Optimization Analysis of AR-HUD Technology Application in Automobile Industry

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Abstract. Currently, how to make the driving system safer and more intelligent has been a heated topic. To achieve the goal, quite a few companies argued about introducing HUD technology, which was originally used in aircraft, to the automobile industry. In order to make HUD have better performance in the new area, the public's attention was paid on the combination of AR and HUD technology. AR-HUD is seen as a good way to improve the convenience and safety factor of driving. This article introduces the usage of AR-HUD in the traffic analysis, man-machine interactive, intelligent navigation and aided driving. Moreover, SWOT method was introduced to this new area, to find out the prospect of AR-HUD application. It is found that although AR-HUD is technology is still relatively immature up to now, it has the power to have broad application space in the future. AR-HUD's time is around the corner.

1. Introduction
Head up display (HUD) was originally applied in the aviation industry to make the pilot more convenient to watch the instrument parameters, and later was considered applying to the automobiles. The application of HUD technology offer convenience for the drivers of the vehicles by enabling them to see the automobile instruments and driving conditions without bowing their heads, which improves the safety factor of driving. Subsequently with the combination of augmented reality (AR) and HUD Technology, the usability of HUD in the automobile industry has been largely enhanced.
In this essay, the feasibility of AR-HUD application will be talked. It is believed that AR-HUD technology can implement the traffic analysis, man-machine interactive, intelligent navigation and so on. In the driverless era, HUD technology can also assist drivers in driving assistance. According to these uses, we want to find that whether AR-HUD has the power to gain large-scale using in the automobile industry. So next, SWOT analysis will be firstly introduced to this area, used to search the prospect of applying AR-HUD in cars. Finally, there will be discussion of the promotion of AR-HUD technology to the automobile industry, and have a conclusion of the article.

2. Background
Head up display (HUD) was originally used in aircraft, which is a good method to let the pilot see the essential flight parameters and driving instruments when looking ahead. Thereafter in order to reduce the driver's visual distraction, automobile manufacturers began to consider the application of HUD to vehicles. In 1998, Ford Motor Company applied HUD on "Oldsmobile" model "Super Short Sword", which is believed to be the first application of HUD technology in the automobile industry [1]. Nowadays, with the development of 5G, high speed and low delay communication has become feasible. What follows is the rapid development of Internet of things (IoT) and augmented reality
technology (AR) technology. In that case, AR and HUD are combined to form AR-HUD. The combination of AR and HUD can directly project the identified driving safety warning information onto the windscreen, and integrate it with the actual road conditions. It can not only improve the driving experience, but also reduce the hazard coefficient of noticing some necessary information when driving. Because of its characteristics of combination of virtual and reality, and real-time interaction, AR-HUD will provide assisted driving (for future vehicles), vehicle entertainment and navigation for automobile driving [2].

3. Application Scenario

Here is the detailed introduction of the application scenario AR-HUD. AR-HUD has two projected surfaces distinguished by different projection distances, which is near projection and Distant projection [3]. Near projection (also known as state projection) appears at the end of the hood in front of the driver. It is often used to free drivers from looking down for information, which can make the drivers and passengers safer. While distant projection (also known as enhanced projection) provides vehicles with entertainment and navigation. It is also believed that AR-HUD can assist drivers in driving assistance when driverless age comes. The application of AR-HUD can be listed as follows.

3.1. Display Vehicle Driving Information

Displaying driving related information, including vehicle speed, remaining fuel, vehicle status and other crucial information that originally showed on the instrument cluster is one of the functions of HUD.

![Figure 1. AR-HUD used for displaying vehicle driving information.](source)

Source: Z.C. Cao and L. Dai, Application of HUD on Automobile and Domestic and International Developments

3.2. Display Road Condition and Traffic Information

HUD helps to display road information during driving, prompt driver's lane, no parking place [4], one-way road and other information just as figure 2 shows.

