Detection of Safety Checking Actions at Intersections Significant for Patients with Cognitive Dysfunction

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Short Resume of the Presenter

- Tomoji Toriyama received the B.E. and M.E. degrees in electrical engineering from University of Toyama, Japan in 1985 and 1987, respectively. In 1987, he joined Nippon Telegraph and Telephone Corporation. He received the PhD degree in information engineering from Toyama Prefectural University, Japan in 2005. From 2005 to 2008, he was group leader of ATR Knowledge Science Laboratories, Japan. From 2008, he has been a professor at Toyama prefectural University.

Research Interest of the Presenter

- His research interests include intelligent environments, computer mediated communication systems, and supporting systems for elders. He is a member of the Institute of Electronics, Information and Communication Engineers, the Information Processing Society of Japan.

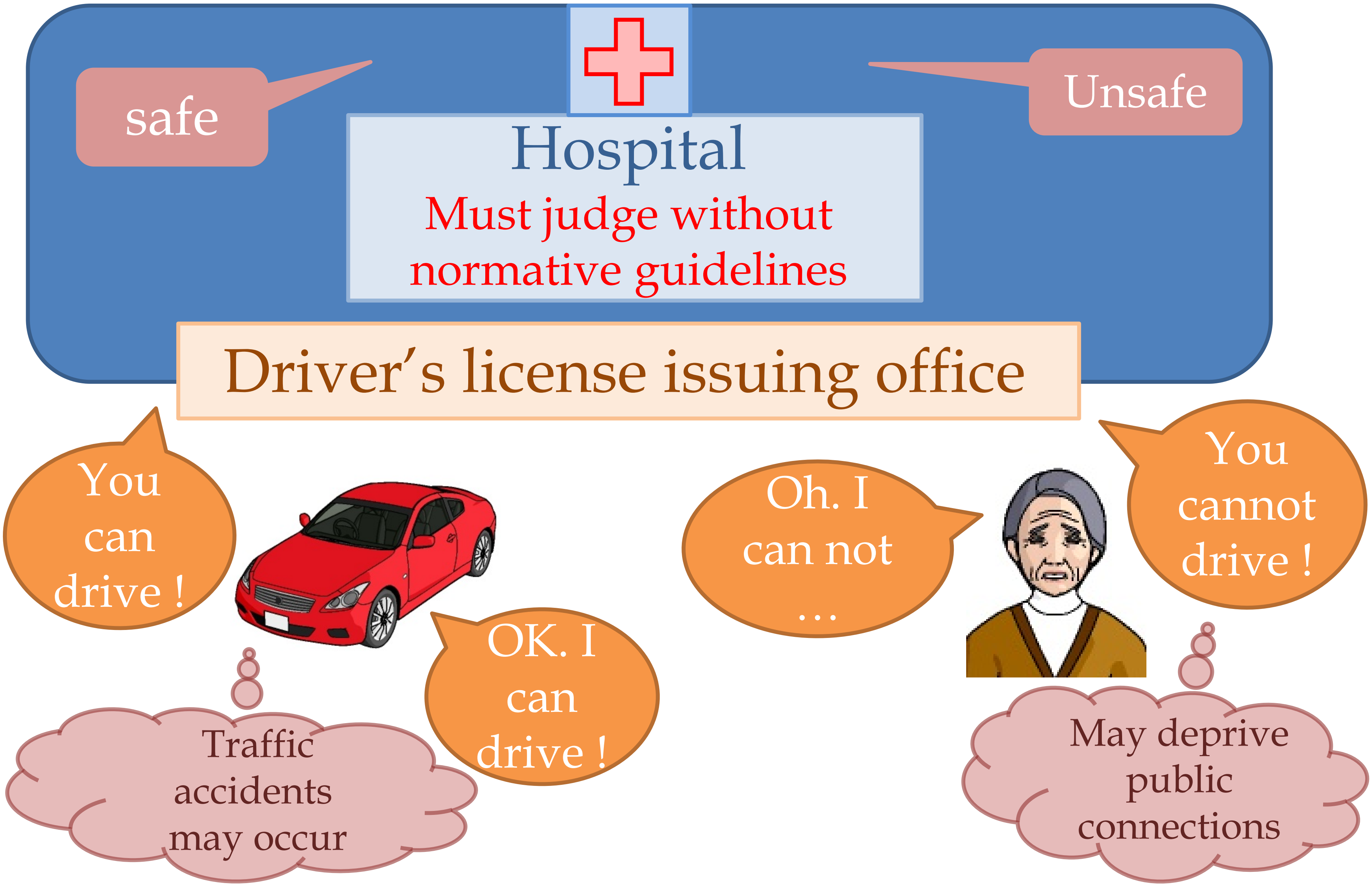
What is Cognitive Dysfunction?

