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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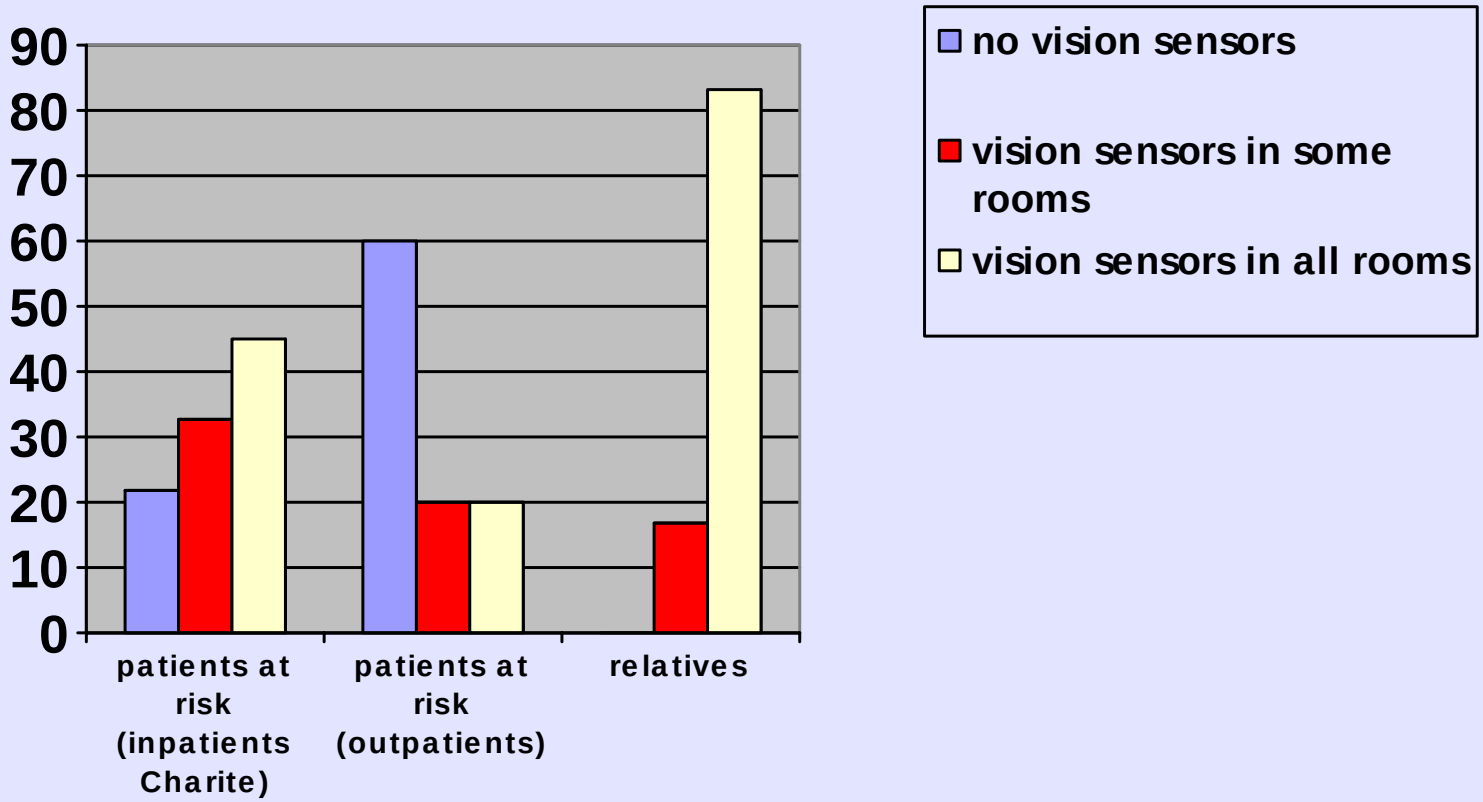
Requirements analysis

