Master's Degree Thesis

Synthetic-to-Real Domain Transfer with Joint Image Translation and Discriminative Learning for Pedestrian Re-Identification

Masters Degree in Data Science and Engineering
Politecnico di Torino

Supervisors:
Prof. Barbara Caputo
Dott. Mirko Zaffaroni

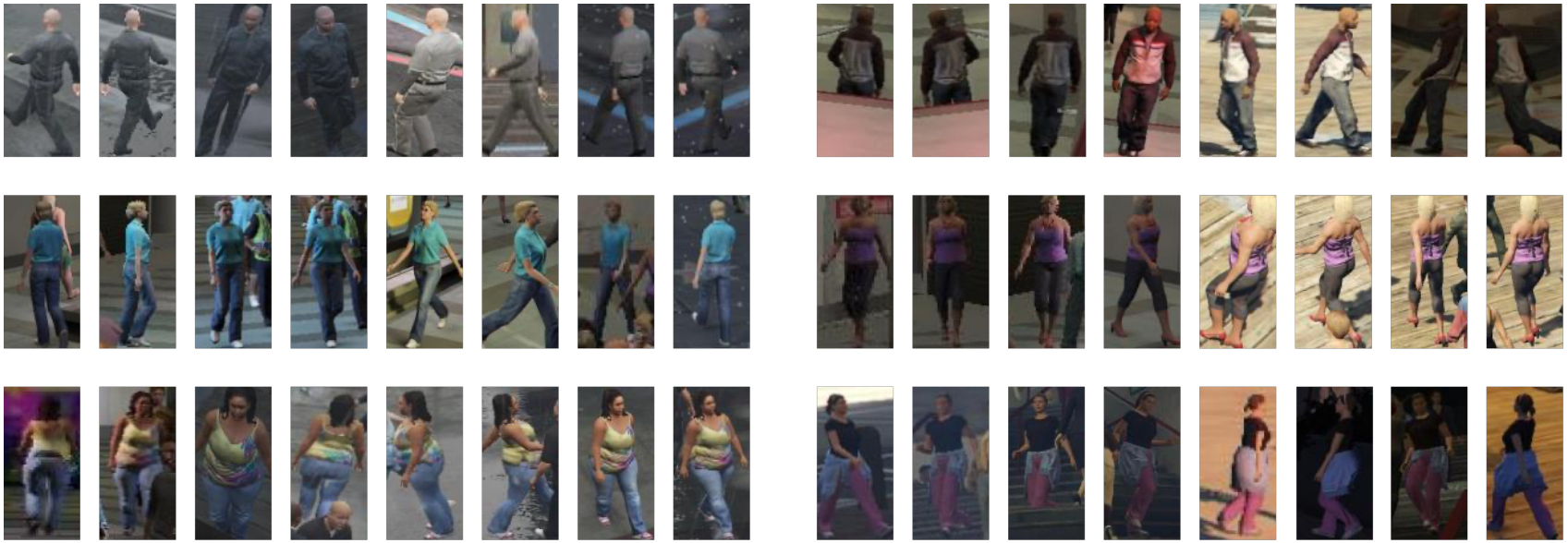
Candidate:
Antonio Dimitris Defonte

Objective: generalize from our synthetic dataset to real-world data using a generative framework applied to pedestrian re-identification.

- Recognizing the same pedestrian across several camera views.
- Person re-identification systems provide further intelligence and security in high-risk areas.
- The thesis and internship were completed at the *Links Foundation*.

