摘要

目标重识别旨在从海量监控摄像头拍摄的图像或视频中准确识别出给定的查询目标。该技术在智能安防、商业分析等多个领域都有广泛的应用，具有重要的研究价值。当前主流的研究主要关注于设计高判别力的特征，以提高模型对于光照、视角等干扰因素的鲁棒性。然而，目标重识别的任务难点不仅限于训练阶段，在实际的模型开发部署流程中，每个环节都有各自的挑战。例如在数据标注阶段，重识别任务因其类别数量不固定，并且个体间外观差异较小，导致标注工作尤为困难；在模型迭代阶段，新版本的模型需要重新提取检索库的图像特征才能继续有效地执行任务，这在大规模应用场景下会耗费大量时间和资源成本。本文针对上述两个问题展开研究，分别以降低数据标注成本、提高模型部署效率为目标提出相应的方法。本文的主要创新点如下：

第一，针对数据标注成本高的问题，本文提出了面向弱监督行人搜索的主动学习设定。该设定希望挑选少量有价值的数据对进行身份标注，并利用这部分主动标注的数据以及剩余的无标注数据进行训练，以弥补弱监督和全监督方法之间的性能差距。针对该设定，本文提出了上下文辅助的主动学习框架。该方法利用一个聚类拆分模块和聚类合并模块来挑选和标注样本，进而根据标注结果对聚类结果进行优化，以生成更加准确的数据伪标签。行人搜索作为行人重识别的扩展，拥有更为丰富的上下文信息，可以在主动学习过程中起到辅助作用。此外，所提方法还引入了成对关系预测器来挖掘最有价值的样本对，进一步减少标注成本。在多个行人搜索数据集上的实验结果表明，该方法可以在显著缩减标注预算的同时取得与全监督近似的性能。

第二，针对模型迭代后部署效率低的问题，本文提出了多原型和蒸馏约束的向后兼容表示学习方法。向后兼容训练的目标是使新模型与旧模型兼容，即二者的特征可以相互比较。基于该技术，新版本的模型可以直接部署到重识别系统中，无需离线更新检索库中的图像特征，有效提升模型迭代和部署效率。本文通过为每个类别保留多个差异化的原型来互补地表示旧模型的类内特征分布，进而提供全面的兼容约束。此外，本文还提出了双教师蒸馏策略，额外引入一个高判别力的强教师分支，与旧模型一并对新模型进行联合蒸馏。在多种模型更新场景下的实验结果表明，该方法可以在维持自身判别力的同时提升与旧模型的兼容性能。

综上所述，本文面向目标重识别任务的实际应用，从数据主动标注和模型兼容两个方面展开研究。本文的研究有效降低了数据标注成本，提高了模型部署效率，这不仅有助于推动目标重识别技术的实际落地，还有望促进智慧城市的发展。

关键词：目标重识别，行人搜索，主动学习，向后兼容训练

Study on Active Learning and Compatible Training for Object Re-identification

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ABSTRACT

Object re-identification (ReID) aims to identify the given query object from images or videos captured by surveillance camera networks. ReID has broad applications in intelligent security and business analytics, presenting significant research value.

The current research on ReID mainly focuses on designing high discriminative features to enhance model robustness against disturbances like lighting and viewpoints. However, the difficulties of ReID not only lie in the training phase, but also extend to every stage of model development and deployment. For instance, during the labeling phase, annotation workload for ReID task can be very high due to the large number of classes and similar appearance between individuals. In the model updating phase, new model needs to re-extract all gallery embeddings before the deployment, which can take days or weeks in practical industrial applications. To address thses issues, this thesis propose methods to reduce the annotation cost and improve the efficiency of model deployment ,respectively. Innovations of this thesis can be summarized as follows:

1) This thesis proposes a context-assisted active learning methods for weakly supervised person search to alleviate the heavy annotation burden. Active learning aims to select a small number of valuable data for identity labeling and use the annotation to train the person search model. The framework consists of a split module and a merge module, which leverage two types of contextual cues for label refinement. Besides, a pairwise relationship predictor is introduced to estimate relations between instances so that annotation cost can be further reduced. Extensive experiments demonstrate that the proposed method could achieve comparable or even better performance than recent fully supervised methods at a much lower annotation cost.

2) This thesis proposes a multi-prototype based backward-compatible training method to address inefficiencies in model deployment. Backward-compatible training aims to train the model that is compatible with the old ones, so that new features from the updated model can

be compared with old features directly. In this way, new model can be deployed on system immediately after training, improving the efficiency of model deployment. This thesis proposes a novel multi-prototype based backward-compatible training method. The method uses several discrepant prototypew to complementarily represent a class, and leverages these prototypes to impose comprehensive compatibility constraints on new model. Besides, the method introduces a dual-teacher distillation strategy, incorporating a stronger teacher model to jointly teach the new model with th old one. Experimental results in various model updating scenarios show that our method ensures backward compatibility without impairing the discrimination of the new model.

In conclusion, this thesis studies the practical application of object re-identification, exploring two key aspects: active learning and model compatible training . The study significantly reduces the annotation cost and enhances the efficiency of model deployment. It is expected to promote the practical application of object re-identification and advance the development of smart cities.

KEY WORDS: object re-identification, person search, active learning, backward-compatible training