Outdoor Gesture Recognition System Using Accurate Absolute Position Coordinates

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Abstract. In this paper, we propose a gesture recognition system using accurate absolute position coordinates, which are acquired by an Real Time Kinematic Global Navigation Satellite System(RTK-GNSS) sensor. The RTK-GNSS sensor is not affected by sunshine and does not need to be calibrated; additionally, drift does not occur, even for long-term use. The system consists of an antenna, a 10-Hz RTK-GNSS processor, and a PC. The user wears the antenna connected to the processor on the back of the hand and may freely move the hand when the antenna receives satellites signals. As an experiment, we implemented gesture-sensing trials using our system to input a line and an arbitrary path. As a result, they were well observed with an accuracy on the order of a centimeter, even outside without any calibration. Through this experiment, our system has great potential to be used for gesture recognition system in flexible outdoor environments.

Keywords: Gesture sensing · GNSS · Outdoor environment · Absolute position coordinates · Wearable device

1 Introduction

Recently, various gesture recognition systems have been proposed for human–computer interaction using sensors such as a depth camera [1,2] and an accelerometer [3,4]. These systems are sold as products, even for end users, as a user interface. Additionally, the range of their applications extends from fixed indoor environments to flexible outdoor environments. However, the vision sensor has disadvantages due to sunshine, occlusion, and calibration for the extended environment. Moreover, the accelerometer has disadvantages due to drift, which results in a lower accuracy. On the other hand, the number of GNSS satellites is increasing [5], and the accuracy of the absolute position coordinates is improving more and more. A GNSS antenna has the advantage of outside use, and it complements conventional gesture sensing systems.

2 Method

Our gesture-sensing system is based on an Real Time Kinematic Global Navigation Satellite System (RTK-GNSS) sensor using accurate absolute position coordinates.

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An RTK-GNSS sensor has a good accuracy, does not need to be calibrated, and is not affected by sunshine. Additionally, even for long-term use drift does not occur. The entire system consists of a wearable antenna, a 10-Hz RTK-GNSS processor, and a PC.

To demonstrate our strategy, we use a high-accuracy GPS device (Topcon GB-3) and the RTK-GPS method; therefore, it is possible to achieve an absolute position of ±10 mm + 1 ppm horizontally and ±15 mm + 1 ppm vertically in the RTK-GPS mode in an ideal situation. The user wears the antenna connected to the processor on the back of the hand and may freely move the hand when the antenna receives satellites signals. We set up the system on the roof of the four-story 6th engineering building at the University of Tokyo in Japan (latitude: 139.761142, longitude: 35.714122). A few tall buildings surround this building, but we were able to verify that around 10 satellites were detected at all time.

As an experiment, we implemented gesture-sensing trials using our system to input a line and an arbitrary path. In the first trial, we prepared a slider with an antenna to input a line path. As illustrated in Fig. 1(a), we mounted a GPS antenna onto the slider. For acquisition under motion, we loosened the screws and moved the slider linearly and smoothly by hand. The antenna orientation was fixed using screws, and everything was mounted onto a heavy surface plate to remove measurement errors. Moreover, we placed the entire system on a heavy table lift. The table height of the lift can be set arbitrarily from 0.3 m to 1.5 m. We set the height around 1.0 m to reduce errors caused by the multipath problem.

In the second trial, we prepared a wearable antenna system (see Fig. 1(b)). The arbitrary path is controlled by the user's gesture for the input. Note that the angle of the antenna should be upside to maintain the best conditions for obtaining satellite numbers.

3 Results

Figures 2 and 3 show the basic accuracy of our system. In Figs. 2 and 3, the units were converted from absolute coordinates to millimeters to discuss the accuracy. As a result, the mean distance from the linear regression line to the original points is 5.52 mm. Hence, the accuracy was usually well observed within the order of a centimeter or less, even outside without any calibration.

