
NCIG 2020
第二十届全国图象图形学学术会议
The 20th National Conference on Image and Graphics
图像图形智能处理
6月28日-30日
线上召开
主办单位：中国图象图形学学会
承办单位：新疆大学
协办单位：南京理工大学
金牌赞助：清新互联
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NCIG 2020

第二十届全国图象图形学学术会议

The 20th National Conference on Image and Graphics

智慧城市中的车辆搜索

分享嘉宾： **刘鑫辰 研究员**

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00 | 个人简介

刘鑫辰

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视觉与多媒体实验室
京东人工智能研究院

- 2018年6月　于北京邮电大学-智能通信软件与多媒体北京市重点实验室取得博士学位
- 2018年7月　通过技术博士管培生项目加入京东人工智能研究院
- 2019年3月　任京东人工智能研究院-视觉与多媒体实验室研究员

- 主要研究方向包括车辆和行人重识别、车辆和行人解析、商品搜索等
- 在重要期刊和国际会议IEEE TIP, IEEE TMM, CVPR, ACM MM, ECCV等发表论文十余篇
- 曾获 IEEE Trans. on Multimedia 2018 Multimedia Prize Paper Award
  IEEE ICME 2016 Best Student Paper Award
  2019年获中国图象图形学会优秀博士论文奖

何为车辆搜索/重识别？

查询车辆

车辆搜索

在大规模城市视频监控网络中快速识别、定位、跟踪目标车辆

有何应用？

智能安防

智慧停车

智能园区

智慧城市

有何挑战？

挑战一：

- 车辆外观的多样性与相似性

挑战二：

- 监控环境下外观的多变性

车辆重识别是一项极具挑战的任务！

基于外观的车辆重识别方法

1. Global Appearance + Metric Learning

- **Xinchen Liu,** Wu Liu, Huadong Ma, Huiyuan Fu: Large-scale vehicle re-identification in urban surveillance videos. ICME 2016: 1-6
- Hongye Liu, Yonghong Tian, Yaowei Wang, Lu Pang, Tiejun Huang: Deep Relative Distance Learning: Tell the Difference between Similar Vehicles. CVPR 2016: 2167-2175
- Ke Yan, Yonghong Tian, Yaowei Wang, Wei Zeng, Tiejun Huang: Exploiting Multi-grain Ranking Constraints for Precisely Searching Visually-similar Vehicles. ICCV 2017: 562-570
- Haiyun Guo, Chaoyang Zhao, Zhiwei Liu, Jinqiao Wang, Hanqing Lu: Learning coarse-to-fine structured feature embedding for vehicle re-identification. AAAI 2018.
- Yan Bai, Yihang Lou, Feng Gao, Shiqi Wang, Yuwei Wu, Ling-Yu Duan: Group-Sensitive Triplet Embedding for Vehicle Reidentification. IEEE Trans. Multimedia 20(9): 2385-2399 (2018)
- Jianqing Zhu, Huanqiang Zeng, Jingchang Huang, Shengcai Liao, Zhen Lei, Canhui Cai, Lixin Zheng: Vehicle Re-identification Using Quadruple Directional Deep Learning Features. IEEE TITS (2019)

2. Local or Multi-view Appearance

- Xiaobin Liu, Shiliang Zhang, Qingming Huang, Wen Gao: RAM: A Region-Aware Deep Model for Vehicle Re-Identification. ICME 2018: 1-6
- Yi Zhou, Ling Shao: Viewpoint-Aware Attentive Multi-View Inference for Vehicle Re-Identification. CVPR 2018: 6489-6498
- Bing He, Jia Li, Yifan Zhao, Yonghong Tian: Part-Regularized Near-Duplicate Vehicle Re-Identification. CVPR 2019: 3997-4005
- Yi Zhou, Li Liu, Ling Shao: Vehicle Re-Identification by Deep Hidden Multi-View Inference. IEEE Trans. Image Process. 27(7): 3275-3287 (2018)
- Yihang Lou, Yan Bai, Jun Liu, Shiqi Wang, Lingyu Duan: VERI-Wild: A Large Dataset and a New Method for Vehicle Re-Identification in the Wild. CVPR 2019: 3235-3243
- Yihang Lou, Yan Bai, Jun Liu, Shiqi Wang, Ling-Yu Duan: Embedding Adversarial Learning for Vehicle Re-Identification. IEEE Trans. Image Process. 28(8): 3794-3807 (2019)
- Zheng Tang, Milind Naphade, Stan Birchfield, Jonathan Tremblay, William Hodge, Ratnesh Kumar, Shuo Wang, Xiaodong Yang: PAMTRI: Pose-Aware Multi-Task Learning for Vehicle Re-Identification Using Highly Randomized Synthetic Data. ICCV 2019: 211-220

