Neurogroup

FOOTSTEP IDENTIFICATION FROM PRESSURE SIGNALS USING HIDDEN MARKOV MODELS

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Outline

- Introduction
- Emfi Material
- Hidden Markov Models Classification
- Data
- Test Results
- Conclusions

Introduction

- **What we have done ?**
  - Initial experiments on recognizing walkers from the measurements achieved with a pressure sensitive floor
    - A 100 square meter pressure sensitive floor used
    - Test classifications included footsteps from three walkers
- **Methods**
  - Discrete Hidden Markov Models (HMM)
    - One HMM per walker created for classification
    - Overall 78 % successrate of footstep identification
- **Aim**
  - A part of research on intelligent environments: to learn and react to behaviour of occupants
    - Monitoring hazardous situations
    - Surveillance systems
    - Helping child care

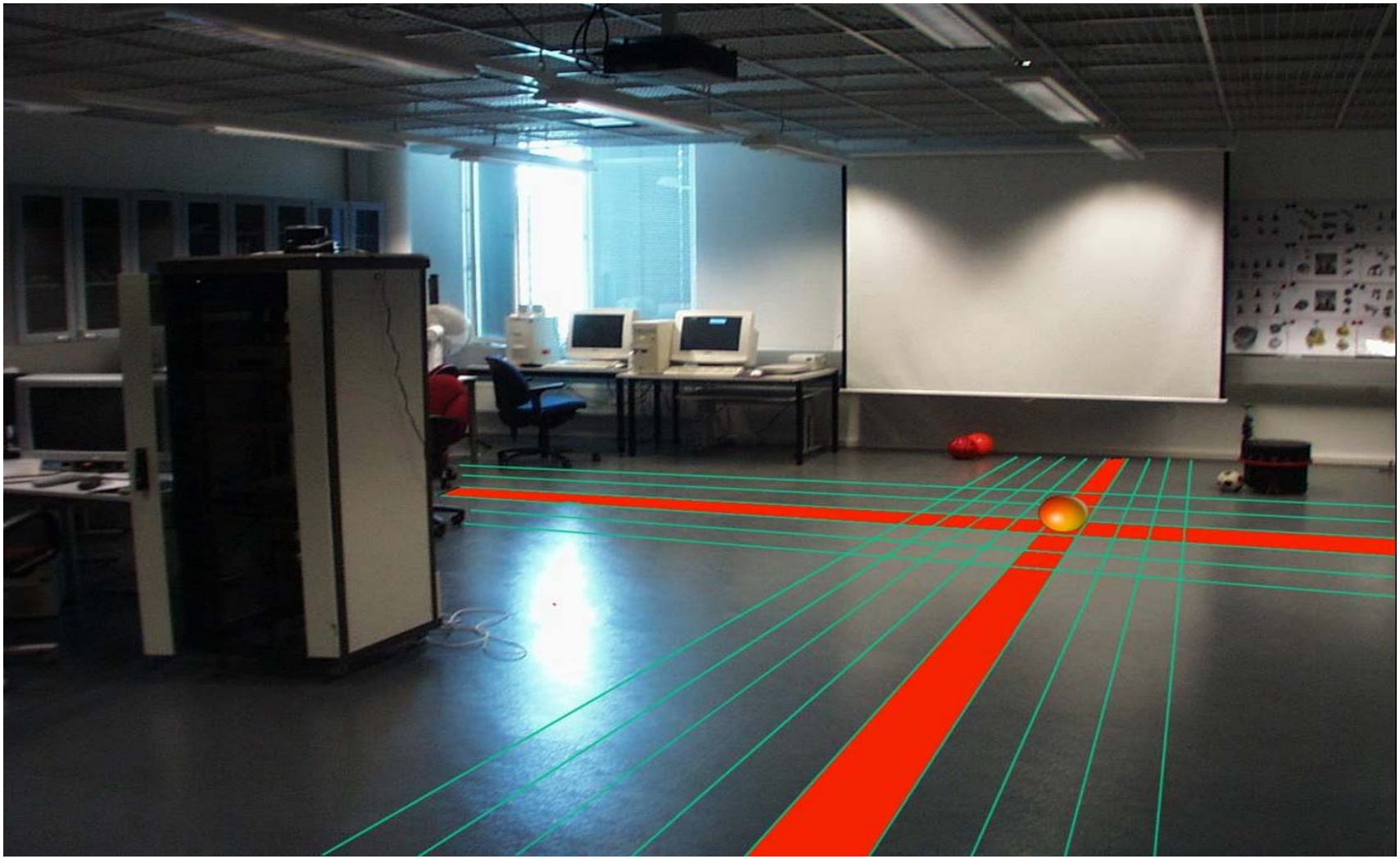
Emfi Material

- **Material**
  - ElectroMechanical Film (EMFi)
    - A thin, flexible, lowprice electret material, which consists of cellular, biaxially oriented polypropylene film coated with metal electrodes
