Human Centered Automotive Cockpit HMI

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ABSTRACT

An automotive display in the cockpit is an HMI device. It projects useful information for the driver, but it can also causes driver distractions. Driving safety is the most important factor in automobiles, and HMI device design requirements must be met for that purpose. Since automotive displays emit and reflect light, light control technology is important for automotive displays.

1 INTRODUCTION

Evolution of automotive technology makes human life easier and safer. It also provides " Driving Pleasure" through act of driving and "Feel alive" by expanding one's range of activities. So we must not forget to improve the technology to bring our customer these joys to increase the value of automobile.

The former evolution aims at fully automated driving by machines and responds to risks by switching to manual driving when the behaviors of machines go out of control or wrong. On the other hand, the latter aims that driving an automobile makes a driver feel alive, and the machine takes over the operation when the person is not able to drive correctly. This is called human-centered concept.

2 AUTOMOTIVE COCKPIT FUNCTION

Tasks performed by a driver in an automobile cockpit include primary tasks such as run, turn, and stop. Secondary tasks such as operating audio and air conditioners require interface functions. To perform these secondary tasks correctly, interface layout, shape, and functions should be designed considering what you want a driver to do. In other words, "the state of correct driving" should be defined from human-centered point of view.

An interface used for the secondary tasks are generally called HMI and the most important thing for HMI design in the cockpit is "safety". You must not forget that driving an automobile while sitting in the cockpit means that you are driving a body of iron weighing more than 1t when pedestrians are only a few meters away from you and might turn around suddenly. Therefore, it is essential to create an environment where a driver can concentrate on driving while minimizing the secondary tasks performed by a driver. The attractive design and various comfortable and convenient functions of the cockpit are crucial to enhance product quality, but most importantly, the cockpit must be developed by defining design requirements to minimize so-called driver distractions.

3 COCKPIT HMI DESIGN CONCEPT

There are three driver distractions that impede concentration on driving [1]. Visual distraction when "eyes" leave the front road, manual distraction when "hands" leave the steering, and cognitive distraction when "mind" leaves the front road. Since a display is a device that projects contents seen by human eyes, there is a risk of visual distraction depending on its layout. There is a danger of so-called "eye glance". When driving a car, you should pay the most attention to the direction you are going and want to minimize the time you look away from it.

When a display called Center Information Display (CID) can display not only navigation but also various comfortable and convenient applications, the risk of "eye glance" increases. Therefore, it is desirable to locate the display in the upper part of the cockpit to shorten line-of-sight movement time and focus adjustment time (Fig.1). However, in recent years, the CID has increased in size, and it has become difficult to achieve intended designs and packages.

Fig.1 Automotive Cockpit

Vehicle speed, tachometer, fuel consumption and ADAS control information are displayed on the instrument cluster in front of the driver's seat (Fig.2). Since many display devices must be also installed here, full display types are becoming popular. However, generally, the position of the instrument cluster is close to driver's eyes and increases focus adjustment time. As people grow older, their vision becomes blurry. If too much information are placed in this area, it will take time to read or understand.

Fig.2 Instrument Cluster

Head-Up Display (HUD) is a device that reduces the focusing adjustment and distracted driving. The HUD displays information as a virtual image through the front window on the driver side (Fig.3), so there is almost no need to refocus without looking aside. However, it is necessary to design contents and expressions not to disturb the view since the display is always visible and overlapping with the driving environment.

Fig.3 Head-up Display

4 Design requirements of automotive display

The environment in which automobile displays are placed is different from consumer displays such as televisions, personal computers and smartphones.

- Exposed to direct sunlight
- Atmosphere temperature becomes high or low
- Ambient brightness varies greatly with time
- Viewing angle and distance cannot be changed much
- Less flexible in installation location

Despite of the environment, the driver must be able to see the information displayed at any time and the information must be easy to understand. Furthermore, since the display is a part of the interior design, the quality of the display itself and the beauty of the entire device including the housing must meet user expectations. Followings are the three main points to focus on when designing an automotive display device that meets this environmental difference and user expectations.

4.1 Reflection control

Automobiles need to have windows as wide as possible in order for the driver to be aware of the surrounding driving environment, but at the same time, it increases the amount of external light that enters the cockpit. Even if the display is positioned at a location or an angle where sunlight reflection does not reach the driver's eyes, the reflection of the seat or occupant's clothes will still appear on the display (Fig.4). Even if such light is incident on the surface of the display, the reflection can be suppressed by the following methods so that the driver cannot recognize the reflection.

