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Content-based Retrieval of Humans using Gait Biometrics

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Overview

- **Problem outline**
- **Semantic Biometrics**
- **Gait Biometrics**
- **LSA**
- **Results**
- **Conclusions and Future Work↑**

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Problem Outline

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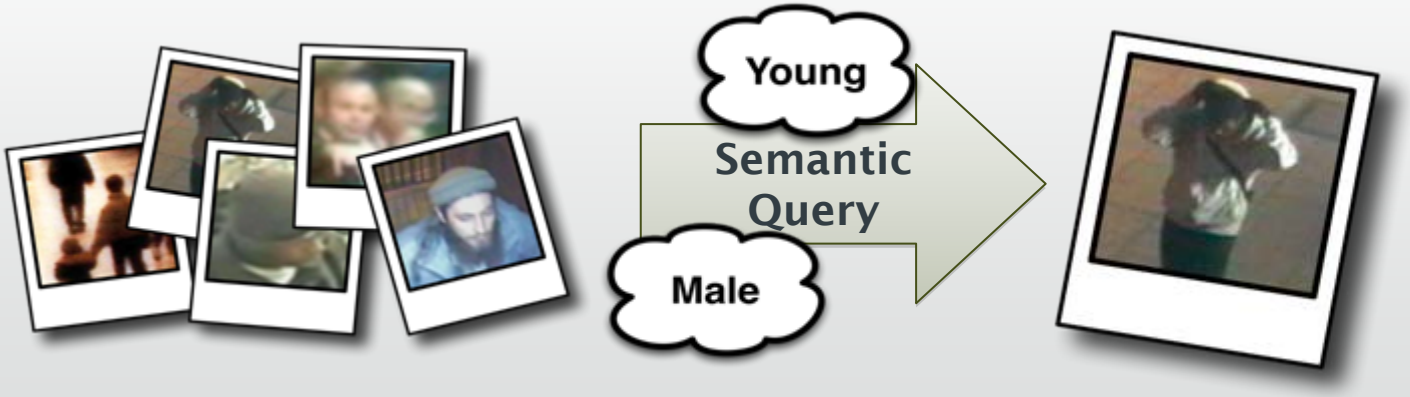
Surveillance

- Increased interest in **surveillance** technologies
  - 3.2GBytes of CCTV footage capture **per hour per camera**
  - Estimated use of **6 million** CCTV cameras in the UK
- **Semantic queries** are an efficient method to facilitate **human exploration**



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Automatic analysis required

- Videos require **semantic enrichment**
- Can be performed **manually**, however:
  - Too slow for live CCTV
  - Susceptible to various kinds of human error
- Analysis using **Biometrics** and **Automatic** Surveillance
  - Generate **low level** signatures automatically
- These signatures are not inherently **comparable** to human semantic queries
- This is the multimedia **semantic gap** problem

