Smart insole for measuring actimetry of frail people

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Nano Engineering and System Integration (N2IS)
Plan

- Context and issues
- The developed device: smart insole
  - Application requirements
  - Hardware integration
  - Software development
- Experimentation and results
  - Gait speed
  - Weight variation
- Conclusion
Context : worldwide ageing

Frailty in France (>65): 15% frail, 50% pre-frail
Issue: frailty syndrome

Fried criteria

- Exhaustion
- Low level of activity
- Slow gait speed
- Involuntary weight loss
- Less muscle strength
- Higher vulnerability to stressors

Contribution

How to encourage frail people to practice walking?

- Quantified self approach: to each his own goal
  - Distance or number of steps
  - Minutes of activity

- Designed in a medical context
  - Reliability
  - Link with health professionals

- Intrusiveless and adapted for everyone

Smart insole connected to a web interface
The smart insole: application requirements

- **Goals:**
  - **Subject:** to inform, to motivate, to maintain physical activity
  - **Physician:** to set goals, to interpret results, to follow
  - **Relatives:** to help the subject

- **Bottlenecks:**
  - **Ambulatory Measures:** speed (average and variation), weight (variation), daily activity
  - **Minimum invasiveness:** thickness
  - **Friendly and easy-to-use** interface
  - Indoor and outdoor
  - **Lifetime:** at least 3 **months**
The smart insole: hardware integration

Global architecture

Insole                  Pad                  DB                  Web site

Respect
Data Collector

Instrumented insole

LIPO rechargeable battery

3 axis accelerometer LP

Microcontroller 32 bits

Pressure sensor

BLE communication

Y. Charlon, F. Bettahar, E. Campo “Design of a smart shoe insole to monitor frail older people,” Int. Conf. on Modern Well-being for Societies and Territories (LivInWell), 2013
The smart insole: software development

Stride detection

$\bar{a}_j = \frac{1}{2w+1} \sum_{q=i-w}^{i+w} a_q$

local mean of acceleration (15 samples)

$\sigma_{ai}^2 = \frac{1}{2w+1} \sum_{j=i-w}^{i+w} (a_j - \bar{a_j})^2$

local acceleration variance

$step_n = \alpha C_n + \beta RMS_n + \gamma Mean_n$

Stride’s length

$C = \frac{6}{t_j - t_{j-3}}$

Cadence (last three strides)
Experiments and results: gait

- 3 young volunteers
- **Test 1**: 3 different speeds: slow (1 m/s), medium (1.25 m/s) and fast (1.75 m/s)
- **Distance**: 400m

<table>
<thead>
<tr>
<th>Speed</th>
<th>Volunteer 1</th>
<th>Volunteer 2</th>
<th>Volunteer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow speed</td>
<td>3.9%</td>
<td>4.2%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Medium speed</td>
<td>2.6%</td>
<td>2.5%</td>
<td>2.4%</td>
</tr>
<tr>
<td>Fast speed</td>
<td>3.2%</td>
<td>3.2%</td>
<td>3.3%</td>
</tr>
</tbody>
</table>

Table 1: Covered distance error

- **Test 2**: 3 months follow up with 3 volunteers
- **67 days of autonomy**
Experiments and results: weight

Average of maximum output voltage over 10 strides
Experiments in living lab (Maison Intelligente de Blagnac)

Population:
• 10 robusts
• >65 years

Charge by induction
Web user interface
Conclusion

- Good monitoring tool for frailty
  - Gait speed and distance
  - Weight variation

- First tests already realized:
  - 3 young volunteers: insole technical validation (in laboratory)
  - 10 robust elderly (>65 years old): insole and GUI technical validation and acceptability (in living lab)

- What’s next: Widespread technical and clinical test
  - 30 frail people at home
  - Uses’ evaluation, validation of installation process, feedback on the insole and the web interface
Thank you for your attention
Question(s) ?

http://anrrespect.livehost.fr