Interaction Design of an Animated Robotic Interface in Vehicle

Yi Li*, Yumi Tanaka, Misa Ono, Minoru Hashimoto

** Shinshu University, liki@shinshu-u.ac.jp*

Abstract: In this paper, we present an interaction design between the driver and an animated robotic interface by using a driving simulator. The interface robot has LCD, LED, speaker and movement at three degree of freedom. Each part can be controlled with various patterns which make the robot human-like animated and be capable to interact with the driver emotionally and intelligently. Also we measured various information during the driving, such as vehicle speed, acceleration, steering angle, the distance between cars and so on. We proposed an interaction method for the driver and robotic interface in this study and we have the hypothesis that the interaction between the driver and the animated robotic interface could have positive influence on the driver's behavior and emotional state. In other words, to find the appropriate interaction method or the critical factor to lead a safe and enjoyable driving.

Key words: Human engineering, information, communication and control, robotics interaction, human machine interface

1. Introduction

With the technical progress of the vehicle and robots, robotic interface for driving support has been paid much attention these years. Several car interface robots are developed. The interface robots Camaby and ROB [1] can assist the drivers by some announcements, such as pointing the driving direction or flashing the color like the traffic lights. And Pivo 2 [2] gives the driver some advices or encouraging words with the face turns towards the driver. AIDA developed by MIT Media Lab and Volkswagen [3] analyzes the past route selected by the driver and proposes the best one. It has many kinds of sensors to realize affective and intelligent interaction.

The interface robots provide information for driving and interact with the driver in various ways using voice, expression and movement. It is expected that the drivers' stress will be decreased and the driving will become much more safe and enjoyable. In our previous research we had proposed the facial robot Kamin-FA1 as a car interface and found that the integrated robot system is valid to understand the situation around the car and the emotional expression of the robot provides the information intuitively and easily[4]. Ohta et al. [5] have evaluated the psychological effect on the driver using a robotic device installed on a simulator and a test vehicle, respectively. It proved that joint attention and eye contact with the interface robot cause drivers an attachment to the interface robot.

On the other hand, there are worries about the driving safety because communication with the interface robot can take drivers' eyes off the road or make a diversion from the driving. However, they can drive safely even when they talk with fellow passengers of human, that's why we think that communication is compatible with a safe drive. And our previous study [6] has proposed a fellow passenger robot which makes utterance and movement due to the driving situation to enable a safe and delightful driving. It was found that the fellow passenger robot didn't give extra stress to the driver during the driving but make the driving with pleasant and merriment. However, it didn't get the significant positive result for the safety of the driving by the interaction, and the interaction method designed in the system was lack of universality since the content of the speech and the interaction time for each situation was determined beforehand and performed unchangeably during the driving.

A fellow passenger interacts with the driver during the driving not only using the verbal information but also using the nonverbal information as facial expression, the line of sight and body motion. Also we think it is necessary to design the interface robot with the human characteristics to make the robot as a human-like fellow passenger to communicate with the driver (e.g. to warn or entertain the driver) to make the driving more safe and enjoyable. So in this study, we have proposed a new animated interface robot which can express its emotional states in various ways from LED light, LCD screen and head motion. And the robot has its own emotional states and not just only provides information to the driver but also can communicate with the driver like a human fellow passenger which making the robot a sense of life. Furthermore, we have proposed the interaction method for the robotic interface to make a more safe and enjoyable driving.

This paper is organized as follows: the animated robotic interface is addressed in section 2. The interaction design is discussed in section 3.Discussions and future works are presented in section 4.

2. Animated robotic Interface

The animated robotic interface means the robot as an interface has a sense of life. That is, the robot will not just be a mechanized device but has its own emotional state and can express its own emotional state. Some previous studies show that the color, voice and head motion have relation to the emotional expression. And we think the strength and period of the color and the voice are related to the arousal of the emotional state. According to those mentioned above, we have developed an interface robot which can express its emotional state by LED light, LCD screen and head motion with a three-degree freedom. Figure 1 shows the developed interface robot.

