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Real-time Beacon Distance Revision Method in Indoor Environment

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Abstract. The position of the unmanned aerial vehicle (UAV) in indoor environments is commonly calculated using wireless signal based triangulation or fingerprint. However in indoor environments, the calculated distance is inconsistent, and therefore it is difficult to calculate the position of the UAV accurately. In this paper, we propose a real-time method that measures and calibrates the distance between the beacon attached to the UAV and the access point (AP).

1 Introduction

Recently, increased interest in the unmanned aerial vehicles (UAVs) has led to a growing number of studies measuring the position of the UAVs. There are studies where the UAV recognizes the marker and controls the current position of the UAV [1]. There are also studies that utilize Simultaneous Localization and Mapping (SLAM) to create maps and locate positions [2]. Other studies have used a beacon to calculate positions [3-5]. For instance, a study used a beacon's signal and access point (AP) to locate and calibrate the position of the UAV [6]. However in general, applying the existing beacon approach - based location measurement techniques in indoor environments is difficult due to inaccurate distances and therefore there are limitations.

In this paper, we propose a method that calibrates the beacon distance measured in the indoor environment. In general, the calculated beacon distance contains noise, which can be also eliminated by using this proposed method.

This paper is organized as follows. Section 2 proposes a real-time beacon distance calibration algorithm. Section 3 creates experiments based on the proposed method. Finally, Section 4 concludes the paper.

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2 A Real-time Revision Approach of Beacon Distances

The proposed method for real-time measurement and calibration of the distance between the beacon and AP can be divided into three stages as shown in Fig. 1. First, in the Initialization Stage, time t and the distance d_t between the measured beacon and the AP, and the distance average a_t are set to 0. The calculated distance set C is initialized to null set.

Second, the distance average a_t is calculated by measuring the distance d_t in the Measurement Stage as follows. Distance d_t is measured and placed into distance set C. When the value of the t factor is 1, then the process enters the Distance Transition Step of the Revision Stage. If the direct prior distance d_{t-1} presents a higher value compared to the current distance d_t, then the previously measured distance d_{t-1} is the peak value. If the peak value is revealed, the Distance Average Calculation Step is performed. In this Step, all the elements of distance set C are aligned by distance and the distance to the lower α% is derived, based on which the distance average a_t is calculated. After which, the distance set C is initialized. In the Distance Accumulation Step, the current distance d_t is added to the distance set C.

Third, in the Revision Stage, the current distance d_t is revised using the distance average a_t. When there are more than or equal to one calculations of the distance average a_t, if the current distance d_t is greater than the distance average a_t, then the current distance d_t is replaced with the distance average a_t in Distance Revision Step. The revised current distance d_t is returned in Distance Transition Step. In the Previous Distance Update Step, the current distance d_t is saved as previous distance d_{t-1}.

