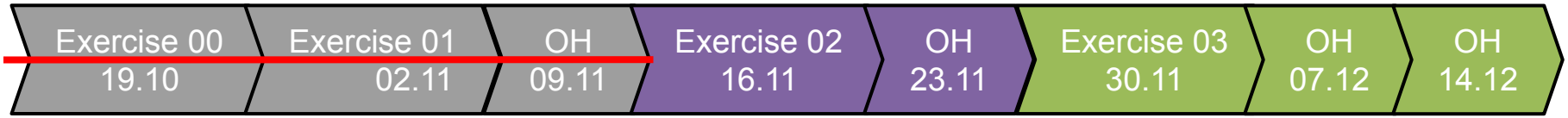
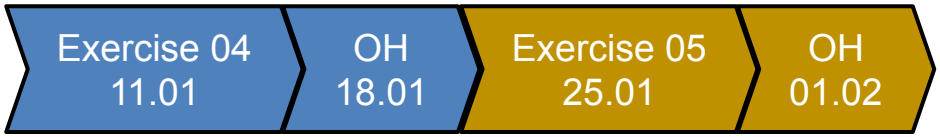
Exercise 2

Timeline

- 2 weeks for each exercise + Office hours (OH) for questions in between

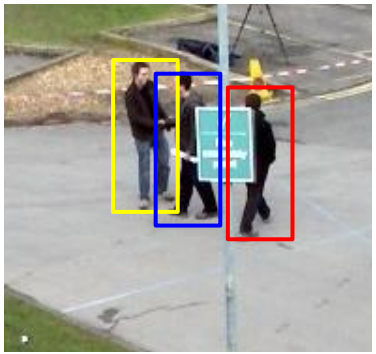


Holidays and New Year



Deadline always 23:59 CET on due date

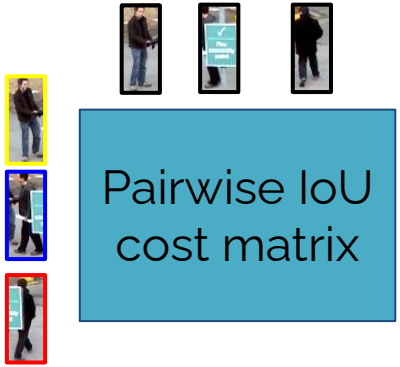
Tracking by Detection



Tracks in past frame

Current Frame detections

Motion Model: IoU

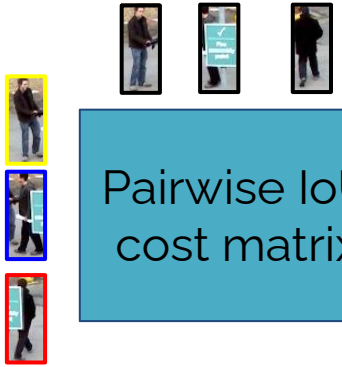


Pairwise IoU cost matrix

Tracks in past frame

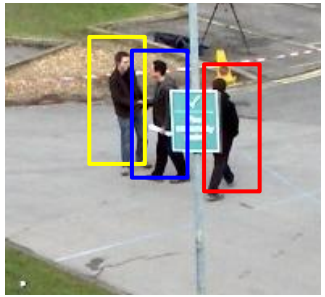
Current Frame detections

Minimum IoU Tracker

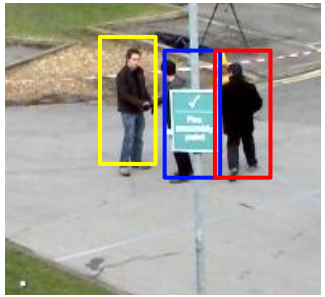


Pairwise IoU cost matrix

Assign detection with lowest cost (1-IoU) to track!

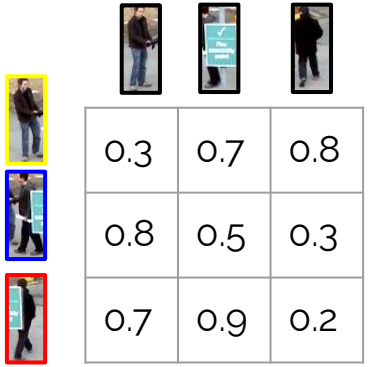


Tracks in past frame



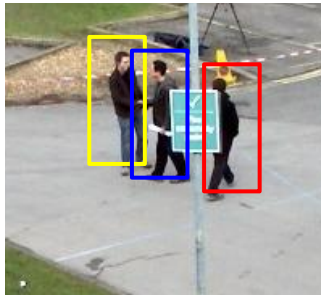
Tracks Frame detections

Minimum IoU Tracker

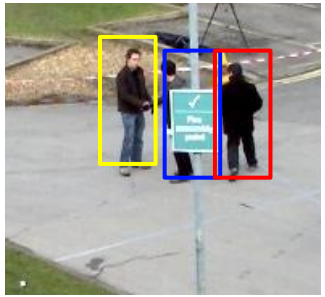


0.3	0.7	0.8
0.8	0.5	0.3
0.7	0.9	0.2

Assign detection with lowest cost (1-IoU) to track!



Tracks in past frame

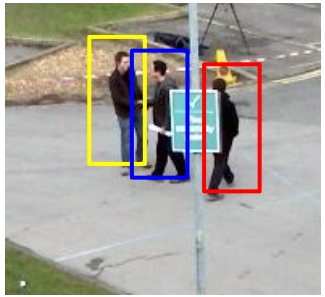


Tracks Frame detections

Minimum IoU Tracker

0.3	0.7	0.8
0.8	0.5	**0.3**
0.7	0.9	**0.2**

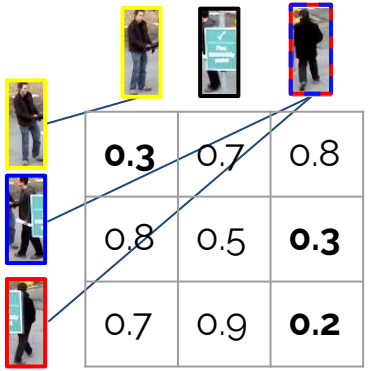
Same bounding box assigned to two tracks!



Tracks in past frame

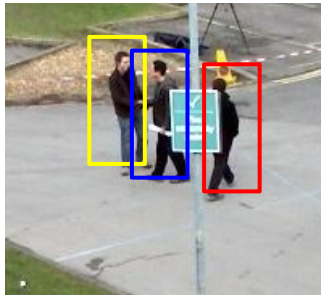
Tracks Frame detections

Minimum IoU Tracker



0.3	0.7	0.8
0.8	0.5	**0.3**
0.7	0.9	**0.2**

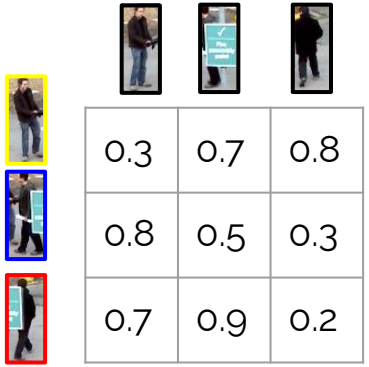
Same bounding box assigned to two tracks!