- 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

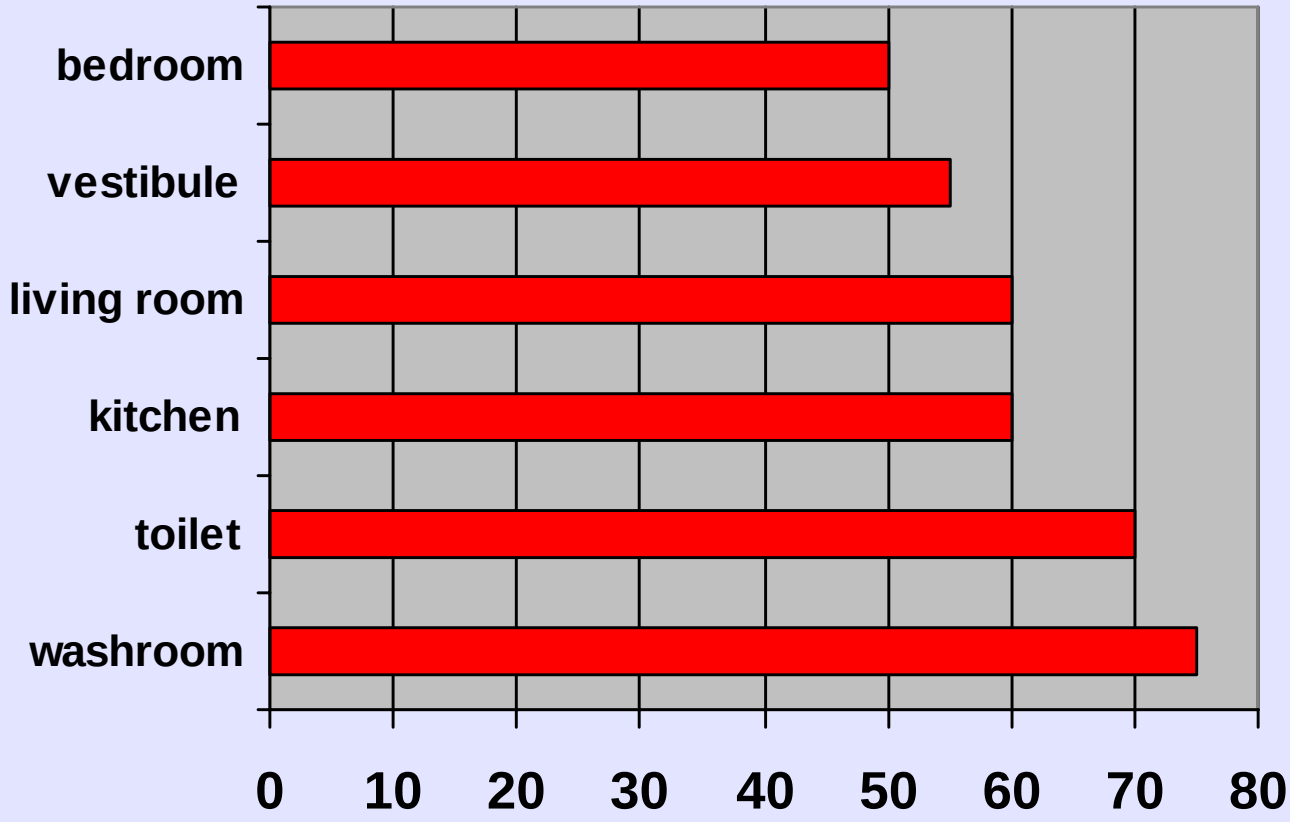
Requirements analysis – pros and cons

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

