

# Locality-constrained Linear Coding for Image Classification

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# How do we classify visual object categories?



Monkey?



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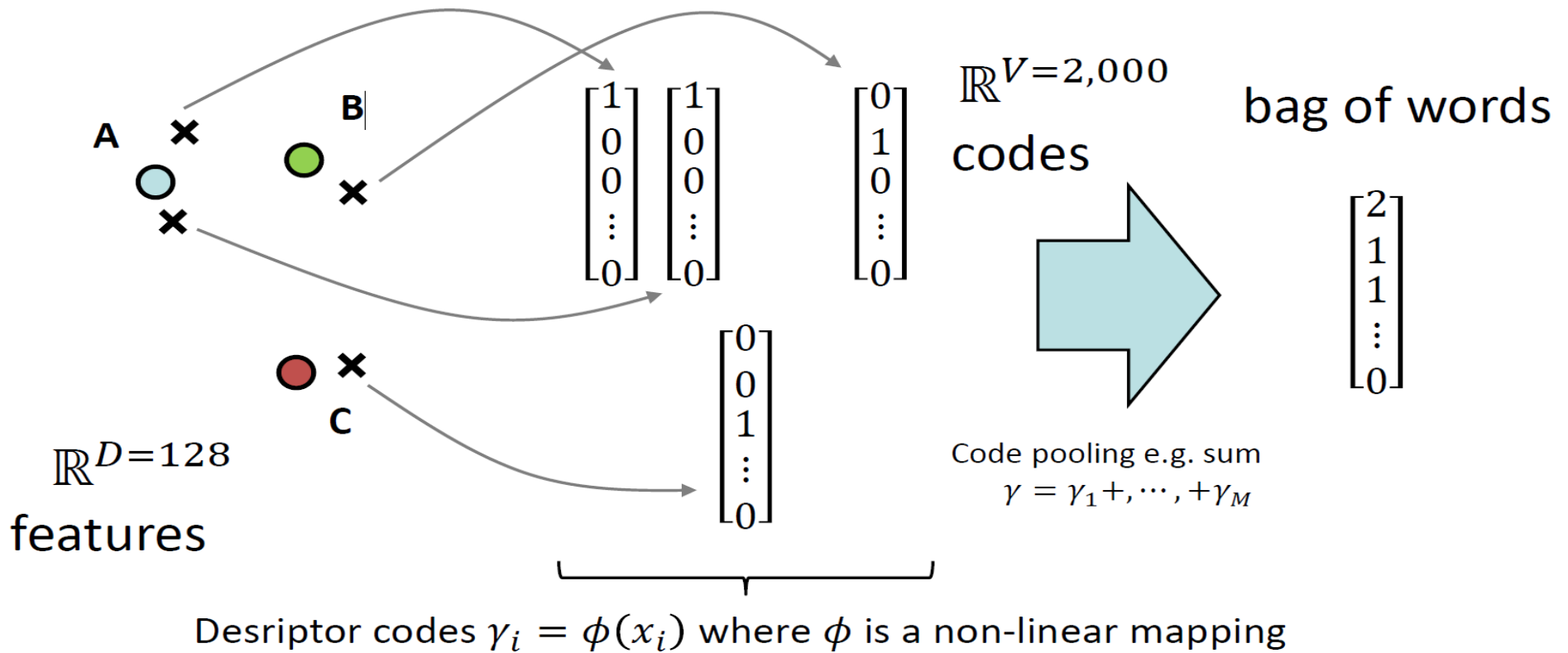


Monkey?

# Recent approaches

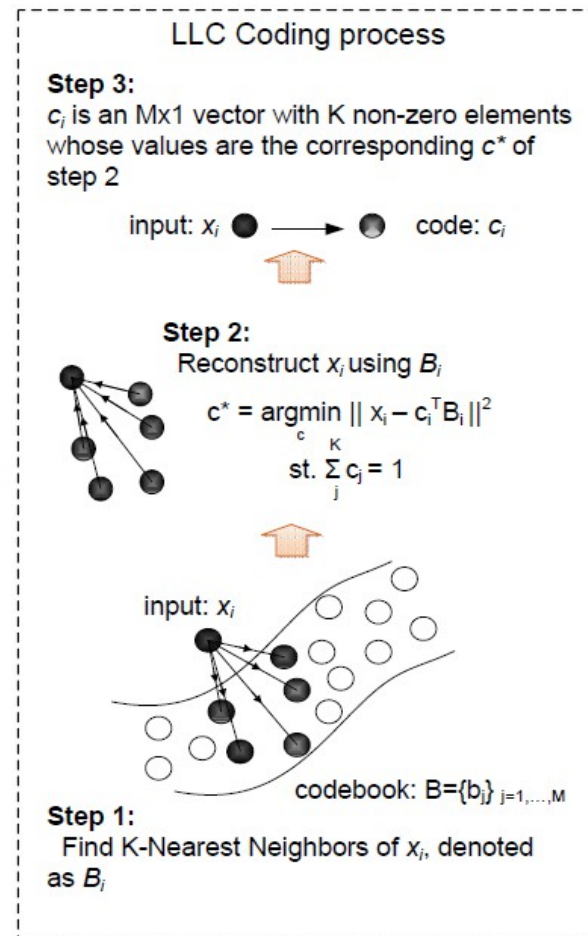
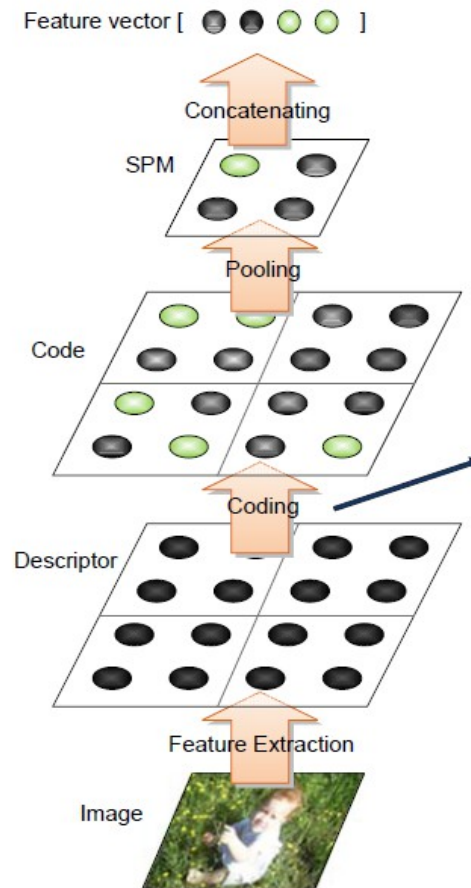
- Bag Of Features (BOF)
- Generative Part Models
- Geometric Correspondence Search
- Discriminative Codebook Learning
- Spatial Pyramid Matching (SPM)