Tracks in past frame

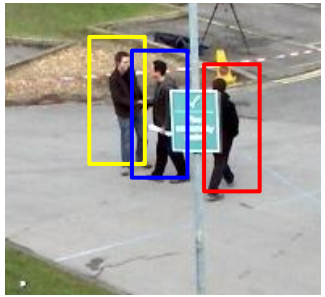
Tracks Frame detections

What we want...

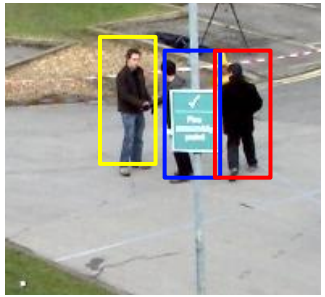


0.3	0.7	0.8
0.8	0.5	0.3
0.7	0.9	0.2

Assign detection with lowest distance cost to track BUT allow each bounding box to be assigned to one track only!

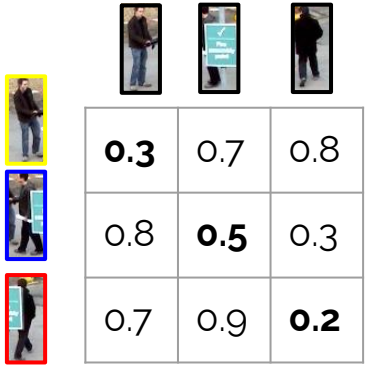


Tracks in past frame



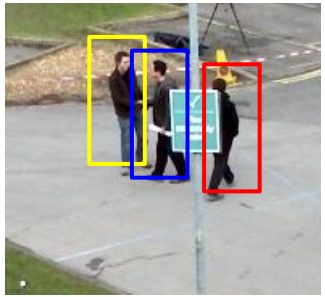
Tracks Frame detections

What we want…

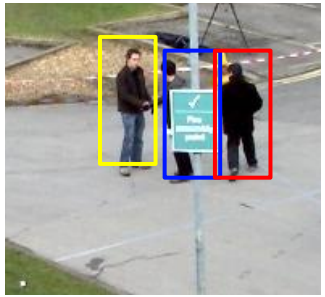


0.3	0.7	0.8
0.8	**0.5**	0.3
0.7	0.9	**0.2**

Assign detection with lowest distance cost to track BUT allow each bounding box to be assigned to one track only!



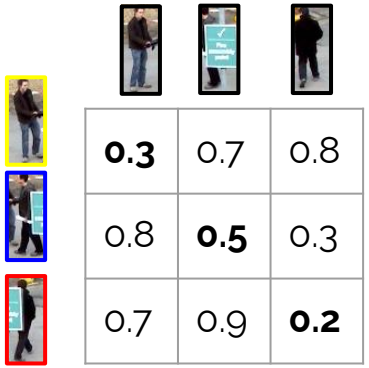
Tracks in past frame



Tracks Frame detections

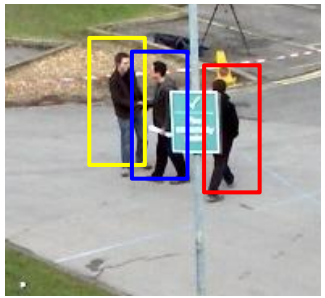
What we want...

Bipartite matching using Hungarian algorithm!

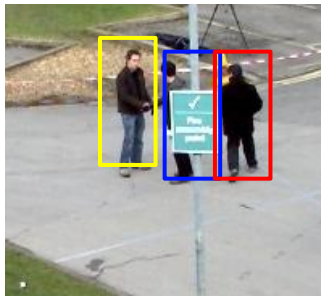


0.3	0.7	0.8
0.8	**0.5**	0.3
0.7	0.9	**0.2**

Assign detection with lowest IoU cost to track BUT allow each bounding box to be assigned to one track only!



Tracks in past frame



Tracks Frame detections

Exercise 2

- **Implementing Hungarian Algorithm for bipartite matching**
- Training appearance features for matching
- Using Hungarian Algorithm and Appearance Features

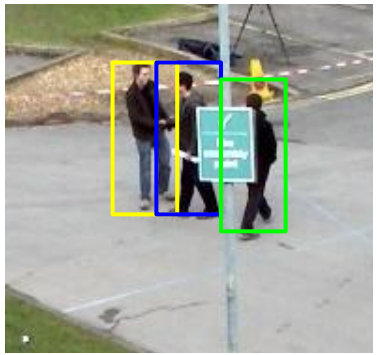
What we want...

0.5	**0.2**	0.8
0.4	0.6	0.3

Difficult with IoU

Add previously unmachted tracks to assigment step!

Missed Detection



What we want...

0.5	**0.2**	0.8
0.4	0.6	0.3

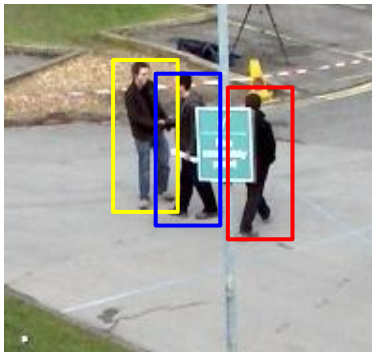
Difficult with IoU

Add previously unmachted tracks to assigment step!

Exercise 2

- Implementing Hungarian Algorithm for bipartite matching
- **Training appearance features for matching**
- Using Hungarian Algorithm and Appearance Features

The Task of Multi Object Tracking



Tracks in past frame

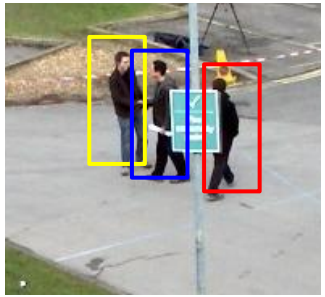
Current Frame detections

ReID

- Fast Movements
- Missing Detections
- Occlusions

Appearance Model: ReID Features

Pairwise feature distance



Tracks in past frame

Current Frame detections

What we want...

