Selected Topics of Pervasive Computing

Stephan Sigg

Georg-August-University Goettingen, Computer Networks

30.10.2013

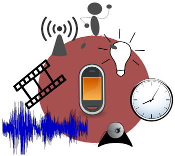
Overview and Structure

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

Sensors and sensor classes

- We are surrounded by a multitude of sensors



Time

RF

Temperature

Light

Audio

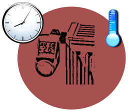
Video

Smoke

Fingerprint

...

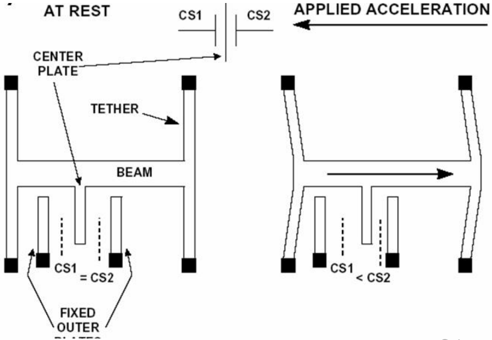
- Sensor readings utilised for
  - Information provisioning
  - Situation classification
  - Authentication
  - Cryptography



Sensors and sensor classes

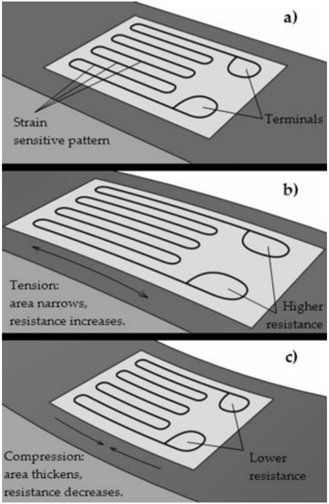
Sensors and sensor classes

- 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

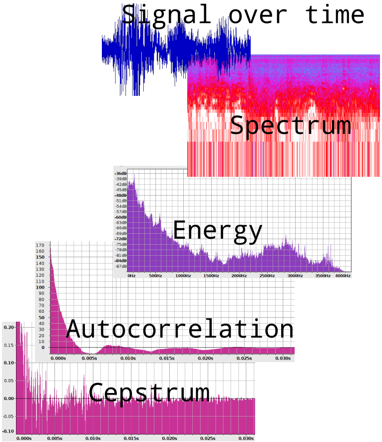


Sensors and sensor classes

- 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

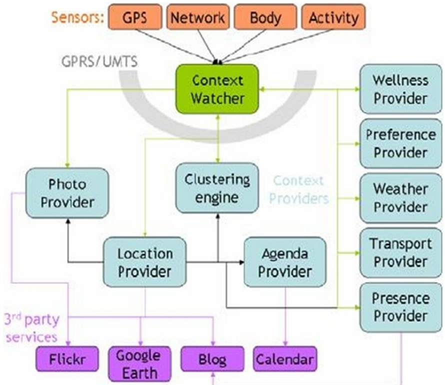


Examples and case studies: Media Cup

- 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
    - calender based
  - Bio-data
    - heart and foot sensors
  - Weather
    - location based over internet
  - Photo/picture
    - camera



