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Sujet de Thèse :

Machine Learning And Local Image Region Descriptors For Texture and Material Recognition

Abstract :

Image classification is the most popular and active area of research in computer vision and machine learning, and it's growing quickly because it has so many uses. In addition, with the rising trend of "big data," there is a much greater need for strong image descriptors and learning methods that can process a large number of images for many different visual applications. In this perspective, the main focus of this dissertation is to look into new feature extraction methods (FEMs) by adding important visual elements and improving the way features are represented in the discriminative space for advancing image classification. Moreover, the fact that FEMs play an important role in a variety of vision applications and have excellent performance that should be enhanced, particularly in challenging scenarios, is the primary motivation for the continued research in this field. In this thesis, aiming to further improve the texture classification performance and keep the simplicity and efficiency of FEMs and address their weakness, we came up with five new models of local feature descriptors for texture representation.

The thesis starts by introducing a new modeling of local binary patterns for efficient texture classification. The proposed model, referred to as repulsive-and-attractive local binary gradient contours (RALBGC), is anticipated to more accurately depict the prominent local texture structure. Thanks to the flexibility of repulsive-attractive characteristics, which represent the cornerstone of the proposed descriptors, two distinct LBP-like descriptors are built: repulsive and attractive local binary gradient contours (RLBGC and ALBGC). Unlike conventional methods such as LBP, BGC1,2,3, LTP, nLBPd, and several other LBP-like methods which are based on pairwise comparison of adjacent pixels, the RLBGC and ALBGC operators encode the differences between local intensity values within triplets of pixels along a closed path around the central pixel of a 3 × 3 grayscale image patch. In order to increase the robustness of the proposed RLBGC and ALBGC descriptors, the triplet formed by the average local and average global gray levels and the central pixel is incorpo rated in the modeling. To capture the coarse and fine information of the features and thus to make RLBGC and ALBGC more robust and stable, the RLBGC and ALBGC are concatenated together to form multi-scale repulsive-and-attractive local binary gradient contour (RALBGC) descriptor.

Then, we provide a new framework for texture classification that is based on a mixture of feature extraction methods. In this framework, two level descriptions from LTP and directional features from LDP are combined to generate two new local feature descriptors, referred to as local directional ternary pattern (LDTP) and multi directional guided mixed mask based local ternary pattern (MDGMM-LTP).

LDTP and MDGMM-LTP are two frameworks, which consist in encoding both contrast information and directional pattern features in a compact way based on local derivative variations. The essence of the proposed methods is to progressively extract comprehensive micro-structure features by analyzing the differential excitation and directional information according to relationships between pixels sampled in various spatial arrangements within each 3×3 squire neighborhood. The processes of LDTP and MDGMM-LTP involve creating eight directional edge responses utilizing, on one side, eight Frei–Chen masks for the LDTP method and on the other side, our suggested mixed hybrid directional kernel for the MDGMM-LTP method. In addition, for both approaches, a central edge response is also constructed using the second derivative of the Gaussian filter to collect more detailed information. Spatial relationships among the neighboring pixels through the edge responses are exploited independently with the help of both LDP's and LTP's concepts to enhance the dis crimination capability. Indeed, the implicit utilization of both concepts of LTP and LDP encodes more information in comparison to the existing directional and derivative methods in less space, and simultaneously allows can capturing more stable and discriminating microstructure information.

Furthermore, based on the same framework of combining characteristics from distinct categories (i.e., dense and graph-based methods), we propose two new image feature descriptors for texture and material classification: Petersen graph multiorientation based multi-scale ternary pattern (PGMO-MSTP) and oriented star sampling structure based multi-scale ternary pattern (O3S-MTP). Due to the flexibility of the graph theory and dominating set, the proposed methods are histogram representations that efficiently encode the joint information within an image across feature and scale spaces, exploiting the concepts of both LTP-like and LGS-like descriptors in order to overcome the shortcomings of these

approaches. In contrast to the existing non-oriented local graph structure-based texture descriptors, which cannot fully represent the extent of pixel difference, the main goal of the proposed methods is to encode the structure of the local neighborhood by analyzing the differential excitation and orientation information using two new distinct effective oriented graphs based sampling local structures: Star graph for O3S-MTP and Petersen graph for PGMO-MSTP.

Finally, extensive experiments show that the proposed methods provide reliable performance stability over a large number of challenging texture and material databases. Furthermore, the proposed texture operators achieve competitive and superior overall texture classification performance than a large number of old and recent most promising state-of-the-art texture descriptors including handcrafted texture operators and deep learning-based feature extraction approaches. Moreover, to further show the effectiveness of the proposed methods, the obtained classification results were statistically validated through the Wilcoxon signed rank test based ranking method, demonstrating thus that the proposed methods are strong candidates for texture modeling and classification with low resource requirements.