Sparse Coding for Third-order Super-symmetric Tensor Descriptors with Application to Texture Recognition

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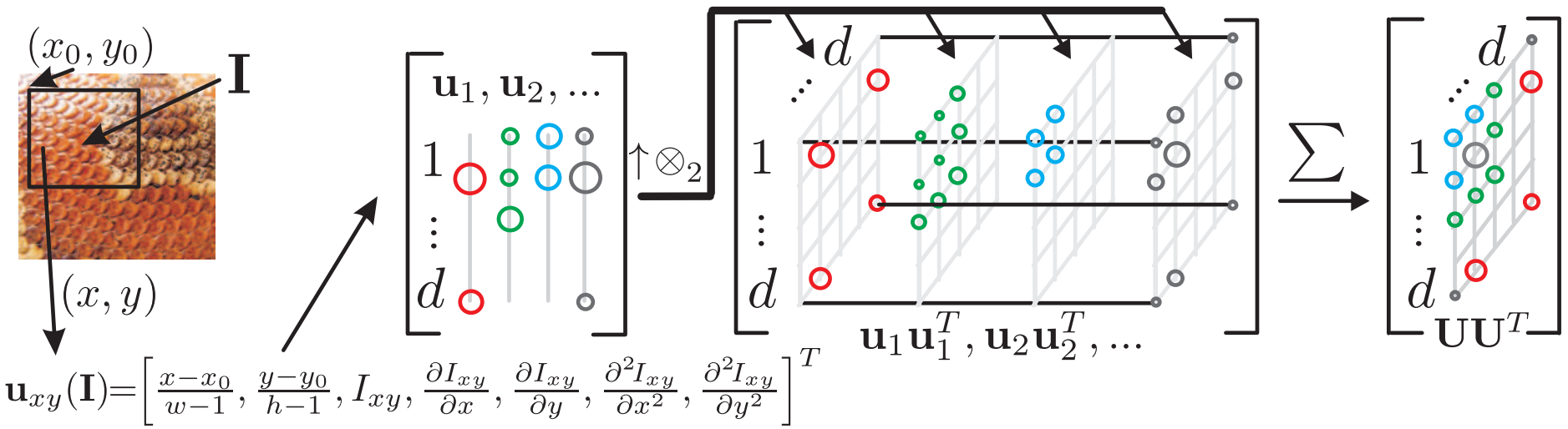
TOSST Texture Descriptors

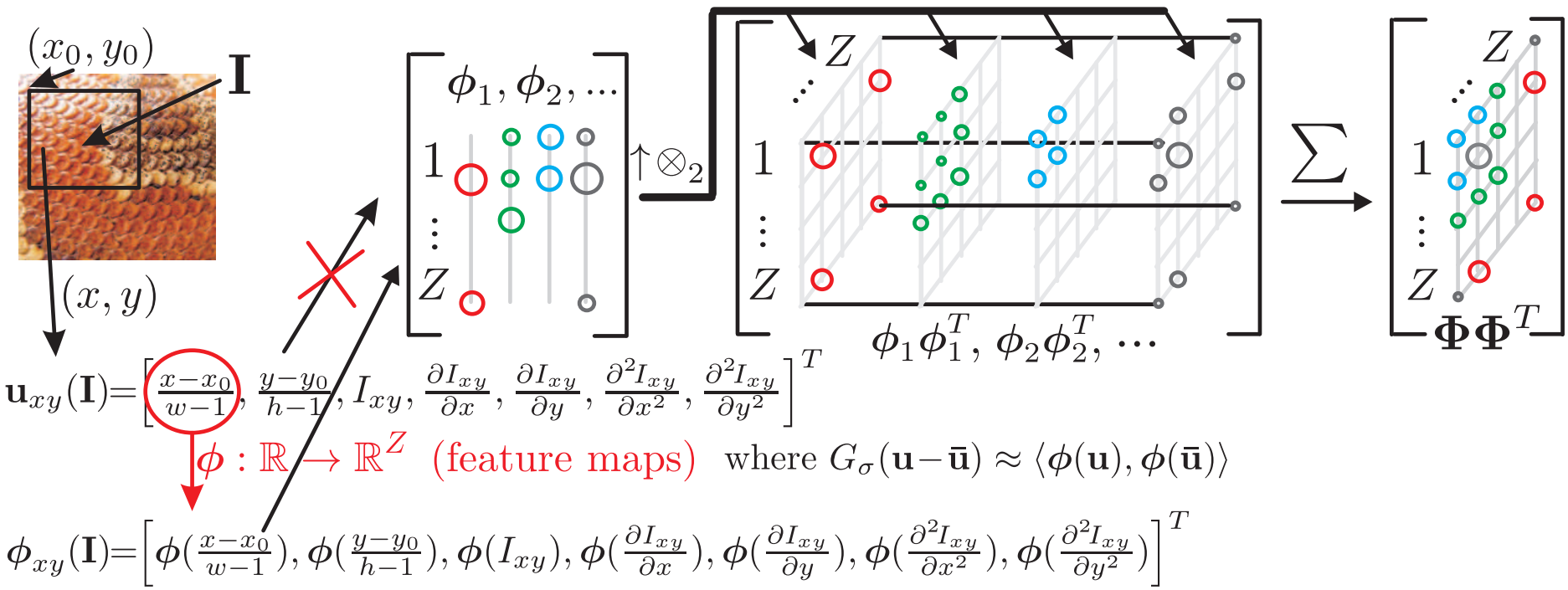
- Region covariance descriptors (co-occurrences).
- They typically use outer-product of low-level feature vectors $\uparrow\otimes_2\mathbf{u} = \mathbf{u}\mathbf{u}^T$.



