



Computer Science

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**Johan Häger**

**Your Title**

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Bachelor's Project

2015:xx



**Your Title**

**Johan Häger**



This report is submitted in partial fulfillment of the requirements for the Bachelor's degree in Computer Science. All material in this report which is not my own work has been identified and no material is included for which a degree has previously been conferred.

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Approved, Date of defense

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Advisor: Donald F. Ross

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Examiner: NN



# Abstract

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# 1 Introduction

o Project goal and motivation o Project summary and overview - the "red thread" o Project results (brief summary) o Dissertation Layout

## 2 Background

On April 4th, 2012, Google announced “Project Glass” [3]. Google Glass, as the device is now known, was under development for several years at Google’s research and development department, Google X. As part of the announcement Google stated: “We think technology should work for you—to be there when you need it and get out of your way when you don’t.” [5].

Sergey Brin, one of the founders of Google, gave a Ted Talk in February 2013 [16] where he talked about why Google decided to produce the device. His argument was that users stayed on their smartphones for too long. Brin also argued that when users were using their smartphones they were looking down at a screen and were not aware of their surroundings. Instead Google wanted to create a device that would give the user notifications that could quickly be dealt and done with. Google also wanted to make the device hands-free and put the display where the user did not have to look down. Brin stated that the development team at Google X added the camera later on in the development process but in fact the camera had been a great addition to the device and enabled Google Glass to capture the user’s surroundings, for instance by taking photographs.

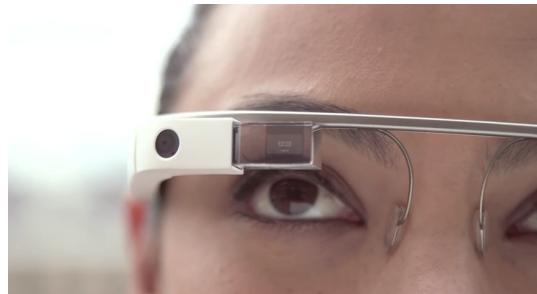
Thad Starner, technical lead/manager (responsible for both the technical direction as well as people management [15]) on Google Glass, claimed that Google Glass was intended to be an extension of the self [46]. He compared Google Glass to a watch. Not in terms of where the user keeps his or her focus (with a watch you must look down, similar to a smartphone), but rather in terms of how a watch is easy to access and how the access is instant. Starner said that with Google Glass, Google wanted to minimise the time between intention and action.

## 2.1 What is Google Glass?

Google Glass, or simply “Glass” as the device is known within Google, is a head-mounted display (HMD)<sup>1</sup> that can be seen as an augmented reality device<sup>2</sup> designed to bring notifications to the user more easily than a smartphone does. Google Glass is shown in Figure 2.1. According to Google “Glass is designed to be there when the user needs it and to stay out of the way when the user does not” [25]. Google Glass is meant to give the user relevant information at relevant times.



(a) The user can control Google Glass with the touchpad.



(b) The display sits slightly above the user's line of sight, on the right hand side.

Figure 2.1: Google Glass is equipped with a touchpad and a camera [14].

Google Glass is partially controlled with a touchpad, but can also be controlled through voice commands. The touchpad sits on the right hand side of the user's glass frame and runs from the temple to the ear (see in Figure 2.1 (a)). When the user touches anywhere on the touchpad Google Glass “wakes up” from stand by and displays the start screen (which consists of a clock). The display is mounted above the user's line of sight, on the right hand side (see Figure 2.1 (b)) and can be slightly adjusted so that the user can see all that is currently being displayed.

The display is a projection that goes through an optic lense in the glass piece, seen in Figure (b), which creates a virtual image. A virtual image is an image that, projected

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<sup>1</sup>See section 2.1.1.

<sup>2</sup>See section 2.1.4.

through optic lenses, appears to be located at a point where the actual projection is not [45]. In the case of Google Glass the display appears to be located further away from the user than the display actually is. The display is said to be equivalent of a 25 inch high definition screen seen from a distance of approximately 2.5 meters [26].

### **2.1.1 Head-Mounted Display (HMD)**

A head-mounted display (HMD)[40] is a device that is worn on the head and that places a small display in front of one or both of the user's eyes. The device can either be a stand alone device or a part of a helmet. A branch of HMDs are optical head-mounted displays (OHMDs)[43]. A OHMD is a HMD with a see-through display, for instance Google Glass.