基于多模态信息的车辆搜索方法

- **Xinchen Liu**, Wu Liu, Tao Mei, Huadong Ma: A Deep Learning-Based Approach to Progressive Vehicle Re-identification for Urban Surveillance. ECCV (2) 2016: 869-884
- Zhongdao Wang, Luming Tang, Xihui Liu, Zhuliang Yao, Shuai Yi, Jing Shao, Junjie Yan, Shengjin Wang, Hongsheng Li, Xiaogang Wang: Orientation Invariant Feature Embedding and Spatial Temporal Regularization for Vehicle Re-identification. ICCV 2017: 379-387
- Chih-Wei Wu, Chih-Ting Liu, Cheng-En Chiang, Wei-Chih Tu, Shao-Yi Chien: Vehicle Re-Identification With the Space-Time Prior. CVPR Workshops 2018: 121-128
- Zhongdao Wang, Luming Tang, Xihui Liu, Zhuliang Yao, Shuai Yi, Jing Shao, Junjie Yan, Shengjin Wang, Hongsheng Li, Xiaogang Wang: Orientation Invariant Feature Embedding and Spatial Temporal Regularization for Vehicle Re-identification. ICCV 2017: 379-387
- Wu Liu, **Xinchen Liu**, Huadong Ma, Peng Cheng: Beyond Human-level License Plate Super-resolution with Progressive Vehicle Search and Domain Priori GAN. ACM Multimedia 2017: 1618-1626
- **Xinchen Liu**, Wu Liu, Tao Mei, Huadong Ma: PROVID: Progressive and Multimodal Vehicle Reidentification for Large-Scale Urban Surveillance. IEEE Trans. Multimedia 20(3): 645-658 (2018)
- Zheng Tang, Milind Naphade, Ming-Yu Liu, Xiaodong Yang, Stan Birchfield, Shuo Wang, Ratnesh Kumar, David C. Anastasiu, Jenq-Neng Hwang: CityFlow: A City-Scale Benchmark for Multi-Target Multi-Camera Vehicle Tracking and Re-Identification. CVPR 2019: 8797-8806

大规模多模态车辆重识别数据集—— VeRi [Liu et al., ICME16&ECCV16]

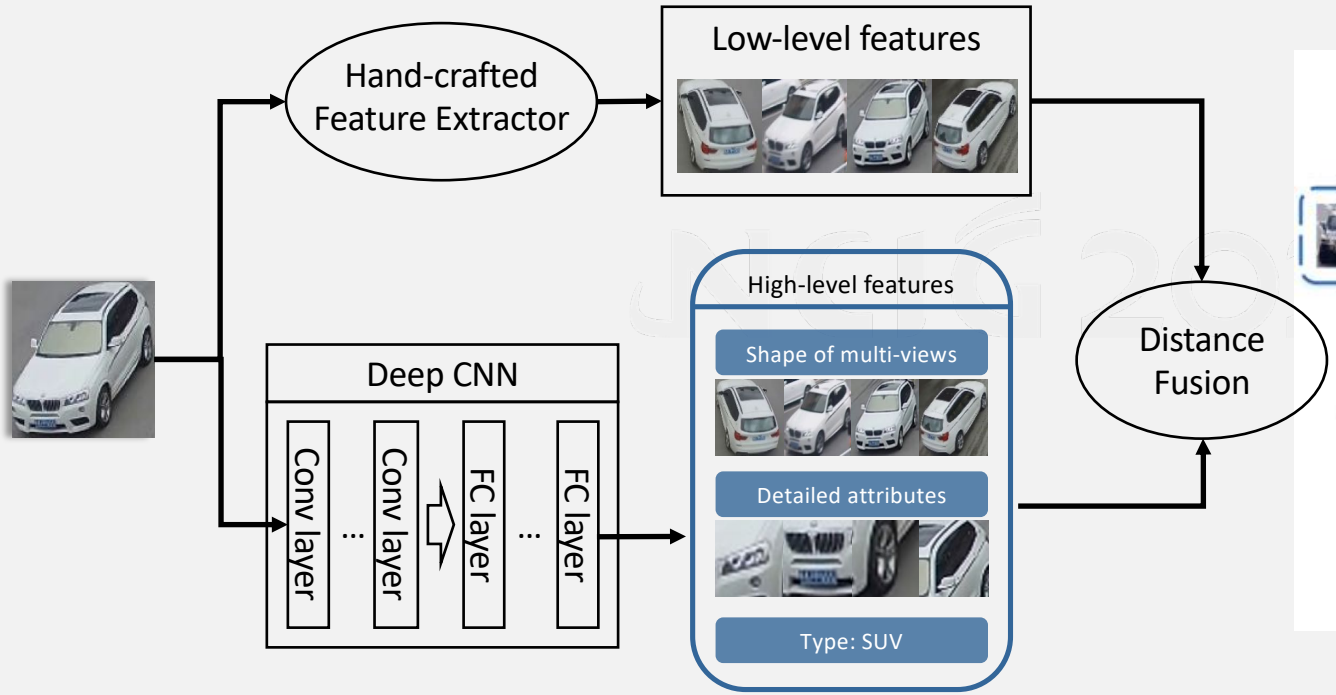
1. 50, 000+ 包围盒、9, 000+ 轨迹
2. 10 颜色、9 车型、30+品牌、车牌
3. 20 个摄像头内的车辆重现
4. 约50, 000 图像、775个不同车辆