GTASynthReid

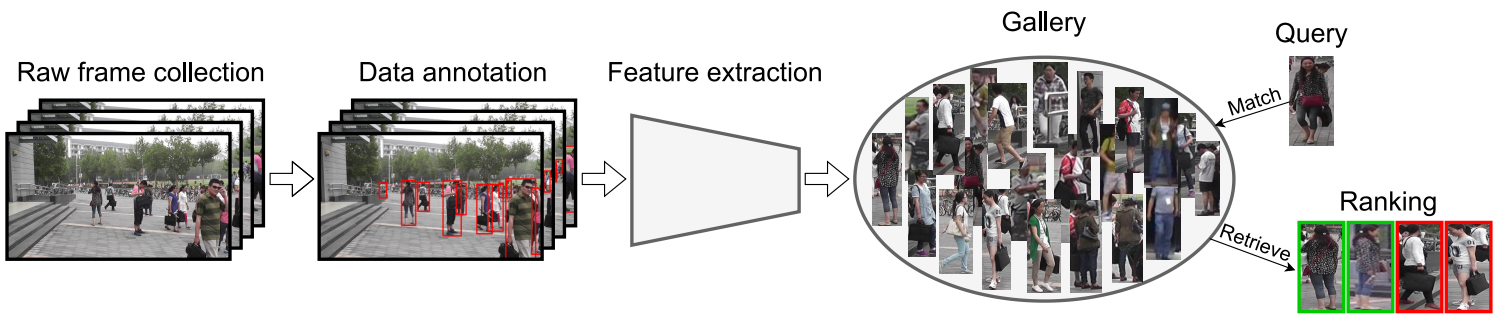
- Exploited the graphic engine of *Grand Theft Auto V*.
- A total of 94312 images with 538 synthetic identities.
- There are 19 camera views, from 2 to 5 for each pedestrian.



Person re-identification

Recognizing the same pedestrian across several camera views.

- Pose, illumination and viewpoint variations.
- Occlusions and person-to-person interactions.
- Training and test sets do not share the same identities.
- Retrieval between query and gallery images.

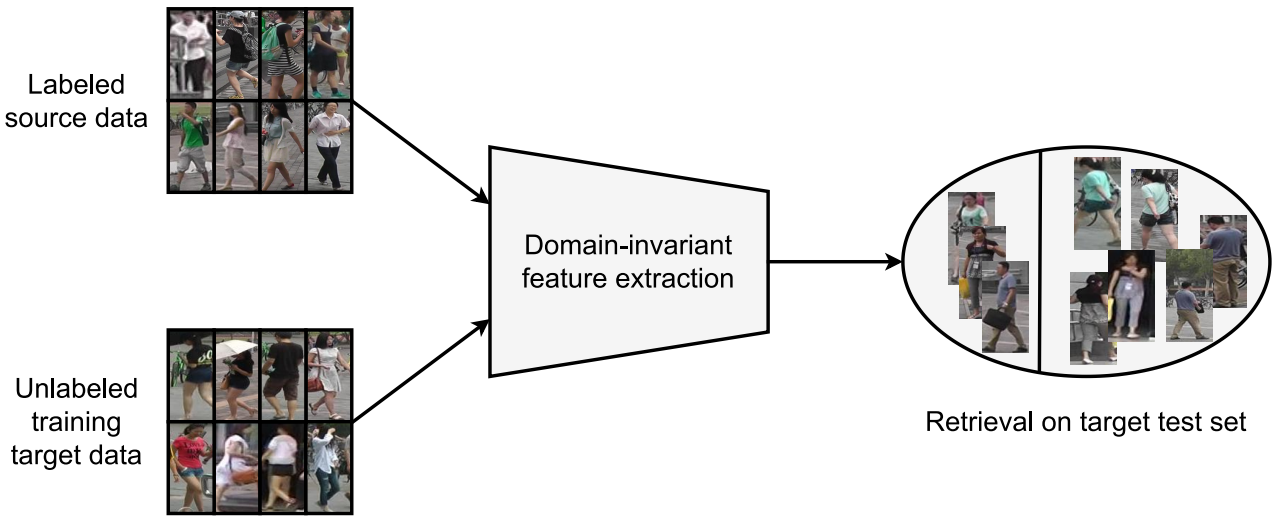


Bounding boxes are from the PRW dataset [1].

Cross-domain techniques

Source-to-target cross-domain techniques.

- Drop in performance when evaluating on other data.
- Evaluate on the test target data (unseen identities).
- Most works embrace generative approaches or *iterative pseudo labeling* techniques.