### **2.1.2 Heads-Up Display (HUD)**

A heads-up display (HUD)[41] is defined as any transparent display that, when presenting information, does not require users to look away from their usual viewpoints. In other words, a HUD may be a HMD and a HMD may be a HUD. While a HMD is always worn on the head a HUD can be a stand-alone display. In contrast a HUD must be a transparent display. A requirement a HMD does not have. A OHMD, however, is always a HUD since a OHMD has a transparent display.

### **2.1.3 Virtual Reality**

Virtual reality[37] is defined as a computer generated simulation that enables users to interact with a three-dimensional environment. Virtual realities are common in interactive mediums such as video games. Virtual realities can also be combined with a HMD in order to completely engulf the user in the virtual reality. One such example is the Oculus Rift, seen in Figure 2.2, that completely covers the user's eyes, allowing the user to experience the virtual reality.





Figure 2.2: The HMD “Oculus Rift” is a virtual reality device [31].

Google Glass is able to display a virtual reality but does not work as a virtual reality device. Google Glass only covers a small part of the user’s field of vision and as such does not have the capability of simulating a three-dimensional, interactive, environment in contrast to the Oculus Rift. Oculus Rift, unlike Google Glass, is able to replace the user’s reality with a completely virtual reality since Oculus Rift completely covers the user’s eyes.

#### 2.1.4 Augmented Reality

Augmented reality[20] is defined as the combination of reality (or what is within current context being perceived as reality<sup>3</sup>) with useful, computer generated, data. Augmented reality, unlike virtual reality, is not meant to replace reality, but rather to enhance interaction with the current reality.

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<sup>3</sup>Augmented reality is for instance common in video games to give the player environmental and health information.

A HUD may create an augmented reality. The reason a HUD does not always create an augmented reality is due to the fact that the information being presented might not be useful within the current context. An augmented reality is, as stated above, meant to enhance reality, while a HUD does not have that requirement.

Google Glass is a HUD that has the potential (and intent) to create an augmented reality. Google Glass is intended to present useful information to users while not distracting them from reality. One example of useful information that could enhance the users interaction with reality would be a shopping list while shopping, as seen in Figure 2.3.



Figure 2.3: A shopping list while the user is out shopping is useful information [25].

## 2.2 Similar Products

Today there are several products either already on the market or under development that are more or less similar to Google Glass. Following is a short list<sup>4</sup> describing some of the competition Google Glass faces, with each product shown in Figure 2.4.

- **Microsoft Hololens**[29]

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<sup>4</sup>A more extensive list of devices can be found on wikipedia [43].

