Threshold-based Fall Detection on Smart Phones

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HEALTHINF 2014, 5.3.2014

Outline

- The Kompass Project
- Threshold-Based Fall Detection
- Evaluation for Android-Smartphones
- Demo

The Kompass Project - started 2008

Kompass supports seniors and their caretakers:

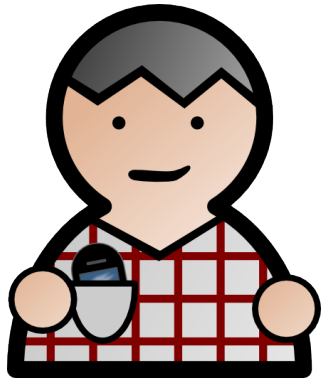
1. Appointment reminder,
2. Fall detection with alarm call,
3. monitoring of seniors suffering from dementia with alarm call

Cooperation with the nursing home Florencehort, LAFIM, in Stahnsdorf

Kompass Requirements

- **easy-to-use:** Caretakers should be supported $\Longrightarrow$ no additional technical devices, but alarm call to their office mobiles
- **easy-to-use:** Input of appointments via PC
- **Low operational costs** and **easy to install** (i.e. no extra constructional costs are required).

$\Longrightarrow$ Seniors get a smartphone with Wi-Fi, the
$\Longrightarrow$ *Kompass–Assistent*.



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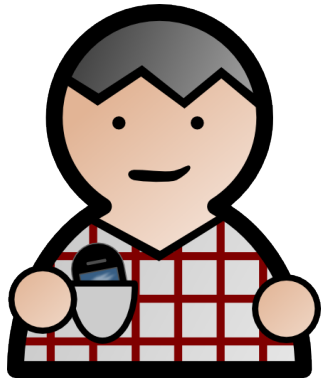