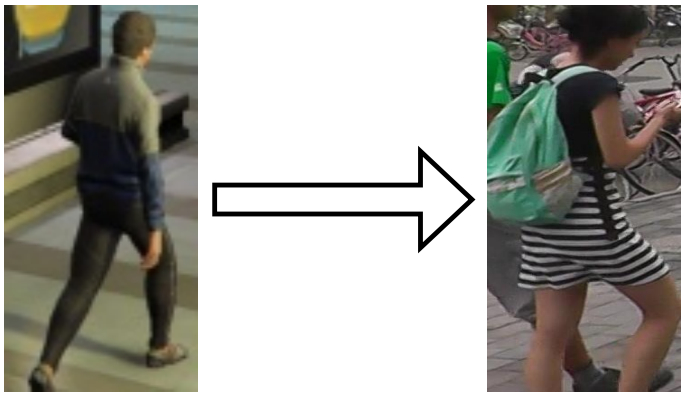


Bounding boxes are from the PRW [1] and Market [2] datasets.

Synthetic data

Adapt from computer-generated characters to real pedestrians.

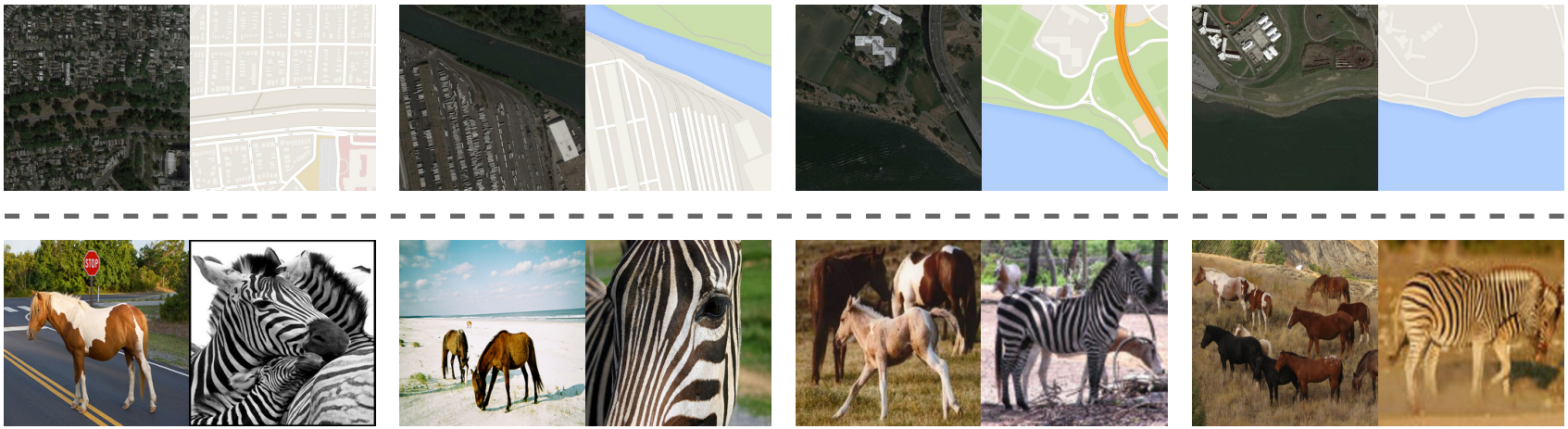
- Collecting data is error-prone and time-consuming.
- Synthetic worlds can model far more environment variations.
- Growing ethical concerns of real-world data.
- Additional complexity for synth-to-real adaptation.



Right bounding box is from the PRW [1] dataset.

Image translation

Matching the style of the target data, it can be paired or unpaired.