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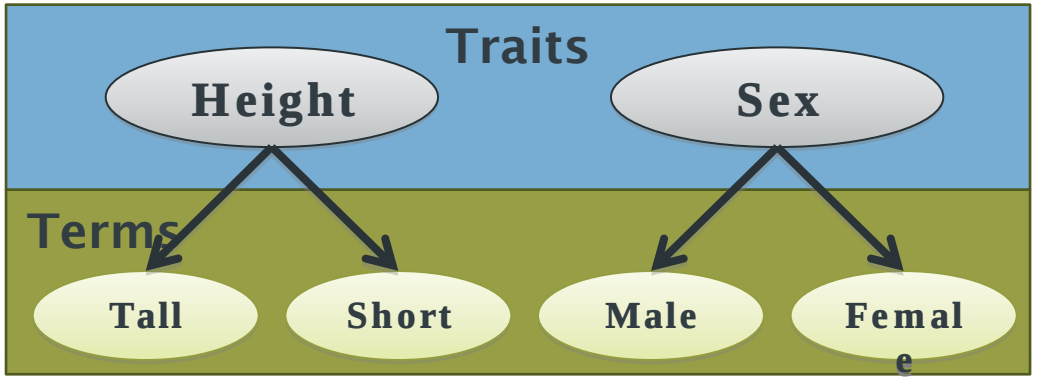
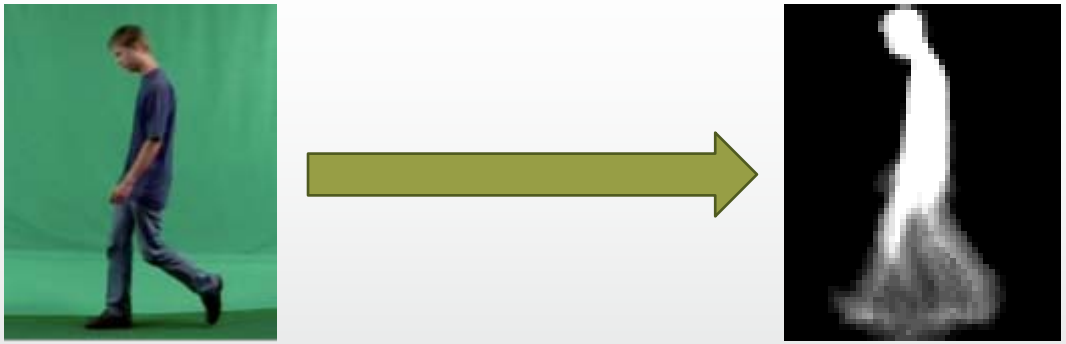
Exploring Human Descriptions

- We explore semantic descriptions of:
  - … physical **traits**
  - … semantic **terms**
  - … visible at a **distance**



- Find their correlation with **automatic gait signatures**



- In order to facilitate **semantic queries** against **automated gait signatures**

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Semantic Biometrics

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Terms and Traits

- What **traits are described** and what **terms used** depends on **situation**
  - **Mug shots** vs **CCTV**
- **Traits** chosen such that
  - They are visible at a **distance**
  - Mentioned **consistently**
- Complementary **qualitative terms** selected
  - To avoid issues with value judgments

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Traits and Terms

Global Features

- Features mentioned most often in witness statements
- **Sex** and **age** quite simple
- **Ethnicity** undeniably important in terms of mention
  - Notoriously **unstable**
  - There could be anywhere between 3 and 100 ethnic groups
  - We've chosen 3 "main" **subgroups** and 2 extra to match UK Police force groupings

- **Global**
  - Sex
  - Ethnicity
  - Skin Colour
  - Age
- **Body Shape**
  - Figure
  - Weight
  - Muscle Build
  - Height
  - Proportions
  - Shoulder Shape
  - Chest Size
  - Hip size
  - Leg/Arm Length
  - Leg/Arm Thickness
- **Head**
  - Hair Colour
  - Hair Length
  - Facial Hair Colour/Length
  - Neck Length/Thickness

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Traits and Terms

Body Features

- Based on **whole body** description **stability** analysis by MacLeod et al.
  - Features showing **consistency** by different **viewers** looking at the same **subjects**
- Mostly comprised of **5 point** qualitative measures
  - (Very Thin -> Very Fat, Very Short-> Very Long)
- Most likely candidate for **association** with gait

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Traits and Terms

Head Features

- Mentioned **consistently** by people even at **long distances**
- Prominent area of **gaze**
- **Hair Length** and **colour** inherently connected with **style**
  - **Hundred** of different hair styles
  - **Avoided** due to unfamiliarity of annotators

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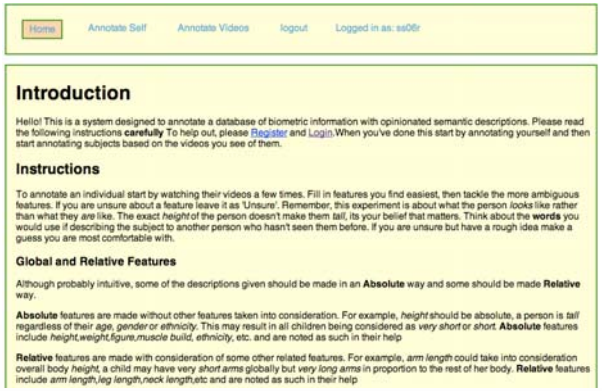
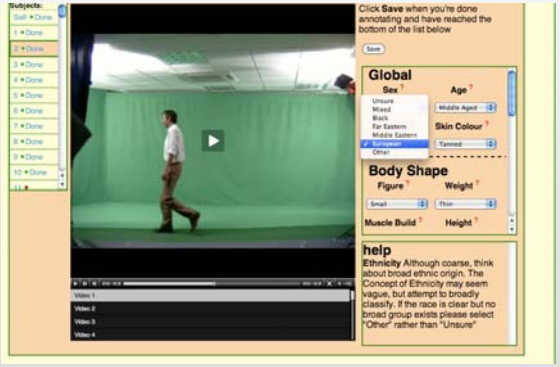
Annotation Interface