0.3	0.7	0.8
0.8	**0.5**	0.3
0.7	0.9	**0.2**

Distance metric only based on IoU

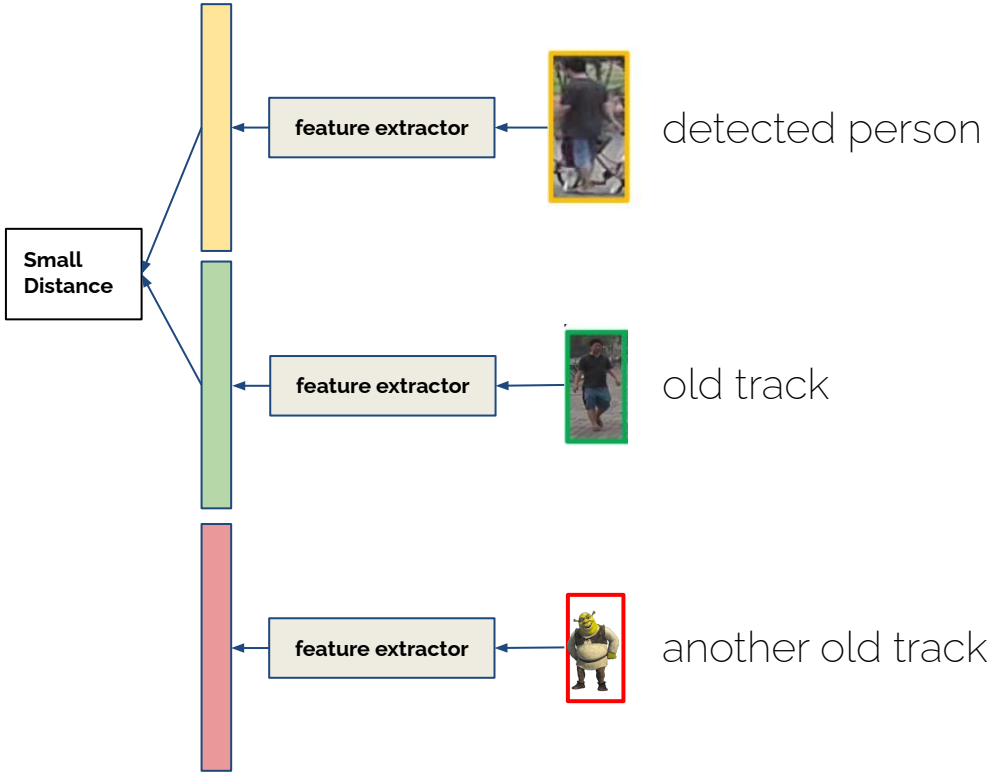
What we want…

0.3/ 0.5	0.7/0 .5	0.8/0 .7
0.8/0 .7	**0.5/ 0.3**	0.3/0 .8
0.7/0 .8	0.9/0 .7	**0.2/ 0.3**

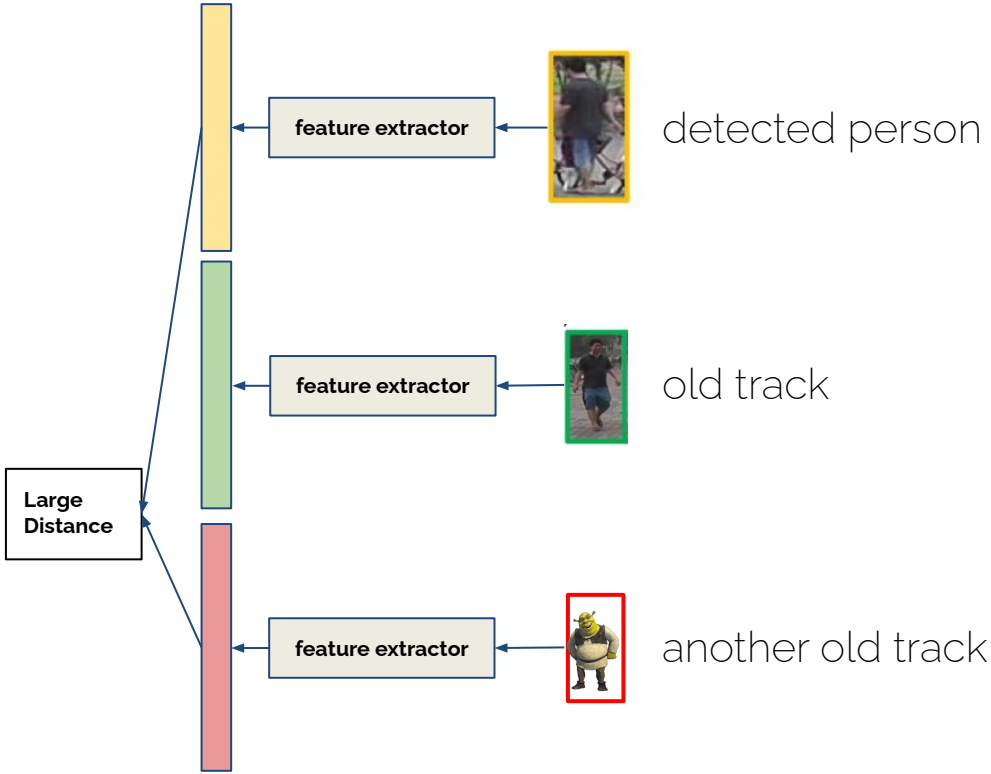
Re-ID:
add distance metric based on appearance