    - It is possible to store a large permanent charge in the film by corona method using electric fields
    - An external force affecting on the EMFi's surface causes a change in the films thickness resulting a charge between the conductive metal layers
      - This charge can be detected as a voltage, which describes the changes in the pressure affecting the floor
- **Applications**
  - Used for many commercial applications
    - Keyboards, microphones in stringed musical instruments and as small and large area sensors

Emfi Material (2)

- **Emfi-floor**
  - In our research laboratory EMFi-material is placed under the normal flooring
  - Consists 30 vertical and 34 horizontal EMFi- sensor stripes, 30 cm wide each
  - Why not Squares ?
    - Number of wires

Emfi Material (3)

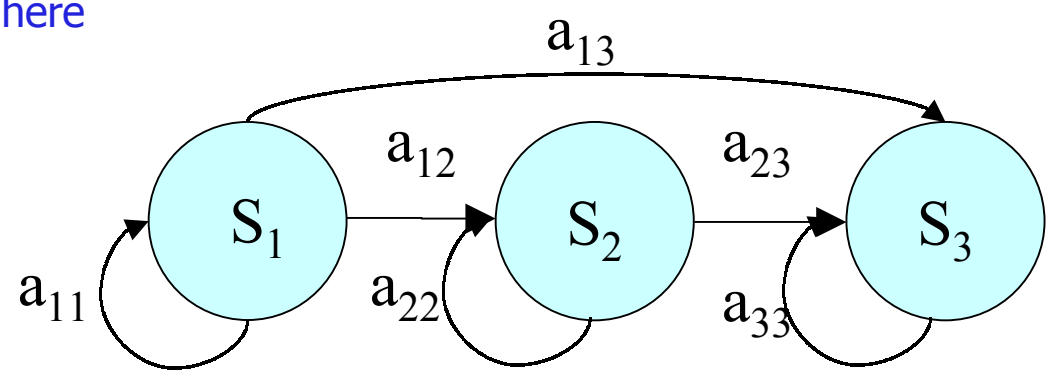


Emfi Material (4)

- **EMFi-data**
  - Each 64 stripes produces continuous signal
  - Streamed into a PC from where the data can be analysed in order to detect and recognize the pressure events
  - The analogous signal is processed with National Instruments AD-card (PCI-6033E), sampling rate can be chosen between 0.1 - 64 kHz
    - 100 Hz sampling rate is used in these experiments

