

# Real-Life Activity Recognition

Kai Kunze

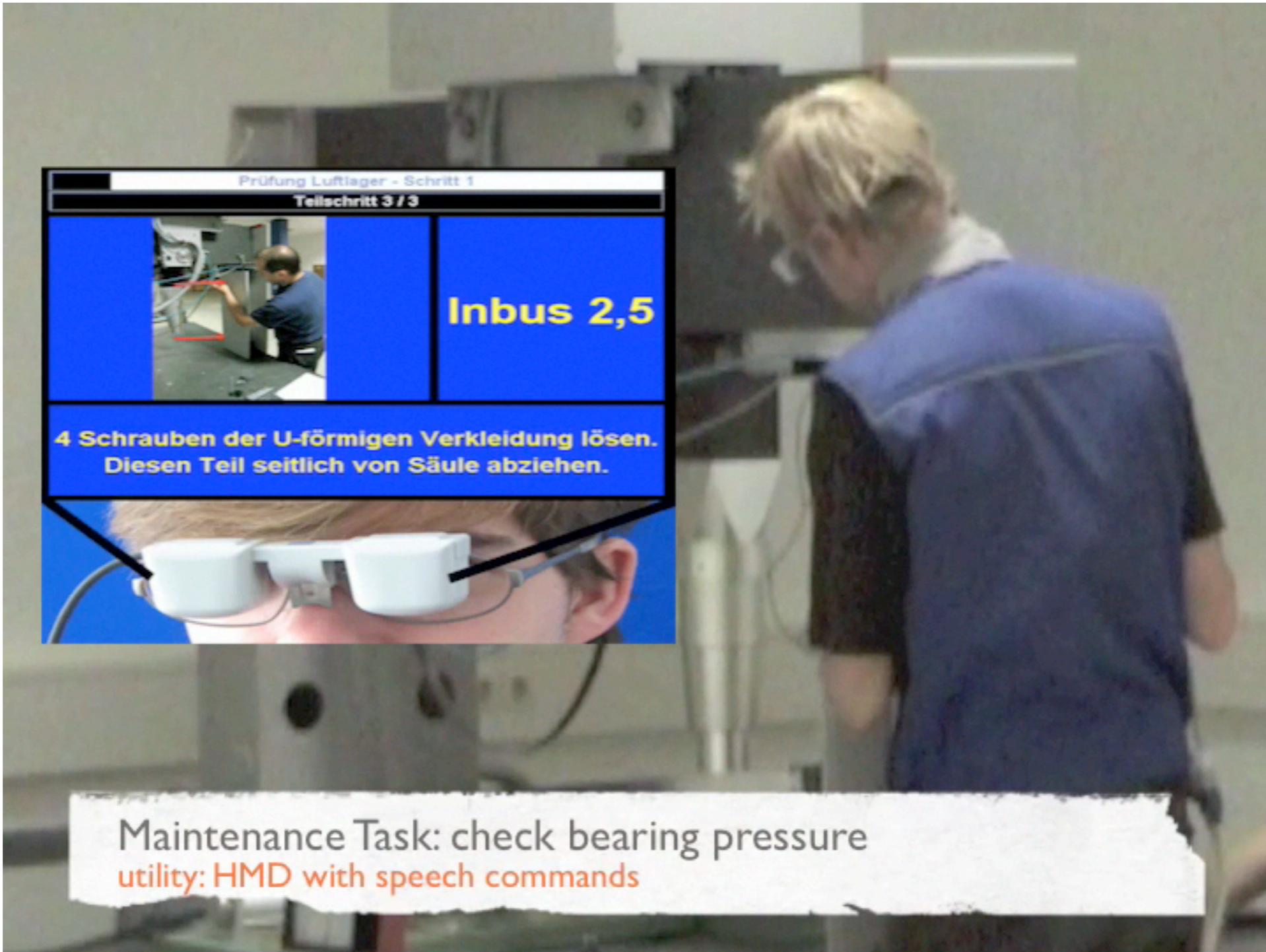
# Compensating for On-Body Placement Effects in Activity Recognition

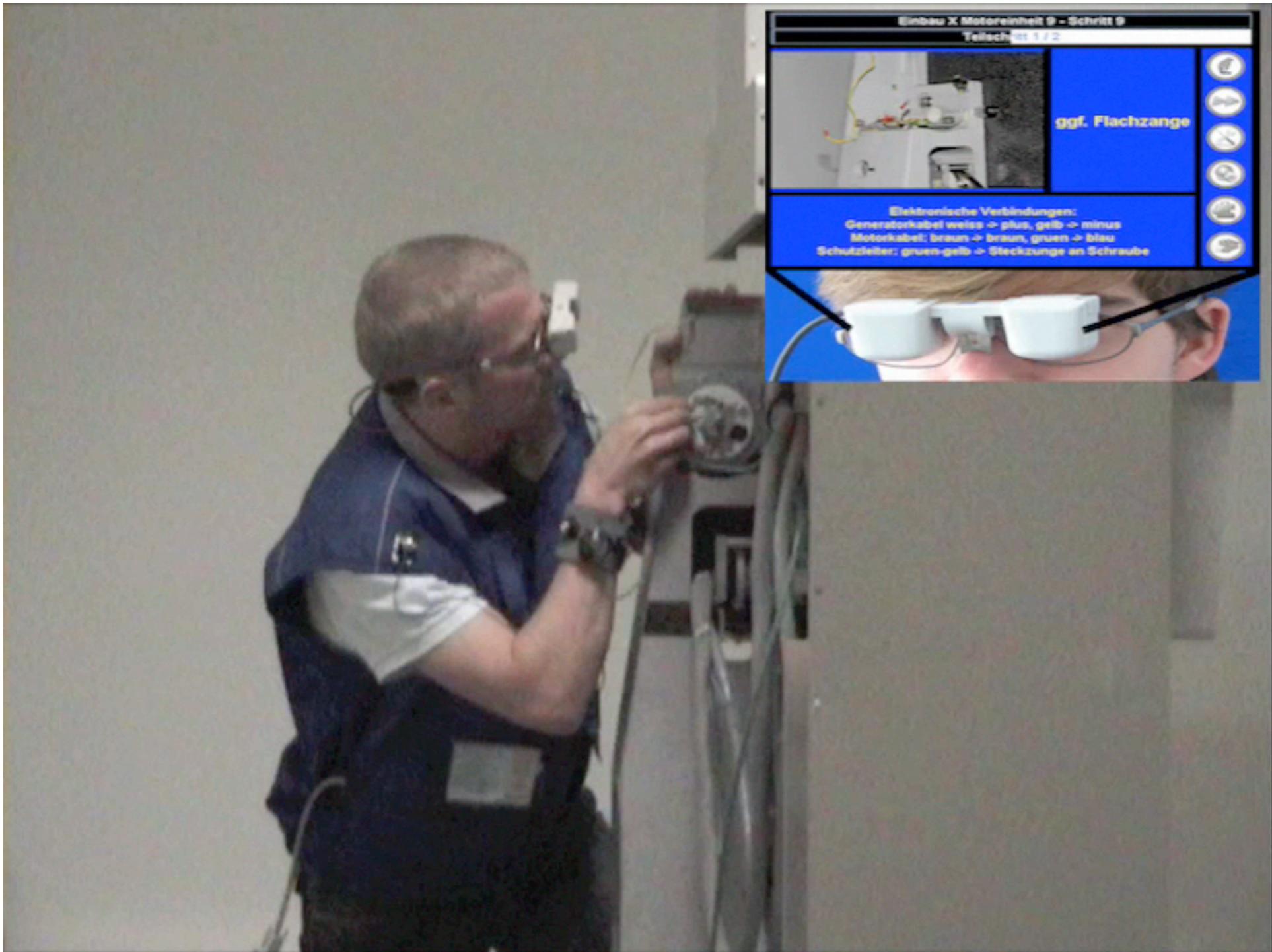
## Recognizing Reading Activities

# Compensating for On-Body Placement Effects in **Activity Recognition**

Kai Kunze





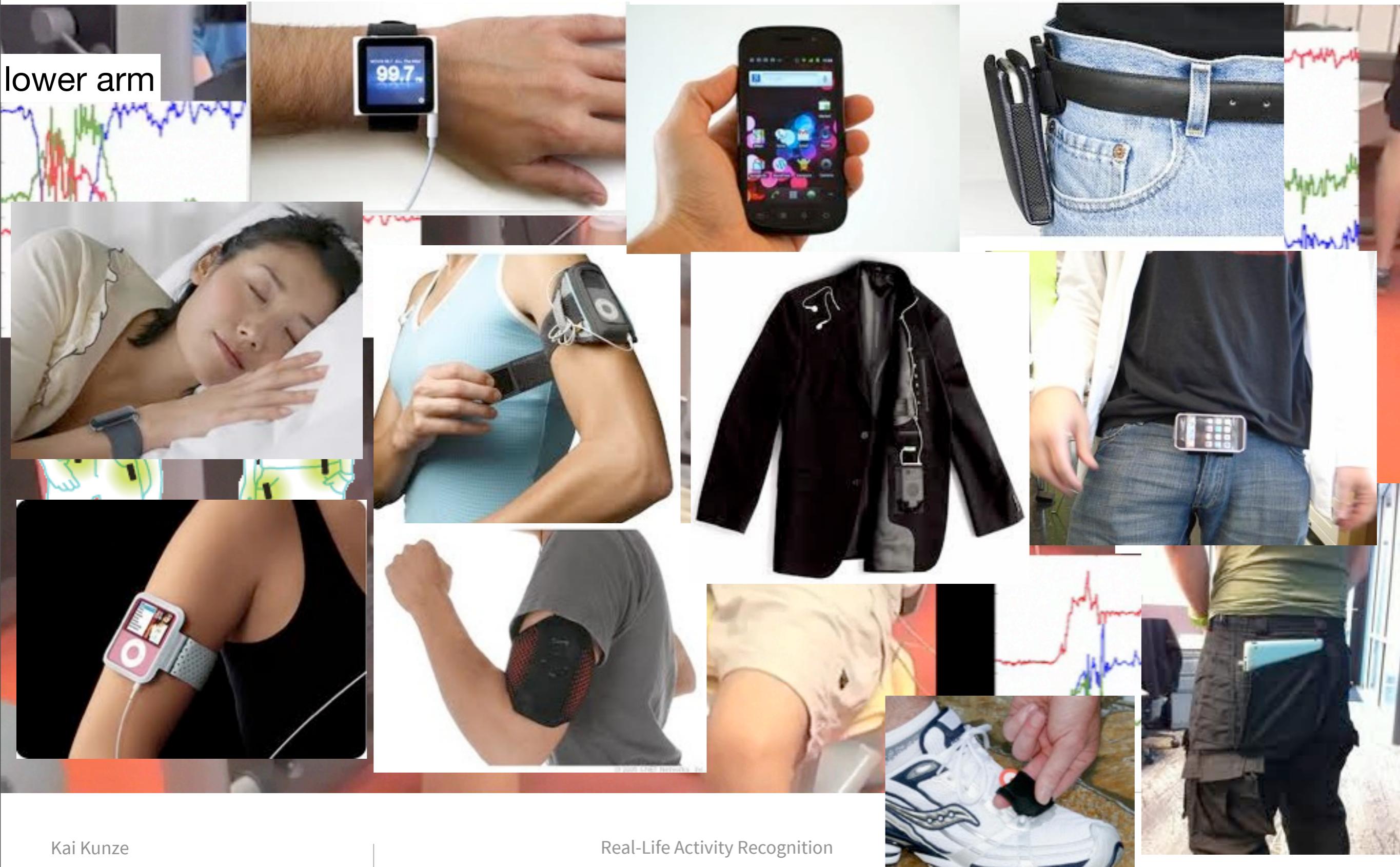


Kunze, K., Wagner, F., Kartal, E., Morales Kluge, E., and Lukowicz, P. Does Context Matter ? - A Quantitative Evaluation in a Real World Maintenance Scenario. In *Proceedings of the 7th international Conference on Pervasive Computing Nara, Japan, May 11 - 14, 2009.*

# Applications



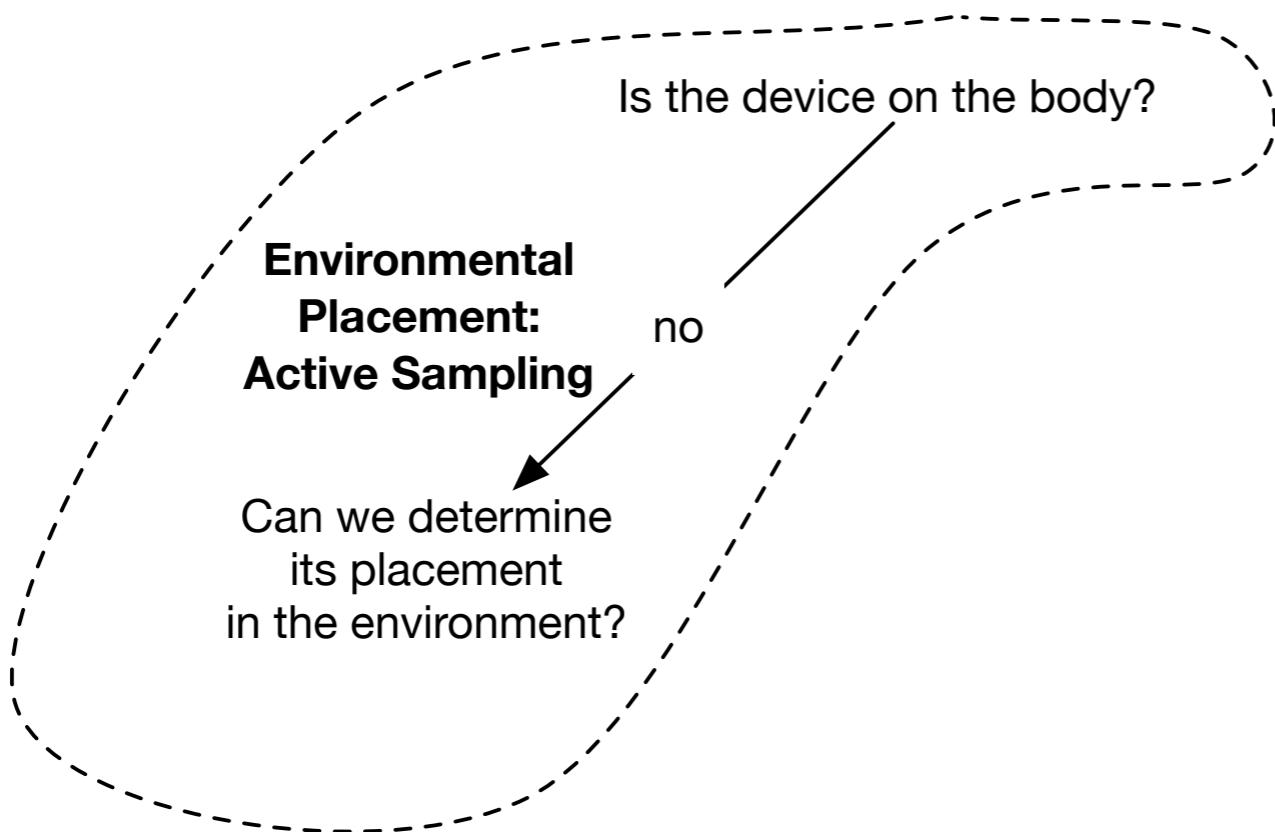
# ... using environment and onbody sensors



# Compensating for On-Body Placement Effects in Activity Recognition

Kai Kunze

# Overview and Contributions



Kunze, K. and Lukowicz, P. *Symbolic object localization through active sampling of acceleration and sound signatures*. In Proceedings of the 9th international Conference on Ubiquitous Computing. Innsbruck, Austria, September 16 - 19, 2007.  
**nominated for best paper.** (Acceptance rate: 14%)

