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Wireless Indoor Localization Algorithms and Techniques for Human Activity Sensing

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Motivation

1. Reliable, accurate and real-time indoor positioning and position-based services are required by people even more strongly than ever.
2. Wireless indoor localization technologies gradually play an important role in all aspects of people's daily lives.
3. Indoor localization technologies address the inefficiency of GPS (Global Positioning System) because there is no Line-of-Sight (LOS) between receivers and satellites in indoor environments.
4. Precise location information of human activity could improve the efficiency of control systems, such as air-condition control system and light equipment control system in buildings.

Wireless Indoor Localization Algorithms

Trilateration Approach

- Trilateration uses the geometric properties of triangles to estimate the target location.
- Trilateration estimates the position of an object by measuring its distances from multiple reference points.

Fingerprinting Approach

- Offline stage: A site survey is performed in an environment.
- Online stage: A location positioning technique uses the currently observed signal strengths and previously collected information to figure out an estimated location.

Wireless Indoor Localization Algorithms

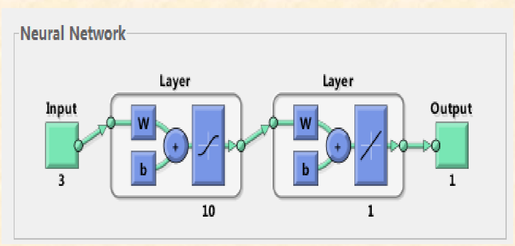
Trilateration Approach

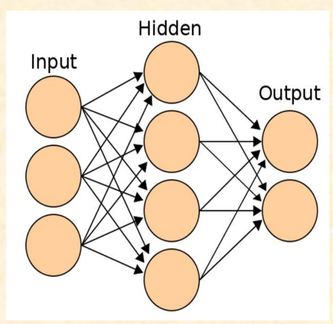
- Time of arrival (TOA)
- Time of difference of arrival (TDOA)
- Received Signal Strength(RSS)

Fingerprinting Approach

- Probabilistic Methods
- K-nearest-neighbor(kNN)
- Neural Networks
- Extreme Learning Machine(ELM)

Neural Networks



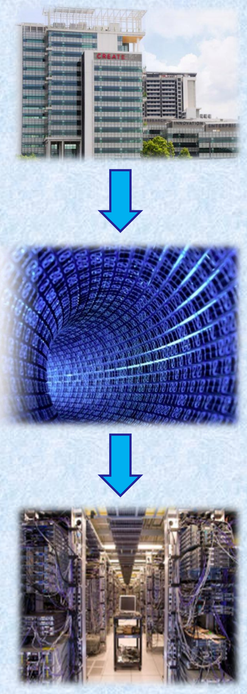


Probabilistic Methods

Choose L_i *if* $P(L_i|s) > P(L_j|s)$ for i, j=1,2,3….n j $\neq I$

$$P(L_i|s) = \frac{P(s|L_i)P(L_i)}{P(s)} = \frac{P(s|L_i)P(L_i)}{\sum_{j=1}^{n} P(s|L_j)P(L_j)} \quad \textit{Bayes Formula}$$

Human Activity Sensing and Building Control System



Indoor Human Activity Sensing

✓ Capture human presence and behaviors by using carried tags or devices (i.e. mobile phones)

Data Collection and Analysis

✓ Understand human activity patterns
✓ Develop human activity forecasting algorithms based on machine learning techniques

Building Control System

✓ Develop human occupancy dynamic models in buildings to map localized energy requirements
✓ Forecast building energy consumption

Wireless Indoor Localization Techniques

- Infrared (IR) Localization System
- Ultra-sound Localization System
- Radio Frequency Identification (RFID)
- Ultra-wideband (UWB)
- Vision-based Localization System
- WLAN (IEEE 802.11 Wi-Fi)

Ultra-wideband (UWB)

Advantages	Disadvantage
✓ High accuracy ✓ No LOS requirement ✓ No path distortion ✓ Less interference ✓ High penetration ability	× Expensive ($16875 for a research package)

WLAN (IEEE 802.11 Wi-Fi)

Advantages	Disadvantage
✓Use the existing WLAN infrastructures ✓Reuse WLAN wireless devices as tracked targets to locate person ✓Low cost positioning technology	×Wi-Fi signal is affected by multipath fading, reflections and obstructions ×Indoor radio propagation model has to be changed due to variation of the environment