Deep Joint Discriminative Learning for Vehicle Re-identification and Retrieval

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Outline

Background

Deep Joint Discriminative Learning

Experimental Results

Conclusion

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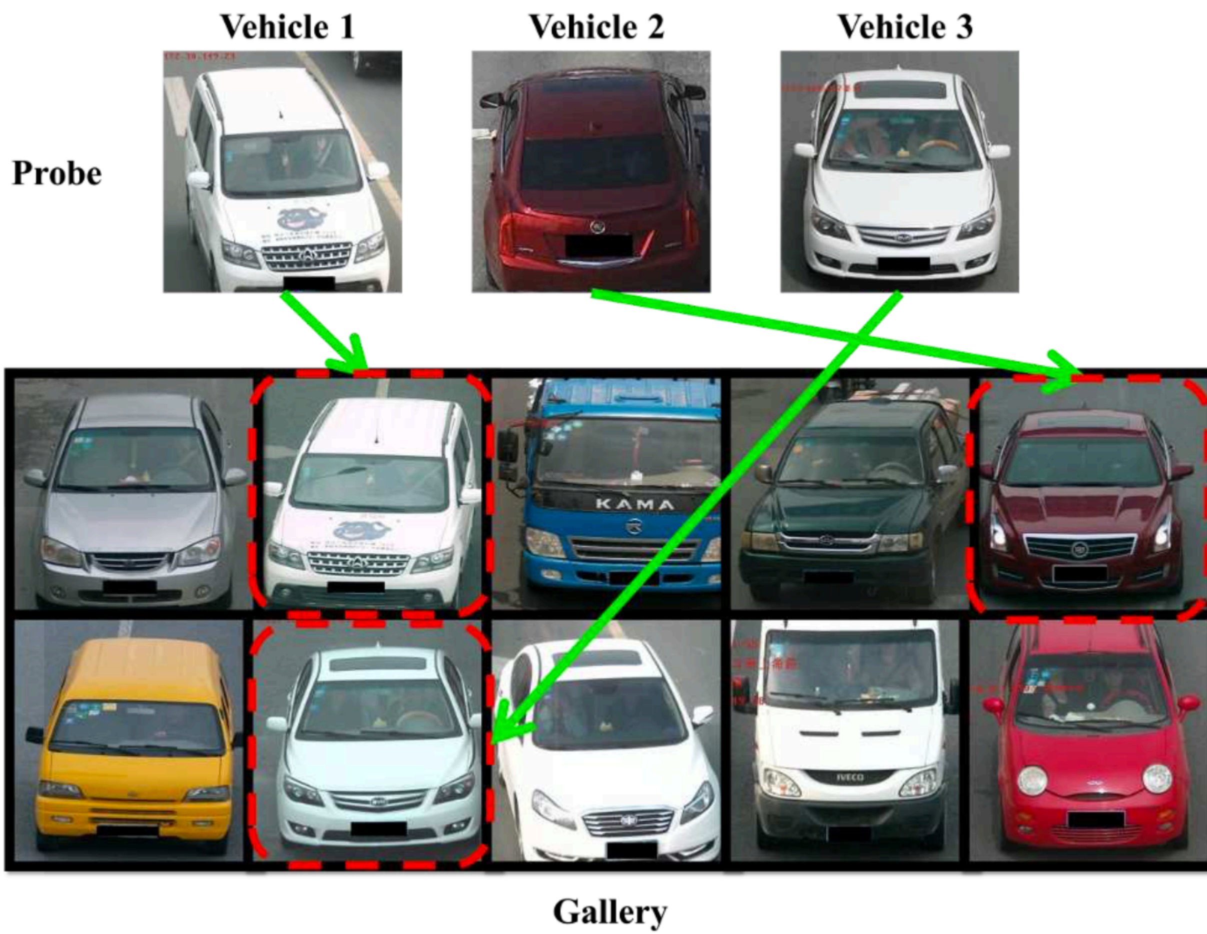
Vehicle search and re-identification



Vehicle search and re-identification

- Practical applications in video surveillance systems
- Challenge
  - License plate is not clear
    - Low-resolution
    - Occluded or removed
  - →Vehicle ReID based on **appearance information**

Vehicle search and re-identification

- VehicleID dataset
  - Labeled in identity level
  - Remove license plate

Hongye Liu et al. “Deep relative distance learning: Tell the difference between similar vehicles,” in *CVPR*, 2016.