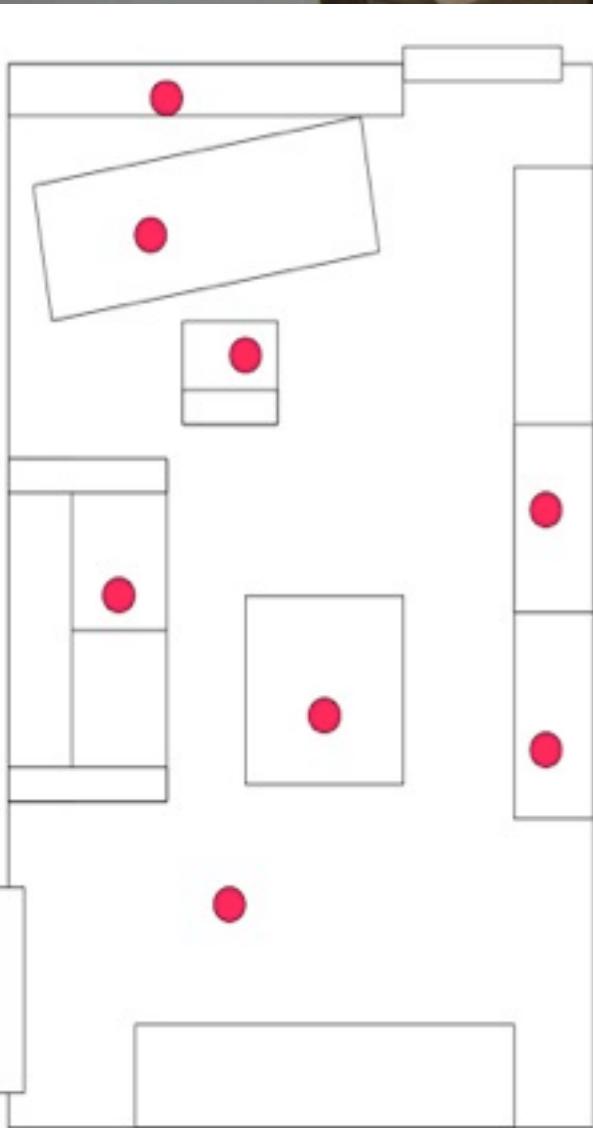
# approach



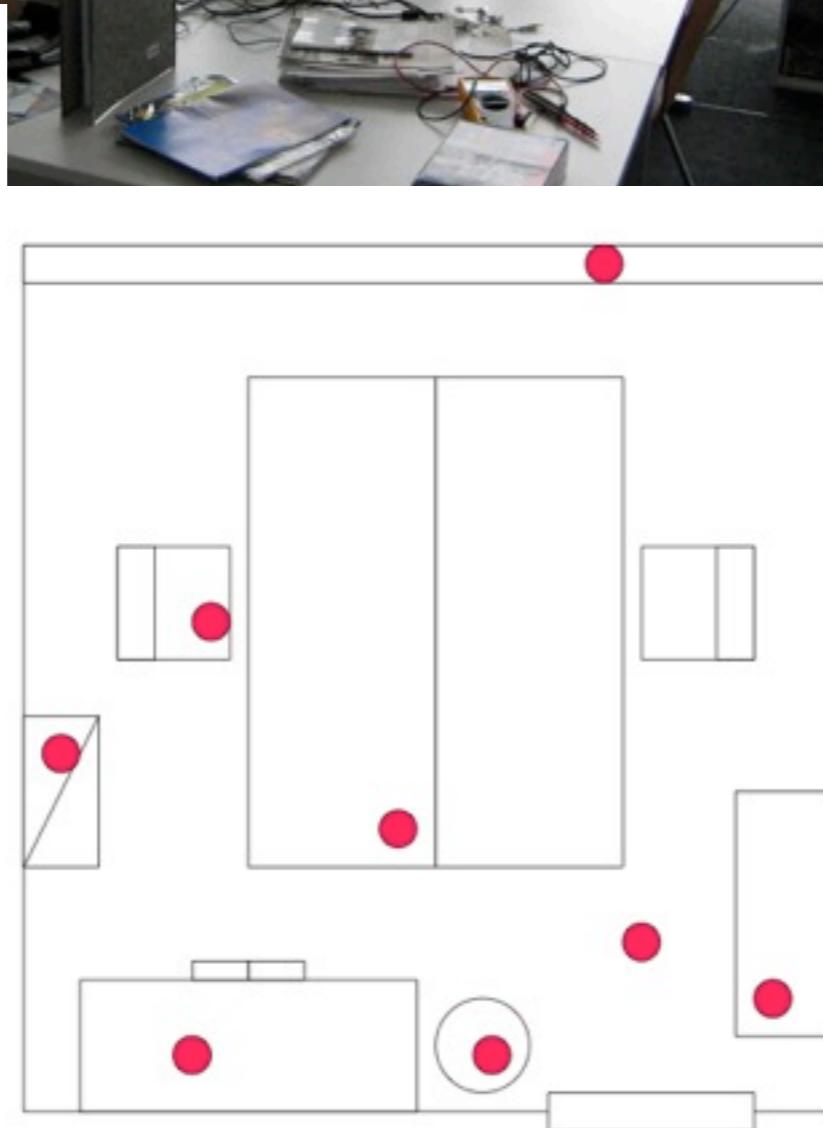
A mobile phone ringing or vibrating sounds differently depending on where it is.

scenarios

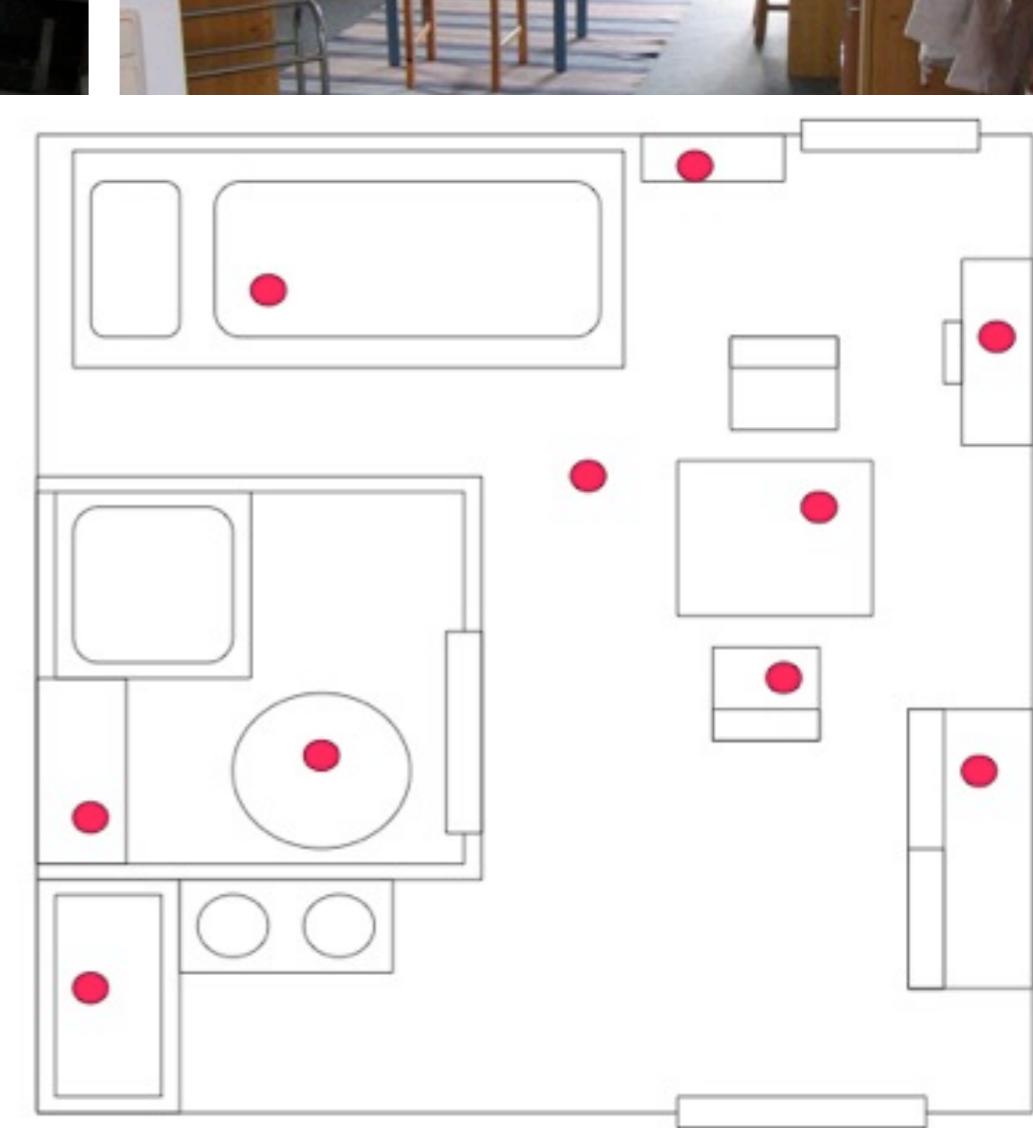
30 samples per location  
10 for training 20 for testing



living room  
9 locations



office  
12 locations



apartment  
11 locations



# abstract classes

surface types:

padding

glass

iron

metal

stone

wood

compartment:

Open/closed (except metal)

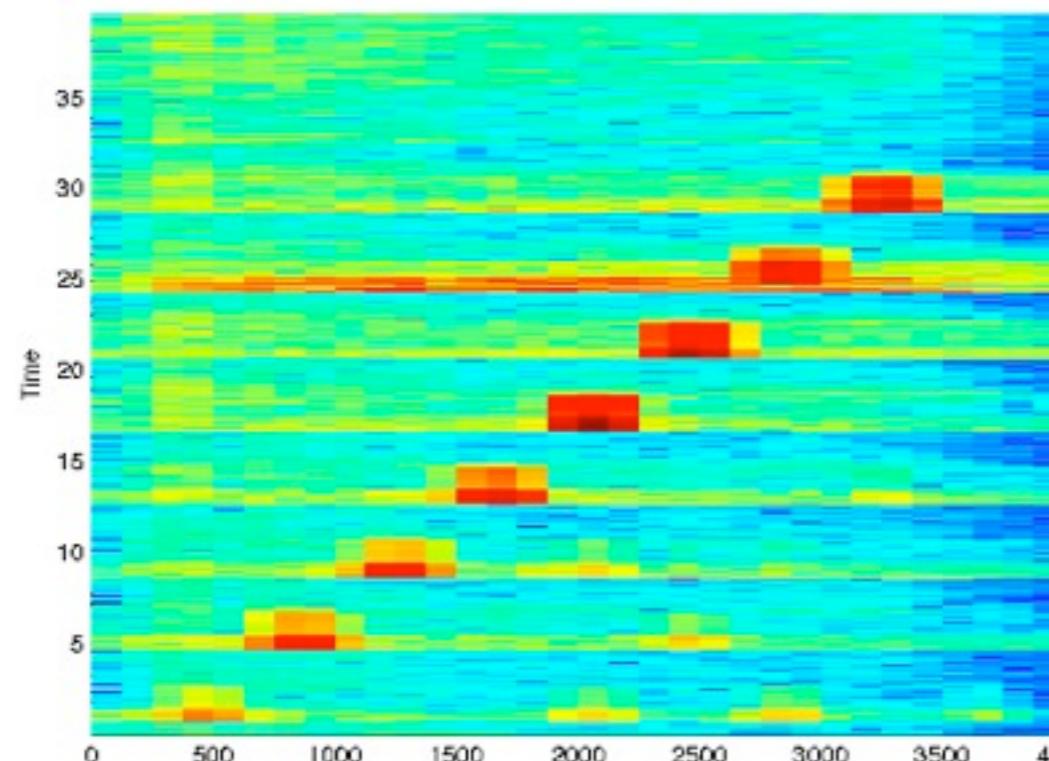


For each type and compartment:

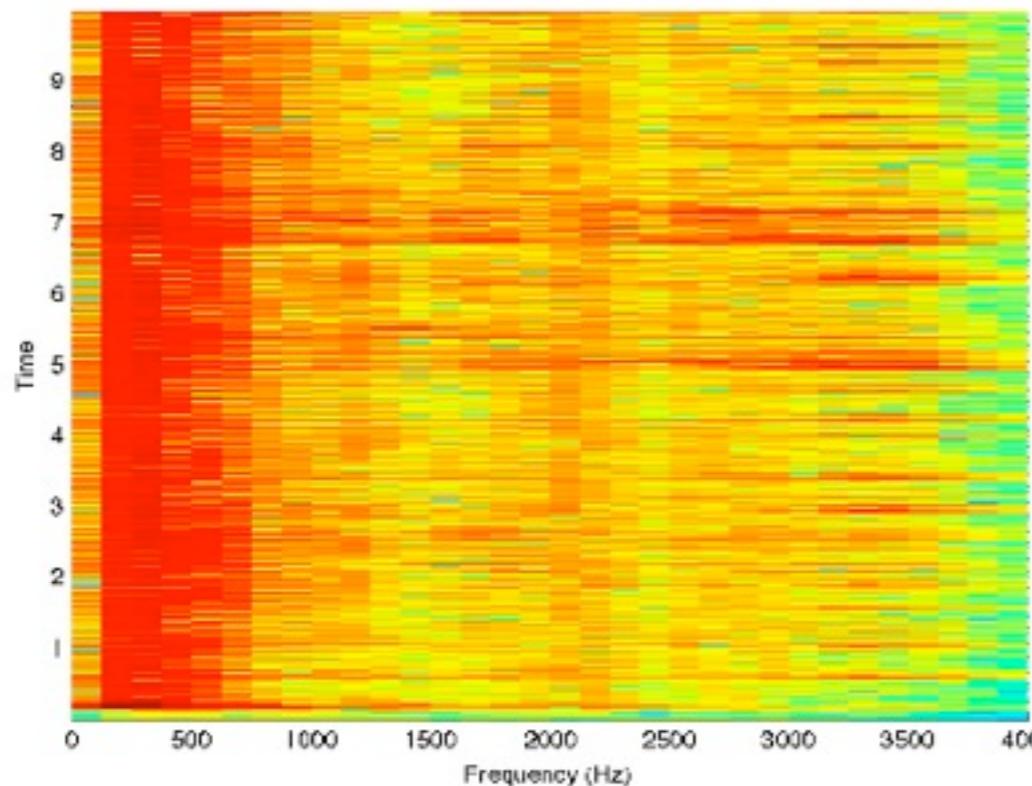
6 different kinds of furniture 12 samples each