- Low-level features $\mathbf{u}$ (linear). Non-linear features are better. We embed $\mathbf{u}$ into RKHS/linearize the RBF kernel by feature maps.

TOSST Texture Descriptors

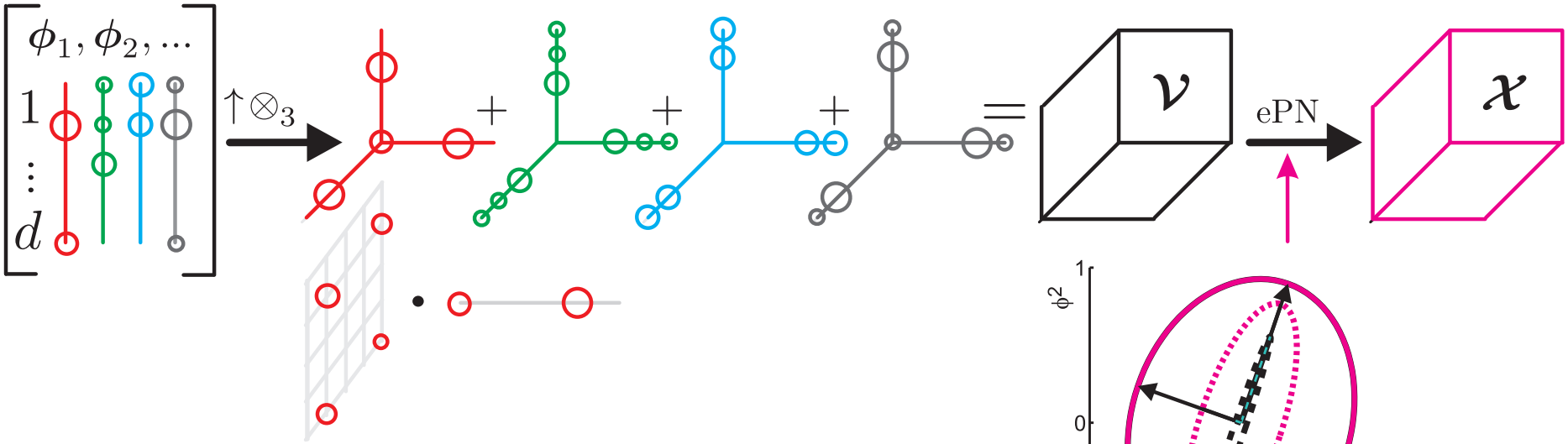
- Non-linear co-occurrence descriptors.



- Can we form more informative co-occurrences?
  Yes, we extend $\uparrow\otimes_2$ to third-order outer product $\uparrow\otimes_3$.

TOSST Texture Descriptors

- Non-linear third-order descriptors
  +eigenvalue Power Normalization (ePN).