Figure. 1 Overview of the interface robot

As shown in figure 1, there is a LCD screen of 1.8 inch in the ball head which can display some movies (e.g. flashing color movie or expression movie). In order to strengthen the emotion expression, eight LED lights are arranged under around the robot head, having ten patterns of flashing with seven colors as white, red, yellow, green, blue, purple and water color. The head can move as disappearing end bumper from the dashboard, right-left and up-down movement. And the speed of the head movement can be controlled by the servomotor. When the engine is on, the robot moves up from the dashboard with a half-face height, and then the head turns left and right to check around and finally moves out the whole head from the dashboard. And the robot moves into the dashboard when the power is turned off. Figure 2 shows the structure of the dashboard with the robot. There is an infrared set at the left part of the dashboard which makes it possible to control the robot only by the driver's action. Also there is a speaker on the dashboard that can play any sound.

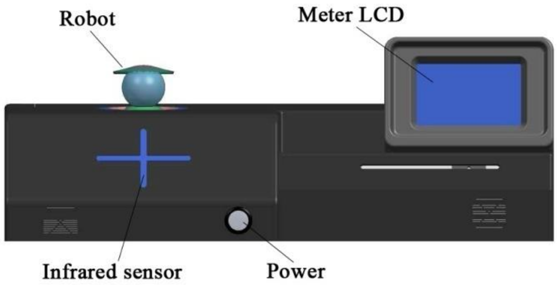

Figure. 2 Structure of the dashboard with the interface robot

3. Interaction Design

3.1 Propose of interaction

In order to make the robot have a sense of life, it is necessary to consider the emotional model of the robot. C. Hasson et al. [7] has proposed that the emotions must be understood as a dynamical system considering two aspects: one devoted to social interaction (i.e. communication aspects) and another one devoted to the interactions within the physical world (i.e. survival purpose aspects). By this way, the robot can make self-monitoring and modify its behavior by switching back and forth the attention between the navigation task and the human partner.

In this study, refer to the two sides of the emotional model, we consider the safety and pleasure of the driving are the same physical survival purposes both for the robot and the driver. And meanwhile the robot and driver fulfill the purposes by their own strategies respectively. Furthermore, we think it is more effective to achieve their own goals by considering the communication aspects between the robot and the driver (see Fig.3).

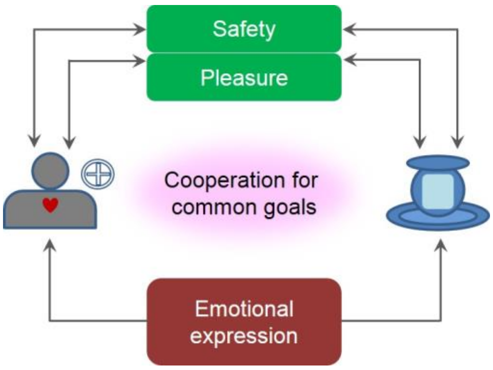

Figure. 3 Interaction between Human and Robot

On the other hand, I. Jonsson et al. [8] has investigated the influence on the driver's behavior and attitudes using the characteristics of a car voice. They found that drivers who interacted with voices that matched their own emotional state had less than half as many accidents on average as drivers who interacted with mismatched voices and drivers paired with matched voices also communicated much more with the voice. It is expected the same effect in this study by using both the aural and ocular information to match the driver's emotional state during the interaction of driving.

As the robot has the same goals of the driver, the robot understands the situation of its own goals by analyzing the information of the driving (e.g. find out the velocity). The behavior of the robot is varying according to the states of the goals. When it is far from the goal, the robot interacts with the driver to try to get close to the goal. To escape the repetitive behavior of the robot when the goal is not satisfied, we introduce a generic frustration mechanism based on the evaluation of an unlimited number of signals, either drives or goals or even strategies. A binary frustration decision F(t) (1)can be achieved from a frustration level f(t) (2).

$$F(t) = \begin{cases} 1 & (f(t) > T) \\ 0 & (otherwise) \end{cases} \tag{1}$$

$$f(t) = [f(t-\Delta t) + R(t) - P(t) + \epsilon - r - F(t-\Delta t)]^{+} \tag{2}$$