2 pieces of furniture for training, 4 for testing

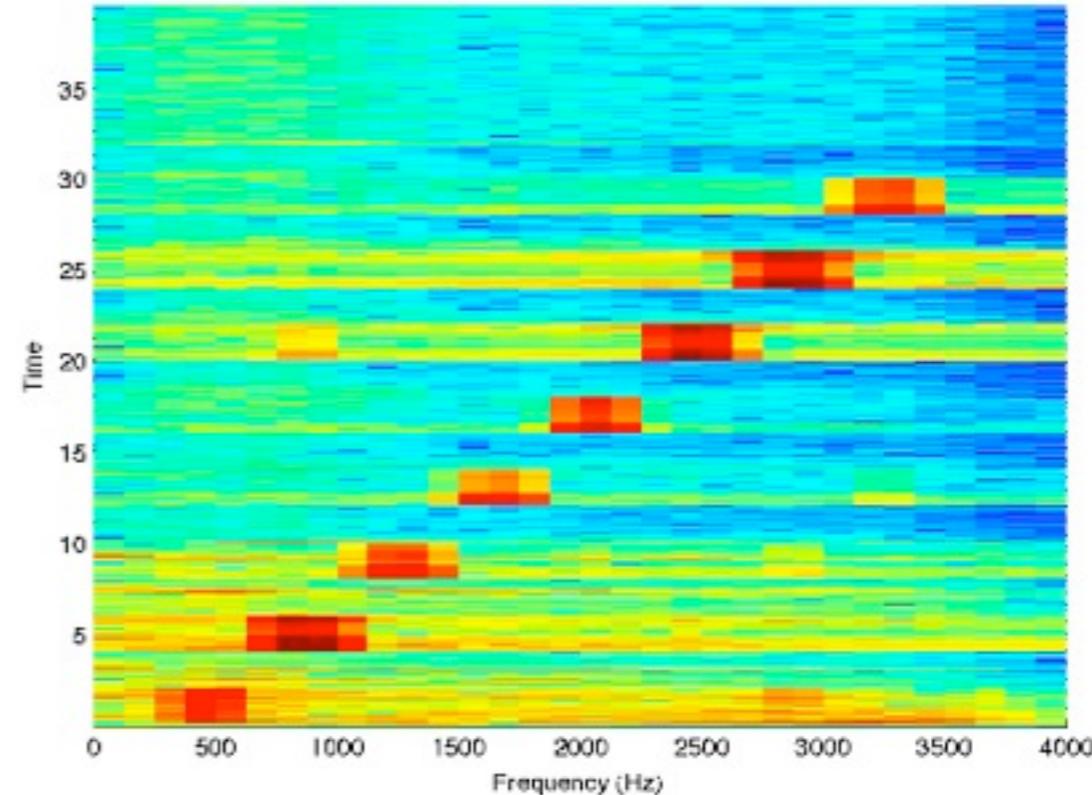
# fingerprint and vibration sounds



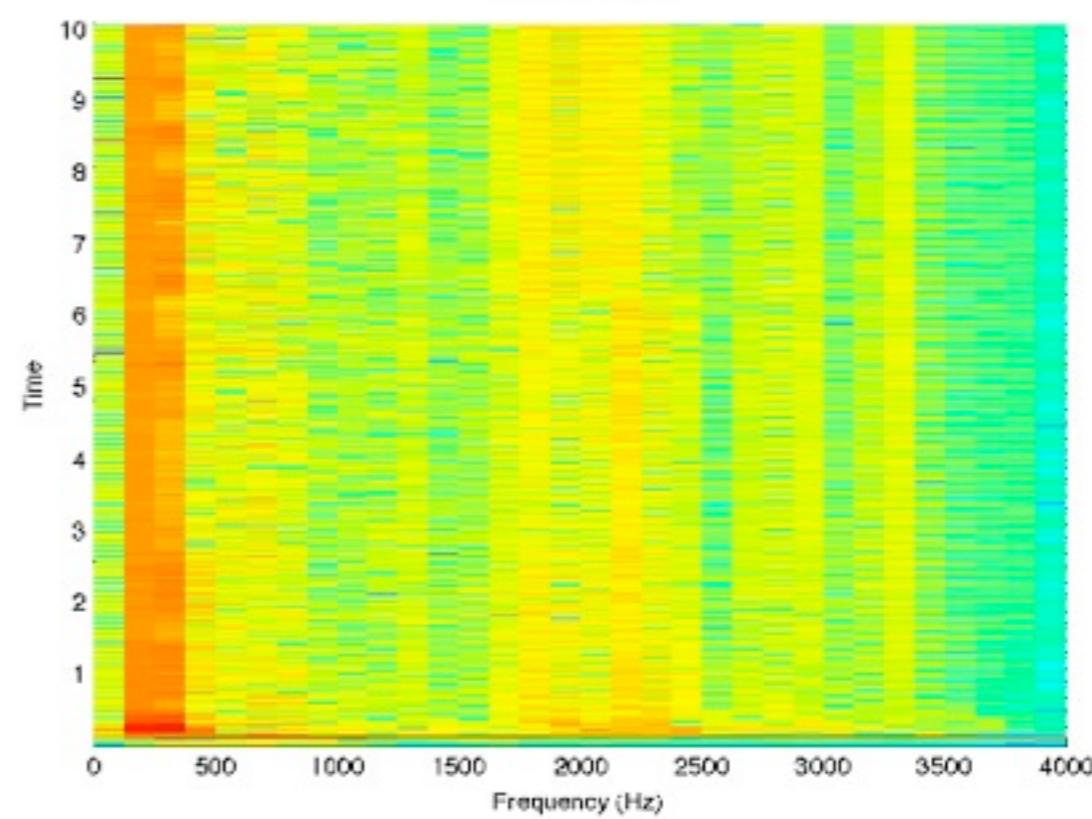
desk



Kai K



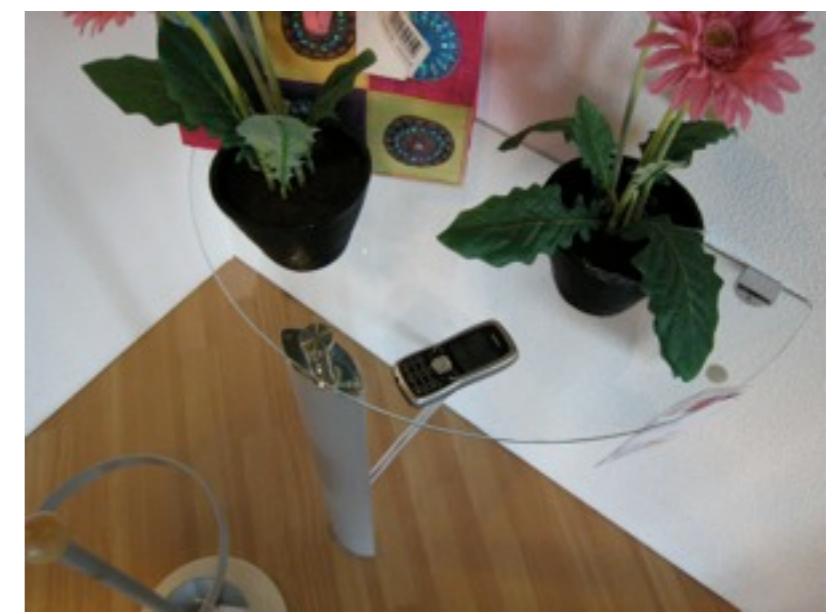
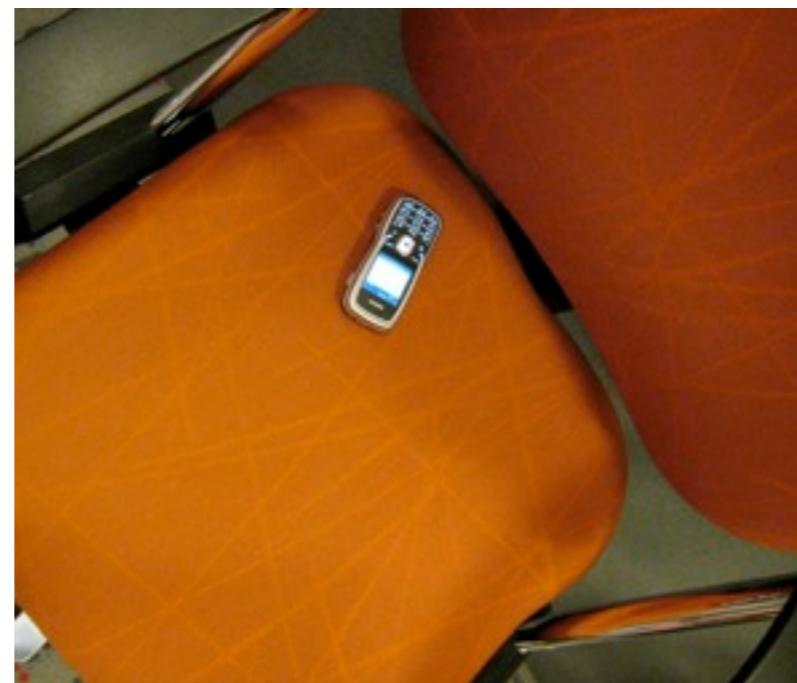
carpet



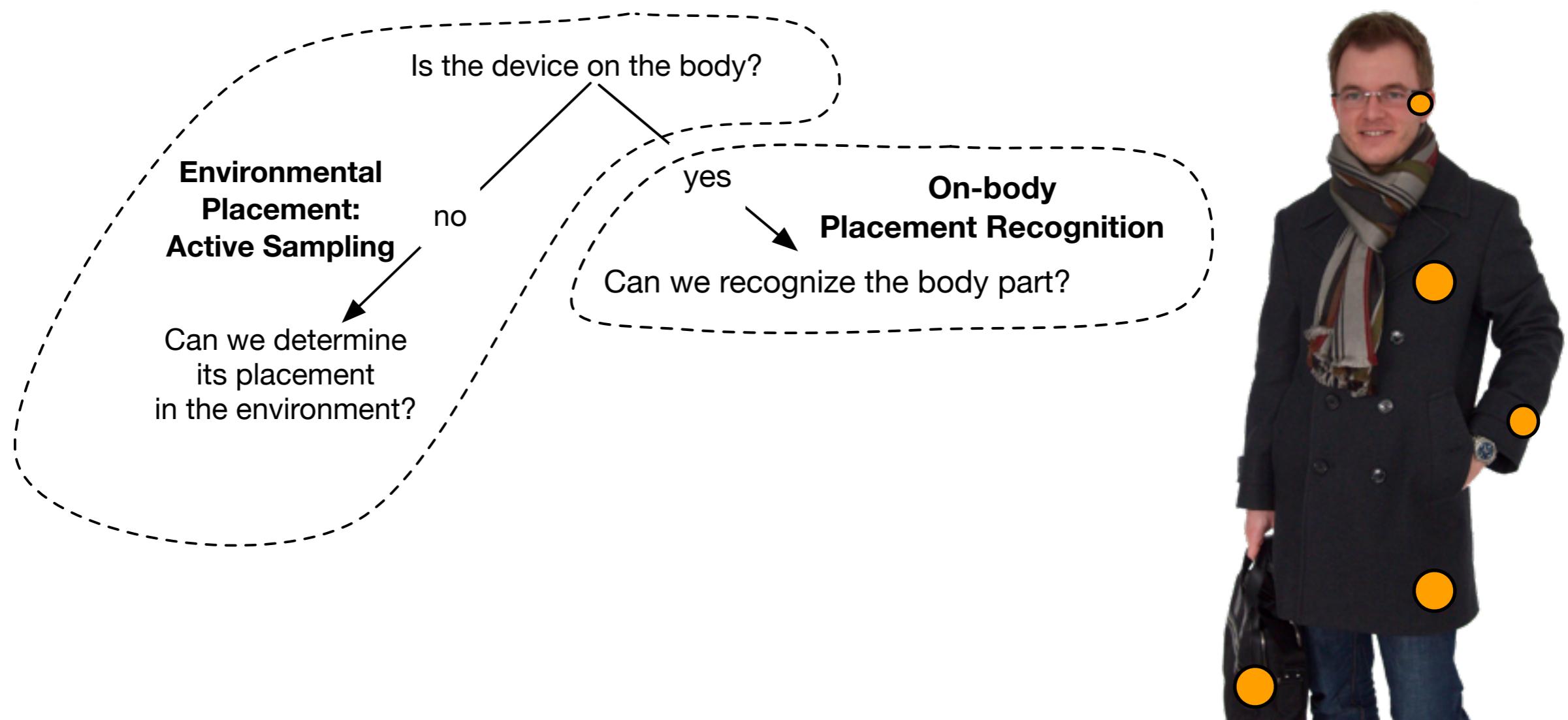
# Environmental Placement Detection -Active Sampling-



- up to 96 % per room
- up to 92 % for abstract classes



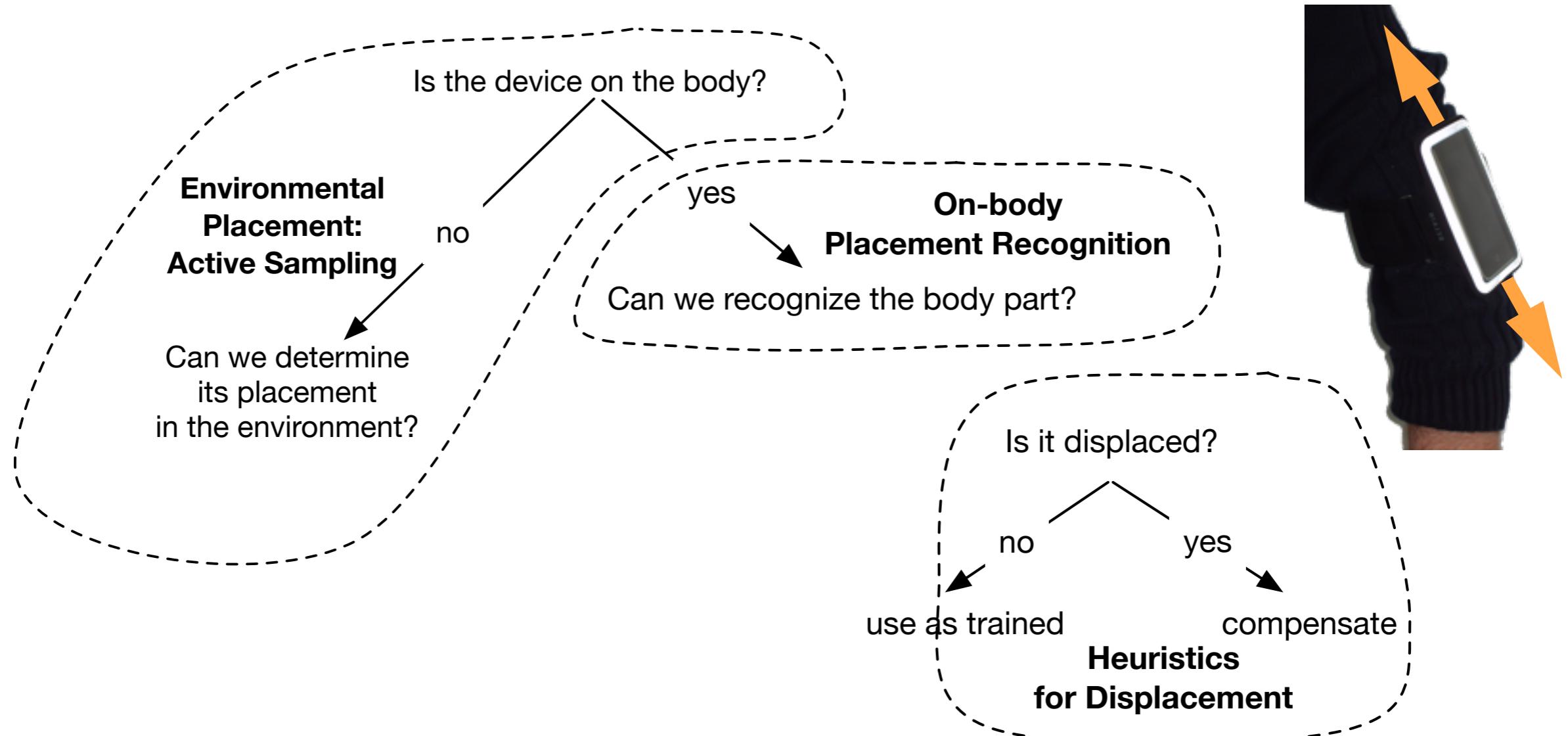
# Overview and Contributions



K. Kunze and P. Lukowicz. *Using acceleration signatures from everyday activities for on-body device location*. 11th IEEE International Symposium on Wearable Computers, Sep 2007.

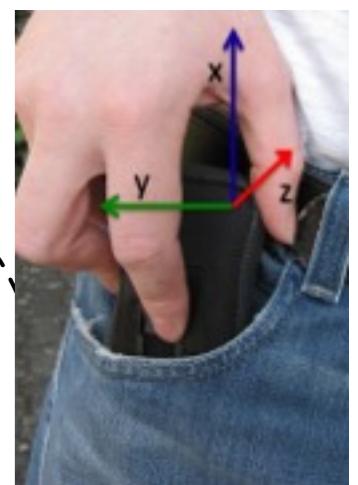
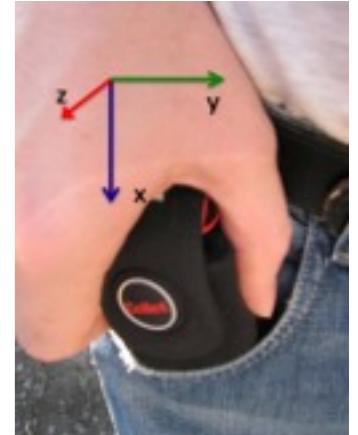
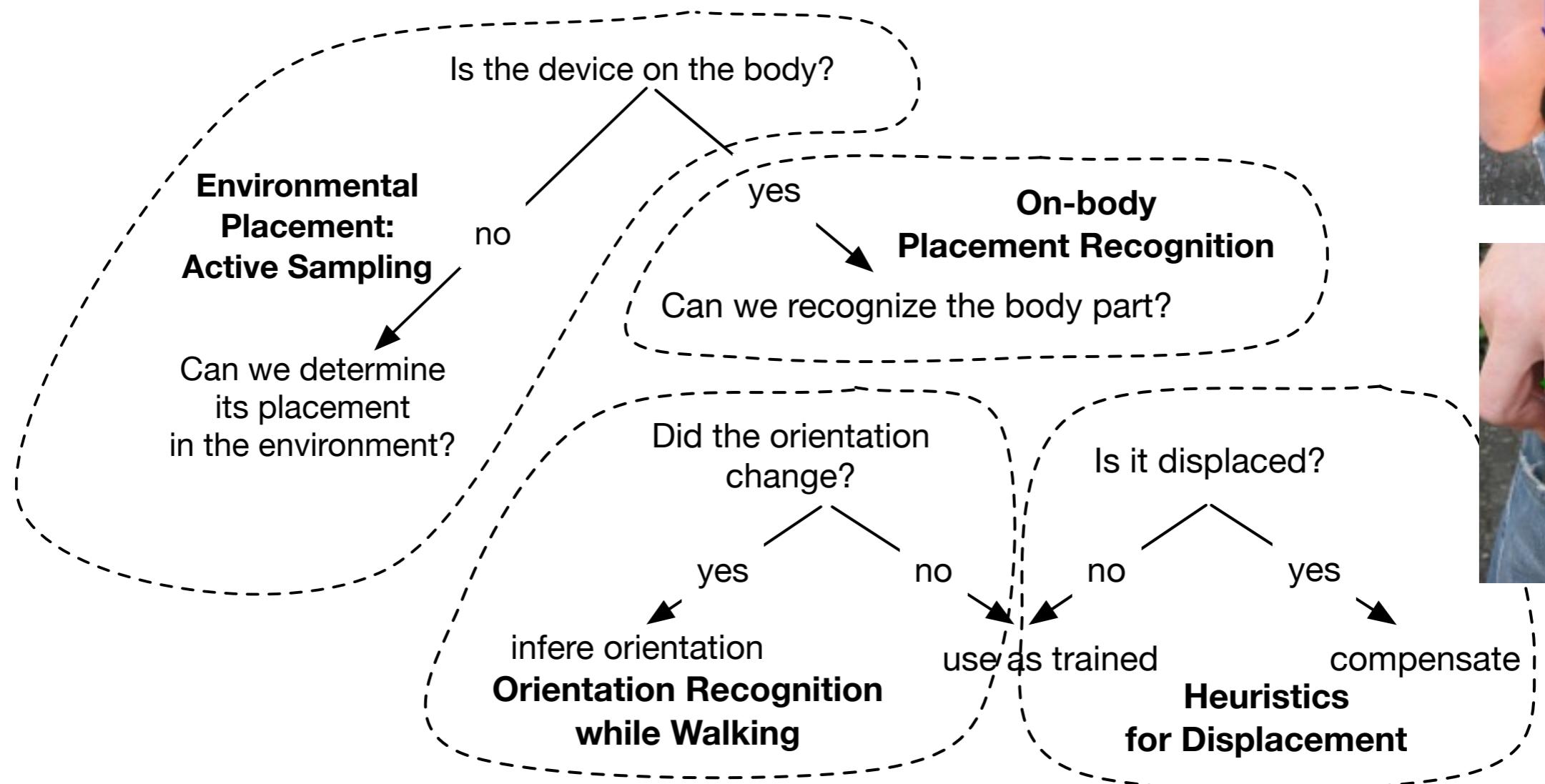
K. Kunze, P. Lukowicz, H. Junker, and G. Troester. *Where am i: Recognizing on-body positions of wearable sensors*. LOCA'04: International Workshop on Location and Context Awareness , Jan 2005.

