Neurogroup

Learning Vector Quatization in Footstep Identification

Jaakko Suutala

Assistant Researcher

e-mail: jaakko.suutala@ee.oulu.fi

Susanna Pirttikangas, Jukka Riekki and Juha Röning

Intelligent Systems Group

University of Oulu, Finland

Infotech Oulu

Outline

- Introduction
- EMFi Material
- Learning Vector Quantization Classification
- Data
- Test Results
- Conclusions

Introduction

- What we have done ?
  - Experiments on recognizing walkers from the measurements achieved with a pressure sensitive floor
    - A 100 square meter pressure sensitive floor was used
    - Test classifications included footsteps from eleven walkers
- Methods
  - Identification made with Learning Vector Quantization
    - All the footsteps were extracted from raw data and featurized
    - Discarding a known error type overall 78 % successrate was achieved

Introduction (2)

- Aim
  - A part of research on intelligent environments: to learn and to react to behaviour of occupants
    - Monitoring hazardous situations
    - Surveillance systems
    - Helping child care

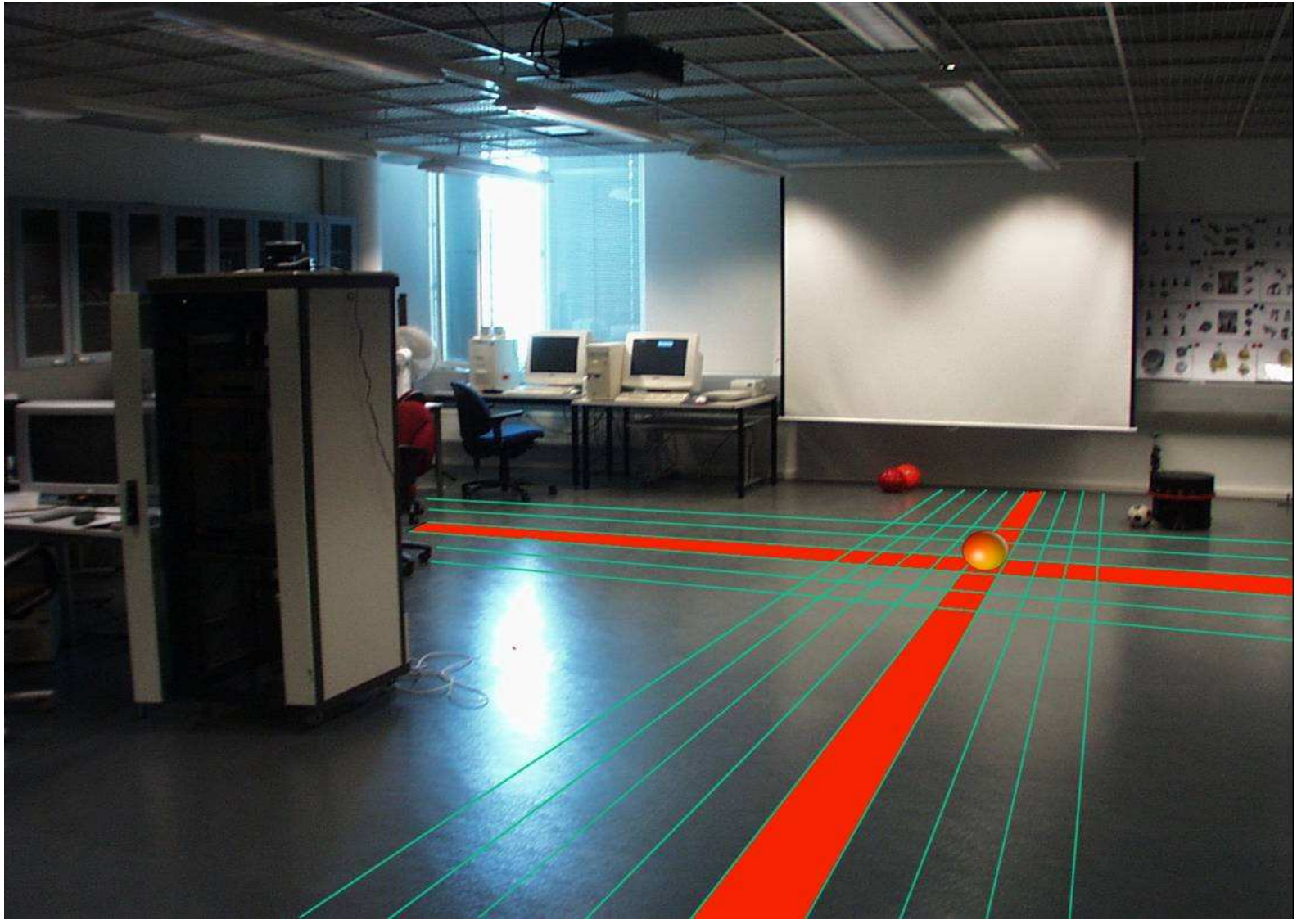
EMFi Material

- ElectroMechanical Film
  - A thin, flexible, lowprice electret material
  - 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

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)



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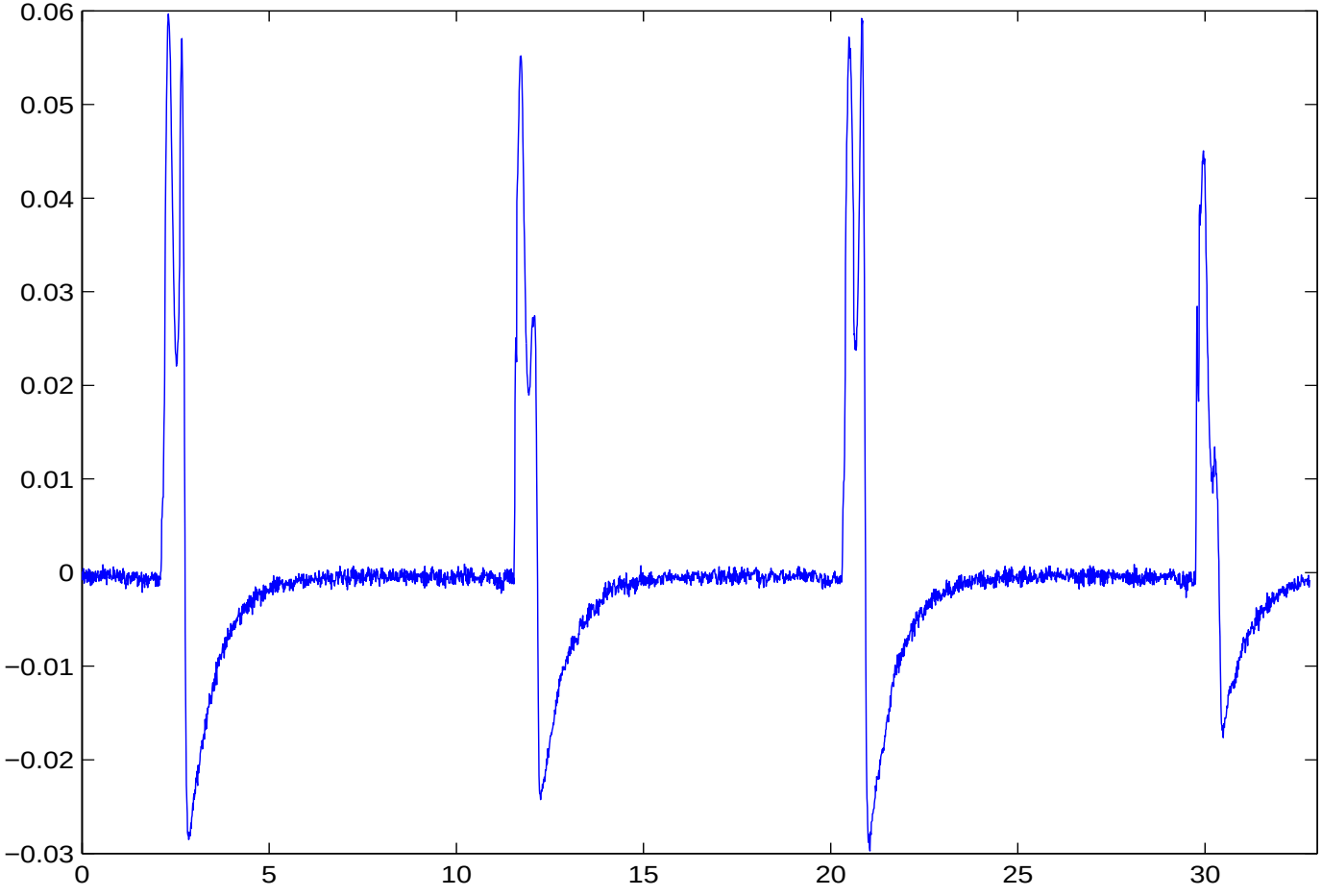
EMFi Material (4)