Examples and case studies: Context Watcher

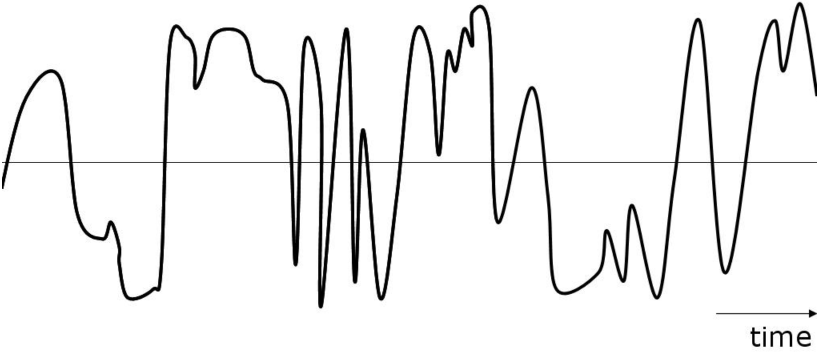
Examples and case studies: TEA

TEA-Audio

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

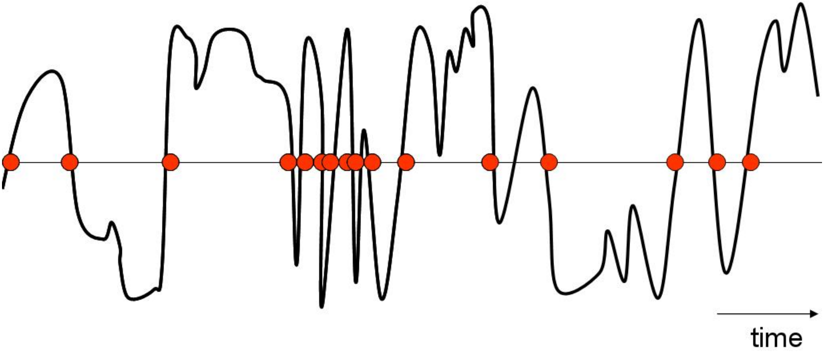
Examples and case studies: TEA

- Audio data in time domain



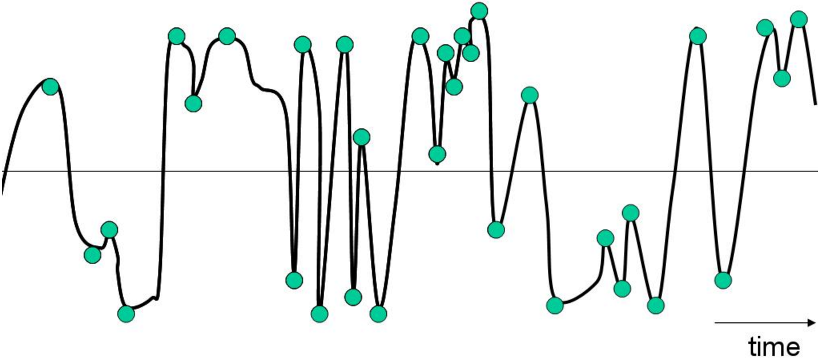
Examples and case studies: TEA

- Count zero crossings
- Distance between zero crossings



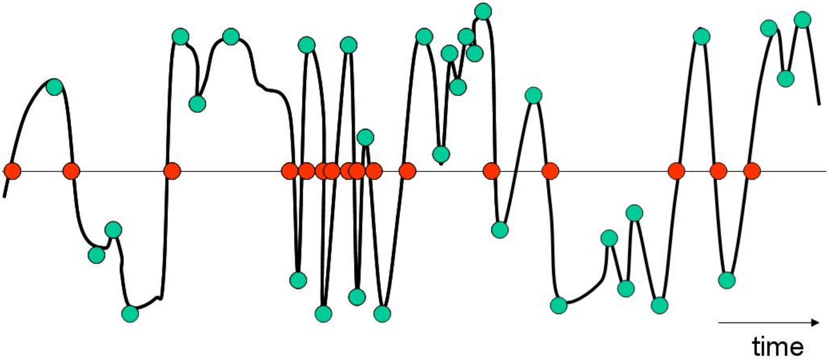
Examples and case studies: TEA

- Count of direction changes



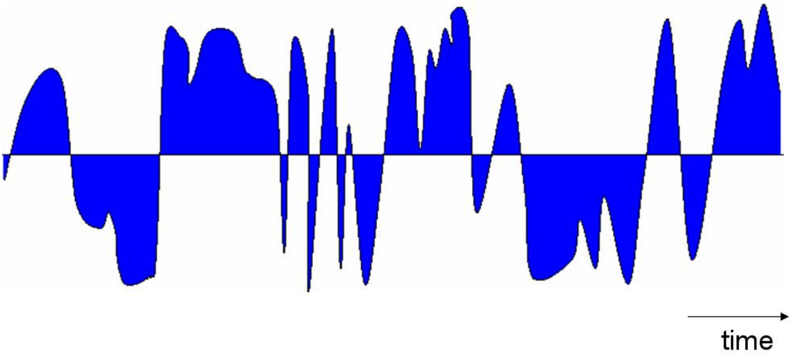
Examples and case studies: TEA

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



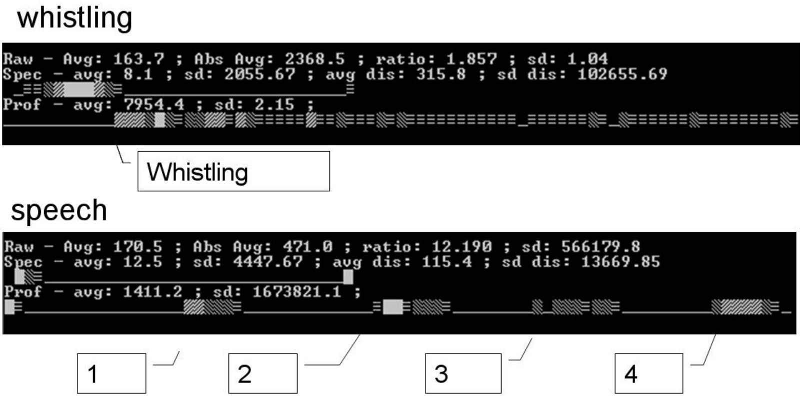
Examples and case studies: TEA

- Integral



Examples and case studies: TEA

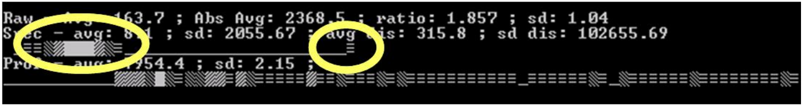
- Several chunks for speech



Examples and case studies: TEA

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

whistling

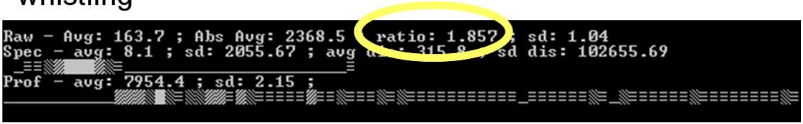