Distance metric only based on IoU

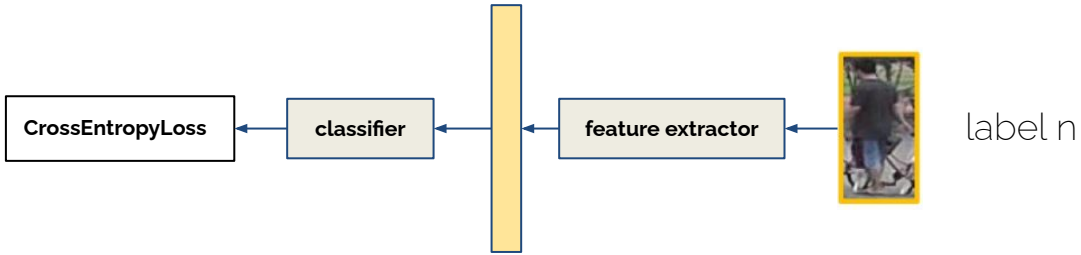
What we want… at Test Time



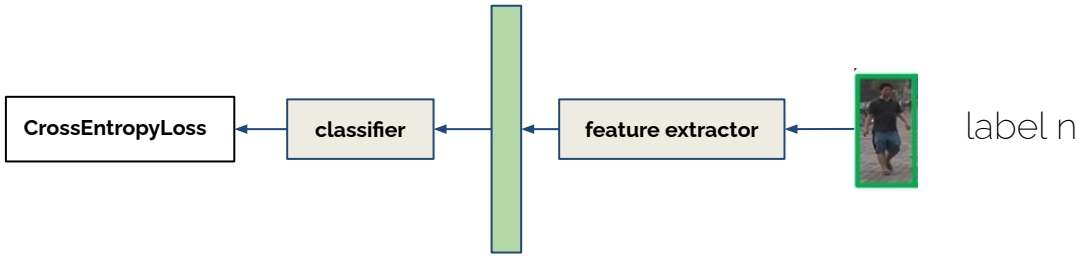
What we want… at Test Time



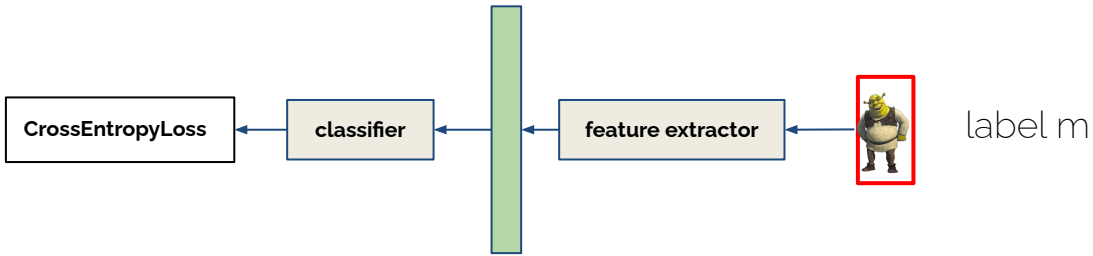
What we want... at Training Time



What we want… at Training Time



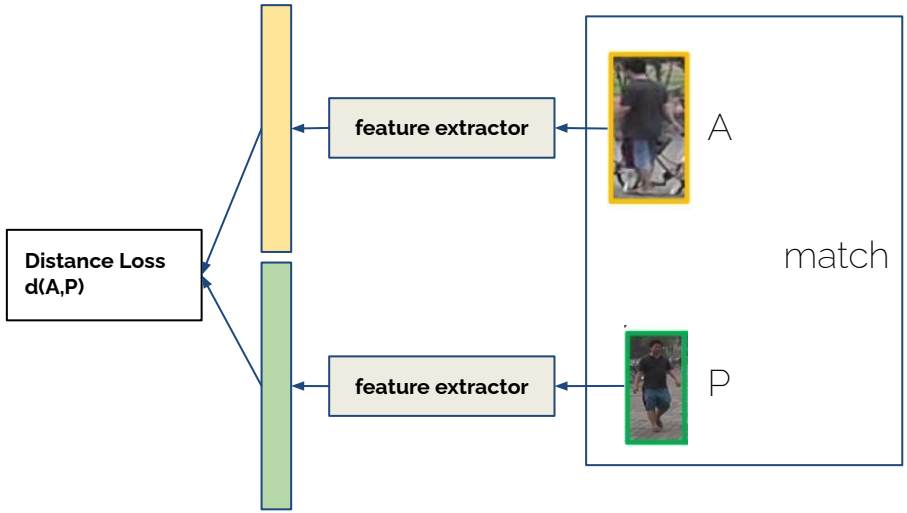
What we want… at Training Time



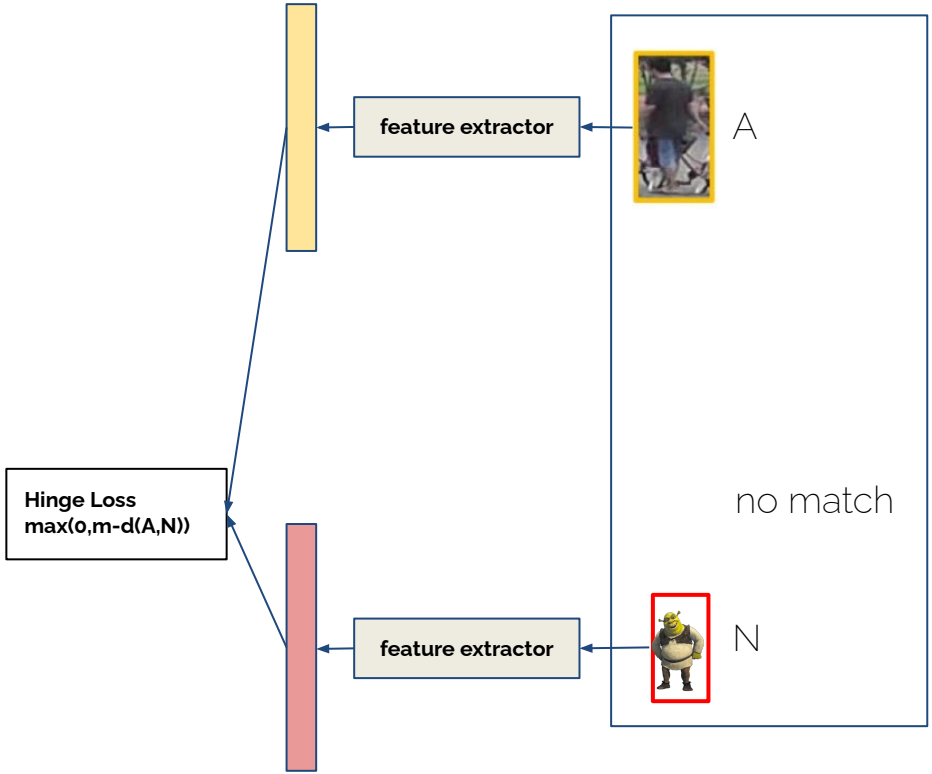
Question

- Can we use the trained feature extractor also for a new set of people?

