Establishment and Analysis of Information Processing Models on Intelligent Overtaking Behavior

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Abstract. In order to avoid the traffic accidents caused by drivers, unmanned ground vehicles are expected to run on the road, so correct and safe driving behaviors are most important. This paper aims to give a new way of perception based on information processing for control system of intelligent vehicles, and focuses on the present overtaking ability of intelligent vehicles, meanwhile implies the ability of recognizing traffic environment. First we built intelligent driving behavior models with construction perception and pattern recognition on prototype matching; second, based on "Future Challenge" contest we investigated the features of velocity and latitudinal distance of intelligent driving. Our results describe that the intelligent vehicle does have the basic ability of cognizance, and it can make correct reactions corresponding to the driving environment, but its intelligence still needs improving.

Keywords: Driving behavior, cognitive science, pattern recognition, intelligent vehicle.

1 Introduction

Studying on intelligent vehicles with the abilities of cognizing driving environment and making decisions autonomously, based on theories about audio-visual information processing and key technologies on audio-visual collaborative algorithms, can greatly enhance our research strength in this field. Road traffic safety is restricted by man-vehicle-road (environment) [1], and the latest news shows that human factors give rise to 92% of all road accidents, up to 88.29% of which are caused by drivers, so we can see driver plays an important role in the road traffic control system. There are some advantages and disadvantages in this system, the former is the driver can rely on his own audio-visual features unconditionally, and cognize the surrounding traffic environment timely and effectively to make decisions; the latter is some invisible and uncontrollable factors from the driver, such as negligence, fatigue and so on, may lead to a large number of traffic accidents indeed. Therefore, to solve this huge security problem thoroughly, why not let the driver "walk" out of the road traffic control system, that is, the intelligent drive closed-loop system "vehicle - road (environment)" is created so as to improve security

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and efficiency. The core of this new traffic control system is to get artificial intelligence theories and technologies involved, and make unmanned vehicles drive smoothly and intelligently in the future. Unmanned intelligent vehicles are able to learn the correct behaviors of human drivers, and discard the bad behaviors, furthermore there must be some day unmanned intelligent vehicles can drive safely and effectively as well as the human drivers, perhaps even better, so it is of great help to improve road safety significantly.

This paper focuses on the information processing of intelligent driving. First of all, on basis of cognitive science, we analyze the process of driving behaviors: beginning with the perception of driving environment, then matching the existed pattern in Memory, then making decisions to take corresponding actions; second, in accordance with construction perception and pattern recognition theory, further analysis is carried on; finally, using test data, we attempt to recover the exact intelligent behavior of the test vehicle by the characteristics of the latitudinal distance and driving velocity, and we can see the test vehicle has its own sensing and cognizing skills, which sets up a good foundation of our research on intelligent vehicles in the future.

2 Overview of Cognitive Psychology

Information processing is the core of cognitive psychology. Compared with computer, human brain is considered as the information processing system according to information processing theory. The major areas of cognitive psychology include perception, attention, representation, learning and memory, thinking and speech, and other psychological processes or cognitive processes, also pattern recognition and knowledge of the organization. The core is to reveal the internal psychological mechanisms of cognitive processing, that is, how to obtain, storage, process and use information.

There are two opposite points of views in perception theory: the first one is (i.e. construction perception) that human's perception depends on knowledge and experience, people base on the existing knowledge of things in the natural environment, and are guided by the relationship between the perception of activities and the natural knowledge; the second view denies the existing knowledge and experience, but holds that the perceptive stimulation is complete, also can provide rich information, which people can make use of to generate corresponding perceptual experience, instead of relying on the past experience. However, generally speaking, cognitive psychologists have enough reasons to believe perception depends on the existing knowledge and experience, and perceptive information is the result of the interaction between real stimulation information and memory information [2]-[4].

3 Research on Intelligent Driving

Intelligent driving, relying on in-vehicle intelligent devices with computer systems[5], develops driver's visual and auditory performances, real-timely interacts with the driving environment and perceives the environment around the vehicle using some sensors, such as laser radar, ultrasonic sensors, microwave radar, Global Position System, odometer and magnetic compass etc., then according to the road, vehicles

and obstacles autonomously controls steering and speed, intelligently plans their own behaviors, so that the intelligent vehicles can safely and reliably run on the road [6].

