Modeling an Ergonomic Driving for In-Car Interaction: A Propose Framework

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Abstract

Global automotive arena has overshadowed by intense competition because customers nowadays being more selective about their preference towards car selection. In a different dimension, car's interior design promised maximum satisfaction for customers. For long distance drivers, comfort feeling influence by many factors, which one of them contributes by interacting with in-car environment. This paper primarily concentrated into the human comfort study which studying the driver in-car activity such as handling the steering, monitoring the driving and using the in-system. Ultimately, this paper proposed a knowledge based system framework of interaction of driver with in-car system. The current problem face by driver relates to car interior compartment (car seat, navigation system, signaling panel, instrument panel, gear knob, pedaling system, and mirror) can be understand and recommended for improvement. Also, this study helps to measure the satisfaction of drivers while cooperate with in-car system. In order to measure in-car driver interaction, an intelligent system introduces a knowledge base system which using hybrid technique called neuro-fuzzy techniques. The neural network involve with developing the system in multi layer concept and the fuzzy basically using IF-THEN rule. This research explores the human-machine interaction through a driver knowledge based system. The conceptual framework contributes on optimize the design process, decision making and analysis in assisting automotive productivity and quality.

Keywords
In-car interaction, driver interaction, expert system, intelligent system, human-machine interaction

1. Introduction

When the drivers start to turn on the car engine, drivers will completely responsible as a pilot to handle the car and ensure that the driving session will be arrived safely. Some of the drivers only drive for couple hours or less for short distance driving. However, some other drivers who involve with long distance driving will easily caused fatigue and discomfort. By concentrated to the long distance drivers, they actually will spent most of the driving time handling and interacting with in-car system such turn on the radio, slowing and increase the radio volume, pinch the signal's panel, monitor the other vehicles through the mirror, rest the hand on the arm rest, changing the posture to keep comfort on the seat, hold the steering wheel, monitor the fuel meter and etc. This situation proved that drivers deal their time more to the in-car system compared talking to passenger, enjoying the outside view or maybe thinking about the next pit stop. So, the interaction between drivers and in-car system supposedly give optimum satisfaction towards comfort, relaxing, friendly, easy, and simple where technically can influence to driver's physical, physiological and psychological.

Lately, many researchers have alert and sensitive about the problems face by the drivers and car interior design. Many of researchers focused on tackling the discomfort, injuries, and fatigue effect between drivers and individual compartment such car seat, mirror, arm rest, pedal system and so on. There also encountered the environment parameters such vibration, thermal comfort, visibility, in-door air quality and noise. This situation is shows a good sign for automotive development. However, from the literature reviewed showed there are less study have been conducted that relates to driver-in-car interaction. Due to this point, this paper is proposing a framework to study about interaction of driver with in-car system. The driving simulator technology has being more popular among

research to develop intelligent behavioral models especially for autonomous vehicles for many years (Talal and Ronald, 2001).

2. The Revolution of Knowledge Based System

Currently, there were many kinds of expert system has been developed that related to automotive application. Theoretically, there were many version of definition been used to described the definition of expert system. The expert system describes as software that capable to stimulate human performance in specific fields. Nowadays, most of work area used the expert system efficiently because it offered accurate decision making in complex environment. The term expert system, intelligent system or knowledge based system become familiar especially in engineering applications (Qu, Fu and Qiu, 2008).

In early of 1990, people started to concern about the development of automotive vehicles, interaction on the road and vehicles safety. Many researched interested in doing studies in the automotive area (Niehausl et. al., 1991). After that, the theory of fuzzy set has surprised the world its capability that pioneered by (Zadeh, 1965). This theory is a multi-value that able to deal with indefinite data where fuzzy technology is forwardly advanced at that time. Many years later, this technology is widely used in solving the complicated system such in automotive, manufacture, medical and etc [Fangqin and Li, 1998). From time to time, the fuzzy theory evolves and its application enhanced by demands. The hybrid system born as the weaknesses and limitation of previous theory has been overcome including the researches towards driving seat design for evaluating the human comfort level (Kavita, et. al. 2012; Zhi et. al., 2009). The implementation of neuro-fuzzy inference system used to have maximum customer satisfaction towards car seat design. The neuro-fuzzy interference system has using the combination of MATLAB with effective M-Code. Car seat design encounter attributes such influencing parameters are shoulder support, sweat, safety child, lumbar support, head rest support (Kavita, et. al. 2012). Meanwhile, application of support vector regression (SVR) as the evaluation method for predicting subjective perceptions of automobile seat comfort together without he algorithm of least squares support vector regression (LSSVR) used to analyze the experimental result (Zhi et. al., 2009).

