different types of networked sensor nodes, a data storage which enables binding information to these nodes and - to accommodate all types of firefighter brigades - a flexible architecture (a detailed description of the architecture and of the findings which led to these requirements may be found in [8]).

The requirements were realized using 6LoWPAN as network technology connecting two different types of devices: the firefighter device and the landmarke node. In this first demonstrator a linux based smart phone was used to realize the firefighter device. Further on a model-view-controller (MVC) architecture was implemented to handle data access and allow a flexible coupling of fire brigade specific components.

Leonardo Ramirez, Sebastian Denef, Matthias Betz and Tobias Dyrks are with Fraunhofer Institute for Applied Information Technology FIT, Schloss Birlinghoven, Sankt Augustin, Germany and Department of Information Systems and New Media, University of Siegen, 57068 Siegen, Germany. Email: {firstname.lastname}@fit.fraunhofer.de. All other authors are with TecO, Karlsruhe Institute Of Technology, Vincenz-Priessnitz-Str. 3, 76131 Karlsruhe, Germany. Email: {lastname}@teco.edu. The work presented in this paper was in part supported by the Federal Ministry of Education and Research of Germany through the landmarke project.

An object oriented model was selected to represent the individual knowledge of a single firefighter. In this model typical relationships are represented. I.e. a troop consists of two or more firefighters and they initially carry a fixed number of landmarke nodes. The object oriented model also enables simple synchronization between the knowledge of two firefighters. The components which were connected to the firefighter device using the MVC architecture were:

- a modified breathing mask
- a wearable display
- an integrated control bar
- the Jennic integrated RF SoC

Around the Jennic integrated uC and 802.15.4 transceiver, to which be ported [9] Contiki OS, the landmarke node was build. It is outfitted with various actuators and sensors. The node was further integrated into a wedge formed housing replacing the wooden wedges of the regular firefighting equipment.

IV. Evaluation

Following the participative design approach of the research project the described system was evaluated together with the firefighters. The handling properties of the landmarke nodes and its fixation possibilities were explored and tested. Further analysis was directed at the breathing mask awareness i.e. the representation of landmarke based ambient information in the field of vision of the firefighters. Investigations regarding visualization on the wearable display were carried out to explore how more complex information could be presented to the user in an understandable manner. One of the key features of the landmarke vision is the possibility to rediscover landmarke nodes. Hence, tests regarding re localization of nodes were conducted using various prototypes. Rediscovery was evaluated using:

- optical signals (focusing on LED luminescence and blink frequency)
- acoustical signals (alternating frequency and tone sequences)
- and radio signals (regarding antenna type and antenna placement on a fully equipped firefighter, see [7] for details).

V. Results

The implemented architecture worked well in a complex test with 10 connected landmarke nodes in proximity of the firefighter device and various connected views. On this basis it was possible to define and evaluate features together with the firefighters in order to obtain information about handling and acceptance under more practical conditions. Development cycles for the incorporation of new suggestions were reduced as technologies like 6LoWPAN in combination with frameworks like QT enabled a simple portable system design. The demonstrator was further used to investigate radio based tracking in a firefighting environment. While still experimental, it may be used to determine a rough direction of a landmarke node.

VI. Conclusion

In this video we presented a first complex system demonstrator for the landmarke vision. A vision which aims to support navigation in harsh environments by building on the skills of firefighters through respecting the nature of human navigation as an entanglement of technologies and practices. The basic idea of the system is the placement of physical markers, the landmarken, with which the environment can be augmented physically and virtually. The presented system is based on an three layered architecture consisting of a heterogeneous ad hoc WSN, a MVC design pattern and an object oriented data model. The MVC approach allows a flexible and modular configuration of the landmarke system depending on the preferences, skills and resources of the fire brigade (professional and voluntary) and the place of action. Using the continuous object related data storage, it is also possible to evaluate the sequence of events and actions to optimize firefighter strategy and tactics in future missions.

Future work will be directed towards the the development of a landmarke specific multi hop algorithm, the integration and fusion of landmarke sensory information and the design of innovative interaction methods for firefighters like the mentioned in mask awareness. Using direct or indirect non disturbing (visual and/or acoustical) information representation methods a complex pattern of spatial information (like position of the firefighter in relation to the landmarke nodes) and physical conditions (temperature, pressure, gas content, vibration, impact and others) could be perceived by the firefighter to help him navigate in difficult environments and make firefighting a safer job.

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