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NUI-based Indoor Location Estimation Method

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Abstract. Natural User Interface (NUI) is a motion interface that utilizes and recognizes body movements without using input devices directly. This paper proposes a method that estimates user indoor location to utilize the user indoor locations as control signals. The user indoor locations are estimated by utilizing measured distance from a beacon to APs.

Keywords: NUI/NUX, Human-computer Interaction, Indoor Location.

1 Introduction

A recent study proposed a natural user interface (NUI) for user location recognition based on the distances between a beacon and multiple access point (AP) [1]. As an important factor in location recognition, the user location is utilized for a variety of fields. User location recognition requires an additional recognition step to the learned distance function. Also, in some NUI-related studies, a beacon signal is used to recognize the location of the user in indoor environment [2-4]. In a study, mouse control through user's finger motion capture was demonstrated using Kinect multiple-depth cameras [5]. In another study, leap motion was used for 3D character animation [6].

This study proposes a method for beacon-based user location recognition. The user location is detected on the basis of the beacon held by the user and pre-determined AP-AP distances. The proposed method is operable with control signals from the Internet of Things (IoT) or digital contents.

The rest of the paper is organized as follows. In Section 2, user location estimation method is presented. Section 3 presents the results of the experiment of the proposed method. Section 4 summarizes the proposed method.

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2 User Location Estimation Framework in Indoor Environment

Fig. 1 shows a flowchart of applying user location estimation in indoor environment. In the initialization stage, 4 APs are set around the user location. AP positions are defined as front space s_f, down space s_d, left space s_l, and right space s_r. In the learning stage, the user learns the beacon–AP distances within the space [1]. In the expectation stage, location estimation is performed on the basis of the beacon–AP distances covered by the user while moving around and the learned distances.

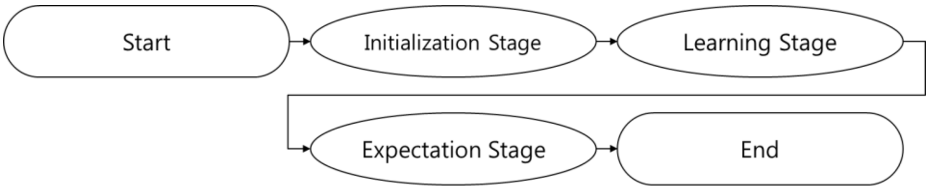

Fig. 1. User indoor location estimation method

In the expectation stage, user location is estimated in six steps described below, as shown in Fig. 2. Accurate estimation is possible only when the user holding the beacon is in the four pre-defined AP spaces. First, in the distance measurement step, the distance to each of the four pre-determined APs is measured upon receiving a beacon signal.

Second, the use of beacon signal is checked. If a beacon signal is not received, a beacon signal is measured again, repeating the first step. If the signal received is weak or the distance measure does not lie within a zone covered by one of the Aps, it is not used.

Third, in the distance normalization step, the four distances are normalized on the basis of the learned data. Normalization is done in compliance with the normalization method applied when learning [1]. The normalized value of the distance between the beacon and i-th AP is defined as d_i. Using the max and min values derived from the learning state, a measured distance is converted into 1 or treated as 0, depending on whether it larger than the max value or is smaller than the min value, respectively.

Fourth, in the location determination step, the spatial position of the user is determined, thereby using the real-time normalized value d_i and the mean value $a_{s,i}$ calculated from the normalized distance between the beacon learned in space s and the i-th AP, as in Eq. 1. The space s having the min value is then determined to be the current spatial position of the user.

$$s_t = \underset{s}{arg} Min(\sum_{i=1}^{4} |d_i - a_{s,i}|) \tag{1}$$

Fifth, in the location transmission step, the spatial position determined in the location determination step is transmitted to outside so that the space around the user location can be utilized. The proposed method is a method for determining the user location, which is applicable in the system including the proposed method.

Finally, it is decided whether to continue user location estimation. If yes, it continues by going to the space visit step, and if no, the operation is terminated.