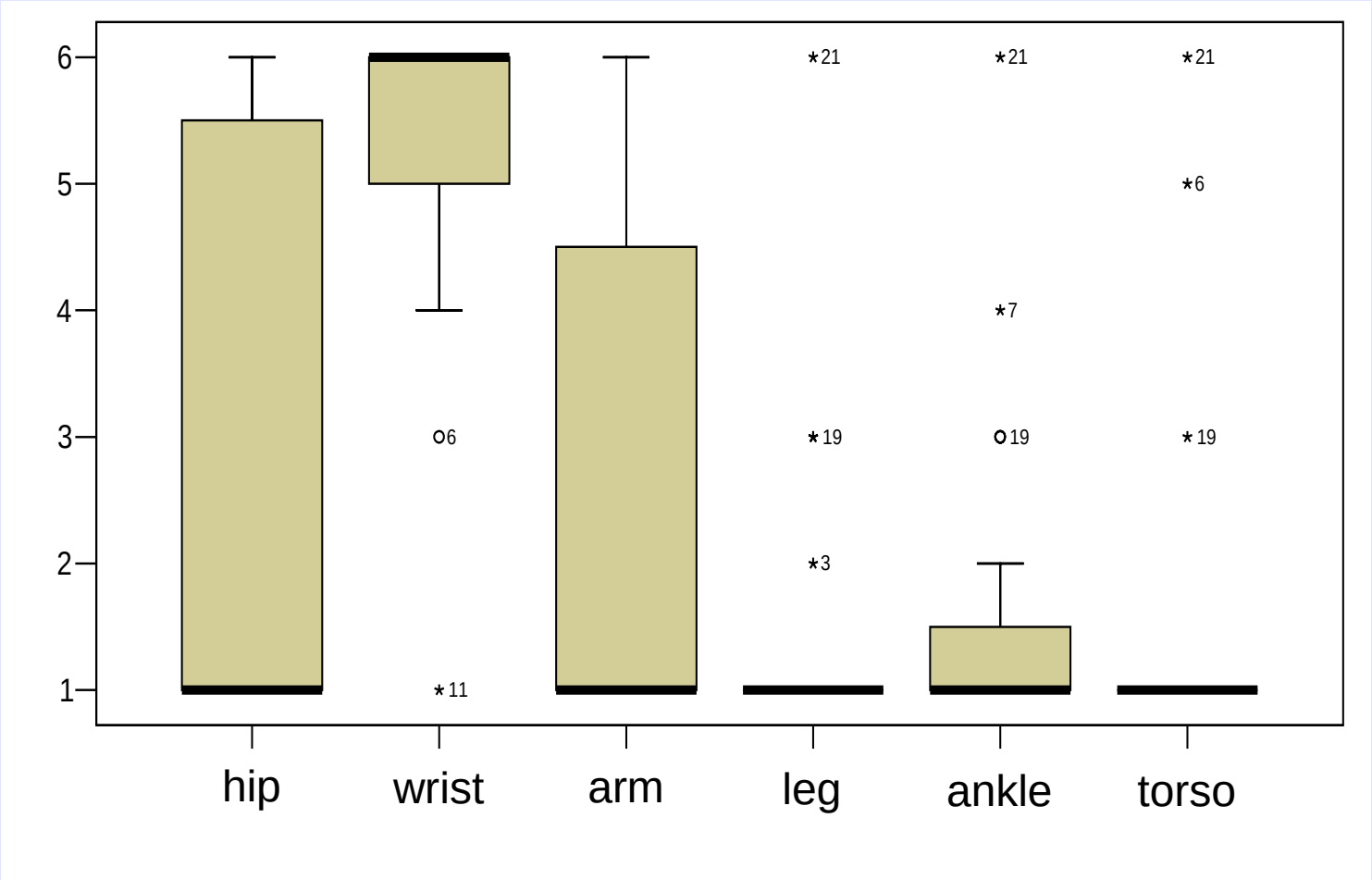
RA – vision sensors‘ acceptance



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

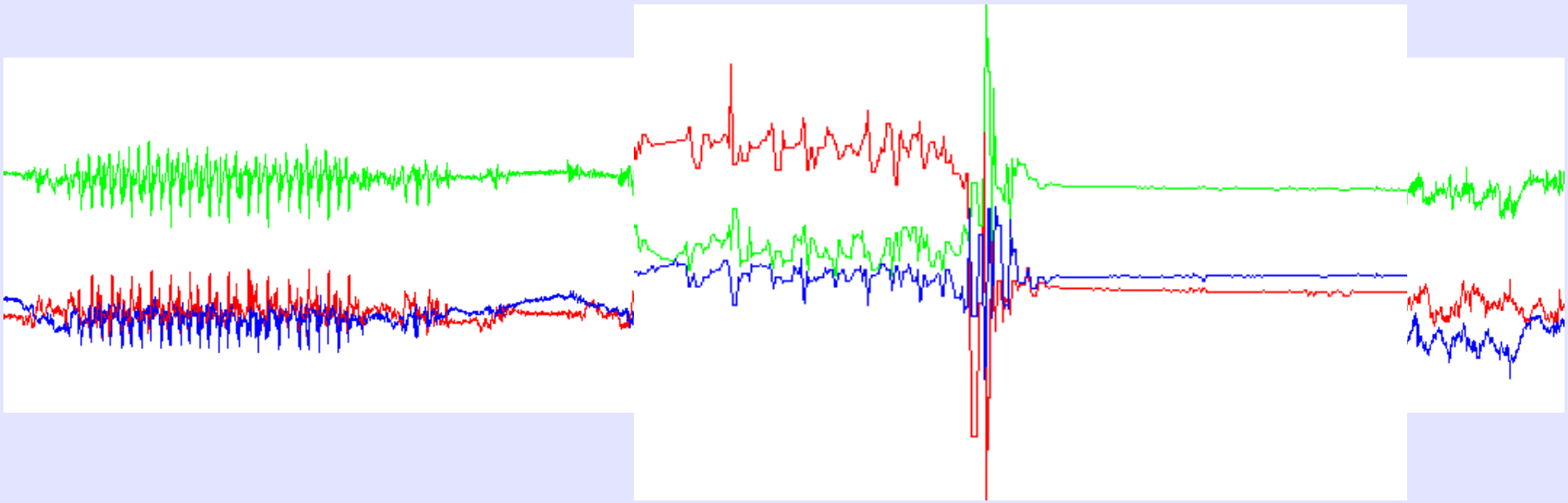
Methods:

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

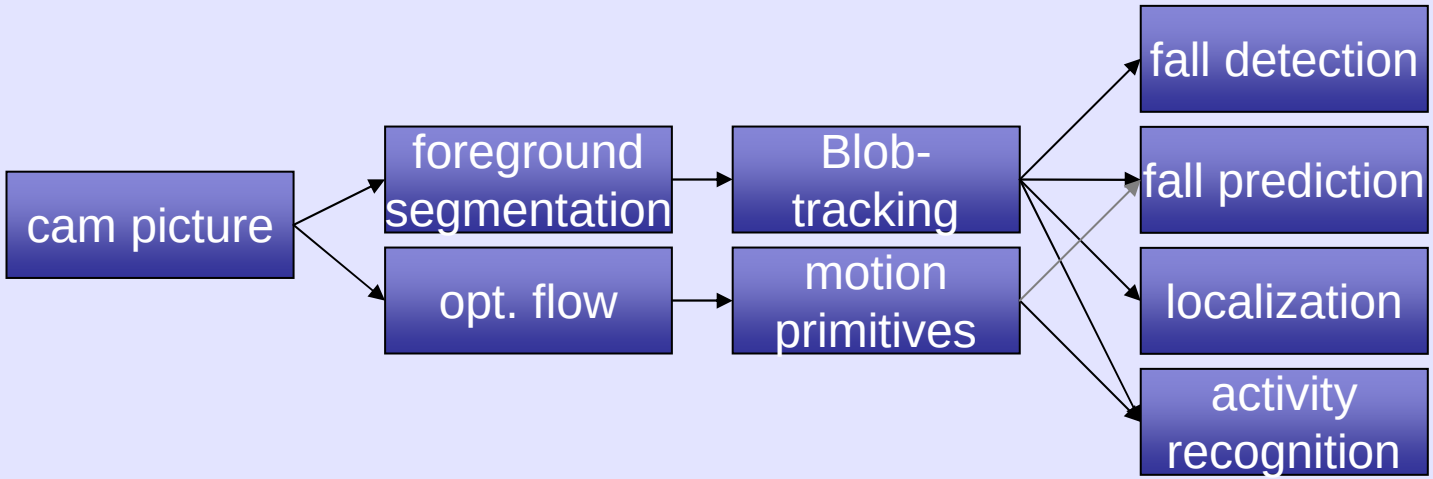
Accelerometer data

