Project Phoenix

CS 6750 HCI - P3

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INTRODUCTION

Based on the feedback from our poster session, we have decided to expand on the Augmented Reality Heads Up Display. Although there certainly was interest in the smart fire alarm system and the Paint Grenade on display, most questions and comments were directed towards the augmented reality and the feedback it would provide firefighters. This combined with the fact that the Heads Up display unit solves important problem spaces as pointed out by the interviews, and also fulfills the requirements of "information aggregation" set forth in class, made it the premier choice for prototyping.

Firefighters currently have very limited options of assessing their surrounding and maintaining their bearing during a rescue mission inside a burning building. Fire and smoke reduce visibility to near zero. The AR Heads up display attempts to alleviate these problems by providing a virtual 3D presentation and overlaying it over the physical world, augmenting our natural vision.

The AR Heads up Display takes input from devices such as sonar,radar and thermal imaging and maps a virtual layout of the world to a heads up display. It is also capable of presenting non-visual information in a visual way, such as the temperature of nearby objects and aids such as compass locators. The display will be built into fire fighter's visor so it does not add additional equipment for the fire fighters as they are already carrying more than 60-70 lbs of equipment. When the AR display is used, the information is aggregated automatically in real-time and requires no user intervention, thus freeing the fire fighter to focus on other things. The minimal demand for user control is a great advantage because most of the time, fire fighters will have both of their hands occupied with equipments and/or will be crawling on their hands and knees.

The AR Heads Up Display design focuses upon output and does not concern itself where the information comes from. This is reflected in our prototype mockup design.

DESIGN

Of all the design alternatives that were considered, the AR Heads Up Display is the most suited design because it fits well within the context of the problem space. In order to provide a solution for the problem space, which is how to assist fire fighters to save lives (including their own) in an emergency situation, good room navigation is the key and AR Heads Up Display can provide just that. By overlaying real-time virtual information on top of real world environments, augmented reality technology has the capability to aggregate numerous information and convey them spatially in 3D displays. The main navigation issue for fire fighters is extremely poor visibility caused by heavy smoke and it can be overcome through utilizing augmented reality technologies to gather room information and mapping them back immediately to the fire fighters.

Currently, fire fighters rely on the Thermal Imaging Camera to help them navigate through smoke-filled rooms. The camera displays heat information of where it is pointed at instantly to the fire fighters. The display shows heat in different colors according to the temperature range. It is a very useful technology but there are several limitations. First, it lacks depth perceptions. The information the camera returns only shows heat spots but cannot pinpoint the extra location of where it is coming from in relation to the room. A second limitation is that the device requires to be hand-held during use, which could limit fire fighter from using other equipments or devices such as radios for communication and fire axes for breaking into rooms. In addition, another limitation is the difficulty to switch orientation of visual information between the small camera display and the actual scene.

The aforementioned limitations with current navigation technology can be resolved with augmented reality. By aggregating information ahead of time using motion sensors, nanosensors, or location-based tracking systems, the AR Heads Up Display aims to fully present the room with wire-frame displays and the user will have the option to turn on or off the thermal imaging on top of the wire-frame. The instant switching between only wire-frame and wire-frame with thermal imaging information generates better depth perceptions than the current system of only using the Thermal Imaging Camera (TIC). Because the AR Heads Up Display incorporates in part the Thermal Imaging Camera, it should give fire fighters a base familiarity with the new technology. On top of that, the AR Heads Up Display also incorporates current mask gear to avoid the hand-held limitation faced by the old technology. The wire-frame images generated by the system will always be superimposed on the image shown on the visor. This includes occasions when the visor presents thermal imaging information as well as when it is not.

