You Are How You Walk: Uncooperative MoCap Gait Identification for Video Surveillance with Incomplete and Noisy Data

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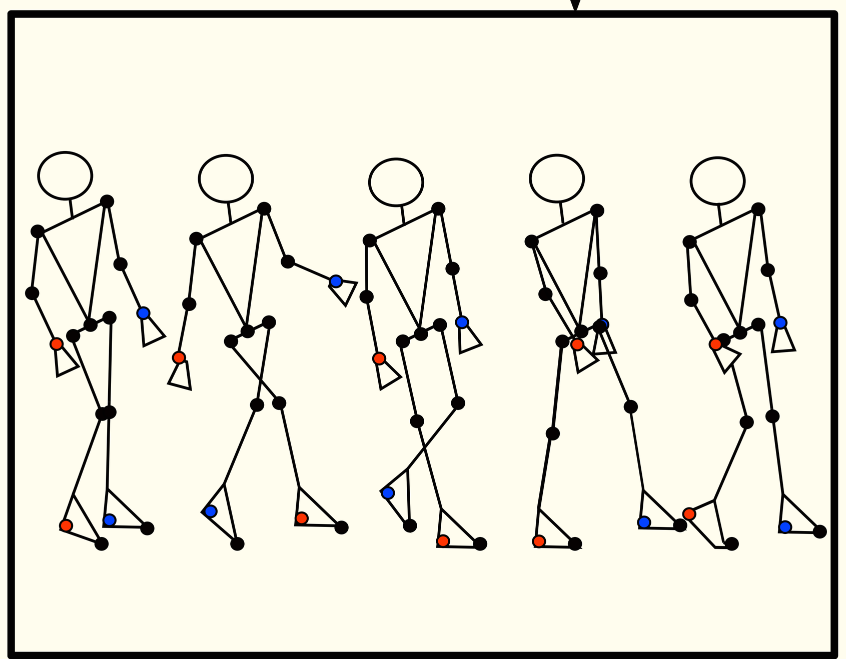
`https://gait.fi.muni.cz`