# Overview and Contributions



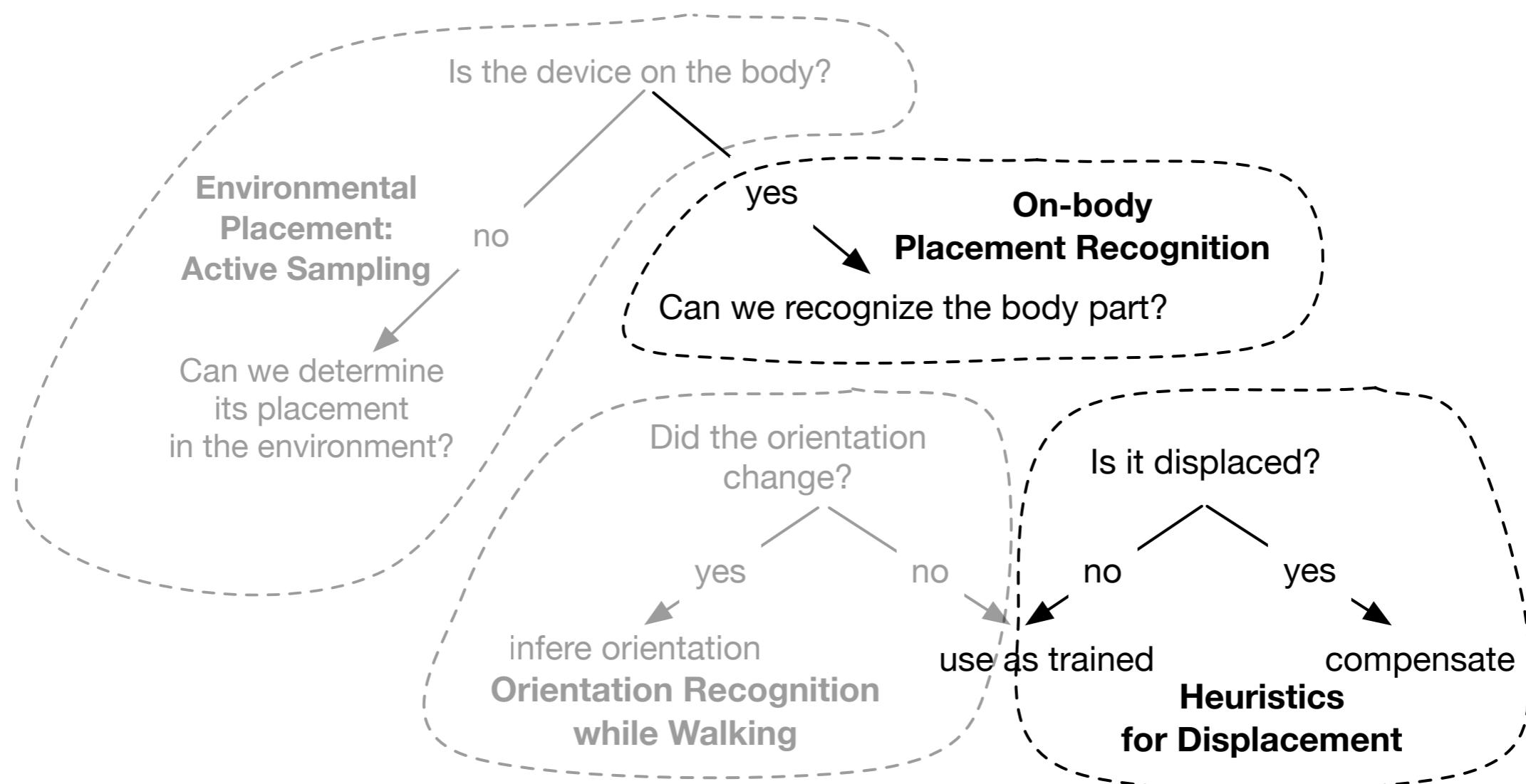
Kunze, K. and Lukowicz, P. *Dealing with sensor displacement in motion-based on-body activity recognition systems*. In Proceedings of the 10th international conference on Ubiquitous computing (UbiComp '08). Seoul, Korea, September, 2008.

# Overview and Contributions

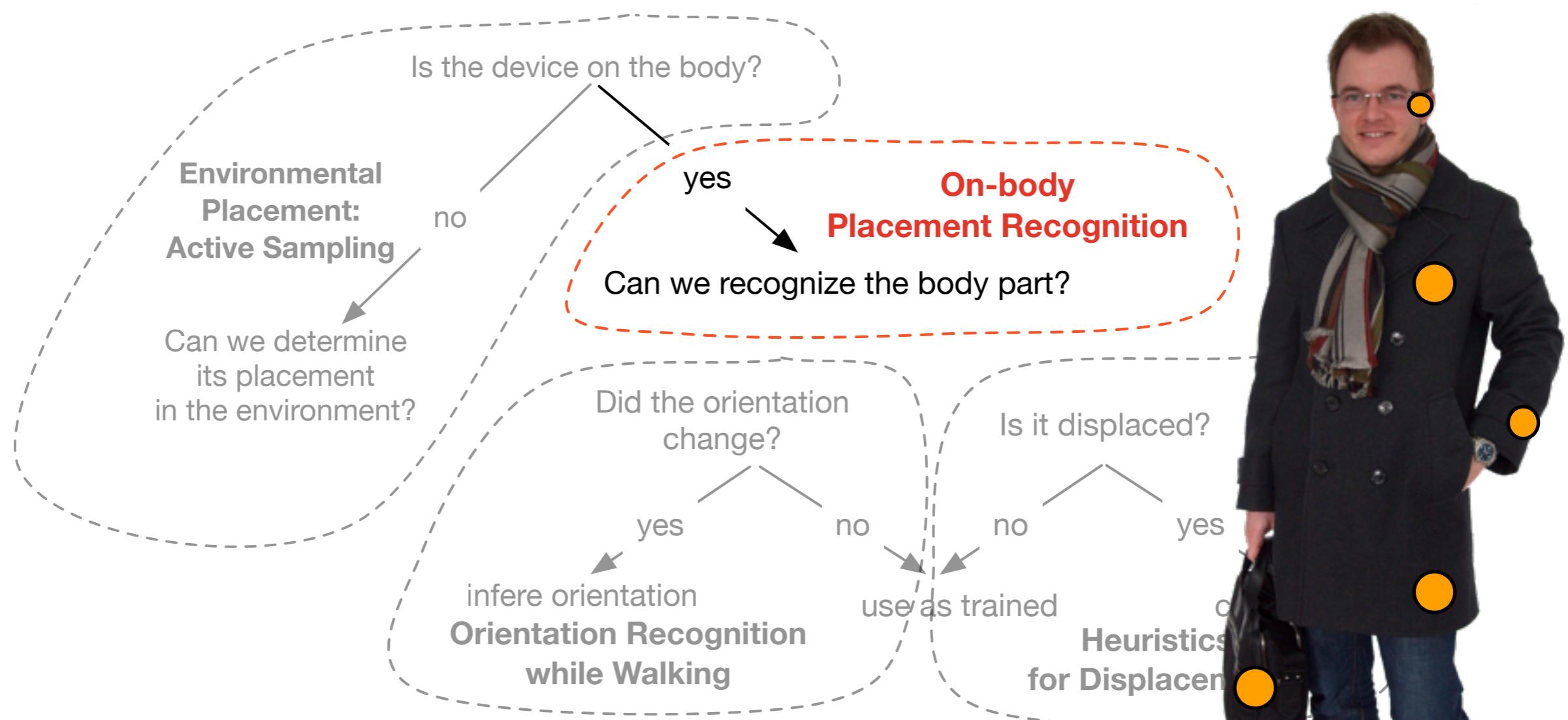


Kai Kunze, Paul Lukowicz, Kurt Partridge, Bo Begole, *Which Way Am I Facing: Inferring Horizontal Device Orientation from an Accelerometer Signal*, 13th IEEE International Symposium on Wearable Computers. Linz, Austria, 2009.

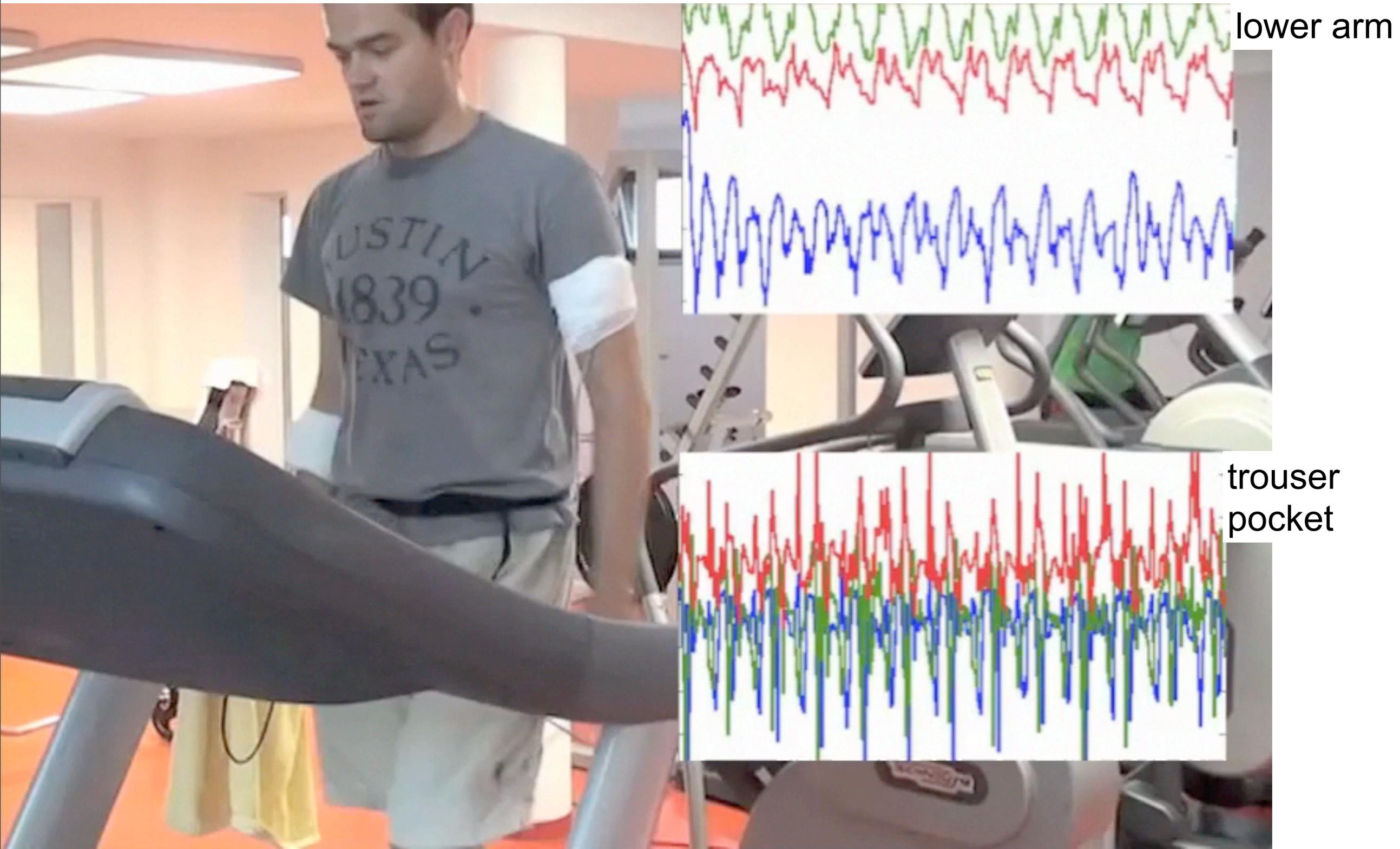
# Overview and Contributions



# Overview and Contributions

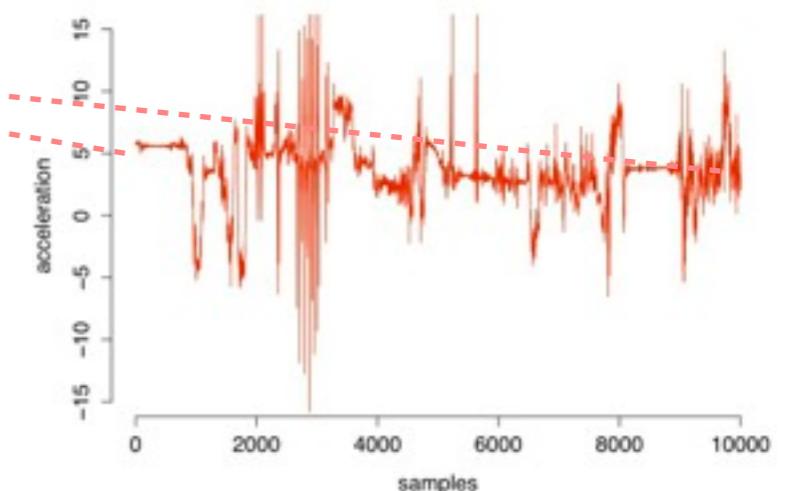
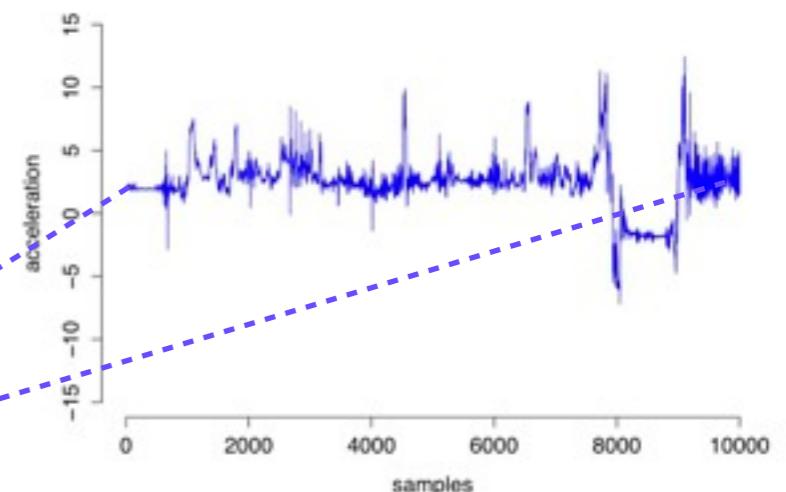


# Walking

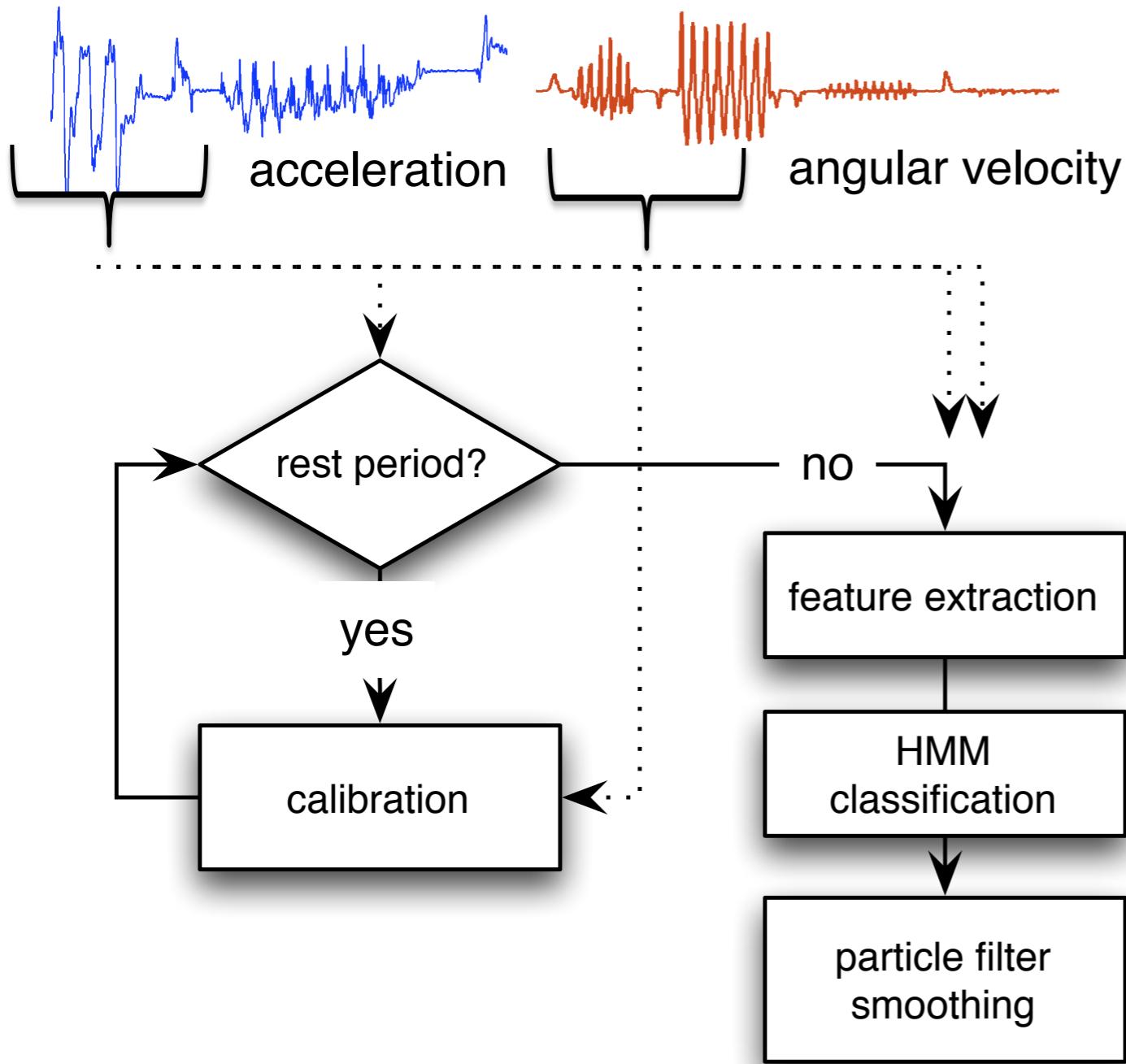


# Unconstraint Onbody Placement Recognition

- rest periods need to be filtered out
- “carrier” frequency is gone (compared to walking)
- probabilities of distinct movements for a given body part differ greatly
- time-series approach necessary
- smoothing
  - majority decision too crude
  - stochastic filtering needed