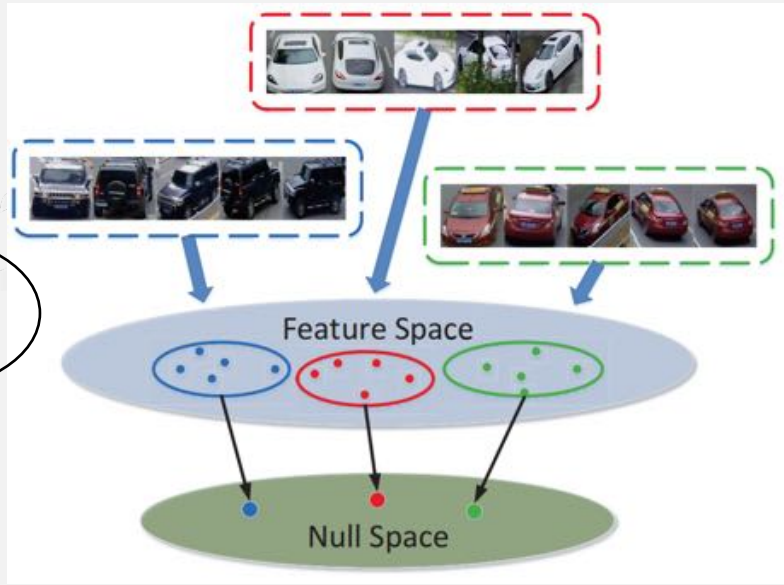
- **Xinchen Liu**, Wu Liu, Tao Mei, Huadong Ma: A Deep Learning-Based Approach to Progressive Vehicle Re-identification for Urban Surveillance. ECCV (2) 2016: 869-884

车辆重识别数据集的发展

Benchmark	Year	Cameras	Boxes	Boxes/ID	Identities	Video	Geom.	Multi-view	License Plate
VeRi-776	2016	20	49,357	63.6	775	X	√	√	√
VehicleID	2016	12	221,763	8.4	26,267	X	X	X	X
PKU-VD1&2	2017	-	846,358	6.0	**141,756**	X	X	X	X
Vehicle-1M	2018	-	**936,051**	16.8	55,527	X	X	X	X
VeRi-Wild	2019	**174**	406,314	10	40,671	X	√	√	X
CityFlow	2019	40	229,680	**344.9**	666	√	√	√	X

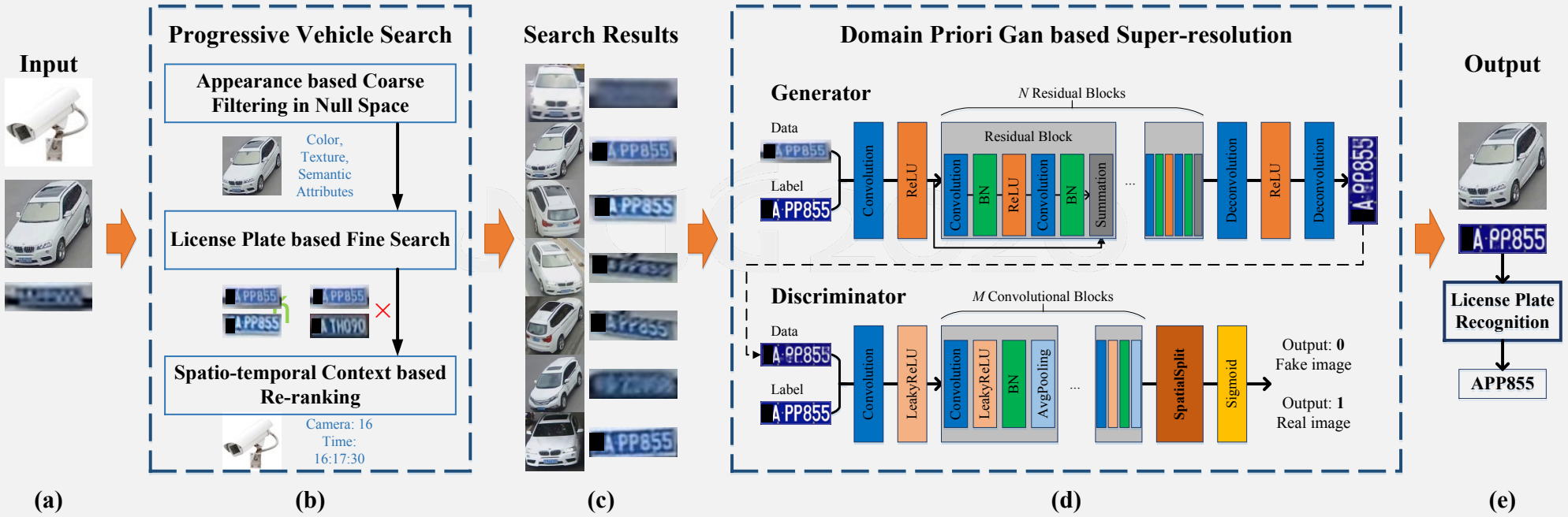
外观特征：手工特征 + 深度学习 + 度量学习 [Liu et al., ICME16]