- Interfacial layer refractive index control
- Transmittance control of surface parts

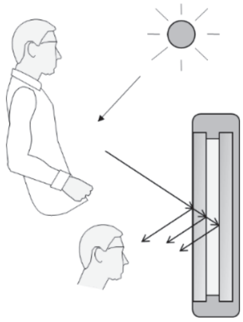

Fig.4 Reflection

4.2 Field angle control

A display such as a home television is required to look beautiful when viewed from top, bottom, left, and right. The car display is similar except for top and bottom (Fig.5). Furthermore, since the projected image and the instrument panel are reflected on the front window at night due to upward and downward light, those must be suppressed.

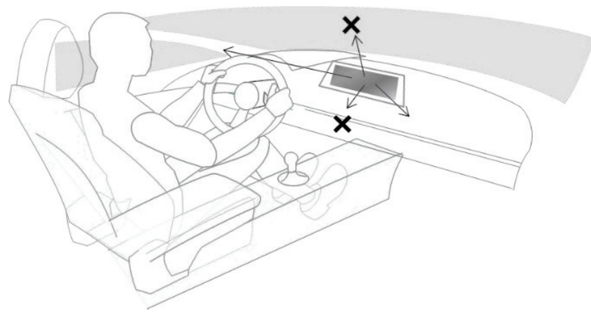

Fig.5 Field angle

4.3 Narrow border

The technology to reduce the space between the projection area of the display and the casing surrounding has been employed in televisions and smartphones. Conventionally, automotive displays were in-dash type, however, since the display is no longer embedded in the dashboard, this narrow border technology is also required for automobiles (Fig.6). In addition to ensure the strength required for automobile parts, simplifying module components such as lens, liquid crystal, backlight, and housing as well as cooperation between suppliers is also important.

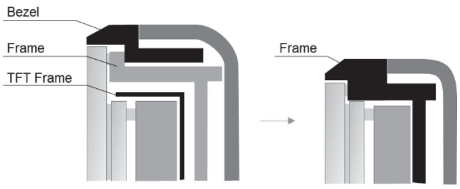

Fig.6 Narrow border structure

5 Future automotive display technology

In general, displays including consumer products offer basic functions such as high display brightness and resolution as well as improved freedom of shape (deformed, curved, etc.), transparency, 3D, and aerial stereoscopy.

In automotive display, similar technologies are being developed for provide product differentiation and to provide a new value assuming level 4 or higher autonomous vehicle will be widely used.

On the other hand, technologies other than information display must be incorporated in a limited space of an automobile. In case of smartphones, under-display cameras and fingerprint authentication devices have already been developed. In automobiles, driver monitoring functions using infrared cameras are beginning to be introduced (Fig.7). In addition, personal authentication will become commonplace in terms of personalized functions and security enhancement.

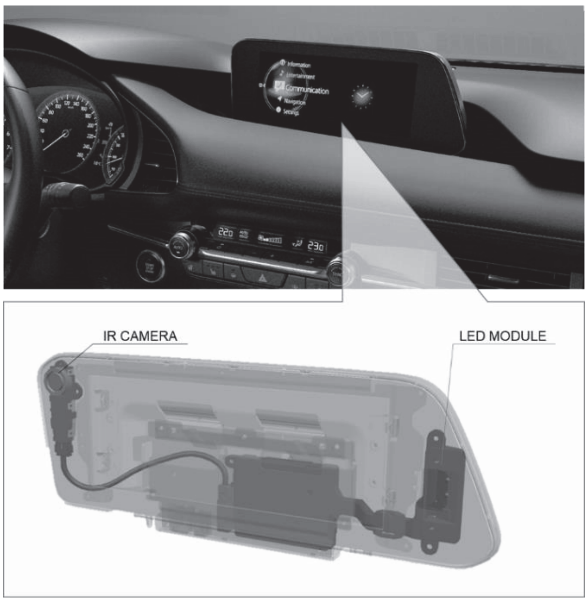

Fig.7 Driver monitor camera in CID

Various new technologies in consumer displays are usually introduced ahead of automobiles and it takes more than 5 years for introductions to automobiles. As mentioned earlier, the usage environment in automobiles may be severe, but there may also be situations in which the needs in automobile application are delayed. However, with the evolution of IoT and autonomous driving technology, there is no boundary of functional needs between consumer products and automobiles any more and technologies of automobile is equal to or in some cases, more advanced than consumer products.

Humans receive external stimulus information through their sensory organs, but more than 90% of the information is obtained visually. Controlling visual stimuli is indispensable to maximize human capabilities and provide joy of driving and living. Safety is a top priority at all times in automobiles. Display technology precisely controlling light and robust to various noises should be further developed in the human-centered automobile cockpit environment and living environment.

REFERENCES

[1] NHTSA Docket No.NHTSA-2010-0053: Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices (2013)