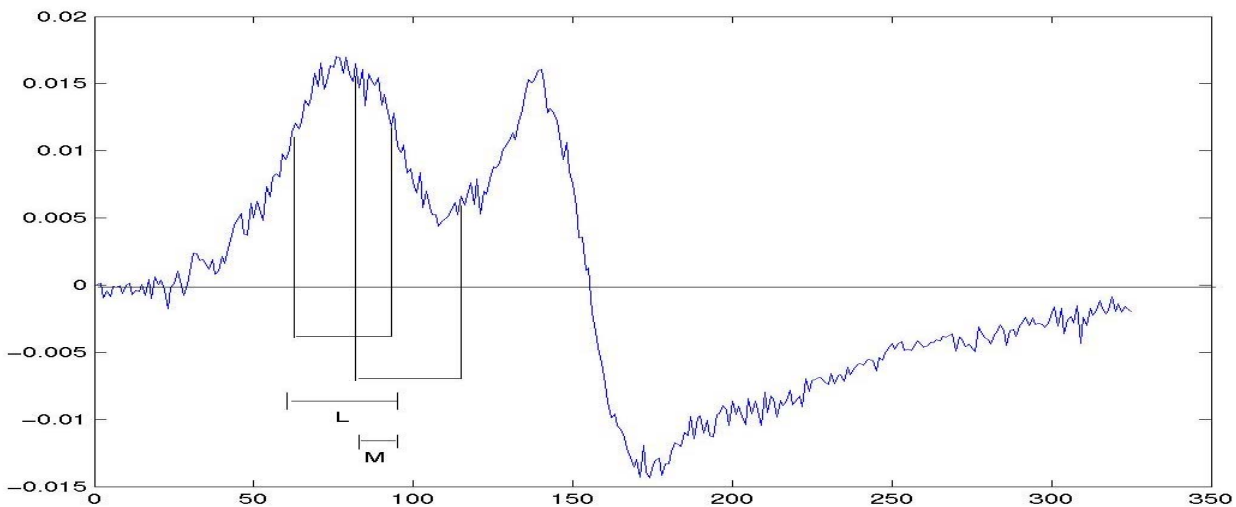
Hidden Markov Models Classification

- **Hidden Markov Models (HMM)**
  - A natural way for modelling time dependent signals
  - Widely used for speech recognition
- **HMM based classification**
  - Observation sequence generated by a Markov model
    - A Markov model is a finite state machine which changes its state once every time unit
    - Each time t that state S_j is entered, a vector O_t is generated from a certain probability distribution B.
    - In practise, only the observation sequence is known and the underlying state sequence is hidden
    - There are different types of HMM's, discrete Left-Right model was used here



