An Accurate User Step Detection Algorithm Using Stretch Sensors

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Abstract

The step detection algorithm for IMU sensor-based indoor localization system plays a significant role in user position estimation. The position accuracy of IMU sensor-based indoor localization system depends on the accurate user step detection. The conventional IMU sensor-based indoor localization approaches use accelerometer sensor data for user step detection. The peak values from the accelerometer sensor data are estimated as the user makes a step. However, the accumulated sensor errors from the accelerometer give a false step detection thus reducing the step detection accuracy. The accuracy of the step detection also depends on the IMU sensor position on the user's body, such as wrist, waist or ankle. The IMU sensor data from a user's ankle gives unstable data and the results are not free from false step detection. The IMU sensor data from wrist gives better and more stable data than when placed on the waist. To solve the IMU sensor position problems and the sensor accumulated errors, we propose a step detection algorithm which uses a stretch sensor instead of IMU sensor. The proposed step detection approach detects the user steps with minimum step error. The experiment results show that the proposed stretch sensor-based step detection approach outperforms conventional IMU sensor-based approaches.

Ⅰ. Introduction

Using IMU sensors is the most popular indoor localization technique and the results from an IMU sensor-based localization system show accurate user position results than other indoor localization approaches [1]. As compared to Wi-Fi [2] or camera [3] based indoor localization systems, the IMU sensor-based localization system provides accurate user position results without utilizing any of the indoor infrastructure. In IMU sensor-based localization, we estimate the current user position by combining the user's step length [4] and heading information [5]. The localization performance is tied to accurate step length and heading estimation [6]. The step length algorithm utilizes the accelerometer sensor data and estimates the user's step length information from estimated user's steps. The performance of the step detection algorithm determines the indoor position accuracy. In step detection, the algorithm identifies the peaks of accelerometer data and estimates the user's steps [7]. The signal fluctuations and the accumulated errors from the accelerometer sensor data affect the step detection accuracy. The IMU sensor position on a user's body is also another influencing factor of step detection accuracy and its performance. To enhance the step detection accuracy and remove the step detection challenges from accelerometer sensor data, we propose a step detection algorithm which effectively uses the data from a stretch sensor. The data from the stretch sensor is more stable than accelerometer sensor data and estimates the user's step accurately without almost no error. The step detection results from proposed approach shows better performance than conventional IMU sensor-based approaches.

In this paper, we proposed a stretch sensor-based step detection algorithm for indoor localization. The proposed stretch sensor-based approach is free from false user step detection and improves the indoor localization performance. In the experiment results and analysis, we compared the results from the proposed approach with conventional IMU sensor-based approaches. The experiment results demonstrate the effective performance of the proposed step detection approach and validated it with conventional IMU sensor-based step detection approaches. The rest of the paper is organized as follows. Section 2 presents the proposed step detection algorithm using a stretch sensor. In section 3, we demonstrate the experiment and result analysis of the proposed system and conclude the paper in Section 4.

Ⅱ. Proposed Step detection approach based on the stretch sensor data

The unstable characteristics of accelerometer sensor data increase the step detection error and it is necessary to add some filters before this data is used for step detection. The filtering of accelerometer sensor data adds to the system's complexity complex and the accumulated errors from the accelerometer show many false step detections. To solve this problem, we proposed a step detection algorithm which uses the advantages of stretch sensor data. Fig. 1 shows the proposed step detection algorithm with stretch sensor data.

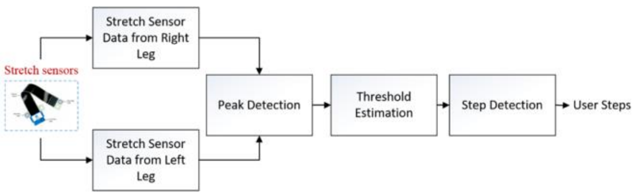

Fig. 1 Proposed step detection approach.

In Fig. 1, the step detection algorithm uses the stretch sensor data for peak detection. In peak detection process, the peak of the stretch sensor data is identified as the user's step. The peak detection algorithm detects a step when the valid maximum peak occurs in the stretch sensor data. We can use a threshold value for detecting the maximum peaks. The proposed step detection algorithm uses a threshold value to avoid the false step detection. The signal stretch from the stretch sensor data determines the threshold value. Through analyzing several experiment results from stretch sensor data, this paper defines a 430 μ f threshold value for right leg stretch sensor data and a 420 μ f threshold value for left leg stretch sensor data for the user's step detection.

Ⅲ. Experiment and Result Analysis

To evaluate the performance of the proposed step detection approach, we did an experiment with two stretch sensors. The user attached two stretch sensors on his legs and walked in the experiment area. The stretch sensor data is collected on the fifth floor of IT building 1, Kyungpook National University, Daegu, South Korea. During data collection the user (Age 28, Height 175 cm) uses two stretch sensors and attaches the sensors on his right and left legs. Fig. 2 shows the step detection results from the stretch sensor data.

