Supporting emergency management using Google Glass

Glass Commander - GCOM

Suresh Sapkota, Fangrongling Fu, Fahd Newaz

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Introduction

SINTEF is currently involved in several projects in the field of emergency management, through which they have developed several decision-support systems for first responders and incident commanders. These include MASTER which aims to increase situation awareness by providing relevant information to responders, and the GGS system which primarily monitors and controls unmanned vehicles during search and rescue.

The main requirement for our project was the use of Google Glass. Google Glass is a wearable device with an optical head-mounted display developed by Google. It can display information similar to smartphones, and can be controlled by voice commands or gestures to a touch panel on its side. It contains the following technical features:

- 640×360 Himax HX7309 LCoS display
- 5-megapixel camera, capable of 720p video recording
- Wi-Fi 802.11b/g
- Bluetooth
- 16GB storage (12 GB available including OS)
- Texas Instruments OMAP 4430 SoC 1.2Ghz Dual(ARMv7)
- 2GB RAM
- 3 axis gyroscope
- 3 axis accelerometer
- 3 axis magnetometer (compass)
- Ambient light sensing and proximity sensor
- Bone conduction audio transducer

Additionally it is capable of connecting to mobile data networks through any bluetooth enabled smartphone with a data connection.

Initially we had a broad range of possible directions we could choose to go in order to develop a Google Glass related tool that would benefit the emergency services. We realised that the Google Glass brought in a whole set of features that could really improve emergency response, especially during an operation. These could aid all three of the emergency services including Fire, Ambulance and the Police force.

We therefore started out doing research on the technology and forms of communication currently used by the emergency services. We discussed with our supervisors, who have had extensive experience with the emergency services during development of the previously mentioned systems. We decided to develop a Google Glass application which could improve

the form of communication between headquarters and emergency operatives during an emergency operation.

Further we decided to use the Google Glass's head-mounted display to enable a visual form of communication between the command centre and the field operatives, as well as use the camera to send visual feedback back to the command centre.

Process overview

Once we had finalised our basic idea, we got busy planning. Below is the initial plan we had made for the project.

