A Real-Time Indoor Position Tracking System Using IR-UWB

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Outlines

- Features of indoor position tracking system based on IR-UWB
- Deployment and application of the position tracking system in warehouse
- Deployment and application of the position tracking system in shopping mall
- Conclusion remarks
### Definition of UWB

- **GSM:**
  - Frequency: 30KHz
  - Power: +35 dBm/MHz

- **W-CDMA:**
  - Frequency: 5MHz
  - Power: +15 dBm/MHz

- **UWB:**
  - Frequency: 500MHz ~ several GHz
  - Power: -41.3dBm/MHz

**UWB must have a bandwidth of FBW ≥ 20% or larger than 500MHz**

**Definition of fractional bandwidth**

\[
FBW = \frac{2(f_H-f_L)}{(f_H+f_L)}
\]

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### Typical IR-UWB Modulations

- **One symbol**
  - ‘0’
  - ‘1’

**Transmitter**

1. Pulse generator
2. Controller
3. BPF

**Non coherent receiver**

1. BPF
2. LNA
3. Decision
4. Controller
The Advantages of IR-UWB

- IR-UWB can provide high precision ranging, that is desired in applications of positioning or radar.
- Because of the extremely low emission power density, the effect to human body is very limited.
- Because of the extremely low emission power density as well as the high frequency, the transmission distance is limited. That is good for co-existence.
- IR-UWB is inherently low power consumption. That is favorable for devices to operate on battery.

Regulations on UWB

<table>
<thead>
<tr>
<th>Country</th>
<th>Frequency Bands</th>
<th>Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>3.1-3.4 GHz, 4.2-4.8 GHz, 6.0-7.25 GHz, 7.25-10.25 GHz</td>
<td>DAA or LDC needed</td>
</tr>
<tr>
<td>Europe</td>
<td>3.1-3.4 GHz, 4.2-4.8 GHz, 6.0-7.25 GHz, 7.25-10.25 GHz</td>
<td>DAA or LDC needed</td>
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<tr>
<td>Japan</td>
<td>3.1-3.4 GHz, 4.2-4.8 GHz, 6.0-7.25 GHz, 7.25-10.25 GHz</td>
<td>DAA or LDC needed</td>
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<td>USA</td>
<td>3.1-3.4 GHz, 4.2-4.8 GHz, 6.0-7.25 GHz, 7.25-10.25 GHz</td>
<td>DAA or LDC needed</td>
</tr>
</tbody>
</table>

Use at -41.3dBm/MHz, DAA or LDC needed, not allowed at -41.3 dBm/MHz
Time-Of-Arrival Using IR-UWB

- By measuring the Time-Of-Arrival (TOA) of UWB pulse, high precision of distance measurement can be achieved.
- TOA gives much higher precision than Signal Strength Ranging (SSR) method.

Structure of Positioning System

- Node transmits and receives
- Round time between anchor and node is measured.
- Synchronization among anchors is not required.
Deployment In a Warehouse (1)

anchors

Deployment In a Warehouse (2)

Mobile node

Picking cart
### Configuration of Anchor Nodes

- **Anchor Antenna direction**
- **Stock racks**

### Positioning Precision Analysis

<table>
<thead>
<tr>
<th>Position</th>
<th>Axis</th>
<th>Min.</th>
<th>Average</th>
<th>Max.</th>
<th>Dev.</th>
<th>Dispersion range</th>
<th>Number of data</th>
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</table>

*(unit: mm)*
Example of Picking-card Tracking

By reconfiguring the route, average time of picking one article is reduced from 8.5s to 6.5s

Deployment In a Shopping Mall (1)

Northport Mall in Yokohama
(One minute walk from a subway station ‘Center North’)
Navigation in Shopping Mall

- Real-time navigation is made by providing both distance and direction to a target point while the route selection is based on the real space environment.
- Push-type information distribution is triggered out when approaching the target point.
- Automatic tracking for a moving target is available.
- Voice input/output function is installed for assisting visually impaired people.
Example of Smart Order

When detected an approaching registered customer, the signage shows recommended articles for this particular customer. The customer can draw-in those information to personal terminal and order articles directly.

Accumulated Tracks (Heat Map)
Conclusion Remarks

- IR-UWB is inherently of high time resolution. Real-time position tracking system using IR-UWB at UWB high band are developed.

- Deployment in an in-operating warehouse achieves precision around 40cm. The results are used for increasing operating efficiency.

- Deployment in a shopping mall provides a number of applications that may benefit both shop operators and customers.

Thank you for your attention!