Identification Pipeline

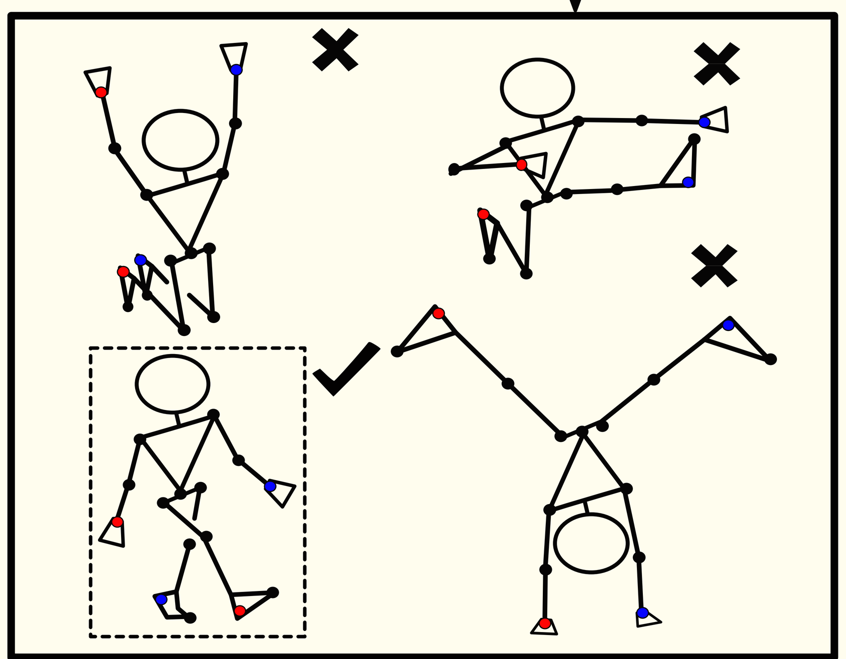
Spotted walker

Phase I: Acquiring MoCap data



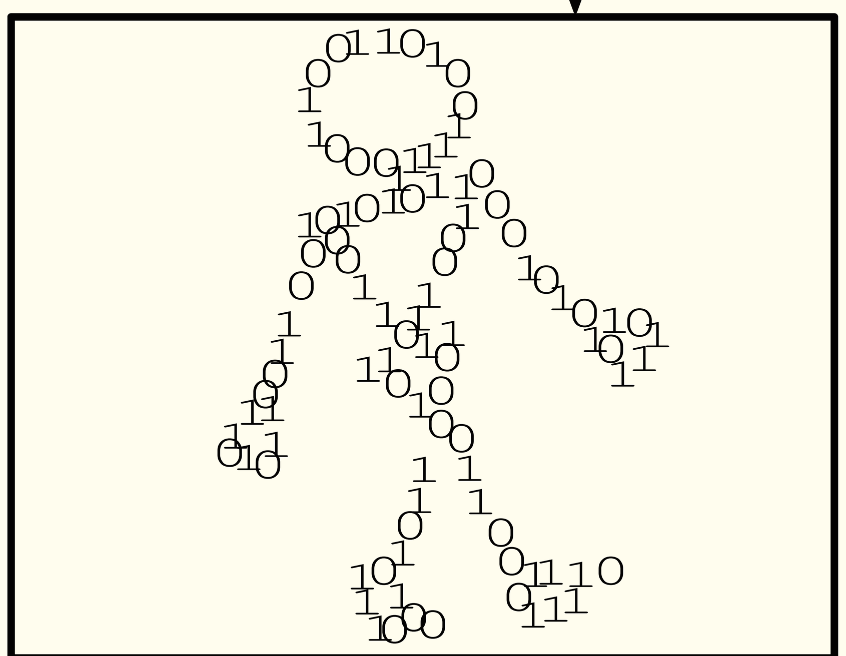
MoCap data

Phase II: Detecting gait



Gait sample

Phase III: Extracting gait features



Gait template

Phase IV: Identifying walkers

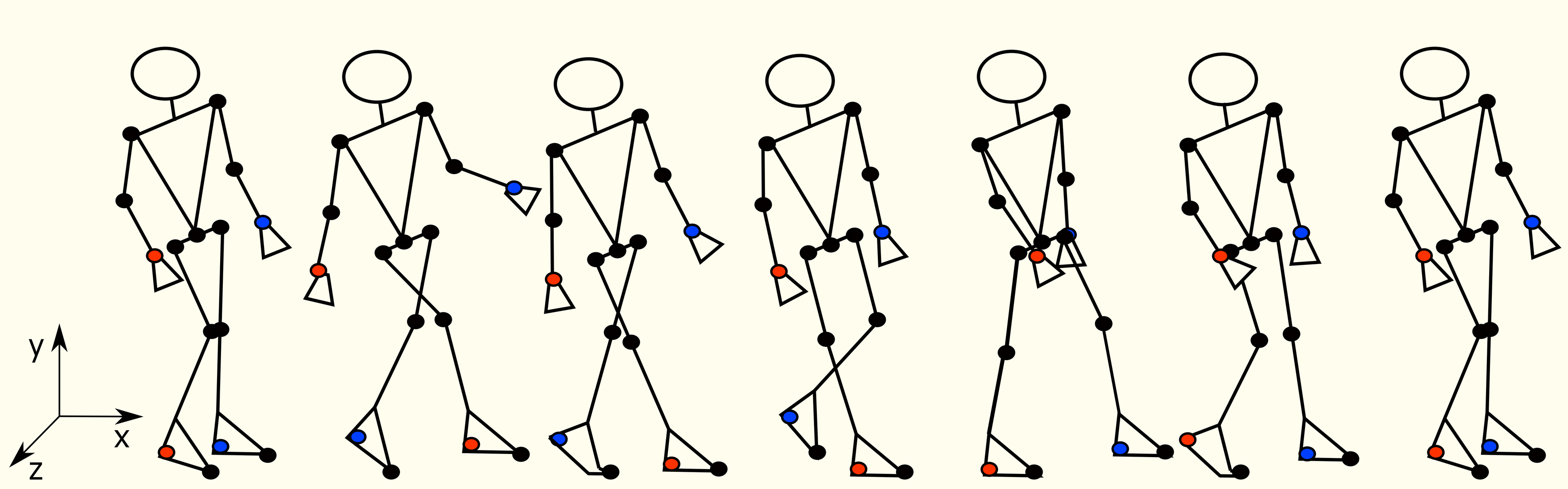
Identified walker

Phase I – Acquiring Motion Capture Data

Motion capture (MoCap) technology provides video clips of moving individuals containing an overall structure of the human body and estimated **3D joint coordinates**.

MoCap data can be collected online by a readily available system of multiple cameras (Vicon) or by a depth camera (Microsoft Kinect).

To visualize MoCap data, a **stick figure** that represents the human skeleton can be recovered from joint spatial coordinates in time.



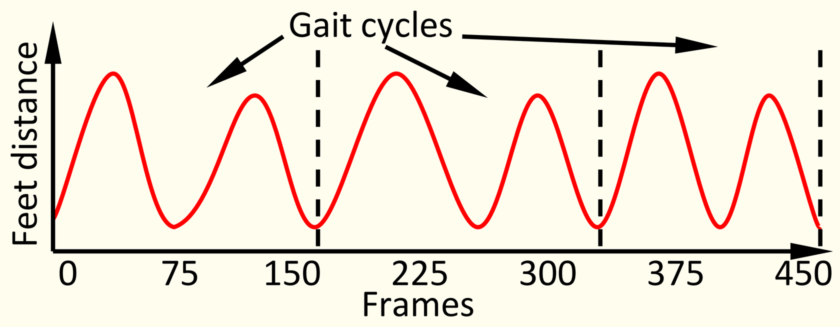
Phase II – Detecting Gait Cycles

People spotted in our tracking space do not walk all the time; on the contrary, they perform **various activities**.

Identifying people from gait requires video segments where they are actually **walking**.

Clean **gait cycles** need to be first filtered out.

There are methods for **detecting gait cycles** directly as well as **action recognition** methods that need a demonstrative example of a gait cycle to query general motion sequences.



