CS 6750 HCI

PROJECT PHOENIX

P4

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INTRODUCTION

We have decided to focus on solving one of the many problems that firefighters face when they go into an emergency situation. This is the problem of visibility and navigation in the dark and smoky confines of a burning house. And navigation is a big problem for firefighters because often they are completely unaware of layout of a house when they go in. Currently the firefighters use a handheld Thermal Imaging Camera (TIC) to enable them to see. The TIC is effective in helping them find people, but it is not very helpful in allowing them to navigate the house because it provides very poor depth perception.

As a solution to this problem we decided on a Augmented Reality heads-up display which overlays a wireframe of the room and the objects in the room in the firefighter's visor (which is part of their standard equipment already). The heads-up display was chosen so that the firefighter's hands are free to do other tasks. The firefighter will be able to switch between the TIC display, the AR display and normal vision, depending on the situation: when they need to navigate they can use the AR display, periodically switching to the TIC display to look for people. The AR system is composed of two parts - the display component and the data gathering component.

For this project we have primarily focussed on the display component of this AR system and have not prototyped a method of gathering the data (i.e. room layout, etc) required to create a complete AR system. But, in our brainstorming sessions we came up with a bunch of ideas about how this data may be gathered. Some ideas include the use of a Nanosensor Grenade which sprays nanosensors around the room to gather information. Another is to use a method such as Sonar to get the room layout. Yet another idea is to get the room layout (say when installing a security system) before hand and store it in a place which can be easily accessed by a firefighter in the event of an emergency.

We predict that the addition of the wireframe overlay will help the firefighters get better depth perception and hence allow them to navigate more effectively and quickly through the house. We have thus designed an evaluation method which allows us compare the AR system and the TIC system to see which is more effective at helping a person navigate a dark room.

EVALUATION RATIONALE

Firefighters have to navigate through rooms and closed spaces at the site of the fire. At such times they navigate the environment filled with smoke and fire. To add to that the electricity to the premises is usually shut off to reduce risks of electrical fires spreading. This smoke and the low light make an already hazardous environment even more difficult to navigate. The goal of our project was to design a system that will help firefighters navigate in such an environment and effectively reduce the time they take to rescue victims from burning premises. Keeping this in mind we designed an experiment using the mock up of our AR HUD system and a mockup of the TIC the firefighters currently use to navigate these environments. The AR HUD system was mocked up using a blacklight and blacklight reflective material while the TIC was mocked up using an infra red night vision goggles that provides the user with reduced depth perception (monocular v. binocular visual cues).

The experiment location consisted of two rooms each with obstacle courses made of cardboard boxes and cartons to represent furniture and other objects in real environments. Both the rooms were of approximately the same size and the obstacles were arranged in such a manner that they were equally difficult to navigate through. The rooms had no windows and had no access to natural light, because of which we could simulate the low visibility environment that firefighters work in simply by switching off the lights. Eight white paper cranes were placed in specific locations in both the rooms and the participants had to navigate through the obstacle courses and find all the paper cranes.

The room that was meant to be the mockup of the AR HUD had a blacklight installed in it. The walls of this room and the obstacles in it were lined with special tape that reflected the light from the blacklight. When the lights were switched off and the blacklight was turned on, the outline of the room and boxes became visible due to the reflective tape on the walls and objects. No part of the room was actually visible except the tape, however the tape on the obstacles acted as the outlines of objects and the tape on the wall gave a notion of space. Thus though the obstacles in the room or the room itself was not visible a person was able to navigate the space using the outlines of objects.

The other room was to be navigated using the mock up of the TIC: night vision goggles. The room was set up so that there were obstacles made out of cardboard but there was no black light or reflective tape to aid a person to navigate in the darkness so with the tubelight in the room switched off the room was in complete darkness.

For our evaluation we had two variables; TIC mockup and AR mockup at two levels each: baseline (with high room visibility) and experimental level (with low visibility).

The condition where the lights were switched on is labeled the 'high visibility condition' and the condition where the lights in the room were switched off is labeled the 'low visibility condition'.

