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RESEARCH ARTICLE

Implementation of flexible and customizable free-from mirror heads-up display

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Abstract

To implement a supreme interactive medium using the Free from mirror Technologies to improve the user experience and try to create a customizable Heads-up display in the cockpit so that the user can well optimize the digital indicators and Navigation to a certain control and constraints. A free from mirror arrangement can help the driver during driving without any disturbance in viewing and doesn't require a separate reflector arrangement for projection to be projected. Due to this the setup can be cost effective. For the customization part of the HUD, we can directly use the touchscreen infotainment system or even the digital instrument cluster to customize the HUD layout. Therefore, the factors to consider during the HUD setup and an idea to provide customization to the HUD by the infotainment system is discussed in this paper.

Keywords: Heads-Up Displays (HUD), Projection, Dashboard, Automobiles.

Introduction

The road viewpoint is right in front of the driver's line of sight; hence a car's driver's cluster is typically mounted closer to the driver's view. The car driver prefers to shift his line of vision to comprehend both the dashboard and the traffic situation. Regular dashboards are finding it difficult to convey the enormous and continuously growing number of infographics to the driver nowadays. It prevents the driver of the vehicle from having to concentrate on a convoluted instrument cluster and lessens the chance of cognitive overload, which can result in accidents (Santos et al., (2017). The current paper is mainly planned at a certain type of windshield surface to project the panel in a free-from mirror Heads-Up Display (HUD) format.

A detailed review of the HUD and free-form Mirror technologies was done and exhibited a new character to the Customizable Information cluster in the Heads-Up Display. The main aim is to reduce the Instances where the user has to change line sight while driving, which is considered dangerous (Ng-Thow-Hing et al., 2013). Therefore, offering an Interactive HUD can improvise the User experience and the free-from mirror HUD technology helps us to Project the Cluster directly to the windshield which is in the line of sight. It also considers safety factors and must be designed in such a way that it doesn't disturb the view of the road.

Heads up Displays

HUD are the technology that is designed to reduce the disturbance to the drivers during operation. Driving requires an immense level of concentration and also requires attention from the driver for multiple things simultaneously. Therefore, creating a comfortable environment for the driver to reduce accidents is very important. One such important factor to consider is the line of sight and the field of view for the driver during driving. Line of sight and the field of view are considered to be a very important factors because they help the driver in terms of vision and better line of sight lower the chances of disturbances (Liu & Seipel, 2018).

But the problem with modern automobiles and the conventional way of having the instrument cluster below the line of sight for driving requires the driver to divert his vision to have a glance at the cluster. This deviation to have a visual of the cluster at a longer span can create a problem both by driving comfort and creating an uncomfortable situation or even driver fatigue (Ge et al., 2016). To avoid this

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deviation from the line of sight and provide the freedom to the driver to look at the cluster based on the requirement, Head's Up displays are being developed and employed in the automotive industries. HUD is an electronic device that is used to protect the instrument cluster information to a place within the line of sight of the driver. Therefore, the driver won't need to change his line of sight during driving (Kress & Starner, 2013).

Anatomy and types of hud

HUDs are mainly used to display information to the driver in the required area. Therefore, there are many types of HUDs used in the automotive sector.

Classifications of the HUD are explained as follows:

Based on the structural design

Combiner Glass HUD

This type of display Uses a reflective type of screen to project the digital information. Usually, this reflective surface is either made of glass or higher quality (in terms of strength and opacity) plastic composites. They contain a projector that can project information onto this surface therefore, a floating transparent cluster is made in the field of view of the driver.

Windshield (Or) Free From Mirror HUD

This type of heads-up display is very similar to that of the former type. But the only difference is the absence of a reflective surface. This type of projector is calibrated or collimated to project the information directly to the vehicle windshield. This reduces the space requirements and has a greater position in the field of view of drivers.

Based on the position of the projector

Over-Head Projector Type

In this type of projection, the projector is placed over the driver's head or front of the sunshade. It is then collimated to the area of projection and according to scaling.

Rearview Mirror Projector Type

In this type of projection, the projector is placed behind the rearview mirror and thus collimated to the area of projection. One demerit of this type is that the projection angle is very complicated and it is an area prone to higher external interference.