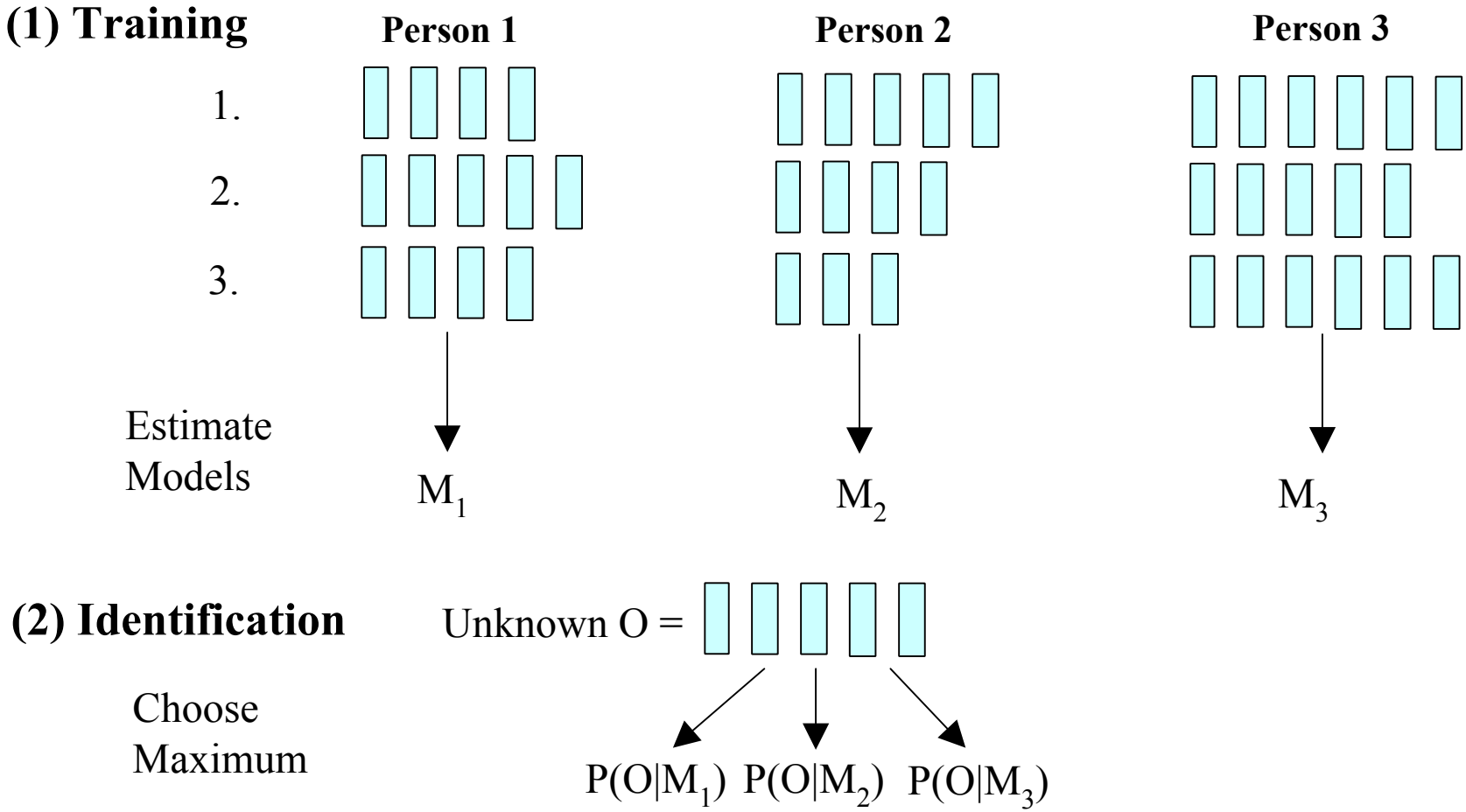
Hidden Markov Models Classification (2)

- **Footstep classification**
  - Features calculated using overlapping time window
    - Features: mean, standard devitation, maximum, minimum
  - The observation sequence is obtained using Learning Vector Quantization (LVQ) codebook
  - One HMM model for each class (person), prototype model trained with example steps using Baum-Welch estimation
  - Test footsteps are classified choosing the maximum likelihood for each model



Hidden Markov Models Classification (3)