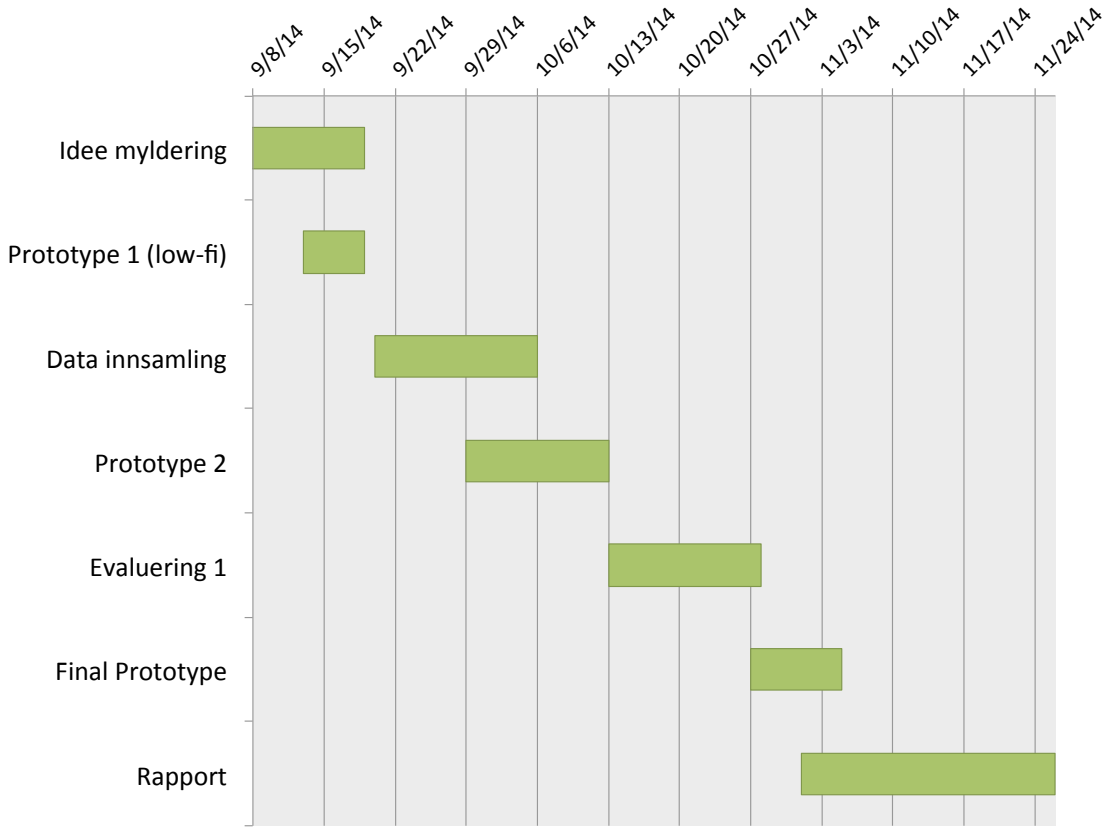

Figure 1: Projected timeline

Although we wanted to create our initial low fidelity prototype only after gathering data from the users, this was not possible due to difficulties in getting hold of the users. Therefore, we created our first low-fidelity prototype based on input from our supervisors at SINTEF and our own research. This allowed us to get even more constructive feedback when we finally did get the chance to talk to our users. However, we generally followed the classical design process

(Rogers, Sharp, Preece 2011). This allowed us to keep regular contact with the users in order to have a tool that would be most beneficial to them.

There were some delays in creating the final prototype due to some technical difficulties with the Google Glass, as well as the fact that we were two groups with access to only one Google Glass.

Finally we also designed an experiment to test whether there was any improvement in efficiency by using Google Glass as opposed to a smartphone.

Identifying the needs and establishing the requirements

Genius Design

Our design process started with extensive meetings and discussions with our supervisors at SINTEF. We got a very detailed background on all the different projects they had already worked on, and are currently working on in cooperation with the emergency services. Based on what they told us, we came back to them with key questions that would help us pinpoint a limited number of issues which we could address within the scope of this project.

Initially we had as our target users, all three emergency services i.e. Fire, Ambulance and Police. However, it quickly became apparent that our idea would not be suited for all three of the emergency services. The current materials used to produce the Google Glass would be extremely inappropriate in a situation with fires due to the high temperatures, and thus we decided not to include the fire services in our target user group, leaving just the police force and ambulance services.

Ethnography

We also used a form of **virtual ethnography** (Blomberg and Burrell, 2007), where we watched several episodes of the TV show "Nattpatruljen", which is a show that follows different police patrol teams whilst on missions and records the events. It also has the police personnel speak about what is going on during the events. This was the only form of ethnography we had the opportunity to conduct, as it proved to be extremely difficult for us to arrange any form of live observation with the police. In this case we played the role of a complete observer (Gold, 1958). Although this meant that there was a greater chance of misinterpreting what we were observing, it also allowed us to not lose our perspective. The part when the police officers describe the events also helped us understand the situations

correctly. We also did not have to worry about building relationships with those we were observing nor did we have to make any contracts.

Needs and Requirements established

Currently the only form of communication between the command centre and operative teams, is radio communication, i.e. voice communication. Additionally the communication is such that only one person within an operative team can speak at a time. This greatly decreases efficiency due the longer amount of time used to speak within teams, as well as due to the limited amount of information that can be conveyed using voice only.

Based on this major observation, we identified two needs, which were

- a more efficient replacement/supplement to the current radio system
- some form of visual communication between command central and field operatives

We consequently established four main requirements to our product which would enable us to fulfil these two needs

- Text briefs
- Map
- Image Sharing
- Video Stream
- (all this would be in addition to voice communication which currently exists)

First design and low-fi prototype

We then started placing these features on paper trying to figure out how they could be implemented. We made sketches of what the interaction would look like with all the required features. We based our sketches on the fact that the Google Glass programs are based on cards, and thus we were drawing our features as different cards, and we were linking them together in the most logical and user-friendly manner.

Image 1: Low Fi prototype designing

Since it was a very low fidelity prototype, we did not focus much on the design principles or form, but rather the content and functionality of the program we were going to build.

Preliminary evaluation and further data gathering

Before gathering our data, we established a list of factors that could be important for the end-user but would not be within the scope of our project. These were the following: performance (how fast the glasses were, and how fast they could communicate with any central database), robustness (how robust the glasses were in terms of physical form and composition) and battery life.

