Development of Vehicle-to-Pedestrian Communication Technology

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1. Introduction

Aiming to reduce the number of traffic fatalities in Japan to under 2,500 by the year 2018, this project contributes to Japan's national objective of becoming the world's safest traffic society by the year 2020. As the vision of autonomous self-operating vehicles moves closer to reality, development of new technologies to avoid collisions with pedestrians and other accidents will become increasingly important. Here we describe several initiatives that will contribute to this goal.

More specifically, our work focuses on R&D of a vehicle-to-pedestrian communication system that cuts down on accidents involving pedestrians, cyclists, etc. that occur at blind intersections and other places with poor visibility through the exchange of positional data between pedestrians and approaching vehicles. The project involves two basic R&D components: a direct communication scheme permitting pedestrians to communicate with on-board systems using a dedicated pedestrian terminal, and use of a mobile phone type network over a widely deployed mobile phone network. With these two components, direct communication would provide early warnings while the mobile phone network would provide useful data for preventing traffic accidents on roadways with the full range of vehicles and other users—cars, trucks, pedestrians, cyclists, electric wheelchairs, etc.—based on a variety of data stored in the past and present.

2. R&D Issues and Fiscal 2014 Research Results

2.1 Direct Vehicle-to-Pedestrian Communication Technology

This project seeks to develop and deploy a vehicle-to-pedestrian communication system that averts traffic accidents through the exchange of positional information over dedicated terminals between pedestrians and approaching vehicles. The project has three basic components: (1) a technique for positioning pedestrians more accurately, (2) a pedestrian-vehicle communications protocol to be developed in parallel, and (3) proof-of-concept trials integrating the above two developments to assess and verify that the system actually mitigates collisions.

(1) High Positional Accuracy Technology

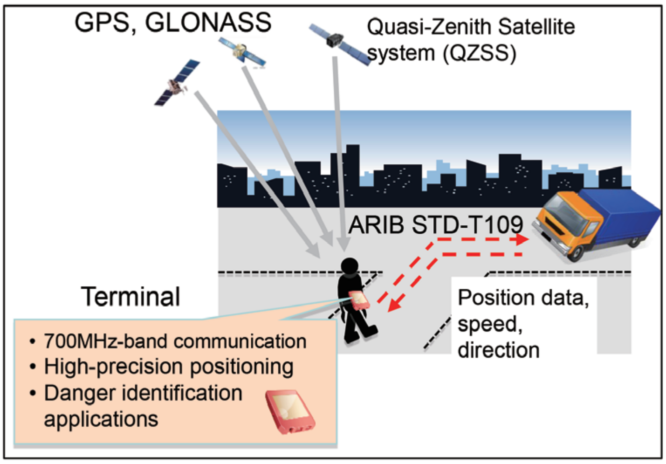
High positional accuracy of pedestrian terminals can be achieved by combining a number of techniques including compensation using L1-SAIF signals from quasi-zenith satellites, measures to correct for multipath errors, and pedestrian dead-reckoning that complements satellite positioning. Feasibility of the system was verified through experiments to assess the system's ability to identify danger and prevent accidents using "danger zone detection by maps", "detection of crossings based on the direction of movement and speed of pedestrians," and "relative positioning between vehicles and pedestrians". Positioning accuracy trials were conducted in fiscal 2014 using the quasi-zenith satellite to identify issues in environments with poor satellite reception, to evaluate traceability while moving, and to evaluate positioning performance in the height direction.