- **Web interface** constructed to gather annotations against any source
- Designed to deal with **issues of human description**
  - *Memory issues:* View a **subject** as many times as **required**
  - *Defaulting:* Explicitly asked to fill out **every feature**
  - *Value Judgments:* Categorical qualitative values.
  - *Subjective variables:* Collect **description of annotators**

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Gait Biometrics

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Automatic Gait Signatures

- Gait biometrics **work** under the **constraints** of CCTV
  - Long **distance** to camera, noisy data etc.
- Several **gait signatures** can be generated from video
  - **Statistical** vs **model based**
- Average Silhouette **baseline** algorithm chosen for these preliminary tests
- We use the Southampton dataset
  - **115** subjects
  - At least 6 **fronto-parallel** videos of natural gait

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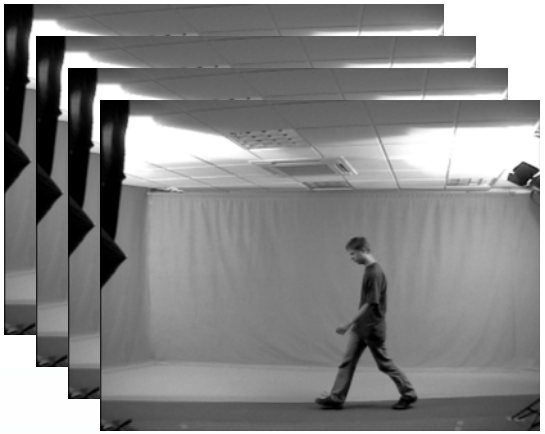
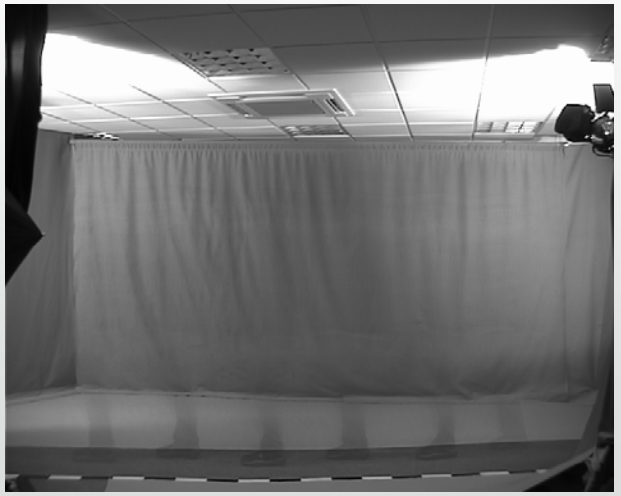
Average Silhouettes Signature

- Video background calculated using median of each frame
- This background is taken from each frame and pixels thresholded resulting in a binary image
- Normalise silhouettes by height to account for distance
- Add all silhouettes together and divide by the number of frames
- Resulting image is the signature