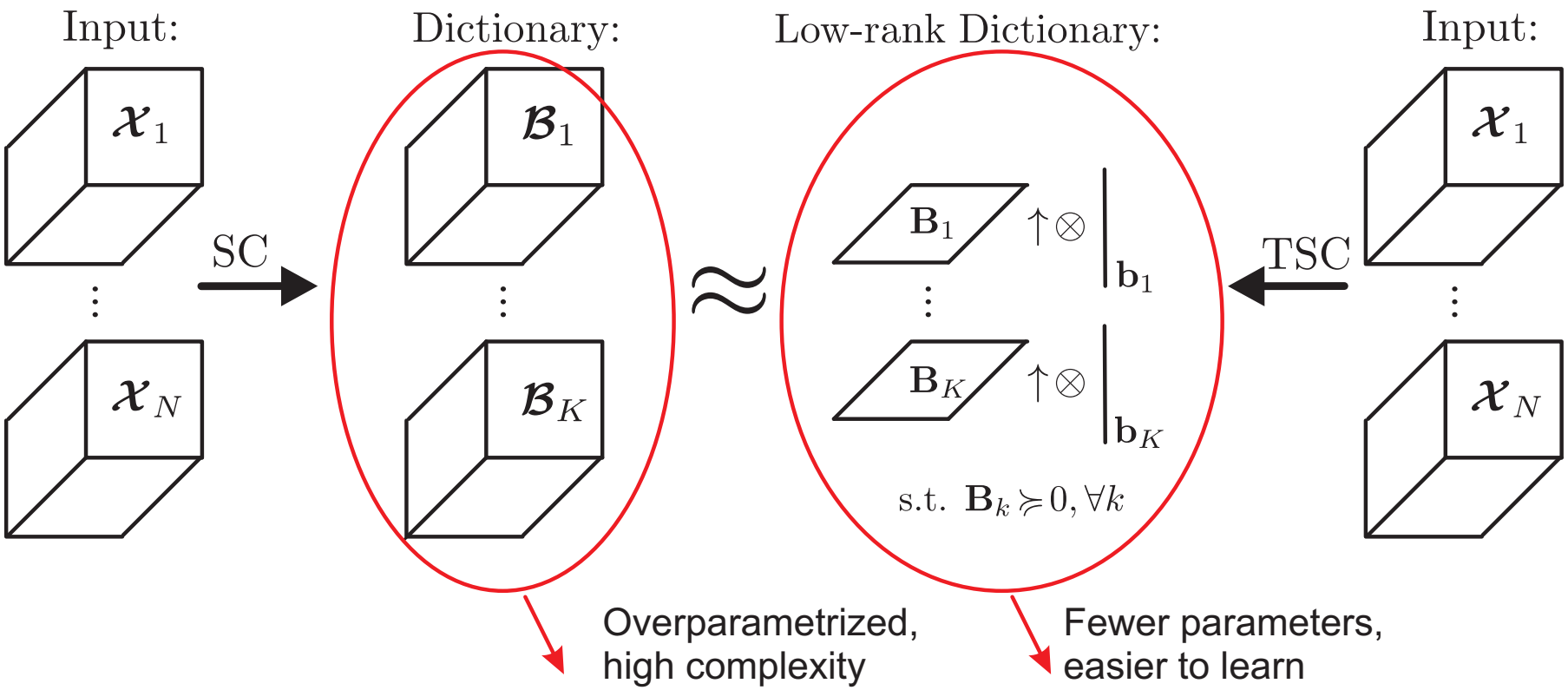
- However, $\mathcal{X}$ is cubic w.r.t. size of features.
  We propose Sparse Coding for
  Third-order Tensor Descriptors.
- We learn a dictionary to encode TOSST:

$$\underset{\substack{\mathcal{B}_1,\ldots,\mathcal{B}_K \\ \alpha^1,\ldots,\alpha^N}}{\arg\min} \sum_{n=1}^{N} \left\| \mathcal{X}_n - \sum_{k=1}^{K} \mathcal{B}_k \alpha_k^n \right\|_F^2 + \lambda \left\| \boldsymbol{\alpha}^n \right\|_1.$$

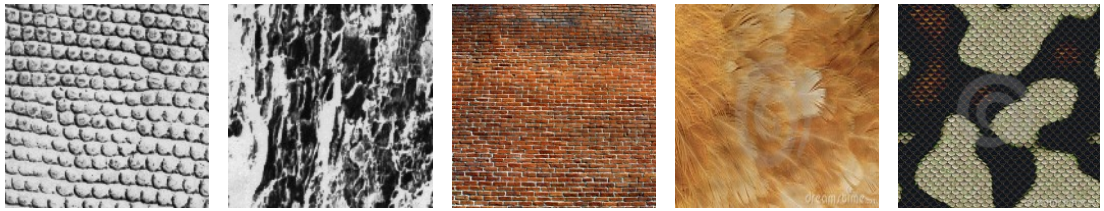
- Resulting sparse codes $\boldsymbol{\alpha}$ are pooled and used to train SVM.

Sparse Coding for Third-order Tensor Descriptors (TSC)

- We use training set of TOSST descriptors $\mathcal{X}_1, ..., \mathcal{X}_N$.
- We learn low-rank dictionary atoms $\mathbf{B}_1 \uparrow\otimes \mathbf{b}_1, ..., \mathbf{B}_K \uparrow\otimes \mathbf{b}_K$ (outer product of matrices with vectors).
- They approximate full-rank tensor atoms $\mathcal{B}_1, ..., \mathcal{B}_K$.



Results



- Brodatz textures; 99.9% accuracy (the state of the art); others score $\sim 98.72\%$.
- UIUC materials recognition; 58.0% accuracy.
- PASCAL VOC07 descriptor compression: 61.2% mAP ($25K$ signature) vs. 61.3% mAP ($176K$ signature).

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- References:

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