Phase III – Extracting Gait Features

Let a model of the human body have J joints and all N_L learning samples of C_L walkers be linearly normalized to their average length T.

Labeled learning data in a **sample space** have the form $\mathcal{G}_L = \{(\mathbf{g}_n, \ell_n)\}_{n=1}^{N_L}$ where

$$\mathbf{g}_n = [[\gamma_1(1) \cdots \gamma_J(1)] \cdots [\gamma_1(T) \cdots \gamma_J(T)]]^\top$$

is a **gait sample** (one gait cycle) in which $\gamma_j(t) \in \mathbb{R}^3$ are 3D spatial coordinates of joint $j \in \{1, \ldots, J\}$ at time $t \in \{1, \ldots, T\}$ normalized to the person's position and walk direction.

Each learning sample falls into one of the learning **identity classes** $\{\mathcal{I}_c\}_{c=1}^{C_L}$ labeled by ℓ_n.

Feature extraction is set by matrix $\mathbf{\Phi} \in \mathbb{R}^{D \times \widehat{D}}$ from D-dimensional sample space $\mathcal{G} = \{\mathbf{g}_n\}_{n=1}^{N}$ to $\widehat{D}$-dimensional **feature space** $\widehat{\mathcal{G}} = \{\widehat{\mathbf{g}}_n\}_{n=1}^{N}$ with $\widehat{D} < D$.

A given gait sample $\mathbf{g}_n$ can be transformed into **gait template** by $\widehat{\mathbf{g}}_n = \mathbf{\Phi}^\top \mathbf{g}_n$.