Related work

- Most identification works focus on face or person
  - Face recognition
  - Person re-identification
- Target: learn discriminative representations
  - State-of-art → Deep CNN based
  - DeepID [Sun et. al, 2014]
    - Directly classify identities (~1w)
  - DeepID2 [Sun et. al, 2014]
    - Pairwise verification loss
  - Triplet loss [Schroff et. al, 2015, Ding et. al 2015]
    - Triplet relationship between positive and negative pairs

Related work

- Difference of vehicle identification
  - Previous works focus on **model** classification
    - Recognize models instead of identities
  - Vehicles of same model → similar visual appearance
  - Capture special marks

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- Large scale vehicle identification dataset
  - VehicleID [Liu et al. 2016]
  - Facilitate deep learning models

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    - Recognize model instead of identities
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- Large scale vehicle identification dataset
  - VehicleID [Liu et al. 2016]
  - Facilitate deep learning models

- Deep Joint Discriminative Learning (DJDL) model
  - A unified framework to extract discriminative features

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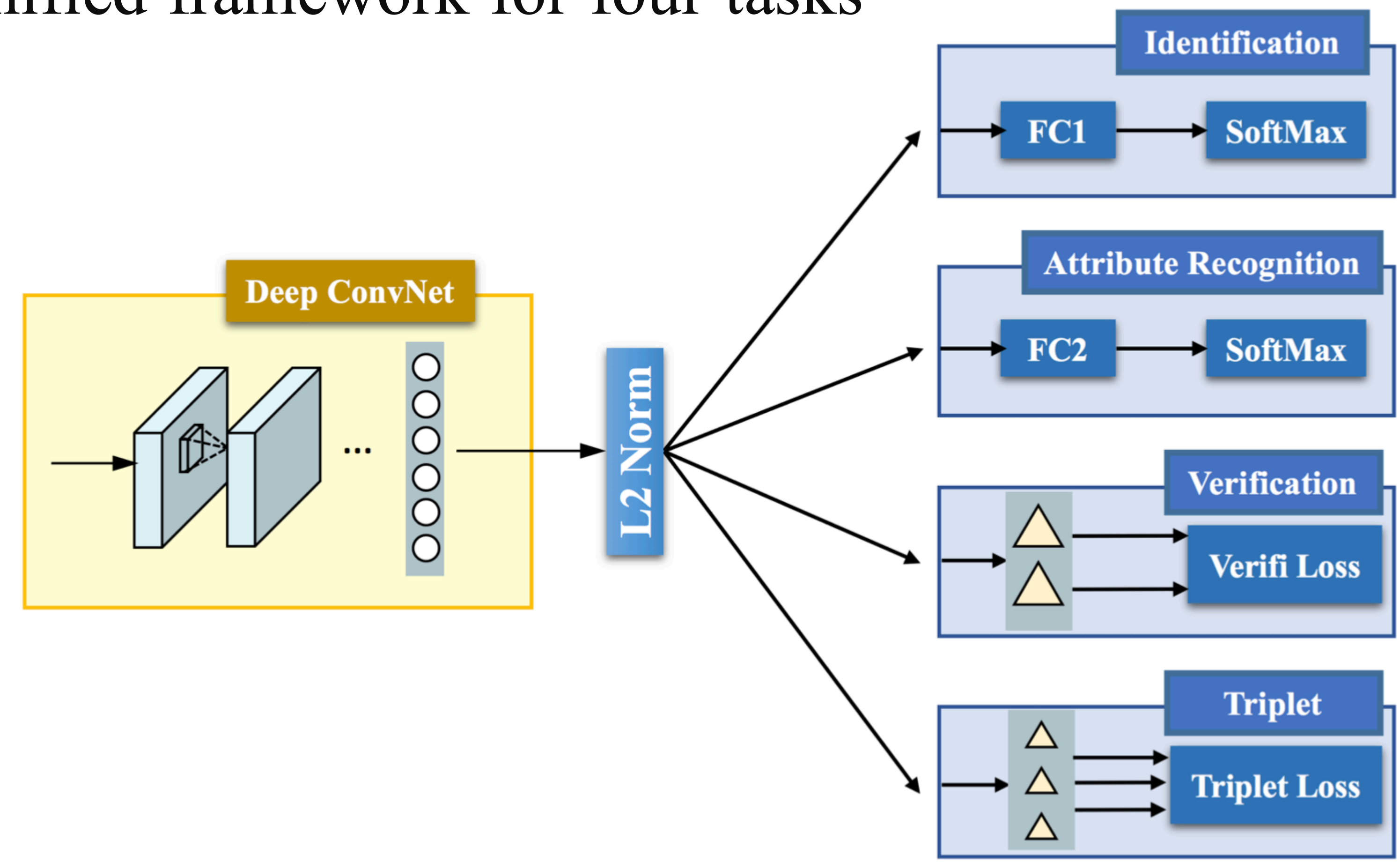
Architecture Overview