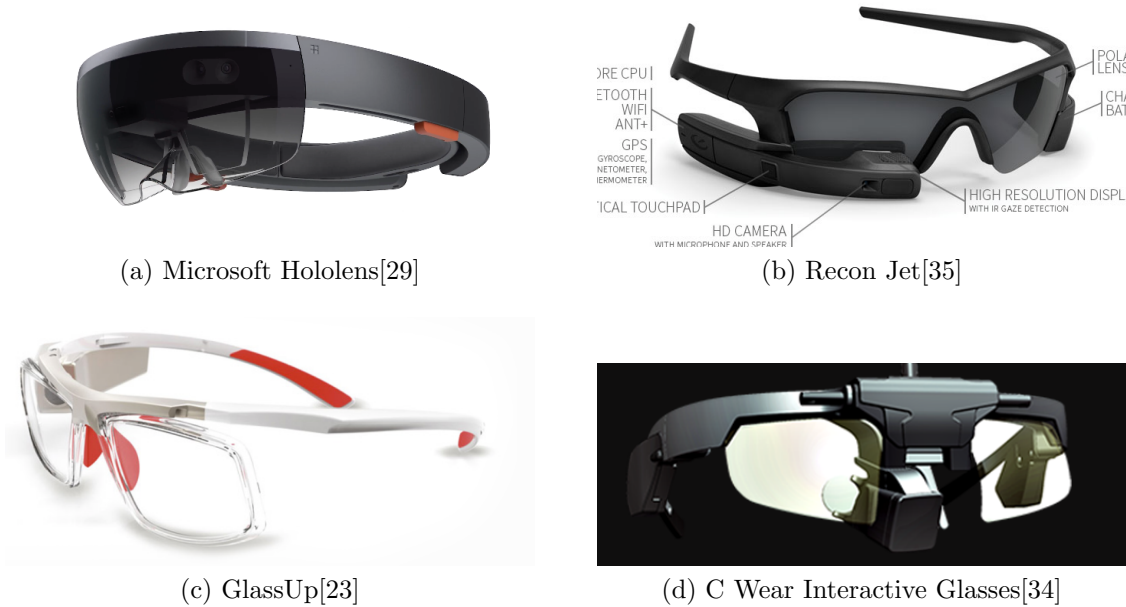


Figure 2.4: There are many OHMD devices similar to Google Glass [43].

Microsoft's offer in the augmented reality device space is a HUD that displays information in front of both of the user's eyes, called Microsoft HoloLens, seen in Figure 2.4 (a). The intention, according to Microsoft, is not to be an immediate competitor to Google Glass. Microsoft's aim is not to make the same device as Google Glass. Google Glass is meant to be worn all the time, at all times. Microsoft HoloLens is rather a device users only wear when they intend to use it. Google Glass is, as Thad Starner stated [46], meant to be an extension of the self and is meant to be worn even though the user might not be actively using Google Glass at the time in order to bring helpful notifications and information to the user. Microsoft HoloLens is rather a tool to be used actively for a certain purpose, such as modelling [28], and then put away. Google Glass may be used the same way if the user wants to, but that is not the intent.

The most striking difference between Microsoft HoloLens and Google Glass lies in the interaction with the real world. Google Glass is a two dimensional (2D) display that

sits slightly above the users line of sight (see section 2.1). Microsoft Hololens, on the other hand, is meant to interact with the world even further.

Microsoft intends to give the user tools to work in a three dimensional (3D) space. Microsoft's concept video[30] of Microsoft Hololens shows examples of 3D modelling with the use of kinetic hand-movement detection, meaning that users will be able to see what they are working on from different angles simply by walking around it, just as if the object in question was real and had a physical mass.

- **Recon Jet**[35]

Recon Jet, seen in Figure 2.4 (b) is an HMD developed by Recon Instruments. Recon Jet is suited for athletes. Because of the target audience Recon Jet has been fitted with a display that has high contrast in order to give good readability in high ambient lighting. The display's virtual image appears as a 30 inch wide screen at approximately 2 meters distance,[36] to be compared with Google Glass' virtual image which appears as a 25 inch high definition screen seen from a distance of 2.5 meters [26].

Unlike Google Glass, Recon Jet's display is located below the user's line of sight, as seen in Figure 2.4. Recon Jet's target audience, athletes, are used to having their information below line of sight. For instance a bike may have dashboard mounted to the handlebar, or an athlete might be using a watch to check the time. Google Glass is meant to be worn at all times while the location and the brightness of the display indicates that Recon Jet, however, is meant to only be used while the athlete is working out and not more regularly.

- **GlassUp**[21]

GlassUp is an Italian company that received most of its founding for the HMD device, GlassUp (seen in Figure 2.4), through the crowd-funding site Indiegogo [22]. GlassUp has been accused of being too similar to Google Glass, partially because of the name

of the device [8]. GlassUp does however make distinctions between the two products. On GlassUp's Indiegogo page the company made the comparison that looking at Google Glass' display was similar to looking in the back view mirror while GlassUp was similar to looking out the windscreen. The comparison referenced the fact that Google Glass' display is located above the user's line of sight, similar to a rear view mirror.

GlassUp instead displays information close to the center of the user's line of sight. GlassUp claimed, on the company's Indiegogo page, that the display was placed closer to the center of the users line of sight so that there would be less strain on the user's eyes. However, the biggest difference from Google Glass is that GlassUp is meant only to act as a second screen. GlassUp is a "receive only" device which displays information from the device currently connected through bluetooth, for instance a smartphone. GlassUp does not do any calculations on its own and must stay connected to a bluetooth device in order to display information [22].