We went for between group evaluation. To ensure that the results we got for through the evaluation were valid we did single blind between groups testing with 9 candidates on different days, at different times of the day. The candidates were randomly put into either of groups – the one using the night vision goggles, or the one using the blacklight. For the evaluation each participant went through an experimental condition for one room and a baseline condition for the other room. This means that if a person went through the experimental for the AR mock up they would go through the baseline condition for the TIC mock up and vise versa. We counterbalanced by having half the participants perform the baseline condition before the experimental condition and having the other half do the experimental condition first and the baseline condition later.

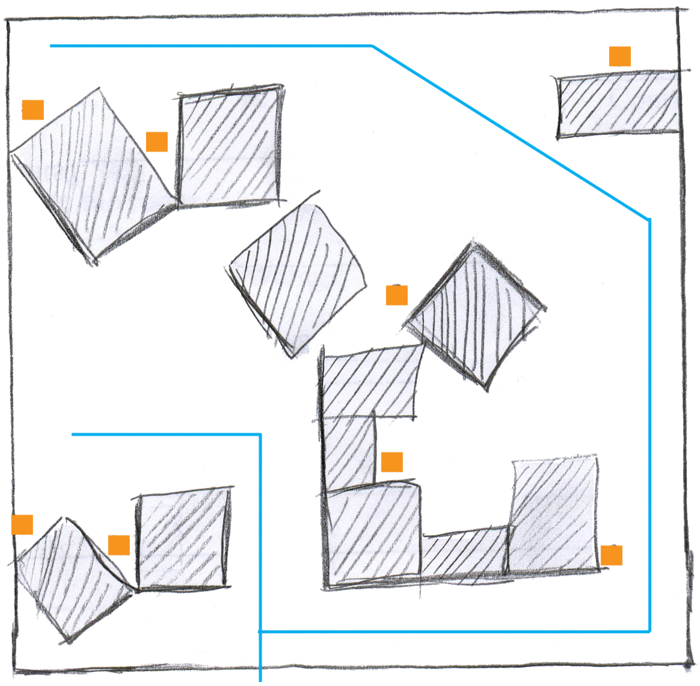
Conditions:

1	AR – with low visibility	Night vision – with high visibility
2	AR – with high visibility	Night vision – with low visibility
3	Night vision – with high visibility	AR – with low visibility
4	Night vision – with low visibility	AR – with high visibility

Since our prototype evaluation tested whether persons could navigate using the given visual aids we recruited participants who have no visual disability and who have no mobility problems. We evaluated our prototype with students and faculty of Georgia Tech. These participants had not received any of the training that firefighters have to navigate through obstacles in environments with low visibility however all of them had 20/20 vision with/ without spectacles.

