Human-Robot Interaction (HRI)

Case: WorkPartner
WorkPartner

- Multipurpose service robot for lightweight outdoor tasks
  - Janitor of future
  - Gardening
  - Guarding
  - Handling of Objects
- Cooperation with humans
WorkPartner

• Hybrid energy system to provide autonomy
• Control commands and interaction by normal human communication
• Communication should be easy for both human and robot cognition
HRI – Communication media

• The primary media: seeing, hearing and touch
  – Visual displays (GUI or/and augmented reality)
  – Gestures (hand and facial movements) and movement-based signals
  – Speech and natural language (both auditory speech and text-based responses)
  – Non-speech audio
  – Physical interaction and haptics (force feedback)
HRI – Format of the information exchange

• Speech
  – Natural language, scripted, formal language etc.

• Sounds
  – Alarms, 3D awareness

• Haptics
  – Warnings, feeling of telepresence

• GUI
HRI-functions of WorkPartner

- Communication with the robot in all situations
- Direct teleoperation
- Task supervising and assistance
- Task definition/teaching
- Environment understanding through common presence
- Information management in the homebase (internet server)
Teleoperation - Applications

- Direct control of Robot
- Assistance of work tasks
Teleoperointi – Control methods

- GUI + Mouse
- Joystick
- Teleoperation device
Joystick

- Laptop + holder
- Vehicle control
  - Driving
  - Height control
  - Inclination
  - Driving modes
- Turning the head
Teleoperation device (yoyo)

- 2 x 3DoF handtrackers for Wopa torso control
- Wire potentimeters in gimbals
- Wrist and back positions with inertial sensors
- Tasks
  - Gestures without camera
  - Pointing
  - Direct teleoperation of:
    - Vehicle movements
    - Torso waist
    - Manipulator hands
Teleoperation

- Video: teleoperointi_editoitu
- Video: roska_teleop
Defining work tasks

- Visual Programming
- Micro Tasks are the base of the skilled tasks
- Tasks are constructed like state diagram
Skilled Tasks - definition

- Skilled tasks are defined as tasks that need to adapt the environment and the present situation, and they cannot be executed by blindly repeating a sequence of movements.
- Skilled tasks are non-trivial actions that may require learning or training before successful execution.
- These tasks are usually executed in an unstructured environment, such as a yard, a parking lot, a park, etc.
- Also tasks need to be programmable by the user without extensive user training, and they have to be adaptable to varying situations.
Micro Task - definition

- Lowest level building block for the work task, the root of the skilled task
- A micro task will always be executed as a whole, and the feedback will be used as additional information to the later tasks
- Divided to three groups in the framework
  - movement
  - perception
  - calculation
Example: Pick Up Litter

INITIALISATION
- LMR_SPEAK
- LMR_LOADCODE
- LMR_SAVEPOS

DETECT LITTER
- PS_DETECTCOLOROBJECT
- LMR_OBSCONTO
- MANIP_SETANGLES
- MIR_TURN

LOCATE LITTER
- PARAM_COPY
- MANIP_SETANGLES

PREPARATION
- MANIP_SETANGLES

BACK TO HOME
- LMR_MOTADVANCED
- LMR_OBSTADVANCED
- LMR_MOTADVANCED

APPRAOCH
- MANIP_SETANGLES

LOCATE GRIPPER
- PS_LOCATEGRIFFER
- MIR_TURN

PICK UP
- MANIP_SETANGLES

LOCATE LITTER
- MANIP_SETANGLES
- PS_LOCATEGRIFFER

Example: Pick Up Litter

29.4.2008   AS-84.3147, Mikko Heikkilä
Work Task Control

- GUI
  - Control of work tasks (startup etc.)
  - Map
  - Objects
Information Exchange Methods

- **Speech**
- **Gestures**
  - Teleoperation device
  - Camera based
- **Signs**
- **Pointing**
  - Laser pointer
  - Pointing tool (red ball)
  - From the camera image
- **Leading**
- **Expressions, Lights**
- **3D Mapping of Environment**
Use of Speech

- Speech Processing (recognition) and Natural Language Processing (NLP) are complex processes and are not reasonable to study in this context.
- Commercial speech processors (Phillips, IBM, MS, etc.) are used.
- Robot is mostly commanded with relatively few discrete commands to maintain reliability.
- A very simple language, based on commands and presence symbolic information, has been created.
Speech Synthesizer

- Robot responses with speech
  - Dialog based
  - Status information

- Speech Synthesizer
  - The Festival Speech Synthesis System
Gestures

• Gestures can be given
  – by camera and image processing, or
  – by control yo-yos

• Jacket with a specific color is analyzed by camera and gesture shapes recognized.