Dashboard Projector Type

In this type, the projector is placed just adjacent to the instrument cluster facing the windshield or the reflective surface. Off all the types mentioned above, the over-head and the dashboard, projectors are the most frequently used designs because of their merits such as ease to design and place, cost-efficient and other factors provided by them Figure 2.

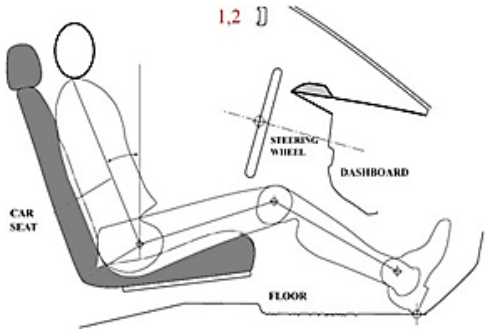

Figure 1: Overhead (1) and (2) Rearview mirror type projector

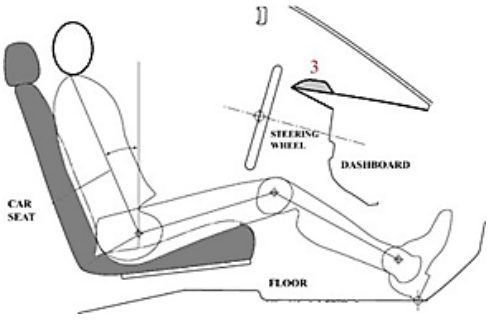

Figure 2: Dashboard type projector (3)

Free From Mirror Dashboard HUD

Free from mirror HUD are proven to be far more effective, efficient and better in terms of characteristics when compared with the other. Placing them in the dashboard eventually increases the user experience and provides freedom to customize them on the requirement (An et al., 2021). Significant merit to be considered in this type of HUD is the freedom it provides on

placing the projector eventually increases the option to adjust them on driver requirement and also alter the area it will project in the windshield.

Due to the absence of a requirement of a reflective surface user gets a large area to place the projection to his/her own will. Multiple factors such as driver height, the field of view, and environmental conditions can all be satisfied with the flexibility it provides. Therefore, this type of HUD is selected for experimentation.

Design parameters to consider

Some of the main design considerations for constructing optimized and user-friendly HUDs are as follows:

Position of Projector

One of the important factors to consider while designing the system is the projector's placement. Because they define the degree up to which the HUD can be user-friendly or customizable. Also, they decide the interference in the driver's field of view. A greater field of view with minimum interference is accepted as the best practice.

Collimation

Collimation refers to the projection quality as how well-defined and parallel the rays are to each other. This is important because they protect the information and decide how well the image is projected. They also determine how the projection feels. If the rays are said to be projected with rays not paralleled then it appears to be a very different unit than the environment, which requires separate effort such as refocusing to read them. If projected perfectly, the projection won't feel separate and feels like overlaying on the environment.

Visible Projection

Another important factor is the outbox projection. The projection of information in an outbox region will not be pleasant or will not be visible to the driver if the line of sight is altered or the neck is rotated. If there is a disturbance in the equilibrium, the projection becomes invisible to the driver.

Sizing

It is also important to govern the sizing or scaling of the elements in the HUD. Having an improperly scaled element in the projection will distract or make it hard for the driver to read the cluster information. Therefore, it must be important to have the ratio between the projection box and scaling compromised.

Transparency

The last and the important factor is the luminance or the contrast of the information displayed. Having a low luminance or very higher contrast is going to be a disturbance and not provide a pleasant experience (Xiaofeng & Yeinping, 2017).

Having a good luminance between day and night along with a suitable contrast, will eventually improvise the experience and will not be disturbing to the driver.

Position of Hud Projector

In this free from mirror type of HUD, the projector placement is decided to be between the steering wheel and windshield refer Figure 3.

This provides

- Better space for projector placement
- Area prone for very little exterior interference
- Not disturbing the driver's field of view
- Close to instrument cluster electronics, therefore, integrating it will be easier
- Provides the freedom to adjustment
- Easily accessible to the driver

The projector's position is an important factor because it will determine how well the projection of the image will be and how much freedom it provides us for customization. Placing the projector in the dashboard behind the instrument cluster facing the windshield is the best idea; the merits are mentioned above to support the idea. Therefore, it is best to place them to create a flexible system.

