Improving Augmented Reality in Driving

Research Report

Venkatesh Boddapati
P.No. 9306099053
vebo15@student.bth.se

Akash Varma Manthena
P.No. 9211199592
akmb15@student.bth.se

I. Group Members' Participation

The group members participated in idea creation and in report writing with the following amount of involvement.

Group Member	Idea Creation	Report Writing
Venkatesh Boddapati	70 %	70%
Akash Varma Manthena	30 %	30%

***Abstract*—Augmented Reality is an emerging technology that has made its foray into the driving assistance systems. In this paper we try to find a viable solution to the problems of cluttering and occlusion. In order to do so we use both qualitative and quantitative research methods. The result is a novel algorithm that effectively prevents occlusion and cluttering on the AR display. A lot of development in this technology can be expected in the near future.**

Keywords: ***augmented reality, driving safety, human vehicle interaction, head up display, head mounted display.***

II. Introduction

Augmented Reality deals with the augmentation i.e. supplementing the view of our surroundings with that of synthesized data. In the context of driving this synthesized data can be real time information of the car (e.g. speed, navigational information, vehicle alerts, locality references, etc.). At present most of the work in this field is being directed at improving the recognition and differentiation between the people, ground objects, other vehicles [4],[5],[8] or the calibration of the camera and virtual depth of projection [2],[9],[10]. Fitch et al.[1] gives a valuable insight into the technology and the different concepts related to its use, namely the types of information that can be displayed, the types of displays, the ways of integrating information from different sources onto a single output.

The problem when implementing this technology in practical application is mainly related to the distraction factor. In other words the driver can get distracted from the primary task of driving carefully while using the AR application. While the Heads up display ensures that the driver need not look down at any other device the limited resource, concentration, may get under strain for requirement of taking in the information or understanding it. This need for increased concentration is a direct result of cluttering (too much information on the display) and occlusion (the displayed information blocks the view of the road ahead). These terms will be explained in detail later. In order to standardize the implementation of the technology worldwide it is of vital importance that this problem of distraction be researched on.

Hence the objective of our research is to find solutions to the above problem. We have explicitly focused on the problems of cluttering and occlusion. Our research questions are also along the same lines. As a result of this research we will obtain a new algorithm that filters the information to be displayed and consequently diffuse cluttering and occlusion.

A combination of qualitative and quantitative methods are used in our study. The preliminary algorithm is deduced from qualitative analysis of existing works. The experiment conducted to test the algorithm measures its efficiency and accuracy.

As a whole this paper contributes by filling the important gap in the development of this technology which, to our knowledge, hasn't been worked on yet.

The remaining of the paper is structured in the following way: Section 3 deals with the background knowledge that gives the reader an insight into this technology. Section 4 deals with the research questions and their motivations. Section 5 deals with the process of our research. Section 6 deals with the interpretation of the results. Section 7 deals with the discussion of our contributions and the threats to our work. Section 8 summarizes our work and extrapolates on the future opportunities.

III. Background and Motivation

Augmented Reality is a visual phenomenon where the real world, as we see it, is overlapped with visual information from a computer. The SLR which was conducted initially revealed rapid progress in this technology, with quite a few consumer applications already present. The working of an

augmented reality system with respect to driving can be best described as follows:

The real world objects around the car are tracked and recognized. Then the information about them will be displayed to the driver. The objects can be road signs, business establishments, other vehicles or any obstacles. The information that can be displayed about these objects can be visually enhanced images, warnings or their description. This concept involves computer vision, image processing, etc. as mentioned in [1],[3],[5],[6].

Another facet would be to display the information about the vehicle like speed, condition of the mechanical parts, etc. and navigation based display like the route to be taken, etc.[1]

Our focus is on improving the way this information is displayed. The type of display can be a head mounted display (HMD) (worn by the driver), windshield based (head up display- HUD) or an auxiliary screen on the dashboard. The most important problem would be the display of too much information and the consequent inconvenience caused to the user in terms of distraction or plain loss of visibility.

Earlier in this paper we mentioned cluttering and occlusion as the problems:

Cluttering refers to the phenomenon where too much information is shown to the user on the display. Due to this the driver will either be come distracted by unnecessary information resulting in the lowering of the concentration on the primary task of driving the vehicle or the various elements on the display can overlap with each other resulting in the reduction in the inability of the driver to understand the necessary information.

Occlusion is the situation where the information displayed on the HUD or HMD inadvertently obstructs the view of the real world in a dangerous way, for example blocking the view of the road ahead. Daytime and nighttime brightness levels of the display also play a major role in the occlusion principle.

Another issue is the depth of display. The displayed information is closer to the driver's eyes than the real world objects in front of the car. This results in the driver having to repeatedly shift the focus between the screen elements and the road ahead [1].