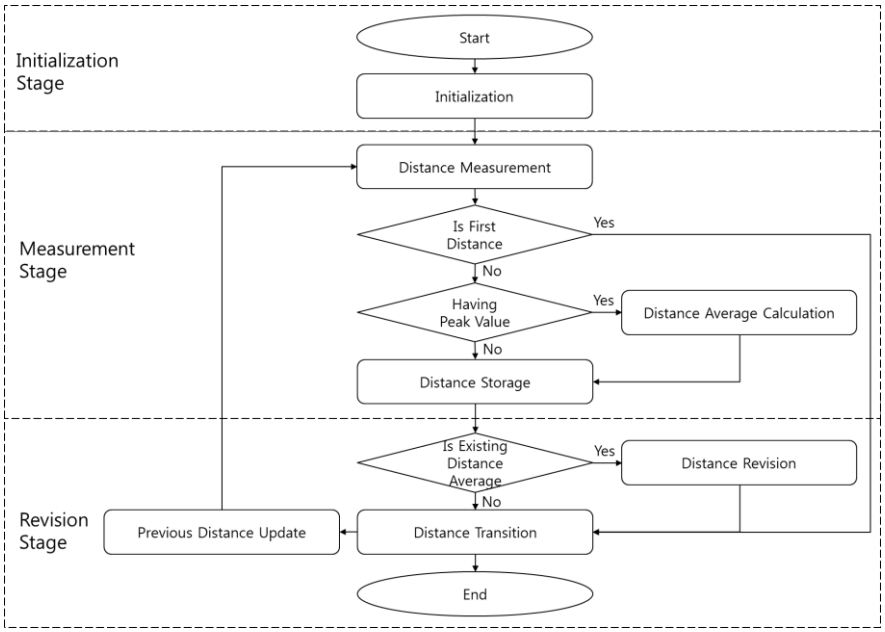

Fig. 1. The process of real-time distance revision

3 Experiment

The distance between the AP and the beacon is set by 2*m*, and a comparison was conducted between the method in which the AP measures and the proposed method. Fig.2 shows the distance d_t measured through the method in which the AP provides and the revised distance d_t calibrated through the proposed method. The distance average a_t was calculated by using the lower 80% of the distance set.

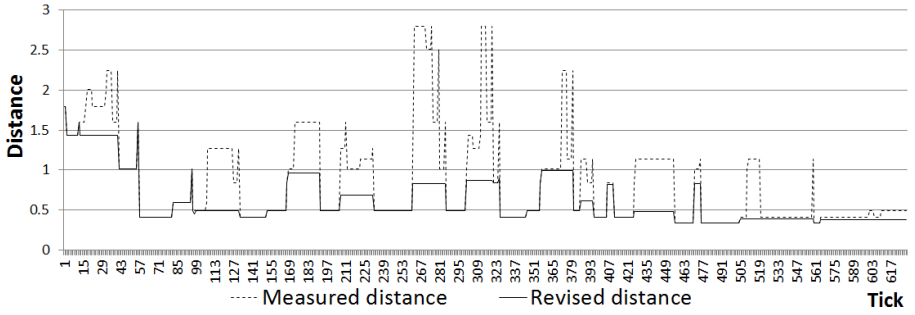

Fig. 2. Distances measured by AP and calculated through the proposed method

The difference between the average distance a_t and each measured distance d_t obtained by AP is accumulated as shown in Fig.3. The difference for the proposed method was also calculated through an identical process. Initially, the difference in distance between the two methods was small; however, this difference became greater with time, the proposed method can reduce the difference by up to 51.45% compared to the AP-method.

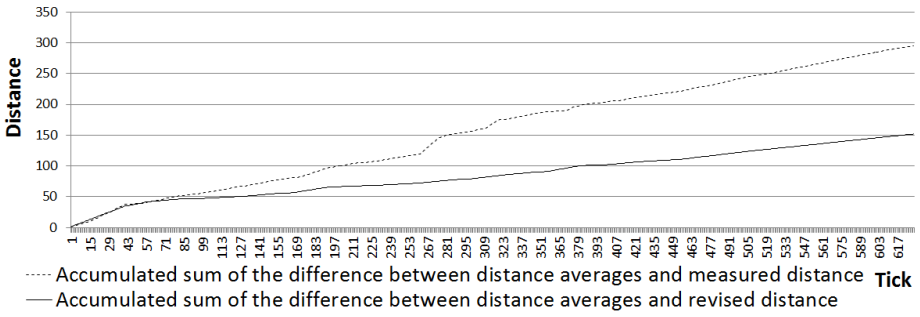

Fig. 3. The accumulated sum of the measured distance and the average distance difference

4 Conclusion

This paper proposes a method of revising the measured distances between a beacon-attached UAV and the AP in real-time. An experiment was conducted in which the distance measurements calculated through the AP-method and the proposed method

were compared. The proposed method can reduce the difference by up to 51.45%, compared to the existing method. Therefore, the application of the proposed method will produce an accurate estimation of the UAV's location through the reduction of errors in distance measurements.

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