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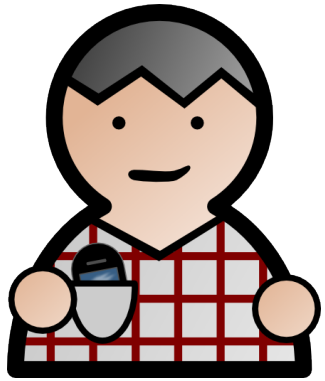
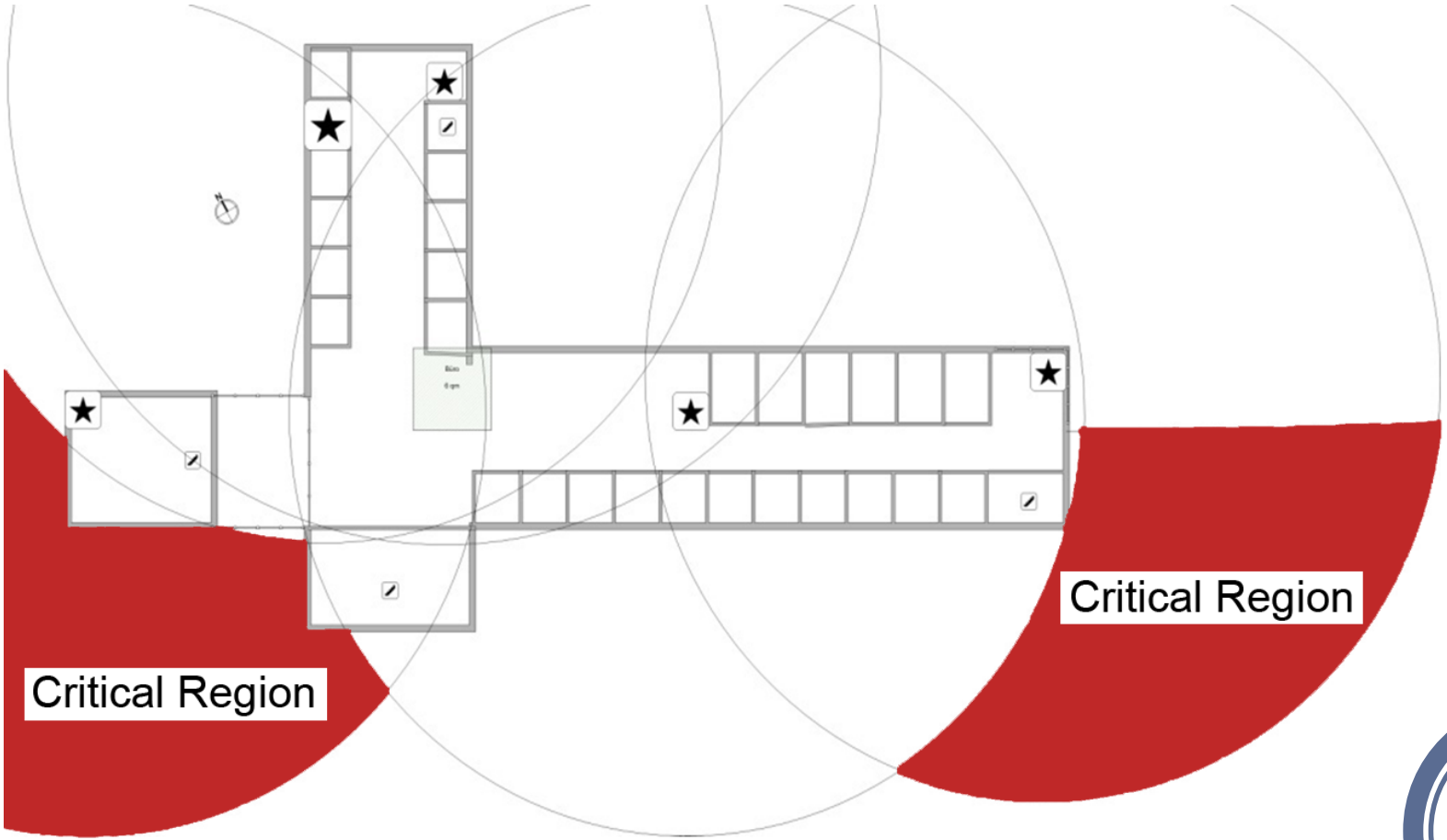
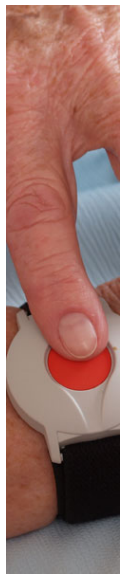


Monitoring/Localization

- 6 Wi-Fi Router
- Lokalization based on the Received Signal Strength (RSS)



Differences to existing systems: German Red Cross



Alarm center acts 365/24:

- Alarm Buttom
- Keep-alive-Signal $\Longrightarrow$ Button has to be activated twice a day

  $\Longrightarrow$ **no active fall detection**

Alternative Solutions

- **Smart Cameras** for Fall Detection:
  - restricted to dedicated areas (garden?)
  - blind spots?
  - costs,
  - privacy?

- **Sensor mats:**
  - restricted to dedicated areas (garden?)
  - stability?, hygiene?
  - costs

Kompass Approach

Smartphone:

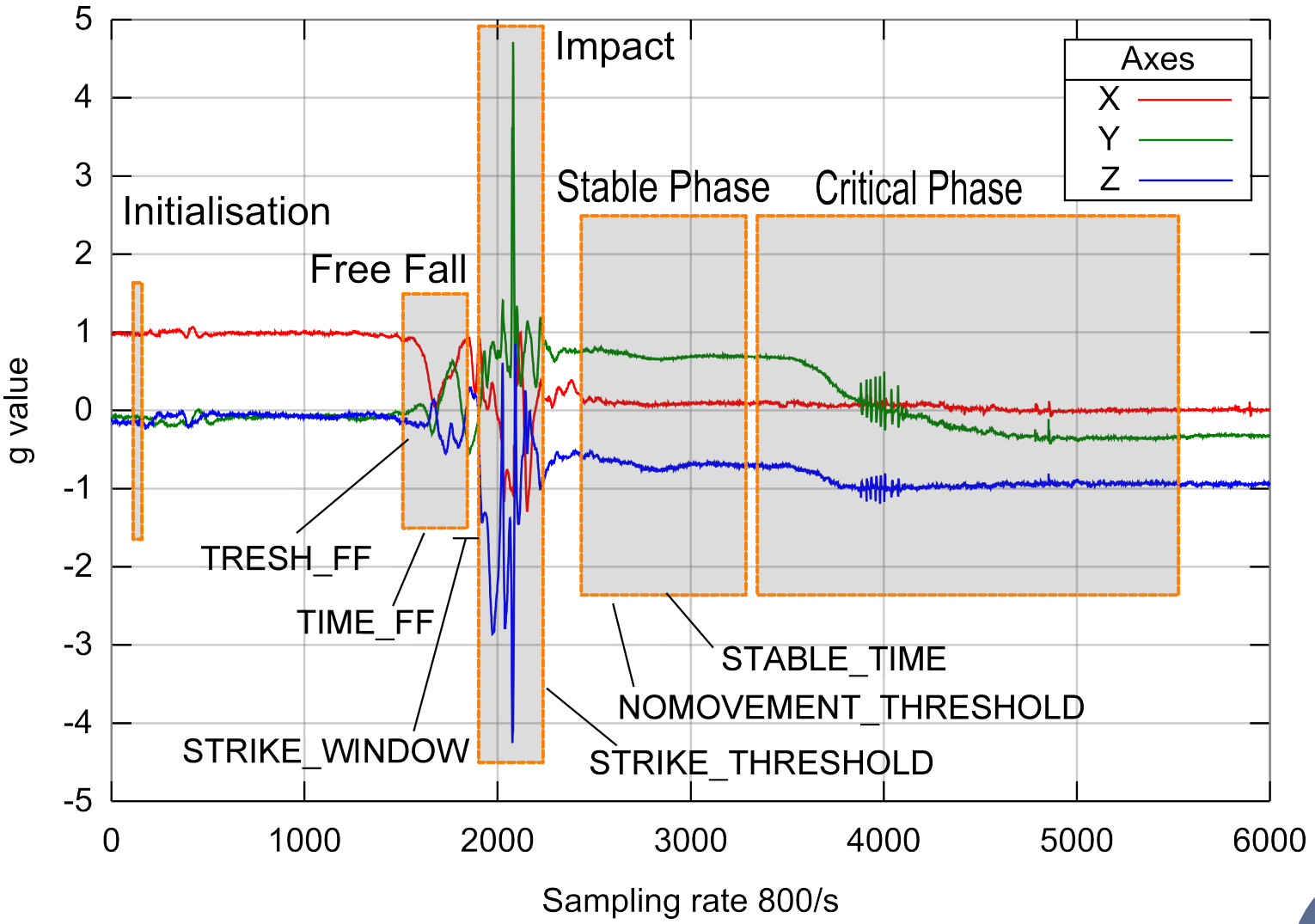
1. (almost) at hand
2. modern smartphones are equipped with a **tri-axial accelerometer**
3. localization indoor (Wi-Fi based) and Outdoor (GPS) possible
   $\Longrightarrow$ enables an alarm call with information about the fall position:
   “Mrs. Smith is fallen outside in the garden."’

Kompass Fall Detection: First Approach

Self-made device: Efficient Mobile Unit (EMU)

- first experiments with the **tri-axial accelerometer ADXL345** from Analog Devices
- Sampling-Rate up to 800 Hz
- threshold-based fall detection algorithm proposed by Jia from Analog Devices
- in-hardware preprocessing $\Longrightarrow$ energy savings

Kompass Fall Detection



States of a fall shown for a frontal fall without loss of consciousne

Fall Detection on Android-Smartphones

Differences:

1. Sampling Rate of Android-Smartphones:
   - Sony Ericsson Xperia Arc **ca. 80Hz**
   - HTC Evo 3D **ca. 50Hz**
2. no in-hardware preprocessing

Research questions:

1. Are the accelerometers in standard smartphones *good* enough for fall detection?
2. What about energy consumption? $\Longrightarrow$ Usability