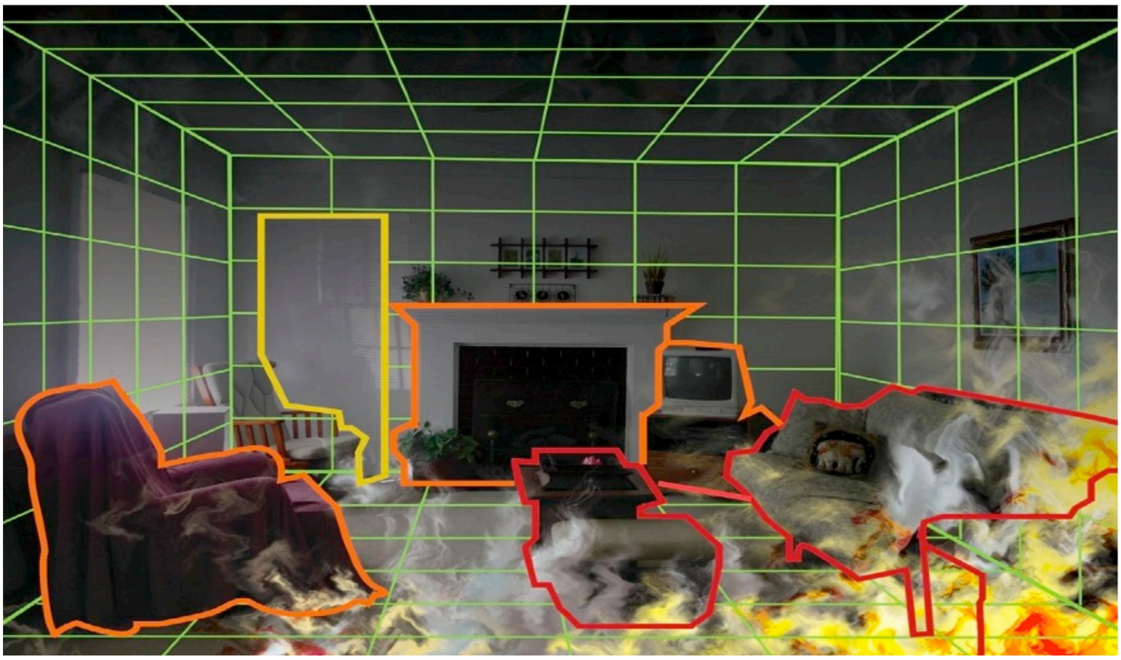


Figure 1: Wire-Frame + thermal imaging display shown by AR Heads-up Display

The AR Heads Up Display can become an invaluable navigation system that can improve poor visibility for fire fighters. However, the drawback of such system is that it is currently difficult to develop the actual implementation of such technology. Although augmented reality has become more prevalent in recent years, there are still much needed to be done before the AR Heads Up Display can be truly implemented. The closest attempt made so far is one where tracking sensors are set in fire trucks to track fire fighter locations within an occluded structure. Instead of putting sensor in trucks, we would like to use sensors within the home through partnering up with home security companies or assimilate the sensor inside fire alarms. But for the purpose of this project, our main focus will be the system output rather than focusing on the system input. Please continue below to see a prototype of the system.

USABILITY PRINCIPLES

Following are some of the usability principles that we would want to incorporate in our design and the prototype that should be tested for.

Learnability

Our design visually gives room layout information to the firefighters. The firefighters do not need to learn how to operate new technology using specialized controls. This makes the design particularly high in learnability and reduces the training time required to train firefighters to use the system optimally. This is particularly useful as firefighters are not necessarily a tech savvy group and some of the older firefighters may have minimal exposure to technology.

High predictability will lead to lower operation time (due to lesser cognitive load) when the users are learning to use the system as well as when they are using it in the field. While our system has no specialized controls for the firefighters to operate there is still the question of the display shown by the system and how quickly the firefighters are able to correctly recognize the objects shown in the display. The system′s augmented reality display will help the firefighters get depth perception and spatial perception better than a TIC and will increase the overall understanding of the layout of the room. The quick switching between the two modes of the system allows for better synthesizability of information as and both the modes of display help the firefighter using the system to get complete data about the room layout, heatmap of the room and victims trapped in the room.

Highly familiar color metaphors used for the wire-frames of objects: red for very hot, to say yellow for moderately warm, to blue for cold will help increase the learnability factor of the system as these are the colors used in the TIC. This also increases the consistency of the the two views: wire-frame view and wire-frame with TIC view.

Flexibility

The system functions in two modes: wire-frame and wire-frame and TIC view. It allows the firefighters to switch between both the modes as and when they require. This puts the user in the drivers seat. The thermal data provided by the system allows the firefighters to multitask and look for victims while navigating through the room.

The switching of modes allows the user to decide how he wants to perceive his environment allowing him to navigate using either or both of the views as and when he wants and leads to good system substitutivity.

Robustness

The display changes with every small head movement of the firefighter using it. It also changes with the location of the firefighter. This gives the firefighter good depth perception along allowing him/her to navigate easily. The quick response time of the system is a key feature making this possible. It also makes the system ideal for the highly dynamic environment in which it is to be used.