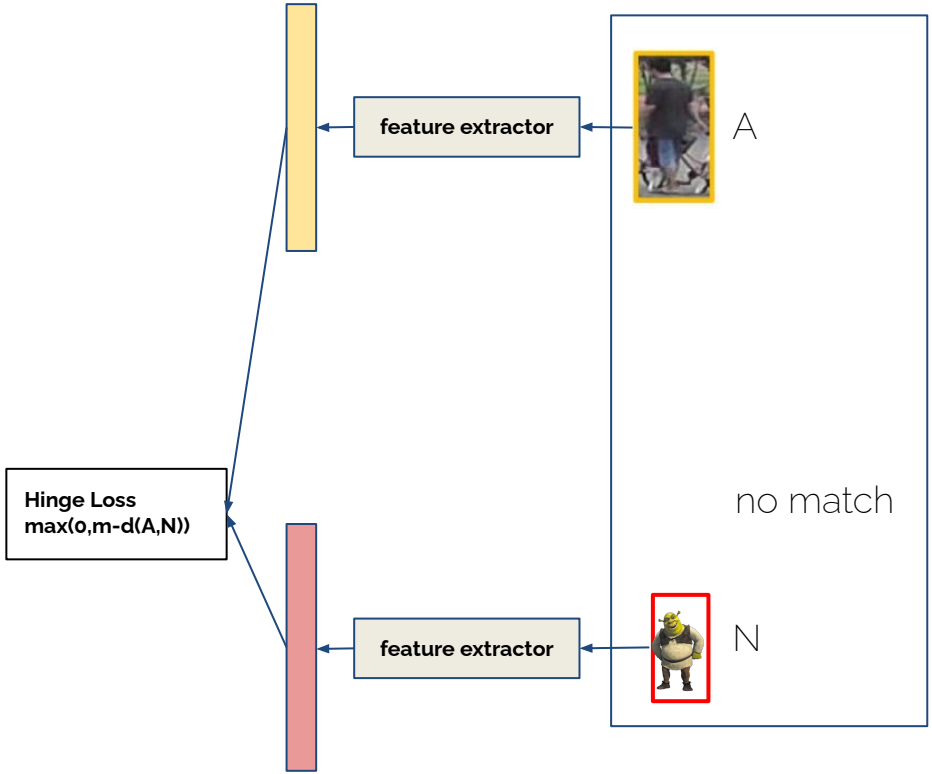
What we want… at Training Time

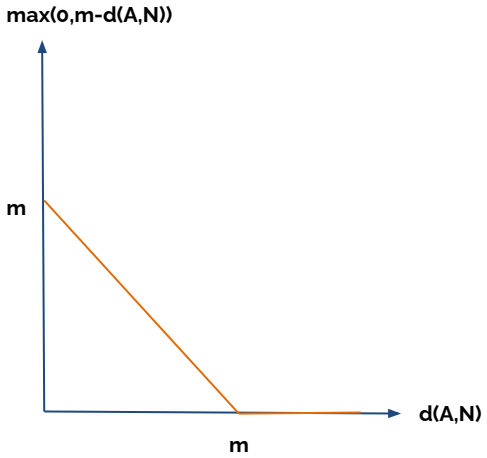


What we want… at Training Time

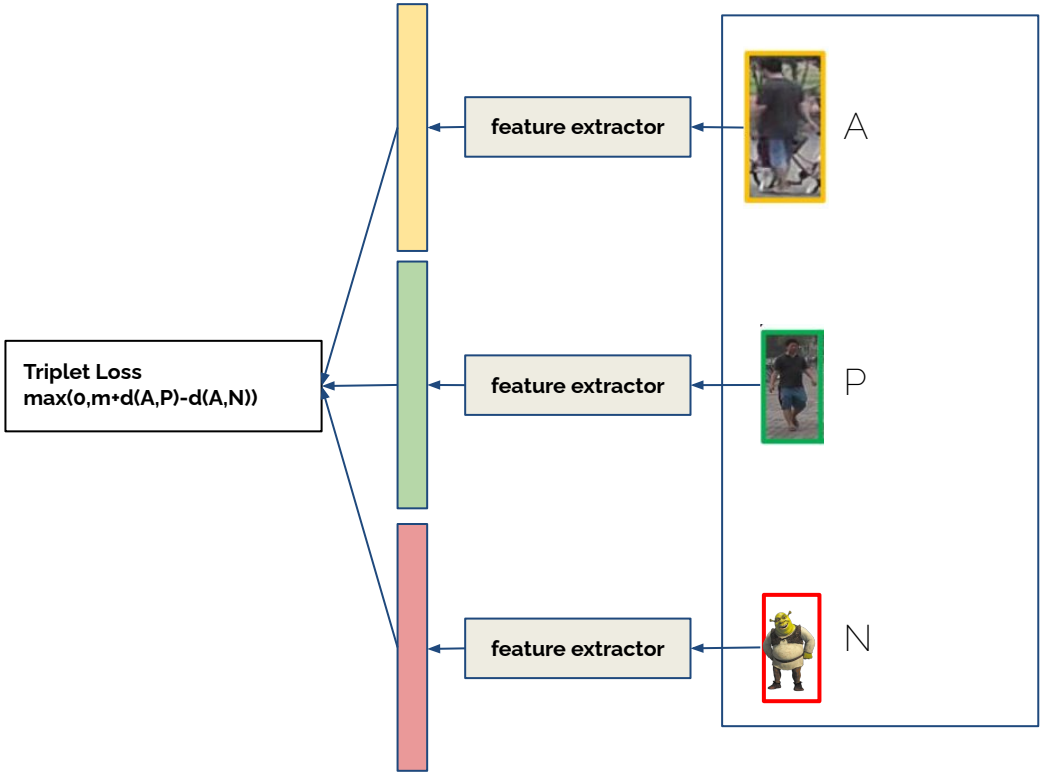


What we want… at Training Time

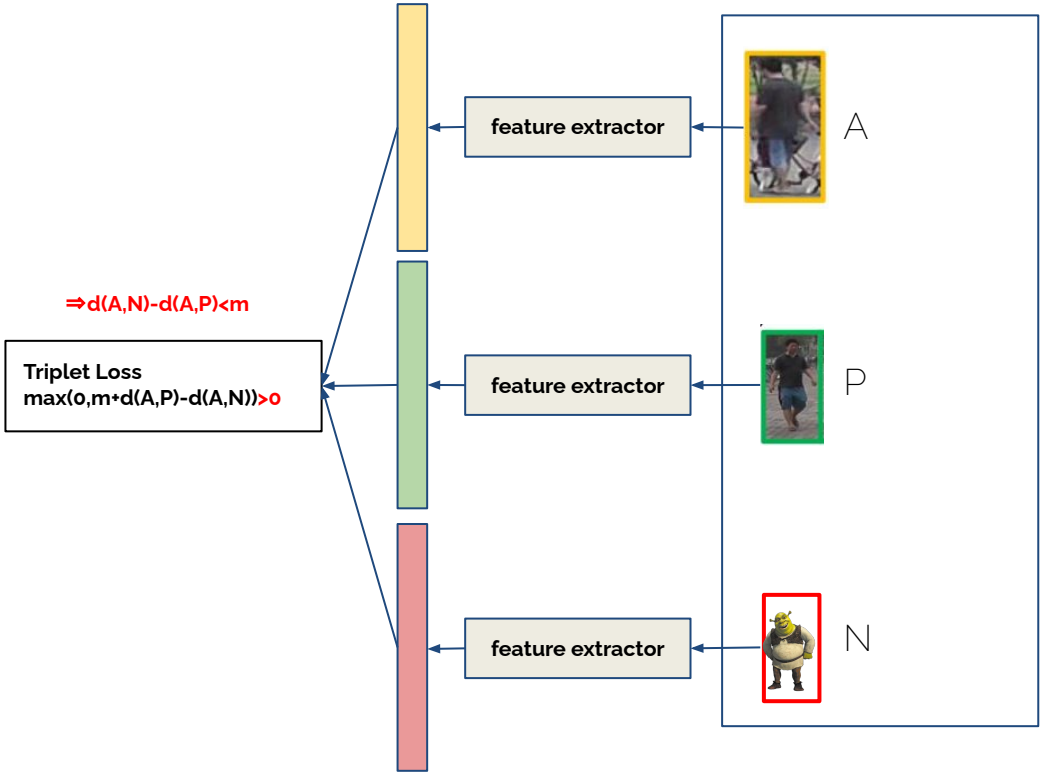




What we want... at Training Time

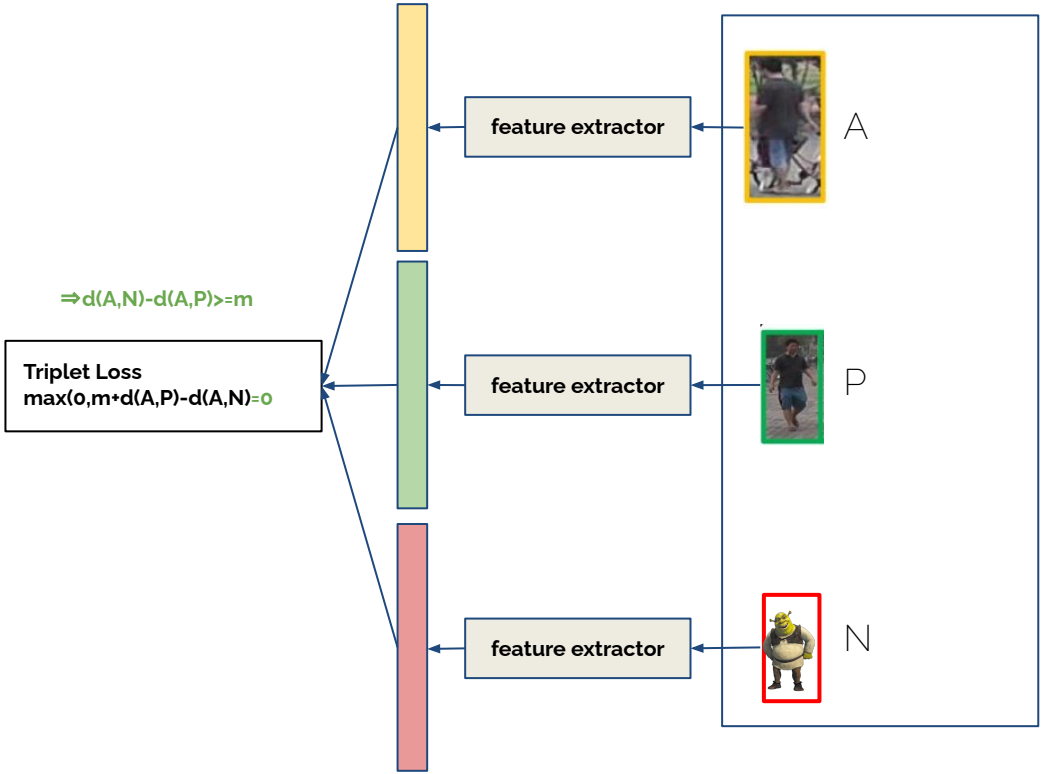


What we want… at Training Time



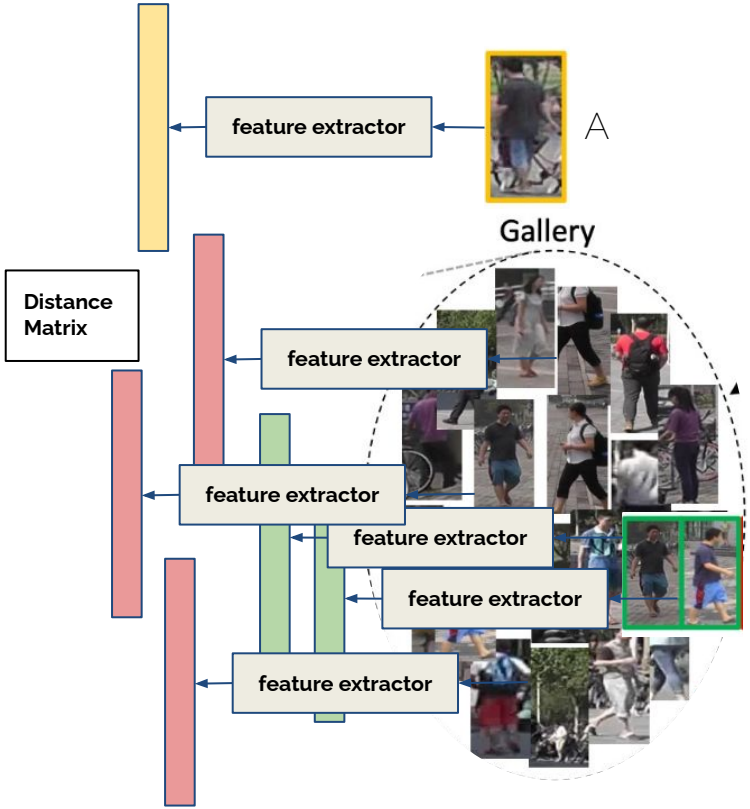
"We want this distance to be at least m"