- **HMMs for walker identification**



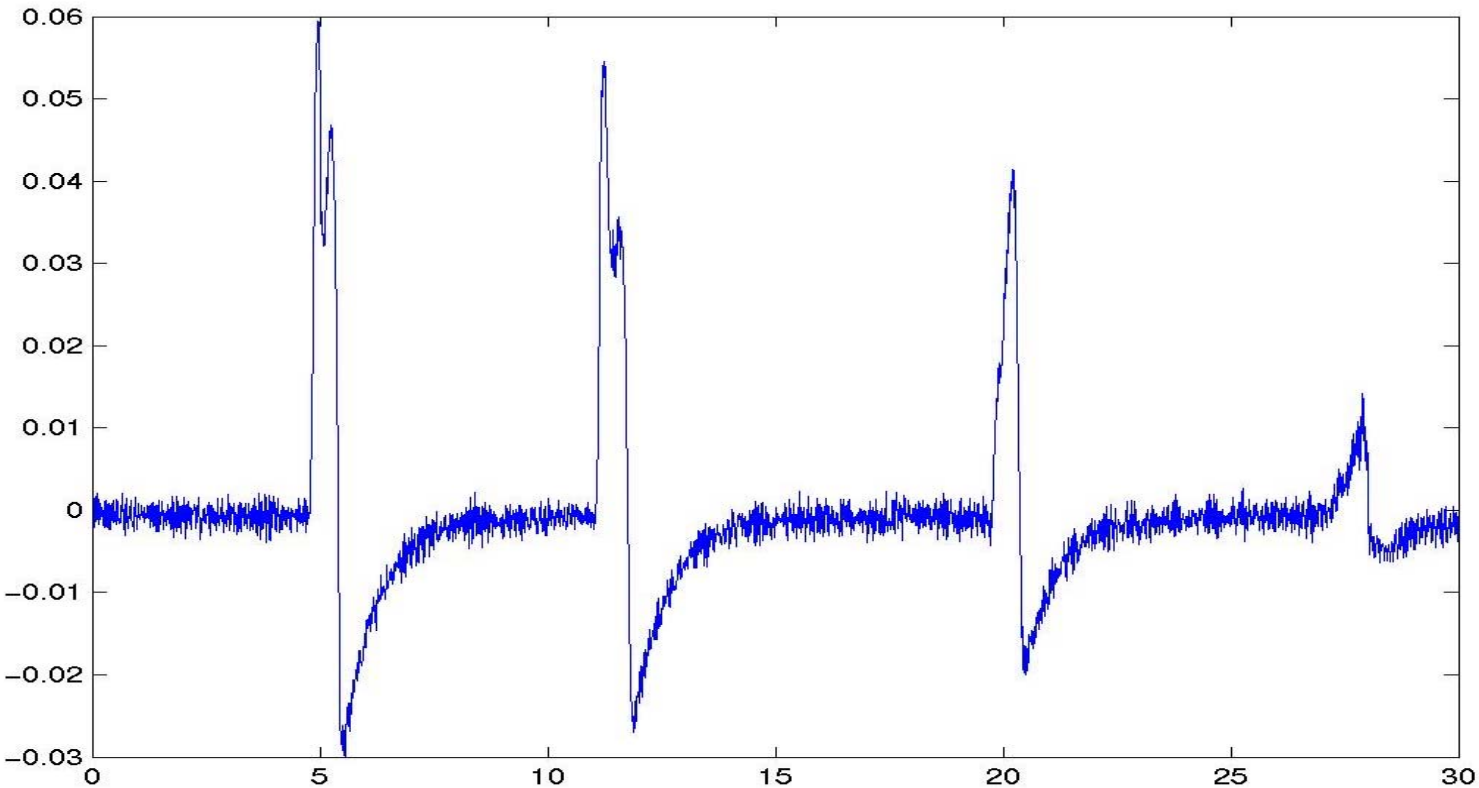
Data

- **Collecting data**
  - Footsteps from three persons, walking alone and casually on the pressure sensitive floor for 30 seconds
    - Data recorded from all the 64 channels
    - Testees weighted 66 kg ± 2, wore their own shoes

- **Pre-processing data**
  - Finding "good-quality" steps from noisy data
    - A raw segmentation made with hybrid-median filters
    - The best footsteps were selected manually

