Chapter 1

How augmented reality can help safety

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1.1 Abstract

In this paper, different types of accidents are analyzed to see what the main causes of these accidents are. Most of the accidents are driver errors and therefore there might be an opportunity to use new technologies like augmented reality (AR) to help drivers.

In section 1.3.1 the different types of accidents and the main causes are explained. Section 1.3.2 gives a description of augmented reality and which augmented reality systems are currently on the market to help drivers. Section 1.3.2 and section 1.3.2 will give the advantages and disadvantages of these systems and the use of AR in cars in general. Finally, in the conclusion (section 1.4) future possibilities are given that do not have the disadvantages of the systems mentioned earlier.

1.2 Introduction

Augmented reality (AR) used in traffic might be a technology that could decrease accidents. There are different types of augmented reality, one of them is visual augmented reality but even this type has different forms. In this paper, possibilities, advantages and disadvantages of the use of AR will be mentioned.

1.2.1 Motivation

Augmented reality is being used in several disciplines nowadays but the use of it in traffic is rare. Road traffic injuries put significant strain on health care budgets. For everyone killed, injured or disabled by a road traffic crash there are countless others deeply affected. Many families are driven into poverty by the cost of prolonged medical care, the loss of a family breadwinner or the extra funds needed to care for people with disabilities. Road crash victims, their families, friends and other caregivers often suffer adverse social, physical and psychological effects. That is why it might be interesting to analyze the use augmented reality it this sector.

1.2.2 Research question

The research question of this paper will be:

How can the use of visual augmented reality help to prevent road accidents

To be able to answer this question the following sub-questions have to be answered:

• What type of accidents occur the most?
• What are the costs, causes and consequences of these accidents?
• What is augmented reality?
• In what way is augmented reality already used in traffic and how do they decrease traffic accidents?
What are the advantages and disadvantages of the use of augmented reality in vehicles?

Answers on the mentioned questions will be given after reading literature and internet studies.

1.3 Results of literature research

Road traffic crashes cause over 1.27 million deaths a year worldwide and are the second leading cause of dead \cite{GRSP, 2008}. Apart from laws and regulations more and more technological innovations are used to help reducing traffic incidents. Anti-lock Braking System (ABS), Driver Alert Control (DAC), Lane Departure Warning (LDW) and Side Collision Prevention (SCP) are good examples of such modern safety precautions. Even with the help of these systems the most accidents happen due to mistakes of the drivers. Therefore it is necessary to search for more opportunities and chances to help the driver by providing him or her with information or warnings. Augmented reality is a technology that shows information for pilots but is not used regularly in cars yet.

Research of the World Health Organization concludes\cite{WHO}:  
- Road traffic crashes kill 1.2 million people a year or an average of 3242 people every day;  
- Road traffic crashes injure or disable between 20 million and 50 million people a year;  
- Road traffic crashes rank as the 11th leading cause of death and account for 2.1% of all deaths globally.

It is estimated that every year, road traffic crashes cost:  
- US$518 billion globally;  
- US$65 billion in low-income and middle-income countries, exceeding the total amount received in development assistance;  
- between 1% and 1.5% of gross national product in low-income and middle-income countries;  
- 2% of gross national product in high-income countries.

1.3.1 Types of accidents

"Nearly 80 percent of crashes and 65 percent of near-crashes involved some form of driver inattention within three seconds before the event. Primary causes of driver inattention are distracting activities, such as cell phone use, and drowsiness." \cite{NHTSA}

There are three kinds of accidents that have to be distinguished in favor of this paper:  
- Single vehicle accidents  
- Non-motorist accidents  
- multiple vehicle collision

There are more types of accidents like a collision between a train and a vehicle but as these accidents happen rarely, they will not be taken into account.

Single vehicle accidents

A single vehicle accident is an accident in which only one vehicle is involved. A vehicle crash against a tree is an example of a single vehicle accident. The causes of these accidents are often alcohol, drowsiness, speed, bad vision (visibility of the road) or a mechanical failure.

Non-motorist accidents

A vehicle-pedestrian or a vehicle-cyclist accident can be seen as a non-motorist accident.

In 2008, 4,378 pedestrians were killed and 69,000 injured in traffic crashes in the United States. Most pedestrian fatalities occurred in urban areas (72%), at non-intersection locations (76%), in normal weather conditions (89%), and at night (70%)\cite{NHTSA}. Bad visibility of the pedestrian or cyclist is often the main cause here along with alcohol, drowsiness, speed and distraction.

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Multiple vehicle collisions

Research of the NHTSA (see figure 1.1) shows that the most occurring collisions are front-to-side (T-bone), front-to-front (head-on), Front-to-side (opposite direction) and front-to-rear (rear-end)

![Figure 1.1: types of collisions](image)

**Front-to-side collision** The Fatality Analysis Reporting System (FARS) of the National Highway Traffic Safety Administration (NHTSA) distinguishes three different types of front-to-side collisions:

- **T-bone**: where one vehicle rejects to yield and crashes into the side of another vehicle.
- **opposite direction**: where one vehicle fails to give way to a vehicle coming from the opposite direction
- **same direction**: where one car overtakes another while he turns left

**Front-to-front collision** Typical front-to-front or head-on collisions are when one driver hits an upcoming car while taking over or is at the wrong side of the road for any other reason. Driving into a one-way street in the wrong direction might also result in a head-on collision.