- **C Wear Interactive Glasses**[33]

C Wear Interactive Glasses, seen in Figure 2.4, is an industry focused device developed by Penny in Västerås, Sweden [6]. C Wear Interactive Glasses projects an image onto the actual glass in front of the user's right eye and as such covers a larger area than similar devices such as Google Glass, Recon Jet and GlassUp [32]. The display is said to be perceived as a 75 inch display at a distance of 2.1 meters [34]. The projection is transparent which enables users to still see what is happening in front of them.

Being industry focused C Wear Interactive Glasses is also equipped with a hands-free user interface that does not require voice command. C Wear Interactive Glasses uses a jaw sensor which lies against the user's jawbone muscle. The sensor detects tension in the muscle, which registers as a click, to be compared with a touch on the Google

Glass touchpad [34].

C Wear Interactive Glasses, similar to GlassUp, is designed to be connected to an external device [34]. However, where GlassUp is connected through bluetooth C Wear Interactive Glasses is connected through an adapter which can send data and visual information via USB and HDMI. The external device can be a smartphone, a tablet, a PC or even a TV.

## 2.3 User Interface

The Google Glass graphical user interface (GUI) is called a timeline[14] (see Figure 2.5). The timeline consists of a row of cards. Cards are basic applications such as a clock (see Figure 2.6 (a)) or information about the weather. Cards can also represent more in-depth applications, on Google Glass called “Immersion” (see Figure 2.6 (b) and (c)). Immersions handle activities such as browsing an image gallery or playing a game.



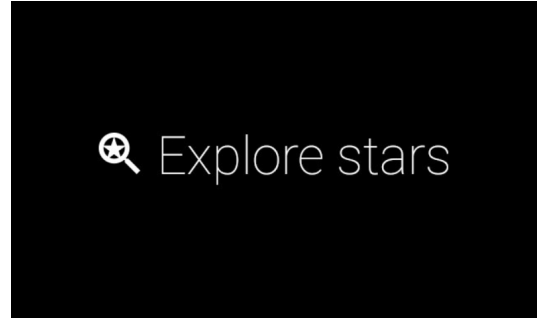
Figure 2.5: A visualisation of the timeline as the timeline is perceived by the user [14].

The first screen the user sees when starting up Google Glass is the home screen. The home screen displays a clock and also shows the text ”ok glass”, as seen in Figure 2.6 (a). The home screen is a part of the timeline and acts as the center point. Cards to the left of the home screen are upcoming activities such as an event in the user’s calendar or an

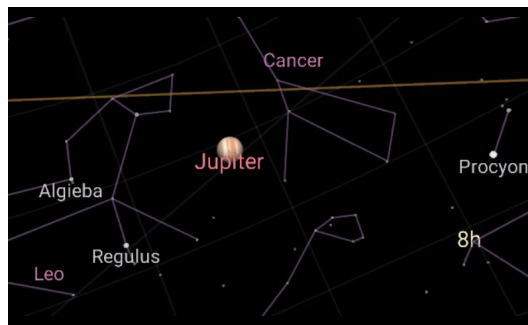
upcoming flight. Cards to the right of the home screen are from the past. Cards from the past will for instance show text messages or photos.



(a) The Google Glass home screen is a card that displays a clock.



(b) The card “Explore stars” represents an immersion.



(c) The immersion “Explore stars” allows the user to look around at stars using the built-in head motion tracker.

Figure 2.6: Cards can either display basic applications or represent immersions.

In order to move left on the timeline (forward in time) the user must swipe a finger backwards on the touchpad. In order to move right on the timeline (backward in time) the user must swipe a finger forward on the touchpad. The fact that the user must swipe backwards when stepping forward in time might not seem especially intuitive. In western culture a timeline is normally represented as going from left to right. One example is books, where the reader not only reads each line from left to right, but also turn pages from the right (the future) to the left (the past). However, on Google Glass, the swiping action could be thought of as swiping cards behind the back. Swiping forward when stepping

backwards in time would then in turn mean bringing cards placed behind the back into focus. Cards in the past are behind the user while cards in the future are in front of the user.

When the user wants to turn off Google Glass the user swipes down on the touchpad. Swiping down on the touchpad will put Google Glass in stand-by mode. If the user wants to turn off Google Glass entirely, in other words power down the device, there is a power button on the opposite side of the touchpad. Holding down the power button for a few seconds will turn off Google Glass. For a better visual understanding of how Google Glass works see Figure 2.5 as well as the video referenced in the caption.

