Intelligent Stroke Driver Assistance System to Enhance Driver's Safety

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***Abstract*—Driving is essential to the quality of life and is a complex task requiring higher cognitive and perceptual skills.. However, a stroke driver suffers from one or more problems such as sudden physical or sensory changes, slower reaction time, reduced memory, low concentration, low ability to solve problem, low vision and visual perception. Among them, the slow reaction time is especially significant, causing an accident. A stroke driver should be cautious about recurrent stroke and monitored for a long time. In order to assist a stroke driver in risk situations and monitor symptoms of the recurrent strokes, we proposes intelligent Stroke Driver Assistance System (iSDAS). The iSDAS is designed for enhancing stroke driver's safety, and two main functions are proposed in car-following simulation. The first function is for collision avoidance, triggering emergency braking when time-to-collision (TTC) is in a high risk of collision due to the slower reaction time of a stroke driver. The second function is for assessment of driving performance, which is used for monitoring status of stroke. Performance Analysis of Driving Ability (P-Drive) is designed for the assessment of driving abilities. 27 driving items of the P-Drive is scored from 1 to 4 according to driving performance by an occupational therapist. The reaction time is selected from the driving items to be used for evaluating the assessment performance. The TTC-based brake data from 13 stroke drivers and 11 normal drivers in STISIM driving simulator are evaluated for analysis of driving pattern in terms of safety driving. The main contribution of this work is to propose iSDAS framework for assisting stroke driver's driving and monitoring status of stroke. For a feasibility test of proposed system, we analyze reaction time data in car-following simulation from normal drivers and stroke drivers in the STSIM driving simulator. Other traffic simulations such as lane change, intersection control will be tested for the assessment of driving performance in 27 driving items of P-Drive.**

Keywords—intelligent stroke driver assistance system; stroke driver; collision avoidance; assessment of driving performance

I. INTRODUCTION

Driving is essential to the quality of life and requires many different cognitive and perceptual behavior skills. Many stroke patients eager to get back in driving seat, but it causes a worry about risk of motor vehicle crash due to stroke driver's poor driving skills and stroke recurrence risk [1]. The stroke patients have one or more difficulties such as physical or sensory changes, slower reaction time, reduced memory, low concentration, low ability to solve problems, difficulty with eye sight and visual perception, increased fatigue, increased risk of epilepsy, etc [2]. In order to drive again, stroke driver should pass clinical and on-road test. These tests examine driving abilities such as cognitive, visual and motor skills [3]. However, the stroke driver who passed these tests should be careful about recurrent stroke, and status of stroke driver is monitored in-real time for the driver's safety. Advanced Driver Assistance System (ADAS) is developed to enhance driver's safety by monitoring collision risk caused from driver inattentions such as driver distraction and fatigue [4]. We proposed an intelligent Stroke Driver Assistance System (iSDAS), which is designed for enhancing stroke driver's safety and provides a driving assistance and assessment of driving ability. The iSDAS considers a slow reaction time which is a significant predictor from stroke driver [5], and it takes over maneuvering of vehicle and control the vehicle itself when the stroke driver does not handle collision risk. Furthermore, the system assesses driving feasibility according to driving performance. This paper is a preliminary research for integrating whole system requiring multiple driving skills, and focused on car-following simulation in the iSDAS.

II. METHODS

A. System Overview

Proposed the iSDAS assists driving abilities in diverse traffic simulations. In this paper, car-following simulation in the traffic simulations is selected to analyze driving abilities related to reaction time. The iSDAS assists brake performance when the reaction time initiating the brake is late. Besides, the low driving abilities causing a collision are checked for health management of stroke driver.

