

Fall detection and fall prediction – latest results

Work package 4 of the
Lower Saxony Research Network
Design of Environments for Ageing (GAL)

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Outline

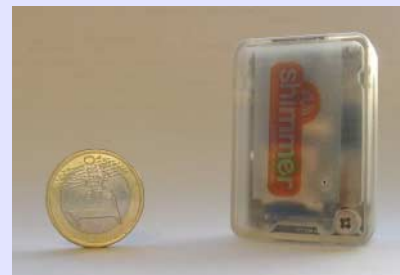
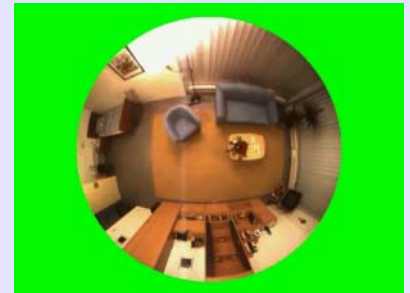
- Background and aims
- Results of a requirements analysis
- Automated fall detection
- Sensor-based fall prediction
- Conclusion and outlook

Aims

- (1) automatic and reliable recognition of fall events
- (2) assessment of individual fall risk as a basis for timely preventive intervention (prediction/prognosis)



- general approach: combination of
 - stationary vision sensor
 - wearable accelerometer



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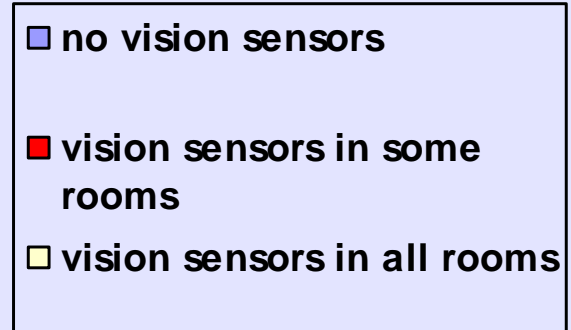
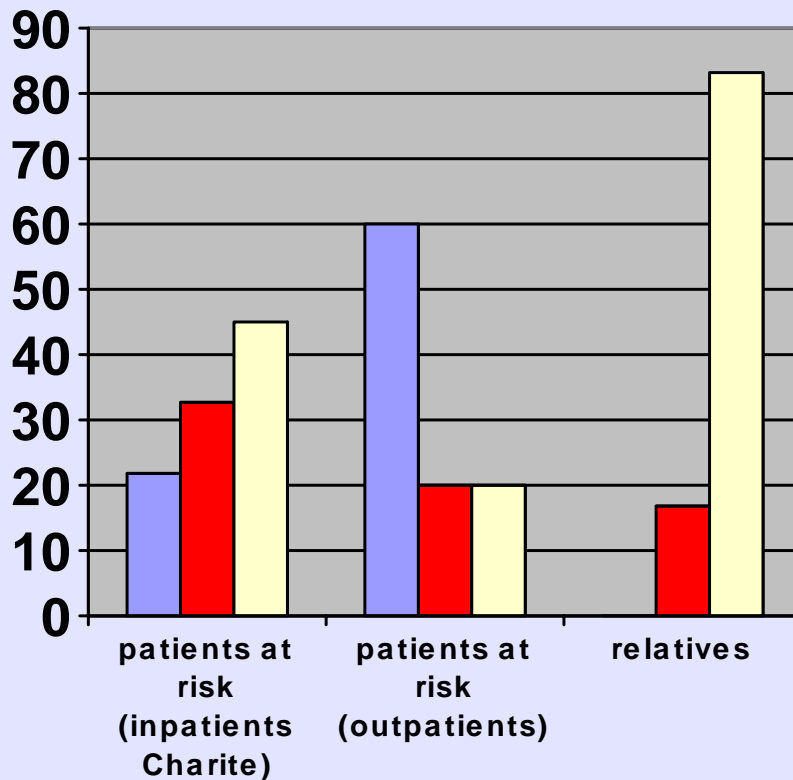
Requirements analysis

