Evaluation of Threshold-based Fall Detection on Android Smartphones

Tobias Gimpel, **Simon Kiertscher,** Alexander Lindemann, Bettina Schnor and Petra Vogel

University of Potsdam

Germany

Before we start …

Outline

- Motivation
- Threshold-based fall detection
- Experiments and results
- Evaluation of fall detection applications in the Google Play Store
- Conclusion and future work

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Motivation

Why is fall detection necessary?

- Elderly people have a high risk of falls
- 33% fall unintentionally each year [Mellone et al., 2012]
- Especially falls with loss of consciousness are dangerous → fast help is needed

Motivation

Why fall detection on smartphones?

- Easily accessible
- Cheap in contrast to dedicated hardware
- Future generations will have one by default
- Portability

Why no bracelets?

- Fall detection works bad if device is worn at the arm
- Device should be close to the center of the body

Alternatives

Smart Cameras for fall detection:

- Restricted to dedicated areas (garden?)
- Cost intensive
- Blind spots?
- Privacy?

Sensor mats:

- Restricted to dedicated areas (garden?)
- Cost intensive
- Stability?
- Hygiene?

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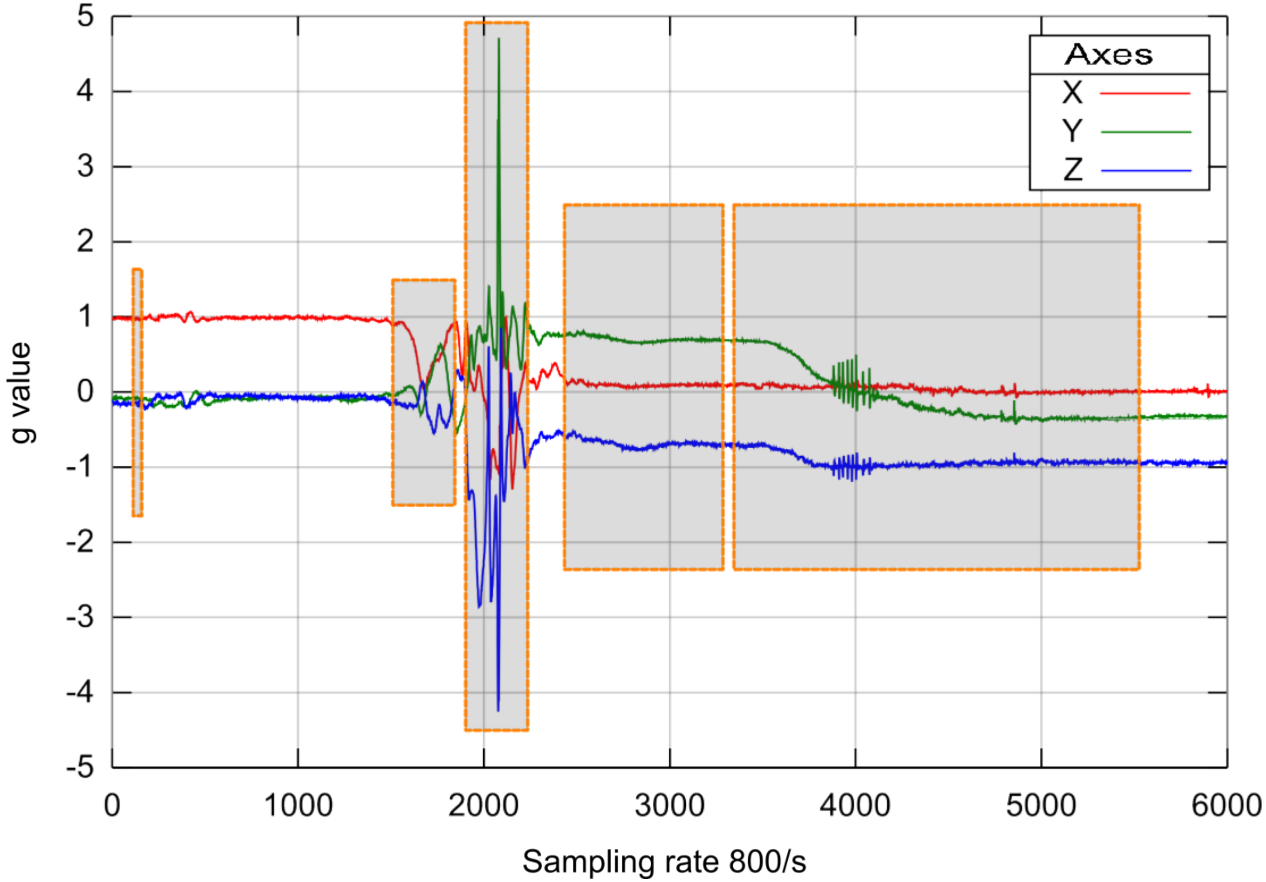
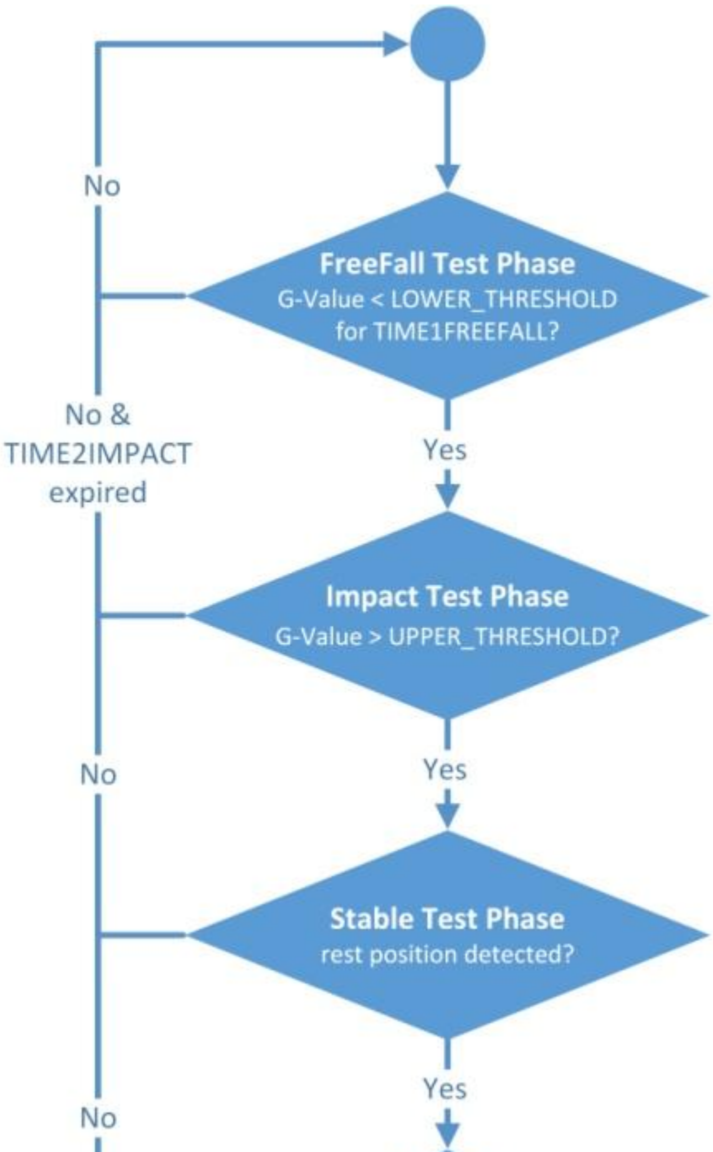
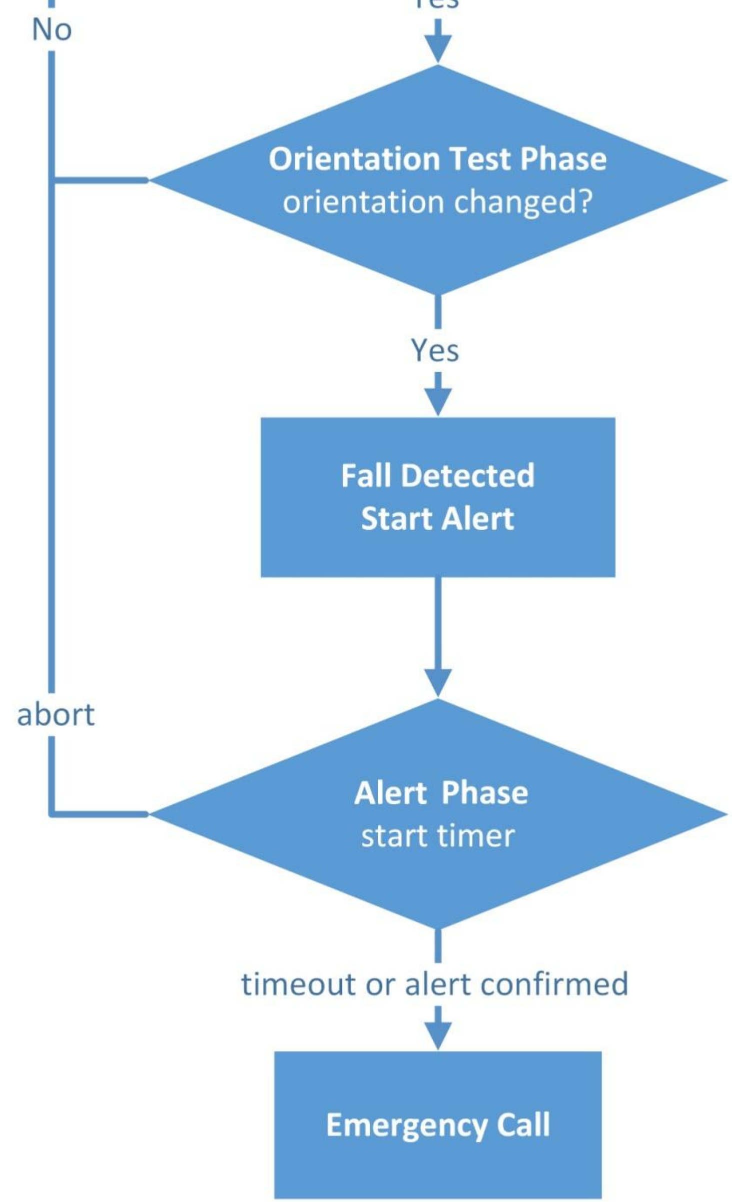
Threshold-based fall detection