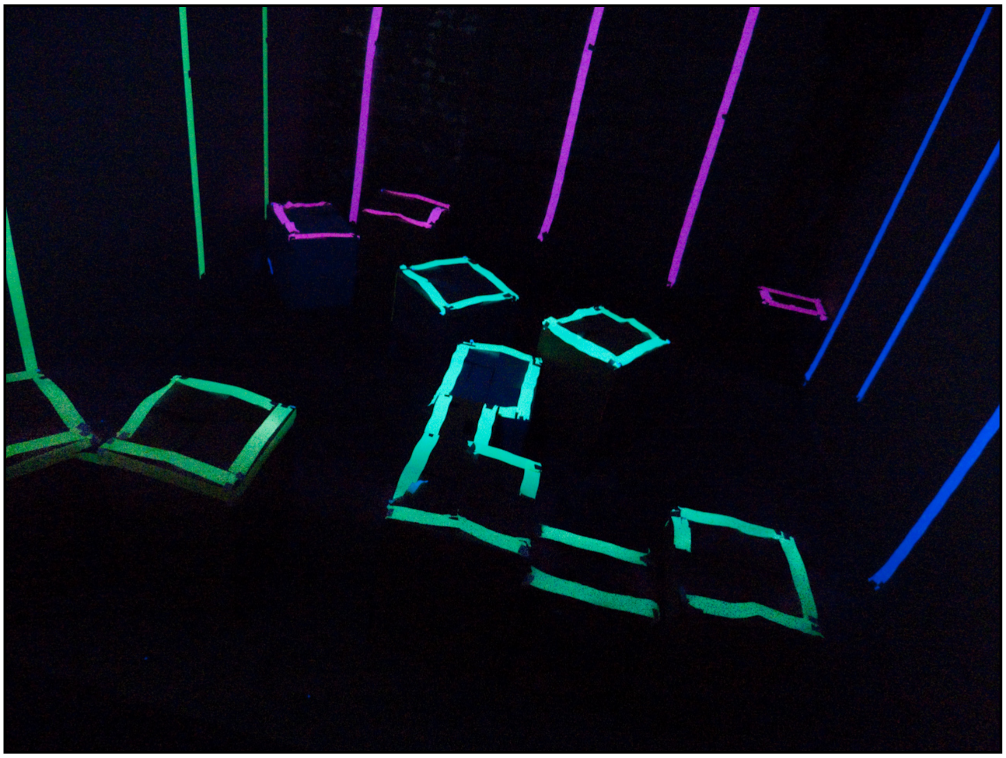
EXPERIMENTAL SETTINGS

BLACKLIGHT ROOM



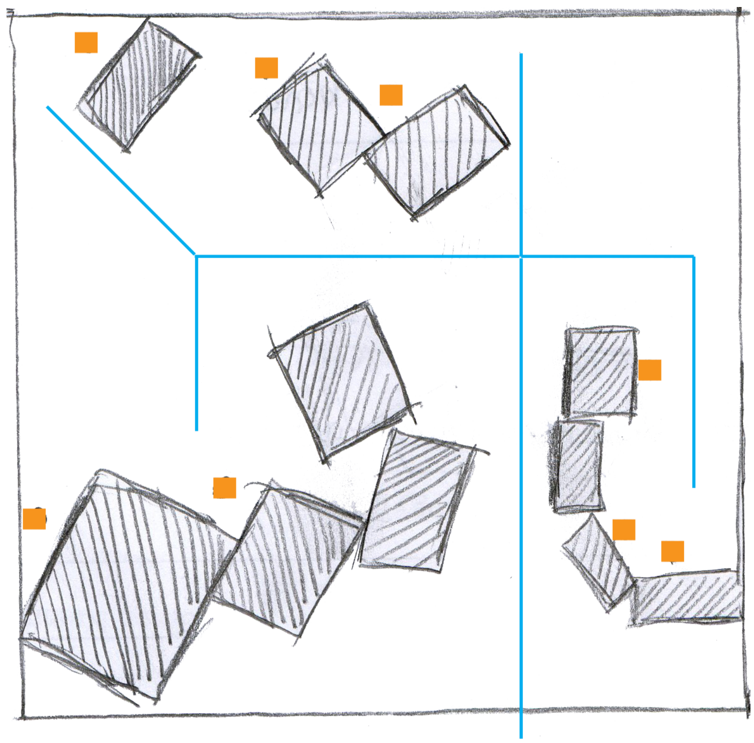
Blacklight room layout (Orange squares indicate crane location, Blue lines indicate possible paths)

Blacklight room with the lights on



Blacklight room with the lights off

NIGHT VISION ROOM



Night Vision room layout (Orange squares indicate crane location, Blue lines indicate possible paths)

