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 infirm 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 using Wi-Fi using the Bregman's technique based on a probablistic 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.

IPS Methods
![Diagram](Fig. 3. Positioning approaches)

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

Architecture of the Fingerprinting method

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

- Offline
  - Site Survey
  - Fingerprint Database
- Online
  - Location Estimation
  - Localization Algorithm

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.

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

Analysis of PNN-JBD implementation and discuss results
![Graph](Fig. 6. Tracking results on the 2D layout for the first floor of the College of Engineering and Applied Sciences at WMU)

<table>
<thead>
<tr>
<th>Technique</th>
<th>Median (m)</th>
<th>Accuracy 90% (m)</th>
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</thead>
<tbody>
<tr>
<td>kNN</td>
<td>1.8</td>
<td>3.7</td>
</tr>
<tr>
<td>Kernel-based</td>
<td>1.6</td>
<td>3.6</td>
</tr>
<tr>
<td>CS-based</td>
<td>1.5</td>
<td>2.7</td>
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<tr>
<td>PNN-JSD</td>
<td>0.89</td>
<td>1.93</td>
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</tbody>
</table>

Summary and Conclusion
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 Wi-Fi signal distribution in space.

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Bibliography