- aim: to assess the requirements for a sensor-based fall recognition and prediction system
- results are to guide the technical development of the demonstrator system
- general requirements → *Steinhagen-Thiessen et al., 2003*
- method:
 - focus groups interviews (guideline-based)
 - n=22 (16w, 6m); 16 potential users with a fall risk, 6 relatives
 - scenario-based presentation, rating, open discussion

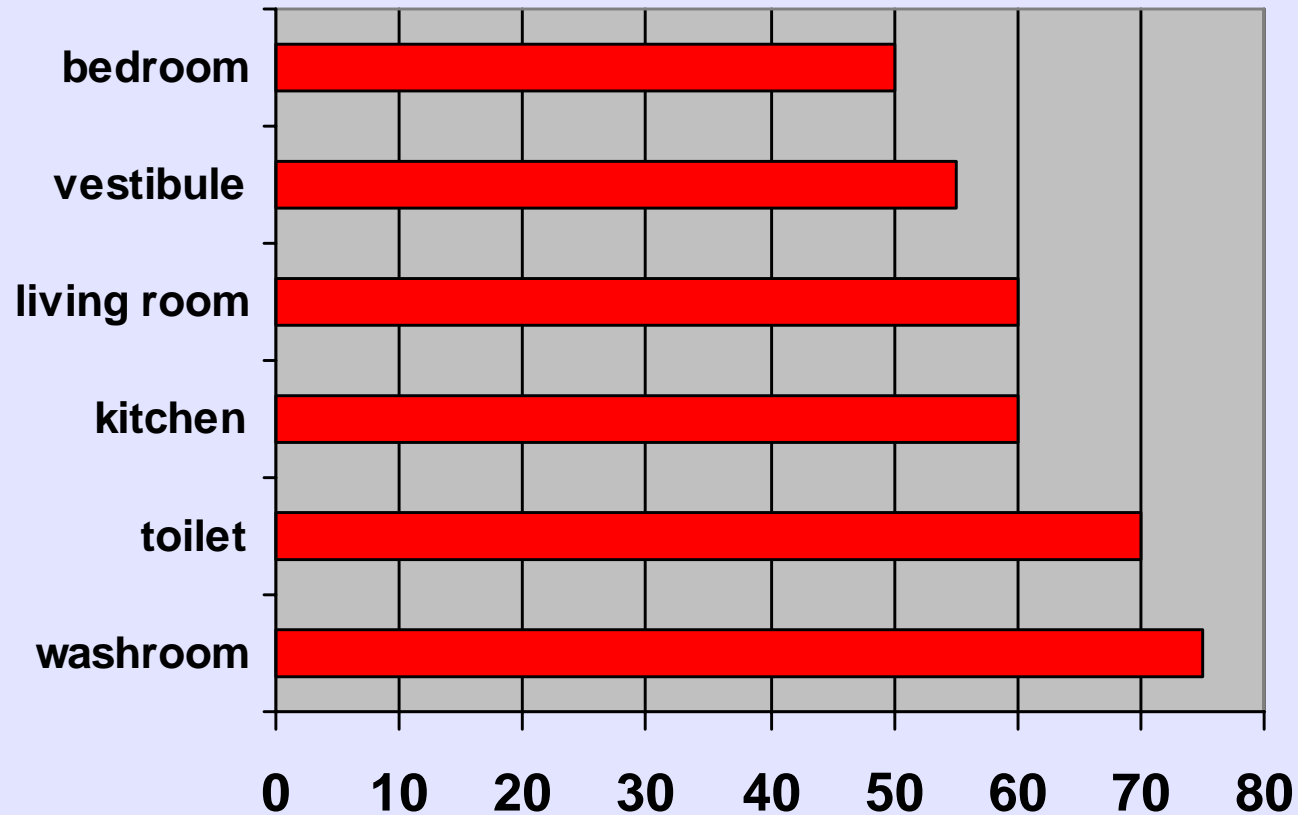
Requirements analysis – pros and cons

PROS	CONS
Fall recognition and prediction in general	
enhanced security (persons + relat.)	realization unclear
automated fall detection	prognosis possible?
allows for prognosis	
vision sensor system	
wearing not necessary	works only indoors
	time-consuming/ exp. installation
wearable accelerometer	
mobility	belt pos. not well accepted by women
inexpensive	reliability outdoors