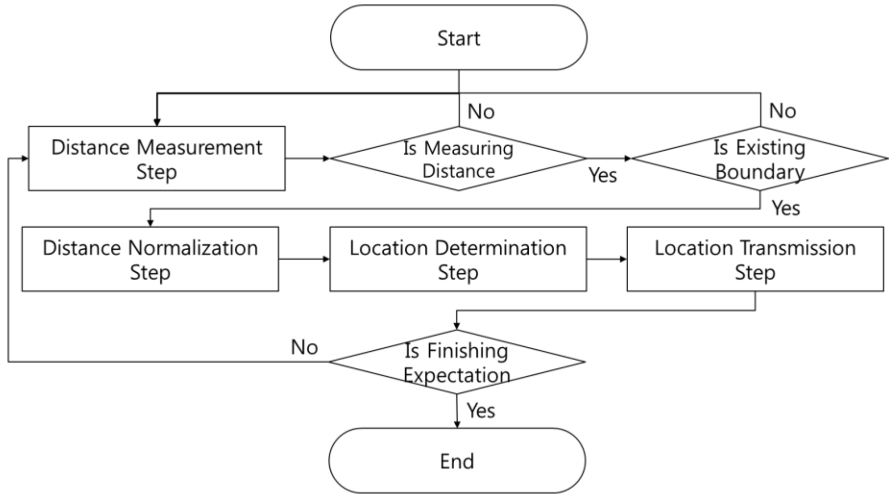

Fig. 2. Steps in the location recognition process

3 Experiment

In the experiment, one beacon and four APs were used for user location estimation. In the initialization state, APs were set at the AP-AP distance of 1m. In the learning state, the measured distances were learned while the user was moving around the four AP spaces for 20 sec. In the expectation state as well, the four spaces were visited at any given order.

Fig. 3 depicts the real location and estimated location. Excluding the NONE, where the user moves to other spaces, the degree of estimation accuracy was 74.36%. Analysis of measured distances revealed that in s_l, significant discrepancies occurred between learned distances and those used while distance estimation, or distance estimation was not performed adequately. This suggests that distance measurement in indoor environment requires adjustment of inaccurately measured distances.

4 Conclusion

This paper proposed a NUI-based method for estimating the space covered by the user in indoor environment. To perform user location estimation, it is necessary to run a commonly used learning procedure beforehand. This was done by measuring beacon–AP distances. The user location was then estimated on the basis on the post-learning beacon–AP distances differing according as the user moves around in the spaces defined by four APs.

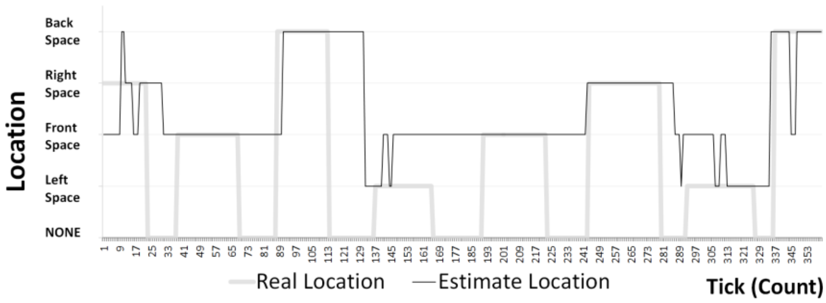

Fig. 3. Comparison between real location and estimated location

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References

1. Kwak, J., Sung, Y.: Indoor Location-based Natural User Interface for Ubiquitous Computing Environment," The 4th International Conference on Ubiquitous Computing Application and Wireless Sensor Network (UCAWSN-15), Jeju, Korea, July 8-10 (2015)
2. Lee, H. C., Lee, D. M.: A Study on Localization System using 3D Triangulation Algorithm based on Dynamic Allocation of Beacon Node, The Journal of Korea Information and Communications Society, vol. 36, no. 4, pp. 378-385 (2011)
3. Lee, H. C., Lee, D. M.: The 3-Dimensional Localization System Based on Beacon Expansion and Coordinate-Space Disassembly, The Journal of Korea Information and Communications Society, vol. 38B, no. 1, pp. 80-86 (2013)
4. Liu, H., Darabi, H., Banerjee, P. Liu, J.: Survey of Wireless Indoor Positioning Techniques and Systems, IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, vol. 37, no. 6, pp. 1067-1080 (2007)
5. LEE, G., SHIN, D., SHIN, D.: NUI/NUX framework based on intuitive hand motion, Journal of Internet Computing and Services (JICS), vol. 15, no. 3, pp. 11-19 (2014)
6. Nam, J., Yang, S., Hu, W., Kim, B.: A new study on hand gesture recognition algorithm using leap motion system, Journal of Korea Multimedia Society, vol. 17, no. 11, pp. 1263-1269 (2014)