speech

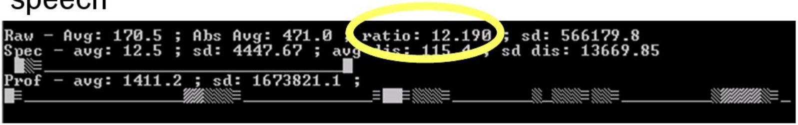
Examples and case studies: TEA

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

whistling



speech



Examples and case studies: TEA

- Significant change in standard deviation of chunks

whistling

speech

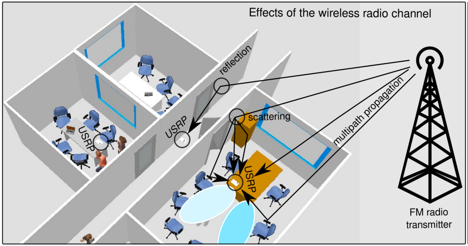
Outline

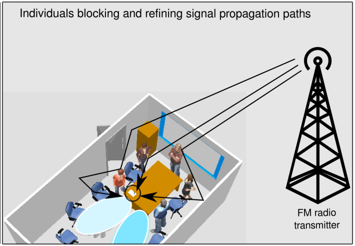
RF-based activity recognition

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

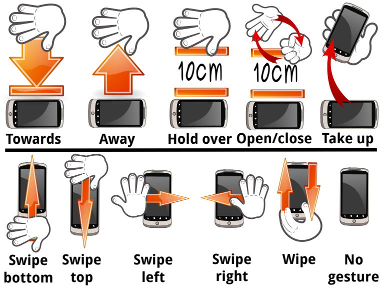




RF-based activity recognition

Sensewaves Video

RF-based activity recognition

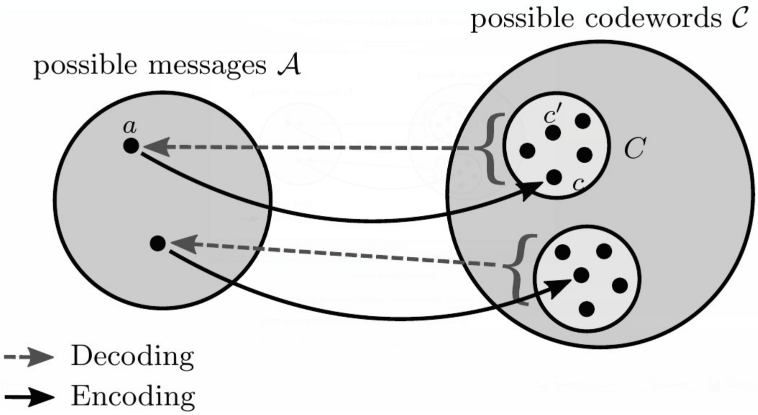


	Classification: Aw	Ho	To	No	Op	Sr	St	recall
Aw	**.7**	.02			.06	.09	.13	.70
Ho	.03	**.28**	.22	.05	.2	.16	.06	.28
To		.09	**.76**	.07	.06		.02	.76
No		.05	.06	**.73**	.14	.01	.01	.73
Op	.01	.15	.1	.14	**.49**	.04	.07	.49
Sr	.02	.01		.01	.06	**.83**	.07	.83
St	.12	.03	.01		.05	.14	**.65**	.65
prec	.795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