3.1 Information Process for Intelligent Driving Behavior

As shown in Fig. 1, human receive information by visual, auditory, tactile, and other sensors, then the information from these sensors will be transmitted via the bus and protocol into Electronic Control Unit (ECU). Inside ECU, the input information will be identified to make appropriate decisions, and Memory is needed in all these procedures. Finally, the information processing system outputs information to take appropriate actions issued by the Controller.

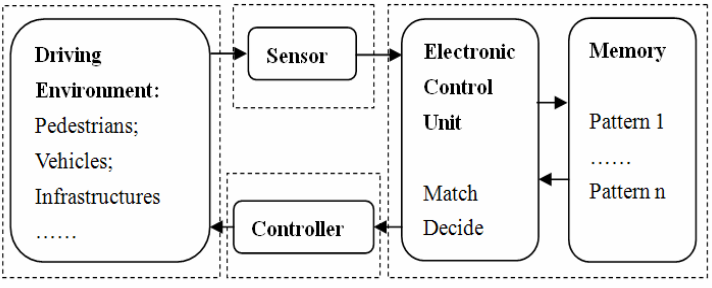

Fig. 1. Information Processing of Intelligent Driving Behavior

The process of intelligent driving behavior includes cognitive phase, decision phase and operation phase, so a variety of vehicle behaviors will be acquired through these three phases, using all kinds of equipments, computers to replace human brain, completing cognizing and decision-making phases.

3.2 Model of Intelligent Driving Behavior Based on Construction Perception

Cognitive psychologists generally confirm that perception depends on the past experiences and knowledge, and perception is the result of the interactions between stimulating information and memory, which is the main idea of construction perception (i.e. hypothesis test theory).

Construction perception holds the idea that the knowledge and experiences in the past play a significant part in assumptions, expectations in perception. People base on the past experiences to form the assumption of the current stimulus. Bruner (1957) and Gregory (1970) considered that perception was a construct procedure including hypothesis and test [7]. First people receive information, make assumption and test assumption, second, accept or search for information again, then test this assumption, until validate this assumption, thus they can make the correct explanation of this stimulus[8].

Based on construction perception, comparing and analyzing the detailed recognition process of sensing stimulation, receiving information and perception provides a sufficient basis to the following research.

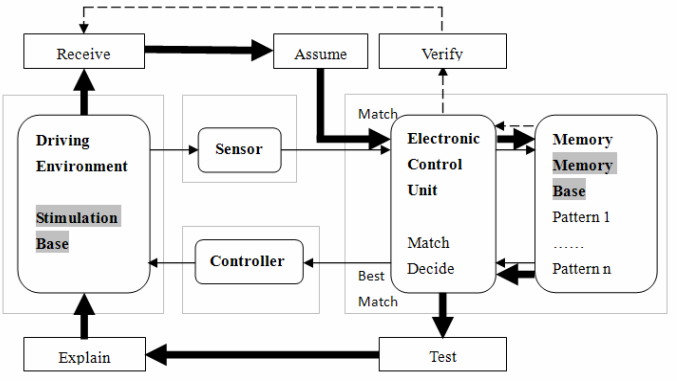

Fig. 2. Information Processing Model of Intelligent Driving Behavior Based on Construction Perception

Fig. 2 tells the information processing model of intelligent driving behavior based on construction perception and the bold arrows show the core of construction perception. Receiving information, making and testing assumptions again and again, help to validate an assumption, and give correct explanation of sensory stimulus.

3.3 Model of Intelligent Driving Behavior Based on Pattern Recognition

Pattern refers to a certain number of elements or components to form a certain stimulus obeying some rules. Pattern recognition is to detect, identify and confirm patterns, that is, through the human brain to match the stimulus previously acquired and stored in the long-term memory with the current information, to convert and analyze stimulus information for identification of external things, in order to include or expand into the cognitive structure of the human brain.

Prototype pattern recognition regards some abstract model existed in human's long-term memory as a prototype, which contains many similar shapes of the same pattern, obtaining identification by matching. In prototype pattern recognition, the external stimulus only compares with the prototype, because the prototype is a general characterization, this comparison only needs approximate matching.

