Monitoring the well-being of a person using a robotic-sensor framework

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Autonomous monitoring of the user’s well-being
An integrated, cooperative system for life enhancing applications
Autonomous monitoring of the user’s well-being

An integrated, cooperative system for life enhancing applications

Integrate robots, agents, sensors, and human

- Improve accuracy
- Provide broader view of the well-being
Health Related Applications

- More than 18% of the U.S. population were reported to have a disability in 2010.
- About 38 million people had some form of severe health-related disability.

Source: U.S. Census Bureau reports
Health Related Applications

- More than 18% of the U.S. population were reported to have a disability in 2010.
- About 38 million people had some form of severe health-related disability.
- 36% of people 65 and older had some type of disability in 2012.

Source: U.S. Census Bureau reports

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Health Related Applications

- More than 18% of the U.S. population were reported to have a disability in 2010.
- About 38 million people had some form of severe health-related disability.
- 36% of people 65 and older had some type of disability in 2012.
- Over 18% of students who receive special education services (under IDEA) had certain health impairments in 2012.

Source: U.S. Census Bureau reports
Wearable Sensor Exposure
<table>
<thead>
<tr>
<th>Date</th>
<th>Weight</th>
<th>BMI</th>
<th>Calories Burned</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-03-09</td>
<td>114.99</td>
<td>19.61</td>
<td>1789</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Steps</th>
<th>Distance</th>
<th>Floors</th>
<th>Minutes Asleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>8730</td>
<td>3.73</td>
<td>39</td>
<td>302</td>
</tr>
</tbody>
</table>
Wearable Sensors

http://www.iflscience.com
Robotics
In 2013 the Robotics Caucus Advisory Committee of the U.S. Congress outlined *socially assistive robotics technology* for members of *special needs population* as one of the *key* areas in robotics instrumental in:

- facilitating independence and mobility
- for those who suffer from disability and aging-related disorders
Coordination for Well-Being Monitoring
Coordination for Well-Being Monitoring
Wearable Sensors  OWLS  Immobile Sensors
Figure: Flowchart showing the systematic methodology of our framework.
Figure: Stationary and Wearable sensor system and Turtlebot II robots used in our experiments
Sample data produced by the sensors

<table>
<thead>
<tr>
<th>ID</th>
<th>Date</th>
<th>Time</th>
<th>Accel. (x,y,z)</th>
<th>Magnit. (x,y,z)</th>
<th>Gyro (x,y,z)</th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15/11/2015</td>
<td>20:29:40</td>
<td>1.10, -8.53, -4.83</td>
<td>-2.62, -1.69, 0.24</td>
<td>2.18, -2.19, -8.35</td>
<td>15.63</td>
</tr>
<tr>
<td>100</td>
<td>15/11/2015</td>
<td>20:30:32</td>
<td>1.17, -8.40, -4.80</td>
<td>-2.62, -1.43, 0.56</td>
<td>2.67, -2.68, -8.44</td>
<td>19.62</td>
</tr>
<tr>
<td>800</td>
<td>15/11/2015</td>
<td>20:45:17</td>
<td>6.58, -11.78, -4.88</td>
<td>0.11, 0.19, -0.01</td>
<td>33.94, 22.12, 22.98</td>
<td>37.87</td>
</tr>
<tr>
<td>1200</td>
<td>15/11/2015</td>
<td>20:48:29</td>
<td>5.97, -8.13, -1.40</td>
<td>0.37, 0.18, -0.20</td>
<td>-55.21, 5.94, -17.70</td>
<td>41.87</td>
</tr>
</tbody>
</table>
### Sample aggregated data

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Movement</th>
<th>Distance</th>
<th>Temperature</th>
<th>Heart Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/11/2015</td>
<td>17:18:32</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>15/11/2015</td>
<td>08:34:16</td>
<td>Abnormal Alt. by 200cm</td>
<td>Abnormal 0.1 miles</td>
<td>Normal</td>
<td>Low 60 beats/min</td>
</tr>
<tr>
<td>15/11/2015</td>
<td>16:35:59</td>
<td>Normal</td>
<td>Normal</td>
<td>Abnormal Temp. by 2C</td>
<td>Normal</td>
</tr>
<tr>
<td>15/11/2015</td>
<td>23:20:10</td>
<td>Abnormal High accel change</td>
<td>Abnormal 5.2 miles</td>
<td>Normal</td>
<td>High 102 beats/min</td>
</tr>
</tbody>
</table>
Sample aggregated data
Threshold Value
<table>
<thead>
<tr>
<th>Condition</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>93%</td>
</tr>
<tr>
<td>Slightly abnormal (notify caregiver)</td>
<td>94%</td>
</tr>
<tr>
<td>Abnormal (notify doctor)</td>
<td>97%</td>
</tr>
<tr>
<td>Very abnormal (emergency)</td>
<td>100%</td>
</tr>
</tbody>
</table>
Summary

- Integrated sensor-robot system can provide a broader view of the user and his or her conditions.
- Data is everywhere, including robots, sensors, biomedical field.
Summary

- Integrated sensor-robot system can provide a broader view of the user and his or her conditions.
- Data is everywhere, including robots, sensors, biomedical field.
- Learning techniques can help process and analyze large data.
Integrated sensor-robot system can provide a broader view of the user and his or her conditions.

Data is everywhere, including robots, sensors, biomedical field.

Learning techniques can help process and analyze large data.

Future Work

- Utilize more sensors.
- Conduct more experiments.
- Use text mining to better assess user’s condition based on:
  - the medical history of the user,
  - the research articles relevant to the current user’s condition.

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