Google Glass uses a Bone Conduction Transducer (BCT) to transfer sound to the user [26]. The BCT transfers sound to the inner ear by conducting sound through the bones of the skull [38]. The advantage of this technique is that the sound maintains clarity, even in noisy environments. Also, since the user does not plug any earphone into their ears, external sound is not blocked out.

Google Glass also features a 5 megapixels camera. The camera sits between the touchpad and the display, as seen in Figure 2.1 (b), and is capable of capturing video at a 720p resolution. The camera can be used for video conferencing, as Google showed in 2012 [2], but the camera can for instance also be used when the user wants to scan a QR Code<sup>5</sup>.

The user can also interact with Google Glass using voice commands. As seen in Figure 2.6 the home screen consists not only of a clock but also of the words “ok glass”, in quotes. “ok glass” indicates to the user that voice commands are available. The voice command menu is accessed as soon as the user says the words “ok glass”. Doing so brings up a list of voice commands available, as seen in Figure 2.7.

In order to progress further the user must say one of the options being displayed out loud. Doing so will either make Google Glass perform the task spoken or give the user the option to add an input option to the task chosen. For instance, if the user where to say

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<sup>5</sup>See section 2.6



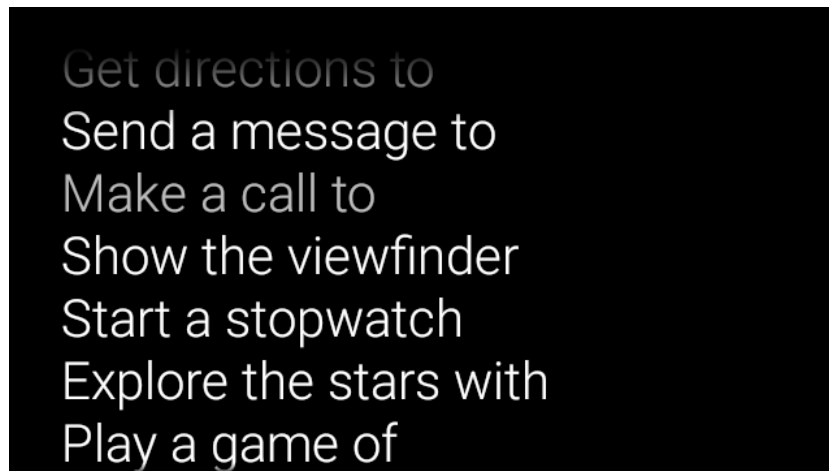


Figure 2.7: Saying “ok glass” will bring up the voice vommand menu. [27]

“ok glass, Start a stopwatch”, Google Glass would start a stopwatch.

Google Glass also supports head motions as a form of input from the user. Head motions are not enabled in the timeline as a way of input but tilting the head may wake up Google Glass from stand by mode, if the user has enabled the head wake up feature [24]. The head motion interface may also be used in certain immersions, such as “Explore stars” seen in Figure 2.6 (c).

## 2.4 A Comparison with Smartphones

Compared to smartphones one of the biggest advantages of Google Glass is the fact that Google Glass is a HMD. With a smartphone the user needs to either hold the smartphone in either one or both hands, or alternatively put the smartphone on a table. In other words can Google Glass offer a hands-free experience that smartphones cannot.

Another advantage of Google Glass compared to smartphones is also comes from the fact that Google Glass is an HMD. The user does not need to look away in order to see what is currently being displayed. Google Glass does not distract from what the user is currently doing as much as a smartphone where the user needs to either look away or hold up the smartphone in from of their eyes.

However, smartphones does give the user a bit more control. The control comes from the fact that smartphones supports multi-touch, which Google Glass does not. On a smartphone users may also touch directly on the screen, in contrast to Google Glass where the touchpad sits on the right hand side of the user. Smartphones also have a larger touch area than Google Glass.

The smartphone screen size has been increasing ever since the iPhone first launched in 2007 [42], as seen in Figure 2.8. Looking at currently available smartphones, in Figure 2.9, the increase in screen size does is set to continue as the average screen size is approaching five inches. In terms of comparison with Google Glass the increase in screen size entails that more information could be displayed on a smartphone than on Google Glass.