In order to understand the needs, practices, concerns, preferences and attitudes of our users at a slightly deeper level, we decided to conduct a few semi-structured interviews.

We also ran a pilot interview with a friend from the university to check how long the interview would take, if there were some questions we felt were inappropriate, as well as whether there were other things we wanted to add. We asked our friend to pretend to be a police officer while answering our questions. This was very helpful in finalising our interview structure which we took further to our target users.

Ambulance personell - Interview

We soon got our first interview with ambulance personnel at Ullevål Hospital. A semi-structured interview was planned with ambulance personnel at Ullevål Hospital, where most of the questions were planned, with some back-up/follow-up questions. We were also prepared to ask questions that may become appropriate during the interview process. We of course started by introducing our project and signing a consent form about the data. The first half of the interview we asked very general questions regarding the current communication methods, and how they can be improved. In the second half we showed them the Google Glass and our sketches to explain our concept. This enabled us to get data that was independent of the Google Glass, as well as feedback on what we had already thought of.

We interviewed three people, of which two participated in the interview together. Our key takeaway from these interviews was the fact that the main function of the ambulance personnel is to transport a patient/injured person back to the hospital as fast as possible. Therefore they did not require any detailed communication with the command centre. Thus, we also removed ambulance personnel from our group of target users.

Police - Interview

Image 2: Interview at the Bjørn Danielsen

Finally on the 9th of October at 9am we got to meet Bjørn Danielsen at the Politihøgskolen. He has over 25 years of experience as an operative, incident commander, and currently a police superintendent. Mr. Danielsen was free that day until lunch, and thus was not in a hurry or pre-occuppied with other thoughts. It was a drizzly day, and that gave us a chance to break the ice discussing the weather, and how glad Mr. Danielsen was to not be out on duty.

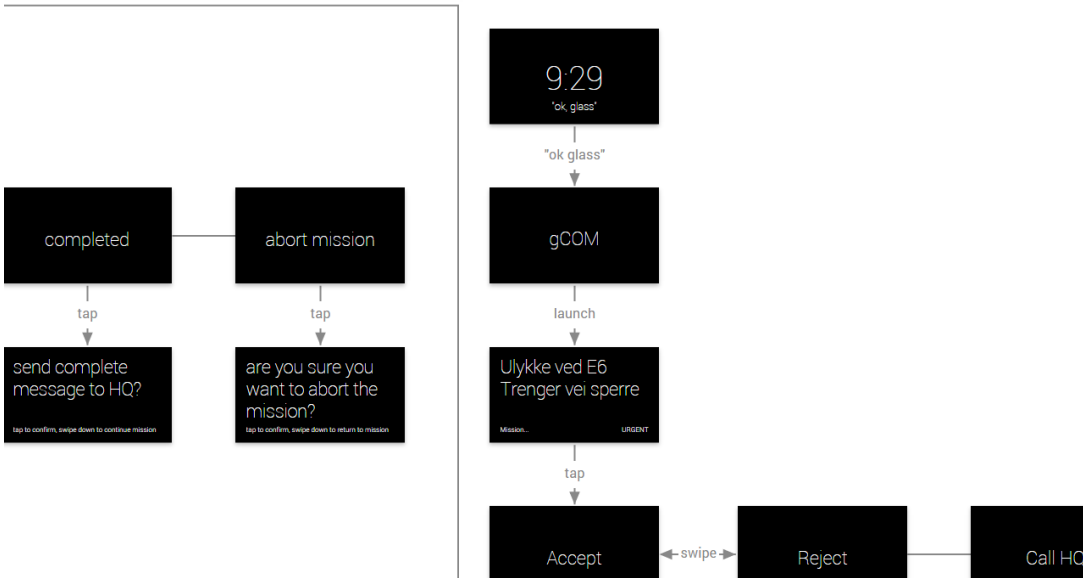

Image 3: Clip of our flow chart for Google Glass

We had slightly improved our prototype by designing it using Google's design framework (above is a snapshot of part of the design). This enabled us to modify our design in order to

avoid any elements that are not possible to implement on the Glass. We could now also print out the cards, which would be much easier for the interviewee to read and understand.