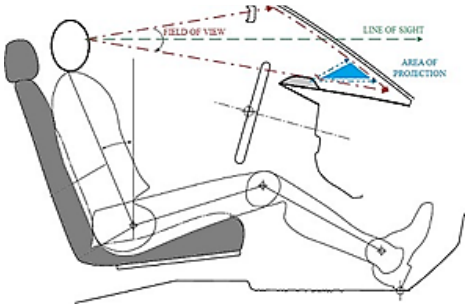

Figure 3: Viewing areas of the driver

The two main important aspects now to provide is as follows:

To Determine the Amount of Flexibility it Provides the User of Various Seating Heights:

Since, not all users of the same kind we need to make sure that it is a flexible system. This can be done by mounting the projector that can project with a tilt of about 10 – 15 degrees both horizontally and vertically. Therefore, with the projector as a hook point, the projection can be adjusted according to the driver's height

To Provide a User-Friendly Interactive Interface:

To implement this type of technology we need a more powerful microcontroller. But that being said, the Engine Management system utilizes the ECU and therefore, an additional micro controller or microprocessor is suggested for infotainment. Controllers such as Infineon tri-core Microcontroller, Atmel AVR Microcontroller, Renesas Microcontroller, 8051 Microcontrollers are suggested.

Heads up Display user Interface

The heads-up display interface is said to be an important factor in deciding how the driver feels and how comfortable he is with the system. As said before the characteristics of the HUD is important. In order to have a system that only aids the driver and not disturbs him must fulfil the following conditions:

It Must be Near to the Line of Sight and Within the Field of View of Driver

- It must be scaled properly (Having a lower scale will make it difficult to see and understand and a larger scale will eventually disturb the driver)
- The illumination and opacity must be precise or adaptive (Having a good amount of illumination which is also opaque can provide a great experience)

These are some of the important things to consider in the design and placement of the HUD. Now the structure of this free from mirror heads up is well defined, and we need to move to the user interface. User interface is the visual and auditory connection between the user (Driver) and the system (Car).

In other words, the user interface will provide various information to the driver or the user and can be a contact

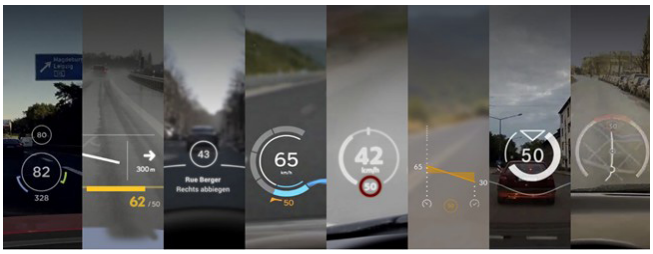

Figure 4: Head's up display user interface

point between the user and the system to collect input from the user. So, it is important to have a well-optimized user interface to provide a pleasant user experience.

Customisable Hud User Interface Providing a User Customizable User Interface Can Actually

improve the user experience and has the capability to satisfy a larger population with a heterogeneous requirement. To have a customizable interface the important thing to know is to know about the information and the format used to display the informations. The Figure 4 shows the Head's up display user interface, figure 5 shows the Numerical information, figure 6 shows the Pictorial information and Figure 7 shows the Abstract graphs.

Now there are some important things to consider here. There is a requirement here to make some of the information as standard because this information's are associated to safety and therefore, must be made as standard information to be displayed. But other things such as the Speedometer, RPM indicator, and Navigation panel can be given the freedom to be customized by the user. This will ultimately result in a situation where the user can have the required details displayed in the way he/she prefers

Another important thing to consider here is the way how this information's are displayed. There are a lot of ways to display these informations. Some of the common ways to present this information's are as follows:

Numerical Information's

Here information utilize numbers to communicate. Details of speed, gear position indicator (in AMT) are displayed in these formats

Pictorial Information's

Here information's are provided in a pictorial format. Navigation, Fuel indicators along with other warning systems utilize this format.