# Unconstrained Method



- acceleration features:
  - std, mean, fft center of mass, duration of rest period
- gyro features:
  - pca angle, frequency range power
- both:
  - sum of the differences in variance per axis

$$\frac{1/2 \sum_{i=1}^n \sum_{j=1, j < i}^n |var(a_i) - var(a_j)|}{var(norm)}$$

# Experimental Evaluation



*around 30 hours  
of sensor data*

- 5 data sets
- house work to bicycle repair
- 3 to 7 participants per data set
- 1 real life data set
- age range 17 - over 60
- 4-5 on-body placements

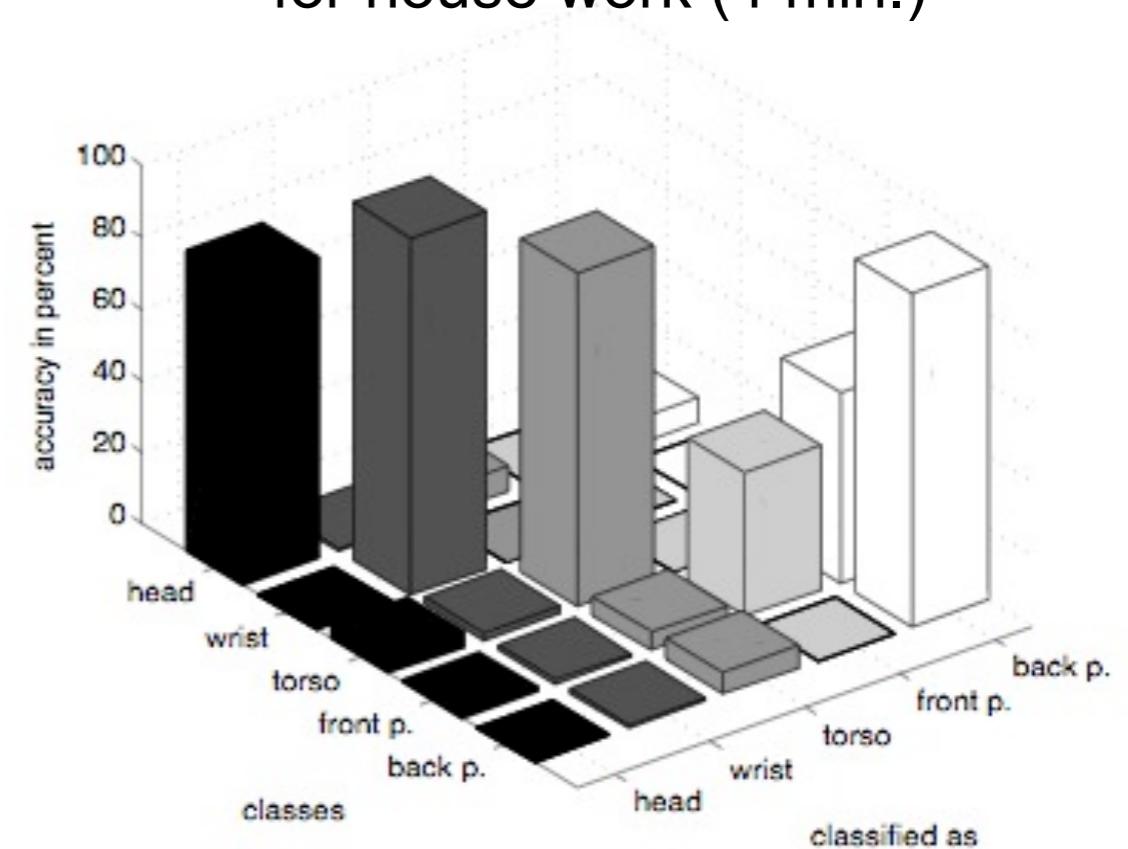


# HMM Method without Particle Filtering

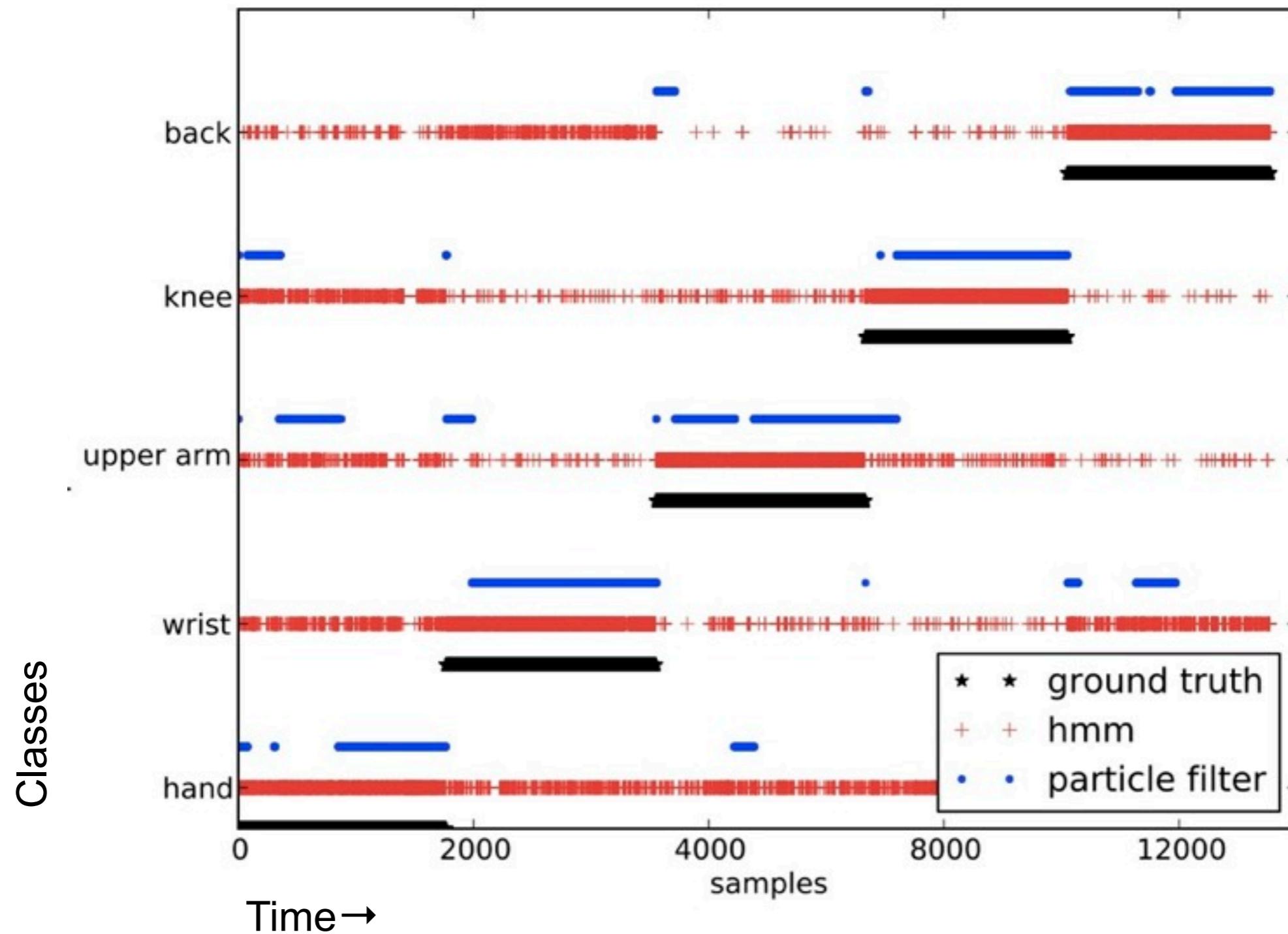
- Evaluation: 33% training, 66 %testing

Set / time	30 sec.	45 sec.	4 min.	5 min.
bicycle	43 %	67 %	83 %	84 %
house	32 %	65 %	82 %	79 %
opp. (accel)	20 %	59 %	80 %	82 %
drink and work	15 %	61 %	72 %	78 %

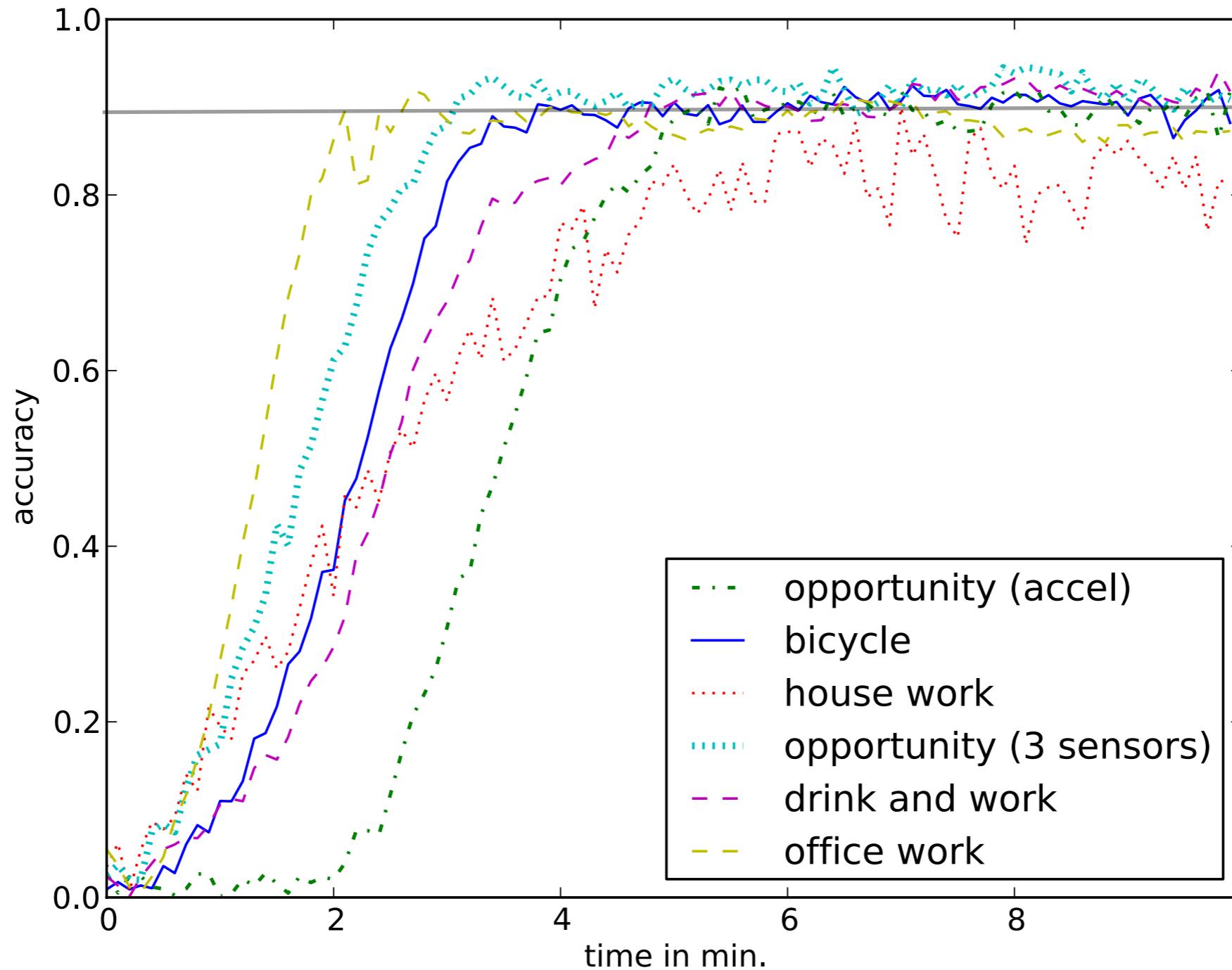
Confusion matrix  
for house work (4 min.)