What we want… at Training Time

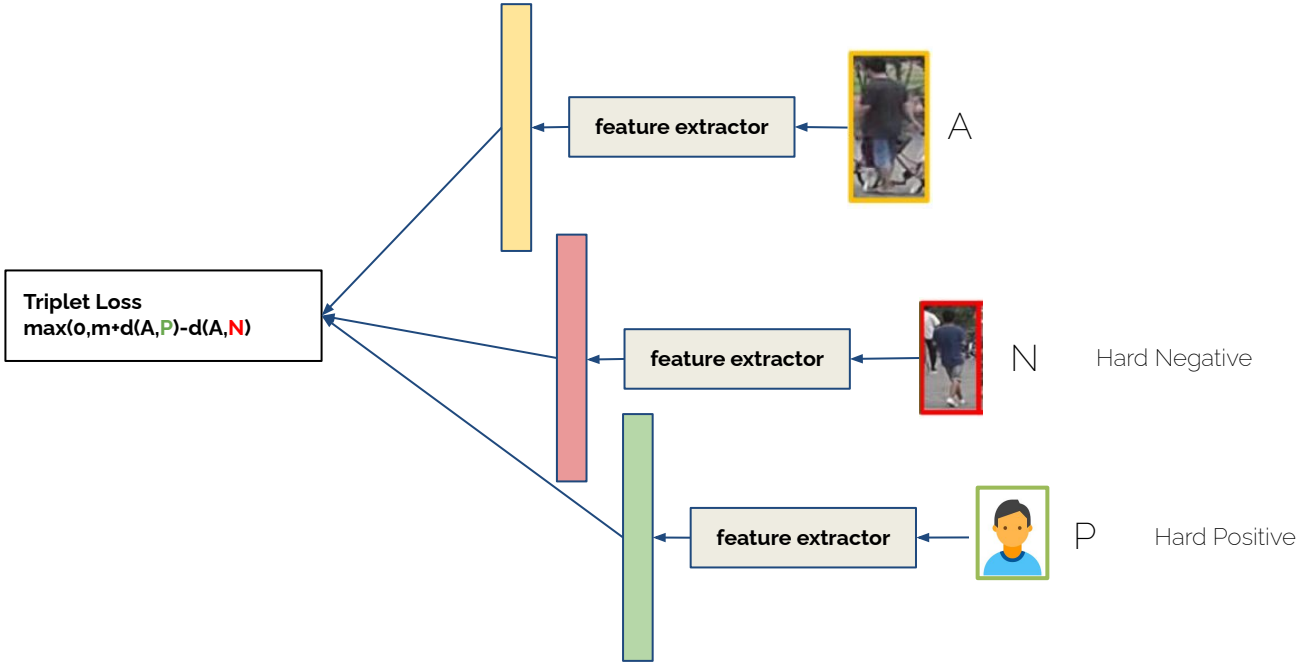


"The distance does not have to be bigger than m"

What we want… at Training Time



What we want… at Training Time



Exercise 2

- Implementing Hungarian Algorithm for bipartite matching
- Training appearance features for matching
- **Using Hungarian Algorithm and Appearance Features**

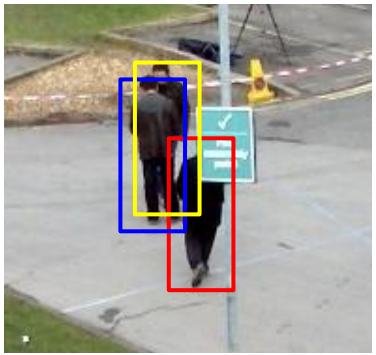
What we want...