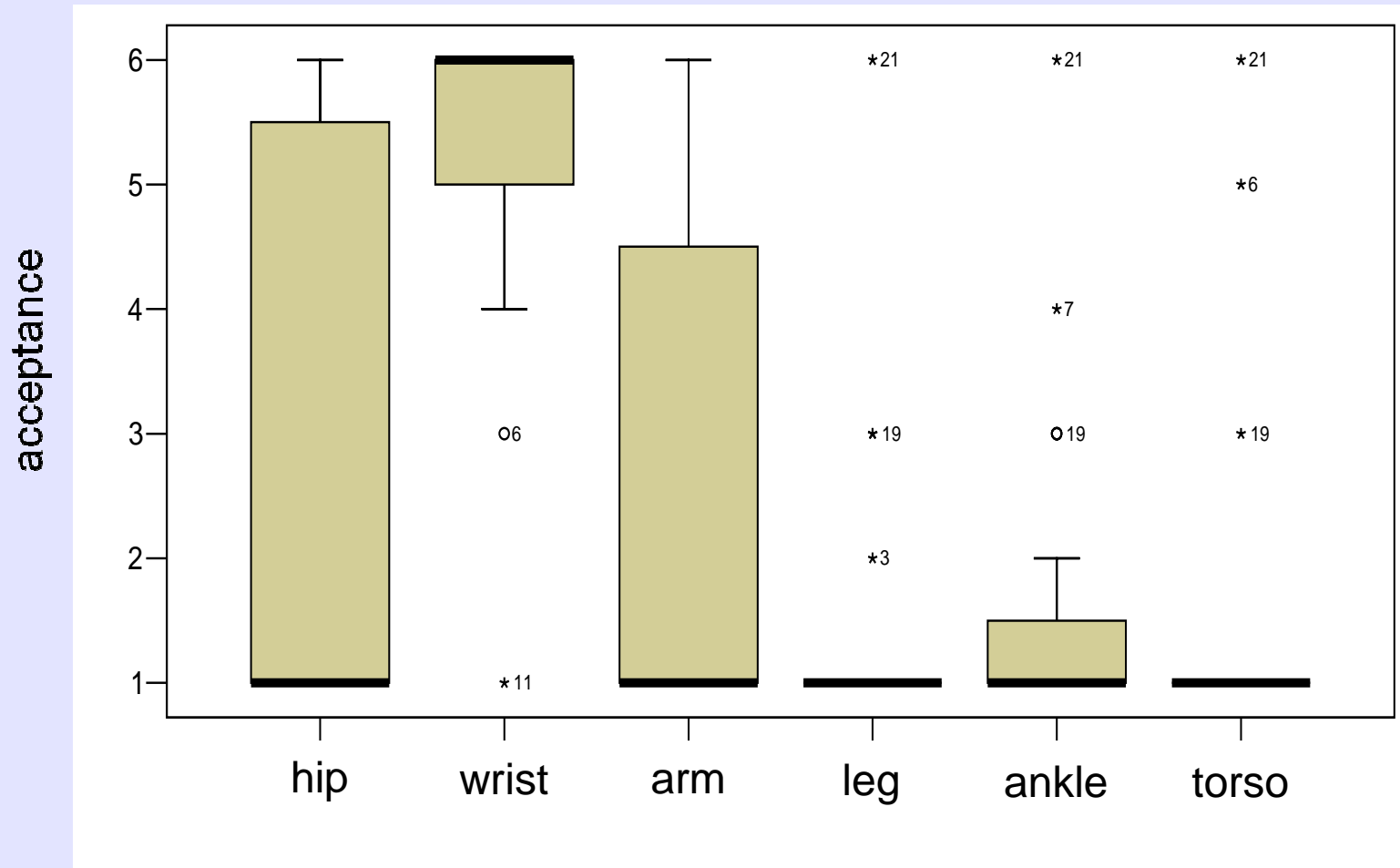
RA – vision sensors' acceptance



RA – vision sensors positioning



RA – accelerometer positioning



RA – conclusions

- the higher the perceived risk, the higher the accepted level of intrusion
- (partial) financing would be accepted by about half of the interviewees
- both sensor systems have perceived pros (security, mobility, unobstrusiveness) and cons (intrusion, installation costs)