Another important issue mentioned by Fitch et al [1] is the color scheme. The color of the displayed elements should be such that the elements are clearly distinguishable against the background consisting of the real world.

IV. Research Definition and Plan

A. Aims and Objectives

The aim of our thesis project is to find solutions to the problems of cluttering and occlusion as explained above.

To realize our aim we have set the following objectives:

- Establish the procedures to identify the most relevant or crucial information to be displayed on the AR system. Deals with the cluttering problem.
- Develop a new algorithm to determine optimal positioning of information so as to avoid occlusion.
- Test the solutions by conducting experiments with a sample population and validate them.

Our ultimate aim is to make sure that the problems mentioned above are adequately addressed and make a contribution to the existing knowledge.

B. Research Question

Our research question in the initial stages was "How to Improve the Implementation of Augmented Reality in Driving". We had decided to deal with this wide question since there was so little work done in this area and catering to more than one problem in the same thesis seemed the proper way.

We formed the research questions with their respective motivations:

RQ1- How to reduce occlusion?

Motivation: The primary task of a driver is to maintain the focus on the road ahead in general and also to look out for any dangers in particular. There is a tremendous importance to the visual input for a driver which must not be compromised with any rate. Since occlusion is the principle of blocking the view of the world that can be seen through the transparent display by placing the information in such an obstructive manner, we decided that the solution to this problem would be the most helpful for the community.

RQ2- How to eliminate cluttering of the display with too much information?

Motivation: When a driver is supposed to concentrate on the primary task of driving, he/she cannot sacrifice the concentration in order to process the information presented

on the screen unless there is a definite benefit in doing so. But cluttering, where the whole display is covered with too much information, makes it difficult for the driver to at least look out for the information that he/she needs the most. Hence in order to reduce such a risk to the driver the problem of cluttering must be dealt with at once.

C. Research Method

We use a combination of empirical and qualitative methods in determining the various solutions to the questions.

Motivation for choosing qualitative method: The research questions that we formulated deal extensively with the discovery or development of the unknown. The most important concepts of implementations have been in explained by Fitch et al [1], Lin et al [3] and Kim et al [4].

They have also extrapolated on the future developments which can be worked on after further advancements are made in technology. We can hence obtain enough information to form theoretical solutions from these works by conducting qualitative analyses on the state of the art.

Motivation for choosing Quantitative method: The inputs that we obtained from the survey are combined with the new algorithms developed in the qualitative analysis and then we conduct an experiment. In the experiment, the users participate in a simulation wherein they drive a car down the street and the information is filtered through the new algorithms and displayed on the HUD. We then record the responses from the participants to questions that will be centered on the feedback format. The questions will be regarding how effective the users found the new display algorithms. We can then calculate the success rate of the algorithms to get a better understanding of the repercussions.

D. Units of Analysis

In the qualitative analysis stage we have extensively processed the various studies regarding the display of the information.

The experiment was conducted with a small group of 20 people. The sampling of participants was done in such a way so as to include persons from the following categories:

- Professional drivers (those who drove for a living)
- Frequent drivers
- Infrequent drivers

We took care to include equal number of male and female participants from each category.

E. Data Collection

In the qualitative analysis stage we created data extraction forms that when applied to the related articles gave an insight into what kind of information is available with those articles. This information helped us to develop a new algorithm.

In the experiment stage we recorded the gaze pattern of the participants which was mapped afterwards in order to see whether the occlusion and cluttering phenomena have occurred or not and how many times have they occurred.

F. Data Analysis

The data from the extraction forms in the qualitative analysis stage ought to give us a brief understanding of what type of knowledge can be gained from which type of articles. We can then easily go through the articles and decide what steps need to take for developing the new algorithm that is required by us.

The experiment stage will record the basic data regarding the eye gaze pattern and the feedback from the users as well. The feedback questions will be regarding any thoughts of the participants on how well they found the experience to be. The data regarding the comfort levels will also be mapped to statistics in order to make it easy to fathom the extent of usability. The feedback information is mainly helpful for us to improve our research methods in the future.