Fall characteristics:



Fall detection phases





Different implementations of the phases

	Karth FF*	Karth*	Mehner FF**	Mehner**	Gimpel
Free Fall	X		X		X
Impact	X	X	X	X	X
Stable A	X	X			X
Stable B			X	X	
Orientation A	X	X			
Orientation B			X	X	
Orientation C					X

*[Karth et al. 2012] (from our working group)
**[Mehner et al. 2013]

Differences in the orientation phase

Orientation A (Karth)

- Moving average → last value before possible fall which is > 0,9g and < 1,1g → compute vector → angle between first vector after possible fall
- Angle > 45° → fall is assumed

Orientation B (Mehner)

- Mean value of the last 100 values for each axis before the possible fall vs. mean value of the 100 values for each axis after the possible fall
- Difference > 0,4g → fall is assumed

Orientation C (Gimpel)

- Mean value of the last 100 values for each axis before the fall vs. mean value of the 100 values for each axis after the presumed fall
- Values are used to compute the angle between the vectors
- Angle > 60° → fall is assumed

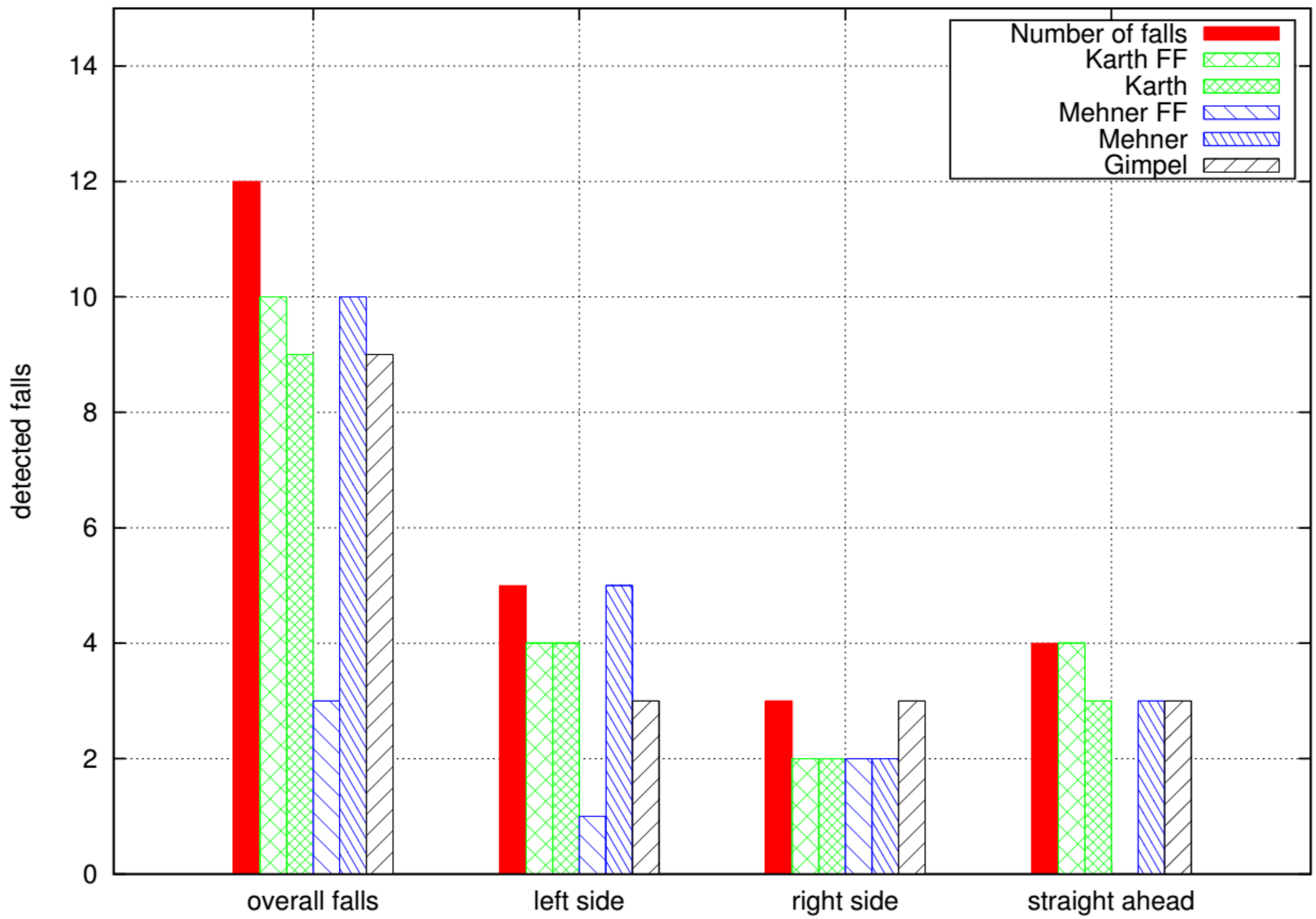
Evaluation

- HTC Desire 816 and Sony Xperia V

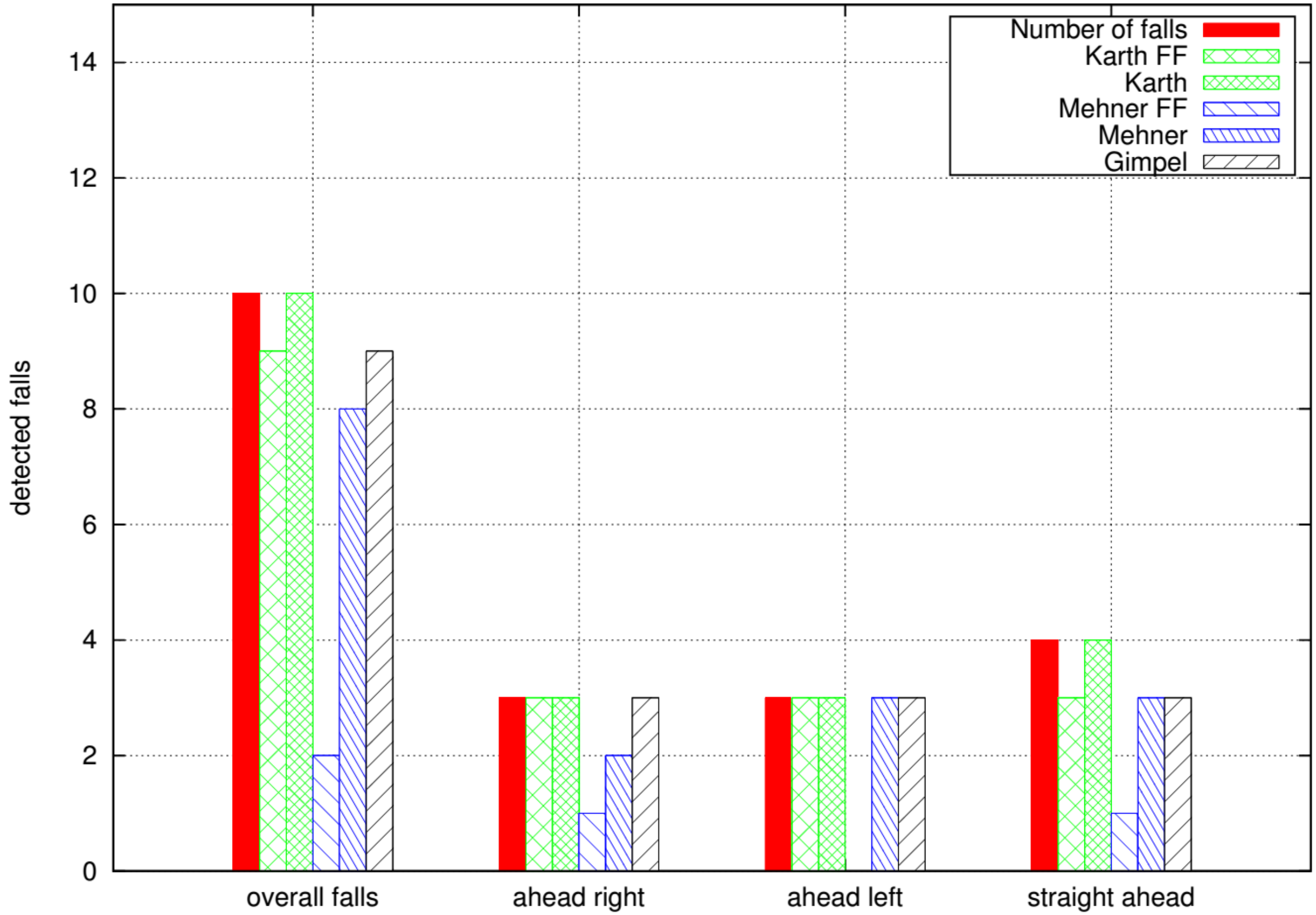
- Worn in a funny bag at the hip in front
- Front, left and right falls
- 3 probands

Age	Front falls	Right falls	Left falls	Device
23	4	3	5	Sony
29	10	10	10	Sony
55	4	3	3	HTC