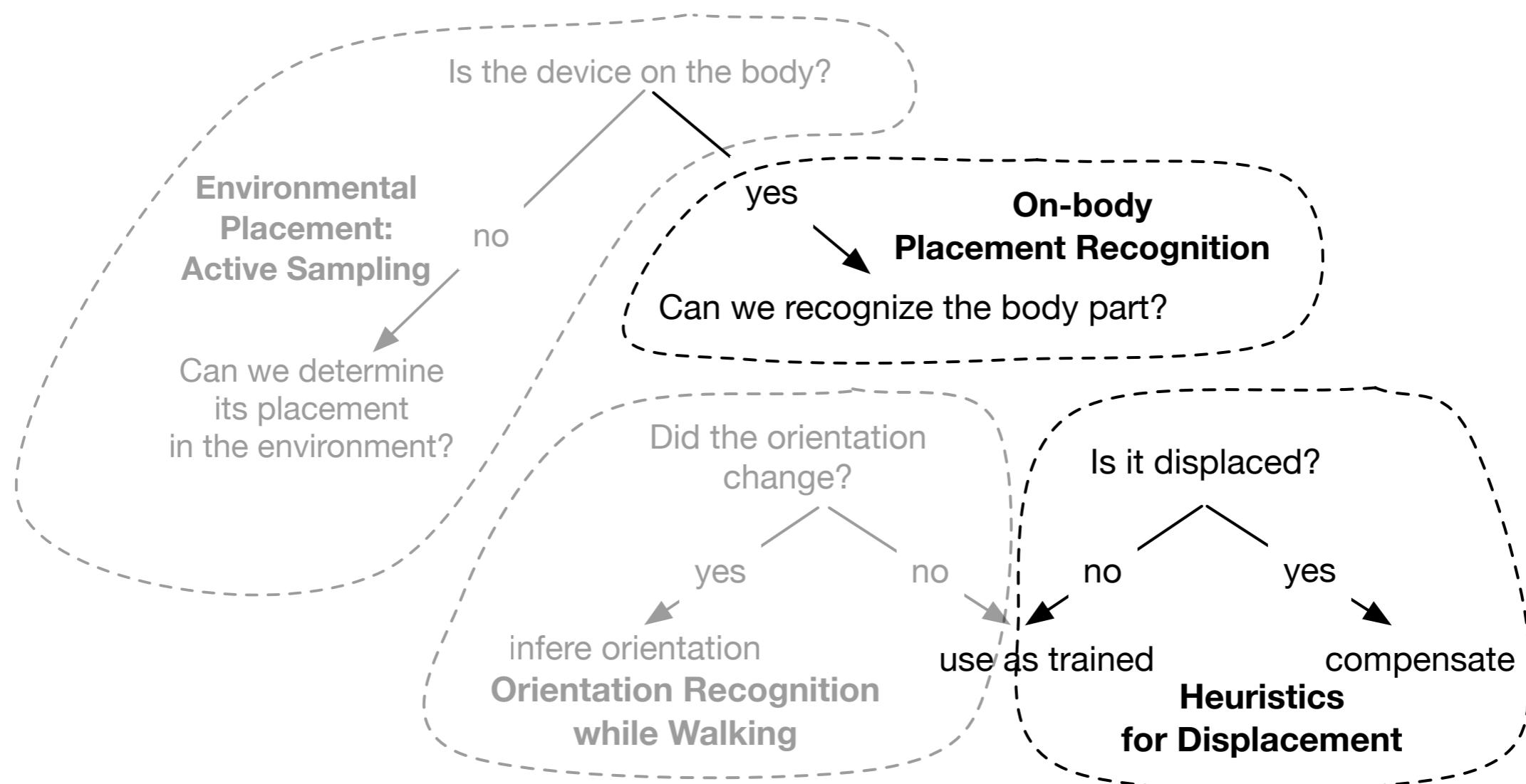
# Smoothing: Particle Filtering



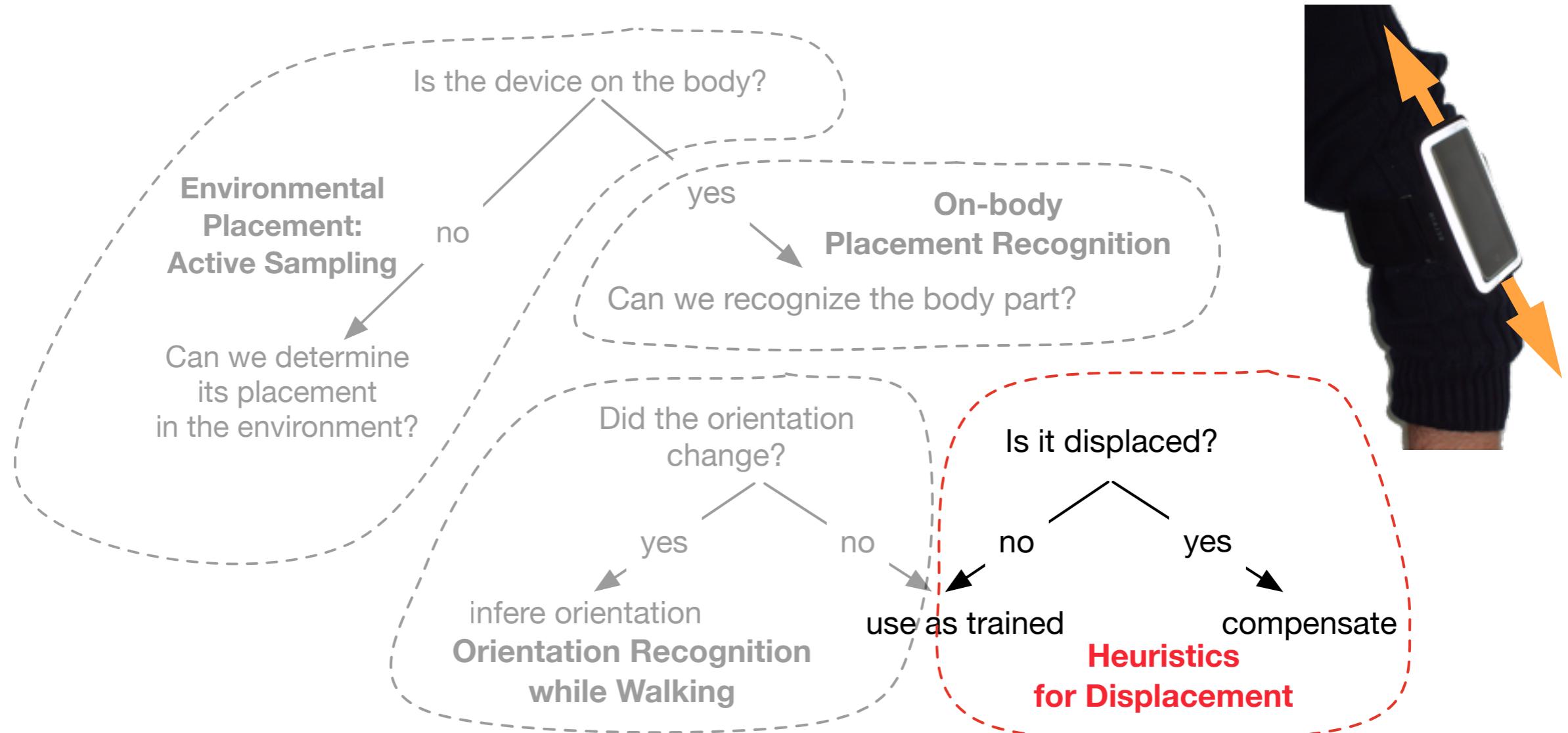
## Results: Particle Filtering



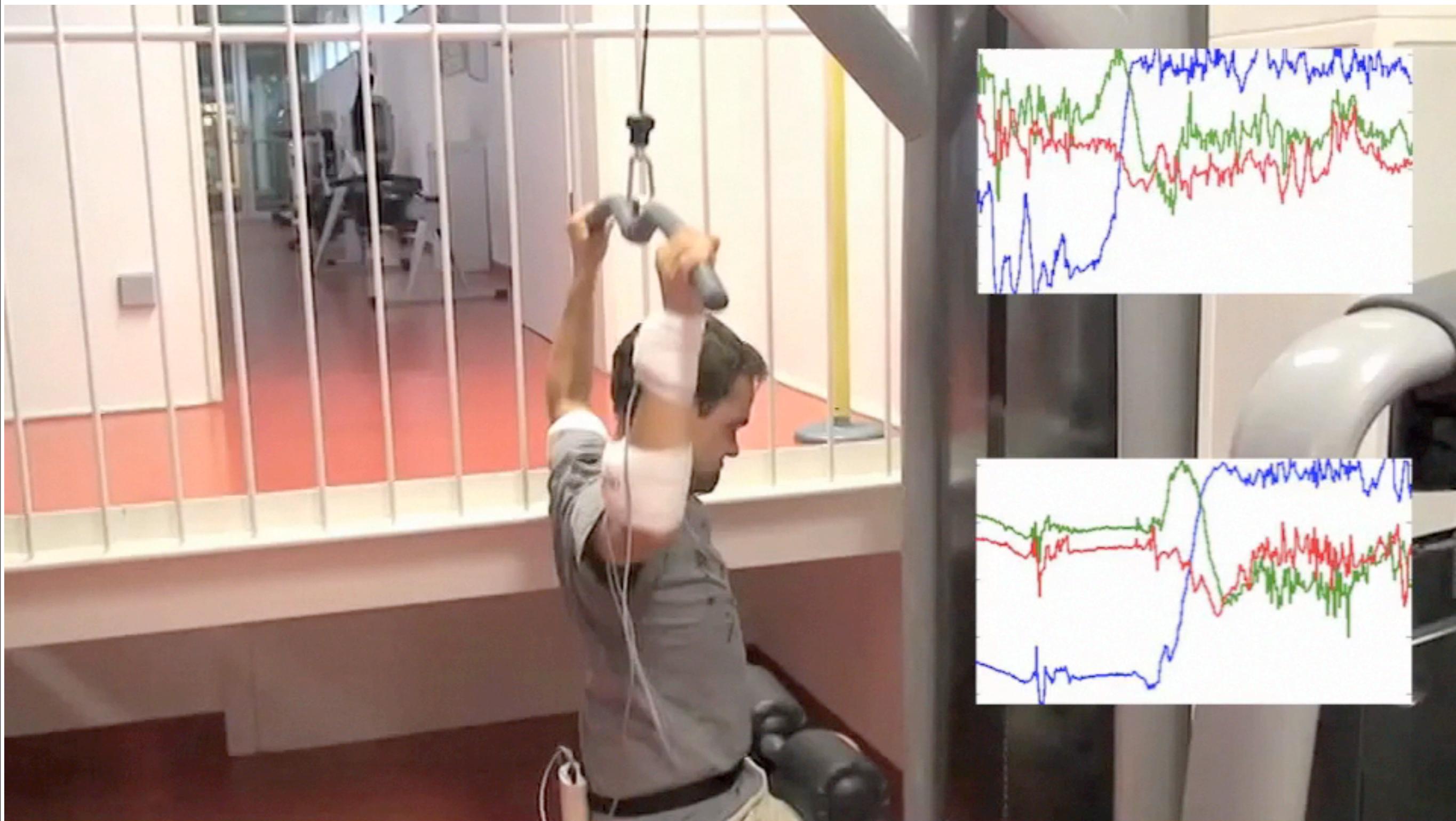
# Overview and Contributions



# Overview and Contributions



## The issue



# The Impact

## Gym Exercises

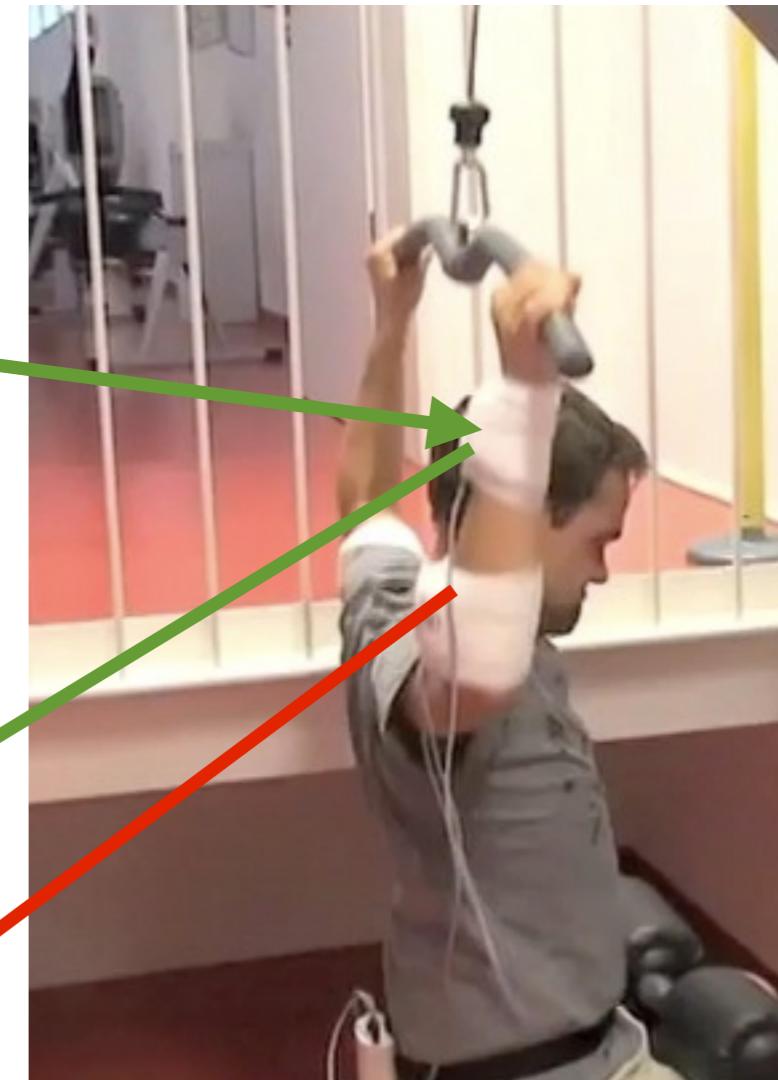
Recognition algorithm trained on sensor 1

Modality  
Acceleration  
Gyroscope

100%  
80%

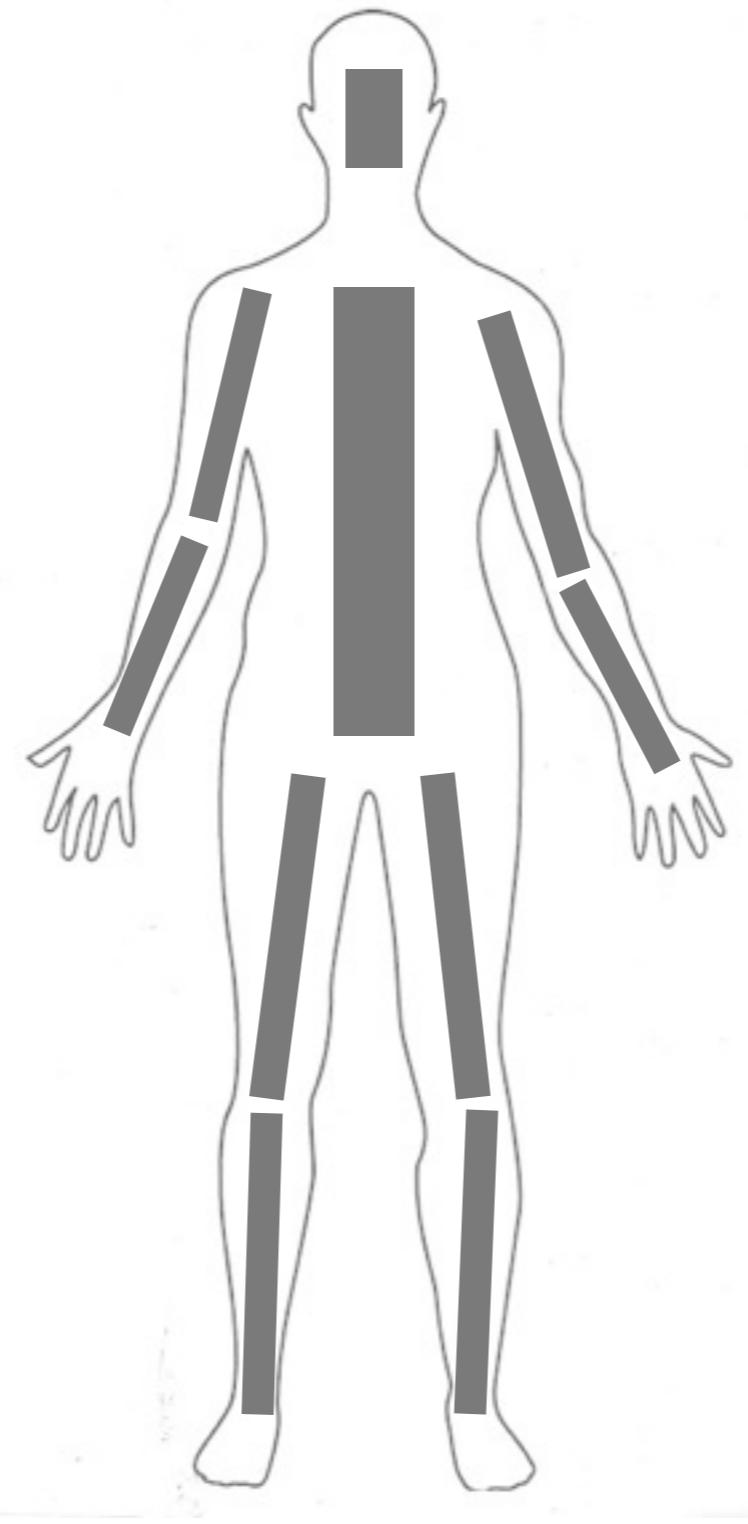
evaluated on sensor 1

63%  
72%

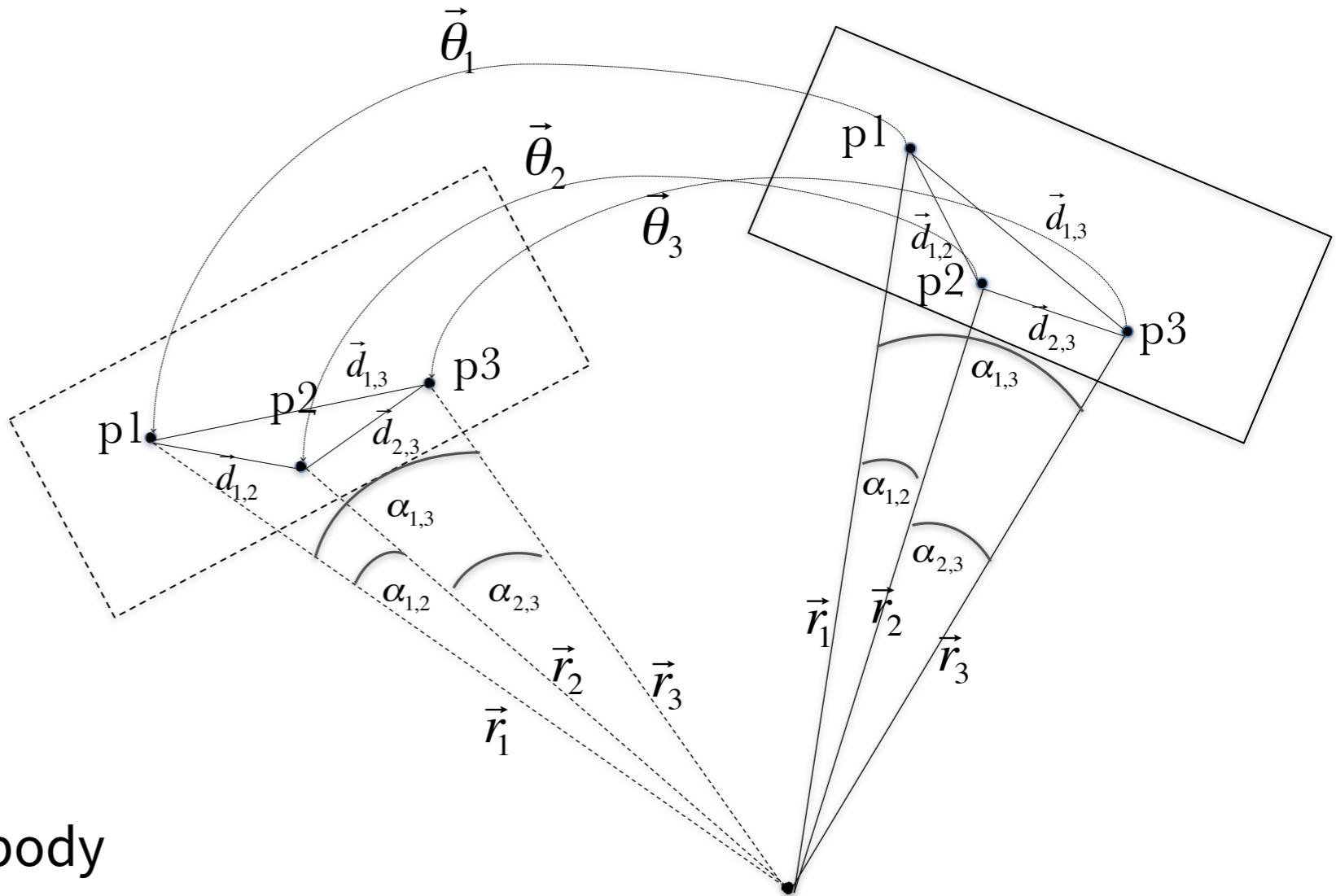
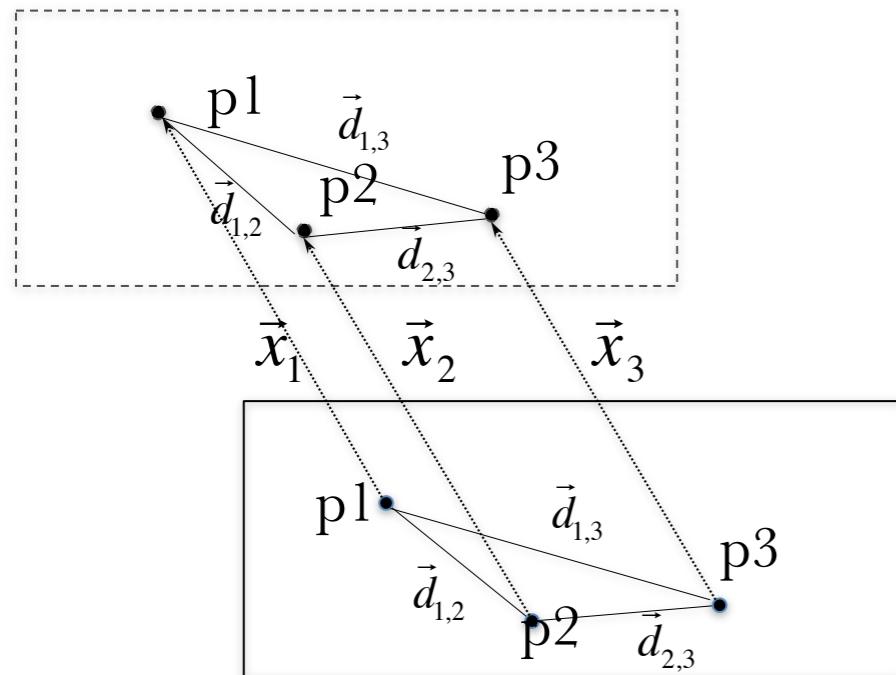