On the other hand, Figs. 4 and 5 show an arbitrary path for gesture sensing. The initial point is indicated by the blue cross, and the end point is indicated by the red cross.

4 Discussion

From the results of the experimental trials, our system demonstrates considerable potential to be used for gesture recognition systems in flexible outdoor environments. In particular, it is possible to improve the accuracy by using other methods [6]; however, in this research, we could not compare with other methods such as a distance sensor and an accelerometer. The characteristics of our

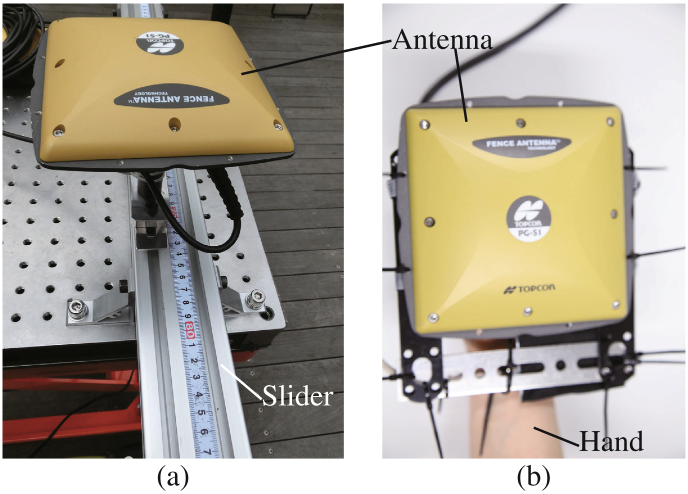

Fig. 1. System setup: (a) antenna placed on a slider to check the accuracy of the system and (b) wearable gesture sensor held by a human hand

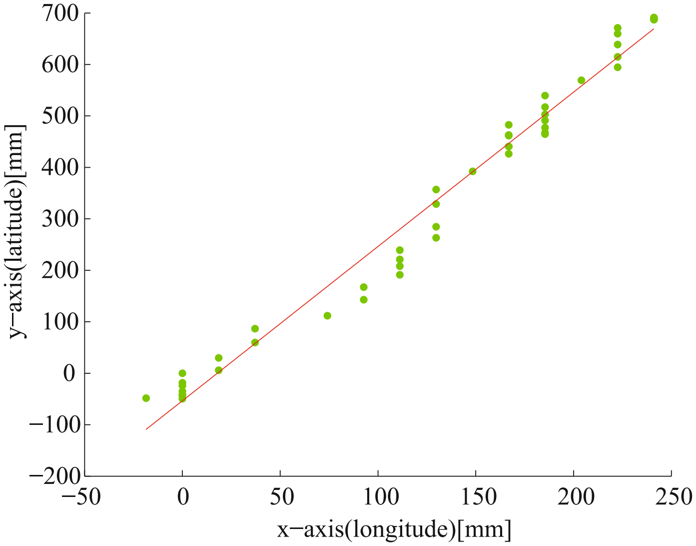

Fig. 2. Original data (green points) of a line path and a linear regression line (red line). (Color figure online)

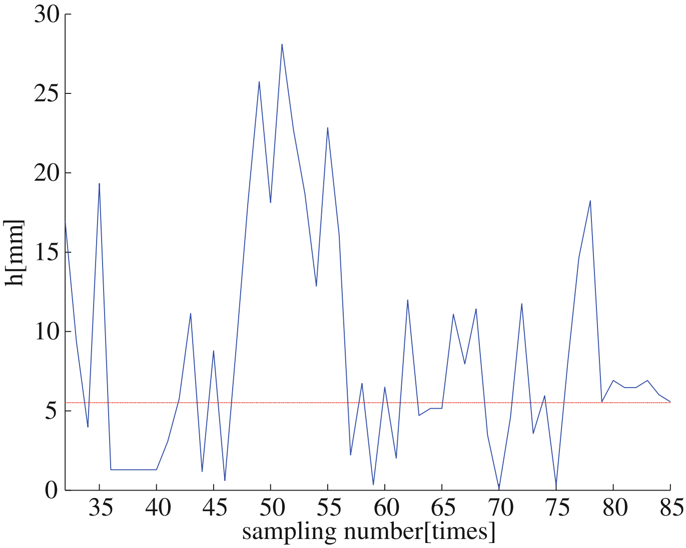

Fig. 3. Mean distance from the linear regression line (red) and each distance (blue). (Color figure online)