Some cognitive symptoms caused by various diseases or injuries.

- Memory disorder
- Attention disorder
- Executive dysfunction

Unsafe driving

Unable to Judge the Driving Skill precisely



Features of Evaluation Method

No standard guidelines for judging driving aptitude

Neuropsychological Examinations

- Mini-Mental State Examine test (MMSE)
- Wechslor Memory Scale-Revised logical memory test (WMS-R)
- ....

• The correspondence relationship between symptoms and unsafe driving is uncertain

Driving Simulators

- Reaction time to sudden dangers on the road
- Avoidance operations such as braking and steering
- ....

• Not providing a sense of acceleration
• Limited visual resolution and coverage angle of the display.

Our Aim

- Finding Cognitive Dysfunction patient's unsafe driving with small wireless sensors attached to the driver and the car.

- Already developing an unsafe-driving detection system using same sensors.
  - For lane changing operation, deceleration for planned slowdown [1]
  - For safety-checking on parking [2]

- In this study, focus on safety-checking actions at intersections.

[1] T. Toriyama, A. Urashima, and Yoshikuni, Detection System of Unsafe Driving Behavior Significant for Cognitive Dysfunction Patients, HCI International 2017 – Posters' Extended Abstracts. HCI 2017. Communications in Computer and Information Science, vol.713, pp.391-396, 2017.
[2] T. Toriyama, A. Urashima, and T Kanada, Detection of Checking Action on Parking Significant for Cognitive Dysfunction Patients, HCI International 2018 – Posters' Extended Abstracts. HCI 2018. Communications in Computer and Information Science, vol.713, pp.404-409, 2018.

Related Work: Evaluation on using Real Car

- Unstable driving was detected on curve and straight road[3]
- Facilitating the safety behaviors with social support was tried[4].
  - Motions of the car do not always represent unsafe driving.
- Unsafe driving of elderly drivers was detected [5].
  - Limited to the behavior with motion of arms.

[3] Y. Sumida, M. Hayashi, K. Goshi, and K. Matsunaga, “Evaluation of Unstable Driving Using Simple Measurement Device on Driving Behavior”, Information Processing Society of Japan, Vol. 57, No. 1, pp.79-88, 2016(in Japanese).
[4] H. Chin, H. Zabihi, S. Park, M. Y. Yi, and U. Lee,"WatchOut: Facilitating Safe Driving Behaviors with Social Support", In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '17), pp. 2459-2465, 2017, doi:10.1145/3027063.3053188
[5] C. Bi, et al., "SafeWatch: A Wearable Hand Motion Tracking System for Improving Driving Safety", ACM Trans. Cyber-Phys. Syst. 4, 1, Article 13 (November 2019), 21 pages.doi:10.1145/3360323