**Front-to-rear collision** Traffic jams can cause a front-to-rear collision when a driver sees the stopped traffic too late. Another cause of a front-to-rear accident is when one car is tailgating and the first car has to make an emergency stop.

**Conclusion**

In 90% of all traffic crashes driver negligence is the main contributor. "Nearly half of them are related to driver inattention, perceptual errors, or decision errors." [Lincoln et al., 2010] Darkness, fog or other circumstances that limits the vision of the driver are not in the top of this list. However, it can not be underestimated as it is often a combination of these causes that lead up to an accident. Late in the evening for example, when a driver is tired he might hit a pedestrian. The pedestrian is harder to see in the dark and the driver might have been able to see him or her in time if it was broad daylight. Furthermore, except for single vehicle accidents, there has to be someone else on the streets and therefore an accident is less likely to occur at 03:00h than at 17:00h [Schoettle, 2004]. Schoettle’s Research shows that having a rear-end collisions in darkness is 2.4
times bigger than in daylight. For side and front-end collisions these numbers are respectively 1.1 and 1.2 times bigger.

### 1.3.2 (virtual) Augmented reality

According to Azuma et al. [1997] augmented reality (AR) is a variation on virtual reality (VR). VR is a technology where the user is in a virtual environment (VE) and cannot see and interact with the real world anymore. On the other hand, AR allows the user to see the real world with the virtual objects 'placed' in it. In short: "AR can be thought of as the 'middle ground' between VE (completely synthetic) and telepresence (completely real)".

For virtual AR at least any type of sensor is required, a camera or laser for example. Furthermore a computer and a display to display the virtual objects. This can be a computer screen (LCD), a window or see-through glasses.

#### Current use of AR in vehicles

There are two types of augmented reality currently in development or in use. One of these types is displaying critical information. Critical (or less critical but distracting) information is in most cars visible on different places. Looking at the speedometer and navigation for instance distracts the driver and is a moment where the driver is not looking what happens in front of him. With the help of augmented reality this critical information can be seen while looking at the road ahead. As for inattention, perceptual errors and decision errors can be reduced with the help of augmented reality [Lincoln et al., 2010]. Some examples are microvision\(^5\) displaying for instance speed and navigation information (see figure 1.2) or the Opel insignia, with the 'Opel eye' which recognizes road signs and displays it.

![Figure 1.2: Microvision](image_url)

The other type can be seen as an extension of the drivers view. General Motors is experimenting with a system where the side of the road is displayed on the windshield\(^6\). The use of this system might reduce the number of single vehicle accidents in darkness or foggy weather.

Pedestrian recognition is another example. BMW has a system where infrared cameras detect humans and displays a warning sign and the thermal images on a LCD screen\(^7\) (see figure 1.4).

#### Advantages and disadvantages of these systems

The possibility to 'keep your eye on the road' is one reason why a system (like Microvision) displaying the current speed and other information on the windshield can reduce traffic accidents. The traffic sign detection displays the traffic sign on the dashboard. This might result in distraction where the driver looks at his dashboard even more. However, accidents due to speed can be reduced this way.

The augmented reality system as can be seen in figure 1.3 has its advantages and disadvantages too. One advantage is better visibility of the road, especially in dark and foggy conditions. A disadvantage is the perception error which occurs when the system does not track the movement of the drivers head resulting in a misplaced object (e.g. line) and can be even more dangerous than driving without the system.

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\(^5\)http://www.microvision.com/vehicle_displays/
\(^6\)http://www.wired.com/autopia/2010/03/gm-next-gen-heads-up-display/
\(^7\)http://www.bmwblog.com/2008/06/05/improved-night-vision-for-next-2009-bmw-7-series/
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The pedestrian recognition can reduce the number of pedestrian fatalities by warning the driver. The consequence of this system is an increase in distraction for the driver. Looking at a warning on the LCD screen means the driver is not looking at the road in front of the car anymore. And the other way round, if the driver looks at the road critical information on the LCD might be missed.

General disadvantages

The offset hypothesis predicts that users of new safety precautions will become more reckless [Winston et al., 2006]. Users of a system projecting thermal images in foggy conditions might drive faster than those without this system. This might be a prediction and therefore not be the case in this particular situation but it can be an negative consequence.

Users of such systems might rely on a system too much. There can always be a situation where a system fails. If a driver does not has his attention to the other traffic anymore because he thinks he will be warned when he has to take action, he might have a problem when a system fails.

Another disadvantage is the information displayed. Too much information can distract or blind the drivers view and can cause serious danger (see figure 1.5).

1.4 Conclusion

Most of the accidents are caused by errors of the driver especially distraction, perceptual errors and decision errors.

8http://www.wired.com/culture/culturereviews/magazine/16-01/found
Figure 1.5: Too much information

The augmented reality already used in cars is primarily displaying information on the wind-
screen or an extension of the drivers view on an LCD screen or dashboard. There is no data
whether these systems reduces the number of accidents. 'The offset hypothesis' predicts that such
systems might even result in more reckless driving.

Instead of displaying the information on the windscreen or a LCD-screen, a head mounted
display might be a possible solution to tackle the perception error and the distraction of the
LCD-screen.

Some other interesting systems might be:

- one displaying the distance between the cars to prevent tailgating. Colors can be used to
  warn the driver being to close;

- one displaying the movement or speed of a car in front. For instance an arrow when a car
  indicates a turn or a note of exclamation above a car with emergency lights on.

1.5 References

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