However, one of the biggest differences between smartphones and Google Glass is the plural, smartphones. There are several smartphone brands competing on the market, each offering several models. Google Glass is simply Google Glass, one product. As seen in section 2.2 Google Glass does face competitors that have approached HMDs differently, and as HMDs increase in popularity there is potential for an even wider offering of models and screen sizes.

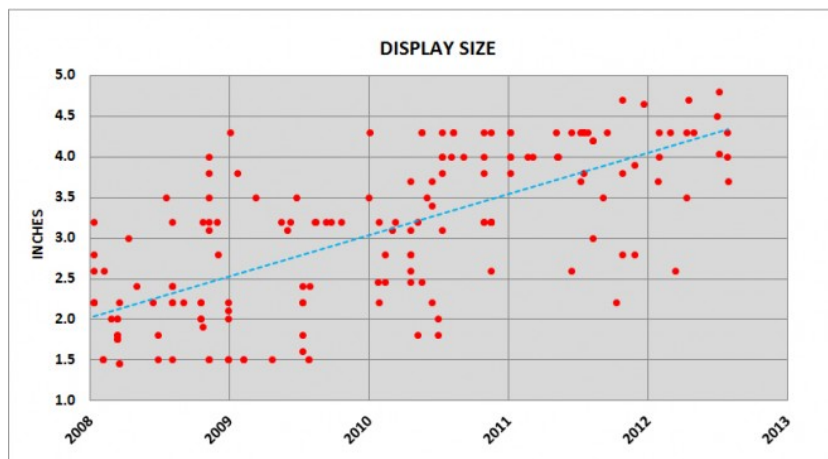


Figure 2.8: Smartphone screens have been increasing in size for several years. [7].

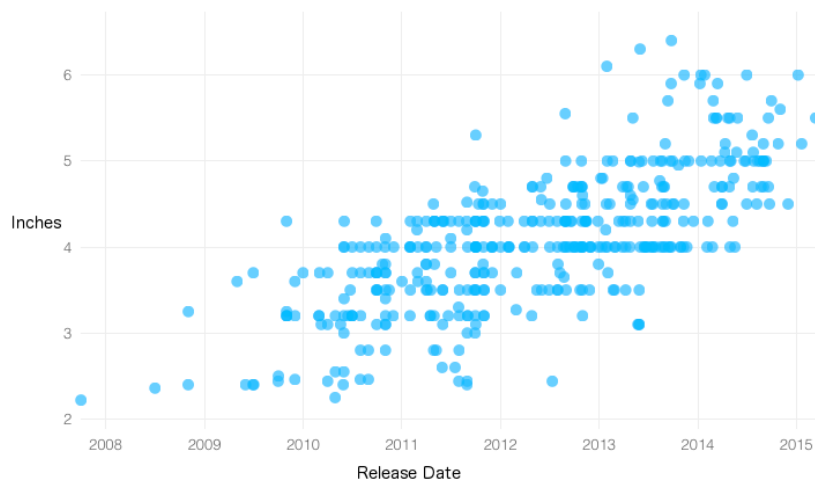


Figure 2.9: Screen sizes of the most popular, currently available smartphones [17].

## 2.5 Limitations of Google Glass

One early concern with Google Glass came from people who wore regular glasses every day, as Google Glass seemed to require separate frames. Isabelle Olsson at Google responded on the issue on April 12th 2012 with the following: “We ideally want Project Glass to work for everyone, and we’re experimenting with designs that are meant to be extendable to different types of frames.” [4].

Today many eyecare providers have been trained for Google Glass and Glass frames. These trained eyecare providers are however mostly located in the United States,[18] but Google points out that many eyecare providers should be able to help replace the lenses on Google Glass’ frames [19].

As described in an article posted on forbes in 2013 [13], a more alarming concern has been the health of the user’s eyes. Concerns were raised regarding eye strain and misalignment of the user’s eyes, as Google Glass placed a screen above one eye and not both. Google also saw these potential issues and approached Eli Peli, professor of ophthalmology who had been studying HMDs for two decades, as the development of Google Glass started.

