A PNN- Jensen-Bregman Divergence for a WLAN Indoor Positioning System

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Abstract

For decades, humans have been keen on creating smart spaces where advanced technology is utilized to provide enhanced services. Indoor positioning systems (IPS) can be used to provide a wide range of user navigation and directions services, particularly in abnormal conditions such as needing emergency healthcare services. IPS also can be a friendly tool for people with vision impairment to allow for better livable communities for them. Other applications for IPS fall under tracking applications which may include activity recognition for security purposes and observation for the elderly or infirmed individuals. An indoor positioning system can be a hybrid system that uses multiple technologies such as wireless LAN, vision via cameras, motion sensors, or lasers to name few. In this paper, we propose a technique for IPS using WiFi. The technique is based on a probabilistic neural network (PNN) scheme in which we incorporate the Jensen-Bregman divergence method. To validate our proposed method, we compare our results with the nearest neighbor method. Results indicate that our integrated system outperforms this method in terms of nearest neighbor estimation. Our results show that this method has the ability to achieve less than 1m accuracy in an academic building.

Introduction

1. Indoor Positioning System (IPS) brings the power of the Global Positioning System (GPS) indoors, the IPS is considered as the Next Big Thing.
2. The GPS can’t be used inside buildings because: it can’t perform a line-of-sight (LOS) with satellite and the lack to determine the floor [1].
3. S. Kumar [2] had reported that the global of indoor localization market around $93.5 million in 2014, and by 2019 is expected to be around $4.424.1 million. The Compound Annual Growth Rate (CAGR) is expected to be 36.5% from 2014 to 2019.

IPS Technology

- WLAN
- Bluetooth
- RFID
- BLE Beacons
- Magnetic Field
- Camera Tech
- Indoor Lights
- Sensors

Fig. 1. Compound Annual Growth Rate of IPS

Architecture of the Fingerprinting method

1. The Offline phase
   • The recording of RSSI was taken with four different orientations (45°, 135°, 225°, and 315°) to prevent the body-blocking effect.
   • Ten scans were taken in the same place with a delay of 10 seconds
2. The Online phase
   • The RSSI is a mobile device will be compared to predefined fingerprints to determine its location using the developed system.

PNN - Jensen-Bregman Divergence formulation

1. Most of the prior work are ignoring the multimodal signal of the WLAN
2. Jensen-Bregman divergence (JSD) seems very attractive to deal with this variation because JSD measures encapsulate both the geometric (squared) Euclidean distance and the information-theoretic relative entropy.

Fig. 2. Different IPS Technology

Fig. 3. Positioning approaches

- Time of Arrival (ToA)
- Time Difference of Arrival (TDoA)
- Angle of Arrival (AoA)
- Phase of Arrival (PoA)

Pattern Recognition/ Fingerprinting

Fig. 4. (a) IPS Architecture and (b) site map in a Wi-Fi indoor localization system.

Fig. 5. Signal-to-Noise Ratio (SNR) of the RSSI Variation Distribution over time

Analysis of PNN-JBD implementation and discuss results

1. This result is adequate for an indoor environment under normal conditions. The PNN-JBD method results have higher accuracy than PNN and both produced slightly better accuracy than the kNN stand-alone method.
2. We are in the process of investigating position prediction error distributions and in need to quantify the localization variation of the WiFi signal distribution in space.

Summary and Conclusion

1. The research was supported by The Faculty Research and Creative Activities Awards (FRACAAs) W2015-008.
2. Part of this project was published at CISS conference at Princeton University. The acceptance rate at that conference was 17%, also some of it has been accepted in EIT 2016 conference.
3. The authors would like to acknowledge the Digital image and signal processing lab for it's support and contributions.

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Bibliography