

# Selected Topics of Pervasive Computing

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Stephan Sigg

Georg-August-University Goettingen, Computer Networks

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30.10.2013

# Overview and Structure

- 30.10.2013 Organisational
- 30.10.3013 Introduction
- 06.11.2013 Classification methods (Basic recognition, Bayesian, Non-parametric)
- 13.11.2013 Classification methods (Linear discriminant, Neural networks)
- 20.11.2013 –
- 27.11.2013 –
- 04.12.2013 –
- 11.12.2013 Classification methods (Sequential, Stochastic)
- 18.12.2013 Activity Recognition (Basics, Applications, Algorithms, Metrics)
- 08.01.2014 Security from noisy data (Basics, Entity, F. Commitment, F. Extractors)
- 15.01.2014 Security from noisy data (Error correcting codes, PUFs, Applications)
- 22.01.2014 Context prediction (Algorithms, Applications)
- 29.01.2014 Networked Objects (Sensors and sensor networks, body area networks)
- 05.02.2014 Internet of Things (Sensors and Technology, vision and risks)

# Outline

Introduction

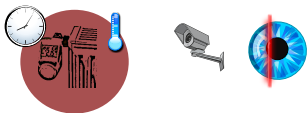
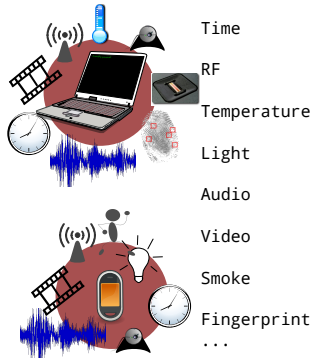
Applications

Conclusion

## Sensors and sensor classes

- We are surrounded by a multitude of sensors

- Sensor readings utilised for
  - Information provisioning
  - Situation classification
  - Authentication
  - Cryptography

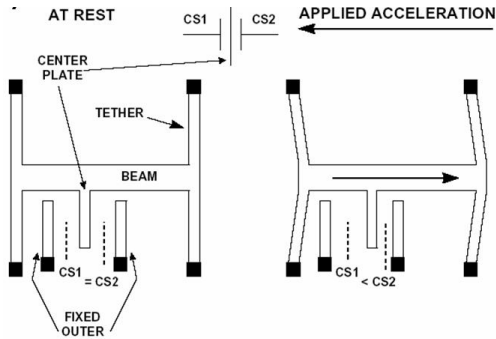


# Sensors and sensor classes



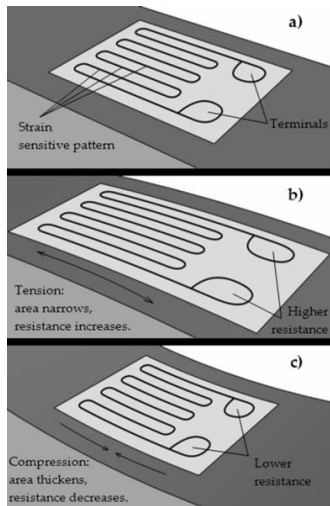
## Sensors and sensor classes

- MEMS acceleration sensors
  - E.g. Analogue Devices ADXL
  - Low energy consumption, small, cheap, medium precision
  - MEMS = Micro-mechanical System: Mechanic in Silicon (Silizium)
  - Here: Comparison of capacity  $CS1$  and  $CS2$  leads to acceleration



# Sensors and sensor classes

- Pressure sensors
  - Z.B. IEE about 3-10 Euro
  - Very imprecise



## Sensors and sensor classes

- Output of sensors has to be interpreted typically
  - Raw electrical signals
  - Interpretation of signals as electric values
  - Binary or Real valued representation
  - Further identification of features
  - Feature extraction
  - Interpretation of features and classification

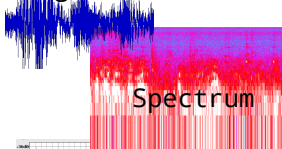




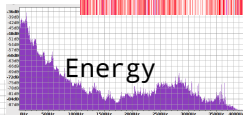
# Features and feature extraction

- What is a feature and why do we need it?
  - Captured data might be hard to interpret
  - Many aspects can be contained in a single data stream
  - Example: Audio
    - Loudness
    - Energy on frequency bands
    - Zero crossings
    - Direction changes