Peli claimed that Google Glass has been designed with more safety and comfort in mind than previous, similar products. Peli pointed out that Google Glass is see-through and only covers a small part of the user's field of vision. As such Google Glass does not require a potentially poorly adjusted camera to capture the environment and display the environment to the user, which could cause eye strain.

Peli also pointed out that Google Glass is meant only to be used for short periods. Google Glass is meant to give the user notifications that can be quickly dealt and done with. The user should not be staring at the display for long periods of time, which would have the potential to cause a misalignment of the eyes. While Peli stated that the risks are zero, he still claimed that the likelihood of Google Glass causing any damage is small.

Even though, according to Google's expert, there might not be any health risks involved, there is still a question of how much help Google Glass may be to users. A study performed in 2002[48], regarding the effects of OHMDs, showed that OHMDs may only be of help to users under controlled forms. Whenever the surrounding environment becomes too distracting, for instance within a moving crowd, performance decreases. The study however noted that pilots had been able to successfully turn HMD into a tool they could use to their advantage. Since the study was not carried out over a long period of time the participants were potentially not given enough time to get used to wearing and using their HMDs, explaining the poor performance when using a distracting background.

## 2.6 QR Code

As mentioned in section 2.3 Google Glass is equipped with a camera that could be used to take photos from the user's perspective. One potential use of the camera would be to scan Quick Response (QR) codes. The QR Code was announced in 1994. Having been under development for several years at Denso Wave [10] the goal was to create a new form of barcode that could carry more information than a linear barcode and be easily read.

A conventional barcode is capable of storing approximately 20 digits while a QR code

can store several thousand digits [11]. Information is encoded using standardised encoding modes and displayed as a 2D barcode. A QR code has several standardised fields, as seen in Figure 2.10. Using position fields a QR code can be read from any direction, compared to a conventional barcode which can only be read horizontally [12].

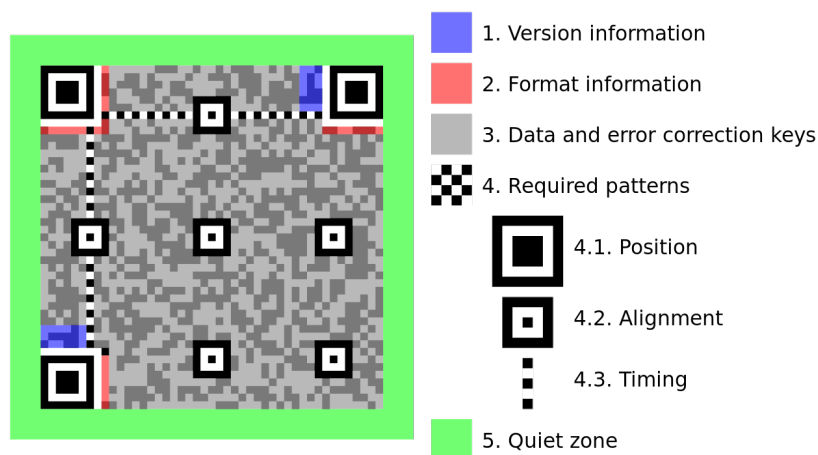


Figure 2.10: The standardised fields in a QR Code [44].

A QR code can be used to encode information, originally written with alphabetic characters, japanese symbols (Kanji) or numeric characters.[9] With the help of a QR code information which would otherwise have taken up a large space can now be easily fitted in smaller areas.

## 2.7 Information (and Ways of Presenting Information)

In 1985 Sture Allén, professor of computational linguistics, and Einar Selander, honorary doctor at Umeå University, in their book—Information on Information—defined information after having gone through “a large number of examples from texts of different kinds”. [47] Allén and Selander defined information as “a certain amount of facts or ideas”. While defining the concept of information can be done, there are several ways of presenting information.

### 2.7.1 Text

Text is one of the oldest forms of presenting information, with written text dating back to 4000 years B.C. [39]. Text is also a simple form of presentation that does not require much high end hardware. Other forms of presenting information require more memory, more computational power and more graphical power. Text also has the advantage that users can read through text at their own pace. Text may be viewed independently of time in contrast to sound and video.