Table 1: Important Things That are Going to be displayed in the windshield

Speedometer along with RPM indicator	*Fuel level indicator*	*Navigation system*
Door and seatbelt warning systems	Indicator reminder	ECU warning systems

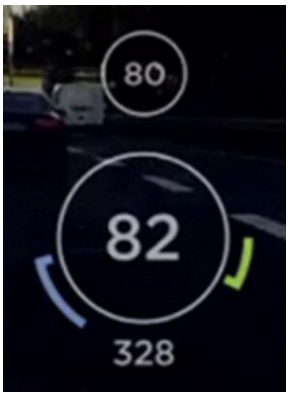

Figure 5: Numerical information

Figure 6: Pictorial information

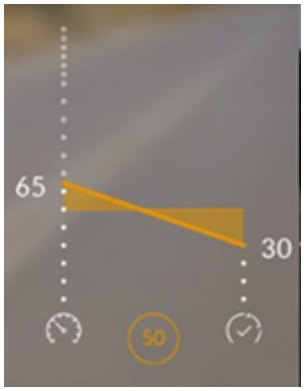

Figure 7: Abstract graphs

Abstract Graphs

This format is used to display information such as driving habits, Fuel economy track, Torque vs power information Therefore, based on the type of information and how the user would like to view that information, we can create an interface that can produce the information in multiple formats. The Table 1 shows the important things that are going to be displayed in the windshield This will help us to create a much more flexible system that provides more variations to the users.

Customizable Hud's

Let us try to explore the versatility of this system, considering a system that as the capacity to adjust according to the input from the user. Let us consider an interface trying to incorporate all the necessary information

In this projection to the windshield, the required information's are displayed according to the default settings.

Figure 8: Experimental HUD projection

Figure 9: Layout change of the HUD (Layout 1)

It has the RPM meter in analog style with the rest in a digital format. It contains all the important check lights on the exterior part and the most important information in the region that is easy to identify. Some of the features that we can provide with the

customization can be in terms of the digital and analog type of clusters, along with color optimization according to the driver's interest. The figure 8 showing the modified HUD. Three type of layout designed which are shown in Figures 9, 10 and 11

- Along with this is the option to place or change the placement of the objects according to user requirements. This is possible because of the availability of touchscreen infotainment systems.
- Due to this touchscreen infotainment system, we can provide the freedom to users to alter the placements within the specified boundaries.

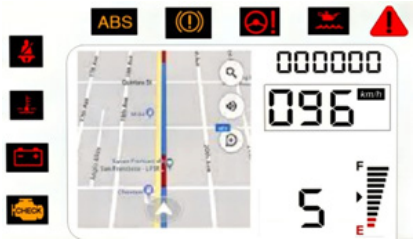

Figure 10: Layout change of the HUD (Layout 2)

Figure 11: Layout change of the HUD (Layout 3)

Figure 12: Experimental setup with Mobile phone as the projector

Figure 13: Reflective film

- All that needs to be adjusted are in the software sector. There will be no need of additional switch or instruments to alter them.

Experimental Setup

The designed interface is projected to the windshield by utilizing the Mobile phone as a heads-up projector shown in Figures 12 and 13 To verify the projection and angles, the mobile phone was used as a projector. It was placed in the dashboard very near to the windshield and the projection were captured:

But the problem with this setup is that the reflection projected

is not clear and appears to have a double image. We can use HUD reflective Films in the Windshield (Wei et al., 2019). It can solve this problem and also does not affect the view of the driver

The In-car heads-up display (HUD) Reflective Film allows you to use your smartphone as a HUD. We can use this film to reflect your smartphone's display, so you can view metrics such as speed, revs, and much more on your windscreen.

Conclusion

The study for constructing a customizable and flexible HUD was done and a simple experimentation was done to verify the study. The results read as follows:

- The study proved to focus on three main things to consider when designing a HUD. The projection of the HUD must be within the field of view and near to the line of sight of the driver.

- The projection must have a well com- promised intensity between the visible opacity and obstruction to view.
- From the experimental study, which utilized a phone as a projector, the projection was flexible to a certain amount (about 15° to 20°)
- Reflective Film can be used to help the driver to have better visibility.

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