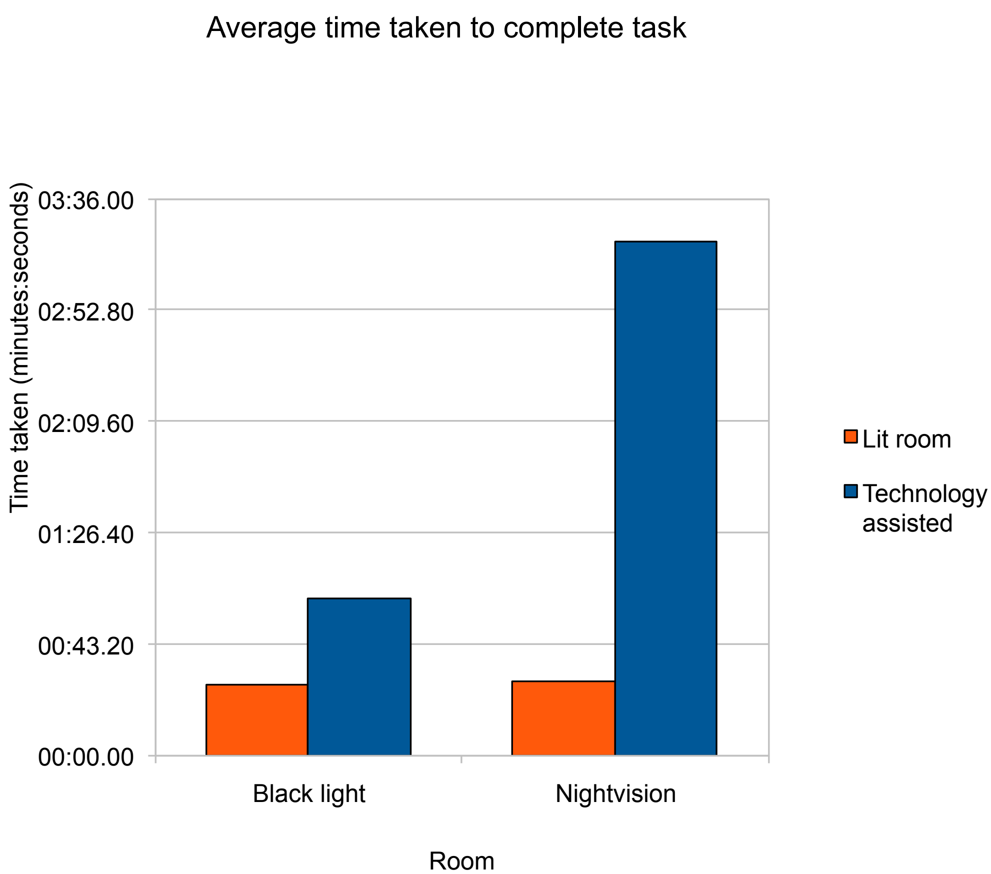
Night vision room with the lights on

RESULT DISCUSSION

Sets of quantitive and qualitative data were gathered from the participants during and after the evaluation. The quantitive data gathered consisted of the time it took for each participant picking up eight 6"x6"x6" paper cranes. Participants had to perform the task twice in two different rooms with different setups. Two times were recorded for each participants. Afterwards they were given a one page questionnaire to fill out (see appendix). The questionnaire was composed of a set of Likert scale questions and additional space for comments underneath and an open ended space at the end for additional feedback.

In total, 9 participants were evaluated. The participants were recruited through convenient sampling. All of them were students or faculty of Georgia Institute of Technology. A majority of the participants were also taking the same course that this project was assigned in and had knowledge of the objectives set within. The group of participants is composed of 3 females and 6 males.