- Unified framework for four tasks



Network Architecture

- Unified framework for four tasks
  - Shared base convolution network
    - A common CNN pretrained on ImageNet
  - Classification tasks
    - Identification
    - Attribute recognition
  - Verification subnetwork
    - Two images
  - Triplet subnetwork
    - Three images

Network Architecture

- Identification subnetwork
  - Each input image → Identity label
  - Conventional recognition task
    - Softmax + cross-entropy loss

$$L_{identi}(f_i) = -\sum_{j=1}^{n} p_j \log \hat{p_j}$$

target label

Predicted probability

Network Architecture

- Attribute recognition subnetwork
  - Jointly recognize vehicle attributes
    - Such as color and vehicle model

$$L_{attri}(f_i) = -\sum_{k=1}^{n_{attri}} \sum_{j=1}^{n_k} a_j^k \log \hat{a}_j^k$$

Network Architecture

- Verification subnetwork
  - Pair-wise siamese network
    - Use Euclidean distance after normalization
      - Distance → small if same identity
      - Distance → large if different identity

$$L_{verif}(f_i, f_j) = \begin{cases} \frac{1}{2}\|f_i - f_j\|_2^2, & v_i == v_j, \\ \frac{1}{2} max(0, \alpha - \|f_i - f_j\|_2)^2, & v_i \neq v_j, \end{cases}$$

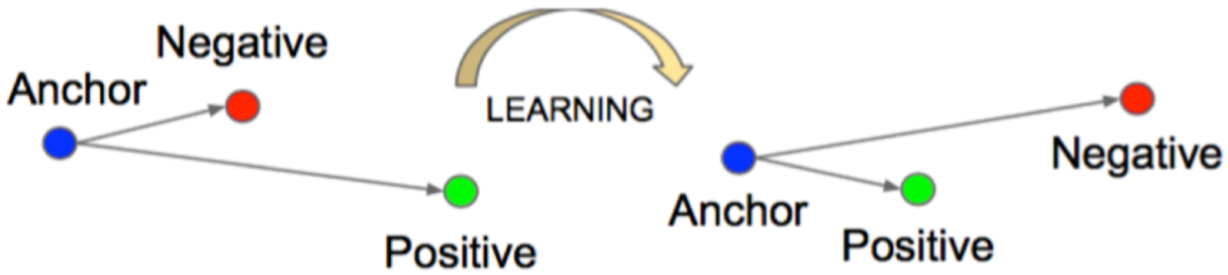
Margin parameter
enforce distance > α

Network Architecture

- Triplet subnetwork
  - Anchor + positive + negative

$$L_{triplet}(f_i, f_j, f_k) = max(0, \|f_i - f_j\|_2^2 - \|f_i - f_k\|_2^2 + \beta)$$