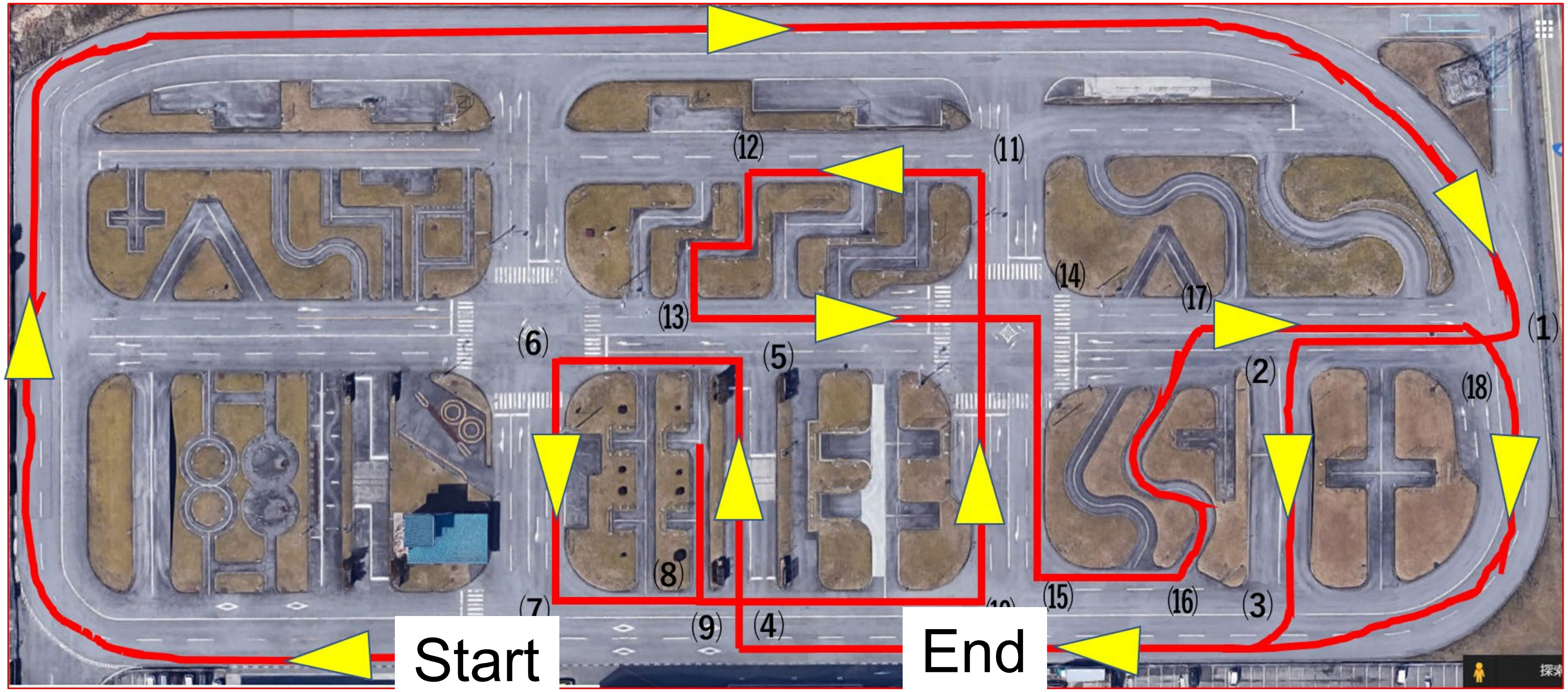
Proposal Overview
(To judge the safety-checking with GPS and small wireless sensors)

1. Use GPS and small wireless 3-D gyro and acceleration sensor to capture the driver's behavior.
2. Do the experimental driving for the cognitive disfunction patients/non-patients with sensors attached on their head and car.
3. Analyze the behavior of drivers on experimental video. Then check the safety-checking timing and common feature of drivers' behavior on safety-checking.
4. Judge the safety-checking with threshold angle value decided from the behavior feature of drivers.
5. Confirm the difference on the count of safety-checking action between the patients and non-patients.

Evaluation Environment (sensors)

Evaluation Environments (driving course)

- Toyama Driving Education Center, Japan with various types of intersections
- All subjects equipped with wearable wireless sensors
- Subjects: male and female between 20 – 60 years old
- 13 without cognitive dysfunction and 14 with cognitive dysfunction who was positioned on the border to be allowed to restart driving after the examination in the hospital.
- Multiple video cameras were installed inside and outside the car
- Driving instructor sit beside the driver



Result of Subjective Evaluation with Video

- Almost of all safety-checkings have done before the entrance of intersections
- Head angle becomes bigger as the drivers approach to the intersection.
- When the drivers check for left-turn collision, they also conduct left forward checking

Result of Subjective Evaluation with Video

- For all checking points on all intersections, evaluators judged safety-checking, and half of evaluators confirmed significant difference on their results
- Focusing on left side checking on left-turn, confirmed a similar result.

evaluator#	T-test (for all checking on all intersections)	T-test (for left checking on left-turn)
1	$t(25) = 2.105$, $p = 0.023$	$t(25) = 1.912$, $p = 0.033$
2	$t(25) = 1.665$, $p = 0.054$	$t(25) = 2.206$, $p = 0.018$
3	$t(25) = 1.458$, $p = 0.079$	$t(25) = 1.806$, $p = 0.042$
4	$t(25) = 0.455$, n.s.	$t(25) = 1.158$, n.s.
5	$t(25) = 0.517$, n.s.	$t(25) = 0.906$, n.s.
6	$t(25) = 0.122$, n.s.	$t(25) = 0.546$, n.s.