Although we made Mr. Danielsen sign a consent form which included details about what the data would be used for, we were also going to record the interview in order to transcribe and take notes from it later if needed. This we did not include in the form. Therefore, in order to have a proof of consent, we verbally asked Mr. Danielsen for consent and recorded his consent before we carried on recording the interview. We knew that an hour of audio recording can take up to 10-hours to transcribe (Robson, 2002).

During the first half of the interview, which was more open questions, Bjørn Danielsen came with a lot of constructive feedback. Interestingly enough, most of what he had mentioned without looking at our concept was in line with what we had already thought of. When we showed him our concept, he was quite happy.

He especially appreciated the fact that the Google Glass was head-mounted, and thus the user would always have his/her hands free to conduct other tasks.

He agreed completely with our 4-point approach, and also explained why they were important.

Text Briefs:

"Over the radio, messages and commands can be lost/misinterpreted due to network issues and sound quality, different accents spoken by different individuals, as well as simply because the operative does not remember a certain message. With a textual representation of the same message, an operative can go back and read what message he/she has received from the command central."

Map:

"For an operative, it is extremely important to be aware of his/her location, as well as where he/she must go to. Police vehicles are equipped with navigation, however, when an operative is outside the vehicle, and needs to travel by foot, he/she currently have no form of navigation assistance. Therefore, having access to a live map with directions will lead to shorter routes to a particular destination, as well as precious time saved by not having to take out a phone/paper map every time the operative is unsure of the direction. Additionally, the maps could show information on altitude which would enable the operatives to make judgements on issues such as gas leaks, where certain gasses that are heavy will always move downwards toward the ground, thus not affecting buildings or roads that are located at a

higher altitude regardless of their proximity to the leak. Therefore, for example, one could avoid unnecessary blocking of areas that may not be affected. "

Image:

"Quite often we are given descriptions of locations or people over the radio. Due to our training we are quite good at interpreting what the central command is trying to describe. However, I have personally faced many situations where the central command had a particular dialect which was hard to understand, and we used more time than necessary trying to get the message. If the central command could send us an image of what they wanted us to look for, it would be far more efficient than trying to get the same message across through radio. "

Video streaming:

"No two days on duty are the same for a police officer, and based on the urgency and complexity of a mission we can get quite stressed. In such cases, there is always a possibility for us to take decisions which may not be optimal for the situation. In these cases, if we have a remote observer, e.g., someone at the control room, who is free from the stress at the situation, and at the same time aware of what is going on, can be a very important resource. He/she can give real-time directions, as well as notify the operative in the field if he/she makes any mistakes."

We also got confirmation that voice communication would always have to be available.

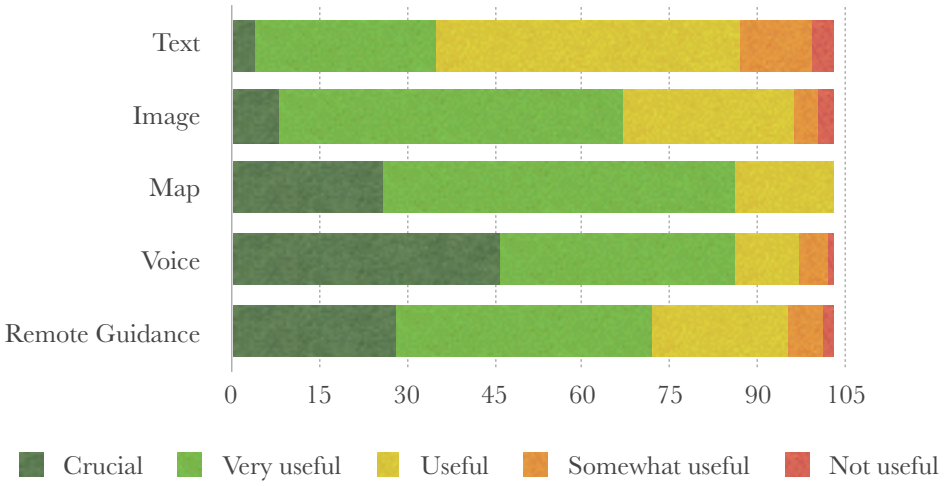

Figure 2: Results of user survey

Students at the Politihøgskolen - Survey

Our 4-point approach was also supported by the results of our survey which we had sent out to students and staff at the Politihøgskolen, where we got a total of 134 responses. However, we only used 103 of those responses which were from students who were either on their 3rd or on their 2nd year of studies, indicating that they had already been out working in the field. We thought this group of students to be more representative of our target group.