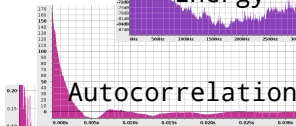
Signal over time



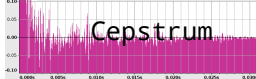
Spectrum



Energy



Autocorrelation



Cepstrum

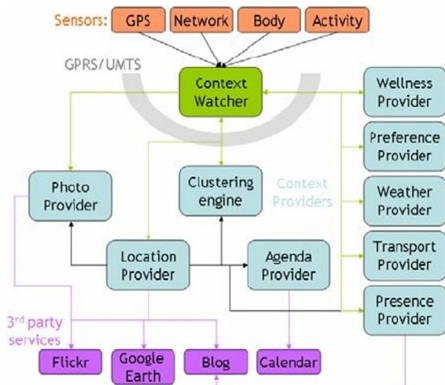
## Examples and case studies: Media Cup

- Media Cup: Context recognition
  - Activity: Trigger sleep mode (save energy)
  - Level of activity
  - Own context: Object movement, person is nervous, specific handling of objects
  - Environmental context: Vibration, earthquake
- Sensor: Ballswitch
  - (nearly) no quiescent current
  - Various types, filled with gas/liquid
  - e.g. Acceleration with fixed value (liquid)
  - Vibration (filled with gas)



## Examples and case studies: Context Watcher

- Context Watcher
  - Location
    - GSM cell-ID; GPS
  - Mood
    - user input
  - Activity
    - calendar based
  - Bio-data
    - heart and foot sensors
  - Weather
    - location based over internet
  - Photo/picture
    - camera



# Examples and case studies: Context Watcher



Picture	Context Data
	cell id: 10571 altitude: 59.4 speed: 115.1 km/h course: 246.6 pos: (52.279, 6.503) range: 1 m street: E30 postal code: 7462 city: Rijssen (NL)



## Johan's blog

Saturday, March 24, 2007

### A day in Papendrecht

The weather that I enjoyed today: it has been rather cloudy in Alblasserdam, 1/9°C, with a relative humidity of 93%, a gentle breeze was blowing from north to northeast. The cities that I visited today: Papendrecht (7.4h), Dordrecht (1.6h), Alblasserdam (4.5h). The max of speed that I had today: 104.9. The photos that I took today:




# Examples and case studies: TEA

## TEA-Audio

- Requirements
  - Restricted memory space
  - Computing power restricted
- Benefit
  - Many sensors → Many features
- Example approach
  - Utilise time domain (no transformation)
  - Utilise statistic measures
  - Feature extraction based on small amount of data