0.3/ 0.5	0.7/ 0.5	0.8/ 0.7
0.8/ 0.7	0.5/ 0.3	**0.3**/ 0.8
0.7/ 0.8	0.9/ 0.7	**0.2**/ 0.3

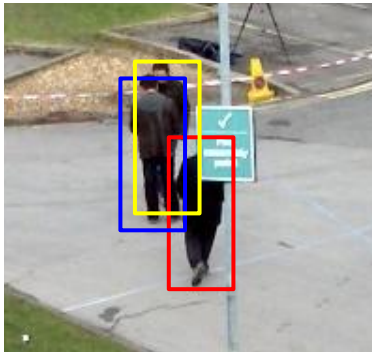
using IoU distance

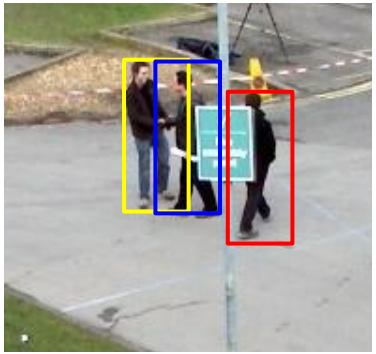


What we want...

0.3/**0.5**	0.7/**0.5**	0.8/0.7
0.8/0.7	0.5/**0.3**	0.3/0.8
0.7/0.8	0.9/0.7	0.2/**0.3**

using ReID distance

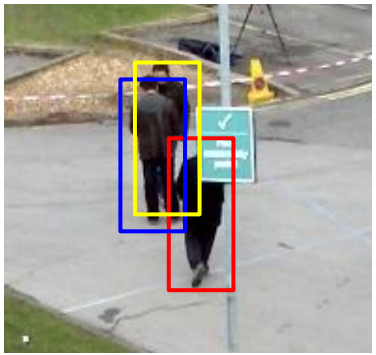


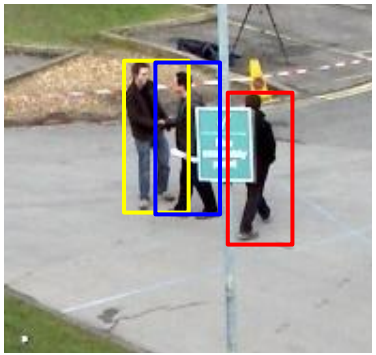


What we want...

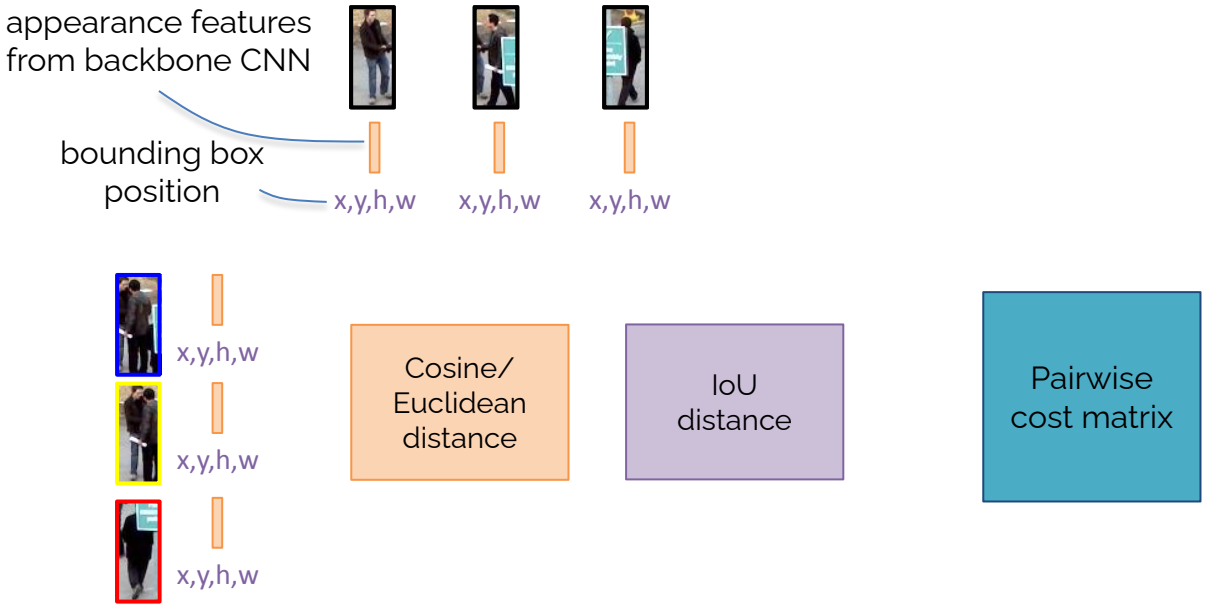
0.3/**0.5**	0.7/**0.5**	0.8/0.7
0.8/0.7	0.5/**0.3**	0.3/0.8
0.7/0.8	0.9/0.7	0.2/**0.3**

Compute distance using ReID and IoU!

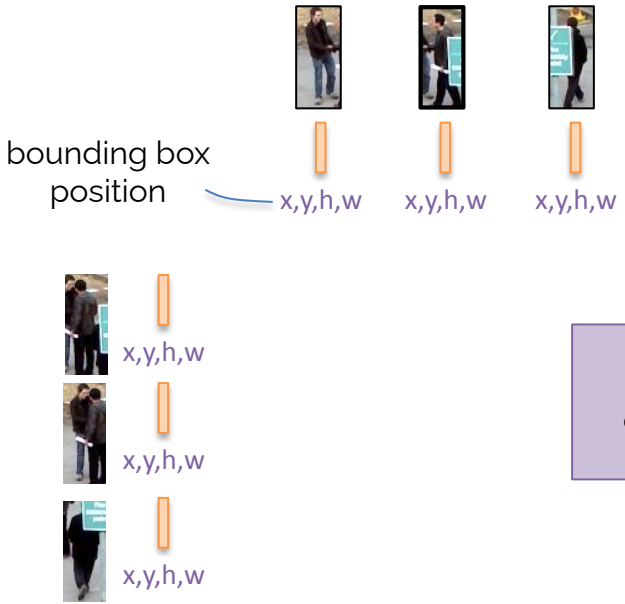




What we want...