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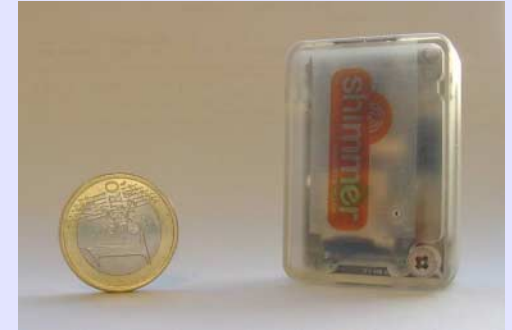
Automated fall detection

Methods:

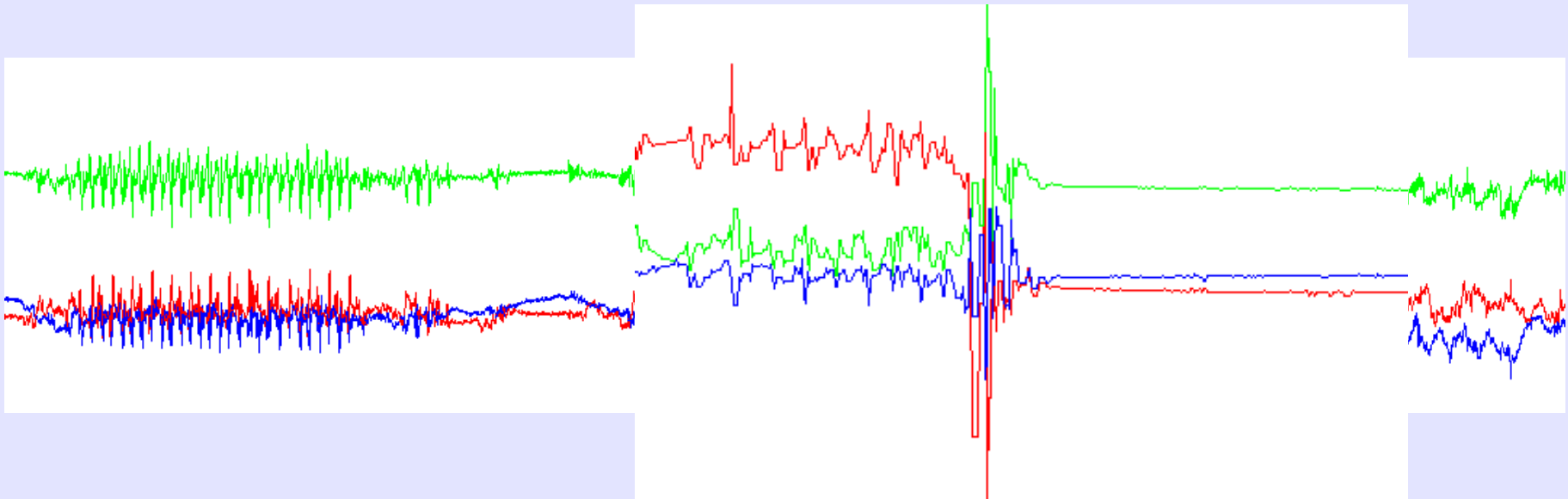
- combination of two sensor systems
 - accelerometer
 - vision sensor
- development of individual fall detection algorithms for both systems
- subsequent data fusion

