Multi Sensor Wrist Device for Surveillance of Elderly Persons
Developed within the FP6 Project EMERGE

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Motivation

- 44% of Emergency Medical Services’ (EMS) system resources are dedicated to patients older than 65 years of age (statistical report of the town of Kaiserslautern 2005)
  - 24.5% of elderly people are living alone
  - only 3% of the affected people in emergency situations have a PERS at hand
  - From these
    - 40% used PERS, PERS indicated 37%
    - 60% did not use PERS, PERS indicated 67%
  - In total, the PERS was used only in 1.3% of all cases to report the incident

- Automatic detection and alarming of emergencies and potentially arising emergencies would be a great benefit
EMERGE – Overview

-assisted Person
-ambient Sensors
-perception
-assistance
-interaction

raise / cancel alarm, inform

Emergency Alarm
Dispatcher
Critical long-term Trend
Family Doctor
Social Information
Care Giver
Relatives

Detailed Instructions
Emergency Doctor
Sensors

- **Vital Data**
  - Electronic weight scale
  - Electronic blood pressure device
  - Pulse and skin temperature with wrist device (watch)
  - Heart frequency and breathing with bed mat

- **Activities (Sensors in the environment)**
  - Light switches, blind switches (home automation)
  - Position tracking of persons at areas of interest (movement sensors)
  - Usage of furniture, doors, windows (contact sensors)
  - Object usage (toilet, shower, faucet)
  - Device usage (power measurement)
  - Fall detection: Wrist device (watch)

In general:
- Sensors in the environment, mountable afterwards
- Battery/batteryless operation
- Wireless data transmission
Functional Health Status

\[ h_t = f_t(p_1, p_2, \ldots, p_n) \]

- perfect
- known restrictions
- normal
- critical
- Dementia
- Depression
- Fall Helplessness
Example of Activity of Daily Living (ADL) Supervision

- Daily measure (orange)
- Personalized region of normality (red)
  - Calculated dynamically
  - Upper limit
  - Lower limit
  - Self learning
- Assessment for various time periods
  - Day -> Week
  - Week -> Month
  - Month -> Half year
Art of Technology AG

- Founded in 1999 as a Spin-Off of the ETH Zurich
- Has its roots in the EU project EUROPRAC TICE (1995), Dissemination of the HDP/MCM technology in Europe
- Contract Developer for
  - Miniaturization, Medical, Aerospace, Fixed and Wireless Communications, Sensor Technology, Computer and many other
- Certified QS-System
- Since 2005 situated in Technopark Zurich
- Staff: 9 Engineers + 2 Management/Sales + 1 Administration
Wrist Wearable Device  Current capabilities

- Watch with rechargeable Battery
- ZigBee „Sensor“
- Alarms sent to Gateway
  - Alarm Button that sends Alarm and starts measurement
  - No activity alarm
  - Battery Low Alarm
  - Not Worn Alarm
  - Fall followed by helplessness alarm
- Measurements (once per minute)
  - Activity Level and no activity detection
  - Skin Temperature
  - Pulse rate (does not clamp impossible values)
- USB Device for charging, setting time and configuration
Minimal Configuration for Inhouse use

- In EMERGE the WMD is integrated into a Multi-Sensor Environment
- This is not a requirement but we must assume that the WMD is not worn during night
- The minimal Configuration is
  - WMD
  - Gateway
  - Sleep monitor in bed
  - or reduced: Presence Sensor in Bedroom
Gateway

- A Gateway can be
  - USB stick in any computer
  - Adhoco residential gateway
Sleep Monitor (EMICS)

- Raw signal provided by EMFIT sensor, charge proportional to change in pressure
- Signal analysis
  - Presence
  - Activity
  - Heart rate
  - Breathing rate
  - Sleep / Non-sleep
- Transmission over IEEE 802.15.4 (MAC layer below ZigBee) to PC
WD Temperature Measurement/Simple Worn Recognition

- Device not Worn
- Alarm
- WD removed from arm
- WD mounted on
Raw Pulse Measurements

- Raw Curve black
- Filtered blue
- Pulse Indication green
Evaluation results: Pulse and Temperature

- Comparison vs. Polar like Device
  - WD measures pulse
  - PD measures rhythm
  - Both do not fully agree with medical grade devices
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Evaluation results: Fall detection

- Scenario based evaluation
- Method of measurement
  - Movement measures in 3 axes and overall for activity measures sent out regularly
  - Impact recognition followed by a period of no movement raises a fall alarm
  - No movement over a longer period raises a no-movement alarm

<table>
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<tr>
<th>Test Setup</th>
<th># performed</th>
<th># positive</th>
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<tbody>
<tr>
<td>Fall of Watch</td>
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<td>9</td>
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<td>Sideways Fall</td>
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<tr>
<td>Forward Fall</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Forward Roll</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Backward Fall</td>
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<td>1</td>
</tr>
<tr>
<td>Slowly Downwards</td>
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<td>1</td>
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<tr>
<td>No Movement</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
Elderly User Opinions

- Levels
  - 1 disagree strongly
  - to 6 agree strongly

- Usefullness: 4.6
- Attractiveness: 3.2
- Usability: 3.42
- Comfort: 4.1
- Acceptance: 3.5

- Measurement technology not known to users
- Design too fancy
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Viewer
Outlook Overall

- **Socio-medical service center**
  - Care center for assisted living
  - Extension of EMS dispatch center
  - Hospitals: Rehabilitation at home

- **Automatic notification**
  - *restricted by law*

- **Interaction facilities**
  - Contact via phone
  - Contact via video phone (with webcams)
  - Remote control of home automation
  - Remote assistance with robot

- **Handover to EMS**

- **Triggering service providers**
  - Social service
  - Psychological service
  - Medical service
  - Emergency service
Outlook Wrist Wearable

- The wrist device is a key product for a continuous, unobtrusive monitoring. All sensors are integrated in a watch like device.

- AOT is ready to provide the Wrist Device as building block into monitoring services. Possible Partners are not yet selected.

- With service partners the requirements for series device shall be defined and then a commercial version developed.
Thank you

- for your attention
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