Application for a Personal Mobility Sharing System Using Two-Wheeled Self-balancing Vehicles

Naohisa Hashimoto(✉), Kohji Tomita, Akiya Kamimura, Yusuke Takinami, and Osamu Matsumoto

Intelligent System Research Institute,
National Institute of Advanced Industrial Science and Technology (AIST),
1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, Japan
{naohisa-hashimoto,k.tomita,kamimura.a,
matsumoto.o}@aist.go.jp

Abstract. To solve urban area traffic problems, one potential solution is to reduce traffic volumes. In order to do so, a modal shift from conventional passenger vehicles to public transportation and eco-vehicles, including personal vehicles, should be considered. We propose a personal mobility sharing system using the Segway. To evaluate this system, it is necessary to perform experiments under real conditions and gather experimental data for a social pilot study. This study introduces an application for a personal mobility sharing system using the Segway-type vehicle. The main feature of the proposed application is to gather and store experimental data on mobility sharing, and to assist a driver to use the Segway-type personal vehicle safely. Each vehicle is equipped with a tablet, on which the application is installed.

Keywords: Personal mobility · Mobility sharing system · Pilot study · Intelligent transportation system

1 Introduction

One potential solution to urban area traffic problems is reducing traffic volumes. To achieve this goal, a modal shift should be considered from conventional vehicles to public transportation and eco-vehicles, including personal vehicles. In this study, we focus on personal mobility and vehicle sharing to reduce traffic volume. Bicycle sharing projects have been initiated in the United States, France, and a few other countries. In the United States, several bicycle sharing projects are being widely used [1–6]. In Japan, a community cycle project organized by a local city government was initiated in a sightseeing area [7]. Such sharing systems are expected to be used for new and eco-transportation programs.

The rapid increase in the elderly population has caused several issues in Japan. Elderly people (above 65 years) in Japan have accounted for more road fatalities than any other age group, as shown in Fig. 1 [8]. The number of fatal accidents due to elderly drivers has increased nearly three-fold in the past 17 years, while the total number of fatal accidents has decreased by nearly 30 % during the same period [8].

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Automobiles are the optimal transportation means for the elderly because they provide door-to-door transportation. However, a shift to public transportation from individual automobiles is required in order to solve current traffic problems. To resolve this problem, convenient and eco-friendly transportation must be provided for elderly people. Public transportation is convenient and eco-friendly, but the last-mile problem of getting each individual to their front door remains, especially for elderly people [9, 10]. To solve this last-mile problem, personal mobility is considered the only option.

To solve the two challenges of reducing traffic in urban areas and supporting elderly drivers, we propose mobility sharing with personal vehicles [15]. The main objective of this study is to evaluate the possibility of a mobility sharing system with two-wheeled self-balancing vehicles, and we have constructed an application for such vehicles in a personal mobility sharing system. The application is installed on a tablet equipped on each vehicle. The main feature of the application is to gather and store experimental data on mobility sharing, and to assist a driver to drive the vehicle safely in a real environment. The Tsukuba designated zone, sharing system, and the application for the system are described in this paper.

The Segway is trademarked by the Segway Inc. of New Hampshire, USA.

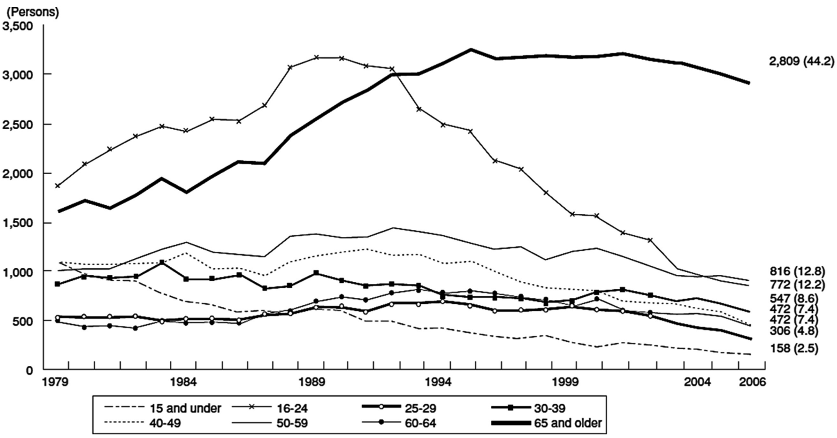

Fig. 1. Number of traffic accident fatalities in Japan by age group

2 Tsukuba Designated Zone for Experiments

As personal mobility is categorized as robotics in Japan, study experiments were performed in the Tsukuba designated zone [11], which was officially approved by the cabinet office in Japan on January 29, 2010. As of February 2012, Segway Japan, Hitachi Corporation, and the National Institute of Advanced Industrial Science and Technology (AIST) are all engaged in conducting personal mobility experiments.

