

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

Osaka Prefecture University
Masashi Sugano

Osaka University
Tomonori Kawazoe, Yoshikazu Ohta, Masayuki Murata

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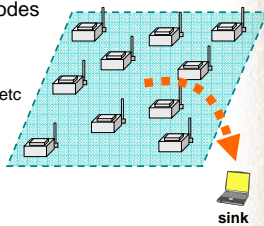
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Wireless Sensor Networks

- 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

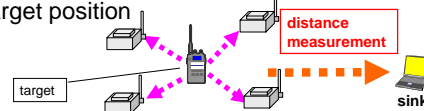
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Localization System in Sensor Networks

- 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



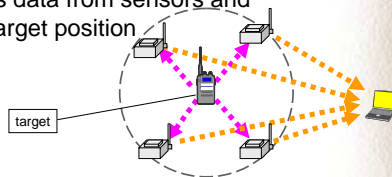
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Details about Localization System

- 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



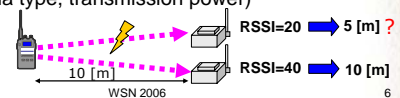
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Characteristics of RSSI Measurement

- 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)



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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

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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.

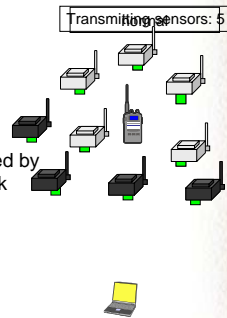
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Data Collecting Technique

- 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



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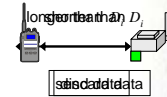
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Transmission Control Method

- 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

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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

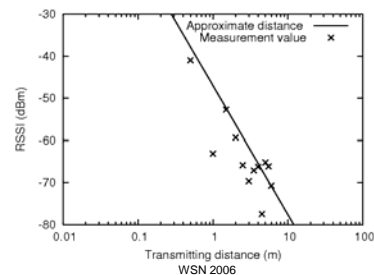
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Relationship between Distance and RSSI

- Distance (m): x
 - RSSI (dBm): y
- $$y = -13.3 \ln x - 47.0$$



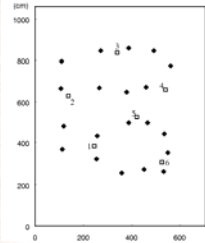
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Measurement Experiments

- Measurements in a conference room ($7 \times 11\text{m}$)
- 20 sensors and 6 targets

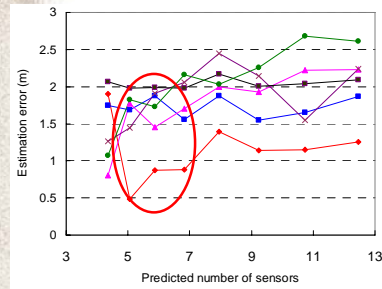


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Evaluation of Position Estimation Error



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

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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

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