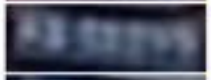
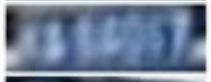
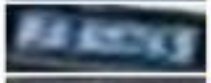
- **Xinchen Liu**, Wu Liu, Huadong Ma, Huiyuan Fu: Large-scale vehicle re-identification in urban surveillance videos. ICME 2016: 1-6 (**Best Student Paper Award**)

多模态信息：外观特征 + 车牌信息 [Liu et al., MM17]



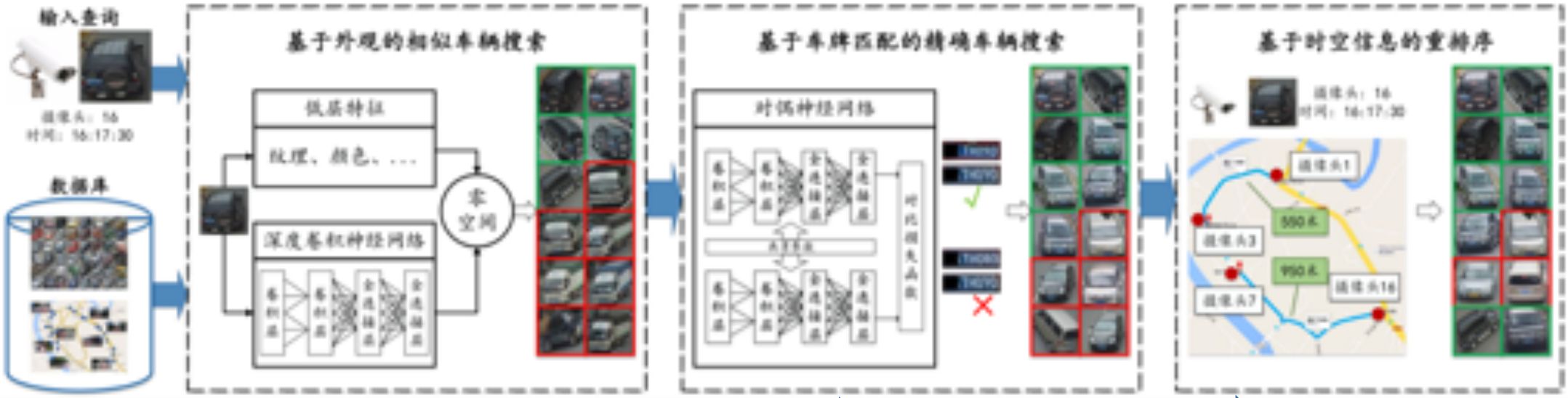
- Wu Liu, **Xinchen Liu**, Huadong Ma, Peng Cheng: Beyond Human-level License Plate Super-resolution with Progressive Vehicle Search and Domain Priori GAN. ACM Multimedia 2017: 1618-1626

多模态信息：外观特征 + 车牌信息 [Liu et al., MM17]

Query	Q-VDSR	Q-DP-GAN	IR+MSR-GAN	DP-MSR-GAN	Groundtruth
	2U872	2U872	2U872	2U872	2U872
	V0721	V0721	V0723	V0721	V0721
	8A899	8A899	8A898	8A899	8A899
	F7162	F7162	F7162	F7162	F7162
	3962N	3962N	3962N	3962N	3962N
	XA531	XA531	YA531	XA531	XA531
	8A017	8A017	8A017	8A017	8A017
	AM763	AM763	AM763	AM763	AM763
	673J5	673J5	673J5	673J5	673J5
	VE739	VE739	VE739	VE739	VE739
	XK936	XK936	XK936	XK936	XK936

