Model-based Evaluation of Psychological Sense of Security for Moving Humanoid Robots Based on Analytic Hierarchy Process

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Background

- In the near future coexisting robots with human are expected to help us in our daily life.

- Need to design the robots and their motions to achieve both “physical safety” and “mental safety”.

- We will try to evaluate psychological sense of security for moving humanoid robots using AHP (Analytic Hierarchy Process).
Experiment by using CAVE

The CAVE is a projection based virtual reality system developed at the Electronic Visualization Lab., University of Illinois at Chicago.
A humanoid robot passing by a human examinee in corridor
Experimental Method

A robot is approaching to a human examinee.

Push a button when he/she wants to avoid.

Get a questionnaire after the experiment.

Movement of robot

**Speed**
- Fast (F)
- Slow (S)
- Speedup (SU)
- Slowdown (SD)

**Head motion**
- Look around (LA)
- Facing forward (FF)
- Facing the examinee (FE)

**Passing distance** $d$
- 0 m
- 0.2 m
- 0.5 m
Example of Experiments

**HRP-2**

- **Distance**: 0.5m
- **Speed**: F
- **Head motion**: FF

**HRP-2**

- **Distance**: 0.2m
- **Speed**: F
- **Head motion**: LA

**HRP-2**

- **Distance**: 0.5m
- **Speed**: F
- **Head motion**: FE

**Examinee**

- **PUSH button!**
Hierarchical Structure for Evaluating Uneasiness

Alternative motions of a humanoid robot to be evaluated

<table>
<thead>
<tr>
<th>Overbear</th>
<th>Overbearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awful</td>
<td>Awful looking</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without noticing me</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>No sign of avoiding me</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looks to fall down</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stumble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looks like stumbling</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Come</th>
</tr>
</thead>
<tbody>
<tr>
<td>Come close to me suddenly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Which way</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which way to come?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rush</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looks to rush</td>
</tr>
</tbody>
</table>
AHP （Analytic Hierarchy Process）

- Originally developed by Prof. T.L. Saaty

Procedure of AHP

1. Describe a hierarchical structure of decision making.
2. Pairwise comparison of each pair of alternatives with respect to each criterion. Pairwise comparison of each pair of criteria.
3. Evaluate weight of each alternative and each criterion.
4. Evaluate overall importance of each alternative by the weighted average.
Evaluation Method

Using AHP compute the value of fear, unpleasantness and uneasiness.

These values are divided into each movement (speed, head motion and distance $d$) of robot.

These values are divided by the mean value of examinees for each movement.

Describe radar chart.
Radar chart for the speed of robot
Radar chart for the head motion of robot

- Uneasiness
- Fear
- Unpleasantness

Look around

Facing the examinee

Facing forward
Radar chart for the passing distance $d$
Concluding remarks

Psychological uneasiness to feel for the movement of humanoid robot is analyzed by using AHP.

Robot movements of getting psychological sense of security are as follows:

- Speed is slow.
- Head motion is facing the examinee.
- Passing distance is longer the better.

But for fear people feel more for slow movement than for fast movement of robot.

We need further research by using different analytical and experimental psychological methods.