

工学博士学位论文

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OBJECT DETECTION BASED ON LOCAL TEXTURE
FEATURES

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OBJECT DETECTION BASED ON LOCAL
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摘要

从计算机诞生以来，让计算机或机器人像人类一样具有视觉能力，是科研工作者一直不懈追求的目标。物体检测是人类视觉中的基本步骤和基本功能，为人类了解周围的环境和景物提供了至关重要的前提。物体检测是计算机视觉学科中极具挑战性的理论研究课题，而且在很多领域具有广阔的应用前景，例如多媒体信息分析与搜索、场景分析与理解、视频编码、视频监控、模式识别等。作为一个研究热点，物体检测越来越受到研究者的重视，研究深度和广度在不断地增强。

本文围绕物体检测展开研究，研究目的是探索一种有效的物体特征表示方法并且应用于物体检测，从而提供物体检测的新方法。针对上述研究目标，本文在基于局部纹理分析的物体表示特征、有效特征的选择和基于局部纹理特征的物体检测算法等方面进行了深入的研究和探讨。论文具体的研究内容如下：

1. 本文基于物体的局部纹理分析，提出了改进的空间直方图特征，用于物体检测任务中的特征表示。空间直方图特征是图像局部纹理的信息分布，它同时反映了物体在不同尺度上的纹理和结构信息。改进的空间直方图特征与目标物体类别相关联，具有对目标物体的判别能力，而且能够适用于各种典型物体的表示。本文以刻画物体的纹理信息和结构信息为着眼点，建立了空间直方图特征的提取方法，并且对空间直方图特征的物体判别能力进行了研究。

2. 提出了基于空间直方图特征的层次化物体检测算法。本文采用空间直方图特征作为物体表示，根据由粗到精的策略，综合利用两种物体检测技术：直方图匹配方法和支持向量机分类器，构建了物体检测的一种通用算法。该算法首先通过直方图匹配方法进行粗检测，达到排除图像中大量非目标物体的目的；其次在精确检测过程中，采用支持向量机分类器提高检测精度。该算法有效的解决了物体检测问题，具有快速、鲁棒的特点。该算法可以处理不同类型的物体模式，包括刚体物体模式、可变形的柔性非刚体物体、以及纹理模式物体。

3. 提出了一种结合类别可分性和特征相关性的特征选择方法。传统的特征选择技术在处理高维数据时，存在训练时间长或者选择所得到的特征子集分类性能不高的局限。本文方法使用 Fisher 准则度量特征的类别可分性，采用互信息计算特征之间的相关性，按照顺序增加的方式产生候选特征，以分类器错误率最小为目标，选择分类性能高而互相之间相关性弱的特征，构成紧致而有效的特征子集。该方法不但可以选择出有效的分类特征，而且在保证分类性能的

条件下降低了特征维数，提高了分类效率。本文将所提出的特征选择方法用于构造空间直方图特征子集，作为物体检测中支持向量机分类器算法的输入特征。实验结果表明该方法可以自动获取与目标物体类别相关联的分类特征。

4. 提出了基于空间直方图特征和纠错码分类器的多姿态人脸检测算法。首先，本文结合纠错码多类分类器算法，研究了如何将基于空间直方图特征的物体检测算法扩展到多姿态人脸检测。其次，针对基于纠错码多类分类算法中单分类器训练困难的问题，本文提出了一种在给定纠错码码本的前提下如何训练有效纠错码多类分类器的方法。该方法以整体纠错码多类分类器的错误率最小为目标，依次选择有效特征和训练单分类器，从而训练得到整体分类性能更高的纠错码多类分类器。最后，本文对基于纠错码的多姿态人脸检测方法进行了实验验证，实验结果表明该方法可以有效的解决多姿态人脸检测问题，取得了良好的检测性能。

关键词 物体检测；多姿态人脸检测；空间直方图特征；特征选择；纠错码多类分类器

Abstract

It was about the initial stage of the computer coming into the world that scientists and engineers began to pursue creating a machine that has the vision ability similar to human beings. Object detection is the fundamental function and process of human vision. It provides essential preconditions for human beings to understand scenes in the real world. As an active research area, object detection has been attracted more and more attention. In computer vision community, object detection has been a very challenging research topic. Moreover, the object detection technology is significant in many real applications.

This dissertation aims to provide a generic object detection framework by exploring novel features for object pattern representation and applying them in automatic object detection. Some key issues and techniques of object detection are discussed and lucubrated, such as object feature extraction methods based on local texture analysis, efficient feature selection methods, object detection algorithms based on local texture features, and multi-view face detection algorithm. The detailed descriptions of the above techniques are as follows.

1. An object representation method based on local texture analysis (i.e. a kind of improved spatial histogram features) is proposed in this dissertation. Motivated by the observation that objects have texture distribution and shape configuration, this dissertation proposes spatial histogram based features (termed as spatial histogram features) to represent objects. As spatial histograms consist of marginal distributions of an image over local patches, the information about texture and shape at different scales of the object can be encoded simultaneously. This dissertation presents the extraction method of spatial histogram features and gives quantitative analysis of the discriminative ability of spatial histogram features.

2. A generic object detection approach based on spatial histogram features is presented. This approach uses spatial histogram features as object representation, employs histogram matching and support vector machine to construct an object detector based on a coarse-to-fine strategy. The object detector receives image samples of a fixed size as inputs and initially produces spatial histogram features from the image samples. In the coarse detection stage, the cascade histogram matching method rejects most non-object instances. In the fine detection stage, a

support vector machine is used to verify whether or not the remained samples are object instances. The proposed method is efficient and robust to object detection, and it can be extended to generic object detection for different object types including rigid objects, non-rigid objects and texture rich objects.

3. A feature selection approach based on class separability and feature correlation is presented in this dissertation. Traditional feature selection methods have limitations, such as expensive training time of selection procedure and low classification accuracy of the selected features. The proposed method uses Fisher criterion to measure class separability of each feature and employs mutual information to calculate features correlation. Optimal feature subset is constructed by selecting uncorrelated and discriminative features through minimizing the classification error rate. The proposed approach is applied to the spatial histogram features based object detection tasks to learn spatial histogram features for support vector machine. The experiment results show that the proposed feature selection method is efficient to extract informative and class-specific features for object detection.

4. A multi-view face detection method based on spatial histogram features and ECOC (error correcting output codes) multi-class classification is presented. First, we use the ECOC multi-class classification framework to extend the spatial histogram features based object detection approach to solve the multi-view face detection problem. Second, we present an approach for designing efficient binary classifiers by learning informative features through minimizing the error rate of the ensemble ECOC multi-class classifier. Finally, we conduct experiments to evaluate the effectiveness and robustness of the proposed multi-view face detection approach.

Keywords Object detection; multi-view face detection; spatial histogram features; feature selection; ECOC (error correcting output codes) based multi-class classifier