• Same gestures can be recognized from yo-yo positions

• Only simple static signs are used presently

• Video: WopaBringsBox
Signs or artificial beacons

- Positions or areas are pointed/demarkated with passive or active sticks
- Comparable to traffic or road maintenance signs
- User uses his cognition when putting the marks. Robot recognizes them and uses the associated information to execute the work tasks.
The Signs

- The signs are a tool for passing information of the work task plan from the human operator to the service robot.
- Using for configuring work tasks interactive.
- The signs are movable.
- Variable looking or/and content of the data.
- Examples: pointing the direction, bounding an area, marking a route, defining location of a target etc.
- E.g. Road signs for humans (they are not movable).
Work Task Configuration by an Interactive Way with assistance of Signs

• Dialog
  – User: ”Clean yard”
  – Robot: “Where is the yard”
  – User: “Backyard marked with passive signs”
Types of Signs

• Passive Signs
  – Variable looking (detected with camera)
  – No electronics

• Active Signs
  – Detected via Bluetooth
  – Includes electronics (GPS etc.)
  – Data saved to memory of the controller
Passive Signs

• Two spheres (the bigger orange one and the smaller yellow one)

• Image handling used for detect and localize the signs
  – Segmented by the color
  – Circles were found and their sizes were calculated
  – 3D pose of the sign was calculated based on the measured distance and the camera orientation
Passive Signs

• The four signs were used to define corner points of a working area
• Each sign shows direction to the next sign
Passive Signs

- The cap between correct angle of the sign and calculated was from -10 to 10 degrees.
- The error was quite huge but small enough in this case.
- The idea was to say to the robot “go to that direction approximately”.
- The image handling caused most errors when measuring locations of the signs (lighting conditions)
Active Signs

- The signs was located in the center of the working area
- The active sign includes microcontroller, Bluetooth and GPS modules
- The sign was located in the center of the working area
- Before starting to clean the area the WorkPartner communicated with the sign via Bluetooth
- Received data from the sign included the location of the sign and the radius of the working area
Cleaning Task

• In both cases (passive and active signs)
  – The working area was determined based on the information acquired from the signs
  – During the task execution the robot wandered a route inside the working area and moved the tool, the plough or the brush, up and down
  – Video: P2060001.mov
Pointing

- Pointing is to define by showing an object or a place
- How to show things to a robot?
  - Difficult in natural 3D environments even between humans
  - Line of hand is difficult to follow
  → Clear and unambiguous methods needed to combine the spatially tied cognition of the user and robot
3DoF mouse

- Pointing by turning the robot head including a laser pointer/range finder
- Always a perfect match!
- Pointing with trackball or control yo-yos
- Telepointing by using the camera
Optical pointing with sceptre

- Stick with red ball
- Optical tracking based on color maps
- Like operator and gesture tracking
- Without any computer hardware on operator
- Only for short distances
- Distance information either from size in camera picture or with ranging laser

- Video: GrabbinBall
Pointing from the Map

- For example: ”The backyard is here” -> Click
- ”Take that ball”
Leading (Haptic interface)

- "Give me your hand. I will lead you."
- The force affected to shoulder joint is measured
- Applications
  - Show the way
  - Focusing the speech
Expressions + Lights

• Express the "feeling" of the robot
  ◦ Happy
  ◦ Sad etc.
  ◦ Usually the express the working mode

• Light on the helmet
  ◦ Status of the robot

• Video: Ilmeet
Environment modelling

- Model created off-line with 3DoF laser scanner
- Objects and work areas are stored in a database
- ECDIS type layer based visualization
- User can see and edit database with PDA
- Both can update the database when needed
Map generation

- Imaging with 3D laser scanner
- Filtering the information to object based 3D elevation map and simple topographic map (both for operator) and 2D occupancy grid (for the robot)
Picking up the Trash

- Video: roskademo.mpg
Box transportation task

• Second task was an interactive task where the robot transported a box from one person and brought it to another.

• The box transportation task was more concentrated on demonstrating the human-robot interaction provided by the robot and control architecture

• The instructions to the robot were given in spoken language using third party speech recognition software
Box transportation task

- In the task the robot first identified the possible users using camera (two users called Jari(Santa) and Tapio)
- In the second phase Jari command the robot as shown in the table
- In the third phase the robot waited more commands (Shake the box, Put box down etc.)

<table>
<thead>
<tr>
<th>Num.</th>
<th>Robot</th>
<th>Main User (Jari)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stereo Hearing ON</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>“Hello WorkPartner”</td>
</tr>
<tr>
<td>3</td>
<td>Locate User</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Stereo Hearing OFF</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>“What Can I Do for You”</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>“Get Box”</td>
</tr>
<tr>
<td>7</td>
<td>“What Kind of Box”</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>“It is red”</td>
</tr>
<tr>
<td>9</td>
<td>“Where Is the Box”</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>“With Tapio”</td>
</tr>
<tr>
<td>11</td>
<td>Locate User (Tapio)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>SavePos (Home)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>GotoXY (Tapio)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Locate Object (Red Box)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Grib (Box)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>GotoXY (Home)</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>“What Can I Do for You”</td>
<td></td>
</tr>
</tbody>
</table>
Box transportation task

- Video: joulupukki2.avi
Future

- Touch Screens
- Wii multi touch screen
- Future work site
- Android science
Thank you
WorkPartner HRI History

- Teleoperointi (Windows GUI + Joystick)
  - Labview
  - Delphi
- PDA
- Seuraa palloa
- Talutus
- Eleet sadetakilla
- Eleet jojohärvelillä
- Seuraa sadetakkia
- Teleoperointi yoyolla
- Skilled task GUI + Kartta
- Puheohjaus tehtävänohjauksessa
- Viitat
- MainPC UI: Process control etc.
- Laser pointeri osoitukseen
- Future: Touch Screen, Multi touch screen, ...