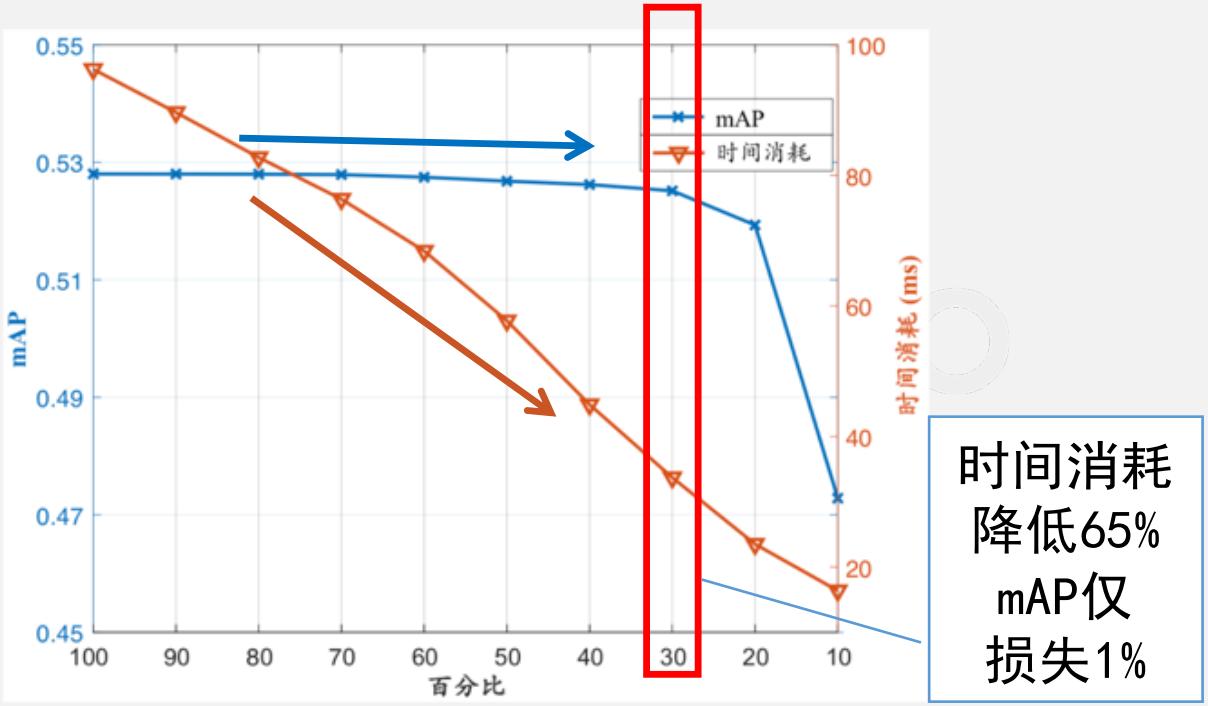
- Wu Liu, **Xinchen Liu**, Huadong Ma, Peng Cheng: Beyond Human-level License Plate Super-resolution with Progressive Vehicle Search and Domain Priori GAN. ACM Multimedia 2017: 1618-1626

多模态信息：外观特征 + 车牌信息 + 时空上下文 [Liu et al., ECCV16&TMM18]



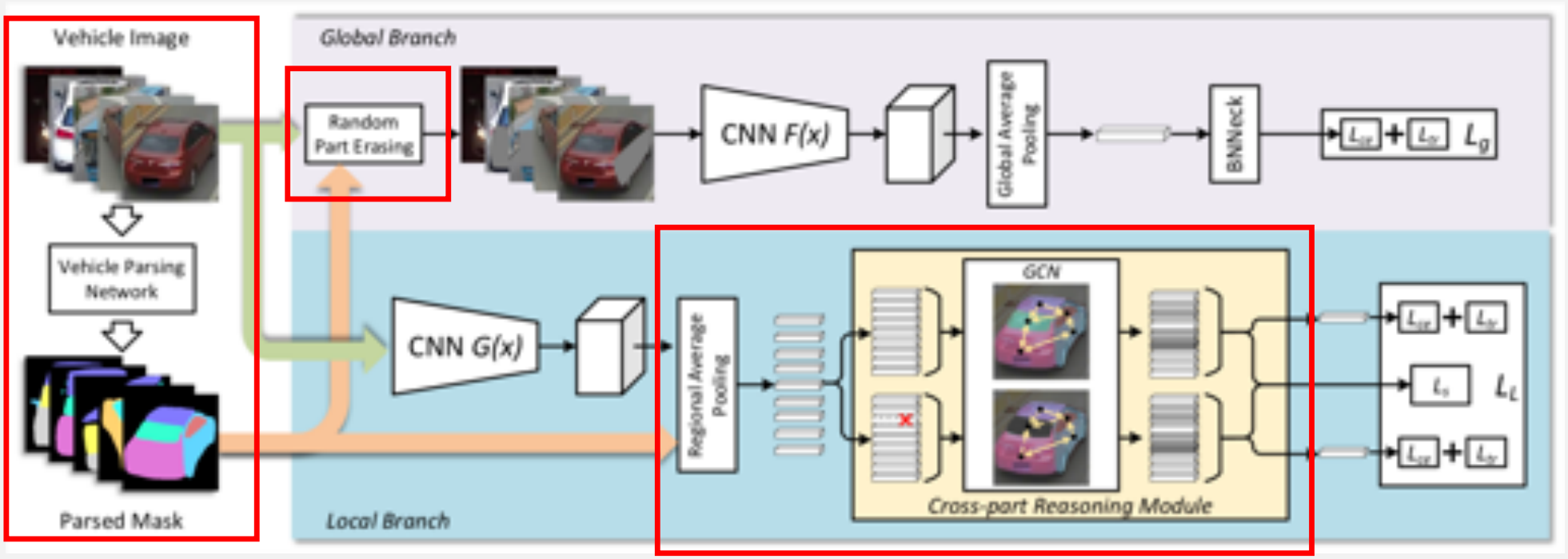
- **Xinchen Liu**, Wu Liu, Tao Mei, Huadong Ma: A Deep Learning-Based Approach to Progressive Vehicle Re-identification for Urban Surveillance. ECCV (2) 2016: 869-884
- **Xinchen Liu**, Wu Liu, Tao Mei, Huadong Ma: PROVID: Progressive and Multimodal Vehicle Reidentification for Large-Scale Urban Surveillance. IEEE Trans. Multimedia 20(3): 645-658 (2018) (**Multimedia Prize Award**)