The results showed that the horizontal positioning error was 5-10 meters due to reflected waves between tall buildings and other urban obstructions, thus requiring measures to correct of multipath errors. We also found that vertical positioning by satellite had a large error, thus requiring an alternative approach. (Figure 1)

(2) Vehicle-to-Pedestrian Communication Protocol

To enhance the portability of the pedestrian terminal required a smaller more compact battery and a more energy-efficient 700MHz-band modem that is compatible with existing 700MHz-band vehicle-to-vehicle and vehicle-to-infrastructure communication systems. To meet these conditions, a new type of control was implemented that only operates 700MHz-band communications when required based on the state and

■ Figure 1: Overview of vehicle-to-pedestrian communication system



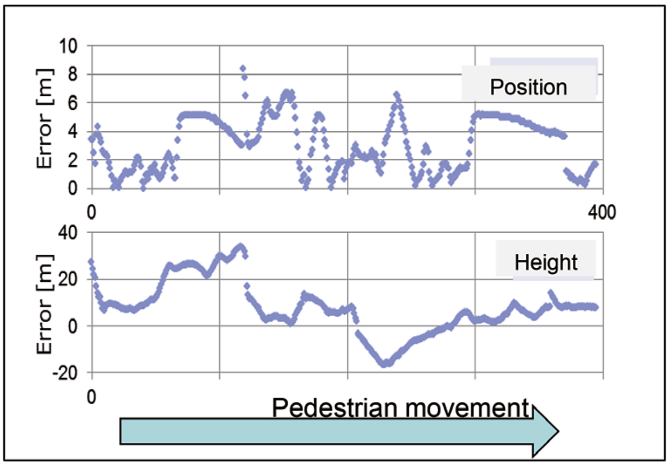
circumstances of pedestrians.

In fiscal 2014, we updated the message set of 700MHz-band communications in the pedestrian terminal to ensure compatibility with on-board terminal and to bring it into line with ITS FORUM RC-013 recommendations. We also implemented a new interface design for turning 700MHz-band communication on and off from outside the terminal, and verified that a Bluetooth (®)-based test model works properly. We confirmed that there is no interference between 700MHz-band communication and Bluetooth when both are operating simultaneously.

(3) Real-World Demonstration and Identification of Remaining Tasks

In fiscal 2014, a pedestrian terminal system was configured using three types of terminal equipment: dedicated terminals for positioning, smartphones, and 700MHz-band communication terminals. Field trials were then conducted on public roads in Yokosuka and Nagoya, and the system demonstrated good 700MHz-band compatibility between the pedestrian terminal and the on-board terminal even while using Bluetooth.

■ Figure 2: Positioning trial results (walking urban streets with quasi-zenith satellite)



■ Figure 3: Field trials: 700MHz-band terminals

2.2 Vehicle-to-Pedestrian Communication Technology Using a Mobile Phone Network

(1) Precision Vehicle-to-Pedestrian Detection System for Electric Wheelchairs

As an aging society with a falling birthrate, Japan can expect to see more and more electric wheelchairs and mobility scooters on the roads, and a growing number of traffic accidents. But if people could be warned of potential danger in advance, this could greatly reduce the number of accidents. This led us to propose a “motion detection system” that captures one’s position using GPS and field intensity to determine the degree of proximity between electric wheelchairs and pedestrians and/or cyclists who are all in motion, and finally notifies both parties of looming danger.