In accordance with the views of the prototype matching model, the external stimulus has to compare with the prototype, not the accurate match, but the approximate match. This means as long as the existence of the corresponding prototype, the new, unfamiliar patterns should be identified to make the pattern recognition more flexible and adapt to environment [9]. Based on prototype pattern recognition of cognitive psychology theory, all elements in driving environment, such as weather, pedestrians, and road alignment etc., can stimulate and affect driving behaviors. We name these different elements a stimulation base, and then sum up different driving behaviors in different environments, such as obstacle avoidance behavior, turning behavior etc..

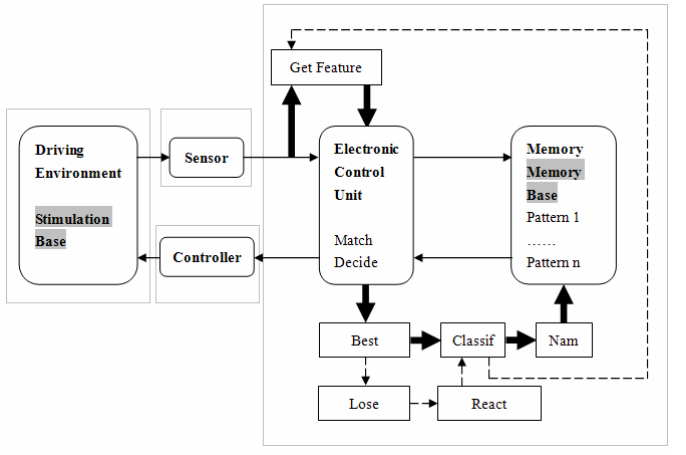

Fig. 3. Pattern Recognition Model of Intelligent Driving Behavior Based on Prototype Matching

Fig. 3 is a prototype pattern recognition model of intelligent driving behavior. Extracting features of the received information, ECU commands the knowledge base to match decisions, and then an exact match is created. After classifying and naming, the results enter the knowledge base, if not succeed, we need to re-feature extraction, and then match; if the accurate matching result loses characteristics, we need to tend to react, and then classified, and eventually into the knowledge base, and output an implementation after a successful match.

4 Analysis of Intelligent Driving Behavior

On basis of "Future Challenge" contest, we chose Vehicle A to make analysis of intelligent driving behaviors. Vehicle A sensed the leading car speed decreasing, and also the forward distance, in view of the construction perception model, first of all this stimulus tended to form Assumption 1, then passed into ECU , which controlled the Assumption 1 to match the patterns in Memory one by one, if not succeed then return to ECU, and tested Assumption 1 again, got stimulating information for the second time, formed Assumption 2, through ECU matched in Memory, this time if succeed, Assumption 2 was verified, the correct implementation wound be taken by Controller, that was to change lane, overtake and return to the original lane. Moreover, according to the pattern recognition model based on the prototype, the message features that the leading car speed reducing and the forward distance lessening was perceived and obtained by intelligent Vehicle A, following the best match, classified, named and stored in Memory, a new pattern was created. If the feature was missing after the match, reaction tendency wound be classified and returned to regain features.

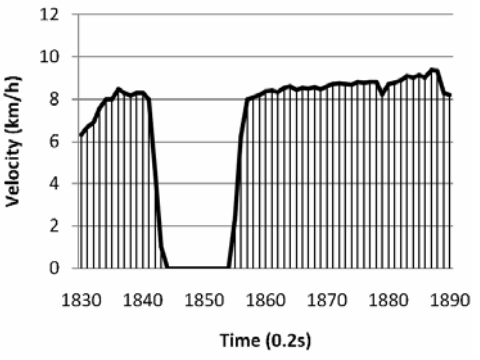

Fig. 4. Velocity of Intelligent Drive in "Future Challenge"

In Fig. 4, the result suggested the velocity changes of Vehicle A during the process of overtaking, and we could find in 1840th to 1855th (the area between two arrows), there was a 2-second period of 0 speed which tells Vehicle A did perceive and recognize the forward moving obstacle getting bigger and closer while running, so it stopped to take some time to make decisions. It was called reacting time, about 2 seconds, obviously it did need a few seconds that were much more than human beings', but it implied the great ability of perceiving and decision-making, we believe that it must be improving in the future, which lays a solid foundation for the future research. Since then, Vehicle A started to overtake, shown in 1855th to 1885th (the area between the two dots), first speeded up to a stable value, about 9 km/h, and then fell to the original speed of about 8 km/h after passing.

