Motivation

- Old age population (> 60 years) in developed countries
  - 2009: 21%
  - 2050: 33%
- Constant monitoring due to their deteriorating health
- Ever increasing costs of elderly care facilities
- More than 70% want to stay at their own homes

Serve the elderly people at their own homes

Mobile Robots in Elderly Care

- SCITOS G3
- Kompaii

Why a Robot has to Find the Human?

- Periodic monitoring of the elderly person
- Doctor wants to remotely inquire about the health
- Reminding the elderly person about appointment
- Recognition of accidental situation
- etc.

In all these scenarios, a mobile robot has to search the elderly person.

Human Search Approaches in Robots

- Random Search
- Closest location based search
- Time based search
- Last known location based search

Searching Human using Mobile Robots

- SCITOS G3
  - Manually defined navigation points
  - Search "closest navigation point"
- Kompaii
  - Manually defined locations
  - Search "least recently visited" location
How Humans Search Lost Objects?

- Locus Search – based on the information where the objects are normally found. (33%)
- Exhaustive search - without any preference. (24%)
- Retrace search - sequentially search at locations where physically present. (19%)
- Memory search - search the locations where there was a prior interaction with the object. (11%)
- Delegation search – delegate the search to someone else. (11%)

Pro-active Approach for Human Search

- Focus on human presence practices
- Learn the location-based human routine
  - Where
  - When
- Generate a knowledge-base about human presence at different
  - Locations
  - Times
- Search human using the developed knowledge-base

Challenges in Searching a Human

- Human is independent in terms of mobility
- Definition of human routine
  - Granularity of time
  - Activities
  - Locations
- Modeling human routine
- Learning and Searching side by side
- Highly interactive with its environment

Addressing the Challenges

- Modeling the human routine as probabilities
- Granularity of human presence – every hour of the day
- Robot navigates from one location to another in search of the human
  - Either human is found or
  - Declare that the human is not present
- Reinforcement learning
  - Markov Decision Process (MDP)
  - Q – Learning algorithm to solve MDP

Experimental Setup

Learned Human Routine (Bedroom)
Human Found in IESE-Fraunhofer

Results of Search with Different Data Sets

<table>
<thead>
<tr>
<th></th>
<th>Total search attempts</th>
<th>Total success (%)</th>
<th>False negative (%)</th>
<th>Success rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Set 1</td>
<td>9401</td>
<td>97.34%</td>
<td>2.66%</td>
<td>72.87%</td>
</tr>
<tr>
<td>Data Set 2</td>
<td>9744</td>
<td>97.08%</td>
<td>2.91%</td>
<td>75.11%</td>
</tr>
</tbody>
</table>

- **Success Cases**
  - Human at home and found
  - Human not at home and not found

- **Success Rate**
  - Human found at current location or in 1st attempt
  - Human found in further attempts contributes accordingly less towards Success rate

![Image](rrlab.cs.uni-kl.de)

**Conclusion**

- Robot pro-actively search the human
- Learning the daily human routine
  - The robot autonomously learns the routine
  - Correlation between reference routine and learned routine more than 90% after 8 weeks
- Policy for searching human
  - Based on learned routine of the human
  - Promising success rate of more than 70%

![Image](rrlab.cs.uni-kl-3)

**Thank you for your attention!**

Questions?