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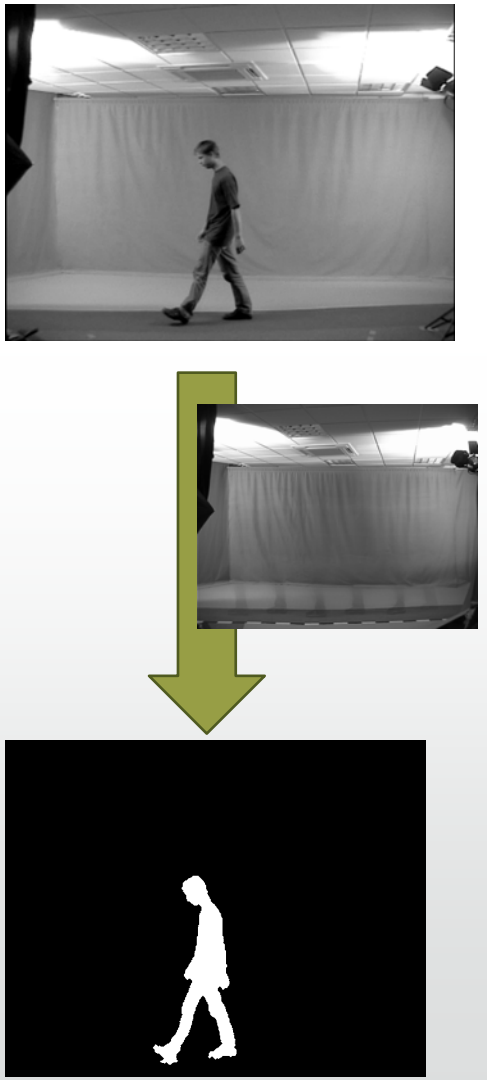

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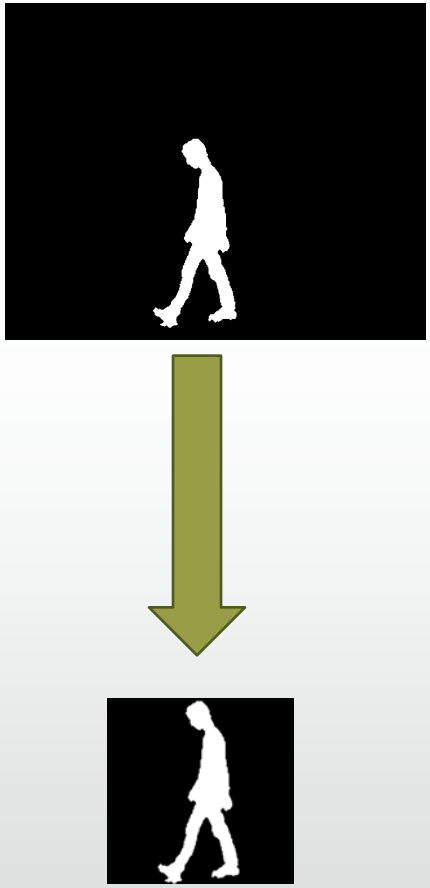

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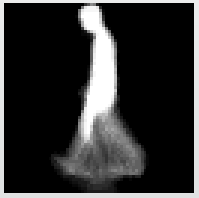

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Latent Semantic Analysis

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Latent Semantic Analysis

- We use **Latent Semantic Analysis** to facilitate **content based retrieval**
- This process involves formulating **observations of subjects** as a matrix of
  - Documents (**subjects**) with
  - Terms (**annotations** and **average silhouette signatures**)
- Based on **observations**, we construct a linear algebraic **semantic space**
  - The axis of which are the **eigenvectors** of the co-occurrence matrices
  - We ignore axis with lower **eigenvalues**, those likely to represent noise
  - (related to **PCA**)
- In this space similar **geometric position** implies similar **meaning**

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Experiment Design

- For each subject
  - Each **video sample** is concatenated with average **semantic annotation**
- Randomly split the set of **subjects** in half
  - **training** and **test**
- Construct **semantic space** from the **training** set
- Project **test** set into the space with **semantic features set to zero**
- Construct a **document** per **semantic annotation** and **project** into the space
- Order subjects by **cosine** distance to query