多模态信息：外观特征 + 车牌信息 + 时空上下文 [Liu et al., ECCV16&TMM18]



- **Xinchen Liu**, Wu Liu, Tao Mei, Huadong Ma: A Deep Learning-Based Approach to Progressive Vehicle Re-identification for Urban Surveillance. ECCV (2) 2016: 869-884
- **Xinchen Liu**, Wu Liu, Tao Mei, Huadong Ma: PROVID: Progressive and Multimodal Vehicle Reidentification for Large-Scale Urban Surveillance. IEEE Trans. Multimedia 20(3): 645-658 (2018) (**Multimedia Prize Award**)

基于车辆部件解析的局部特征推理 [Liu et al., Under Review]



- **Xinchen Liu**, Wu Liu, Jinkai Zheng, Chenggang Yan, Tao Mei : Beyond the Parts: Learning Multi-view Cross-part Correlation for Vehicle Re-identification. (Under Review)

基于车辆部件解析的局部特征推理 [Liu et al., Under Review]

On VeRi:

Methods	Year	mAP (%)	R-1 (%)	R-5 (%)
LOMO [15]	2015	9.6	25.3	46.5
BOW-CN [39]	2015	12.2	33.91	53.69
GoogLeNet [36]	2015	17.9	52.3	72.2
Siamese-CNN [26]	2017	54.2	79.3	88.9
NuFACT [17]	2018	48.5	76.9	91.4
RAM [18]	2018	61.5	88.6	94.0
FDA-Net [21]	2019	55.5	84.3	92.4
MLSL [1]	2019	61.1	90.0	96.0
OIFE+ST [32]	2017	51.4	92.4	-
Siamese-CNN+ST [26]	2017	58.3	83.5	90.0
PROVID [17]	2018	53.4	81.6	95.1
OIFE [32]	2017	48.0	65.9	-
VAMI [44]	2018	50.1	77.0	90.8
EALN [20]	2019	57.4	84.4	94.1
AAVER [10]	2019	61.2	89.0	94.7
PRN [7]	2019	70.2	92.2	97.9
PAMTRI [29]	2019	71.8	92.9	97.0
PRN*[7]	2019	74.3	94.3	**98.9**
PCRNet (ours)	2020	**78.6**	**95.4**	98.4

* Results with input size 512 × 512, others with 224 × 224 or 256 × 256.

On VehicleID:

Settings	Small		Medium		Large	
Methods	R-1	R-5	R-1	R-5	R-1	R-5
DRDL [16]	48.9	73.5	42.8	66.8	38.2	61.6
NuFACT [17]	48.9	69.5	43.6	65.3	38.6	60.7
VAMI [44]	63.1	83.3	52.9	75.1	47.3	70.3
C2F [6]	61.1	81.7	56.2	76.2	51.4	72.2
FDA-Net [21]	-	-	59.8	77.1	55.5	74.7
AAVER [10]	74.7	93.8	68.6	90.0	63.5	85.6
MLSL [1]	74.2	88.4	69.2	81.5	66.6	78.7
OIFE [32]	-	-	-	-	67.0	82.9
PRN [7]	78.4	92.3	75.0	88.3	74.2	86.4
PCRNet (ours)	**86.6**	**98.1**	**82.2**	**96.3**	**80.4**	**94.2**

On VeRi-Wild:

Settings	Small		Medium		Large	
Methods	mAP	R-1	mAP	R-1	mAP	R-1
GoogLeNet [36]	24.3	57.2	24.2	53.2	21.5	44.6
DRDL [16]	22.5	57.0	19.3	51.9	14.8	44.6
FDA-Net [21]	35.1	64.0	29.8	57.8	22.8	49.4
MLSL [1]	46.3	86.0	42.4	83.0	36.6	77.5
PCRNet (ours)	**81.2**	**92.5**	**75.3**	**89.6**	**67.1**	**85.0**