The chart clearly shows that majority felt that text, image, map, and remote guidance would be useful. When asked whether the police could use a better form of communication, 58% answered yes. To our surprise, this number was a bit low. This could have been caused due to the question being placed in the survey before the questions about the individual features. This gave us clear insight into the fact that quite often, when the users are asked an open question about what they want, they are not always capable of providing useful answers. However, if they are given some structure, and some ideas to play with, they can generate results that can be used going forward.

High Fidelity Prototype

The Prototype

Based on the feedback from the interviews and surveys, we started programming. After a lot of struggling with the programming software for the Google Glass, as well as struggling with the Google Glass itself, which quite often would not turn on, we managed to create a basic demo G.COM application.

Our focus was to be able to implement at least the first three of the four features we initially planned to include (text, images, maps, *video streaming*) and implement all the interaction through the Google Glass. Our demo had a set of mission briefs, relevant images, and map directions that could be accessed using the basic Google Glass interactions, and some of the information would be pushed into the user's screen automatically.

We were initially planning to use the current BRIDGE system being developed by SINTEF to communicate with the Google Glass, however, due to lack of resources we were not able to do so. Thus we were also not able to implement the video streaming functionality.

More Evaluation

This demo we took to the Technical Head of Radio Communication at Oslo Police Region, Arne Mjøen. We first gave him an introduction to our project and what we had done so far, followed by a walk through of the different gestures of the Google Glass. We then let him use

Image 4: Arne Mjøen signing our consent form before the interview session

our demo G.COM application followed by a semi-structured interview which we also recorded for later transcription. The main feedback we got from Mr. Mjøen was the fact that we needed to minimise the number of steps it takes to get from one feature to another. He said that, "To make this a product that is actually used by the police, it needs to be as simple and as intuitive as possible." He said we needed to get rid of all the clutter and extra menu items, and keep only that which is necessary. He, as many others, also mentioned his concern about the physical robustness of the Google Glass.

Evaluation - Experiment

Design

In order to test the usability and application of our G.COM program, we looked at several methods of evaluation (Lazar, Feng, Hochheiser, 2010, p. 252; Rogers, Sharp, Preece, 2011, p. 490).

We decided to start by testing one of the features of G.COM which was the map function. We wanted to see the benefits of using map directions on G.COM through the Google Glass, compared to following the same directions on a mobile phone. We would make the user follow a route around Aker Brygge in Oslo, and measure how long it takes using the different devices.

Our null hypothesis was that, "Regardless of whether a user is using a head-mounted display such as Google Glass or a mobile phone for navigation, they will arrive at their destination at the same time." Thus, our alternative hypothesis was "Using a head-mounted display such as Google Glass for navigation results in less time used compared to using a mobile phone."

Our only independent variable was the device the user would use to complete the route, and the dependent variable was the time it would take them. Because we only had one independent variable, and only two conditions we decided to conduct a between-group experiment. We realised that there may be some individual differences, but we were much more concerned about avoiding the learning effect which would be quite relevant to the design of our experiment. We limited that by having a selective recruitment of participants.

Since it was very difficult to use actual police officers or students, we decided to gather a group of users within a similar age range of between 25-36 years. None of our users live or work in the area of the experiment, thus limiting their previous knowledge of the area. In order to minimise the differences within our users even more, we tried to recruit users (among our friends) who had a similar work setting, a desk job. Among our users were programmers, analysts, and consultants.