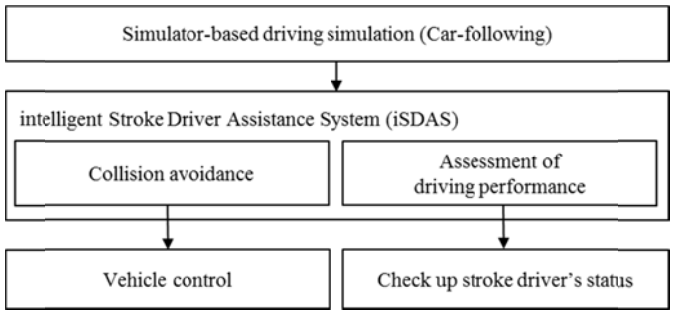

Figure 1 System Overview

B. Crash Avoidance in Car Following Simulation

Criterion of risk level used time-to-collision (TTC) in Eq. (1), where Δx indicate the distance between leading car and following car. $V_{leading}$ and $V_{following}$ means velocity of leading car and following car. High risk time defined that stroke driver is likely to crash, and it is defined in Eq. (2).

- TTC : $t_{TTC} = \left| \frac{\Delta x}{V_{following} - V_{leading}} \right|$ (1)
- High risk time : $t_{TTC} < 2\ sec$ (2)

C. Assessment of Driving Performance

Performance Analysis of Driving Ability (P-Drive) was developed to assess driving ability via driving behavior close to real driving based on simulator, and consists of 27 driving items [6]. Furthermore, the P-Drive for stroke patient in real traffic showed also valid assessment protocol for dementia or mild cognitive impairment [7]. Driving performance of the 27 driving items basically was scored by occupational therapies or trained examiner. Reaction time among the driving items is used for evaluation of assessment performance. The iSDAS used risk-based scoring method for objective assessment of the driving ability [8].

D. Experimental Setup

We recruited 13 stroke drivers and 11 normal drivers, and collected driving data by STISIM Drive™. Distance, speed, steering, throttle, and braking inputs were captured at a nominal sampling rate of 30 Hz. Experimental result shows an example of emergency situations in urban that a parked car suddenly appeared. The parked car is triggered when TTC is below 4 seconds from a predefined position.

III. Result

A time at stepping on brake is highly related to collision. Figure 2 shows relative velocity and distance when the driver recognizes the emergency situation and steps on brake. The relative velocity indicates $v_{parked\ car} - v_{following\ car}$. Relative velocities from stroke drivers are -15.8483 ± 8.1109 (mean $\pm$ std) while that from normal driver are -19.0833 ± 3.9410. This result indicates the stroke drivers shows poor speed control with slow or fast. Below or around TTC 1.5 second are related to collision in simulation results. To assist stroke driver, the iSDAS should take over a maneuvering of the vehicle instead of the driver in the emergency situation within TTC 2 seconds for enhancing safety of stroke driver.

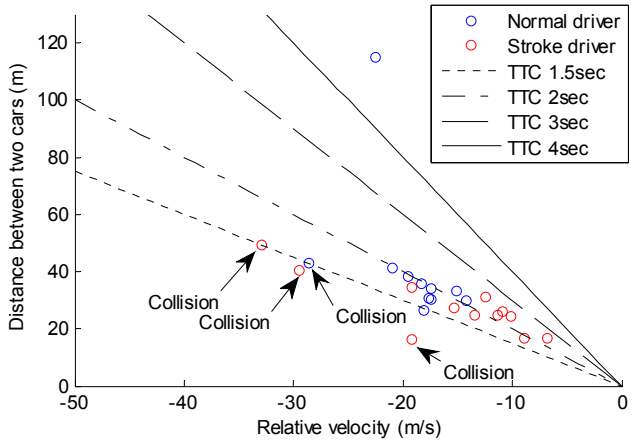

Figure 2 Relative velocity and distance at stepping on brake

IV. Conclusion

We provide a concept of the iSDAS, which is designed to assist driving performance and assess that at the same time for enhancing stroke driver's safety. Preliminary results of driving simulation show driving patterns of stroke driver that slow reaction time and poor speed control. For the objective assessment, we introduced the driving assessment tool, P-Drive, which scores driving performance based on safety considerations such as speed limit, safety distance and attention to surroundings while driving. Many traffic situations and driving items will be covered in future work, and the iSDAS will be loaded in smart car in terms of healthcare service.

Acknowledgment

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