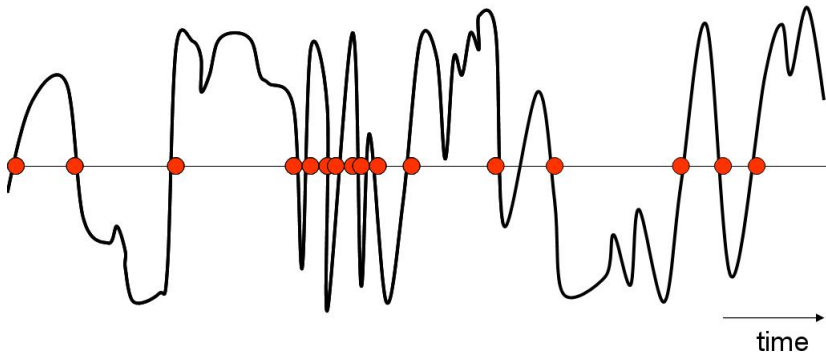
## Examples and case studies: TEA

- Audio data in time domain



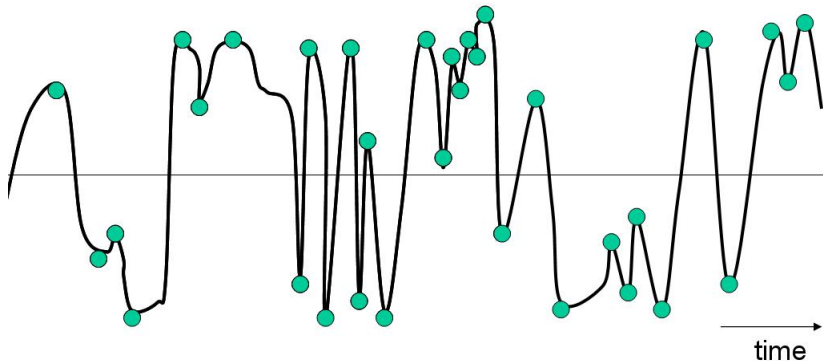
## Examples and case studies: TEA

- Count zero crossings
- Distance between zero crossings



## Examples and case studies: TEA

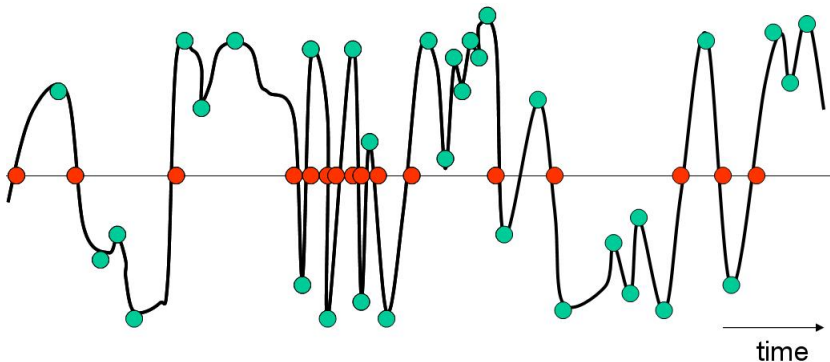
- Count of direction changes





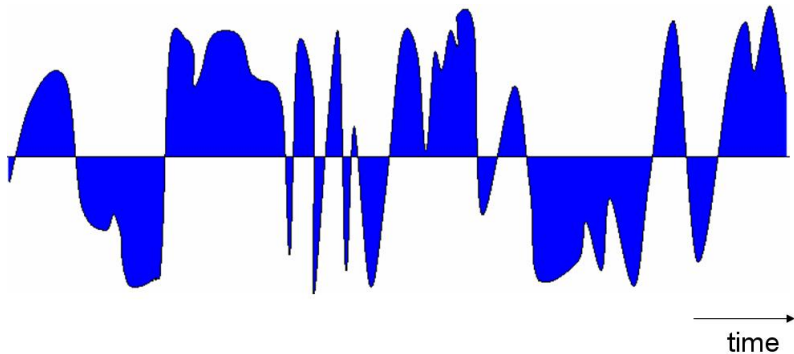
## Examples and case studies: TEA

- ratio:  $\frac{\text{direction changes}}{\text{zero crossings}}$



# Examples and case studies: TEA

- Integral



## Examples and case studies: TEA

- Several chunks for speech

### whistling

```
Raw - Avg: 163.7 ; Abs Avg: 2368.5 ; ratio: 1.857 ; sd: 1.04
Spec - avg: 8.1 ; sd: 2055.67 ; avg dis: 315.8 ; sd dis: 102655.69
Prof - avg: 7954.4 ; sd: 2.15 ;
```

Whistling

### speech

```
Raw - Avg: 170.5 ; Abs Avg: 471.0 ; ratio: 12.190 ; sd: 566179.8
Spec - avg: 12.5 ; sd: 4447.67 ; avg dis: 115.4 ; sd dis: 13669.85
Prof - avg: 1411.2 ; sd: 1673821.1 ;
```

1

2

3

4

## Examples and case studies: TEA

- Distance between zero crossings: distinct behaviour of oscillation at start and end

