Elderly-care Monitoring Sensor Using Stepped-FM UWB Scheme

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Overview

- Background
- Advantages/Challenges of UWB-IR
- Stepped-FM scheme
  - Stepped-FM scheme
  - Detect and Avoid technology
- Elderly-care monitoring sensor
  - Experimental overview
  - Demonstration video of state detection
- Conclusions
Background

- Arrival of increasingly aging society
- Accidents of the elderly in care facilities are increasing
- Limited number of nursing staffs

Increased requirements for monitoring their activities

Monitoring systems

- Video camera $\Rightarrow$ Privacy invasion
- Infra-red $\Rightarrow$ Small detection area
- RFID tag $\Rightarrow$ Coming off devices

$\Rightarrow$ Ultra-wideband impulse-radio has lately attracted
Advantages
- High range-resolution
- Low power emission
- Penetration against clothes and blanket

Challenges
- High speed A/D devices ⇒ several GS/s required
- UWB regulation ⇒ DAA technology required
  *DAA: Detect and Avoid
  ⇒ Stepped-FM scheme based UWB-IR

Comparison among UWB and other narrowband systems

UWB regulation
Stepped-FM scheme

- **Transmitted signal**
  Composed of monotone pulses with different frequency by $\Delta f$
  ⇒ Similar to stepped CW of VNA

- **Bandwidth**
  Wider bandwidth to synthesize several monotone pulses
  ⇒ Low speed A/D devices

- **Resolution**
  High resolution by signal processing

- **Inherent DAA capability**
  • Detection of interference
  • Anti-interference
  ⇒ without additional DAA devices

Range spectrum (target: 5m, 5.5m)
DAA of stepped-FM scheme

Stepped-FM scheme with DAA

Interference

Stepped-FM scheme × OFF ON

Block diagram

Schematic view

⇒ Empirical Study

Detect mode (Tx: off, Rx: on)

Avoid mode (Tx: on, Rx: on)
Empirical Study of DAA

Results

- Interference output (Detect mode)

- Transmitted signal (Avoid mode)

- Received signal (Co-exist mode)

⇒ coexist with exiting radio systems
Elderly-care monitoring sensor

Care facility

Scene for measurement environment

Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Transmitted power</td>
<td>-12.5dBm</td>
</tr>
<tr>
<td>Frequency band</td>
<td>3.5～4.5GHz</td>
</tr>
<tr>
<td>Stepped width Δf</td>
<td>14.5MHz</td>
</tr>
<tr>
<td>Number of step N</td>
<td>70</td>
</tr>
<tr>
<td>Frame period</td>
<td>0.2sec</td>
</tr>
<tr>
<td>A/D</td>
<td>70KS/s</td>
</tr>
<tr>
<td>antenna</td>
<td>Horn(9.88dBi)</td>
</tr>
</tbody>
</table>

Detected state

- fall
- sitting up in bed
- tossing about in bed
- sleeping in bed
- walk in room
- static
- out of room
Elderly-care support system using wireless radio
Kajiwara lab
Graduate School of Environmental Engineering, The University of Kitakyushu

Demonstration experiment

① out of room Observation time : 3 min 30 sec
Measurement results

- **Detection rate**

  ![Graph showing detection rate results](image)

<table>
<thead>
<tr>
<th>State</th>
<th>Detection rate [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>out of room</td>
<td>100</td>
</tr>
<tr>
<td>sitting up in bed</td>
<td>100</td>
</tr>
<tr>
<td>fall</td>
<td>100</td>
</tr>
<tr>
<td>others</td>
<td>99.07</td>
</tr>
<tr>
<td>average</td>
<td>99.23</td>
</tr>
</tbody>
</table>

*others (tossing about in bed, sleeping in bed, walk in room, static)  
*threshold : FAR = $10^{-3}$

- **DAA capability**

  ![Graph showing DAA capability results](image)

  **Detection rate versus spectrum holes**
Conclusion

- DAA of stepped-FM scheme has been proposed
  - Interference detection capability
  - Coexistence capability employing spectrum holes

- Elderly-care monitoring sensor has been suggested
  - Measurement in care house
  - Good detection performance
    - higher than 99% without hole
    - approximately 85% for a hole of 145MHz