QUANTITATIVE DATA: TIME

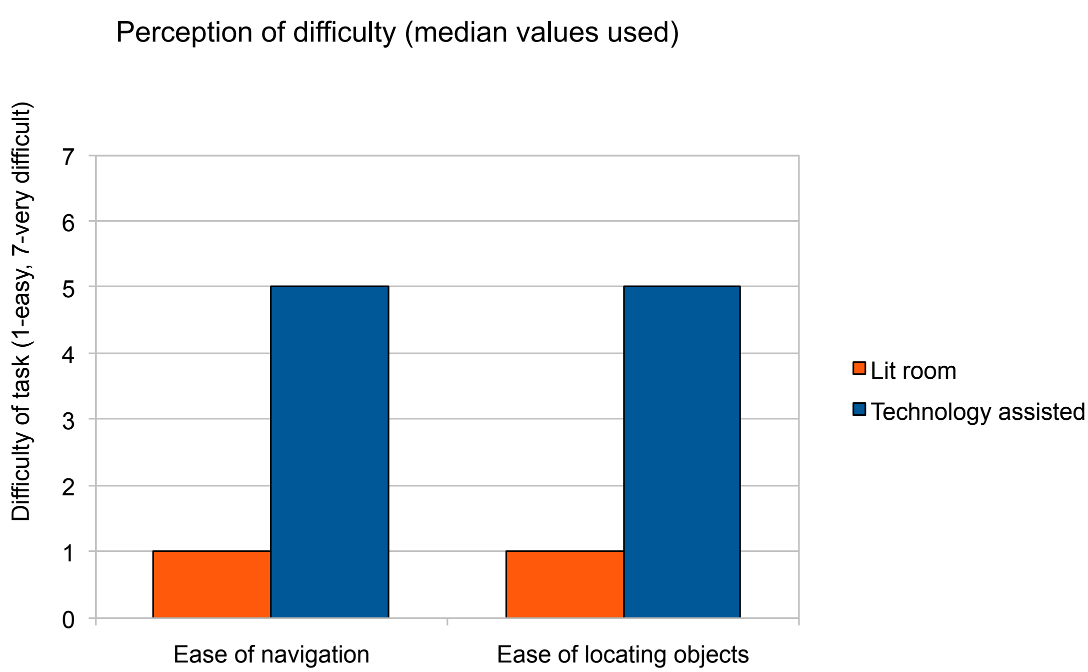


RESULTS

The base time to complete each room was established by having participants perform the task in one of the rooms with the lights on. The average time for the black light room was 27.57s and the average time for the night vision room was 28.26s. The difference between the two baseline times was 0.69s, a little over half a second. Because the baseline time for both rooms were close to equivalent, we can infer that they had comparable difficulty, Thus average time for black light and average time for night vision were comparable. With the low visibility condition, the average time to complete the task in the black light room was 60.87 seconds and the average time to complete the task in the night vision room was 186.55 seconds.

The discrepancy of average time used in technology assisted runs versus not using technology with the lights was 33.30s in the black light room and 158.29s in the night vision room. This indicates that participants had a more difficult time navigating using the technology when compared to performing the same task in a fully lit room. However, the time difference between a lit room and using the black light is much lower than the time difference between a lit room and using night vision camera. Therefore, the results show that black light was much more effective in assisting the participants to navigate a room in poor visibility settings. Comparing the results between the two technologies, the finding was that the users who finished the task in the black light room were able to navigate and search for items better than the users who finished the same task in the night vision room.

QUALITATIVE DATA: QUESTIONNAIRE



RESULTS

The qualitative data we have collected from the participant does not reveal much insight into which technology the participants preferred. An explanation for the lack of difference can be attributed to the fact that each participant only had the chance to use one technology during the evaluation.In the questionnaire, they were asked to compare the difference between using one technology in a dark room versus navigating a room with the lights on. The stark difference between having the lights on in one room and having the lights off in the other can attribute to why the participants find difficulty with the technologies they had to use.

In addition, the format of the questionnaire was inconsistent for some of the participants due to a modification made to our questionnaire. The first three participants were given an iteration of the questionnaire that asked them to write the number corresponding to how much they agreed with the question. A Likert scale was not included and this resulted in some misunderstanding amongst participants. Afterwards a scale was added to the questionnaire for later participants. As a consequence, the qualitative results are not consistent in terms of the number of questions the participant had to answer.

The comments written by participant showed that using the night vision camera, which is comparable to the TIC, did have difficulty with depth perceptions.

"*Dizzy, can't really figure out the size of area*" - *Participant 3*
"*Couldn't gauge distance, lost sense of direction*" - *Participant 4*

The comments written by participant for back light room indicated that the participants did find the black light lines to be helpful in terms of navigating around in a poorly lit room.

"*Seeing top of the boxes was useful, but I still kicked the boxes many times.*" - *Participant 7*
"*The outlines prevented me from bumping into obstacles, but was harder to tell height than when in lighted condition*" - *Participant 2*
"*Much easy to see in the dark with the technology*" - *Participant 5*

RESULTS OVERVIEW

Based on the both quantitive and qualitative results supports the use of AR to improve navigation and search time under poor visibility settings. Unfortunately, we were not able to recruit firefighters to evaluate our prototype. Therefore, although we've obtained successful result form our evaluation, we believe that additional evaluation with the actual users would provide more meaningful data.