- 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

EMFi Material (5)

- Raw data



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LVQ Classification

- Learning Vector Quantization (LVQ)
  - A well known statical classification method
  - Based on piecewise linear class boundaries, which are determined by supervised learning
- LVQ classification
  - Classification is made with codebook, which contains prototype vectors labeled for each classes
  - Learning algorithm iteraratively minimizes the rate of misclassification error by updating the codebook vectors
  - Unknown sample is classified to the closest codebook vector using Euclidean distance

LVQ Classification(2)

- Learning Algorithms
  - LVQ1

$$(1) \quad m_j(t+1) = m_j(t) + \alpha(t)[c(t) - m_j(t)]$$

$$(2) \quad m_j(t+1) = m_j(t) - \alpha(t)[c(t) - m_j(t)]$$

$$(3) \quad m_i(t+1) = m_i(t), \text{for } i \neq j,$$

  - OLVQ1

$$(4) \quad m_j(t+1) = [1 - s(t)\alpha_j(t)]m_j(t) + s(t)\alpha_j(t)c(t)$$

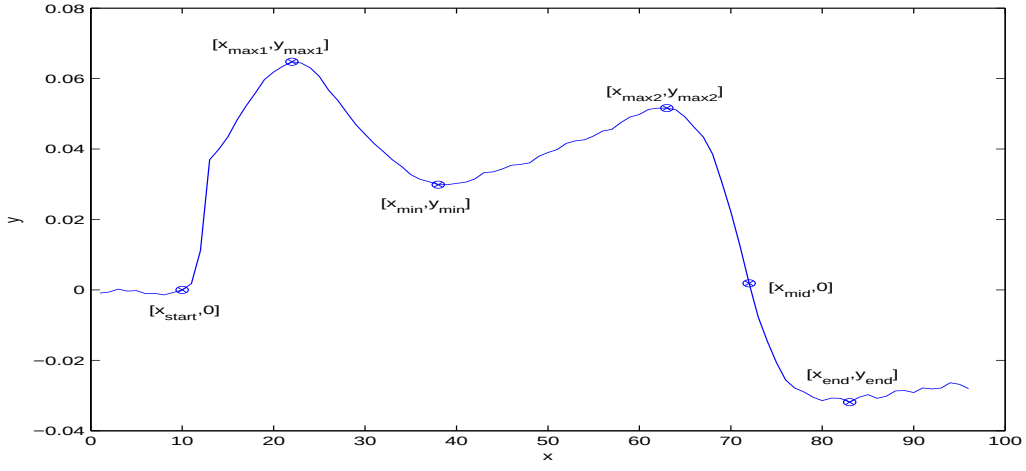
$$(5) \quad \alpha_j(t) = \frac{\alpha_j(t-1)}{1 + s(t)\alpha_j(t-1)}$$

Data

- Collecting data
  - Footsteps data was recorded from eleven different person
  - The testees stepped on one particular stripe
  - Collected data contained about 40 steps/person, including steps from both feet
- Pre-processing
  - Finding good-quality steps from noisy data
    - A raw segmentation was made with hybrid-median filters
    - Footstep parts from adjacent channels were summed

Data (2)

- Feature selection
  - Each step was divided in two sections: The Ball and the heel of the footstep
  - Several features was calculated from both spatial and frequency domain
  - 13 features was selected for classification