Other usability features

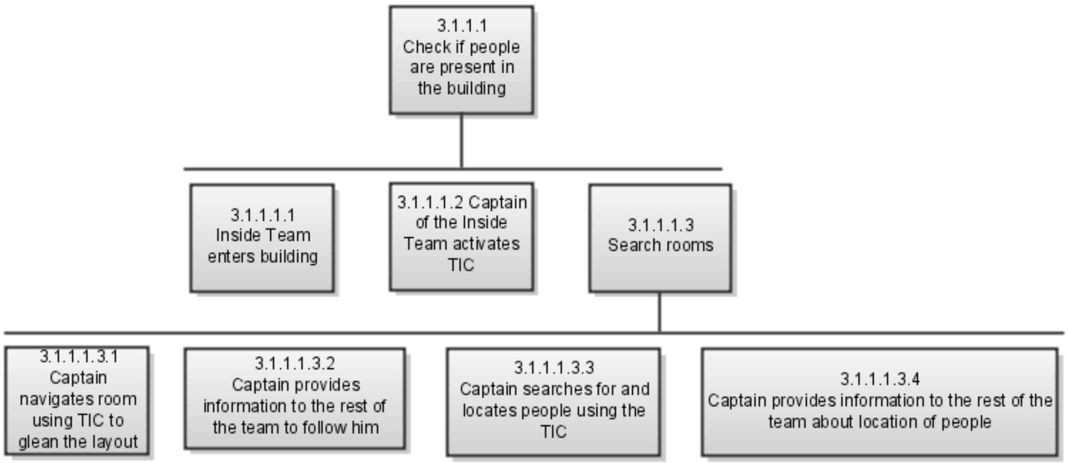
1. It is a light weight system that fits into the current firefighter suit of the firefighters. It does not encumber the firefighters nor require them to carry extra material.

2. The system is not hand held and allows firefighters to use their hands freely.

WORKFLOW ANALYSIS

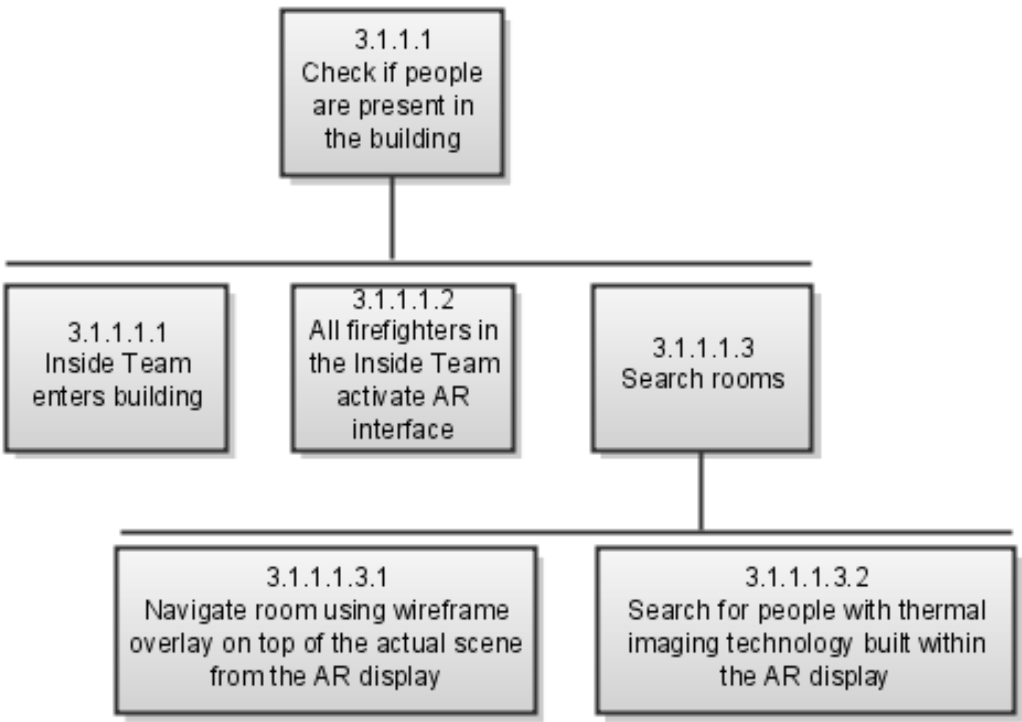
Workflow for the current TIC System

The current TIC system the fire fighters is only being used by the Captain. He uses the TIC to navigate and glean room layouts. Once he has sufficient knowledge of room layout, then the Captain will communicate with his team members through radio to rely information back to them and give command on how to proceed with the operation. The team members will following procedures that are relevant to their position within the operation and will depend on the Captain's descriptions of the room layouts in order to navigate inside the burning building.



Workflow for the new AR system

Unlike the current TIC system, the new AR system will be used by all team members, not just the captain. Each fire fighters will have a head mounted display integrated inside their visor. One significant change from the current TIC system will be that the team members can use the new AR system to assist them through navigating the room instead of depending solely on the Captain's descriptions. An important note to point out is that the Captain will still be the main command person that his team members report to and follow orders from but he will be relief from having to constantly distribute important navigation information to his team members. Instead, he can focus on communicating with the team members through radio and instructing them on how to proceed with the operation.