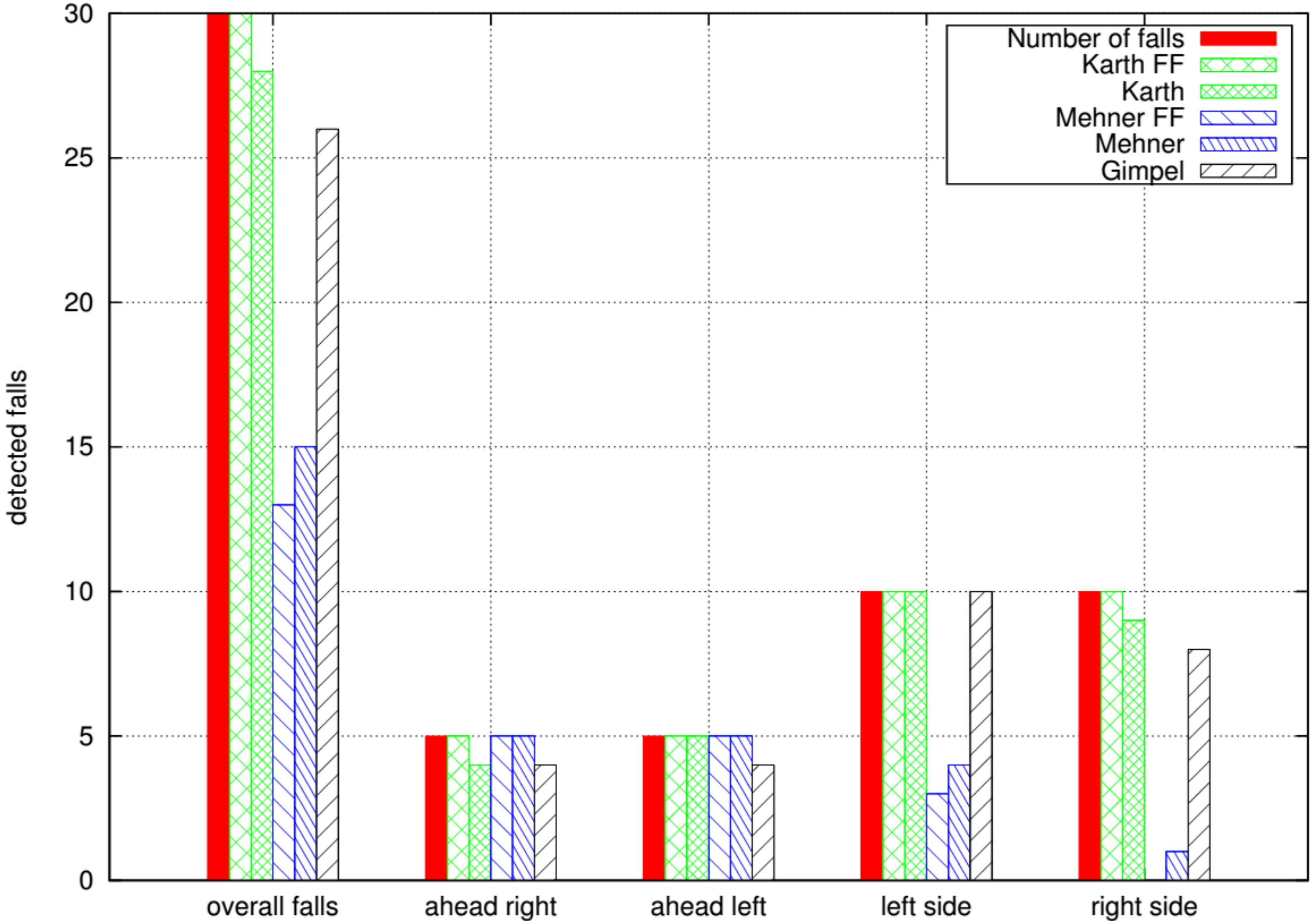
Fall detection results of proband 23



Fall detection results of proband 55



Fall detection results of proband 29



Activities of daily life (ADL)

- Fall detection algorithms have to distinguish between ADLs and real falls
- 2 probands
- False positives:

Age	Duration	Karth FF	Karth	Mehner FF	Mehner	Gimpel
55	286h	24	57	0	5	2
72	11h	0	3	0	1	0

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Conclusion on fall detection

- [Mehner et al. 2013] proposed to exclude the free fall phase
- Our ADL experiments show that the FF phase is vital for a low false positive rate
- Karth FF, Mehner FF, Gimpel
  - Mehner FF performed worse
    34,6% overall detection rate but 0 false positives
  - Karth FF and Gimple are comparable good
    94% / 84% overall detection rate
    24 / 2 false positives

Google Play Store fall detection apps

- September 2014
- 22 hits if searched for “fall detection”
- 13/22 are related to the topic
- 2/13 were commercial applications
(4€ tested / 120€ not tested)
- 8/13 passed our exclusion reasons

Exclusion reasons

Following characteristics resulted in an exclusion for further tests:

- Failed/impossible installation
- No reaction of application after installation
- The need to register for a phone call in a foreign country