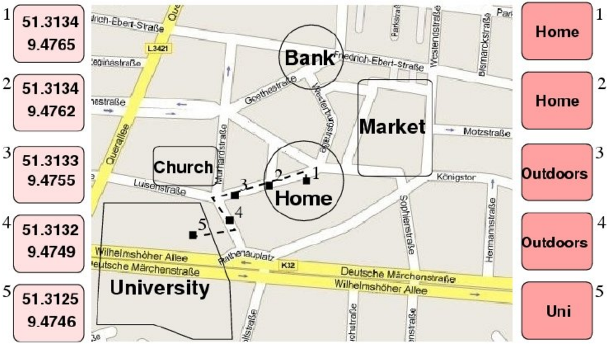
round truth	Classification: Away	Towards	No gesture	S. top	recall
Away	**.83**			.17	.83
Towards		**.88**	.09	.03	.88
No gesture	.01	.05	**.92**	.02	.92
S. top	.14	.02	.02	**.82**	.82
precision	.847	.926	.893	.788	

Context-based security

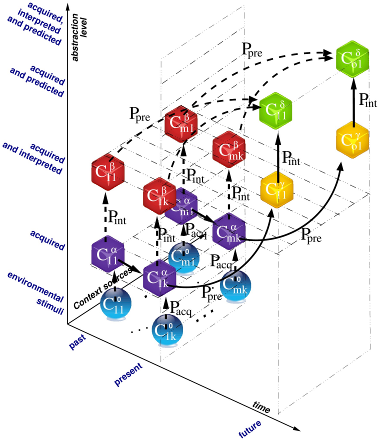
Context-based security

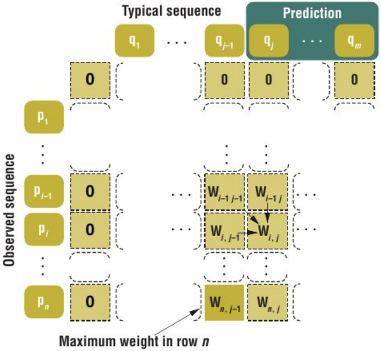


Context prediction

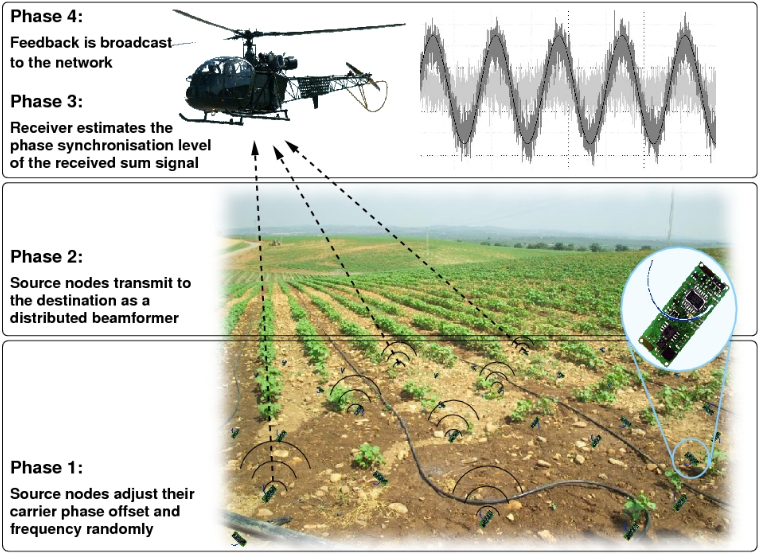


Context prediction





Collaborative transmission



Collaborative transmission / IoT

Outline

Questions?

Stephan Sigg
sigg@ibr.cs.tu-bs.de

Literature

- C.M. Bishop: Pattern recognition and machine learning, Springer, 2007.
- P. Tulys, 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.