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Simulator

1. Optimizing of the threshold parameters of the fall detection algorithm **with/without** free fall phase
2. Evaluation:

$$Sensitivity = \frac{TruePositives}{Number\ of\ all\ falls}$$

3. Evaluation:
   Activities of Daily Life (ADLs)

$$Specificity = \frac{TrueNegatives}{Number\ of\ all\ ADLs}$$

Trace-driven simulation: Falls and ADLs were gathered with EMU devices

Recording of 84 falls of probands in the age of 20-30 years

Sebastian Fudickar, Christian Karth, Philipp Mahr, Bettina Schnor: *Fall-Detection Simulator for Accelerometers with in-Hardware Preprocessing*, 5th Workshop on “Affect and Behaviour Related Assistance”, held in conjunction with PETRA 2012, Heraklion Greece, 2012.

Result: Influence of Sampling Rate

Classification:

1. **normal falls:** cover falls where the proband moves again.
2. **critical falls:** describe falls where the proband does not move after the impact for at least 5 seconds and loss of consciousness is assumed.

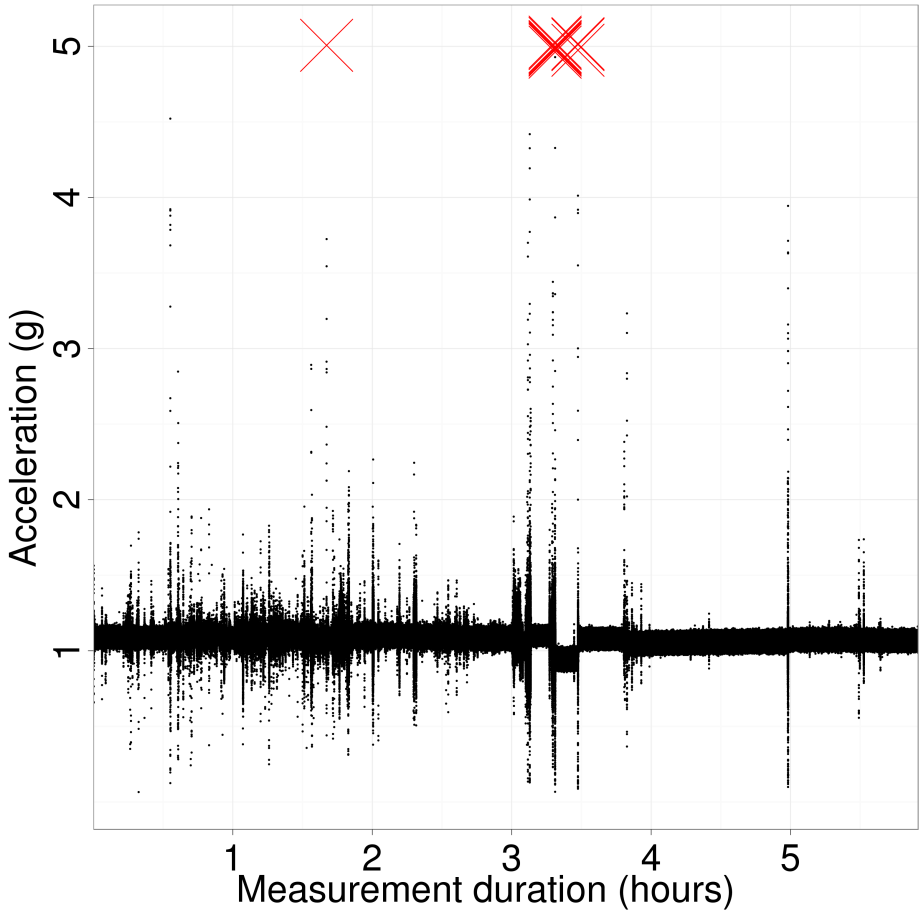
Sampling rate	**with** free fall detection			**without** free fall detection		
	normal	critical	sum	normal	critical	sum
800 Hz	29	49	78 (92%)	35	48	83 (99%)
400 Hz	32	47	79 (94%)	37	46	83 (99%)
200 Hz	29	49	78 (92%)	34	48	82 (98%)
100 Hz	28	51	79 (94%)	34	48	82 (98%)
50 Hz	28	49	77 (92%)	34	49	**83 (99%)**
correct value	36	48	84	36	48	84