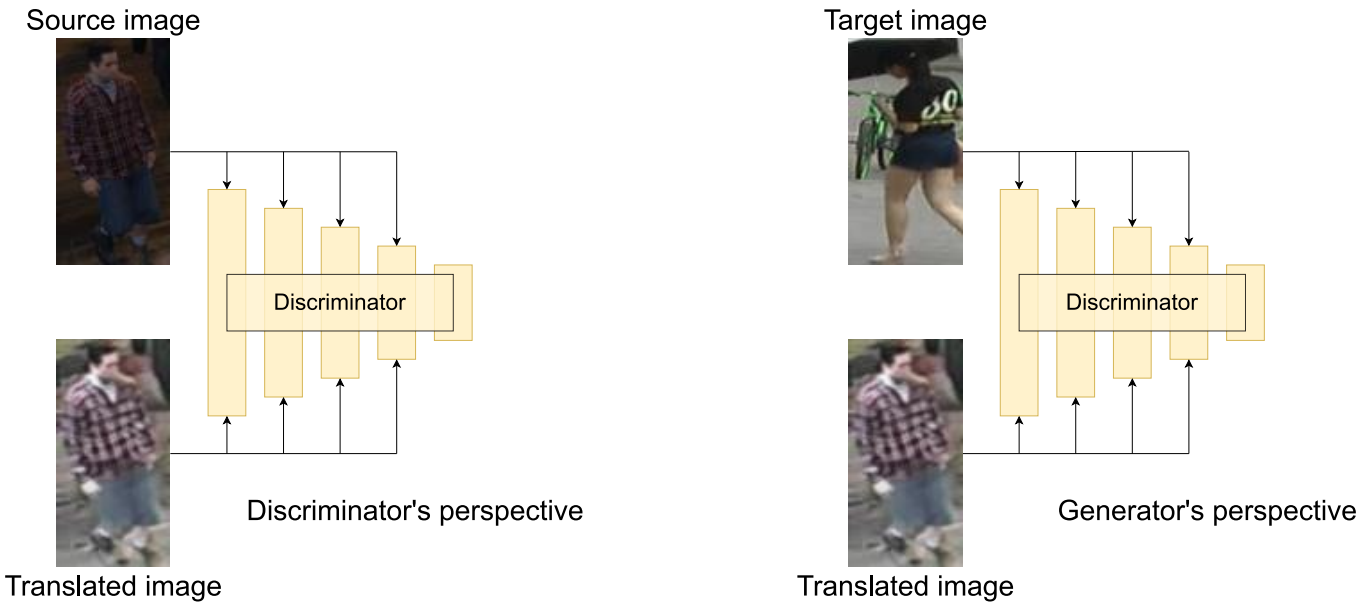


First row: paired image translation [3], second row: unpaired image translation [4].

Domain mapping

Contrastive unpaired translation framework [4] for translation.

- Generator-discriminator structure.
- *PatchGan* discriminator [3].
- Designed a feature matching loss for the discriminator.



Target image is from Market [2].

Relationship preservation

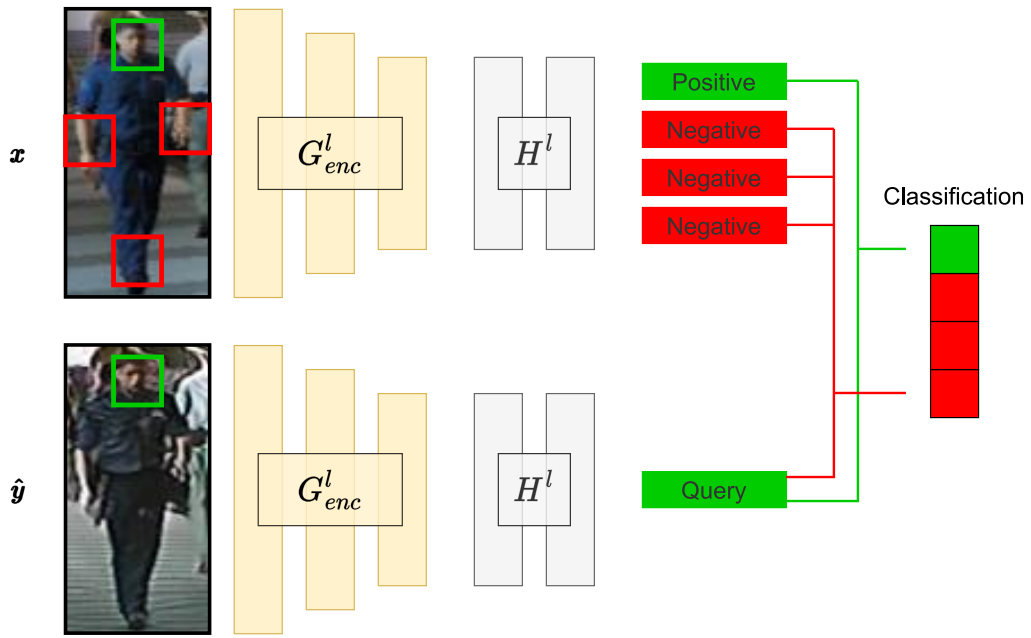
Solely relying on a generator-discriminator architecture does not preserve the original content.

