Gait Recognition in Mobile Security

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The Big Picture

What is Mobile Security?

- Information Storage
- Device Access

How is mobile security evolving?

- No More Passwords
- Something You Are
- Unobtrusive Access

Outline

1. Background
2. Preprocessing the data
3. Feature Extraction
4. Gait Classification
5. Results

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1. Background
   - Biometrics
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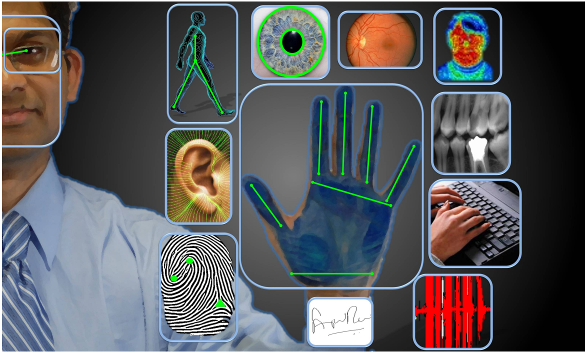
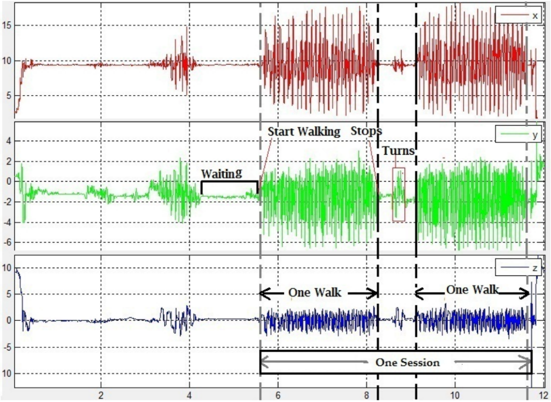
Biometrics

- Biometrics
- Gait Recognition
- Why Gait is Better



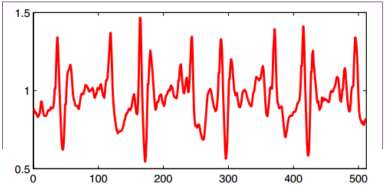
Fixed Method Approach

- Phone Clipped to Waist
- Walked Down 18.5 Meter Hallway



Unfixed Method Approach

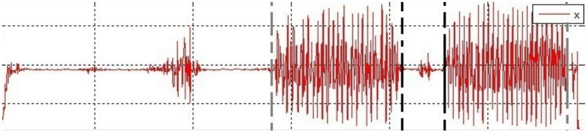
- Phone in more natural location (pocket, handbag, backpack)
- Experiment done in real-world environments



Outline

Linear Interpolation and Zero Normalization

- Walk Extraction
- Linear Interpolation (cure fitting)
- Zero Normalization

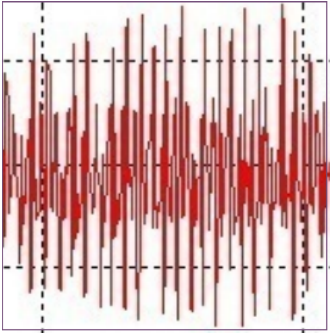


Unfixed Method Overview

- Three Experiments:
  - Training Walking Detector
  - Evaluating Supervised Training Data
  - Unsupervised Training

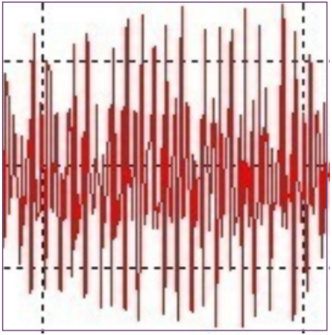
Framing

- Framing
  - Separating Data into Equal Sections
  - Frame Length: 5.12 seconds
  - Each Frame contains 512 Samples



Projection

- Framing
  - Each sample is projected onto a global coordinate system. a = (x, y, z)
  - Each a is projected into a vertical, and horizontal vector
  - Estimate Direction of Gravity
  - Not all frames will be used