Margin parameter



Training and Optimization

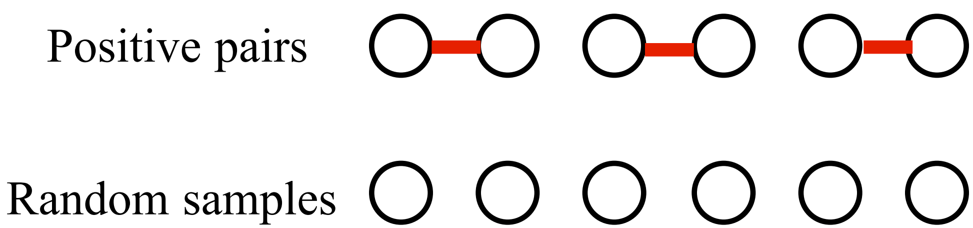
- Objective function

$$L = L_{identi} + L_{attri} + L_{verif} + L_{triplet}$$

  - SGD optimization
  - Jointly learning in a single batch
    - Specific batch composition design

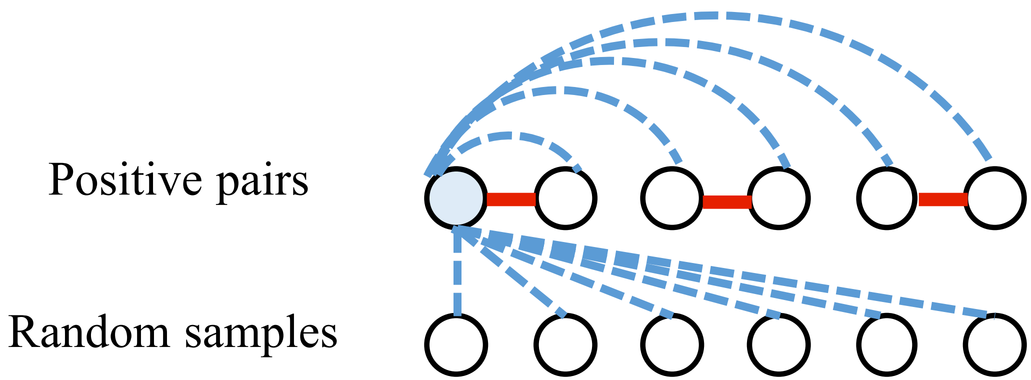
Training and Optimization

- Batch composition design
  - Satisfy four tasks at the same time
    - Half positive pairs + half random samples



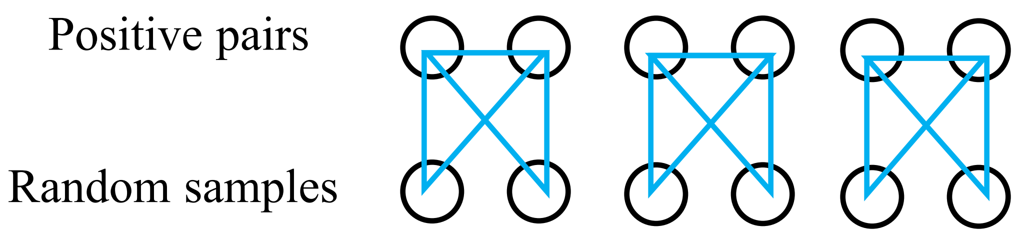
Training and Optimization

- Batch composition design
  - Satisfy four tasks at the same time
    - Verification samples



