摘要

进入 21 世纪后，我国的汽车数量激增，对人民的生活产生了巨大的影响。在时代背景的大前提下，关于汽车的应用需求不断涌现。在实际生活中，如何管理和使用汽车成为一个亟待解决的问题。对车辆图片进行精确性检索能够解决汽车应用中的大量问题，比如停车场收费、犯罪违章车辆跟踪查找等。在诸多关于车辆检索的研究中，利用车牌信息进行车辆检索的问题的相关研究已经比较成熟。但是在实际需求中，对车辆图像检索提出了更高的要求。本文针对车辆检索应用中的无车牌信息卡口图像搜索问题进行了相关的研究，设计了基于移动搜索应用和服务器图像搜索应用的特征提取算法，针对移动搜索应用需求提出了计算复杂度优化方法，针对服务器图像搜索应用提出了新的深度学习框架，具体的研究成果如下：

第一，针对车辆图像检索算法的实时性差和计算冗余等问题，提出了基于尺度金字塔的特征提取快速算法。在传统手工图像特征算法提取特征过程中，由于构造尺度金字塔进行关键点检测需要进行全图的多次滤波操作，在提取算法中占据了超过 70%的计算复杂度，同时存在客观的计算冗余。这类计算冗余很难简单的通过图像处理去除，在实际应用中对移动端提取算法的实时性响应和高效计算造成了巨大影响。本文根据特征点在不同尺度空间分布的聚集性统计规律，分析了计算冗余存在的主要原因，提出了新的尺度金字塔构造方案，通过简单的计算和统计过滤掉大量的滤波面积，同时保留了重要的特征点，获得了 MAP 的损失控制在 1%以内，时间复杂度节省达到 10%-30%的可观性能。

第二，由于深度特征算法检索精度高于传统手工特征算法，提出了基于注意力机制的掩膜对抗学习框架。在现有车辆图像的深度特征提取算法中，由于车牌信息不可利用，存在车型相似性影响检索性能的问题。针对车型干扰的问题，提出了掩膜增强训练的神经网络结构，增强对关键图像区域特征的学习和利用，相比于领域内最优的深度特征算法获得了更好的性能。在计算资源充足的情况下，提供了检索精度优于传统手工特征的解决方案。

第三，结合传统手工算法和深度学习算法设计了一套通用的车辆图像检索系统。系统引入带宽监测功能用作提取模式选择，对移动端和服务器端车辆检测应用适用算法，并设计了移动端的硬件流水并行方案，更好地满足了车辆图像检索的实际需求。

综上所述，本文对车辆图像检索算法的两种类型算法进行了研究和优化，设计了通用的车辆图像检索系统。对传统手工特征算法进行了算法复杂度优化，去除计算冗余获得更优的实时性。对深度学习特征算法，提出了新的训练网络结构，利用对抗训练获得的显著性掩膜特征增强了局部重要特征，超越领域性能最优算法获得了更高的检索精度。最后，设计了结合移动搜索和服务器搜索两种通用搜索功能的车辆检索系统，给出了一个实际可行的解决方案。实验结果表明，本文提出的检索系统解决了实际应用中对移动搜索快速、低复杂度的需求和服务器搜索中对高检索精度的需求，对车辆图像检索问题的研究作了进一步的推进。

关键词：车辆检索，紧凑描述子，车辆再识别，掩膜对抗网络，尺度金字塔

Research on Accurate Vehicle Retrieval Algorithm Based on Image Content

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ABSTRACT

Vehicle number in our nation increases faster in 21st century which leads to tremendous influence in civil lives. Based on this major premise, the actual application requirements for vehicle springs up continually. How to manage and make use of vehicle becomes a problem which needs to solve immediately. Precision retrieval of vehicle images can solve many problems in vehicle application, such as carpark access control and crime vehicles search. Research in past decades achieved great performance in how to retrieval by license plate. But requirements in real world propose higher demand in vehicle retrieval task. In this paper, I optimize two types of algorithm (mobile search and server search) focus on vehicle retrieval problem without license plate in surveillance. Based on the mobile search standard (CDVS), I propose a low computation complexity algorithm. And I also propose a new deep learning structure for deep feature applied in vehicle retrieval. Our contributions are listed behind:

Firstly, I propose an optimized feature extraction algorithm based on scale-space pyramid. The proposed algorithm reduces computation redundancy and improves real-time response ability in MPEG-CDVS which is a feature extraction algorithm standard from MPEG. In extraction stage of handcraft feature, key point detection needs to construct Gaussian pyramid which contains plenty of filter computation. The filter computation accounts over 70% computation in extraction and involves significant computational redundancy. This form of redundancy impacts real-time response ability and reduce computation efficiency but can't be removed easily by image processing. To solve this problem, our work analyzes the main reason for computational redundancy by statistic distribution of key points in different layers of scale-space pyramid. And I propose a new structure to construct scale-space pyramid. The proposed method skips large filter area and maintain important keys through simple statistic and little computation cost. The performance compared with the state-of-art reaches that MAP(mean average precision) decrease less than 1% while time complexity reduces 10-30%.

Secondly, I propose a mask adversarial network structure based on deep learning algorithm to solve the problem of low MAP performance for handcraft feature. Since information for license plate can't be achieved in this task, the performance of exist deep feature algorithms for vehicle re-identification are influenced by the similarity of those cars with same model but different id. To remove the influence of redundancy

information, the proposed mask adversarial network strengthens training of local feature for image and outcomes the state-of-art. The mask adversarial network proposed a better solution for vehicle retrieval while equips with enough computation ability.

Thirdly, I design a general vehicle retrieval system which combines handcraft feature and deep feature. A bandwidth monitoring algorithm is applied to select feature extraction mode. Then two types of algorithms are utilized to detect vehicles based on different environment in mobile client and server. Finally, the solution of hardware parallel pipeline is designed for feature extraction in mobile client. The designed system can utilize the advantages of both algorithm and better fulfill the real-world requirement.

In summary, I have done some research for two types of vehicle retrieval algorithm, optimized them and designed a general vehicle retrieval system. The computation complexity optimization is performed on handcraft feature algorithm which focuses on mobile search. I have removed significant computation redundancy in extraction to improve real-time response ability. To fulfill requirement of high accuracy retrieval, a new deep network structure is proposed. Reinforcement learning for local important feature is performed by the proposed mask adversarial network and performance of this network outperforms the state-of-art. Moreover, a vehicle retrieval system is designed to compose two types of feature. The proposed system gives a solution for real-world application. The experiment result shows that the proposed system makes contribution in two aspects: propose a low bitrate faster algorithm to fulfill requirements of mobile search and a precision deep feature network to fulfill requirements of server search.

KEY WORDS: Vehicle retrieval, Compact features, Vehicle re-identification, Mask_gan，Scale-space pyramid