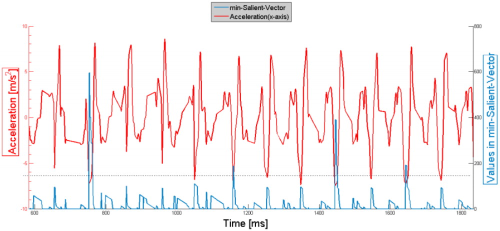
Outline

Fixed Method Feature Extraction

- Four Steps:
  - Cycle Length Estimation
  - Cycle Detection
  - Cycle length normalization
  - Omitting Unusual Cycles

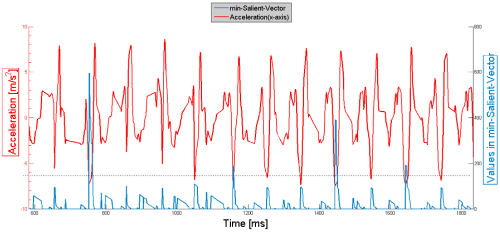
Cycle Length Estimation

- Detect start gait cycles with Salience Vectors
- Distance Between Data Points
- Minimum and Maximum Salience Vector



Cycle Detection

- Detecting Individual Cycles
- Start of each cycle is based on the minimum salience vector
- Spike around points 750, 1150, 1450, 1650
- Long cycles are split again using the same method



Cycle Length Normalization

- The distance of each cycle is measured from the start of one cycle to the start of the following.
- Cycles need to be of a set length for later Gait Analysis
- Linear Interpolation

Omitting Unusual Cycles

- Unusual Gait Cycles
- Dynamic Time Warping (DTW): an algorithm used to measure similarity between two sequences
- Cycles with an acceleration half that of the average are dropped

Feature Extraction I

- Frequency Domain using Spectrum Analysis
- Walking 1-2Hz vs Running >3Hz
- These features are used in the next step

Walking Detection

- Three classifications using a decision tree:
  - Walking: 1-2Hz
  - Non-Walking: >3Hz (running, biking, in moving vehicle)
  - Random Movements: >0Hz (transitional movements, short spikes)

Feature Extraction II

- Once Walking Detection confirms that the frame contains walking data, more relevant features are extracted for data.
- Two sets of features extracted:
    - Fundamental Frequency of Movement
    - Autocorrelation Features

Fundamental Frequencies

- This first set of features computed in this stage is the Compressed Sub-band Cepstral Coefficients (CSCC)
- CSCC based of off feature set for audio analysis.
- CSCC evolves 3 steps:
  1) The energy spectrum is computed using the Fast Fourier Transform (FFT)
  2) Then the energy spectrum is mapped into 26 bands
  3) The discrete cosine transform of the sub-band energy is taken to form a 12-dimension vector representation

Fundamental Frequencies

- The second set of features are computed by Autocorrelation
- Useful to find periodicity and cadence of the gait
- Used instead of segmentation because the unfixed position of the phone creates noise
- CSCC features are extracted form the autocorrelation to summarize the shape and structure of the frame

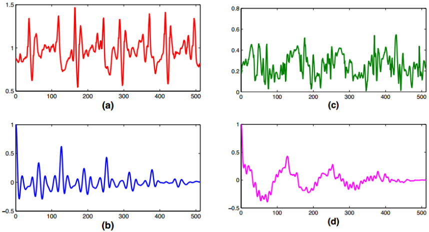


Figure 2: (a) projected vertical component. (b) normalized autocorrelation of the vertical component. (c) projected horizontal component. (d) normalized autocorrelation of the horizontal component.

Outline

Gait Classification

- Fixed Method Gait Classification
    - Template-based
    - Machine Learning
- Fixed Method Gait Classification
    - Gausian Mixture Model-Universal Background Model

Template-based

- Feature Cycle (the best cycle with the lowest DTW distance)
- Probe Cycles (the remaining cycles)
- Two classes are made:genuine and imposter
- 50% of the Prove cycles must vote genuine

Machine Learning

- Extracted gait cycles are split into two groups: 80% go into a training set, 20% go into a testing data set
- The DTW distance matrix is computed from the training data set
- DTW distance matrix is used by a kernel function. This makes the data linearly separable.
- A hyperplane is used to separate the data into two classes: genuine and imposter
- The class with the most votes

Machine Learning

- UBM Training large source of data
- Users gait model is generated relating the odds of one event to the odds of another
- Maximum-a-Posteriori (MAP) is used to adjust Gaussian components and mixture weight to personalize the UBM model
- MAP is also used by recording false negatives

Conclusions

Outline

References