Figure 1: Pairs of original and translated pictures with the basic domain mapping.

Relationship preservation

Constraining the image generation process.

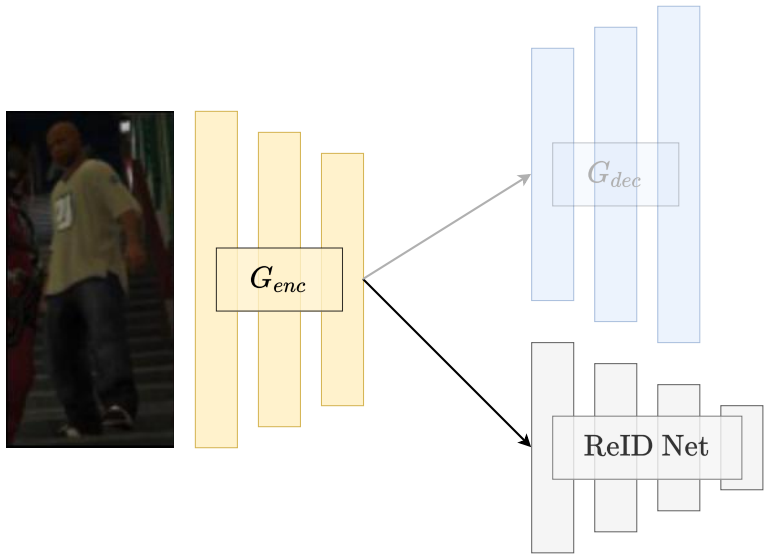
- One-way translation without cycle consistency.
- Corresponding patches of input-output images should be similar.



Discriminative learning

Joint discriminative feature learning with image translation.

- The generator encoder learns features responsible for the translation but they cannot recognize pedestrian identities.
- The last activations of the encoder are passed to a network for standard classification with the source identities.



Existing works

Evaluation on Market, Duke and CUHK03.

- Perform better than earlier domain-transfer methods without having to rely on cycle consistency.
- Evaluated each GTASynthReid-to-target adaptation also on the remaining real-world dataset.

Model	**Source**	Market	
		MaP	R1
SPGAN[5]	Duke	26.9	58.1
Cyclegan[6]	Duke	24.5	52.0
CR-GAN[7]	Duke	33.2	64.5
DG-Net++[8]	MSMT17	64.6	83.1
GLC[9]	Duke	75.4	90.5
Resnet50[10][11]	RandPerson	28.8	55.6
JVTC[12][13]	UnrealPerson	80.2	93.0
Ours	Market	**42.6**	**61.2**

Model	**Target**	Market	
		MaP	R1
Baseline	-	23.3	39.4
Ours	Market	**42.6**	**61.2**
Ours	Duke	40.7	59.5
Ours	CUHK03	41.6	60.0