### whistling



### speech



## Examples and case studies: TEA

- Distinct ratio:  $\frac{\text{zero crossings}}{\text{direction changes}}$

### whistling

```
Raw - Avg: 163.7 ; Abs Avg: 2368.5 ; ratio: 1.857 ; sd: 1.04
Spec - avg: 8.1 ; sd: 2055.67 ; avg dis: 315.9 ; sd dis: 102655.69
Prof - avg: 7954.4 ; sd: 2.15 ;
```

### speech

```
Raw - Avg: 170.5 ; Abs Avg: 471.0 ; ratio: 12.190 ; sd: 566179.8
Spec - avg: 12.5 ; sd: 4447.67 ; avg dis: 115.4 ; sd dis: 13669.85
Prof - avg: 1411.2 ; sd: 1673821.1 ;
```

## Examples and case studies: TEA

- Significant change in standard deviation of chunks

### whistling

```
Raw - Avg: 163.7 ; Abs Avg: 2368.5 ; ratio: 1.857 ; sd: 1.04
Spec - avg: 8.1 ; sd: 2058.18 ; avg dis: 315.8 ; sd dis: 102655.69
Prof - avg: 7954.4 ; sd: 2.15 ;
```

### speech

```
Raw - Avg: 170.5 ; Abs Avg: 471.0 ; ratio: 12.190 ; sd: 566179.8
Spec - avg: 12.5 ; sd: 4418.60 ; avg dis: 115.4 ; sd dis: 13669.85
Prof - avg: 1411.2 ; sd: 1673821.1 ;
```

# Outline

Introduction

Applications

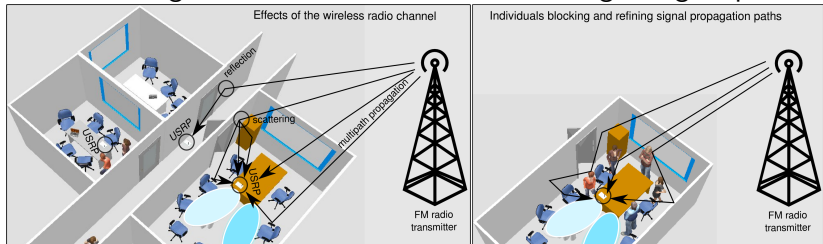
Conclusion

# RF-based activity recognition

During propagation, radio signals experience a multitude of effects due to the environment

Can we learn about the environment from the signal evolution observed at a receiver?

- Multi-path propagation
- Scattering
- Reflection
- Blocking of signal paths

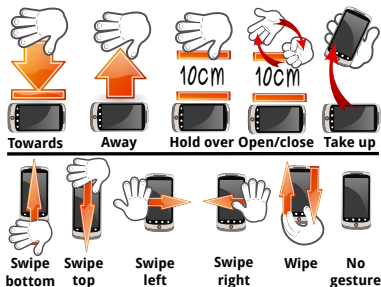




# RF-based activity recognition

Sensewaves Video

# RF-based activity recognition



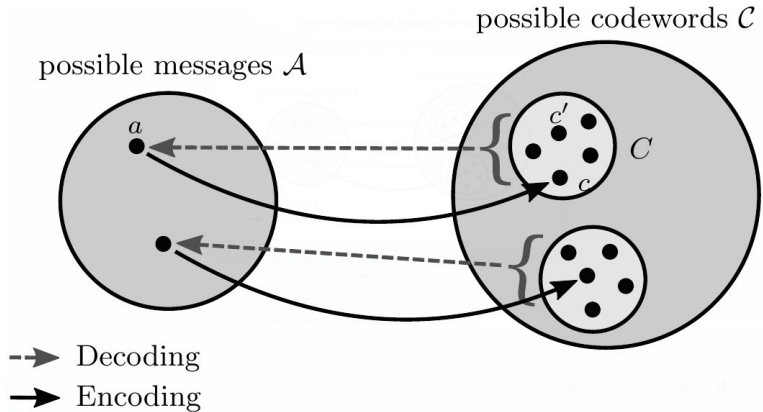
	Classification						recall	
	Aw	Ho	To	No	Op	Sr		St
Aw	<b>.7</b>	.02			.06	.09	.13	<b>.70</b>
Ho	.03	<b>.28</b>	.22	.05	.2	.16	.06	<b>.28</b>
To		.09	<b>.76</b>	.07	.06		.02	<b>.76</b>
No		.05	.06	<b>.73</b>	.14	.01	.01	<b>.73</b>
Op	.01	.15	.1	.14	<b>.49</b>	.04	.07	<b>.49</b>
Sr	.02	.01		.01	.06	<b>.83</b>	.07	<b>.83</b>
St	.12	.03	.01		.05	.14	<b>.65</b>	<b>.65</b>
prec	<b>.795</b>	<b>.444</b>	<b>.661</b>	<b>.730</b>	<b>.462</b>	<b>.654</b>	<b>.644</b>	

