The devil is in the details: an evaluation of recent feature encoding methods

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Recently multiple novel encodings for bag of visual words image classification have been proposed, but often due to small differences in image feature extraction and learning methodology published results cannot be directly compared. Here we provide a thorough comparative evaluation by fixing other pipeline components.

1. Histogram Encoding (VQ) [2]

2. Kernel Codebook Encoding (KCB) [3,4]

3. Locality Constrained Lin. Enc. (LLC) [5]


5. Supervector Encoding (SV) [7]

Baseline - each feature maps to the single nearest word in a k-means trained vocabulary

\[ q_{ki} = \arg \min_{k} \|x_i - \mu_k\|^2 \]

Features mapped in soft manner based on Gaussian weighted distances

\[ [\hat{q}_{ki}] = \arg \min_{k} \|x_i - B_{ki}\|^2 \]

Features mapped in soft manner based on minimized reconstruction error

\[ \hat{q}_{ki} = \arg \min_{k} \|x_i - \hat{B}_{ki}\|^2 \]

where \( B_{ki} = [\hat{q}_{ki}] \) \[ \hat{q}_{ki} \]

\[ f_{sv} = [s_1, u_1^\top, \ldots s_K, u_K^\top]^\top \]

\[ s_k \propto \text{hard/soft assignment} \]

\[ u_k \propto \text{derivative w.r.t } \mu_k \]

Differences with original published results emphasizes importance of controlling carefully all conditions

Super Vector (SV) 1024 (≈ 132k) 58.16

Other combinations of encoding methods/kernels are also tested, but the final encoding is always \( \ell_2 \) normalized.

\[ \ell_2 = \{u_1^\top, \ldots u_K^\top\}^\top \]

\[ u_k \propto \text{derivative w.r.t } \mu_k \]

\( x \) and \( x \) are samples of the same class.

\[ [\hat{q}_{ki}] = \arg \min_{k} \|x_i - \hat{B}_{ki}\|^2 \]

\( \hat{B}_{ki} = [\hat{q}_{ki}] \) \[ \hat{q}_{ki} \]

Capture average first and second order differences using \( \nabla \) operator to GMM centres

\[ \hat{q}_{ki} = \{\hat{s}_1, \nabla \hat{s}_1, \ldots \hat{s}_K, \nabla \hat{s}_K\}^\top \]

\( \hat{s}_k \) \[ \hat{s}_k \]

\[ \hat{s}_k \propto \text{derivative w.r.t } \mu_k \]

\[ \nabla \hat{s}_k \propto \text{derivative w.r.t } \mu_k \]

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