"Text + Eye" on Autonomous Taxi to Provide Geospatial Instructions to Passenger

Xinyue Gui
The University of Tokyo
Tokyo, Japan
xinyueguikwei@gmail.com

Ehsan Javanmardi
The University of Tokyo
Tokyo, Japan
ejavanmardi@g.ecc.u-tokyo.ac.jp

Stela H. Seo
Kyoto University
Kyoto, Japan
stela.seo@i.kyoto-u.ac.jp

Vishal Chauhan
The University of Tokyo
Tokyo, Japan
vishalchauhan@g.ecc.u-tokyo.ac.jp

Chia-Ming Chang
The University of Tokyo
Tokyo, Japan
info@chiamingchang.com

Manabu Tsukada
The University of Tokyo
Tokyo, Japan
mtsukada@g.ecc.u-tokyo.ac.jp

Takeo Igarashi
The University of Tokyo
Tokyo, Japan
takeo@acm.org

Figure 1: Left part shows the apparatus of our prototype. Middle part shows one of our study scenario 1. Right part shows our user study environment. All people in this figure agreed to appear in the paper.

Abstract

While text-based external human-machine interface (eHMI) is widely accepted, one limitation is the lack of capability to communicate spatial information such as a different person or location. We built a mixed-eHMI using "eye" as a target-specifier when "text" shows the clear intention to their communication partners. We conducted a pre-experimental observation to develop two testbed scenarios, followed by a video-based user study via life-size projection with a real-car prototype mounted a text display and a set of robotic eyes. The results demonstrated that our proposed "text + eye" combination may represent geospatial information by increasing the success pick-up rate.

HAI '24, November 24–27, 2024, Swansea, United Kingdom

ACM ISBN 979-8-4007-1178-7/24/11
https://doi.org/10.1145/3687272.3690906

CCS Concepts

• **Human-centered computing** → **Empirical studies in interaction design**.

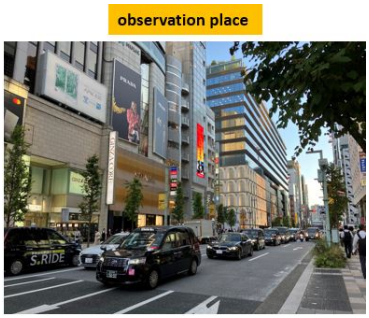
Keywords

mixed-eHMI design, geospatial information

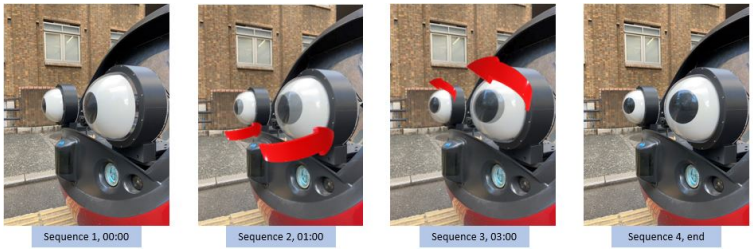
ACM Reference Format:
Xinyue Gui, Ehsan Javanmardi, Stela H. Seo, Vishal Chauhan, Chia-Ming Chang, Manabu Tsukada, and Takeo Igarashi. 2024. "Text + Eye" on Autonomous Taxi to Provide Geospatial Instructions to Passenger. In *International Conference on Human-Agent Interaction (HAI '24), November 24–27, 2024, Swansea, United Kingdom.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3687272.3690906

1 Introduction

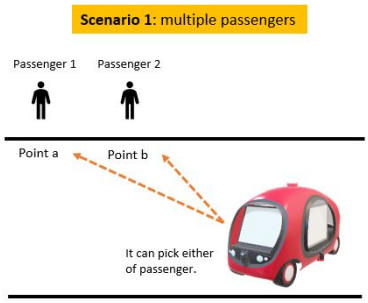
External human-machine interfaces (eHMIs) is a research topic that has emerged with the development of self-driving technology. The eHMI can inform pedestrians about the intentions of autonomous cars when there is no driver. In recent years, researchers have investigated many modalities for eHMI [3, 7], such as text, smile, light, eye, gesture [1, 2, 6, 7].