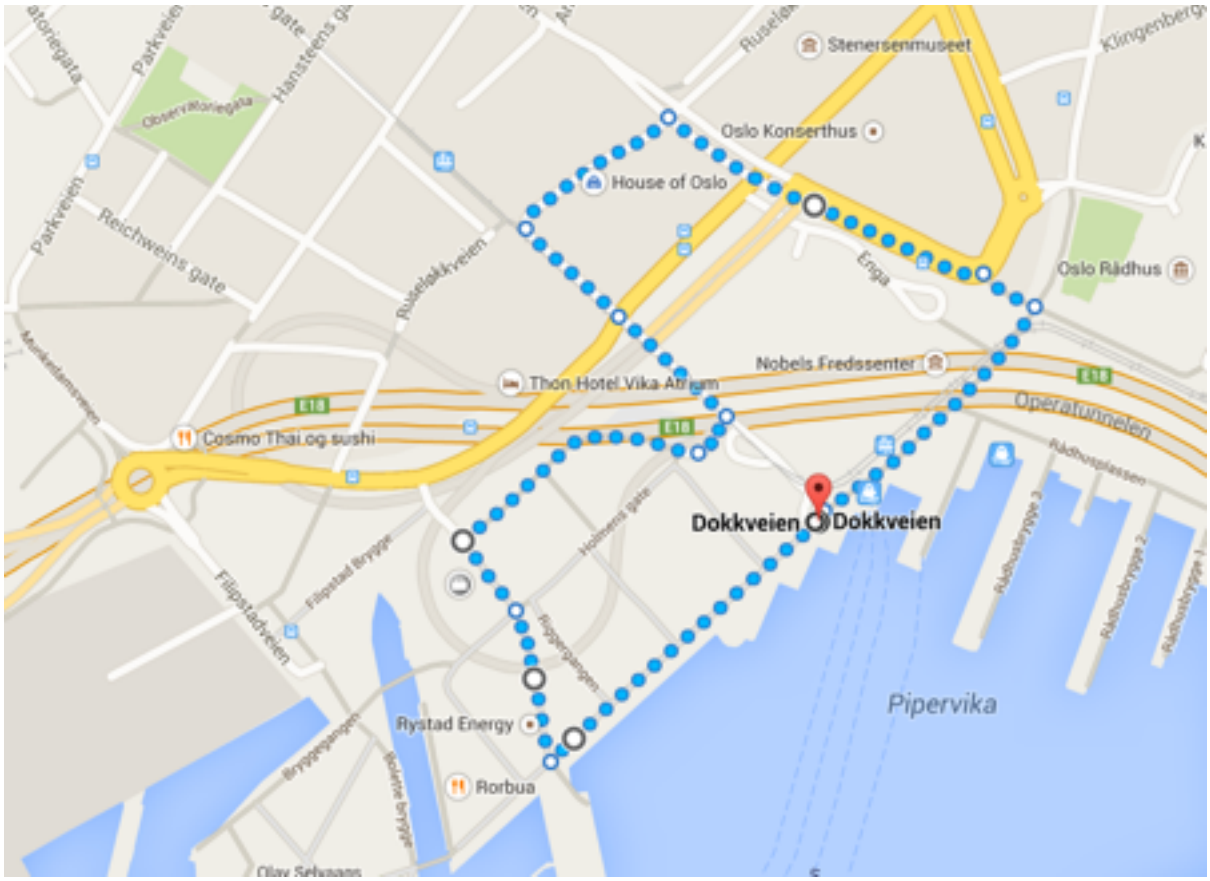

Image 5: Route of experiment

We designed a small route around Aker Brygge. The route was pre-set on the Google Glass or the mobile phone before the user was given the device. When the user was ready, we started the time, and followed the user. Whoever was involved in conducting the experiment was not allowed to answer any questions from the user throughout the experiment, and the users were

only allowed to go in normal walking pace. This was to be clearly communicated to the users before the experiment began. We randomly assigned either mobile or Glass to each user from our pool of 12 users.

Conduct

The users were explained the context of the experiment and all the rules. We had to spend approximately 30-40 minutes with each user, and thus it was not possible to conduct the experiment on one single day. We spread it over 4 days, and tried keep the time of the day the same for all 4 of the days. We also tried to keep an eye on the weather before deciding on the days to have relatively similar weather during all of the experiments. The experiments were conducted between 11 am and 2 pm on days with temperatures between 5-10 degrees Celsius.

As the users were completing their routes, we were also keeping note of their expressions during the experiment.

After the users had completed the route, we conducted a mini-interview to ask them about their experience. This led so some interesting data.