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Results

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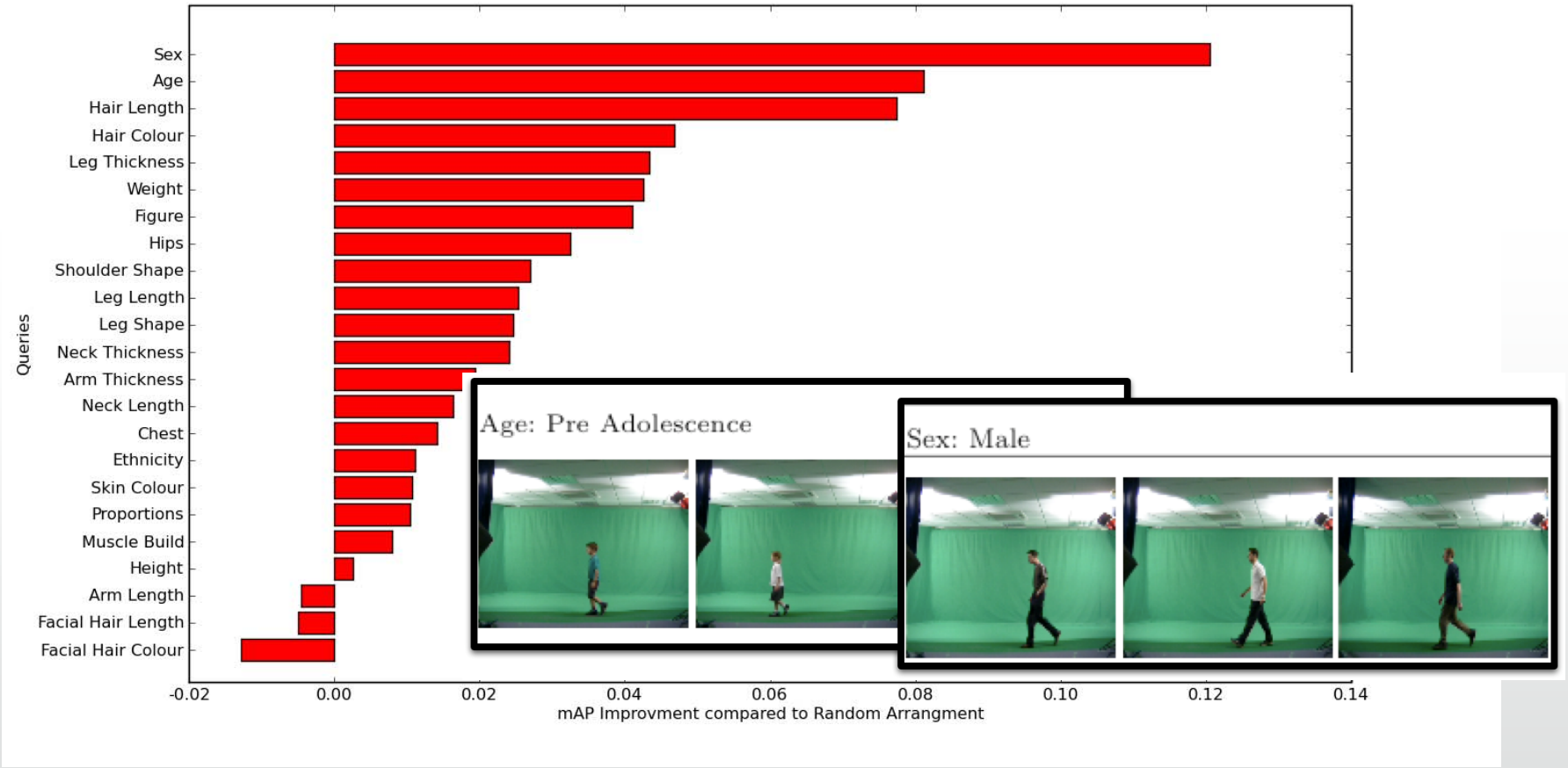
Experiment Results