- The phone call destination is not obvious

Further tests

Specificity tests:

- Fixed set of ADL
  (walking around, climbing stairs, sitting down on chair)
- Done in varying speed in a 10 minutes window
- Smartphone was in a trousers pocket

Sensitivity tests

- 10 falls in forward direction
  (by proband 23 and proband 55)

Results

Name	FP	prob23	prob55	detection rate
T3LAB Fall Detector	no	1/5	3/5	40%
iCare Personal Emergency Alert	no	5/5	2/5	70%
Smart Fall Detection	no	0/5	0/5	0%
Emergency Fall Detector	no	0/5	0/5	0%
Fall Detector	yes	0/5	0/5	0%
Fade: fall detector	yes	3/5	3/5	60%
iFall: Fall Monitoring System	yes	0/5	2/5	20%
SecureMe Active (commercial)	yes	2/5	4/5	60%

Conclusion and Future Work

- Our algorithm (Gimpel) is a good compromise between low false positive rate (2 within 12,3d) and high fall detection rate (84%)
- Free fall phase is vital to distinguish between ADL and real fall
- Only one public available fall detection application with acceptable results (for Google)
- Testing of applications available in other stores and/or for other phones like iPhone (App Store)

Thank you for your attention!
Any questions?

Contact:

{allindem, kiertscher, pvogel, schnor}@cs.uni-potsdam.de

www.cs.uni-potsdam.de/bs/ research/projectAI.html