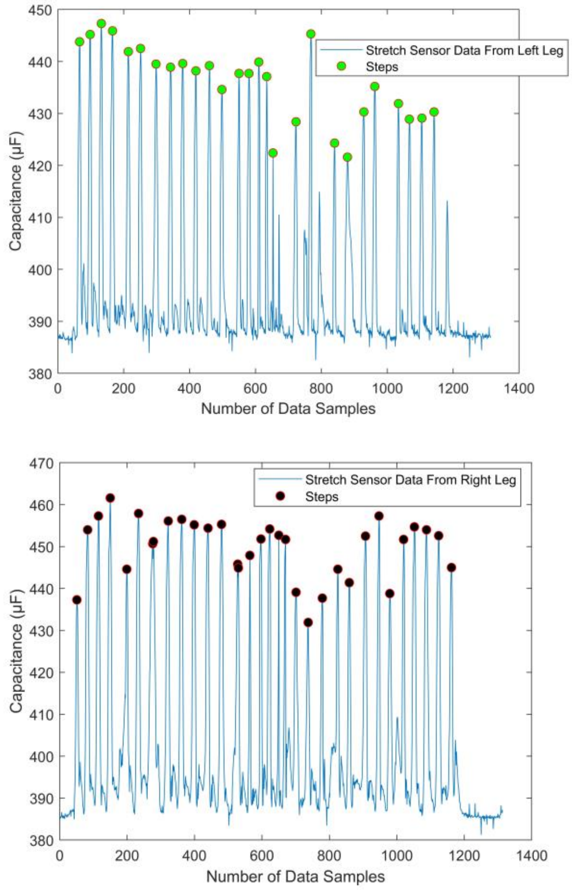

Fig. 2 Step detection results from stretch sensor data.

From Fig. 2, it can be seen that the proposed step detection algorithm estimates user's steps accurately without any step error. To analyze the accuracy of the proposed step detection approach, we did the same experiment with IMU sensor data with different sensor positions on the user's body. Fig. 3 shows the experiment results from IMU sensor-based step detection approaches.

To validate the performance of our proposed step detection approach with IMU sensor-based approaches, we estimated the step detection error and Table 1 summarizes the error results from all approaches.

Table 1: Accuracy comparison of different step detection approaches.

Approach	Error
IMU data from wrist	3%
IMU data from waist	8%
IMU data from ankle	21%
Stretch sensor data	0%

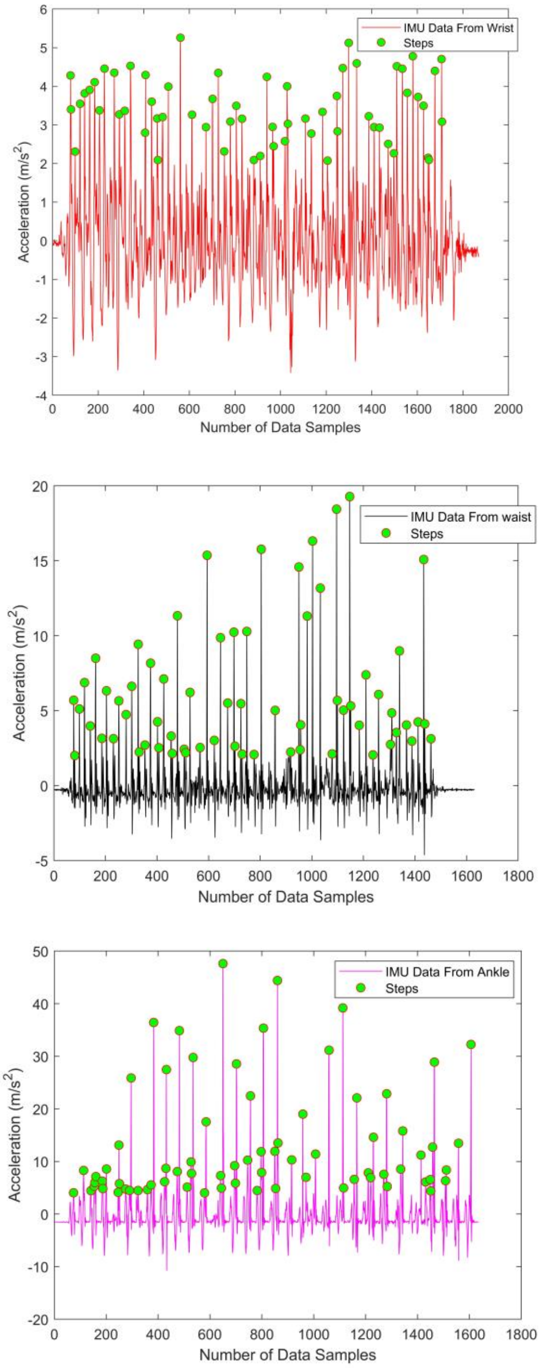

Fig. 3 Step detection results from IMU sensor-based approaches.

From Table 1, it is clear that the proposed approached achieved best step detection results than conventional IMU sensor-based step detection approaches. With conventional approaches, the IMU sensor attached to the user's wrist position gives accurate step detection results compared to other IMU sensor positions. The IMU sensor on the user's waist shows better performance than the IMU sensor on the user's ankle. From all the experiment results and analysis, the proposed step detection algorithm shows accurate step detection performance and improves the system performance for indoor localization.

IV. Conclusion

In this paper, we analyzed the impact of the IMU sensor position on a user's body and estimated the step detection performance. In the experiment result analysis, we estimated the step detection error for different IMU sensor position on a user's body such as wrist, waist and ankle. From the IMU sensor-based step detection results, the IMU position on user's wrist position gives accurate results than other body positions. To overcome the challenges encountered in IMU sensor-based step detection, we proposed a step detection approach that uses a stretch sensor. The step detection results from proposed approach show best step detection performance than conventional IMU sensor-based step detection approaches. Through extensive experiment results, we demonstrated the superior performance of the proposed step detection approach.

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