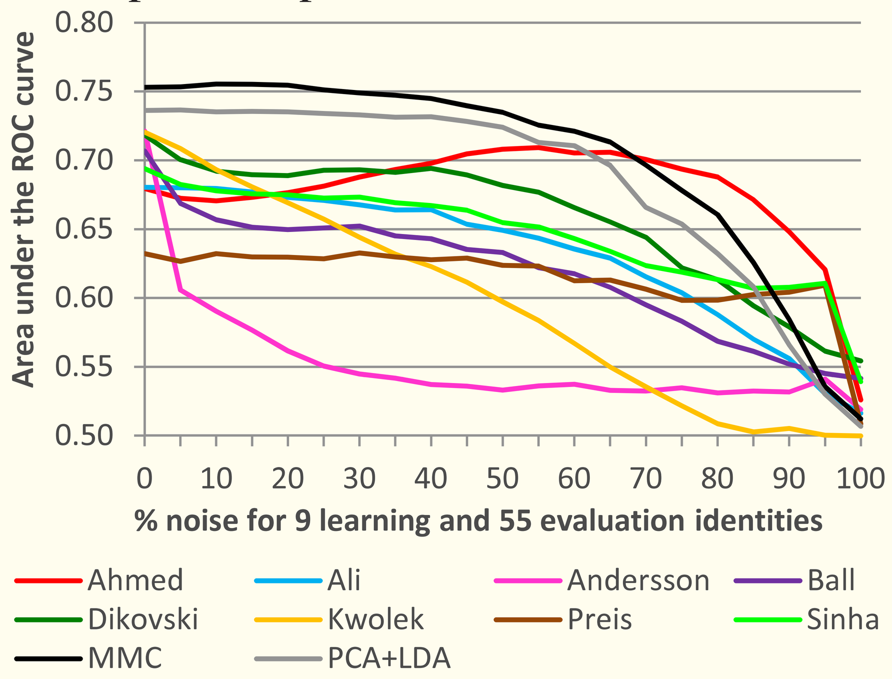
Templates are compared by the Mahalanobis distance.

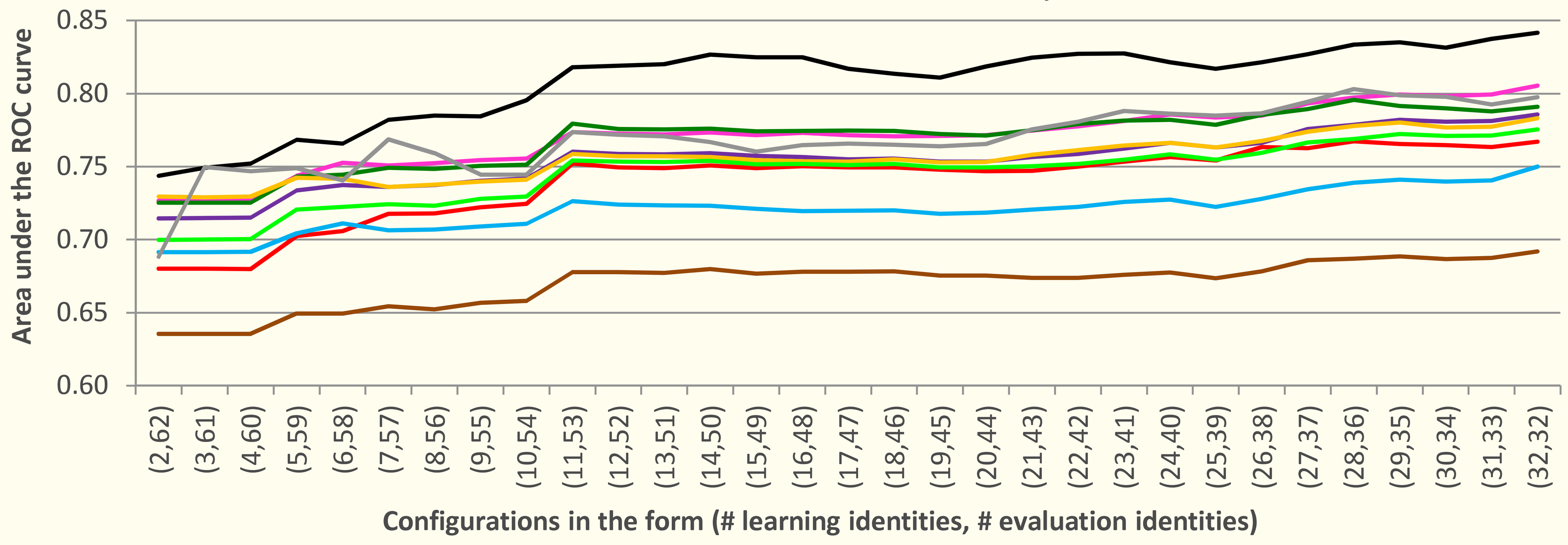
Evaluated **methods**:

- 8 hand-designed geometric feature sets
- Features learned by **MMC**
- Features learned by **PCA+LDA**

Evaluated **metrics**:

- Correct classification rate
- Discriminativeness
- Robustness to noisy and incomplete data
- Clusterability
- Scalability





Specifications of the evaluated methods are available at web `https://gait.fi.muni.cz`.

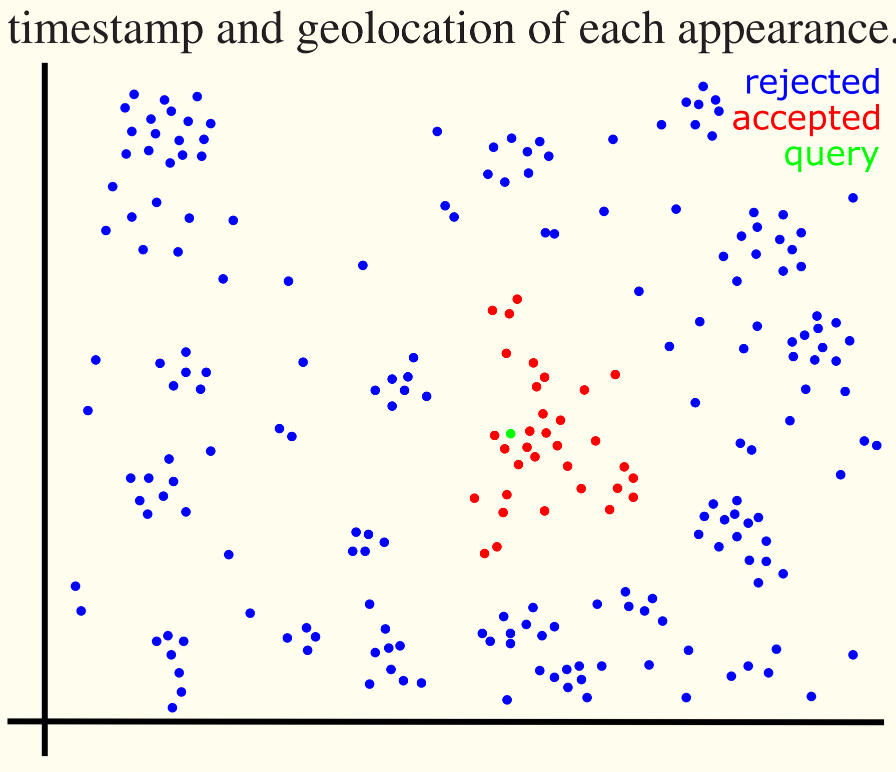
Phase IV – Identifying Walkers

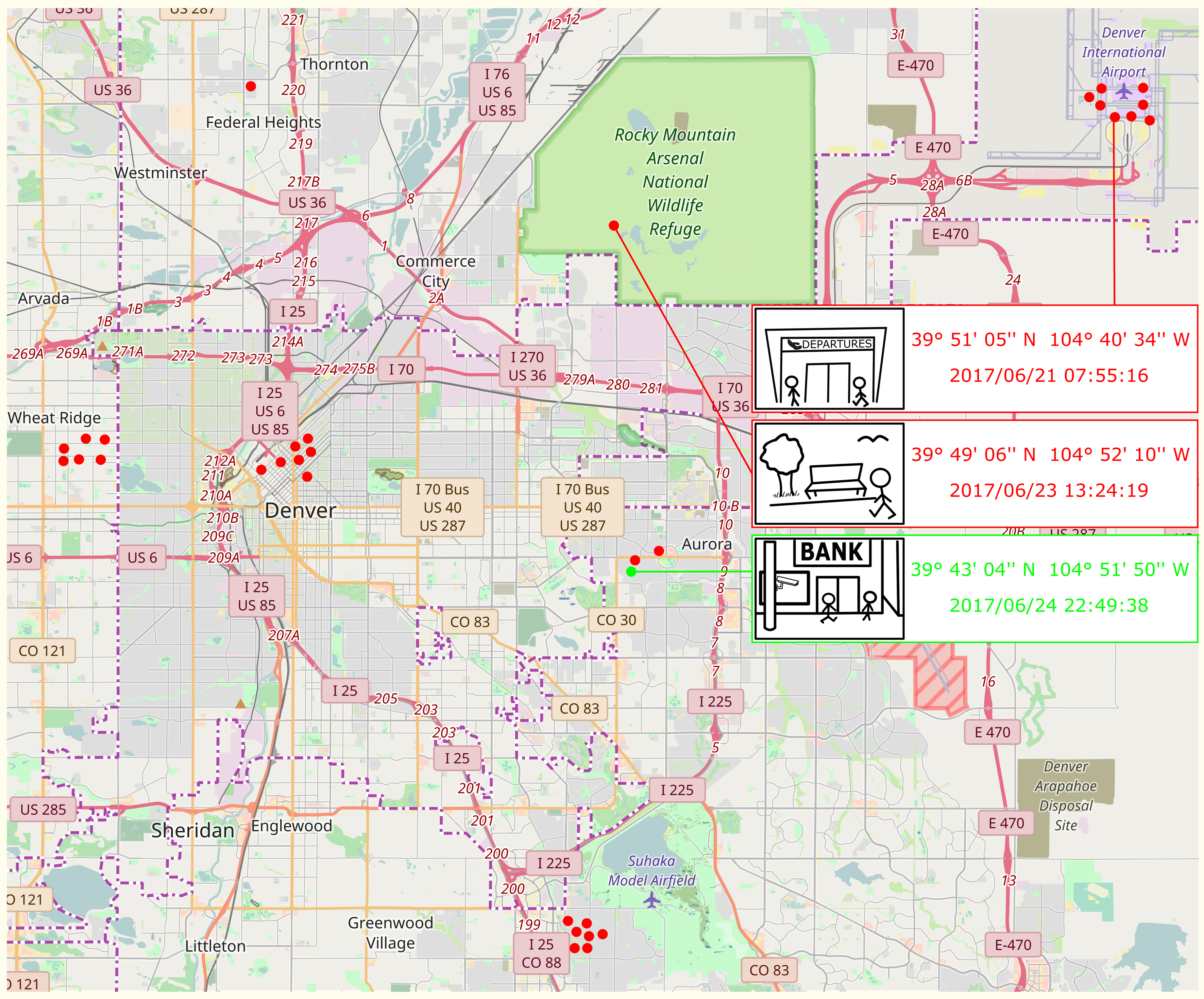
Person re-identification (Re-ID) focuses on spotting people of interest in multiple cameras.

But in **video surveillance**, labeled data for all the people encountered is never available.

Training the model on an auxiliary database creates an **unsupervised environment** suitable for searching for similar gait templates and for clustering them into potential walker identities.

One can retrieve information about a person's appearances captured by the video surveillance system – their **location trace** that includes timestamp and geolocation of each appearance.





Acknowledgements

Michal Balazia and Petr Sojka: **You Are How You Walk: Uncooperative MoCap Gait Identification for Video Surveillance with Incomplete and Noisy Data**, International Joint Conference on Biometrics (IJCB), Denver, 2017.
Michal Balazia and Petr Sojka: **Gait Recognition from Motion Capture Data**, ACM Transactions on Multimedia Computing (TOMM), Special Issue on Representation, Analysis and Recognition of 3D Humans, 2017.
The data used in this project was created with funding from NSF EIA-0196217 and was obtained from `http://mocap.cs.cmu.edu`. Evaluation framework and database are available online at `https://gait.fi.muni.cz`.