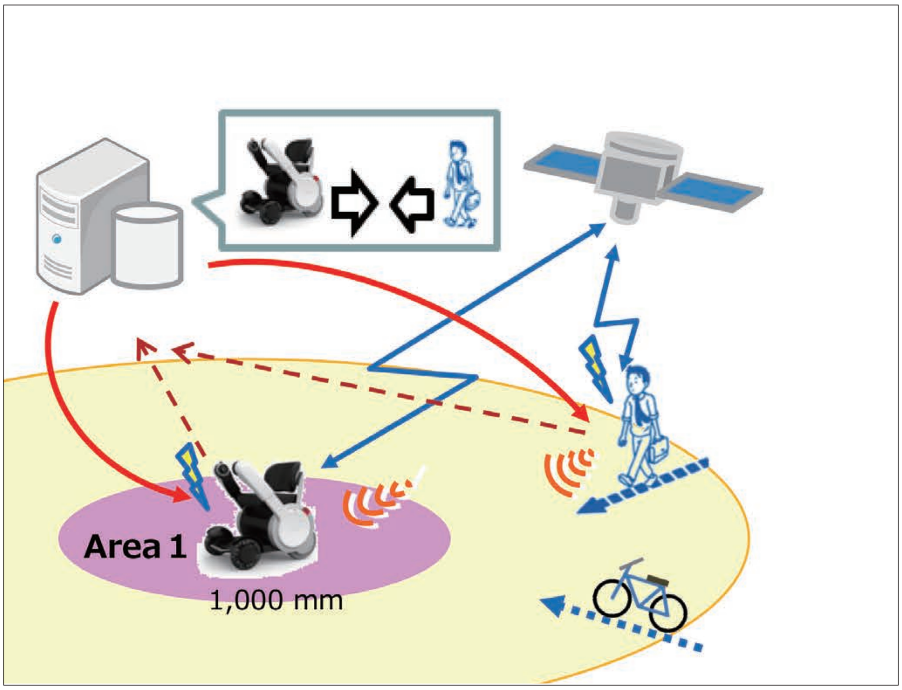
In fiscal 2014 we conducted basic experiments to measure relative position using Bluetooth Low Energy (BLE) field intensity and measure absolute position using GPS + quasi-zenith satellite (L1-SAIF (to reinforce the GPS signal)), and collect the data. We found that data revealing the direction from which an object is approaching a wheelchair (Area 1 in the figure 4) can be accurately positioned/estimated by GPS + quasi-zenith satellite, and a scheme for notifying the person in the wheelchair can be readily implemented by combining this data with BLE signal strength (or amount of variation). On the other hand, Area 1 in the figure 4 must be expanded to exploit the scheme as a danger detection system, and can only be realized by implementing a higher performance more effective combination by tuning the various measurement functions developed through this project.

(2) Information Collection/Distribution Using Web Technology over the Mobile Phone Network

Focusing on danger prediction and avoidance, this Web-based initiative will develop an efficient scheme for collection, analysis and distribution of next-generation probe data to achieve early implementation of a platform for collecting data from all kinds of vehicles and all kinds of roads. In fiscal 2014 we developed a system for collecting and analyzing speed and other driving data in the cloud using Web APIs that are now being standardized by the World Wide Web Consortium (W3C).

We evaluated the system over a one-month period by installing Web API-compatible smartphones on 100 taxis. As one can see in the lower portion of Figure 5, it took less than 5 seconds to upload the data (95% of total data) to the cloud even under very intense upload conditions of a one (1) second period,

Figure 4: Overview of the motion detection system



thus meeting our objective of providing danger predictions and warning messages at least 10 seconds before a potential accident might occur (upper portion of Figure 5).

Turning to pedestrian-related data, we are now investigating and verifying pedestrian-detection technologies based on images taken with an on-board camera and other related issues, while at the same time considering the level of privacy protection that is required by the legal system in developing setting functions.

3. Conclusions

As outlined in this paper, we successfully achieved all of our first year objectives as planned. Let us next consider the direction of planning and research next year and beyond. In order to implement a direct communication approach, we will reduce positioning errors by mitigating multipath errors, and develop ways of detecting danger zones using maps and dangerous situations such as pedestrians crossing the street. We will also develop a communication protocol and conduct proof-of-concept trials on actual roads to verify radio interference by measuring 700MHz-band cellular throughput in the presence of a 700MHz-band communication terminal as a source of interference, then analyze how to miniaturize the built-in antenna to make the terminal more compact.

We also intend to build a vehicle-to-pedestrian detection system for electric wheelchairs by implementing a position calculation scheme and a real-time notification scheme. Finally, we will analyze whether the system provides sufficient lead time to warn drivers in advance so they can take evasive action if necessary.

In pursuing a viable scheme for collecting and distributing data using web technology over the mobile phone network, we have greatly expanded next-generation probe data and developed protective features in line with Privacy-by-Design principles based on the development and verification initiatives carried out in fiscal 2014.

Figure 5: Top: Scope of Web technology development
Bottom: Fiscal year 2014 results