Fig. 5. Latitudinal Distance of Intelligent Drive in "Future Challenge"

Latitudinal distance changing could be found in Fig. 5, corresponding to its reacting time for perceiving and decision-making when stopped, a constant latitudinal distance (the area between two arrows) was seen during this period, so absolutely the area following this one was the overtaking process (the area between two dots). The curve trend showed, the latitudinal distance in the process of passing the leading car decreased a bit, nearly from 5.5 meters down to about 2 meters, and maintained

around 2 meters, so we could infer Vehicle A failed to return to the original lane after overtaking, it was probably because after overtaking there were no signs or identifiable objects in front of it.

We know that intelligent vehicles have autonomous driving capacities, such as keeping running in the same lane, perceiving forward objects, correctly identifying driving environment, safely avoiding obstacles and so on. In this overtaking behavior tests, however, intelligent driving abilities still need improving, for example, shirking the reacting time, increasing running speed much safely, and going back to the lane after overtaking and so on.

5 Results and Discussions

This article gives a new way of perception based on information processing for control system in intelligent vehicles, on the basis of construction perception and prototype pattern recognition theory. The results of overtaking behavior indicate the current intelligent driving ability in China, and the main conclusions are as follows:

(1) On theoretical basis of cognitive psychology, using construction perception (hypothesis test theory) we have established intelligent driving behavior model, clarified the short decision-making process, reflecting the assuming and testing again and again during decision-making, to get the best match;

(2) Intelligent driving behavior model based on prototype pattern recognition theory has been built in order to well match the stimulus and decision pattern;

(3) For the overtaking process, respective velocity and latitudinal distance graphs have been analyzed. During overtaking, intelligent Vehicle A slowed down first and stopped to perceive and make decisions, and then accelerated to overtake, then decreased to normal speed; the latitudinal distance was getting shorter and was kept in 2 meters with the reason that it failed to return the original lane;

(4) As a whole, intelligent Vehicle A has the basic cognitive ability, can not only correctly identify the driving environment, but also perceive the movement of the forward vehicle, and change lanes autonomously, avoid obstacles safely, keep running in the same lane and other intelligent driving behaviors, but efficiency and autonomy in intelligent driving will be better improved in the future

However our results have limitations, because all the tests were taken in ideal situations, without influences from other complicated environmental elements. Meanwhile, it should be noted that this study has examined only the overtaking behavior and further studies on other intelligent driving behavior will be summarized in our next paper.

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References

1. Parent, M., Yang, M.: Road Map towards Full Driving Automation. In: Proceedings of 8th International Conference on Application of Advanced Technologies in Transportation Engineering, Reston, pp. 663–668 (2004)
2. Zhang, Y.: Human-computer interface design based on knowledge of cognitive psychology. Computer Engineering and Application 30, 105–139 (2005)
3. Xiong, Z.: Systematic description for classical style of cognitive psychology. Psychology Science 6, 1510–1511 (2005)
4. Solso Robert, L., MacLin Kimberly, M., MacLin Otto, H.: Cognitive Psychology, Beijing (2005)
5. Yang, M.: Research on Unmanned Autonomous Driving Vehicles. Journal of Harbin Institute of Technology, 1259–1262 (2006)
6. Qin, S., Liu, J., Wen, W.: Research on Autonomous Intelligent Driving Behavior Model. Journal of Beijing University of Aeronautics and Astronautics, 793–796 (2003)
7. Zhou, H., Fu, X.: Cognitive science: the scientific frontier of new millennium. Journal of Psychology Science Prospect, 388–397 (2005)
8. Wang, G., Wang, A.: Cognitive Psychology, Beijing (2001)
9. Wilson, R.A., Keil, F.C.: The MIT Encyclopedia of the Cognitive Sciences (2000)