Clustering, Dictionary Learning & Feature Extraction

CLUSTERING: Sparse Subspace Clustering

The authors address the problem of clustering collection of data points lying in low dimensional subspaces.

Prior work on subspace clustering via iterative, algebraic, statistical methods is sensitive to initialization, subspace independence, noise and outliers. While, with the recent advancements in sparse representation theory and low-rank recovery algorithms proved to be successful by posing clustering problem as one of finding a sparse or low-rank representation of the data points in the dictionary of the data itself, and using the sparse coefficients to build a similarity graph for segmentation using spectral clustering.

The main contribution is to represent each data point using maximal number of other points to reduce computation complexity from its own subspace obtained by applying *K Means algorithm* and then further relaxing it by L1 to make it recoverable using convex optimization. By incorporating the corruption model of data into sparse optimization program and additional linear equality constraints the algorithm is able to handle data inconsistencies like noise, missing values or corrupted data.

Further experiments on synthetic data proves that success of the clustering relies on the success of the L1-minimization in recovering subspace-sparse representations of data points. The algorithm outperforms several state of the art algorithms in motion segmentation and facial image clustering proving that the separation of different motion subspaces in terms of their principal angles and the distribution of the feature trajectories in each motion subspace are sufficient for the efficient clustering.

DICTIONARY LEARNING: Supervised Dictionary Learning

The paper proposes a novel discriminative formulation for sparse representation of images, using learned dictionaries. The authors extends the previous work which was proven good in areas, such as, denoising and texture classification on sparse representation done on either predefined operators or learned dictionaries for reconstructive, discriminative, or generative models.

The authors propose a framework for learning simultaneously a single shared dictionary as well as multi-class sparse models in mixed generative and discriminative models letting multiple classes share some features and use the sparse representations coefficients as a part of classification.

Also, Including generative modeling helps with robustness while the discriminative modeling helps accurately fit the best parameters that will predict the labels of the data.

All models (generative, discriminative, linear and bilinear) are then compared with reconstructive approach in digit and texture recognition which shows the proposed techniques are better compared to state-of-art methods.

FEATURE EXTRACTION: Transform Invariant Low-rank Textures (TILT)

In this paper, the authors propose a new method TILT (transform invariant low-rank textures) to come up with significant low rank textures from 2D images of 3D environment. Finding these low rank textures help captures effective geometric patterns in data found in everyday object recognition tasks.

The authors address shortcomings of current methods requiring pre-processing and sensitivity to local image variations. Thereby, preventing these methods from taking larger regions into account for detecting symmetrical patterns.

The basic idea of the approach is to view each image as a matrix and find efficient low-rank matrix lending transformations. However, the cost function is highly non-convex and discontinuous, and the equality constraint is highly non-linear.

Thus, calculating TILT would be computationally hard, therefore authors leverage recent breakthroughs in convex optimization by using the sum of singular values, L1 norm and iteratively solve the nonlinear constraint problem along with some constraints to avoid converging to a local minima. This enables robust recovery of a high-dimensional low-rank matrix despite gross sparse errors. Experiments show this works well in facial or textual forms which are approximately low-rank in formation.

TILT outshines in effectively recovering projective deforms and domain transforms even in the case of occlusions or noise and is able to rectify not only small local features, such as, an edge and a corner, but, also large global symmetric patterns, such as, an entire facade of a building.