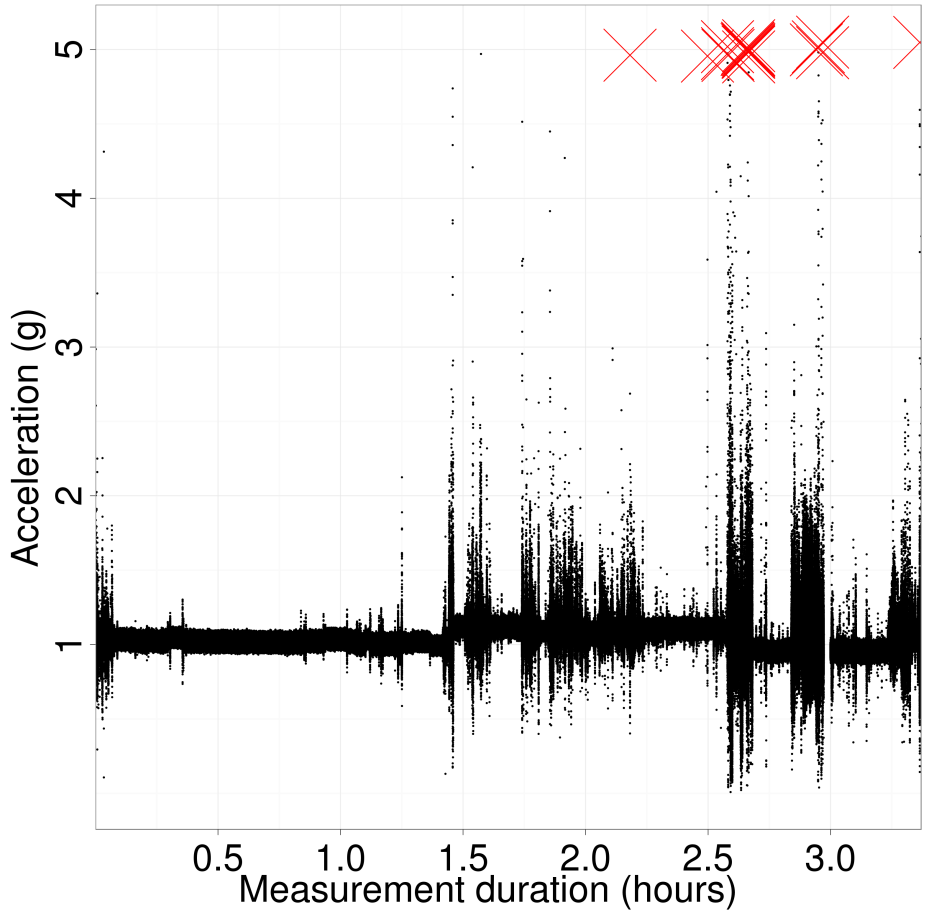
$\Longrightarrow$ The algorithm **without** free fall detection and with our parameter settings detects 83 of 84 falls in our fall set (99 %).

Recording of ADLs:

- 9 seniors from Florencehort in Stahnsdorf
- in the age of 70 up to 95 years
- smartphone was worn in a fanny pack (bum bag)
- altogether about 41 h ADLs recorded

Example of two ADL records (acceleration in g):





Red crosses indicate the acceleration measure exceeds 5 g:

trace a	trace b	trace c	trace d	trace e	trace f	trace g	trace h
17	0	8	0	12	20	7	15

Confusion matrix

Confusion matrix for fall detection algorithm (without freefall detection) **at 50 Hz**

	Detected as Falls	Detected as ADL
Falls	83	1
ADLs	0	all

Energy Consumption?

Runtime

with fall detection: 20 h

Runtime

with fall detection **and** standard use of smartphone: 12 h

Tobias Gimpel, Bachelor Thesis

Demo

Demo-Mode: Smartphone rings if fall detected.