Accelerometer data

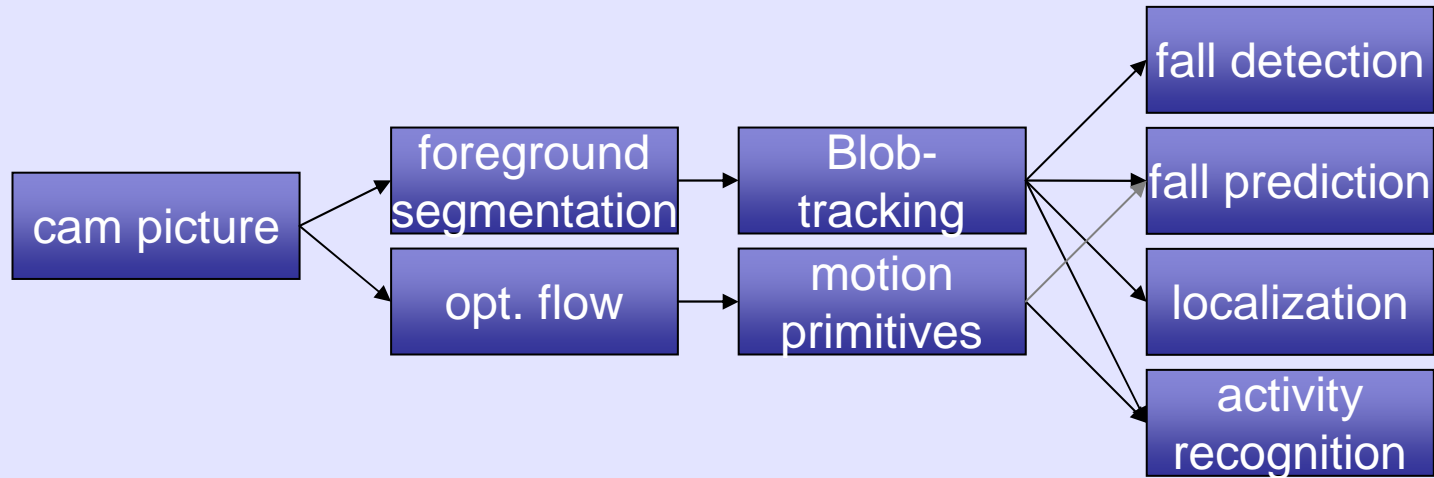
- triaxial acceleration data
- on-board algorithm to detect and record walking; recalibration
- fall detection



<http://shimmer-research.com>



vision sensor



Naive Bayes-based fusion of:

- orientation
- duration of stay
- blob velocity




GAL vision sensor

Jens_Office_Corridor_06 - GAL VisionSensor

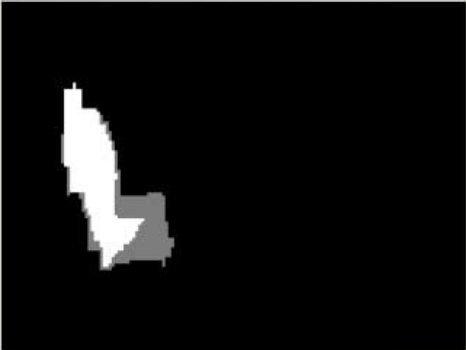
Datei Bearbeiten Workspace Extras Fenster Hilfe

von 705


Input Image




Foreground Image



Mask Output

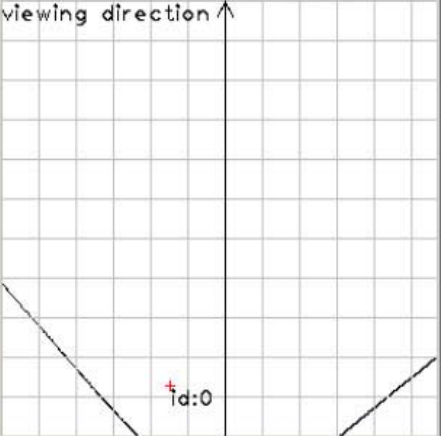


Optical Flow Image



Map

viewing direction ↑



Fall Probability

0.0441041

Fall Reliability

0.945052

GALProperties

Socket Connection

IP 134.169.36.35 Disconnect

Port 1234

Manual Message

ID 2 Send

Data 0.12345 0.54321

Save log file

Send message id(2) data(0.0441041 0.94505; ▲
Send message id(2) data(0.0441041 0.94505;
Send message id(2) data(0.0441041 0.94505;
Send message id(2) data(0.0441041 0.94505;
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Send message id(2) data(0.0441041 0.94505;
Send message id(2) data(0.0441041 0.94505; ▼

Time: 5.73333 FPS: 12.7221 (complete: 7.04168)
Time: 5.79999 FPS: 11.2085 (complete: 6.55502)
Time: 5.86666 FPS: 12.5624 (complete: 6.95957)
Time: 5.93333 FPS: 10.9006 (complete: 6.4676)
Time: 5.99999 FPS: 5.09064 (complete: 3.24142)

FPS: 5.09064 (complete: 3.24142) CPU load:100

position(102, 0) - value(192, 192, 192) ...