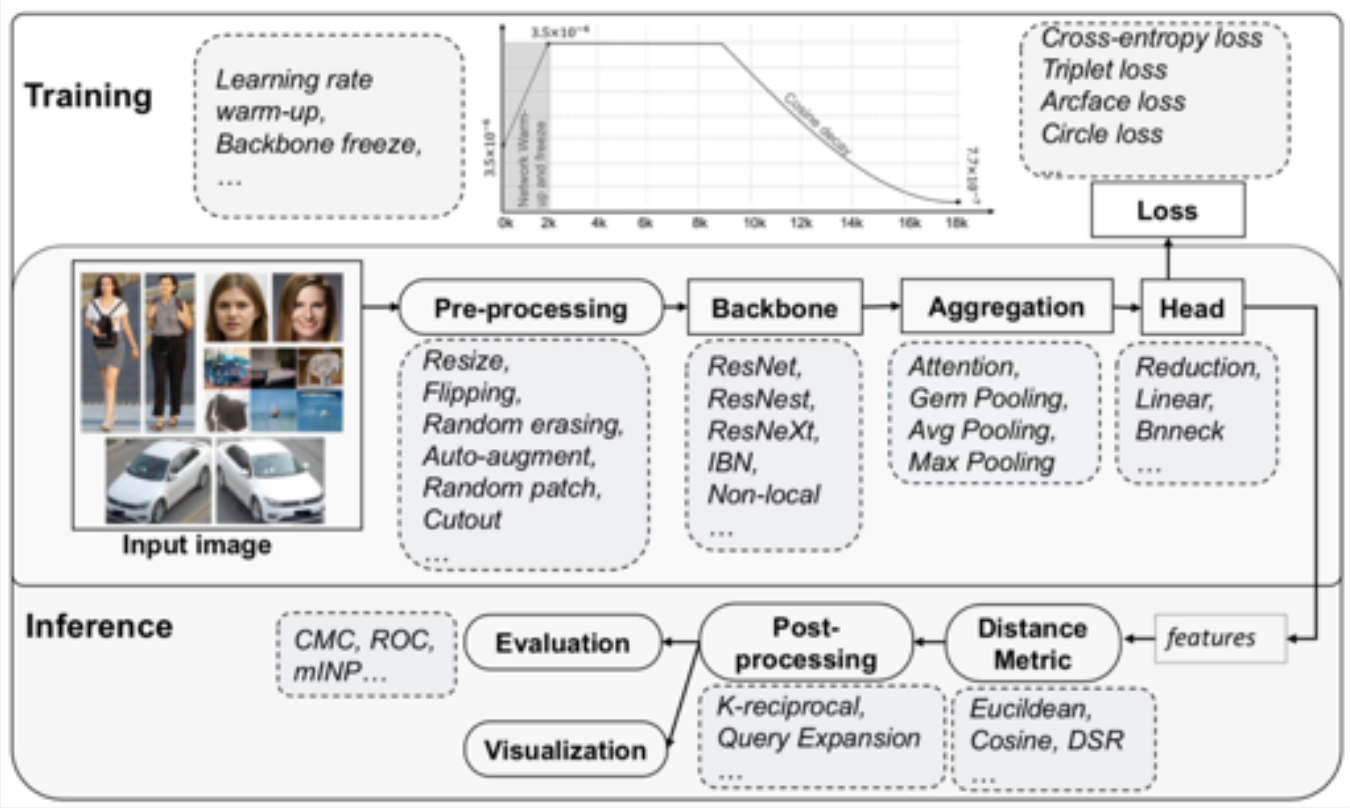
- **Xinchen Liu**, Wu Liu, Jinkai Zheng, Chenggang Yan, Tao Mei : Beyond the Parts: Learning Multi-view Cross-part Correlation for Vehicle Re-identification. (Under Review)

多粒度车辆解析数据集 —— MVP [Liu et al., Under Review]

Dataset	Class #	Image #	Surveillance?
3D Class Dataset-Car [25]	6	960	✗
Pascal-Part-Car [3]	14	1,805	✗
Pascal-Part-Bus [3]	14	501	✗
MVP-coarse	10	21,000	✓
MVP-fine	59	3,000	✓

- **Xinchen Liu**, Wu Liu, Jinkai Zheng, Chenggang Yan, Tao Mei : Beyond the Parts: Learning Multi-view Cross-part Correlation for Vehicle Re-identification. (Under Review)

对象重识别工业化部署 —— FastReID [He et al., arXiv20]



- ✓ 基于PyTorch框架
- ✓ 模块化可扩展设计
- ✓ 灵活的系统配置
- ✓ 丰富的评测系统
- ✓ 面向研究和工程部署
- ✓ 地表最强预训练模型

- Lingxiao He, Xingyu Liao, Wu Liu, **Xinchen Liu**, Peng Cheng, Tao Mei: FastReID: A Pytorch Toolbox for General Instance Re-identification. CoRR abs/2006.02631 (2020)