evaluated on displaced sensor

# Rigid Body Approximation



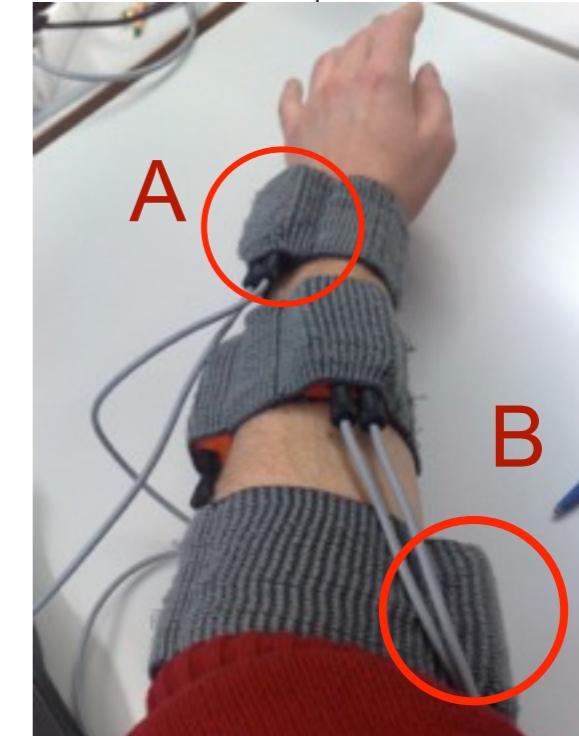
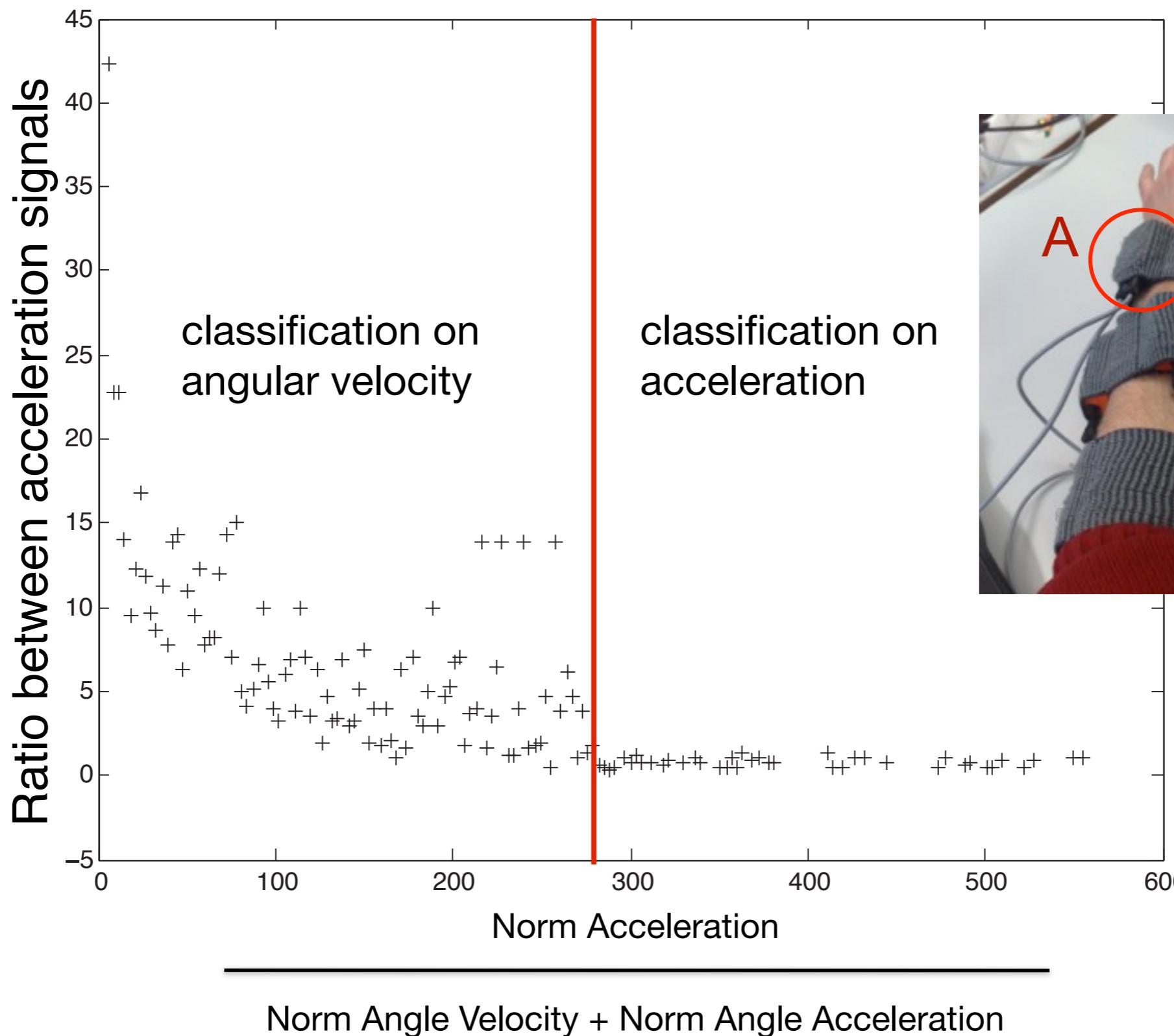
# Rigid Body Approximation



- model a body part as a rigid body
- every movement can be described as a combination of rotations and translations
- for Translation + Rotation: Angular Velocity is displacement indifferent
- for Translation only: Acceleration is displacement indifferent
- How do we decide when to choose what?

# Principle

$$\frac{\| A \|}{\| B \|}$$



# Gym Exercises

- Same setup only on lower arm
- 3 users



8 Exercises: lat machine  
pectorial  
shoulder press  
upper back  
arm extension  
arm curl  
pull down  
chestpress

# Gym Exercise Results

continuous HMMs

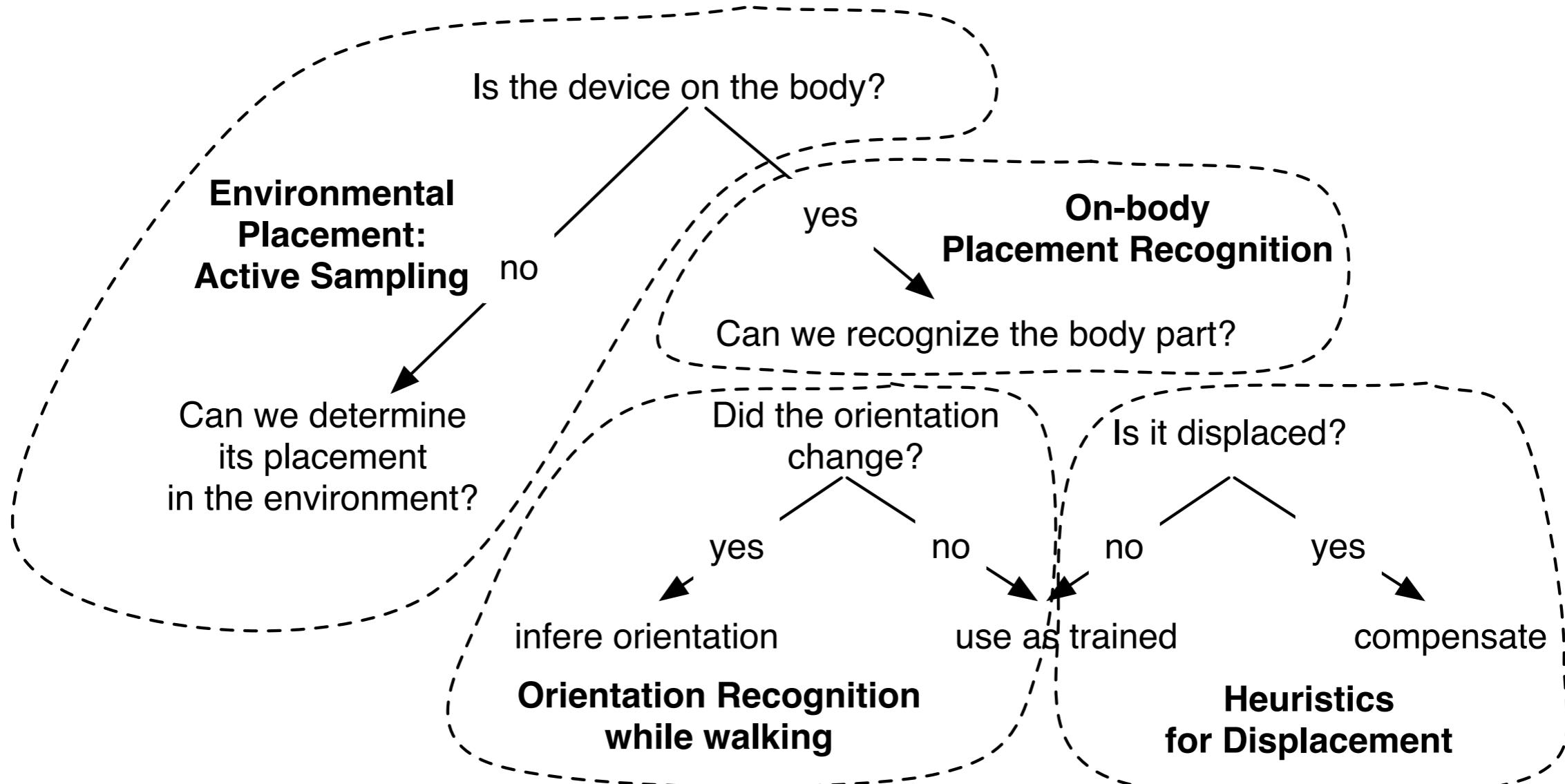
15 sec. sliding window 3 gaussians  
up to 4 hidden states

Modality	Same	Displaced
Acceleration	97%	24%

**Heuristic 74%**

q	r	s	t	u	v	w	x	← classified as
75.6	0	0	0	0	0	0	24.4	q = lat
0	81.6	0	0	0	0	18.4	0	r = pectorial
0	0	88.6	0	11.4	0	0	0	s = shoulder press
0	0	0	100	0	0	0	0	t = upper back
0	0	13.3	0	76.7	0	10.0	0	u = arm extension
0	0	0	0	22.2	77.8	0	0	v = arm curl
12.0	0	0	0	8.0	0	80	0	w = pull down
0	0	0	20.8	0	0	0	79.2	x = chestpress

# Summary



# incorporating environmental sensors



Gernot Bahle, Paul Lukowicz, Kai Kunze,  
Koichi Kise, *I see you: How to improve  
wearable activity recognition by leveraging  
information from environmental cameras*  
Percom, San Diego, 2013.

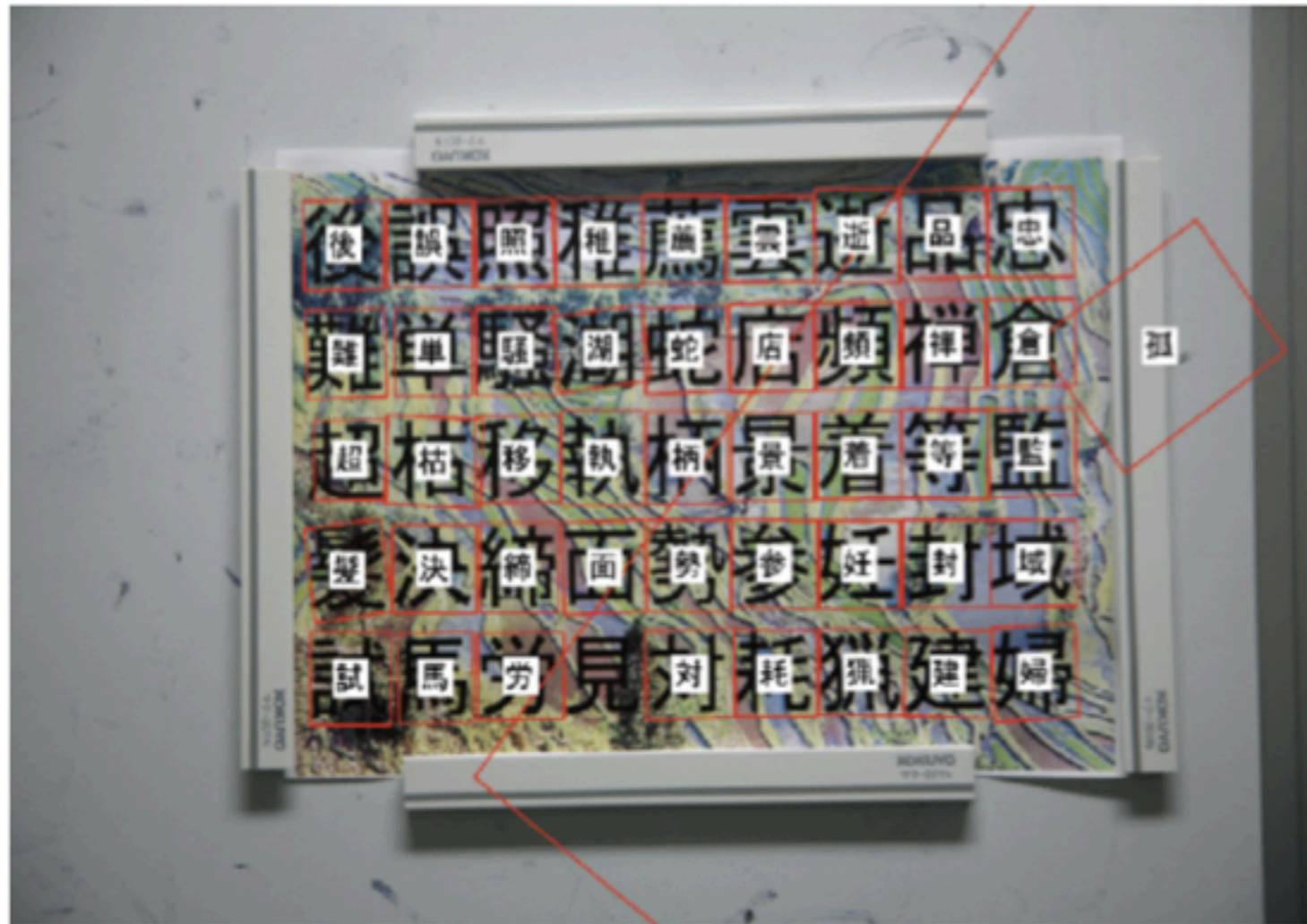
# Compensating for On-Body Placement Effects in Activity Recognition

## Recognizing Reading Activities

# knowledge acquisition

- very few in-situ studies concerning reading activities
- utilizing pervasive sensing and computer vision to recognize:
  - what you read
  - how you read it
- “Reading-life” Log

