

# Avatar Technologies of Team LAST MILE Toward Mobile Smart Device Operation Service

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**Abstract**— The realization of practical teleoperation services can solve the social problem of uneven population distribution, enabling anyone to live/work where and with whom they want to live. We introduce two main strategies of technology development for this purpose: 1) simple and intuitive vision-based operation technology integrated with mobile smart devices, and 2) augmented avatar technology that can be flexibly designed to complete diverse set of tasks.

## I. INTRODUCTION

AVATAR technology is expected to be able to solve the uneven distribution of the working population. Our team “LAST MILE” strives to realize a tele-operation service that enables anyone to live and work where and with whom they want (Fig. 1). In this paper, we introduce two main strategies developed to make this service reality: 1) a simple and intuitive vision-based operation technology using human cognitive characteristics [1]; and 2) an augmented avatar technology, which can be flexibly designed for each task by separating the “mind” and the “body” of the avatar. Our team LAST MILE was ranked 12th place in the XPRIZE/AVATAR competition, in which 820 teams participated over the world, even though we did not rely on any intuitive humanoid robots or head mount displays (HMDs) [2][3].

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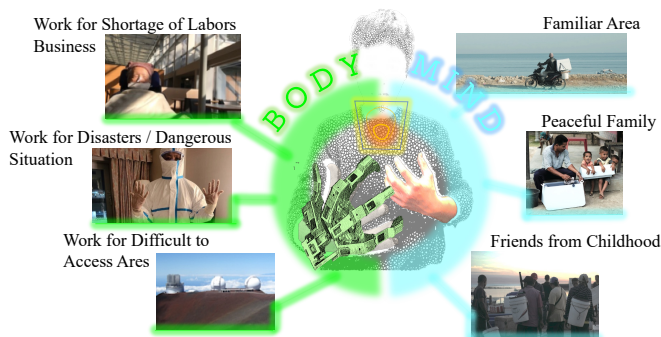


Figure 1. Envisioning future of team LAST MILE.

## II. AVATAR TECHNOLOGIES OF TEAM LAST MILE

### A. Vision-Based Operation

In order to use mobile smart devices as an operating interface, it is of importance to transmit motion information from the operator to AVATAR and sensory information from AVATAR to the operator via the device's monitor as much as possible. For this purpose, we have developed the following four vision-based information transfer techniques and a step-by-step automation technique to reduce the operator's workload (Fig.2).

- **Visual Haptics**

Focusing on the cross-modal phenomenon between human vision and force haptics, we have developed a visual haptics technology that presents force haptic information from AVATAR with augmented reality (AR) at the point of contact. We have confirmed that this technology has a significant benefit by brainwave analysis [4][5].

- **Human Eye Display**

This technology creates more natural visions by adjusting the resolution of the central and peripheral fields of view according to the task and condition. The central and peripheral fields of view are important for manipulation tasks and movement, respectively [1].

- **One-Click Operation**

This technology enables the user to move and approach the arm by tapping on the touch panel monitor. Currently, this technology is evaluated with a mouse click as a preliminary implementation [3].

- **Eye Contact**

Linking a smartphone camera to an extended monitor enables natural eye contact without being aware of the camera [2][3].

- **Human to Automated Operation**

Multiple task operations are segmented into sub-tasks. By gradually automating the tasks step by step, starting with the subtasks that can be automated, the operator's load can be reduced and one operator can operate multiple machines concurrently [1].

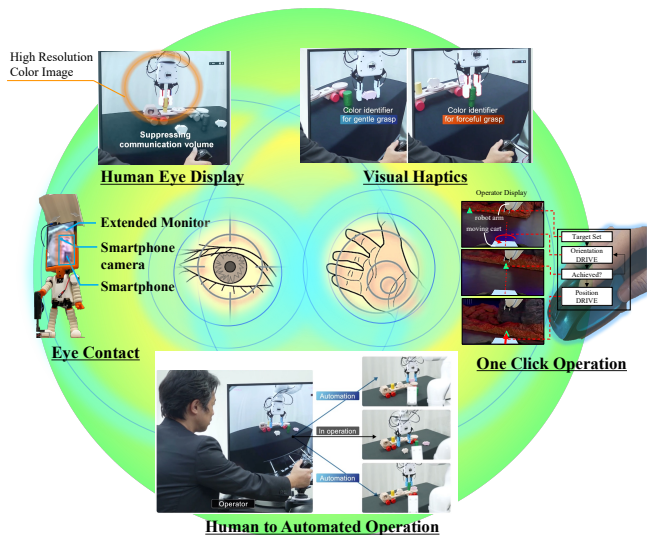


Figure 2. Developed vision-based operation technologies.

### B. Augmented Avatar

We propose an "Augmented Avatar" as a teleoperation system that reconstructs human functions by combining each Avatar after independently designing two functions, "body" and "mind," of human manipulation and communications [3]. The "Augmented Avatar" can be designed with the minimum set of necessary and simple specifications for each function, enabling a low-cost system. The function-specific Avatar designed for each function can be reused in multiple applications, thus improving design efficiency. In addition, when the system is operated in an environment where people are nearby, it is possible to operate the teleoperation system with the "Communication Avatar" while ensuring safety by turning off the power of the "Manipulation Avatar" with high-power motors. The proposed Augmented Avatar has the following features.

- Flexibility and reusability of each functional avatar because of independent designs as manipulation avatar, that is "body" and communication avatar, that is "mind."
- Safety for people around the Augmented Avatar by inactivating the manipulation avatar while communication avatar is working.
- Relatively low cost against humanoid robots.



Figure 3. Proposed augmented avatar and prototype for XPRIZE/AVATAR.

### III. RESULT OF TEAM LAST MILE IN XPRIZE/AVATAR

Our LAST MILE entered XPRIZE/AVATAR by utilizing some of the aforementioned technologies. In the XPRIZE/AVATAR Final, first-time operators were given a 60-minute lecture on the operation of the system, and then tested at a site that was opened to the public two days prior to the event. The test consisted of 10 tasks in series, and if any of the tasks could not be completed, the test ended there. Teams were narrowed down each day for three days, including the final qualification check. Our team managed to stay in the competition until the last day, and finished at 12th out of 820 teams worldwide. Nimbro from Germany, Pollen Robotics from France and Team Northeastern from United States of America won the competition by a landslide [6][7][8]. Although our interface was simple, it did not reach the performance of the top teams at all. It was not sophisticated enough for operators to learn the differences in body structure in the limited time of 60 min, and there were issues with depth perception presentation in the two-dimensional image. Participating in the competition was a great accomplishment for us to recognize the difference from the world's best performance.

### IV. CONCLUSION

Aiming to realize teleoperation technology that can work beyond space as a solution to alleviate the uneven distribution of population, we introduced a set of technologies that enable vision-based operation to make a mobile smart device an operating interface that anyone can use. We participated in the XPRIZE/AVATAR competition, and at the final held in Los Angeles in November 2022, we were ranked 12th place in the world among the 820 teams participating at the beginning of the competition, and the highest ranked in Japan. We believe our team can keep enhancing the development to launch a service that enables remote employment.

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