Text does however have the disadvantage of requiring attention. The person reading the text must focus their attention on the text throughout and cannot look away in order to receive all the information being presented. Text is also restricted to the language the text has been written in. In order to globalise a presentation of information in text several texts must be written so that users from different countries can read the text. For instance, English was in 2010 only the third most spoken language, behind Mandarin and Spanish.[1] In other words would for instance this report require at least two translated versions in order to be globalised.[TODO translation might be a non-issue]

### 2.7.2 Images

The advantage of using images as the form of presenting information is that one can show the viewer the information rather than telling the viewer the information. Showing the viewer could potentially mean that more information could be presented within a smaller space than text could achieve. Images also give the same advantage as text in terms of at what pace the viewer could perceive the information. Images, similar to text, may be viewed independently of time in contrast to sound and video.

In a similar way to text, images require the viewers attention in order to present the information. The viewer cannot look away from an image and still receive the information. Another disadvantage with images is the fact that images can be interpreted in different ways. The saying “a picture is worth a thousand words” goes both ways. On one hand

images may present much information with one single image. On the other hand the information may not be crystal clear and not as clear cut as a describing text might be.

Images may also present information in two different ways. One way is with photographs. Photographs may present abstract and/or concrete information and visualise what might be difficult to describe only using words. Another way of using images is by presenting information graphically. Graphs are usually more clear cut with regard to information they present. However, graphs may in some cases be an insufficient way of presenting information. Graphs are used to present statistical information and are usually easier than photographs to translate into words. Statistical information, and as such also graphs, can summarise a period in time where as photographs captures a moment.

### **2.7.3 Audio**

Images and text both share the disadvantage of requiring full attention in order for the information to be perceived. Audio solves this problem. With audio as the form of presenting information the listener can look away[TODO SE DONALDS KOMMENTAR] and yet still receive the information that is being presented. In other words audio is well suited for multitasking as long as the other task the listener is performing does not involve listening to audio as well.

Audio does however have the disadvantage of having to be understood in real-time. The listener does not possess the same amount of control as he or she does with either text or images. Audio may be paused and rewound but the fact that audio is still tied to a timeline is a disadvantage. Another disadvantage with audio is that, similar to text, audio is dependent on the language. If a information presentation were to be spread globally several audio files would be required (given that the audio contained spoken words) translated into different languages.

#### **2.7.4 Video**

Since video consists of many images bundled together video gives the same advantages as images in terms of showing the viewer the information instead of telling them. Video presents the viewer with images at such speed that the images give the impression of movement. Video may also include audio. The inclusion of audio potentially gives video all the same advantages as audio. In other words video could potentially give the advantages of two other forms of information presentation.

However, similar to audio, video is presented in real-time. The viewer is bound to the playback speed of the video. Even though a video may be paused or even rewind the viewer does not possess the same amount of control as with images or text. With text and images the reader (or viewer) can decide the pace at which the information should be perceived for themselves. If the video does not include audio video, similar to images or text requires full attention in order for the information to be perceived.

### **2.8 Summary**

- o Introduce problem area / give relevant background info
- o Introduction - Explain WHY you are doing this study
- o Information - Background / your study in the wider context
- o Similar work (projects, systems etc.)
- o Summary - for this chapter



## **3 Design**

### **3.1 The Application**

### **3.2 Presenting Information on Google Glass**

### **3.3 Presenting Information on Smartphones**

### **3.4 Summary**

o Design - Present your project design in general o Information - Give details here (possibly several sub-sections)

## 4 Implementation

### 4.1 Summary

o Implementation - Present your project implemetion in general  
o Information - Give details here (possibly several sub-sections)  
o Summary - for this chapter

## 5 Result / Evaluation

o Introduction - Summarise your main results o Give details of the results o Best presentation? (text, tables, diagrams?) o Implementation Evaluation - your results against your expectations o Summary - for this chapter

## **6 Conclusion**

o Conclusion o Project Evaluation o Problems - How would you do this the next time? o Future work

### **6.1 Future Work**

## **7 Abbreviations**

**2D** Two-Dimensional

**3D** Three-Dimensional

**BCT** Bone Conduction Transducer

**GUI** Graphical User Interface

**HMD** Head-Mounted Display

**HUD** Heads-Up Display

**OHMD** Optical Head-Mounted Display

**QR Code** Quick Response Code

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