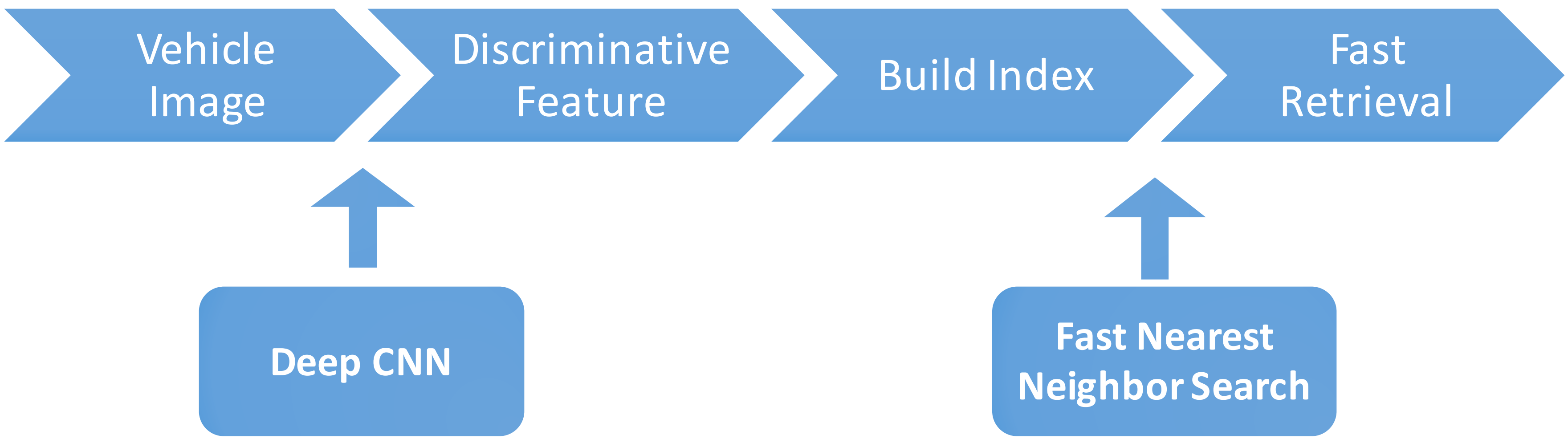
Training and Optimization

- Batch composition design
  - Satisfy four tasks at the same time
    - Triplet samples



Vehicle Retrieval

- Discriminative features → Build index
  - Vehicle Retrieval
    - Nearest neighbor search



Marius Muja and David G Lowe, "Fast approximate nearest neighbors with automatic algorithm configuration," in *VISAPP*, 2009.

Outline

Experimental settings

- VehicleID Dataset
  - 221763 images of 26267 vehicles
  - Three test sets
    - Small, medium, large size
- Two tasks
  - Vehicle retrieval
  - Vehicle re-identification

Experimental settings

- Implementation Details
  - MXNet platform
  - Base convolutional network
    - Inception-BN
  - Augmentation
    - Random crop
    - Random flip
  - Batch size: 64
  - Margin parameters α, β as 0.9

Vehicle Retrieval

- Evaluation protocol
  - Mean average precision (MAP)
- Ablation results

Method	Small	Medium	Large
Identi	0.712	0.684	0.670
Identi+Attri	0.718	0.686	0.672
Identi+Attri+Verifi	0.731	0.705	0.689
Identi+Attri+Verifi+Triplet	**0.786**	**0.747**	**0.720**