As automotive industries evolve drastically due to the high demand of customers, the ergonomics issues also have been highlighted. The customer's right has given exclusive consideration by manufactures as a shortcut to win the market demand. The comfort in the car interior is a key to win the customer's heart and become a needs rather than desires. The noise is one of the factors that invite discomfort feeling to the car's users (Paulraj et. al., 2010; Zamri and Rosnah 2007). Physiologically, the continuous exposure to in-car noise and vibration can risky the driver's and passenger's health. Vehicle Noise Comfort Index (VNCI) that combines the psychoacoustic approach developed for evaluating the sound characteristic of passenger car modeled through the application of feed-forward neural network (Paulraj et. al., 2010). As time passes, the basic fuzzy theory evolved equivalently. More techniques has been introduced such neural, and genetic algorithm. Some of that has been hybrid to advance their ability. In this paper, a new framework of neuro-fuzzy expert system for driver-in-car interaction is proposed.

2.1. The Application of Knowledge Based System in Ergonomic

The revolution of advance technology such human-machine interaction has improved human life where many complicated problems were solved effectively and efficiently. The application of knowledge based system has widely used in ergonomic especially in automotive study. As tabulated in Table 1, several researches related to the application of knowledge based system in ergonomic area have been developed to improve human workplace.

Table 1: The Summary of application of Knowledge Based System in Ergonomic

Authors/Year	Knowledge Based System	Research Application
Kavita T., Chandra M. S., Sridhar (2012)	Neuro-Fuzzy System	Transportation/Automotive: Generate models of car seat design variables to affective user satisfaction(body contact, sweat and heat generation, shoulder support, and child safety)
Chris C. Martin et al., (2012)	Ergonomic Monitoring System	Industrial Workers/Lifting: Determining the level of lifting and carrying methods that detrimental employee's health through real-time

		ergonomic analysis of lifts performed by human.
Ephzibah E. P., Sundarapandian V. (2012)	Neuro-Fuzzy Expert System	Health and Safety: diagnose the heart disease using computing
Paulraj M. P., Sazali Y., and Allan M. A., (2010)	Feed-forward artificial neural network	Transportation/Automotive: Proposing vehicle comfort level indication to detect the comfort level in car through exposure of noise and vibration
Weidong Z., and Yibo A., (2010)	Power assistant control program of information fusion expert system	Transportation/Automotive: Analyzing the driver physiological and psychological during driving process using new type electric power steering system research is to reduce driver's physiological and psychological burdens.
Padma and Balasubramanie. (2009)	Knowledge Based Decision Support System	Safety and Health: Investigating the shoulder and neck pain in work place.
Azadeh et. al., (2008)	Expert System	Oil and Gas: Safety, heath, environment, and ergonomics in gas refinery

Previous researches showed that, many studies have been conducted relates to transportation and automotive. The application of knowledge based system and decision support system being the best alternative to replace the conventional method (Rychtyckyi, 2005).

3. The Implementation of New Framework

This paper proposes new idea of framework for modeling human driving satisfaction within in-vehicle interaction. In this paper, the marriage of several approach system have been done in order to improve the functionality and capability of system visualized in Fig 1. Theoretically, the neural network (NN) is combined with fuzzy logic FL which called neuro-fuzzy based. The neuro-fuzzy based in advanced has incorporate with the expert system (ES). Then, the hybrid technique introduces as neuro-fuzzy expert system. This hybrid techniques used as the backbone in proposing the implementation of Knowledge Based System (KBS) to modeling human driving satisfaction within in-car interaction. The advantages of using the hybrid techniques is because it offers inherent capabilities to handle imprecision and uncertainty cases towards amount of computational complexity (Pratihar et. al., 2009).

Conceptually, this framework develops in close-looping system and structured using the multi layer neural network which contains input and output layers and three hidden layers that represent the membership functions and fuzzy rules.

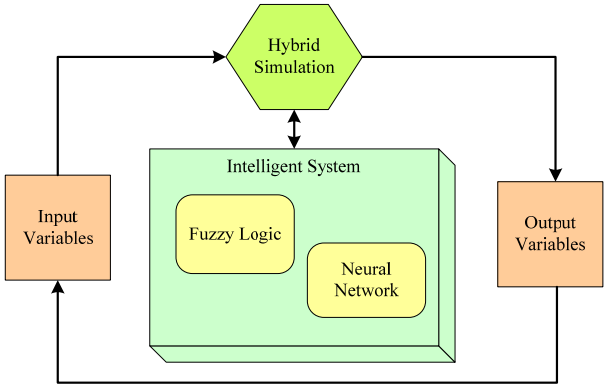

Figure 1: The Propose of KBS Framework to Modeling Human Driving Satisfaction within In-Car Interaction

The development of framework purposely to measure the driver satisfaction while interacting with in-car system. The driver's preference is modeled as fuzzy expert system where the fuzzy rule-based applied. A fuzzy neural approach is used to represent the correlation of the attributes towards driver's behaviors where rule-based fuzzy is based on the rule represent by 'IF-THEN'. Structurally, this proposed framework has been build through the hybridization of neural network and fuzzy logic that graphically visualizes in Figure 2.