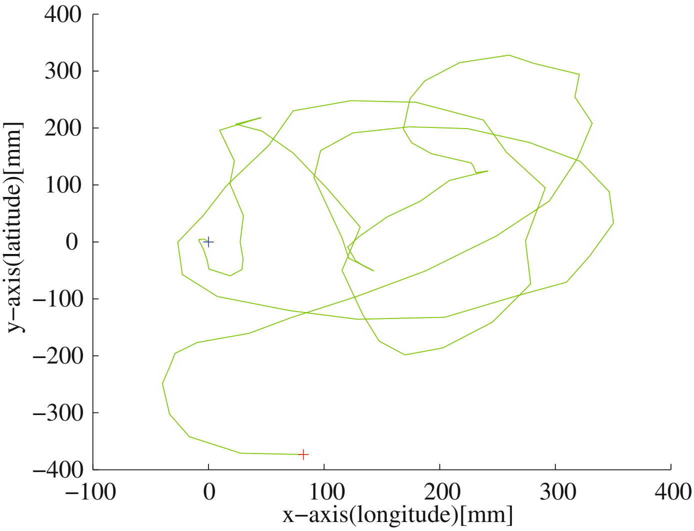

Fig. 4. The first arbitrary path is indicated by a green line. The initial point is indicated by the blue cross, and the end point is indicated by the red cross. (Color figure online)

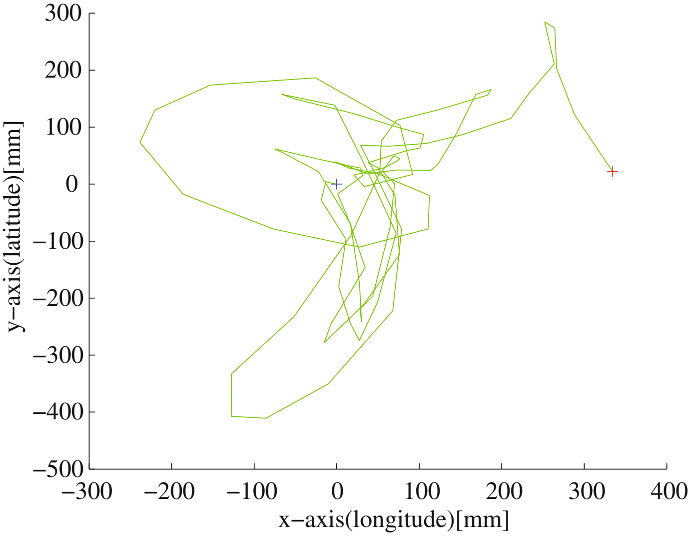

Fig. 5. The second arbitrary path is indicated by a green line. The initial point is indicated by the blue cross, and the end point is indicated by the red cross. (Color figure online)

system are suitable for flexible outdoor environments, and our system does not need to rely on other sensors.

5 Conclusion and Future Work

We proposed a gesture recognition system using accurate absolute position coordinates, which are acquired by an RTK-GNSS sensor. As an experiment, we implemented gesture-sensing trials using our system to input a line and an arbitrary path. As a result, the accuracy was well observed on the order of a centimeter, even outside without any calibration. From the experimental results, we validated that our system has great potential to be used for gesture recognition systems in flexible outdoor environments.

Additionally, we used absolute position coordinates in our research; this has the potential to interact with absolute coordinates. In future work, we will demonstrate that this system can interact with local information on a map for augmented reality.

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