F(t) is computed as the temporal integration of the instantaneous progress $P(t) = \frac{1}{\tau}[G(t) - G(t-\Delta t)]^{+}$ and the instantaneous regress $R(t)=\frac{1}{\tau}[G(t-\Delta t)-G(t)]^{+}$ with Δt is the duration of each calculation time-step and the equation with $[x]^{+}$ equals x if x > 0 and equals 0 otherwise and τ is a time constant (τ=Δt). ϵ is a small constant and r is a reset signal that equals 1 when the goal is satisfied (when the needed resource is detected) and 0 otherwise. The threshold T defines the robot tolerance to frustration. This mechanism differs from a simple timeout because frustration is increased by the number of failures and not directly by the elapsed time.

From analyzing the information of driving, the robot can learn the states of the goals. When a drive is active (e.g. when it is over speed), until the goal of velocity is satisfied, the robot might assume that everything is all right as long as its predicted distance to the goal decreases. But if goal distance G(t) does not decrease, the robot behavior is inefficient. And if this inefficiency is lasting this means the robot is caught in a deadlock and becomes frustrated. Then the robot changes to another goal or strategy. By such view, the robot can escape from the deadlock and naturally reaction to the situations in the interaction of driving.

3.2 Design of interaction

Table 1 shows the designed interaction for the interface robot. The robot has the same desires with the driver as safety and pleasure. The value of the drive shows the strength of the desire. First of all, for a safe driving, we define the drive as safety with the goal setting as appropriate speed slower than the statutory speed limits, sufficient distance between cars and stable steering angle for a stable driving. To satisfy each goal, the robot uses the strategy (i.e. emotional expression) to interact with the driver. The robot expresses its emotional state for the goal using the LCD, LED, voice and head motion. When the driving becomes dangerous or needs some warning, the robot interacts with the driver with negative emotional expression. And when the driving is safe, the robot communicates with the driver with positive emotional expression so as to increase the pleasure of the driving.

Table 1. Interaction design of the drive, goal and strategies

Drive	Goal	Strategy
Safety	Appropriate speed Sufficient car distance Stable steering angle	Emotional expression (e.g. using voice, expressions, motions)
Pleasure	Reaction of driver Detection of emotion	

The drive of safety changes from 0 to 1 to show the level of safety of the driving. The safety equals 0 when the three goals of safety are all satisfied and 1 when all the three goals are not satisfied. And each goal changes from 0 to 1 to show the level of satisfaction. For example, when the speed is under a statutory speed limit, the value of the goal equals 0 and arises when the speed is over the statutory speed limit and become 1 when it is over a threshold.

When the value of the goal is over 0, it means the drive of safety is not satisfied. And the robot uses the corresponding strategy to interact with the driver trying to satisfy the goal. Until the goal is satisfied, the robot might assume that everything is all right as long as its predicted distance to the goal decreases. If the goal distance does not decrease, the frustration arises. When the frustration becomes 1, it means that a deadlock happens between robot and the driver. Then the robot will change to another goal.

If the drive of safety equals 0, then the robot will change to another drive as pleasure to make the driving more enjoyable. By this way, we think that it is valid to make the desires of both robot and driver be satisfied and can make the driving much more enjoyable.

4. Conclusions

In this study, we have proposed a new animated interface robot which can express its emotional states in various ways. Furthermore, we have proposed the interaction method for the robotic interface to make a more safe and enjoyable driving. We designed the interaction method that the robot has the same desire with the driver, and the robot cooperated with the driver for the same goal using strategies of emotional expression. Frustration mechanism was introduced to the interaction to make the interaction more flexible and universal. By such view, we think the robot does not just only provide information to the driver but also can communicate with the driver like a human fellow passenger which makes the robot have a sense of life.

In the future work, we will propose some algorithms to detect the driver’s emotional state in real time during the driving and conduct experiment to evaluate the effectiveness of the proposed interaction method.

5. References

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