GAL vision sensor

The screenshot displays the GAL VisionSensor software interface with the following components:

- Input Image:** A camera feed of a person in a hallway, circled in red.
- Foreground Image:** A binary mask of the person from the input image, circled in red.
- Mask Output:** The input image with a green bounding box around the person, circled in red.
- Optical Flow Image:** A heatmap representing motion vectors, circled in red.
- Map:** A 2D grid showing the viewing direction and a red dot labeled 'id:0', circled in red.
- GALProperties:** A control panel on the right with fields for Socket Connection (IP: 134.169.36.35, Port: 1234), Manual Message (ID: 2, Data: 0.12345 0.54321), and a log window showing repeated 'Send message' entries, all circled in red.
- Fall Probability:** A button showing the value 0.0441041, circled in red.
- Fall Reliability:** A button showing the value 0.945052, circled in red.
- Status Bar:** Displays performance metrics such as Time, FPS, and CPU load.

input picture

image processing

fall parameters

localization

interface with GAL technical platform

GAL fall detection demonstrator

- at TU Braunschweig
- first draft study (n=7, 125 fall events)
- second long-term study at homes of persons with a high fall risk
- n = 6 x 2 months demonstrator installation



- status: awaiting

	Detection rate	False positives
Vision sensor	61.3%	16.4%
Accelerometer	83.6%	19.4%
Combination	90.4%	17.5%

ed,

recent related work

- fall detection:
 - Anderson et al., 2009: multi-sensor vision system, voxel-based person reconstr., 100% recognition (fuzzy-based classifier)
 - Kangas et al., 2009: accelerometer, younger persons' falls (48y) vs. elderly persons ADL, 92.9%
 - Bourke et al., 2009: long-term study, n=5, two weeks, prelim. studies 90% sensitivity/ 99% specificity; no falls with elderly but 115 alarms, 73 taken back, 42 false positives; severe comm problems
 - Tamura et al., 2009: airbag w. accel., n=4 (23y), corr. 93%
 - Nguyen et al., 2009: accel. + ecg + button, 40 falls vs. 110 activities, n=?, corr=?

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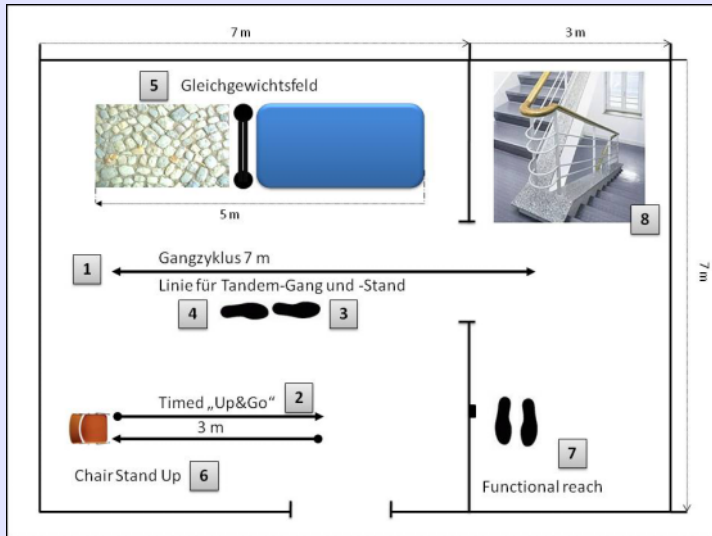
Fall prediction – candidate parameters

- step length
- foot elevation during step
- gait speed and variance (short- and long-term, harmonic vs. disharmonic)
- extent of compensation movements of upper body
- (kinetic) energy expenditure during walking and its variance
- time for sit-to-stand transition
- body balance when walking and standing (3 axes)
- step frequency