V. RESEARCH OPERATION

A. Operation

The entire process of our research operation can be viewed as a flow chart below:

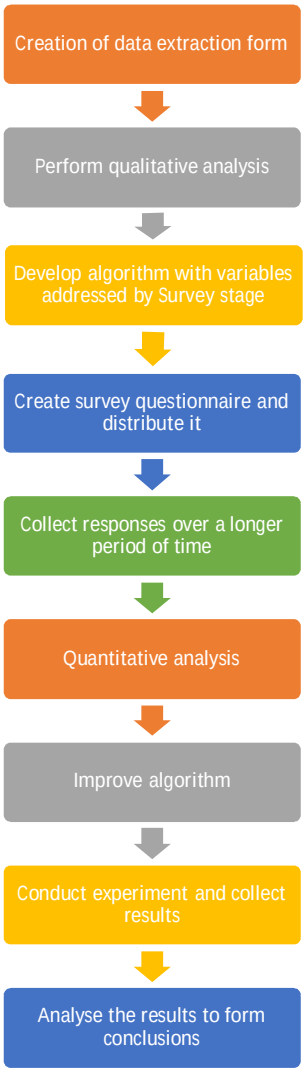

Figure 1: Flow chart depicting our research process

B. Quality Assurance

In order to maintain the quality of our research we need to be careful about how we go about collecting and verifying data. The following steps can be taken as a measure:

1) The online questionnaire was distributed in scientific forums and also actively academic forums so that professionals and the educated individuals can answer our questions.

2) The individuals who answered the questionnaire must state their profession and contact information. This may help us in deciding which responses are more suitable to be included in our research.

3) The duplicate and deliberately given inappropriate responses were excluded to maintain integrity and quality of the study.

4) The questions in the questionnaire were annotated with brief descriptions and links regarding our work were available to the responders so that they could make informed choices.

5) The most important part of this survey is that even a daily commuter should be able to answer the questions. Hence based on the profession of the responders the questions will change in terms of complexity. Such responses were also considered but in a different class from the educated responses.

VI. Data Analysis and Interpretation

In the qualitative analysis stage we read through several articles that explained the process of determining the AR information. Kim et al.[4] proposed a system where the AR elements related to navigation would be processed and the relevant information would be sent to the display engine. Kim et al.[8] proposed a system similar to above but with processing of AR elements related to forward collision warning.

Both of the above systems would provide the input for our algorithm that determines what to display or how much information to display and in what way to display the information on the HUD. The output of this algorithm is sent to the display engine which can then show the AR elements in the desired way.

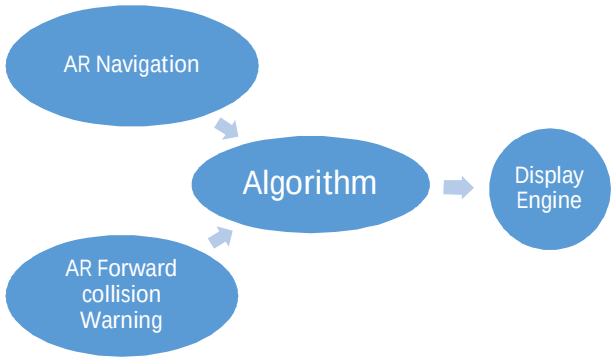

Figure 2: proposed system with the new algorithm

A. Algorithm

The algorithm is best represented in the following flowchart:

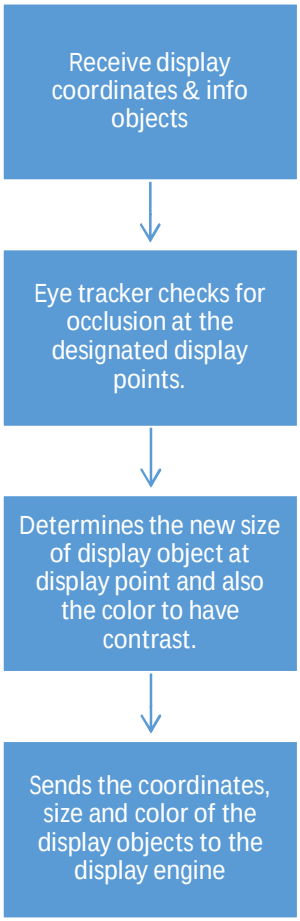

Figure 3: Proposed algorithm

B. *Answers*

The answer to both our questions was to develop a new algorithm that can determine the size and color of the display elements so that the elements don't appear cluttered or block the view of any real objects.

C. *Experiment Results*

Only 20% of the participants reported any cases of cluttering. But 33% said that occlusion still occurred.

VII. DISCUSSION

A. *Contributions*

To our knowledge there haven't been any studies that speculate on the solutions for the problems of cluttering and occlusion. What we have achieved in our research is a novel algorithm that takes the input from the two Augmented Reality systems proposed in [4] and [8] and consequently determines the location and size of the AR elements. The opinions of the survey responders greatly increases the efficiency and accuracy of our algorithm.

B. *Threats to validity*

Since the findings in our research are largely based on the opinions of the consumers in the simulation tests, there is a certain risk that the findings are not completely accurate

The main threats to our study are:

1. The input from people on the survey may not be entirely accurate due to smaller sample population. This can be overcome by conducting special interviews with experts in the field.