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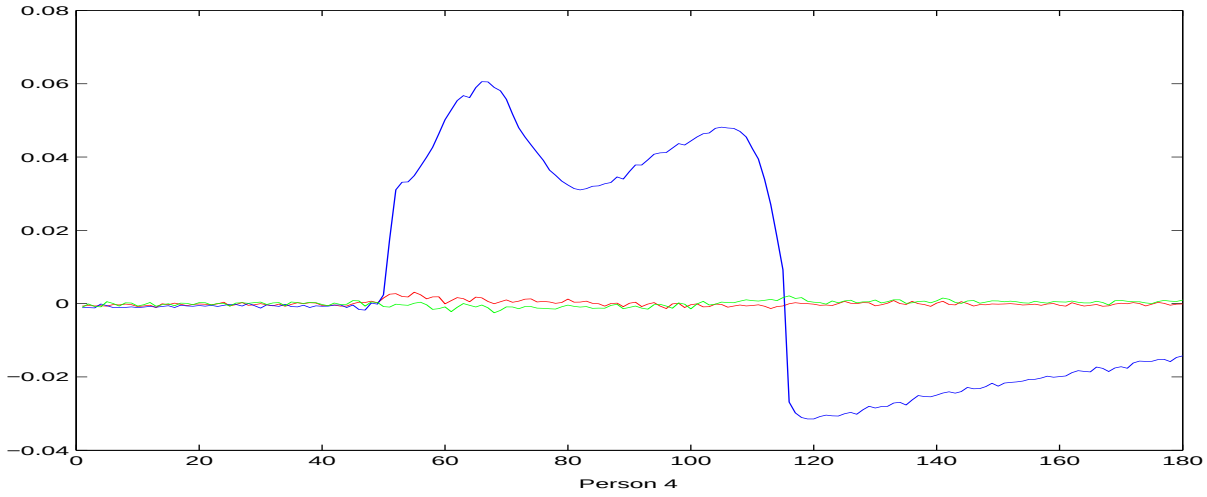
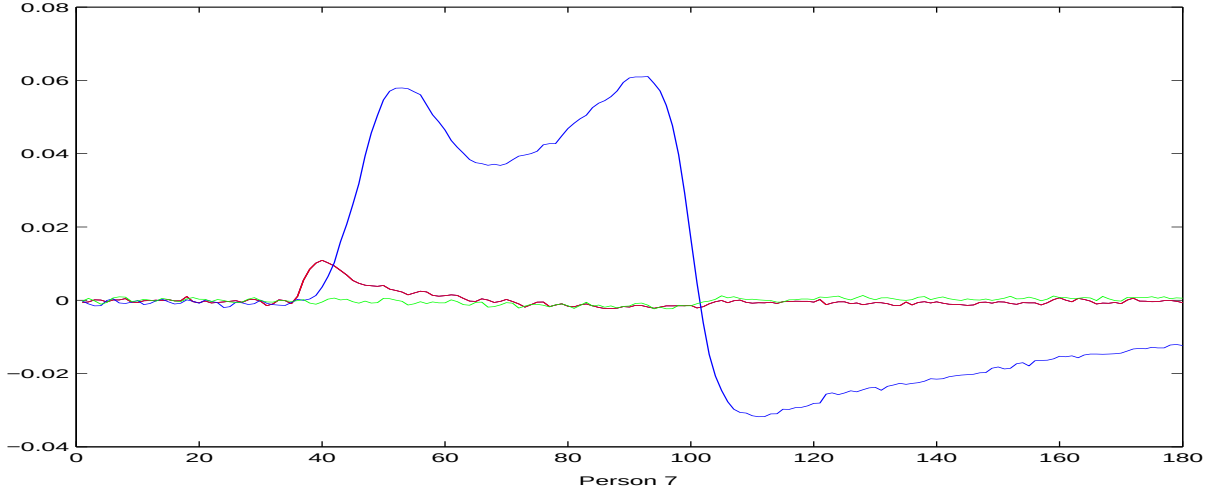
Data (3)