Image 6: Selected images from experiment

Analyze data

Below are the data we gathered from our experiments. The time taken to complete the given route for each user is given in the column "Time." The usernames are coded such that all usernames starting with "G" refer to users who were using Google Glass while those with "M" refer to users that were using mobile phones. The second and third columns show the expressions from the users during the experiment, which we were able to group into two

categories where the users seemed either 'confident' or 'frustrated' during the course of the experiment.

User	Time	Frustrated	Confident
G1	26.23	No	Yes
G2	22.03	No	Yes
G3	24.37	No	Yes
G4	23.44	Yes	No
G5	24.39	No	No
G6	25.09	No	Yes
M1	22.54	No	Yes
M2	25.50	No	Yes
M3	26.22	No	Yes
M4	23.27	Yes	No
M5	24.56	No	Yes
M6	26.02	No	Yes

Figure 3: Data from experiment

Figure 3 shows that the times do not vary significantly between the two groups of users. This is an indication towards the fact that our null-hypotheses might have been correct.

	Variable 1	*Variable 2*
Mean	24,25833333	24,685
Variance	2,048816667	2,28431
Observations	6	6
Pooled Variance	2,166563333	
Hypothesized Mean Difference	0	
df	10	
t Stat	-0,502069279	
P(T<=t) one-tail	0,31324427	
t Critical one-tail	1,812461102	
P(T<=t) two-tail	0,626488539	
t Critical two-tail	2,228138842	

Figure 4: Results from *t* test

Our experiment had a between-group design, with one independent variable and 2 conditions where the two groups were performing tasks each with one condition. "When two groups being compared are presumably unrelated, an independent-samples *t* test can be used," (Lazar, Feng, Hochheiser, 2010, p. 76). Since we initially thought that there would be a difference in the results from the two groups, we decided that an independent-samples *t* test would be appropriate for our experiment.

Results

Figure 4 shows the results from the *t* test performed on the collected data from the experiment. By definition of the *t* test if *t* Stat < -*t* Critical two-tail or *t* Stat > *t* Critical two-tail, we can reject the null hypothesis. As this is not the case with our results, we can say that our null hypothesis was correct, and we must reject the alternative hypothesis. This means that we were unable to find any significant difference in the time used to navigate a route using a head-mounted device and the same using a mobile phone.

Looking at the emotional data, we interestingly saw that there was no relation between how much time one used on the route and their overall experience of the experiment. This was our attempt to play a little with "grounded theory." Based on the users' expressions, we tried to code their experience of the experiment as either being frustrated or confident.

Improvements

Reliability - Overall the experiment was organised well. All the steps were documented, and can easily be conducted by any other researcher.

Validity - Due to only 12 users participating in the experiment, there may be some question about the validity of the results. If there was a larger number of participants, covering a larger range of personalities, we could probably rely more on the results.

Individual differences - It could be such that some users were better at reading maps, and despite our efforts during recruitment, there could be some users who know the area better than others.

Choice of task - The task we put out for our users was quite basic. We could for instance add tasks within the route where the users would have to use their hands. this would really test the "hands-free" design of the Google Glass.

One other factor that could have played a part on the speed of the users. As we were following the users throughout the route, it could have caused the user to hesitate to go too fast and perhaps try to replicate the speed we were walking at.

Ethical Issues

During our project with Google Glass, we were faced with several ethical issues.

Audio Recording

One such issue came up when we conducted our first interview with a superintendent of Police. We had a consent form about using the data from the interview, however we had not included the fact that we would record the interview, in the consent form. We were faced with a bit of a dilemma. We then asked our interviewee whether it was ok for us to record the interview. He agreed, so we were quite relieved. However, we had not proof of the fact that he had given consent. We then decided to ask him for consent on tape. So we recorded our question as we asked him for consent as well as his answer giving consent. That way we were both satisfied about the privacy issues involved with recording the interview. We also made clear that the data would only be used for research purposes, and the recording would not be presented or shared in any form, and deleted when we had gone through the recording and took down all the notes we needed.