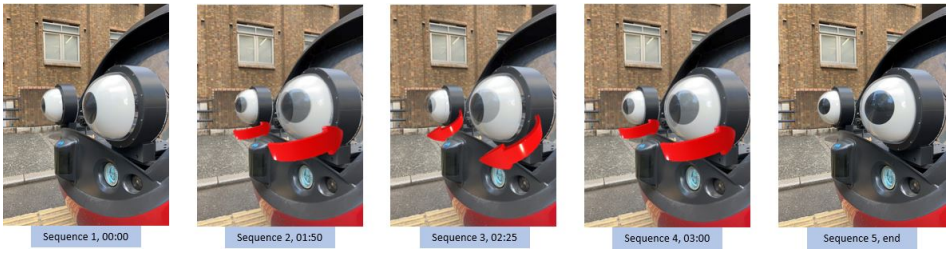
(a) Ginza area, Tokyo, japan



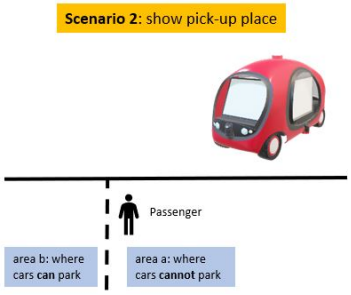
(b) Eye motion for scenario 1. Because of the long distance from the car to the passengers, the eye movement is small to distinguish between sequences (it is about 5-degree at most).



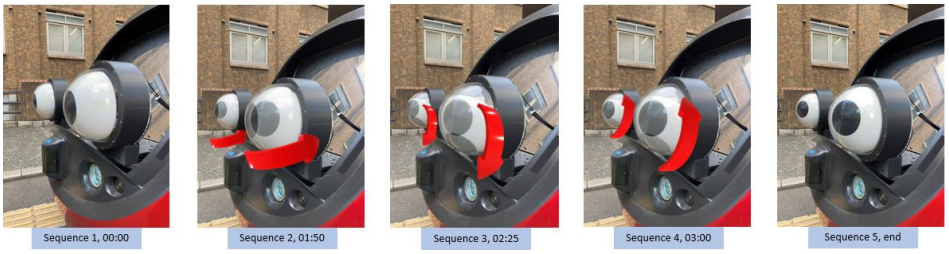
(c) multiple passengers waiting for taxi



(d) Eye motion for scenario 2, when the passenger is standing at the location where the car cannot stop (area a, Figure 2). The taxi indicates that it wants the passenger to move to the location (area b).



(e) cannot stop at the planned place



(f) Eye motion for scenario 2, when the passenger is standing at the location where the car can stop for them (area b, Figure 2). The taxi wants the passenger to stay where they are.

Figure 2: Left is the observation place and designed two testbed scenarios. Right is three Eye motions designed for our two scenarios. Red 3D arrows show the motion of the eyes.

In this research, we explore the interaction with passenger and autonomous taxi [5, 16]. Currently, the traditional taxi-to-passenger interaction can be successful due to the collaboration between the ride-hailing apps and text-based eHMI, such as the small plate show "vacant" on the corner of taxi windshield. When considering the autonomous taxi, they has the limitations. As for the smartphone apps, it tell the position of the taxi, but they do not tell the specific pick-up place determined temporarily. As for the text-based eHMI, when there are multiple pedestrians, it cannot indicate the communication partner. To solve those limitations, we propose combining "text" and "eye" in the eHMI and allowing them to play to their strengths as past mixed-eHMI research did [2, 13–15, 17]: using "eye" [9–11] to specify the geospatial information when "text" [2, 4, 8, 12] expresses the car's clear intention. We conducted a two-step experiment. First, we carried out a pre-experimental observation in the Ginza shopping district and observed two cases (Figure 2 left) where geospatial information is critical in the communication.

We mounted a set of robotic eyes and a standard monitor on a real car (Figure 1). For each scenario, we displayed the text content on the monitor and designed the 3-second eye motion. For the eye motion, we calibrated the eye angle and timeline through our in-house blender-based software (Figure 2, right). Then, we conducted a video-based evaluation. We manually drove the car, lit the text monitor, and activated the large robotic eye to rotate as our designed motion to shoot the videos. During the user study, a participant watched the video via a life-size projection in a big room and was interviewed after. In summary, our work has three contributions:

- two testbed scenarios designed and potential challenges identified through our observational study;
- a novel combination pattern making each modality express different information being explored;
- and run a user study with physical implementation for the mixed-eHMI show how it expressed geospatial information.

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