3.3. Display Navigation Information

HUD can display the navigation route and the congestion road reminders, etc. This condition shows in figure 3.
3.4. Provide A New Way for Entertainment
When the vehicle is stopped, AR-HUD can provide the driver with services such as video calls, music or video play [5], just as figure 4 shows. Of course, all the entertainment functions start after the driver has stopped and located in a safe and compliant area.

3.5. Provide Driving Assistance
Driverless technology can be roughly divided into four stages: Driver assistance, semi-automatic driving, highly automatic driving and fully automatic driving [6]. In the first three stages, AR-HUD technology can be used to assist the driver in driving assistance by means of information prompts, etc. This can be seen in figure 5.
4. Method and Results
In the above, it can be seen that HUD have the ability to be applied in a variety of scenarios. Next, a deep analysis of the feasibility of the AR-HUD application in the automobile industry will be given. To show the direct and prospect of this technology, a method that is new for this area, SWOT was introduced to make a further analysis. SWOT method is often used in management, like enterprise management. This time, it was introduced to analysis the feasibility of AR-HUD, as it can help to make a comprehensive analysis of both the internal conditions and external environment.

4.1. Strength
Compared with the existing car dashboard, AR-HUD has an obvious advantage in the area of ensuring driving safety, because of its reduction of the number of times that drivers bow their heads. What’s more precious is that the combining of navigation system and AR-HUD also benefits to the improvement of safety factor and makes the driver get better experiences.

Besides, AR-HUD also provides users with an effective way to strengthen the interaction between humankind and vehicles. The control screen in AR-HUD system can be applied to control driving behaviours, apply various functions of the car, and realize in-car entertainment.

4.2. Weakness
Then, the weakness of AR-HUD technology needs to be considered.
First, as an emerging technology, AR-HUD will have relatively high cost. At present, HUD used in vehicle products with relatively good quality on the market usually needs more than ¥10000. This may stop some drivers from using it.
Second, today's imaging technology is still greatly influenced by light and temperature. That means that in different situations, AR-HUD may act differently. In some cases, the imaging clarity of HUD may not be good enough.
Third, AR development is still immature. Sometimes the realization of human-vehicle interaction may not be ideal.

4.3. Opportunity
As the development of AR, HUD has new possibilities. According to the data from BI Intelligence, the augmented reality market will reach 120 billion US dollars by 2020, more than 10 times that of 2017. Moreover, 3D-HUD also has some further development. It has been regarded as the most advantage HUD technology [7], and can provide better experiences for the drivers to use HUD.
What’s more, since driverless car has drawn people's attention, the combination of driverless system and AR-HUD technology can also be considered.

4.4. Threats
At present, apart from the professional field, non-professionals still pay less attention to HUD Technology. The research and development of HUD technology are still limited to just a few
companies and vehicle types, and large-scale application still can’t be seen up to now. Figure 6 also shows this situation.

![Figure 6. ‘Proportion of different types of HUD equipment’.](image)

Source: T. Qi, L.Q. Shao, "development status and trend analysis of vehicle HUD"

5. Discussion
After using SWOT method to analyse the feasibility of AR-HUD, both the internal conditions and external environment are shown. It not only includes the current development of this technology, but also shows the future development trend. It helps us to find out the factors that are beneficial to us and worth promoting, as well as the things that are unattractive to us and should be avoided, find out the existing problems, find out the solutions, and make clear the future development direction. After analysis, the sustainability and development direction of AR-HUD in the automotive industry are clearer.

6. Conclusion
Above all, although AR-HUD is technology are still in the development phase, it is believed to have broad application in the future. Just as Doctor C. Merenda (2018) said, AR-HUD “will be widely implemented over the next decade” [8]. Since the technology of 5G and Artificial Intelligent are hot topics, as well as the development of intelligent automobile attracting mounting number of enterprises and people, AR-HUD can be seen as a technology in the front edge and has huge prospect. As mentioned before, AR-HUD also improves the safety, intelligence and comfort level of the vehicles. Maybe just the near future can see the usage of AR-HUD to help us with the driving behaviours.

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