Our experiments were conducted in the Tsukuba Center area, shown in Fig. 2. The terms, detailed roles of various operations in the experiment, and the definition of the

Fig. 2. Tsukuba Center area (zone bounded by the red line)

robot used in this experiment were established [11]. Existing regulations for conducting experiments in the Tsukuba designated zone [11] made it necessary to classify the personal vehicle experiments as a pilot study in order to control the regulations.

3 Application for Standing-Type Personal Mobility Vehicle

The purpose of our proposed personal mobility sharing system [15] is to facilitate transportation between the AIST building and the Tsukuba station, which is the nearest train station. The concept of the proposed system is similar to that of a bike- or car-sharing system [12–14], but personal mobility devices are used instead of other transportation options, and several types of data are tracked using sensors. We chose the Segway two-wheeled self-balancing vehicle [16] for our study, and introduced an application for our proposed sharing system. The application gathers experimental data including near-incident scenes and assists the driver to drive the personal mobility vehicle safely in real-world experiments. Because Segway-type vehicles have not yet spread in Japan, a large amount of experimental data will be necessary in order to evaluate the safety and the availability of these types of vehicles. In addition, Japanese drivers are inexperienced in driving Segway-type vehicles; thus, some assistance is required to ensure driver safety. Each vehicle is equipped with a tablet, in which the application is active. The tablet also has a GPS, acceleration sensors (X, Y, and Z), gyro sensors (yaw, pitch, and roll) and magnetic sensors, as shown in Figs. 3 and 4. The application shows the status information as follows:

1. Current map location. (Awareness of the current location is important for performing experiments in the designated zone, since experimental activity outside the designated zone is prohibited.)
2. Current time, departure place and time, and destination place and time.
3. Sensor information (acceleration, gyro, magnetic, and GPS).
4. Current driving status (estimated using the acceleration and gyro data) shown in Fig. 4. The application has four types of data sets and identifies the current status using the Block Sparse-Sparse Representation Classification method [17]. This algorithm can estimate a current status with more than 90 % accuracy.

Fig. 3. Notifications estimated by the application (top-left: the application notices the driver is outside the planned route; top-right: the application shows a navigation route to a destination; middle-left: the application warns of a rough road; middle-right: the application notes the miles between the destination and the current location; bottom-left: the application notes that the driver is outside the zone; bottom-right: the application warns of dangerous driving)

5. Navigation information, as shown in Fig. 4.
6. Image captured from front camera.

In addition, the application stores all sensor data including the camera image.

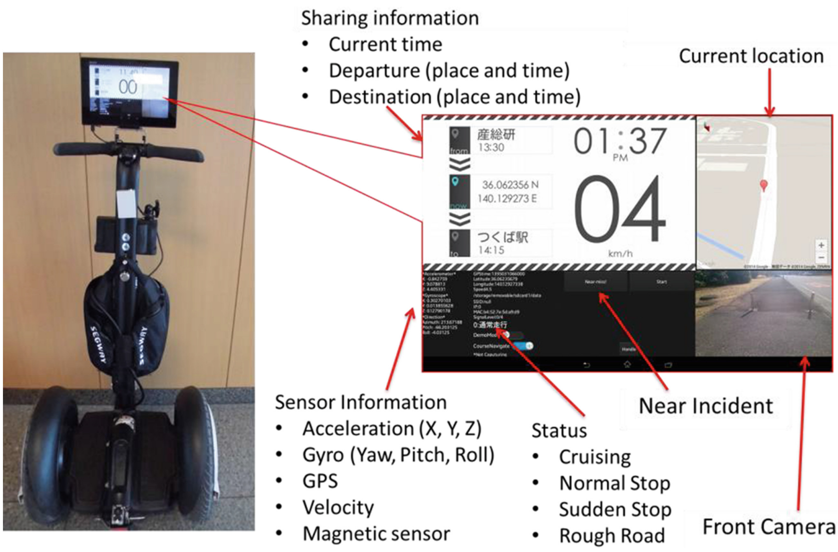

Fig. 4. Experimental vehicle and a screen capture of the application

4 Summary

We introduced an application for a personal mobility sharing system using a two-wheeled self-balancing vehicle. Experiments were conducted in real-world conditions to evaluate the system's potential. The application gathered experimental data and assisted the driver in driving the personal mobility vehicle safely. The functions of the proposed application included the awareness of the experimental area, the provision of warnings about dangerous driving situations, showing the current location and distance to destination, and obtaining and storing experimental data. We also plan to expand this personal mobility sharing system by increasing the number of personal mobility routes and stations for future experiments in different environments, and to perform future experiments with several types of subjects.

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