EVALUATION

Prototype

Our design as described earlier is a heads-up display system which provides two different visual displays - a wire-frame display (which shows an outline of objects around the room) and thermal imaging display (which shows the temperature of various surfaces around the room with different colors) and provides the ability to quickly switch between these two modes. To actually create such a AR heads-up display would take a lot of time and effort - neither of which are currently available to us at this point in time. We therefore intend to prototype this display using a simpler method.

Figure 2: Mockup of the AR Display showing a Wire-Frame of objects around the room

The wire-frame display will be simulated using black-light tape, black light and a darkened room. Black-light sensitive tape will first be used to cover the walls, floors and the edges of the various articles of furniture present in a room. In a darkened room, this black-light tape will glow brightly when exposed to black-light. The user will carry with him a hand-held black-light and when he scans around the room with it, the black-light will cause the black-light sensitive tape to glow thus simulating the look of a wire-frame around the objects in the room. This overlaid wire-frame improves the visibility of objects and the layout of the room.

Figure 3: The TIC used by firefighters

Figure 4: The night vision camera to be used for the prototype

Figure 5: Image as shown by the night vision camera

Figure 6: Image as shown by the night vision camera

In comparison, the thermal imaging display will be simulated by a video camera in "night-vision" mode. The video camera will be held by the user in his hand, similar to how he will hold a TIC. The display of the video camera is quite similar in both size and presentation to a TIC.

Prototype Evaluation

The usability principles and work flow analysis previously presented in this paper have given great theoretical strength to our current design. The final step in assuring the effectiveness of our design will be a user evaluation. This will be done through the recording and analysis of both objective and subjective data. With performance being of optimal consideration for fire fighters, objective data will focus on comparing how effective each technology is at visually identifying objects in a room. Conversely, an uncomfortable or cumbersome design can inhibit performance or be generally hard to use. Subjective data from usage of both technologies will be used to address this issue.

The Task

Users evaluating the prototype will be randomly selected to use either the limited view or augmented view prototypes. The limited view is meant to imitate the current technology fire fighters use: only the thermal imaging camera (TIC). The TIC only gives users a spot light's worth of visual information in a hand held device. In same way, users will use a hand held night vision camera to navigate the room. The augmented view will simulate the same information shown by a wire frame heads up display. Participants in this group will be given a black-light so that the information from the pre set-up black light tape is accessible. Participants will be aged 18 and up.

The task will have participants using one of these technologies in visual search task. Tennis balls will be placed inside the room before participants enter. These items will be placed in various areas in the room, such as behind furniture and under furniture in both high and low areas of the room. There will be 16 tennis balls and participants will be given a certain amount of time to look for them.

Tennis balls were chosen as the task due to how it mimics the necessities of firefighters in the field. In addition to looking for humans, fire fighters are looking for items within the world that may either pose a danger or give an indication as to a where a person is. An example is a flammable hair spray can or a small indication of a child's foot sticking out from under a piece of furniture. A time limit is also appropriate for this task due to the time sensitivity associated with the work fire fighters perform. The time allowed will be determined during pilot testing in order to ensure that the task is not easy enough that all the tennis balls are found within the allotted time. At the same time, enough time will be given to ensure that most tennis balls are found.

To enhance the visual search task, participants will be told how many balls are in the room. This will be extended to if the room is broken into several rooms, where participants will be told how many tennis balls are in each room. Once participants find these tennis balls, they will be asked to pick them up and place them in a backpack they are given. This bag will be collected after the task to record the balls collected.

Objective Data

The primary source of objective data for evaluation will be performance on the task. Each participant will be measured on how many tennis balls they can identify and collect within the given time. In addition, the tennis balls will be numbered and recorded in order to look for trends. For example, if a certain ball is only found by one technology, it can give an indication that the technology may be better for finding items in certain locations.

Subjective Data

Subjective data from using each technology will be compared for further usability information. After completing the task, participants will be asked to fill out the questionnaire.

POST TASK QUESTIONNAIRE

Purpose of the Questionnaire

The purpose of the questionnaire is to collect subjective data from participants about their preferences of use between the limited view prototype and the augmented view prototype. The questionnaire will be delivered to the participant immediately after experiment and it will be collected when they leave the experiment location. In order to collect both quantifiable information as well as subjective information, the questionnaire will have both open format and closed format questions. Simple demographic data such as age, gender, education/ occupation background will be asked to make inferences about the participants.

The Questionnaire

Age:__________ Sex: Female Male

Education:_________________________

Rate how much you agree with the statement with a number from 1 to 7.

1 2 3 4 5 6 7

1 indicates you strongly disagree, 7 indicates you strongly agree.

1 2 3 4 5 6 7

The technology I used was easy to use: ________

The technology was comfortable: ________

The technology was helpful: _______

The task was easy: ________

Any further comments:

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Thank you for your participation!