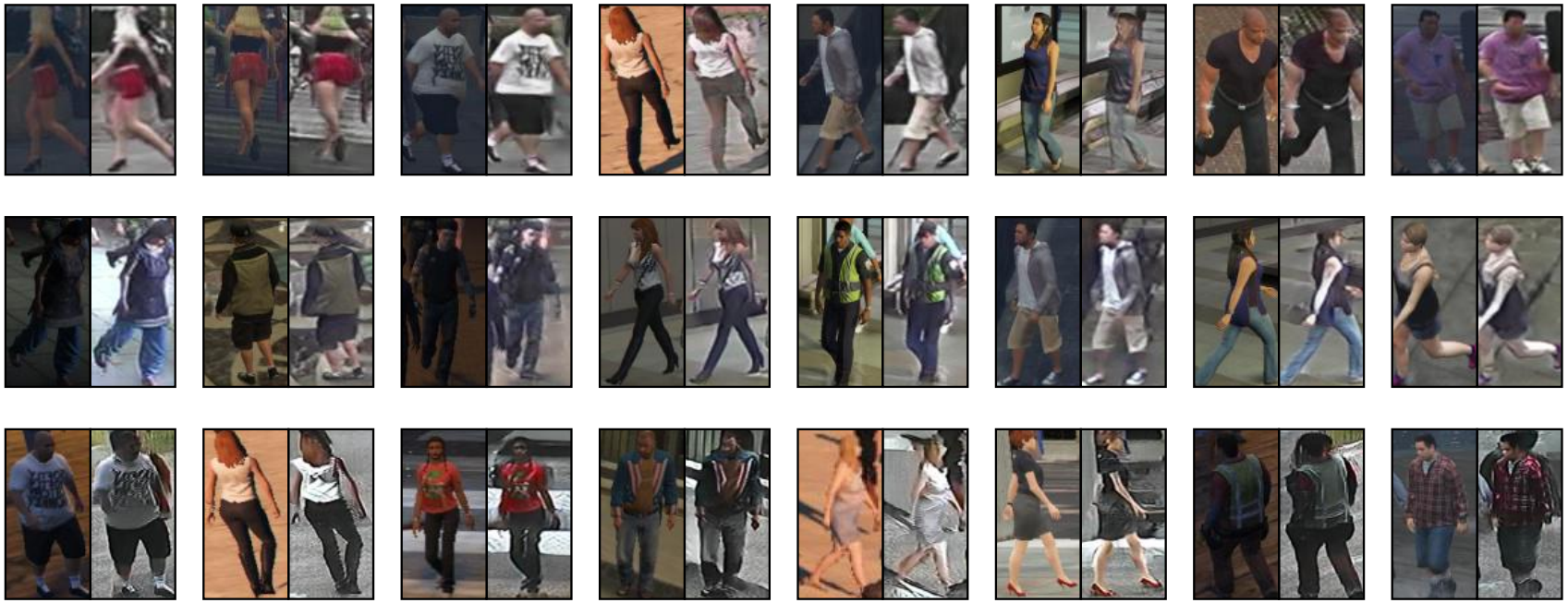
Qualitative results

The resulting pictures are closer to the real-world data.

- Computed Fréchet Inception Distance before translation.
- Computed Fréchet Inception Distance after translation.

Translation	Target	FID
GTASynthReid	Market	45.14
GTASynthReid-to-Market	Market	**24.29**
GTASynthReid	Duke	50.44
GTASynthReid-to-Duke	Duke	**19.53**
GTASynthReid	CUHK03	63.23
GTASynthReid-to-CUHK03	CUHK03	**31.54**

Qualitative results



Original (left) and translated (right) images from our GTASynthReid to Market, Duke and CUHK03 (first, second and third rows).

Remarks

- Extended a Pytorch framework [14] for person re-identification to allow learning via translation from synthetic data.
- Employed the contrastive unpaired translation framework [4] for pedestrian re-identification.
- Designed a feature matching loss that increased performance.
- Achieved better results than some earlier methods with a simpler model.
- Translated images capture the style of the target data.

Future directions

- Design more pedestrians to embed in the video game.
- Develop a method for pose and appearance disentanglement without cycle consistency or external information.
- The adopted framework could be inconsistent with this kind of objective.

Thank You

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[14] K. Zhou, Y. Yang, A. Cavallaro, and T. Xiang, "Learning generalisable omni-scale representations for person re-identification," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, pp. 1–1, 2021.