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Image Classification Using Probability Higher-order Local Auto-Correlations

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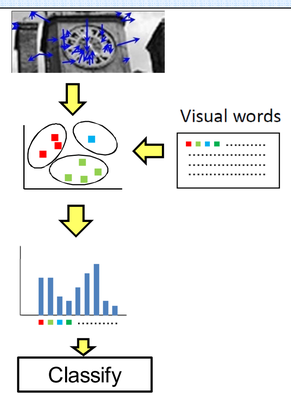
Motivation

Bag-of-features classification

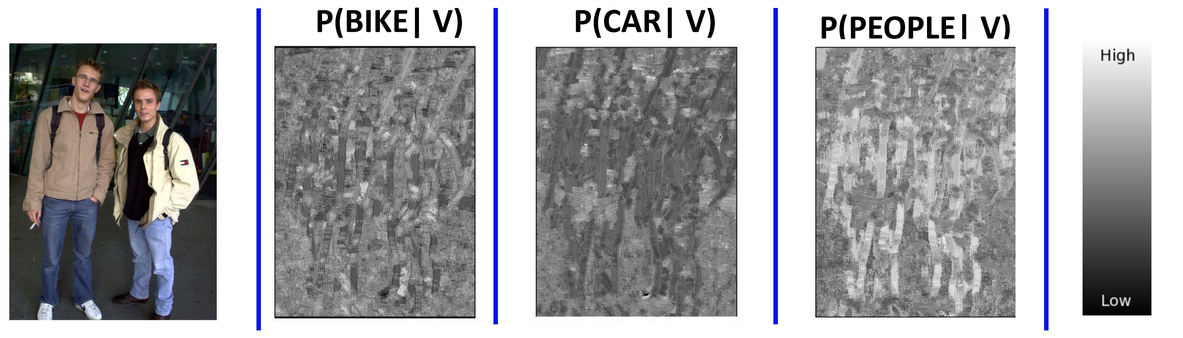
- Most popular approach for genetic object recognition.
- Histogram of Visual Words



- Spatial relationship of local features is not utilized
- Class label information is not utilized

➡ Improve the classification accuracy of bag-of-features by introducing local co-occurence and semantic label information

Posterior probability image



The maps of categorical posterior probability is constructed from visual words (grid sampling)

V : codebook c: category

Estimation method

(a) Bayes Theorem $P(c \mid V_m) = \dfrac{P(V_m \mid c)P(c)}{P(V_m)}$

(b) SVM Weight $P(c \mid V_m) = \dfrac{\alpha_{c,m} - \min\{\boldsymbol{\alpha}_c\}}{\sum_{m=1}^{M}(\alpha_{c,m} - \min\{\boldsymbol{\alpha}_c\})}$

HLAC features on posterior probability images (PHLAC)

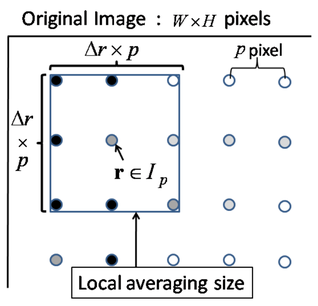
N-th order PHLAC

$$R(c, \mathbf{a}_1, \ldots, \mathbf{a}_N) = \int_{I_p} P(c \mid V_{VQ(\mathbf{r})}) P(c \mid V_{VQ(\mathbf{r}+\mathbf{a}_1)}) \cdot \cdot \cdot P(c \mid V_{VQ(\mathbf{r}+\mathbf{a}_N)}) d\mathbf{r}$$

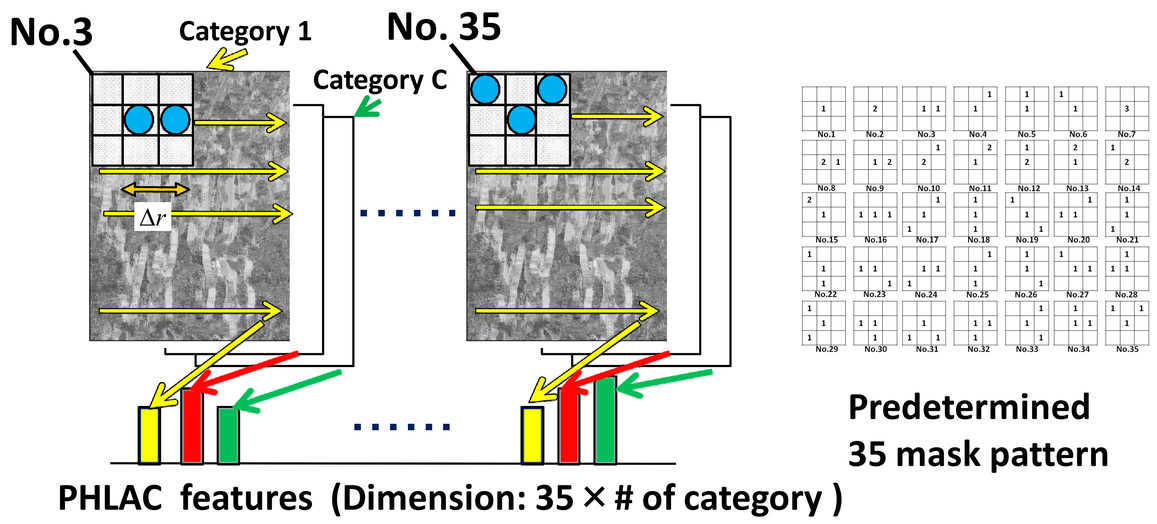
I_p sampling points $\mathbf{r}$ local region $\mathbf{a}$ shift vector

