Title

Smartphone-based Talking Navigation System for Walking Training

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Abstract

We report on a development of smartphone-based talking navigation system, tactile map/trajectory creation system, and analysis of irregular motions in experiments with visually impaired pedestrians.

Section 1. Introduction

A variety of navigation applications for sighted pedestrians has been developed, as the popularity of smartphones grows. If such a device could be equipped with interfaces suitable for visually impaired pedestrians, it would become popular also among them, as it would provide them with increased senses of their surroundings [1].

Walking is known to comprise O & M (Orientation and Mobility) [2]. We have been advancing the research in order to assist both trainers and trainees on walking training and to realize quantitative evaluation on O and M skills for the training [3]. In the research, we deepened the qualitative understanding of relationship between the navigation system and a cane or guide dog. We also found out that obtained sensor logs by the navigation system and other wearable devices would quantitatively represent improvements of O & M skills. The evaluation indices included accuracy, safety, efficiency and anxiety.

However, in the last experiments [3], a specialized talking navigation system was used and participants of the experiments needed to carry several other devices for measuring sensor values and for recording them. It is possible to have a smartphone-based navigation system that have all functions other than to measure EEG and heart rate. The smartphone can have functions such as positioning, route guidance, distance/direction/landmark notification, and logging positions/motions and the guidance during walking.

Thus, in this paper, we report a development of a smartphone-based navigation system. We also report a map/trajectory creation system with which trainees can understand routes in advance and their accuracy of walking trajectories taken in experiments against desired routes. In addition, we discuss about analysis of irregular motions observed in the last experiments [3].

Section 2. Smartphone-based Talking Navigation System

First we introduce a smartphone-based talking navigation system, quipped with function to measure positions and motions during walking, with audio guidance and logging ability.

Hardware consists of a smartphone with 9 axis sensors (acceleration/gyroscope/electronic compass) such as Nexus 5 by SAMSUNG, and QZSS (Quasi-Zenith Satellite System) receiver by CORE CORPORATION. This enables audio navigation based on measurement of relative positioning by PDR [4], absolute positioning by GPS and high precision absolute positioning by QZSS. The talking navigation system is designed to work without, if needed, QZSS, considering limited operational time of a QZSS satellite.

Software is developed considering distribution and promotion of the software in the future. We adopted Free Open Source Software for Geospatial (FOSS4G) for development of the talking navigation system and map/trajectory creation system that will be explained in the next section. The OpenStreetMap (OSM) [5] is used to describe map information as much as possible.

Map and routes data are stored in a database using PostgreSQL and PostGIS [6]. A route search engine, pgRouting [7] working with the database, is used by the smartphone to search route from current and starting position to a goal. The OpenLayers [8], which is the map displaying library utilizing javascript and MapServer [9] that is a WebGIS engine, realizes displaying map information on the screen.

A TTS (Text to Speech) engine for Android, DocumentTalker, developed by the Create System Development Corp is used. Audio guidance is realized by the TTS using text, which is created based on result of route search gained through the pgRouting. Positioning program integrates date of PDR, GPS and QZSS to calculate position. All the calculation related to PDR is also performed on the smartphone.

Section 3. Tactile Map and Trajectory Creation System

In the experiment [3], tactile maps were used so that participants were able to understand the routes in advance. Tactile trajectories were shared with participants after each trials, in order to provide them with feedback of accuracy and degree of deviation of their taken routes. Based on interviews in the last experiment [3], we consider the feedback with tactile trajectory as an important and valuable method that helps participants to understand their performance instinctively.

Now, we briefly explain how tactile map and trajectory creation system works. OSM data, such as roads and buildings, is created by using JOSM (Java OpenStreetMapEditor) [10]. Then, Maperitive [11] is used for drawing bitmap images, based on the OSM data and positioning data from such as GPS and PDR. Finally, we create a tactile map/trajectory from the bitmap image printed on a paper with foaming agent, by using PIAF (a 3D copy machine by Amedia Corporation). It is important that this tactile trajectory creation system would enable us to provide an instant feedback to participants. It is because that tactile trajectory can be created only after obtaining trajectory data from an experiment, while tactile map can be prepared in advance.

Section4. Irregular Walking Motions during the Talking Navigation

Using the result from the last experiment [3], we analyzed relationship between number of observed irregular walking motions and timing of audio guidance made by the talking navigation system. In the last experiment, we found that percentage of audio guidance made was 40% against entire walking time period.

We manually counted number of the irregular motions by observing recorded videos. We defined five irregular motions as "Sudden change of direction while walking", "Sudden stop", "Staggering", "Sudden change in speed", and "making contacts with obstacle".

As a result, frequency of irregular motions occurred during audio guidance was 1.6 times per minute, and 0.5 times per minute otherwise. We found a statistically significant difference between two cases, $p=0.041$, by using Wilcoxon signed-rank test.

The interview in the last experiment [3] shows that the cognitive load for mobility is relatively low for walking with a guide dog as compared to walking with a cane. It leads to a hypothesis that pedestrian with a guide dog have more spare cognitively to manage the talking navigation.

However, there was no statistically significant difference found between walking with a guide dog and walking with a cane. Mann-Whitney U test between pedestrian with a guide dog and with a cane on entire walking time period is $p=0.138$, and the test on time period having audio guidance is $p=0.347$. There is a tendency that participant walking with a guide dog has lower frequency of having irregular motions, but we need further experiments with increased number of trials to make any conclusion.

Section 5. Discussion and Conclusion

In this paper, we reported a development of smartphone-based navigation system and map/trajectory creation system for walking training of visually impaired pedestrians. We also discussed about relationship between number of observed irregular walking motions and timing of audio guidance made by the talking navigation system.

From a discussion in section 4, we can hypothesis that there are strong relationship between audio guidance and irregular motions, and we have learned that it is important to consider content of audio guidance and timing when to provide audio guidance, and how these relate to quality of walking training. A remaining problem is to detect irregular motions automatically. If it is realized, the analysis of relationship between audio guidance and irregular motions would be done more efficiently.

We are designing evaluation indices such as accuracy (micro & macro), safety and efficiency (micro & macro), and a method to calculate scores of the indices automatically as well as methods to provide feedbacks of walking performance, including tactile map with his own trajectory. Then, we plan to conduct further experiment using all the system explained in the paper.

References

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