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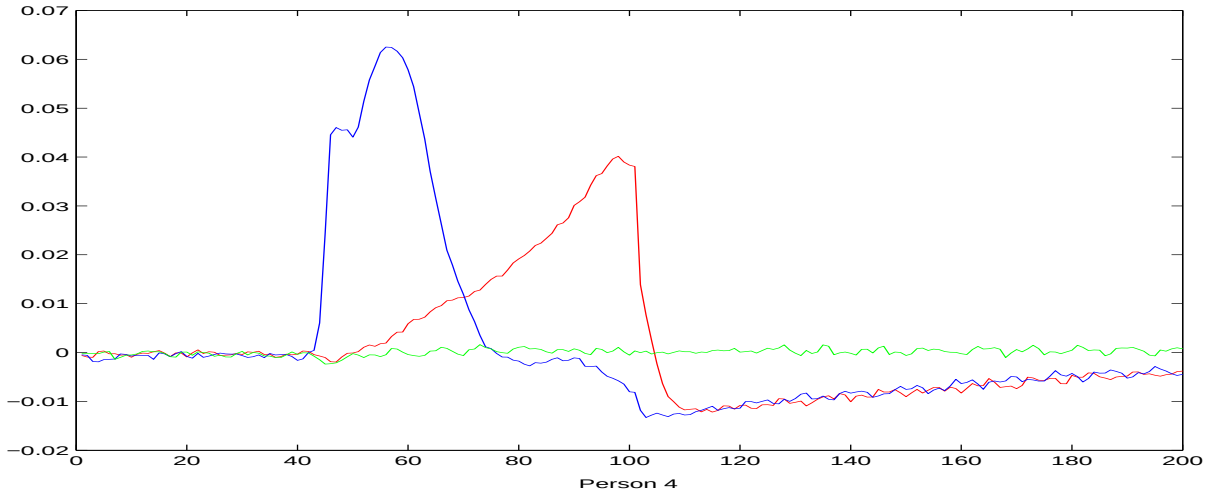
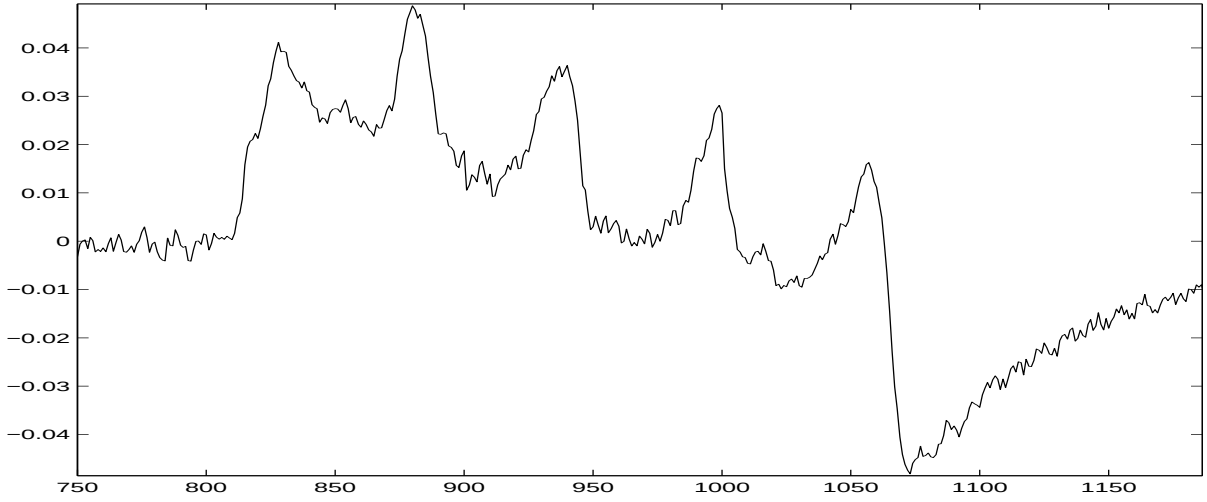
Data (4)





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Test Results

- The best results
  - Codebook size: about 5 prototype vectors/class
  - Learning algorithms: OLVQ1 and LVQ1
  - 2/3 of footsteps were used for training and 1/3 for testing
  - 13 features was used
    - Normalized between 0 and 1
  - The overall recognition accuracy was 67 %

Test Results (2)

Person	%
Person 1	84.62
Person 2	83.33
Person 3	33.33
Person 4	91.67
Person 5	69.23
Person 6	72.73
Person 7	25.00
Person 8	66.67
Person 9	90.00
Person 10	58.33
Person 11	66.67
Total accuracy	67.42

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Conclutions

- Experiments on identifying persons based on their footsteps were reported
- Basic tools for using the EMFi-floor are developed
- Future plans
  - Developing methods for reconstruction of partial data from multiple sensors
  - Real-time learning and recognition application

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