	Classification				recall
	Away	Towards	No gesture	S. top	
round truth	Away	<b>.83</b>		.17	<b>.83</b>
	Towards		<b>.88</b>	.09	<b>.88</b>
	No gesture	.01	.05	<b>.92</b>	<b>.92</b>
	S. top	.14	.02	.02	<b>.82</b>
precision		<b>.847</b>	<b>.926</b>	<b>.893</b>	<b>.788</b>

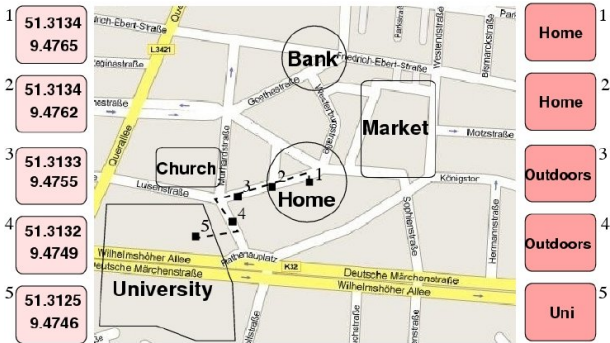
# Context-based security



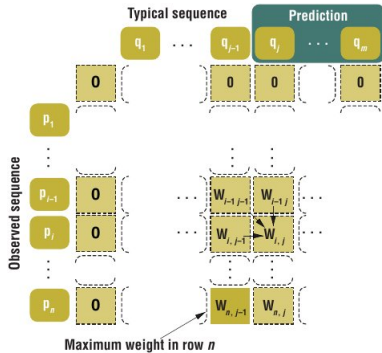
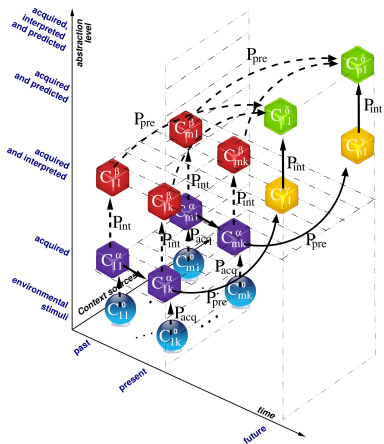
# Context-based security



# Context prediction



# Context prediction



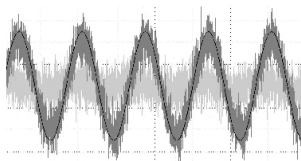
# Collaborative transmission

## Phase 4:

Feedback is broadcast to the network

## Phase 3:

Receiver estimates the phase synchronisation level of the received sum signal



## Phase 2:

Source nodes transmit to the destination as a distributed beamformer



## Phase 1:

Source nodes adjust their carrier phase offset and frequency randomly



# Collaborative transmission / IoT





# Outline

Introduction

Applications

Conclusion

# Questions?

Stephan Sigg

`stephan.sigg@cs.uni-goettingen.de`

# Literature

- C.M. Bishop: Pattern recognition and machine learning, Springer, 2007.
- P. Tulyas, B. Skoric, T. Kevenaar: Security with Noisy Data – On private biometrics, secure key storage and anti-counterfeiting, Springer, 2007.
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001.