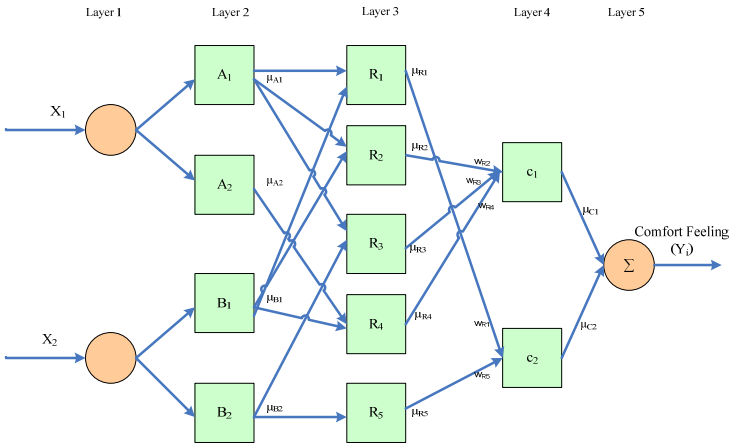

Figure 2: The architecture of the proposed KBS framework

Through the figure, the architecture of framework has been implemented. Multi layer has been designed to decrease the risk of noise (error). The detail of each layer can be understood as followed:

Layer 1: First layer describes as the input layer. In this layer, each neuron has transmitted external crisp signal to the following layer. It is define as:

$$y_i^{(1)} = x_i^{(1)} \tag{1}$$

Where X represent input; Y represent output.

Layer 2: Layer 2 describes as the fuzzification layer. In this layer, the neuron represents fuzzy set which used in the fuzzy rules. It technically is set to membership function that exclusively denote by two parameters {a, b} as below:

$$Y_i^{(2)} = \begin{cases} 0, & \text{if } x_i^{(2)} \le a - \dfrac{b}{2} \\ 1 - \dfrac{2\,|\,x_i^{(2)} - a\,|}{b}, & \text{if } a - \dfrac{b}{2} \le x_i^{(2)} \le a + \dfrac{b}{2} \\ -1, & \text{if } x_i^{(2)} \ge a + \dfrac{b}{2} \end{cases} \tag{2}$$

Where {a, b} represent the parameter input; Y=output

Layer 3: The third layer represents the fuzzy rule layer. In this layer, each neuron is correspondents to the individual fuzzy rule. The fuzzy rule neuron receives input from the fuzzification neurons that represent fuzzy sets in rule antecedents. In this layer for example, neuron R1 that relate to R1 technically received input from neuron A1 and B1.

$$y_i^{(3)} = x_{1i}^{(3)} \times x_{2i}^{3} \times \cdots \times x_{ki}^{(3)} \tag{3}$$

$$y_{R1}^{(3)} = \mu_{Ai}^{(3)} \times \mu_{Bi}^{(3)} = \mu_{R1} \tag{4}$$

Where $x_1, x_2 \ldots x_k$ represent variable input; $A_1, A_2 \ldots A_k$ represent fuzzy set

Layer 4: The layer fourth expresses the membership layer where the neuron is representing the fuzzy set used in fuzzy rules.

$$y_i^{(4)} = x_{1i}^{(4)} + x_{2i}^{(4)} + \cdots + x_{li}^{(4)} \tag{5}$$

$$y_{C1}^{(3)} = \mu_{R3}^{(3)} + \mu_{R6}^{(3)} = \mu_{C1} \tag{6}$$

Where $x_1, x_2 ... x_k$ represent variable input; μ_{C1} represent integrated of fuzzy set rule for neuron R3 and R6

Layer 5: The final layer is describes the defuzzification with each neutron represents an individual output of neuro-fuzzy system. The neuro-fuzzy system can be applied with standard defuzzification method.

$$y = \frac{(\mu_{C1} \times a_{C1} \times b_{C1}) + (\mu_{C2} \times a_{C2} \times b_{C2})}{(\mu_{C1} \times b_{C1}) + (\mu_{C1} \times b_{C2})} \tag{7}$$

In this study, sum-product composition method will be considered. This method calculates the weight average of the centroids of overall output membership function.

4. Conclusion and Future Work

The reviewed session has proved that there are many great and advance systems have been done in ergonomic field which is very beneficial to both side of industries and users. It is a valuable works that every researches struggled and useful knowledge to increase multi complicated problem in human life. Technically, there are lots of applications for knowledge based system towards car driver, passengers, car seats, visibility, noise etc. However, the studies for driver interaction with driving workstation (in-vehicle system) are still limited. Then, this research has proposed research in improving the ergonomics of driver interaction with driving workstation (in-car system). By reviewing the previous studies, this research has found some room for improvements that related to automotive area which directly contributes to human comfort. Thus, this research proposes a new framework for human driving satisfaction within in-car interactions allow modeling for type of driver's task workload apart from driving attention, measure the visibility, evaluate the fatigue and improve the level of satisfaction. The real study on driver interaction with in-car system will be compared to the human-like driving simulator. Both of the result will be compared. After that, an intelligent system will be developed whereas it is useful for engineer's uses in future. This research explores huge benefit in improving the human-machine interaction through a driver knowledge based system. The conceptual framework contributes on optimize the design process, decision making and analysis in assisting automotive productivity and quality.

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Biography

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