Fall prediction parameter study

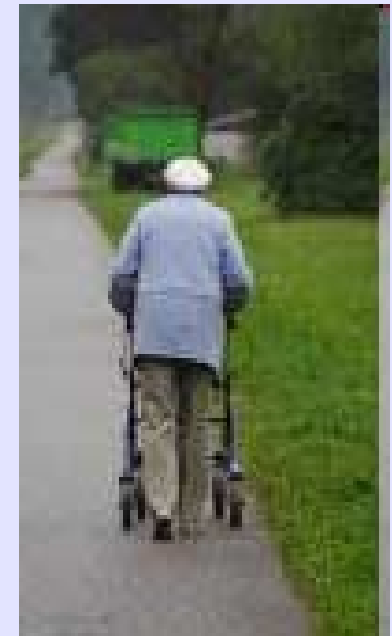
- n = 50; inclusion criteria: TUG > 10s, age > 55y
- geriatric assessment: Tinetti test, TUG, chair stand-up test, tandem stance/walk test, Functional-Reach test, STRATIFY score
- assessment parcours in gait lab (especially built in the Charité): balance test, stairs
- all tests repeated after 6 months
- sensor measurements:
 - one vision sensor
 - five accelerometers (to evaluate different positions)
- telephone interviews every two months, fall diary

Fall prediction parameter study



Fall prediction parameter study – status

- Currently $n = 28$ (21w, 7m) persons have completed part one and are followed up.
- mean age: 73.5 y
- 50% of them had a fall event within the last two months.
- Tinetti test mean points: 18.6
- TUG mean: 20.1s (range 11-88s.)
- STRATIFY score: mean 1.3 pts.
- tandem stance: 7.2s, tandem walk: 6.3 steps
- Functional reach test: 20.3cm (4-31cm)



Fall prediction parameter study – next steps

- data analysis (vision sensor + accelerometers)
- generation and evaluation of prediction models
- evaluation of individual parameter information gain



recent related work

- fall prediction:
 - Narayanan et al., 2009: defined assessment tests (TUG, alternate step test, 5-times sit-to-stand) measured with accelerometer, own risk score, n=68, leave-one-out, rank correlation $\rho = 0.81$

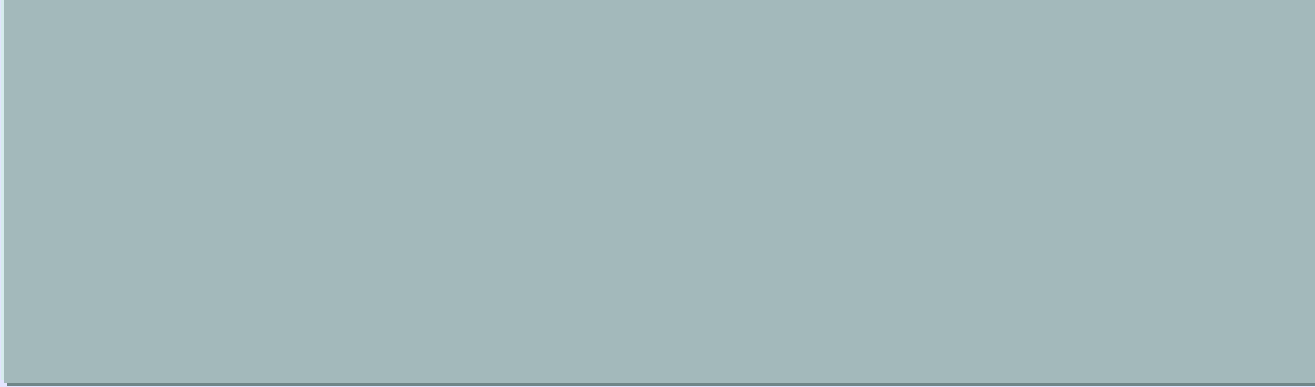
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Conclusion and outlook

- requirements analysis:
 - relevant field of research, important application of sensor-based information systems
 - safety aspect is highly appreciated amongst persons at risk and their relatives
- operational demonstrator using data fusion from vision sensor and accelerometer
 - deployment at elderly persons' homes for prospective study due in May 2010
- fall prediction parameter study is underway, results are due in late 2010

International workshop



WATCH
FOR
ICE