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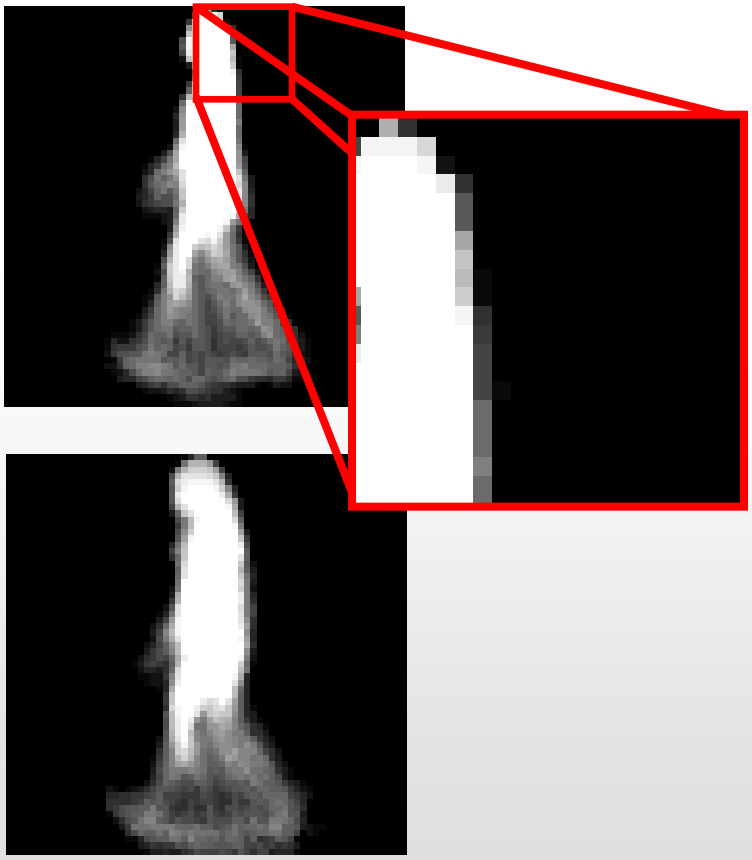
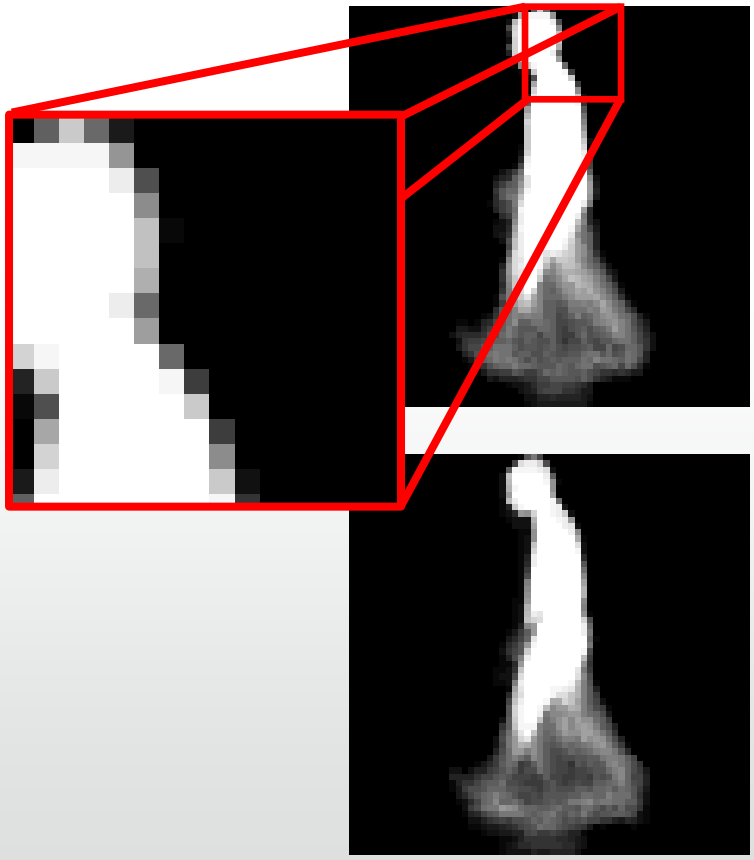
Successful Results

- Hair Length (Long vs Short)