# Bag of Features

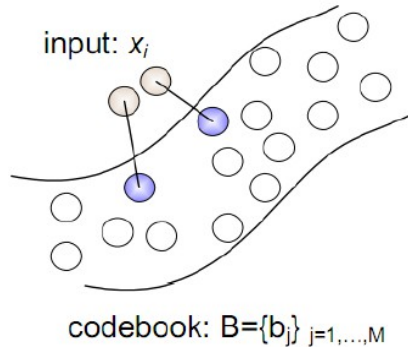


# Related Work

- BOF + SPM with Locality-constrained Linear Coding (LLC)



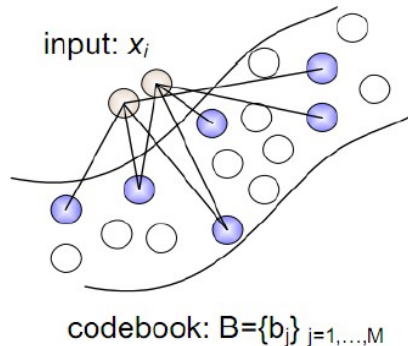
# Coding Alternatives



## Vector Quantization

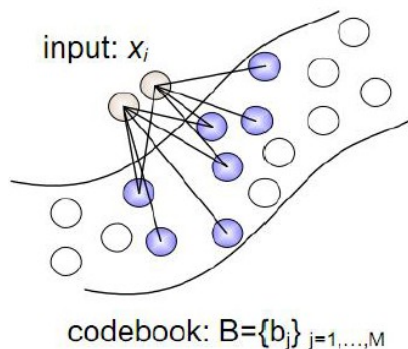
- ✓ Fast
- ✗ Quantization a problem
- ✓ Assigns features to single visual word based on locality

- ✗ Does not minimize reconstruction error



## ScSPM (sparsity regularization)

- ✓ Minimizes reconstruction error  $\sum_{i=1}^N \|x_i - N\gamma_i\|^2$
- ✗ Optimization is computationally expensive
- ✗ Regularization term is not smooth



## LLC (locality regularization)

- ✓ Minimizes reconstruction error  $\sum_{i=1}^N \|x_i - N\gamma_i\|^2$
- ✓ Local smooth sparsity
- ✓ Fast computation through approximated LLC

# Advantages

- Sparsity Regularization Term
  - Able to find a solution on over-complete codebook (multi base response)
  - Detecting salient local descriptors
  - Less reconstruction error
- LLC
  - VQ links to only one word
  - SC is so homogeneous, farther inputs generate close outputs
  - SC computation complexity is so high. LLC can be performed by a covariance matrix computation
  - Fast encoding with k-nn search



# The Codebook

- Kmeans generated results of K-means generated codebook is satisfactory.
- Update codebook with modified Coordinate Descent method
- If the weight bigger than a threshold refit the corresponding element

# Results

Algorithm	15 training	30 training
SVM-KNN (Zhang CVPR '06)	59.10	66.20
KSPM (Lazebnik CVPR '06)	56.40	64.40
NBNN (Boiman CVPR '08)	65.00	70.40
ML+CORR (Jain CVPR '08)	61.00	69.60
Hard Assignment	--	62.00
KC (Gemert ECCV '08)	--	64.14
ScSPM (Yang CVPR '09)	<b>67.00</b>	73.20
<b>LLC</b>	65.43	<b>73.44</b>

↑ Results over Caltech-101 dataset

↓ Results over Caltech-256

Algorithm	15 training	30 training
Hard Assignment	--	25.54
KC (Gemert ECCV '08)	--	27.17
ScSPM (Yang CVPR '09)	27.73	34.02
<b>LLC</b>	<b>34.36</b>	<b>41.19</b>

Thanks