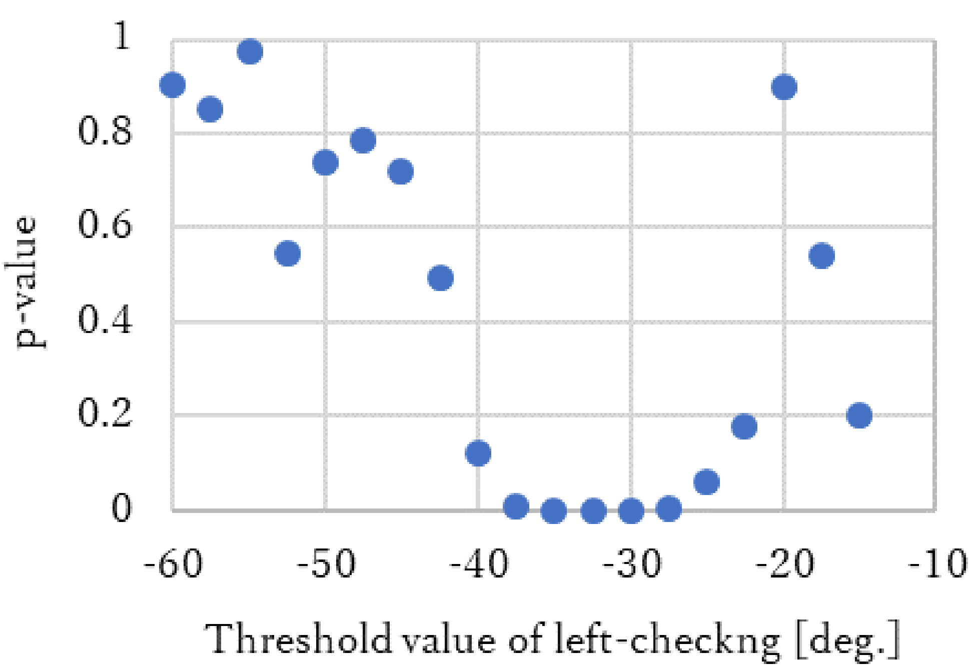
Estimation of the Safety-checking

From the result of subjective analysis. The estimation method of safety-checking is decided as follows

1. Including the margin, determine the start/end time from the time of GPS data nearest to the point that is 30m before entering/5m after exiting the each intersection.
2. If end time exceeds the next start time, the start time is updated to the time that is 5m after exiting the previous intersection.
3. Estimate the straight-running based on the variation of direction(from the point that the car directions are within ±5degree to the point that the car direction becomes more than ±15degree) and extract the time range of the straight-running.
4. Exclude the case that the car did not go straight for a sufficient time (3 seconds).
5. Define the angle of left-checking as the maximum angle of the head direction to the left in the range of the straight-running.
6. The head direction in the car can be calculated by subtracting the car yaw angle from the head yaw angle.

Result of Sensor based Evaluation

- For 27 subjects on 12 left-turn intersections, from the -60 deg to -15 degree (60 to 15 degree to the left) threshold angle, all safety-checking actions on the intersections were judged.
- While head angle values are from -37.5 to -27.5 degree (37.5 to 27.5 degree to the left), significant difference was confirmed on the count of the judged safety-checking by chi-square test.
- At the head angle value of -32.5 degree, significant difference was confirmed by T-test. $t(20) = 1.8276$, $p = 0.0413 < 0.05$.



Discussions

- Difficulties to get the common safety-checking action that can be used to separate patient and not patient.
  - Various parameters of intersection exist which may affect the safety-checking behavior of drivers.
  - Some ways of safety-checking exist such as direct/via mirror checking and more/less head movement.
- Proposed safety-checking action detection method and system may need improvements.
  - The angle calculation method may have calculation error, because it calculates under the assumption of gravity acceleration is always constant and the direction is always vertical to the ground. It has possibilities to cause errors when the car is accelerating or curving.
  - Remove the influence of the sensor noise , the calculation error and the natural small steering offset of the car, the direction angle values which determine the time range of the straight-running has big margins.
  - At the moment, manual resetting of driver’s head angle on every intersection is required. In order to reset automatically, the average head angle before the intersections might be used.
- Not sufficient data
  - Difficult to conduct the experiment with sufficient number of drivers who are on border to restart driving. However, statistical analysis requires sufficient experiments.

Summary

- We propose the method to evaluate safety-checking at intersections that can use for judging the driving aptitude of patients with cognitive dysfunction
- Using GPS and small wireless sensors safety-checking actions of drivers can be judged automatically.
- Significant difference was confirmed on the count of the judged safety-checking between the patients and non patients.
- However, under current situation, proposed safety-checking judging method and system may need some improvements.