DESIGN/PROTOTYPE IMPLEMENTATION

As demonstrated in the evaluation of our prototype, the results support the effectiveness of a visual aid that does not limit depth perception when performing a navigation and object search task. In areas other than fire fighting, there exist visual aids that may have the ability to display objects in a room as if there were a picture. These allow users to see objects in the room with greater detail than they would otherwise have been able to do. Yet in the case of night vision or the thermal imaging cameras, this comes at the cost of the reduction of depth perception cues. Our findings support the use of a less photographically accurate representation of the area that gives better depth perception cues when the purpose is of navigating the said area. An extension of this may also indicate that only a simple set of visual cues are necessary when navigation is needed, such as dotted lines or only indications of corners and edges.

In the specific area of firefighting, the significance of our evaluation does not paint a simple picture about the usefulness of the commonly used TIC. On the surface, the evaluation shows that the augmented reality setup has a clear advantage over the TIC. This conclusion is supported not only when evaluating navigation, but also object search. In the field, what makes the TIC useful is it's effectiveness when searching for people. Inside a burning building, the heat signatures of the heated objects meld, further limiting the aforementioned bad depth perception. Yet from the melded colors, the heat signatures of humans become easier to discern because they have a distinct heat signature. To add to this, they also a distinct shape that aids detection. This makes the TIC the leading technology for this purpose. For this reason, our final design would incorporate the advantages of the TIC as well as the augmented reality heads up display into a single unit. The TIC continues to be the technology to use when searching for people. Navigation and searching for non human objects in the room, especially hazardous one such as flammable aerosol cans or ammunition, will be handled by the AR system.

Though not evaluated, our design carries a second advantage to the domain of firefighting; the ability to have free hands that would otherwise be using the TIC. Both the TIC and AR information are designed to be displayed on the visors that firefighters currently wear. The design will have three visual aid modes: no visual aid, augmented reality, augmented reality and TIC. Selecting a mode maintains the mode that has been selected. This functionality allows the use of the now spare hand for many of the demanding tasks firefighters encounter. Using both hands for tasks otherwise having to be done by one hand reduces fatigue. From a general application basis, the advantages of freeing up of the hand that carries the visual aid must be taken with consideration. Though this may aid in the aforementioned areas, a head mounted unit makes sharing it difficult. For a system that is distributed amongst a team, additional design modifications may have to be made.

With the original intention of aiding firefighters in saving lives, our design can be seen as successful. Preliminary designs approached the problem by trying to give firefighters an overhead view of the house they were entering via maps. The design chosen was seen as more effective due to it's ability to display visual data in the room while firefighters were inside. Though less visual information would be displayed immediately, there was less of a cognitive load since maps did not have to be remembered nor would users have to orient themselves on a displayed map. By aiding navigation there is a direct effect on saving lives. It is projected that most victims in a fire can become unconscious by the smoke in a room within as little as 40 to 50 seconds. At the same time, the fire and smoke will continue to grow by the second. In a mock dorm room fire demonstrated by the Atlanta fire department, a dorm room became entirely engulfed from a trash-can fire within 2 minutes. This adds further gravity to our evaluation data. Each second lost equates to less of a chance of a fire victim surviving. A difference on the magnitude of minutes (as seen in our results) will not only mean multiple lives may have been lost, but also puts firefighters in greater danger.

The next iteration of our design can focus on two areas: further enhancing visual data or finding methods to collecting the visual data. In order to better enhance the visual data, the next iteration should be compared with what firefighters use in the field, the thermal imaging camera. This way, a better evaluation of the current system can be done versus a visual display method that enhances depth perception in exchange for less visual data. The second route the next iteration may go is to implement a way of gaining the visual information needed for the augmented reality display. Currently, the technology to gain the needed information either is not available or difficult to access. Thus designing a form of gaining the information would allow us to fully implement our design.

A different way of gaining this data would have been to conduct it in a method that would have to evaluate user behavior when given both types of information. An example would be to give users the night vision as well as implement the black light condition. Thus, users would be able to use both types of visual information and switch between them, as per our design. Finally, the most surprising portion of our design and evaluation is the large difference between the time to complete the task in the evaluation. The long times taken for the night vision was also unexpected considering that firefighters use a similar technology and still manage to save lives. Thus, further testing of this difference would give more information about how much more advantageous our design is over the current system.