Indoor localization system using RSSI measurement of wireless sensor network based on ZigBee standard

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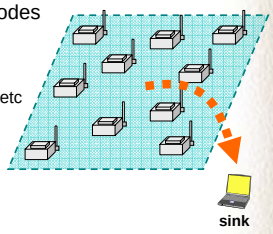
Content

Wireless Sensor Networks

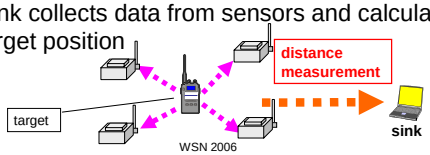
- Consist of micro-sensor nodes
- Objective
  - Monitor environment
    - temperature, humidity…etc
- Features
  - Pros
    - easy deployment
    - low cost
  - Cons
    - limited battery
    - low communication speed
    - low computation power



Sensor nodes cannot send much data

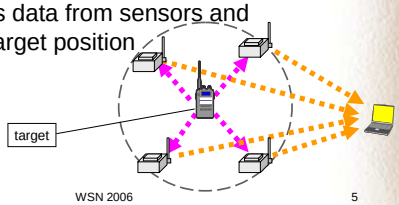
Localization System in Sensor Networks

- Sensor networks are needed for indoor localization, because GPS cannot work indoors, e.g.
  - Localization of sensor position
  - Consumer position in supermarket
  - Visitor position in exhibition
- Sink collects data from sensors and calculates target position



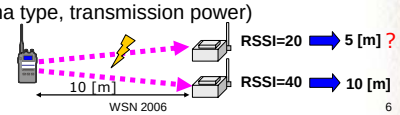
Details about Localization System

- Sensors measure the distance from target
  - Target has device which can send signal
  - Sensors receive signal from target and measure RSSI (Received Signal Strength Indicator)
- Sink collects data from sensors and calculates target position



Characteristics of RSSI Measurement

- Lower configuration cost than other methods (e.g. laser and ultrasonic wave)
- Larger error because the variation of RSSI by the environment is large
  - Radio interference
  - Obstacles (persons, walls)
  - Individual differences of transmitters and receivers (antenna type, transmission power)



Position Estimation Algorithm

- Overview
  - Sink estimates target position (X, Y) by using sensor position and measured distance
- Minimum Mean Squared Error (MMSE)
  - Calculate (X, Y) to minimize $\sum_{i=1}^{N} f_i(X,Y)^2$

$$f_i(X,Y) = \sqrt{(X-x_i)^2 + (Y-y_i)^2} - d_i$$

(x_i, y_i) : position of sensor i d_i : distance measured by sensor i
N : amount of collected data

  - Measurements from at least three nodes required
  - Estimate position accurately in case of target being evenly surrounded by sensors

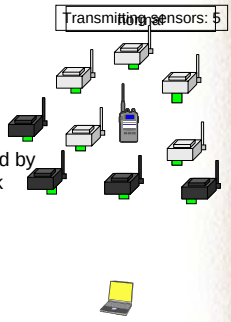
Problem

- It is difficult to collect a large amount of data in wireless sensor networks
  - Long delay
  - High energy consumption

The amount of data collected by the sensors must be controlled.

Data Collecting Technique

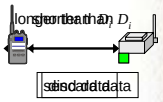
- Control the number of transmitting sensors
  - Use density of sensors and measured distance
  - Sensors as many as required by system send data to the sink
- Our mechanism
  - Measure density of sensors
  - Control the number of transmitting sensors



Transmission Control Method

- To control data transmission of Z sensors
  - Sensors decide to send data depending on the measured distance
    - sensors send data if distance is within D_i [m]
- Calculation of D_i
  - Use proportional relationship between D_i [m] and density ρ_i

$$D_i = \sqrt{\frac{Z}{\pi \rho_i}}$$



Z: amount of required data

Implementation of Localization System

Ubiquitous Device (Oki Electric, Co. Ltd.)

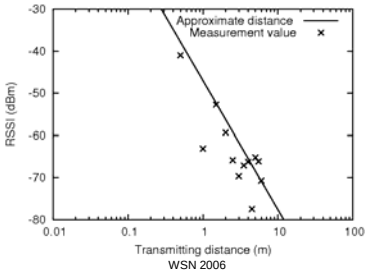
- Communication based on ZigBee standard
- General purpose analog I/O
- Serial communication with PC

Radio frequency	2.4GHz
Transmission speed	250kbps
Modulation	O-QPSK
Spread spectrum	DS-SS
Antenna	1/4λ monopole
Transmission power	1mW

Relationship between Distance and RSSI

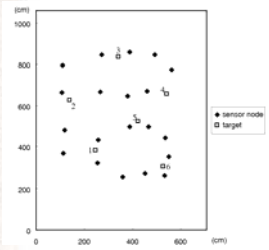
- Distance (m): x
- RSSI (dBm): y

$$y = -13.3 \ln x - 47.0$$

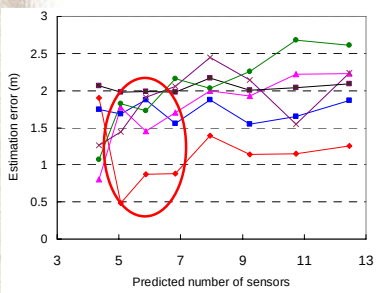


Measurement Experiments

- Measurements in a conference room (7 × 11m)
- 20 sensors and 6 targets



Evaluation of Position Estimation Error



- Optimal number of data: 5-7
- RSSI threshold set to be -60dBm

Conclusion and Future Work

- Conclusion
  - We implemented proposed localization method on a sensor network based on ZigBee
    - The relation between the distance and RSSI was measured.
    - We measured the positional estimation error in a room, and clarified the best RSSI threshold.
- Future Work
  - Evaluation of energy consumption and delay
  - Multi-hop communication for large-scale system