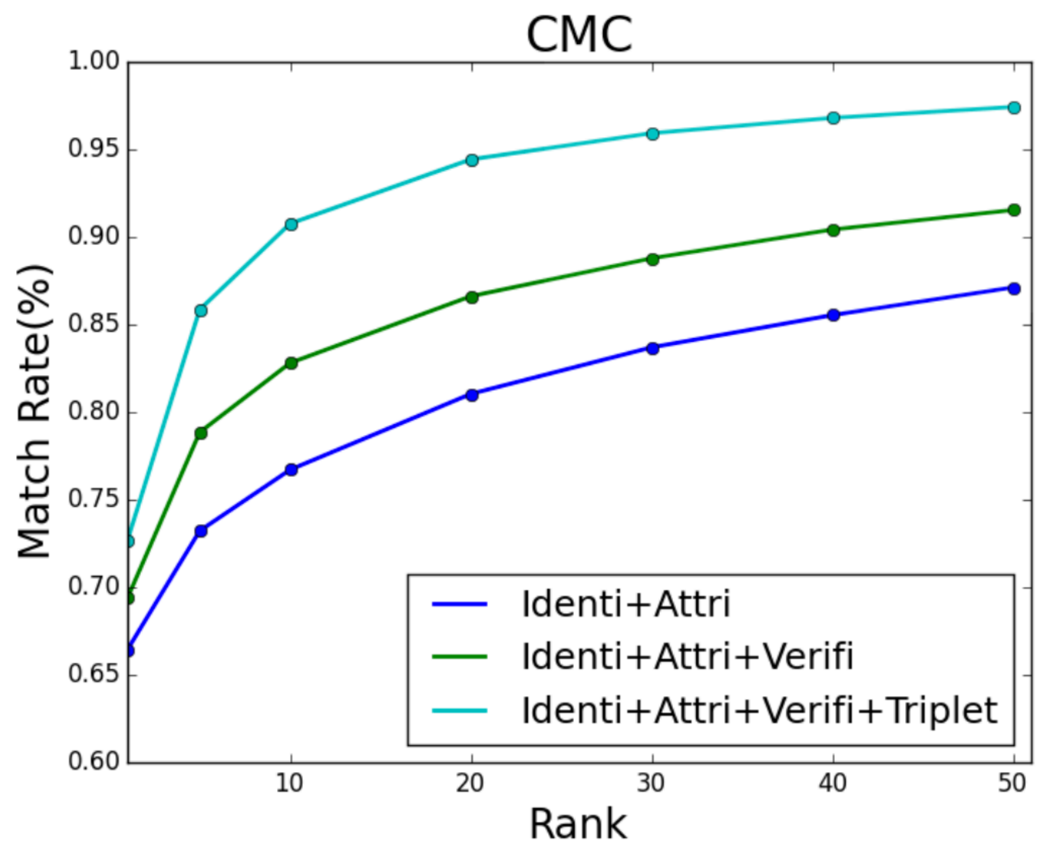
Vehicle Retrieval

- Compare with state-of-art

Method	Small	Medium	Large
VGG+CCL [1]	0.492	0.448	0.386
Mixed Diff+CCL [1]	0.546	0.481	0.455
HDC + Contrastive [16]	0.655	0.631	0.575
Identi+Attri+Verifi+Triplet	**0.786**	**0.747**	**0.720**

Vehicle Re-identification

- Evaluation protocols
  - CMC curve



Vehicle Re-identification

- Evaluation protocols
  - Top1 and Top 5 match rates

Method	Protocol	Small	Medium	Large
VGG+CCL [1]		0.436	0.370	0.329
Mixed Diff+CCL [1]		0.490	0.428	0.382
Identi+Attr	Top 1	0.670	0.667	0.651
Identi+Attr+Verifi		0.689	0.687	0.661
Identi+Attr+Verifi+Triplet		**0.723**	**0.708**	**0.680**
VGG+CCL [1]		0.642	0.571	0.533
Mixed Diff+CCL [1]		0.735	0.668	0.616
Identi+Attr	Top 5	0.735	0.729	0.716
Identi+Attr+Verifi		0.781	0.765	0.737
Identi+Attr+Verifi+Triplet		**0.857**	**0.818**	**0.789**

Conclusion

- A novel Deep Joint Discriminative Learning model
  - For vehicle re-identification and retrieval
  - A unified framework by incorporating four tasks
    - Different properties → benefit each other
    - Jointly optimize
      - specific designed batch composition
- Experiments validate the effectiveness of DJDL model
  - State-of-the-art results on two tasks

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Project Page: http://www.icst.pku.edu.cn/struct/Projects/djdl.html