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

http://shimmer-research.com

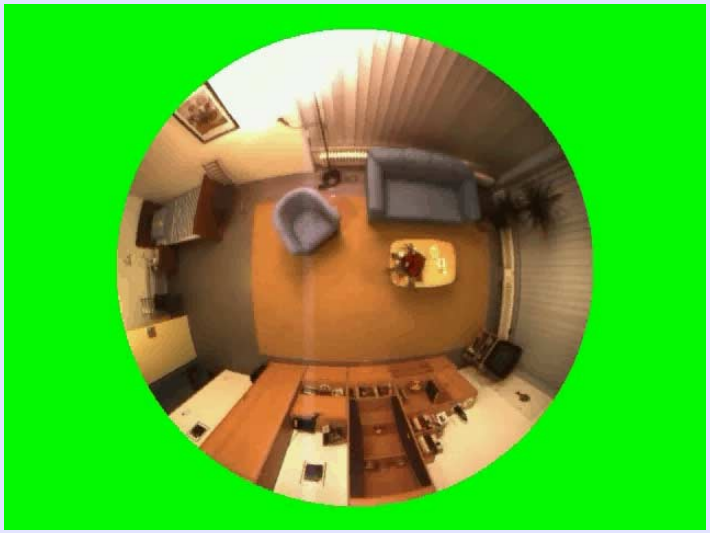


vision sensor

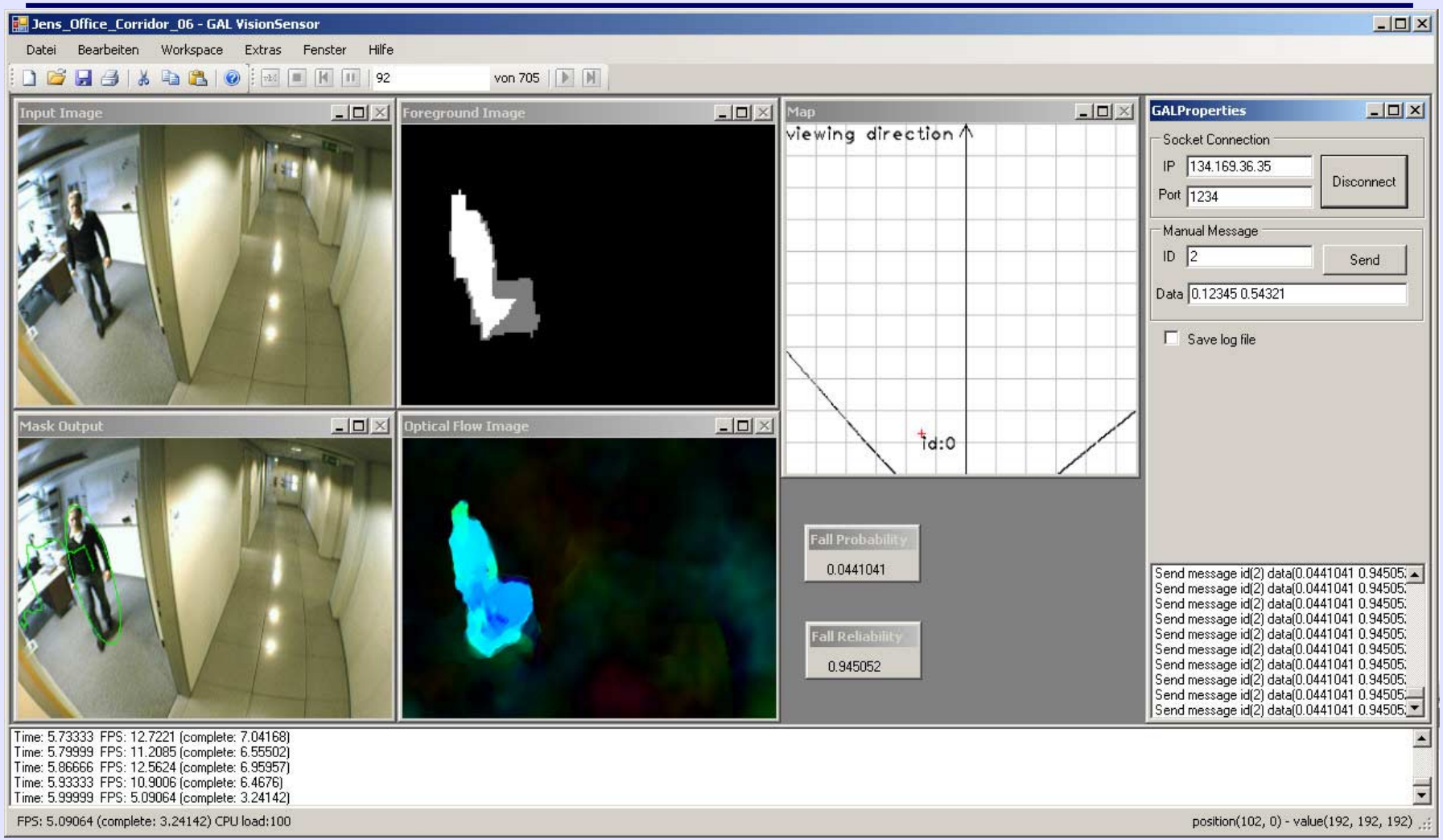