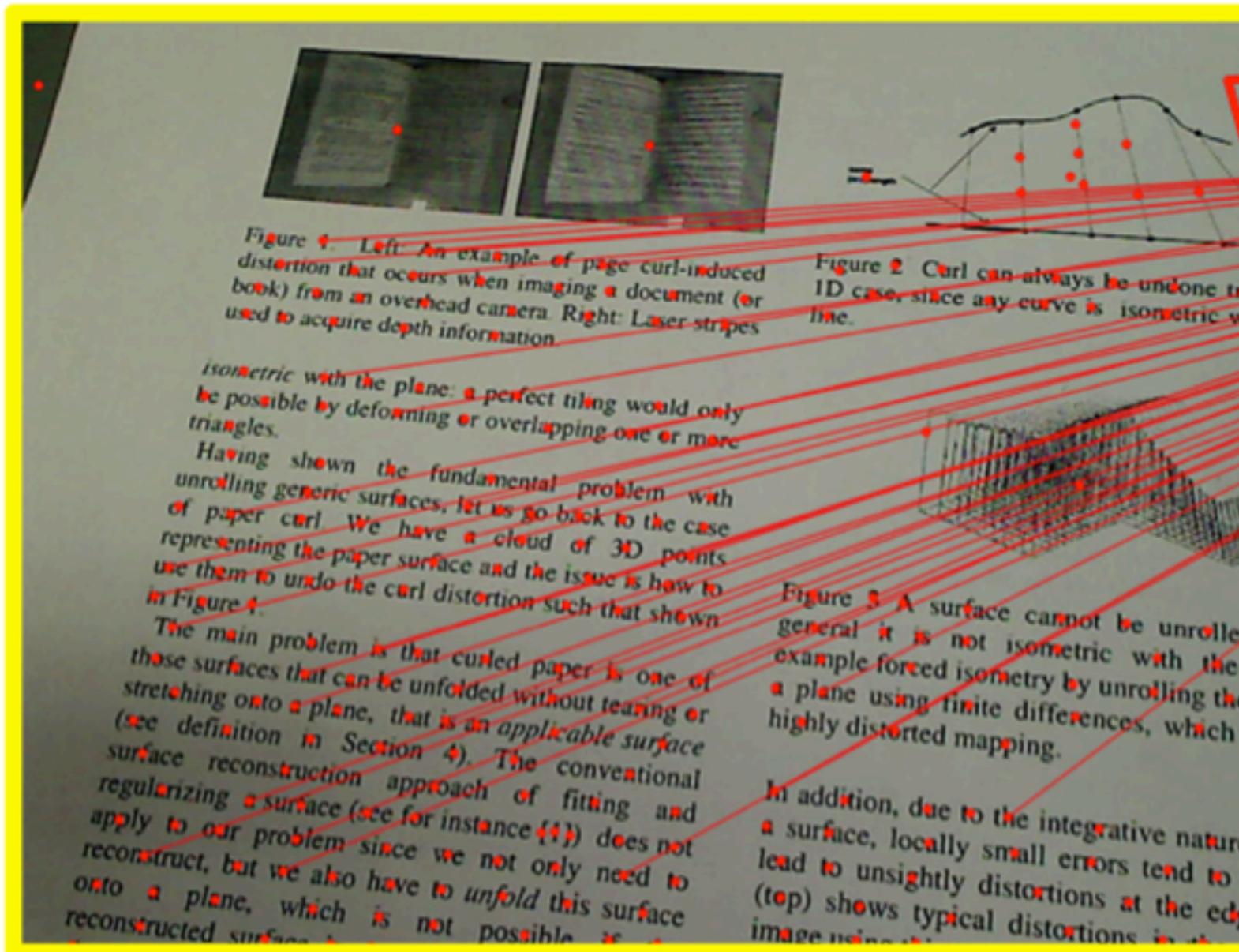
# Character Recognition



Kanji under  
background clutter

# Document Image Retrieval

query



retrieved page



Document Name

**cvpr012a011**

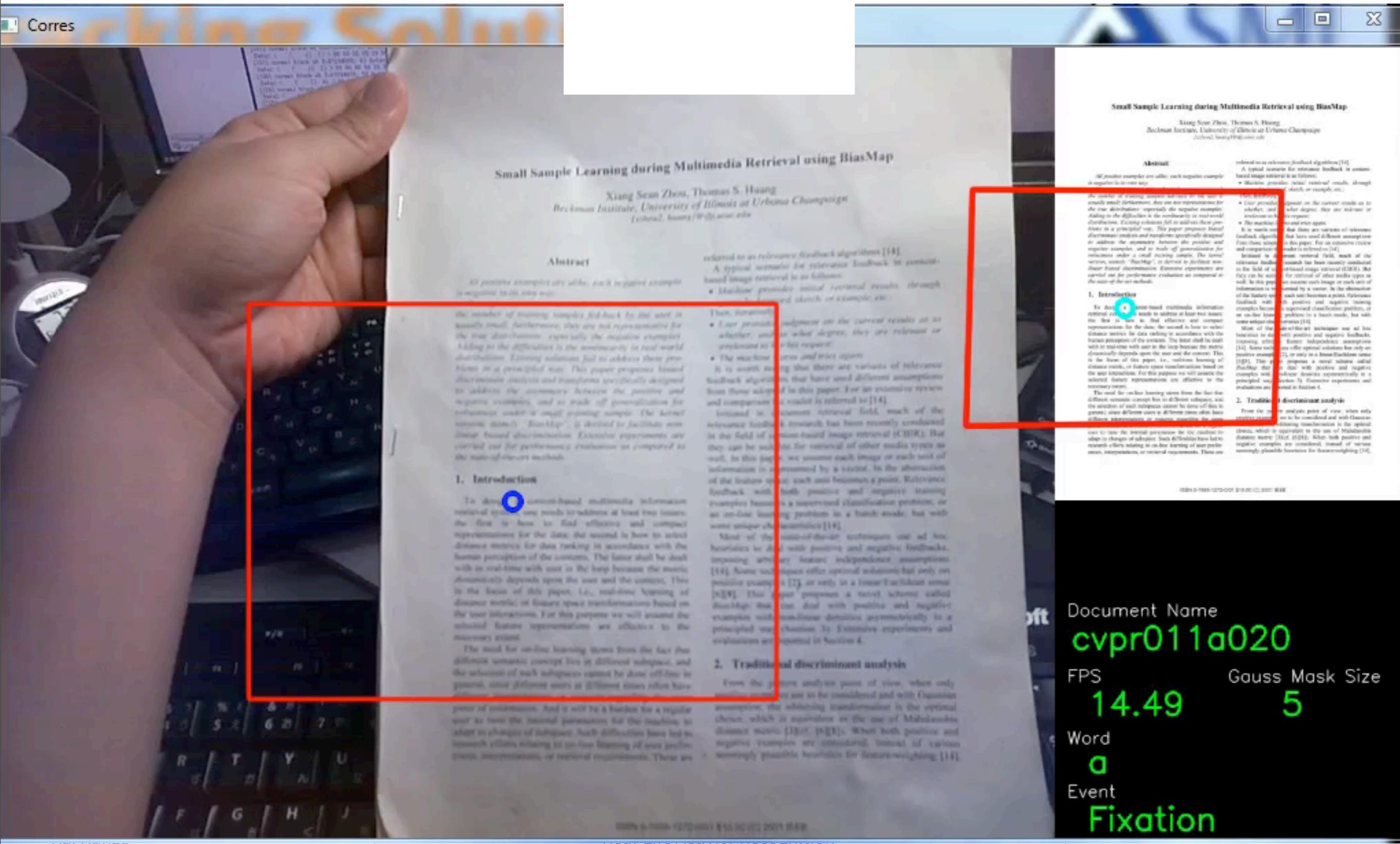
FPS

**16.13**

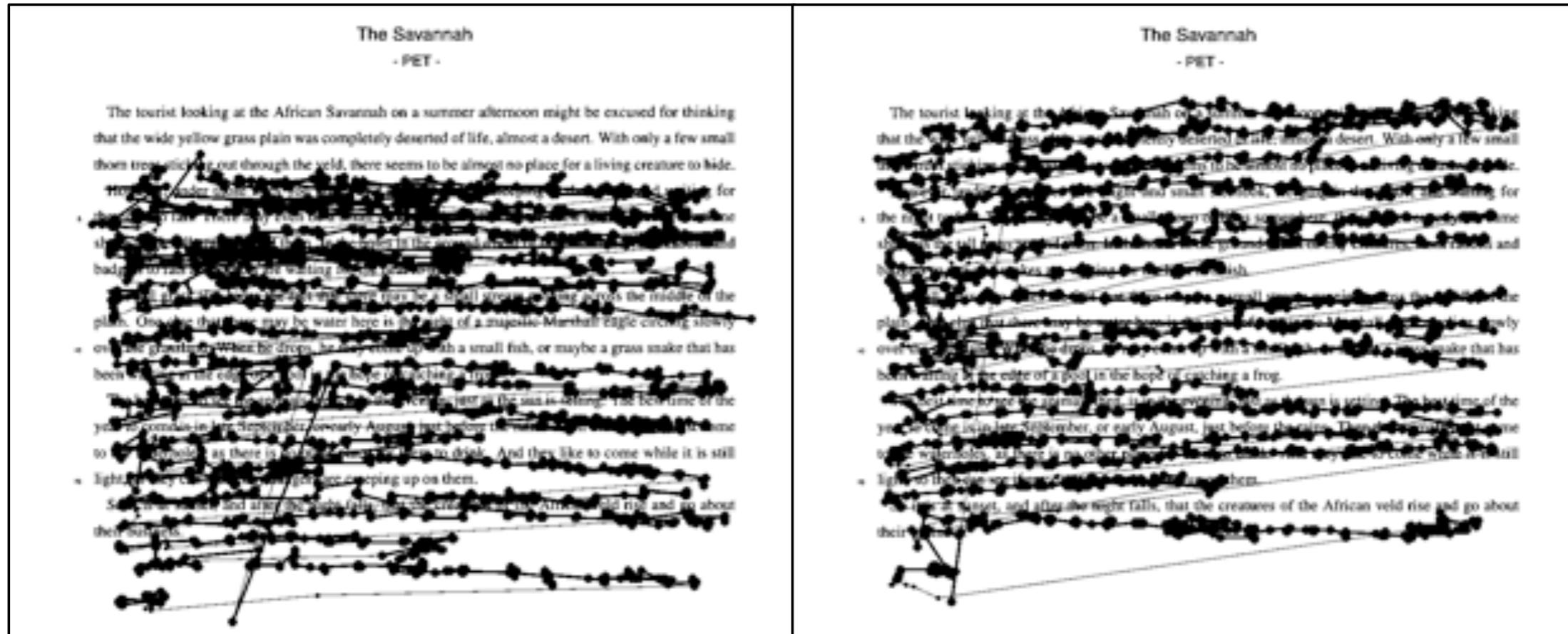
Gauss Mask Size

**11**

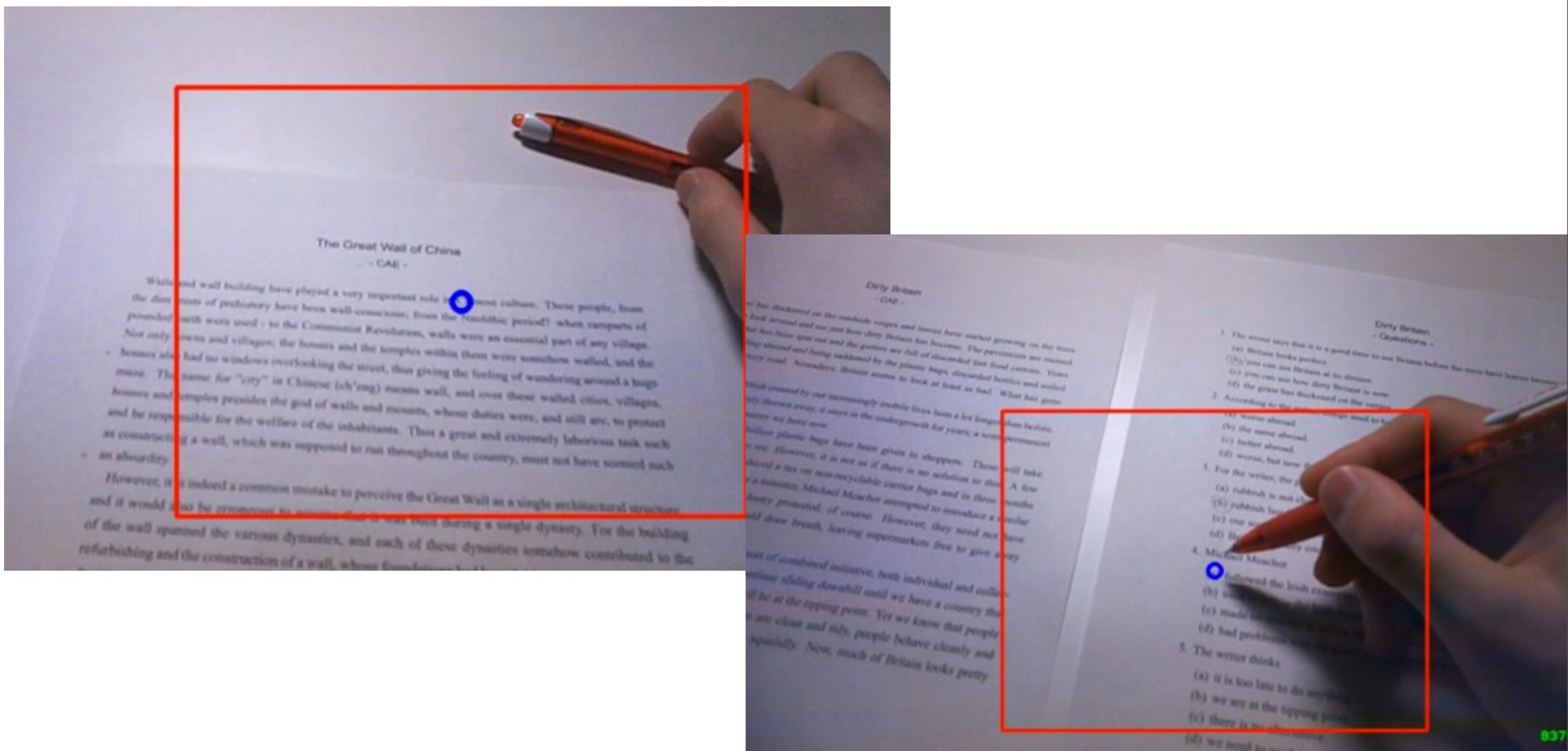
# Eye-tracking with Document Image Retrieval



# Mobile-Eyetracking with document image retrieval



# Inferring Language Expertise



K. Kunze, H. Kawaichi, K. Yoshimura, K. Kise. **Towards inferring language expertise using eye tracking**. accepted as Work in Progress at *ACM SIGCHI Conference on Human Factors in Computing Systems*, Paris, France 2013.

## Neither a Borrower Nor a Lender Be - BEC -

Both borrowers and lenders in the sub-prime mortgage market are wishing they had listened to the old saying: neither a borrower nor a lender be.

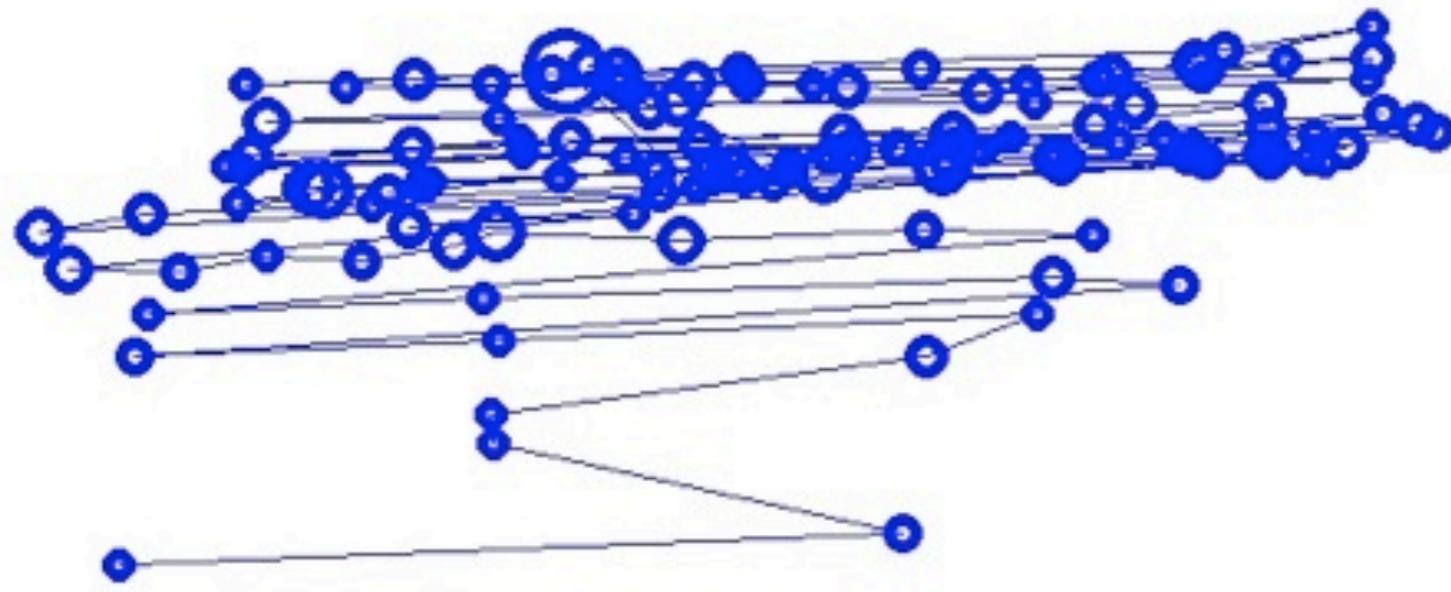
Last year people with poor credit ratings borrowed \$605 billion in mortgages, a figure that is about 20% of the home-loan market. It includes people who cannot afford to meet the mortgage payments on

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# Questions, remarks, violent dissent?



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