Confidence: Ubiquitous Care System to Support Independent Living

Problem
- Fewer than two persons of working age for each person aged 65+ in EU by 2050
- Need of technical solutions that enable the elderly to live independently longer with minimal support from the working-age population

Our solution
Confidence, a care system for the elderly that is able to detect:
- Abnormal events such as falls (short-term)
- Unexpected behavior that may be related to a health problem (mid- and long-term behavior changes)

System architecture

SENSORS
Accelerometer + location tag at the neck; optionally, location tag at the waist and both feet.

PREPROCESSING
Filtering for noise reduction: median filter, anatomic constraints, Kalman filter

ACTIVITY RECOGNITION
- Activities: standing, sitting, lying, sitting on the ground, on all fours, the process of sitting/lying down, the process of standing up and falling
- Attributes: tag velocities, distances between tags
- Predictions: ML module (Random forest) and rules module (domain knowledge); final activity determined by Bayesian inference; activity smoothing performed by HMM.
- User adaptation: semi-supervised learning

FALL DETECTION
Using location sensors:
- Fall event: the user has not got up for s seconds.
- Attributes: user's activities and amount of movement in last t seconds, last falling activity, contextual data
- Predictions: ML module (SVM and C4.5) and rule module (domain knowledge)
- User adaptation: MDP, rewards are derived from user feedback

Using accelerometer:
- Fall event: the difference between the minimum and maximum acceleration in one-second window exceeds the threshold T.

UNUSUAL MICRO MOVEMENT
- Detection of mid-term behavior changes (e.g. limping, slow movement)
- Attributes: gait and posture signature
- Predictions: local outlier factor algorithm

UNUSUAL MACRO MOVEMENT
- Detection of long-term behavior changes (user's space-activity patterns alterations)
- Attributes: user's daily traffic patterns containing spatial-activity distributions
- Predictions: PCA + local outlier factor algorithm

Demo

<table>
<thead>
<tr>
<th>ALARM RAISED?</th>
<th>Inertial</th>
<th>Location</th>
<th>Joint Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALL SCENARIOS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tripping</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Falling slowly</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Tripping + standing up quickly</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>NON-FALL SCENARIOS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lying down quickly</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Searching under the table</td>
<td>No</td>
<td>Yes/No</td>
<td>No</td>
</tr>
</tbody>
</table>