Practical formulation:

- N is Restricted up to 2nd Order
- Local averaging before calculating HLAC features



How to extract feature vectors



PHLAC features (Dimension: 35 × # of category)

Predetermined 35 mask pattern

Interpretation

- Shift invariance and Additivity:

Inherited from HLAC

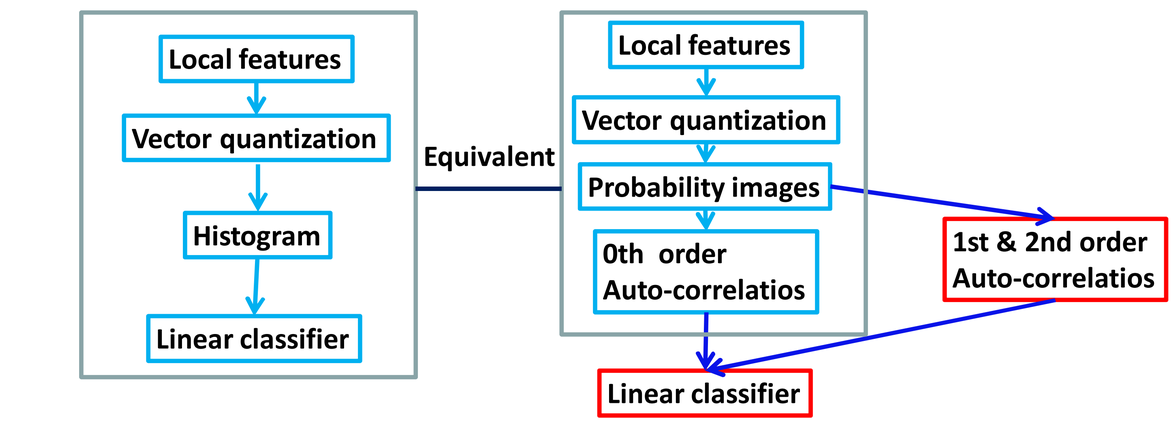
- Synonymy Invariance :

invariant feature to similar posterior probability regions even its appearance is different (synonymy visual words)

- Bag-of-Feature (0^{th}) + Higher order Local auto-correlation:

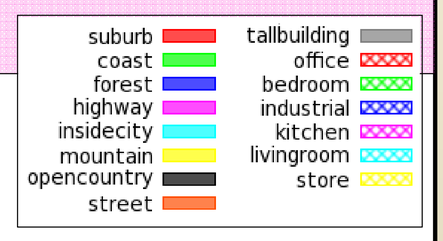
bag-of-feature is maximum category selection of 0-th order PHLAC (Our method train additional classifier using PHLAC)
Higher-order local auto-correlation capture spatial information of the posterior probability images

Comparison with bag-of-features



a) Bag-of-features classification b) PHLAC classification

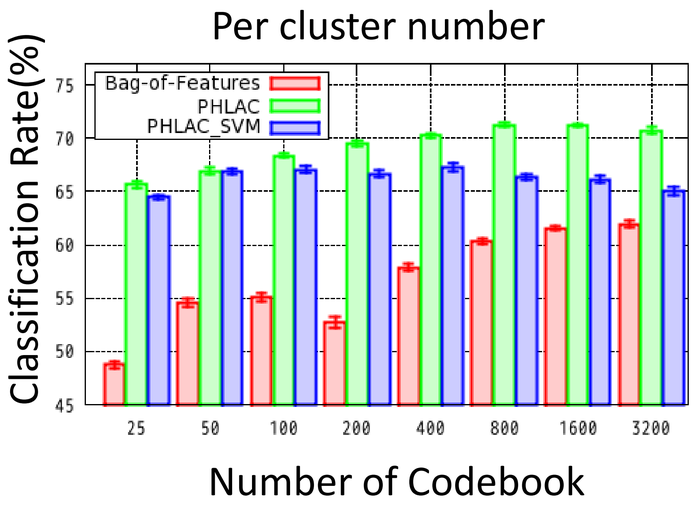
Experimental results using Scene-15 dataset



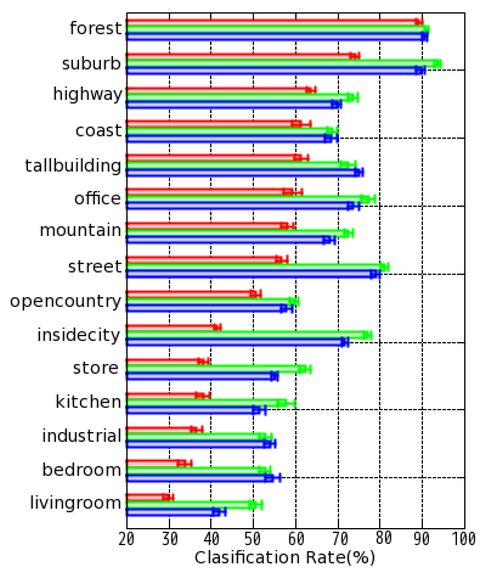
Experimental set up

- SIFT like feature per 8 pixel intervals
- Spatial Interval $\Delta r = 8$
- Vector quantization using k-means clustering
- Classification using linear SVM (one-against- all)
- Average of 10 trial

Per cluster number



Per Category



Correctly classified images