2. The final solutions are not generalizable due to fact that not all people want the same thing. This can be overcome by coming up with option of customizing the solution to the users' needs.

3. As very less work has been done in this particular field, our findings may not be the ultimate solutions as there is always scope for betterment. This risk is mitigated if we update our research in accordance to the new findings.

4. Since the technology is still in an initial stage, a lot of newer knowledge may have yet been unpublished and as a consequence our research may become obsolete.

C. *Limitations*

Augmented reality is a hot topic now and any findings done by us have a chance of getting outdated. Our only chance to not let that happen is to be continually aware of the most recent advances in this field, whether published or otherwise.

Though stringent criteria for inclusion and exclusion of studies were established, it may be possible that some papers were selected due to reviewer's bias. Similarly, the case with the studies that were left out.

The survey responses also pose a limitation where the mischievous respondents may deliberately pose as a professional and mislead or research.

VIII. Summary and Conclusions

In the implementation of Augmented Reality in the context of driving the most important problems are that of cluttering the screen with too much information and the chances that the real world objects are blocked by the elements shown on the screen. Our objective was to find a suitable solution mitigate those problems. So we developed a new algorithm that that makes modifications to the information to be displayed on the screen in such a way that cluttering and occlusion are avoided.

The algorithm is greatly improved by the opinions of the survey respondents. Most of the respondents opted for the display of warning information regardless of the chances of occlusion since the object of interest in the warning would be obviously closer than the occluded object.

The future work in this field must be the development of projection technology that can display the information about an outside object at its depth of vision. This can greatly help in reduction of cluttering and practically avoid occlusion.

References

[1] Fitch, G.M.; Hyungil Kim "Behind the Glass: Driver Challenges and Opportunities for AR Automotive Application" *Proceedings of the IEEE*, v 102, n 2, p 124-36, Feb. 2014

[2] Wuest, H.; Rojtberg, P.; Fellner, D." A Camera-Based Calibration for Automotive Augmented Reality Head-Up-Displays" *2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, p 189-97, Oct. 2013

[3] Cheng-Min Lin; Chyi-Ren Dow; Cheng-Qian Wang "Design and Implement Augmented Reality for Supporting Driving Visual Guidance" *Proceedings of the 2011 2nd International Conference on Innovations in Bio-Inspired Computing and Applications (IBICA 2011)*, p 316-19, 2011

[4] Kyongho Kim; SeungHae Baek; Soon-Yong Park "Development of Augmented In-Vehicle Navigation System for Head-Up Display" *2014 International Conference on Information and Communication Technology Convergence (ICTC)*, p 601-2, 2014

[5] Min Woo Park; Kwang Hee Won; Kyong-Ho Kim; Soon Ki Jung" In-Vehicle AR-HUD System to Provide Driving-Safety Information" *ETRI Journal*, v 35, n 6, p 1038-47, Dec. 2013

[6] Gasper, J.; Seong-Whan Kim *2013 IEEE "Effects of an In-Car Augmented Reality System on Improving Safety of Younger and Older Drivers" International Symposium on Mixed and Augmented Reality(ISMAR)*, p 59-66, Oct. 2013

[7] Goncalves, J.; Rossetti, R.J.F.; Oliveira, E.C.; Olaverri-Monreal, C. "Forward Collision Warning Systems Using Heads-Up Displays: Testing Usability of Two New Metaphors" *2013 IEEE Intelligent Vehicles Symposium Workshops (IV Workshops)*, p 1-6, 2013

[8] Kyongho Kim; Hye Sun Park; Min Woo Park; Soon Ki Jung "Development of Augmented Forward Collision Warning System for Head-Up Display" *2014 IEEE 17th International Conference on Intelligent Transportation Systems (ITSC)*, p 2277-9, 2014

[9] Ng-Thow-Hing, V." Generation of Virtual Display Surfaces for In-vehicle Contextual Augmented Reality" *2012 IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2012)*, p 317-18, 2012

[10] Bark, K.; Beckwith, L.; Cuong Tran; Bhandari, R.; Sridhar, S." User-Centered Perspectives for Automotive Augmented Reality" *2013 IEEE International Symposium on Mixed and Augmented Reality - Arts, Media and Humanities (ISMAR-AMH)*, p 13-22, 2013

[11] Gomes, P.; Kruger Silveria, M.; Vieira, F. **"**Augmented Reality Driving Supported by Vehicular Ad Hoc Networking**"** *2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, p 253-4, Oct. 2013

[12] Felix Lauber; Andreas Butz, " Are HMDs the Better HUDs", 2013 IEEE International Symposium on *Mixed and Augmented Reality (ISMAR),DOI:*10.1109/ISMAR.2013.6671798 *Publication Year: 2013* , Page(s): 267 - 268