Video Recording

Another issue was when we were conducting our experiment. We asked 12 individuals to use either a smartphone or Google Glass to travel from a given point to an assigned destination. We were filming them as they performed their tasks which we were planning to use in our final presentation. We clearly informed the users about the goal with the experiment and the goal with why we were filming. We explained the filming had nothing to do with the study, but rather to do with the presentation of our experiment. We ran into 2 users who were not comfortable being part of a video that would be shown to other students at the University. We again faced a dilemma. Should we ask the users to leave and not do the experiment? Or should we modify the consent form to include that the video for these individual users would not be included in the final video? Or should we not film these users at all? We decided that since the filming did not affect our results, we would not film these two users. So they ended up participating in the experiment and having enjoying as well.

Glass recording

A third issue, which is more related to our product itself. We discussed the fact that if Google Glass is used in an emergency situation, there will always be spectators and others who are within the zone of the operation. This means that if the police officer in the field has turned on his video streaming, his counterparts sitting in the control centre will be able to see everything in the field-officer's field of vision. Additionally this video can be recorded by the head quarters for reviewing later. There is no practical way for the field officers to gather consent from the civilians that may happen to be at the site before beginning to film/record

them. Therefore, the only solution would be to empower the field officers, through legislation, to be able to record video of all civilians within the field of vision of the officer during and only during a mission. The legislation should also include details about how the recorded video will be stored and how its security will be ensured. There should also be a time limit to how long the recorded video will be accessible, and that after a certain period of time, it will be destroyed.

Going Forward

G.COM as a product

At the stage we are now, after multiple interactions with users, we can strongly say that G.COM as a complete product has the potential to be extremely useful for the police force. It can immensely strengthen the communication between field-operatives and command centres and make the police force much more efficient than it is today.

Although we were not yet able to connect our app with the BRIDGE system, we believe that in doing so, one can really test the applicability of G.COM in the real world. Many more issues will of course come up, such as data speed, robustness of the Google Glass, etc.

Alternatively, as a larger and more long term project we have also thought about a concept where an alternative for Google Glass can be produced keeping in mind its use within the police force. This device would not have any of the features of Google Glass that are not necessary for a police operation. Additionally the device could be tailor made to be robust and fit for all types of extreme use.

Us as a group

We have spoken to SINTEF and are planning to do a more thorough experiment on the map function of the Google Glass. As the technology is relatively new, there is a lack of research done on these type of devices. We plan to submit a short paper for CHI 2015 which has deadline on the 5th of January 2015.

Conclusion

INF2260 has been a very intensive learning experience for all of us in the group. We came into contact with many users, who were very experienced in what they do, including our supervisors.

We had the chance to implement a lot of the theory we have learned over the past year and a half in INF1500 and INF1510 as well as INF2260 this semester.

It was a very interesting journey where we started never having used a Google Glass. We also struggled a lot to get in touch with the police. We developed much of our earlier concepts just based on discussions with our supervisors and TV shows. We had no idea how to program for the Google Glass, and none of us had programmed anything for android before.

However as the semester progressed, we started getting responses form the Police, and they were extremely positive and helpful. They were also very interested to see our results. This was very motivating for us.

We eventually started understanding the structure of the Google Glass software, and started programming small demos, which we finally modified to resemble what we saw our G.COM concept to be.

We learned a lot specifically in the fields of experiment design and statistical analysis. These were very new concepts for all of us in the group, and we found these topics to be extremely interesting. The fact that we focused on research methods as well put a new dimension into our view of interaction design altogether. We went much deeper into what was important while gathering data, and all the different ways data gathering can be done.

All in all, we had a great time working on this project. We worked well as a team, we enjoyed our task, and we had very positive and supportive supervisors. Yes, we had our stressful times, when the Google Glass refused to turn on for 2 weeks straight, and when we were 3 weeks into the semester without any response from the users. However we used what we had effectively and moved on.

We now look forward to working with many such projects in the future. We hope to learn from our mistakes from this project, and to continue learning from new projects, new ideas, and new mistakes, as we become more knowledgeable about Human Computer Interaction.

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Student Research Competition : Call for Participation:
<http://chi2015.acm.org/authors/student-research-competition/>
[Read 21.11.2014]

Taser Axon Body on Officer Video:
<http://www.taser.com/products/on-officer-video/axon-body-on-officer-video>
[Read 02.10.2014]

Unknown (2014) Google Glass Tech Specs:
<https://support.google.com/glass/answer/3064128?hl=en&ref_topic=3063354 >
[Read 25.09.2014]