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Analysing drivers' take-over performance in varying HMIs with level 3 automated driving

- Effects of after automated driving guidance on driver avoidance of a parked vehicle -

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In Japan, according to the latest traffic law , SAE level 3 (L3) automated driving vehicles are allowed to run on public roads regardless of road type (highway or urban roads). In L3 Automated Driving System (ADS), human drivers can engage in non driving related tasks when the ADS is activated, but when the ADS encounters a system limitation, the human driver has to take over the driving task. Currently, L3 ADS for urban roads has not been impremented yet, but is under research or development. On urban roads, the need for take-over caused by urban specific factors is possible because due to various traffic situation resultant of many kinds of traffic participants and behaviors that an ADS can encounter. When take-over occurs on urban roads, risks that have not yet been seen may appear. For this reason, collecting knowledge in this research field is necessary. A lot of research on Human machine Interface (HMI) for ADS which aim to improve take-over performance has been conducted, but less research has been focused on urban roads or effects of HMI on driving behavior in terms of psycological pressure.

In this research, we focused on HMI for take-over scenarios of L3 ADS on urban roads, and discussed HMI design requirements for safe and smooth take-over. In order to discuss HMIs, we used the “choking under pressure” appraoch. Choking under pressure is a phenomenon that produces poorer performance compared to usual conditions when a human conducts a task in high-stake situations. In this paper, we hypothesised that some information provision methods lead to the choking under pressure phenomenon, and decreases a drivers' take-over performance as a result. We proposed three types of HMIs with different level of choking under pressure, and we evaluated their effects in terms of safe and smooth take-over.

As an experimental scenario, we set up a scenario in which ADS could not recognize the color of traffic lights at an intersection, resulting in a take-over request. In such a situation, smooth driving can be achieved if a human driver takes over driving and passes through the intersection. In addition, a scenario was set up in which the driver needed to overtake a parked car immediately after passing through the intersection. For the experiment, we set up three HMIs (Fig.1); a basic RtI (Request to Intervene), which only requests take-over, RtI with behavior suggestion, which suggests pedal operation and steering in addition to basic RtI, and RtI with deviation from target course, which presents support information on pedal operation, steering timing, ego vehicle position, and velocity adjustment. Driving performance was then compared when each HMIs was presented in the take-over scenario.

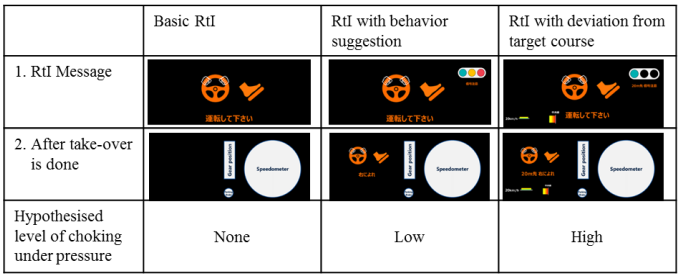

Fig.1 HMI design

In the analysis of the experimental results, we focused on lateral distance from the parked car and velocity distribution between after take-over and overtaking the parked car. The results showed that RtI with behavior suggestion may promote safer and smoother take-over than basic RtI and RtI with deviation from the target course, because lateral distance from the parked car was larger and velocity was more stable with RtI with behavior suggestion. Therefore, it is suggested that the influence of choking under pressure should be considered when designing HMI for take-over scenario, because excessive driving assistance may cause poor performance.

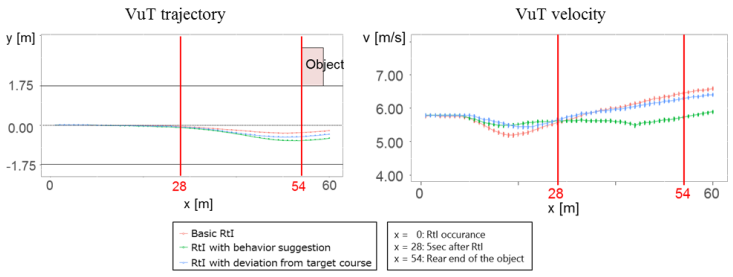

Fig.2 VuT (Vehicle under the Test) trajectory and velocity distribution