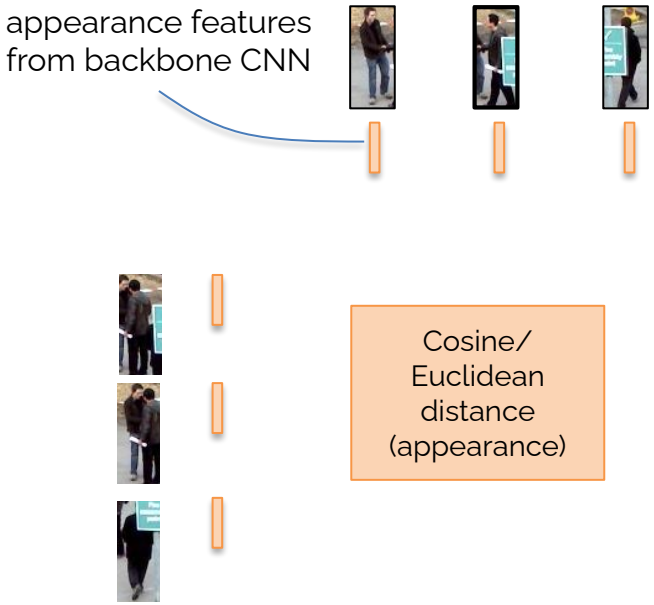

appearance features
from backbone CNN
bounding box
position
x,y,h,w
x,y,h,w
x,y,h,w
x,y,h,w
x,y,h,w
x,y,h,w
Cosine/
Euclidean
distance
IoU
distance
Pairwise
cost matrix

What we want…



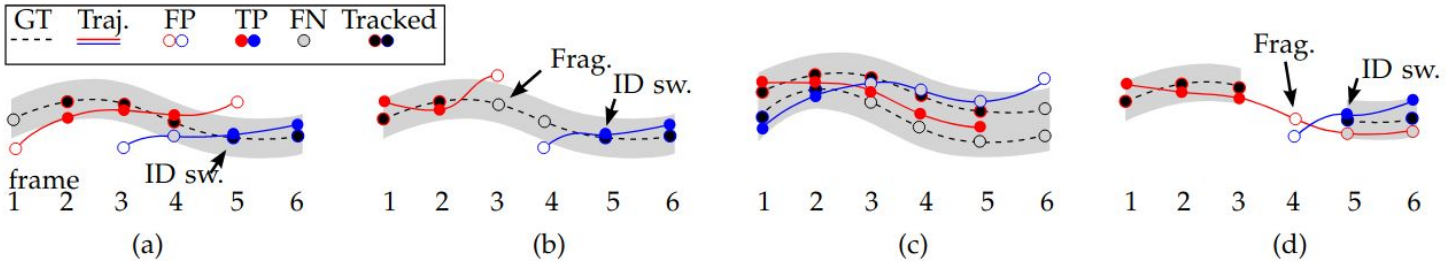
- advanced motion models not covered in this exercise

What we want...



- features from trained ResNet34

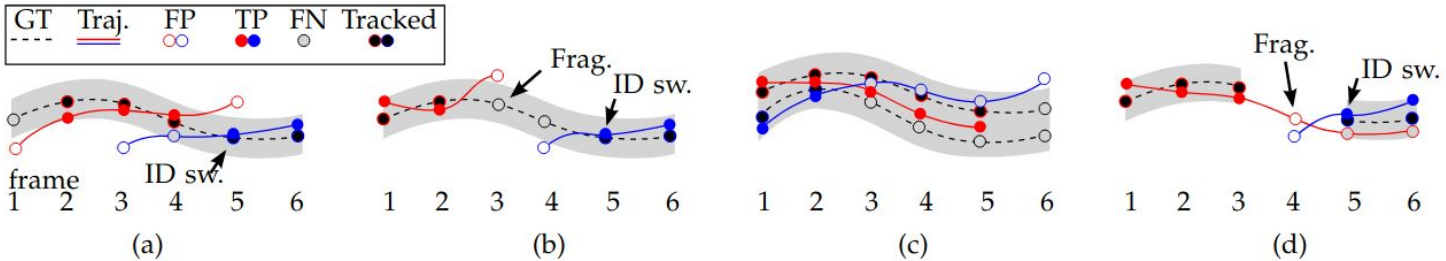
Evaluation Metrics MOT



- FPs: false positives
- FNs: false negatives
- IDsw: identity switches

Evaluation Metrics MOT

- MOTA (higher better)



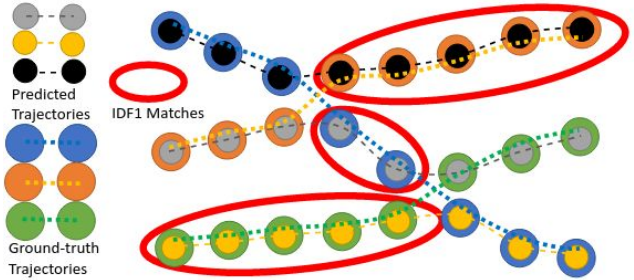
Multi-object tracking accuracy

$$\text{MOTA} = 1 - \frac{\sum_t (\text{FN}_t + \text{FP}_t + \text{IDSW}_t)}{\sum_t \text{GT}_t},$$

Ground truth

Evaluation Metrics MOT

- IDF1 (higher better)



The ratio of correctly identified detections over the average number of ground-truth and computed detections (Paper)

$$\text{ID-Recall} = \frac{|\text{IDTP}|}{|\text{IDTP}| + |\text{IDFN}|}$$

$$\text{ID-Precision} = \frac{|\text{IDTP}|}{|\text{IDTP}| + |\text{IDFP}|}$$

$$\text{IDF1} = \frac{|\text{IDTP}|}{|\text{IDTP}| + 0.5\,|\text{IDFN}| + 0.5\,|\text{IDFP}|}$$

Links

- Test server: https://cv3dst.cvai.cit.tum.de/login
- If you have trouble registering https://forms.gle/yZkZiDiyHxWuNqQG7
- Data for Exercise 02: https://vision.in.tum.de/webshare/g/cv3dst/exercise_02.zip

Links for the individual datasets

- MOT https://vision.in.tum.de/webshare/g/cv3dst/datasets/MOT16.zip
- market https://vision.in.tum.de/webshare/g/cv3dst/datasets/market.zip
- obj_seg https://vision.in.tum.de/webshare/g/cv3dst/datasets/obj_seg.zip
- reid_gnn https://vision.in.tum.de/webshare/g/cv3dst/datasets/reid_gnn.zip