Sorted Random Projections for Robust Texture Classification

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Abstract

Goal: Developing a simple, robust, yet highly effective Texture Classification (TC) system
- Simple, local feature extraction
- Universal, data-independent features
- Low-dimensional features
- Good classification performance
- Robustness to environment changes

Main components:
- Local features: SRP random features → simple, universal, informative, fast, illumination invariant, rotation invariant, robust and effective
- Global representation: Bag-of-Words model → simple, effective, vector feature
- Classifier: Kernel Support Vector Machines (SVMs)

Performances:
- CUR/T: ~99.37%
- Brodatz ~ 97.16%
- UMD ~ 99.30%
- KTH-TIPS ~ 99.29%
- FMD ~ 48.2%

Introduction

TC remains a challenge problem:
- The wide range of various natural texture types
- The presence of large intra-class variations → brightness, contrast, rotation, affine, scale, skew, orocclusion
- The demands of algorithms with low computational complexity

Motivations:
- To leverage the sparse nature of texture images
- To preserve all the advantages of Random Projection (RP) Classifier
- To avoid complex local feature extraction
- To increase robustness
- To use a kernel-based learning classifier
- To combine multiple complementary features

Background

Random projection (RP) refers to the technique of projecting a set of points from a high-dimensional space to a randomly chosen low-dimensional subspace. RP, while reducing dimensionality, approximately preserves pairwise distances with high probability:
- Computationally simple and efficient
- Universal, information-preserving, dimensionality reduction
- Plays an important role in both Johnson-Lindenstrauss embedding and compressed sensing

Sorted Random Projections

Problems with existing approaches for including rotation invariance:
- Add randomly rotated local patches → much more data points, much greater spread cluster, posing storage and processing challenges, and also creating challenges in clustering
- Estimate the dominant gradient orientation → unreliable, computational expensive
- Compute multilevel histograms → computational expensive, low efficiency

Our solution: Sorting followed by Random Projection → intuitive (Figure 1), computational simple, rotation invariant and Discriminative

We have proposed two types of SRP features (Figure 2):
- Pixel-intensity based:
  - SRP Global → globally sorting raw pixel intensities
  - SRP Square → multiscale sorting raw pixel intensities (Square Neighborhood)
  - SRP Circular → multiscale sorting raw pixel intensities (Circular Neighborhood)
- Pixel-difference based:
  - SRP Radial-Diff → multiscale sorting radial differences
  - SRP Angular-Diff → multiscale sorting angular differences

Description and Classification

Two BoW-based representation schemes:
- HOGC: Histogram-Of-Global-Codebook → universal texture codebook learning from all texture classes, histogram + chi square distance
- SOLC: Signature-Of-Local-Codebook → local texture codebook learning from each image, signature + EMD distance

Classifications:
- Nearest Neighbor Classifier → single feature
- SVMs → single kernel
- SVMs → multiple kernel combination