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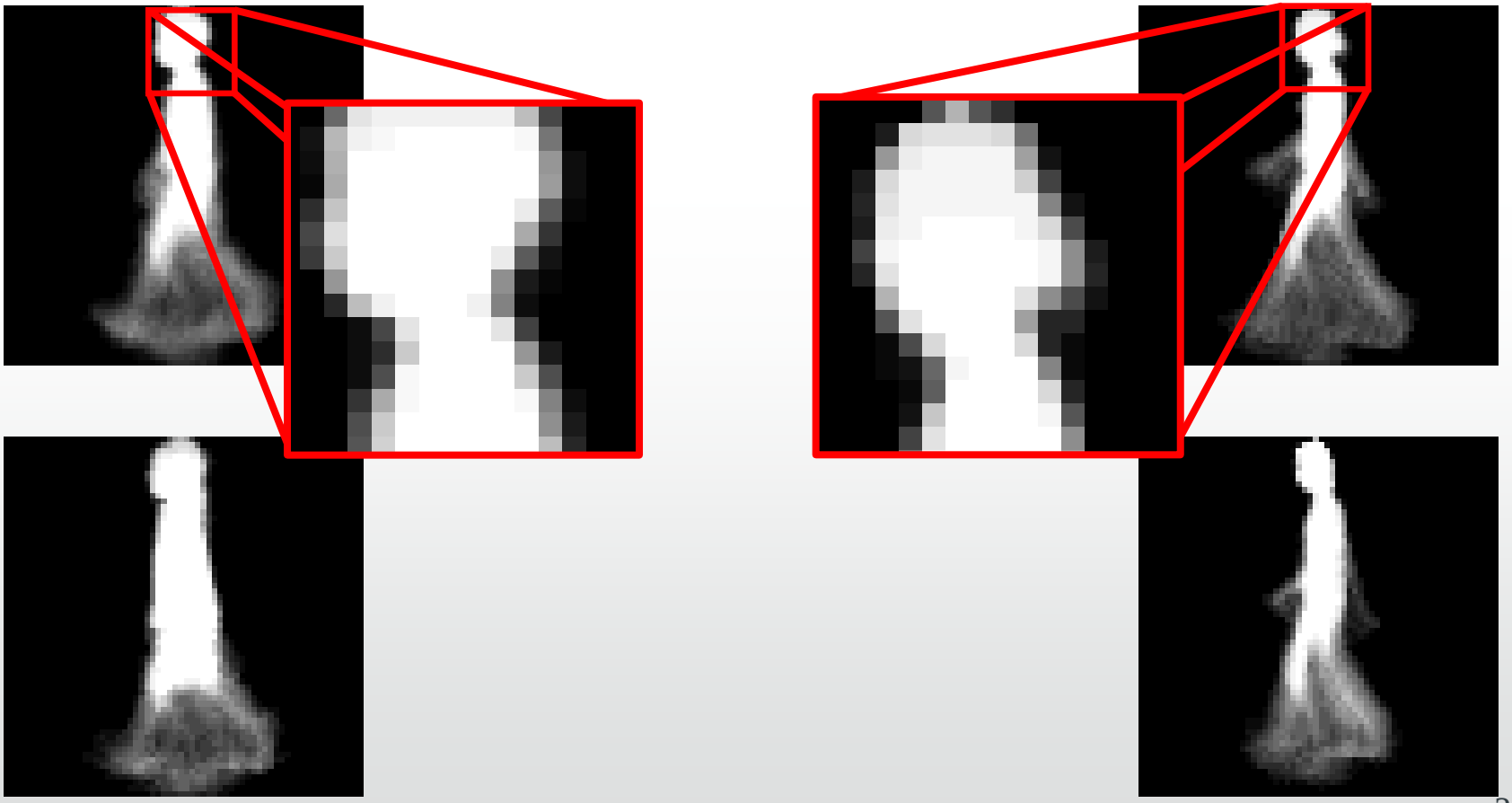
Successful Results

- Age (Pre-Adolescent vs Young Adult)



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Failed Results

- Skin Colour (Black vs White vs Tanned)

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Conclusions

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Conclusions

- Outlined a set of **features** used by people to describe **each other** at a **distance**
- **Examined correlation** with an automatic gait analysis technique
- Exploited these correlations to allow **content-based retrieval**

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Future Work

- More **Data**!
  - Explore other **automatic features**
  - More **semantic data**
- **Trait** and **Term** expansion
  - Better annotations for **humans**

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Questions?