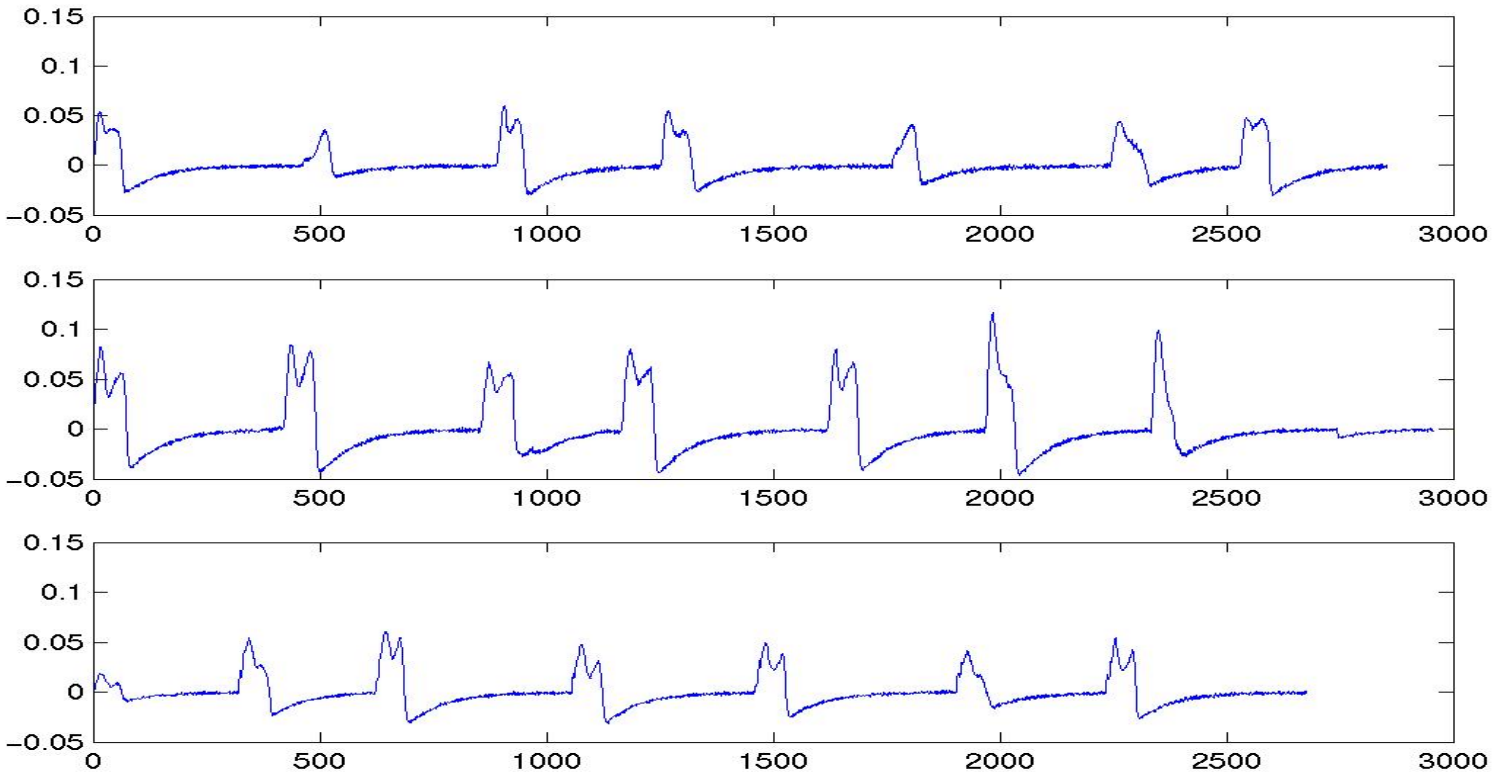
Data (2)

- **Raw data**



Data (3)

- **Extracted footsteps**



Test Results

- **The best initial results**
  - 4 state HMM's
  - Window width: 15 ms, overlapping: 5 ms
  - Features: mean, standard devitation, maximum, minimum
    - normalized between 0 and 1
  - LVQ-codebook size: 256
- **The confusion matrix for three persons' footsteps**

	Person1	Person2	Person3
Person1	72.2	27.8	0
Person2	36.84	63.16	0
Person3	0	4.8	95.2

Conclusions

- **Initial experiments on identifying persons based on their footsteps were reported**
- **Basic tools for using the EMFi-floor are developed**
- **Identification of three persons footsteps is not adequte to enable the generalization of the results for larger population**
- **Future plans**
  - Collecting data from larger population
  - Testing different kind of features
  - Implementing completely different methods