VeRi 排行榜

Reference	Year	mAP	Rank-1	Rank-5
[1]	2016	19.92	59.65	75.27
[2]	2016	27.77	61.44	78.78
[3]	2017	58.27	83.49	90.04
[4]	2017	57.40	86.59	92.85
[5]	2017	58.78	86.41	92.91
[6]	2017	51.42	68.30	89.70
[7]	2018	53.42	81.56	95.11
[8]	2018	59.47	96.24	98.97
[9]	2018	61.5	88.6	94
[10]	2018	61.32	85.92	91.84
[11]	2019	62.62	90.58	97.14
[12]	2019	57.44	84.39	94.05
[13]	2019	67.55	90.23	96.42
[14]	2019	74.30	94.30	98.70
[15]	2019	72.50	93.30	97.10
[16]	2019	71.88	92.86	96.97
[17]	2019	66.34	89.78	95.99
[18]	2019	66.35	90.17	94.34
[19]	2020	78.60	95.40	98.40
[20]	2020	79.50	95.60	98.40
[21]	2020	**81.90**	**97.00**	**99.00**

VeRi 排行榜

[1] Liu, Xinchen, et al. "Large-scale vehicle re-identification in urban surveillance videos." ICME 2016.
[2] Liu, Xinchen, et al. "A deep learning-based approach to progressive vehicle re-identification for urban surveillance." ECCV 2016.
[3] Liu, Wu, et al. "Beyond human-level license plate super-resolution with progressive vehicle search and domain priori GAN." ACMMM 2017.
[4] Shen, Yantao, et al. "Learning deep neural networks for vehicle re-id with visual-spatio-temporal path proposals." ICCV 2017.
[5] Zhang, Yiheng, Dong Liu, and Zheng-Jun Zha. "Improving triplet-wise training of convolutional neural network for vehicle re-identification." ICME 2017.
[6] Wang, Zhongdao, et al. "Orientation invariant feature embedding and spatial temporal regularization for vehicle re-identification." ICCV 2017.
[7] Liu, Xinchen, et al. "PROVID: Progressive and multimodal vehicle reidentification for large-scale urban surveillance." IEEE TMM 20.3 (2018): 645-658.
[8] Bai, Yan, et al. "Group-Sensitive Triplet Embedding for Vehicle Reidentification." IEEE TMM 20.9 (2018): 2385-2399.
[9] Liu, Xiaobin, et al. "Ram: a region-aware deep model for vehicle re-identification." ICME 2018.
[10] Zhou, Yi, and Ling Shao. "Aware attentive multi-view inference for vehicle re-identification." CVPR 2018.
[11] Liu, Xinchen, et al. "PVSS: A Progressive Vehicle Search System for Video Surveillance Networks." JCST (2019).
[12] Lou, Yihang, et al. "Embedding Adversarial Learning for Vehicle Re-Identification." IEEE TIP (2019).
[13] Kumar, Ratnesh, et al. "Vehicle Re-Identification: an Efficient Baseline Using Triplet Embedding." arXiv preprint arXiv:1901.01015 (2019).
[14] Bing He, Jia Li, Yifan Zhao, Yonghong Tian; "Part-Regularized Near-Duplicate Vehicle Re-Identification" CVPR 2019.
[15] Qian, Jingjing, et al. "Stripe-based and Attribute-aware Network: A Two-Branch Deep Model for Vehicle Re-identification." arXiv (2019).
[16] Tang, Zheng, et al. "PAMTRI: Pose-Aware Multi-Task Learning for Vehicle Re-Identification Using Highly Randomized Synthetic Data." IEEE ICCV (2019).
[17] Chu, Ruihang, et al. "Vehicle Re-identification with Viewpoint-aware Metric Learning." IEEE ICCV (2019).
[18] Pirazh Khorramshahi et al. "A Dual-Path Model With Adaptive Attention For Vehicle Re-Identification." IEEE ICCV (2019).
[19] Xinchen Liu, et al.: Beyond the Parts: Learning Multi-view Cross-part Correlation for Vehicle Re-identification. (Under Review)
[20] Dechao Meng, et al.: Parsing-based View-aware Embedding Network for Vehicle Re-Identification. IEEE CVPR (2020).
[21] Lingxiao He, et al.: FastReID: A Pytorch Toolbox for General Instance Re-identification. CoRR abs/2006.02631 (2020).

车辆搜索的未来

- ✓ 工业场景下实际部署
  - ■ 数据快速采集与标注
  - ■ 模型高效增量式学习
  - ■ 大规模数据高效索引
- ✓ 三维视觉 + 车辆搜索
  - ■ 细粒度数据生成
  - ■ 无监督域自适应

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谢谢！

Scan me for Email, dataset, code, and more...