Naive Bayes-based fusion of:

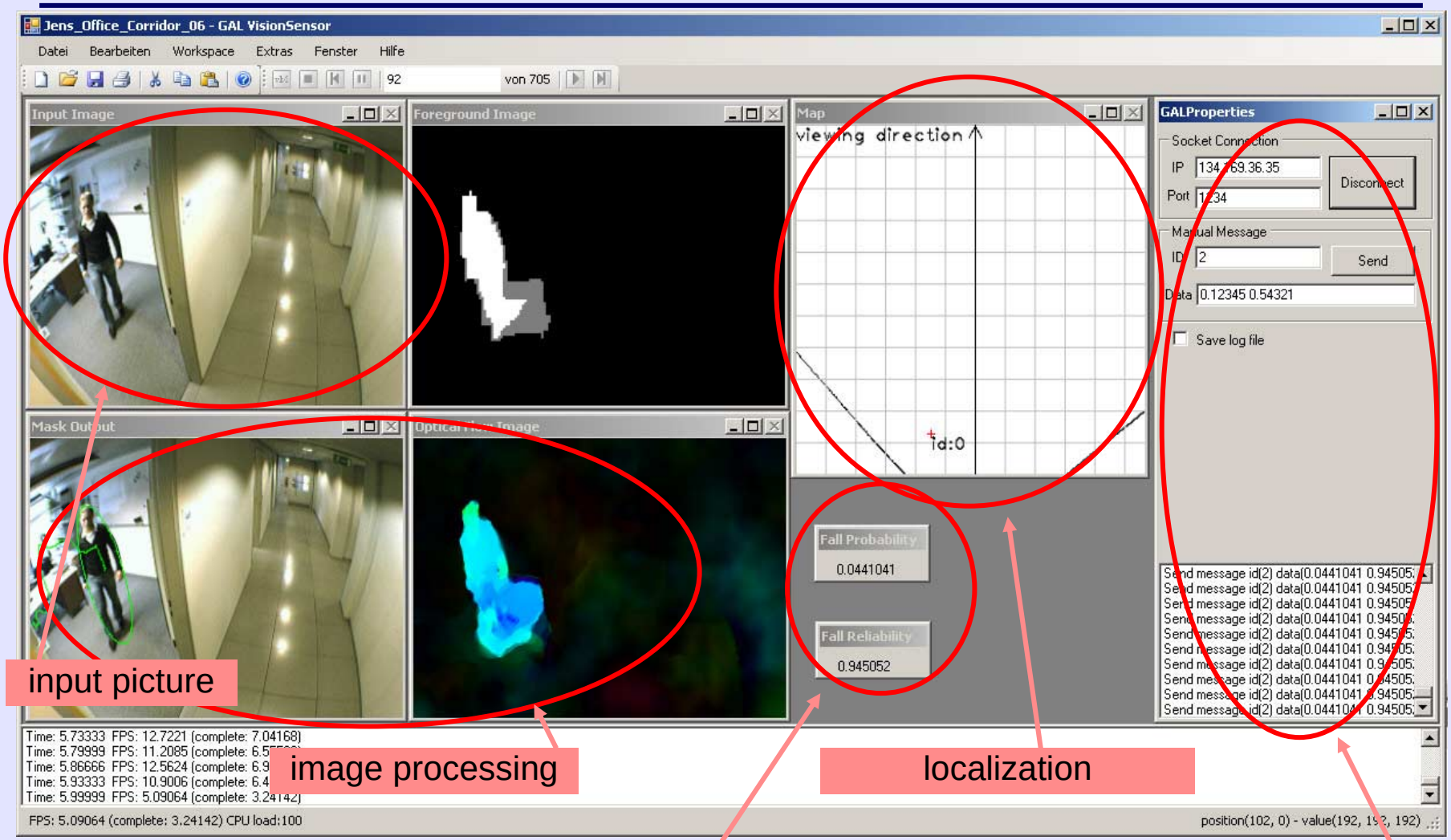
- orientation
- duration of stay
- blob velocity



GAL vision sensor



GAL vision sensor



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: ed, awaitir

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

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

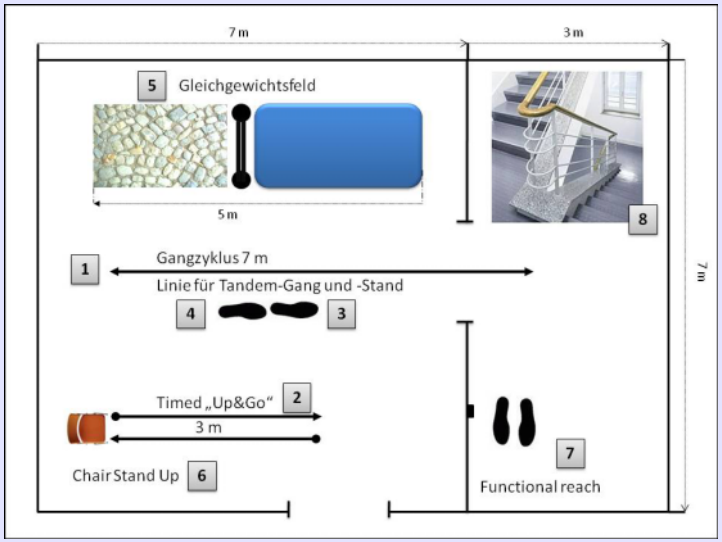
- step length
- foot elevation during step
- gait speed and variance (short- and long-term, harmonic vs. disharmonic)
- extent of compensation movements of upper body
- (kinetic) energy expenditure during walking and its variance
- time for sit-to-stand transition
- body balance when walking and standing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

Marschollek et al., 2008
Gietzelt, 2008

Fall prediction parameter study

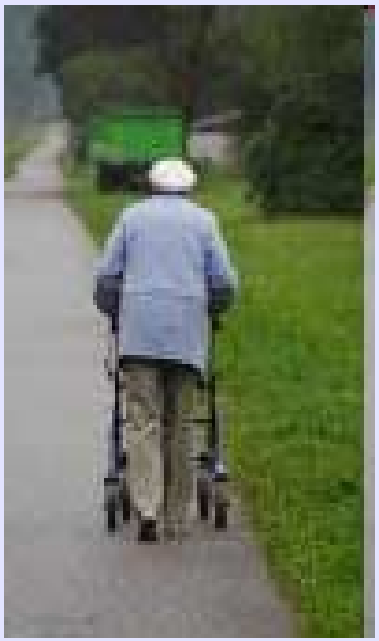
- n = 50; inclusion criteria: TUG > 10s, age > 55y
- geriatric assessment: Tinetti test, TUG, chair stand-up test, tandem stance/walk test, Functional-Reach test, STRATIFY score
- assessment parcours in gait lab (especially built in the Charité): balance test, stairs
- all tests repeated after 6 months
- 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


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