Learning the "Epitome" of a Video Sequence

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Outline

- Image epitome
  - ▶ What?
  - ▶ Why?

- Implementation computation issues
  - ▶ Efficiently implementing the learning algorithm

- Video epitome
  - ▶ Extension to videos
  - ▶ Video inpainting
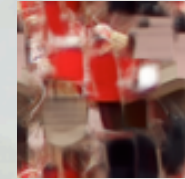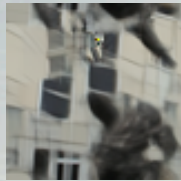
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Image Epitome

- Jojic, N., Frey, B., & Kannan, A. (2003). Epitomic analysis of appearance and shape. In Proc. IEEE ICCV.

- Miniature, condensed version of the image

- Accurately accounts for the interesting properties of the image

- Applications
  - ▶ object detection
  - ▶ texture segmentation
  - ▶ image retrieval
  - ▶ compression

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Image Epitome Examples

Learning the Image Epitome

Training Set

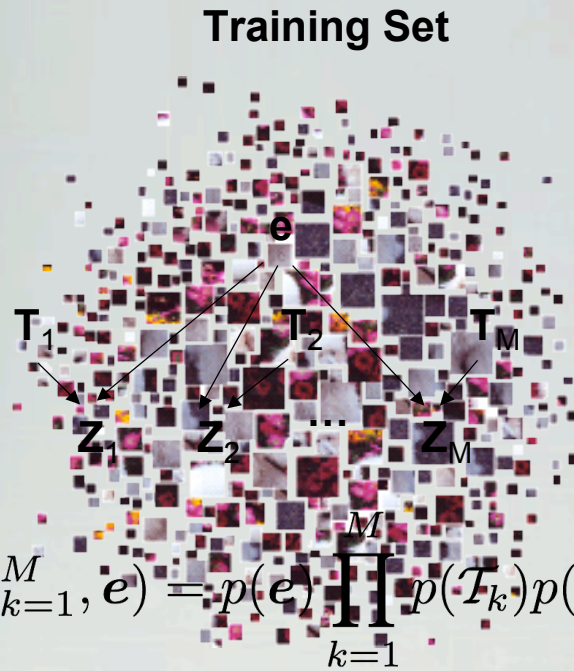**Input image**

Epitome

Sample
Patches

Bayesian
network

Unsupervised
Learning

$\mathbf{e}$ = epitome
$\mathbf{T}_k$ – mapping
$\mathbf{Z}_k$ – image patch

$\mathbf{e}$

$\mathbf{T}_1$ $\mathbf{T}_2$ $\mathbf{T}_M$

$\mathbf{Z}_1$ $\mathbf{Z}_2$ ... $\mathbf{Z}_M$

$$p(\{\boldsymbol{Z}_k, \mathcal{T}_k\}_{k=1}^M, \boldsymbol{e}) = p(\boldsymbol{e}) \prod_{k=1}^M p(\mathcal{T}_k) p(\boldsymbol{Z}_k | \mathcal{T}_k, \boldsymbol{e})$$

$$p(\boldsymbol{Z}_k | \mathcal{T}_k, \boldsymbol{e}) = \prod_{i \in S_k} \mathcal{N}(z_{i,k}; \mu_{\mathcal{T}_k(i)}, \phi_{\mathcal{T}_k(i)})$$
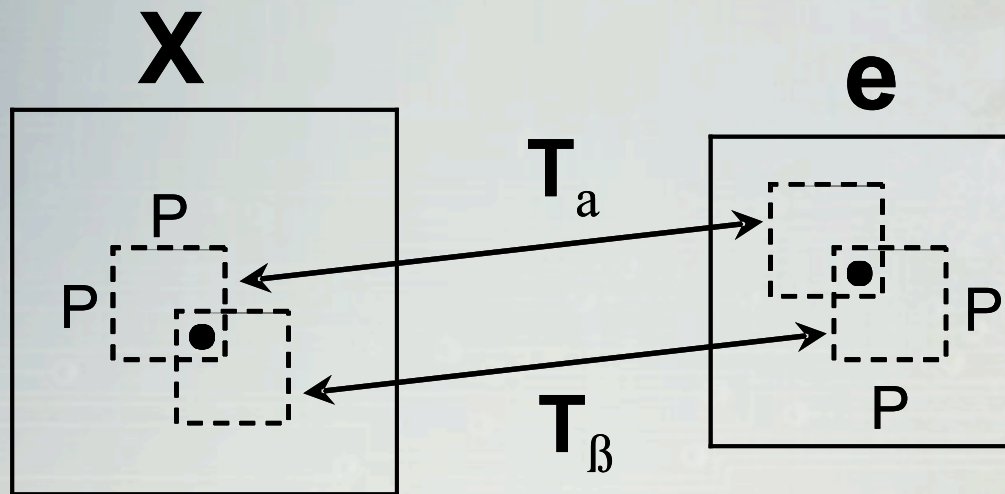
Shifted Cumulative Sum Algorithm

$$q(\mathcal{T}_k) \propto \prod_{i \in S_k} \mathcal{N}(z_{i,k}; \hat{\mu}_{\mathcal{T}_k(i)}, \hat{\phi}_{\mathcal{T}_k(i)})$$
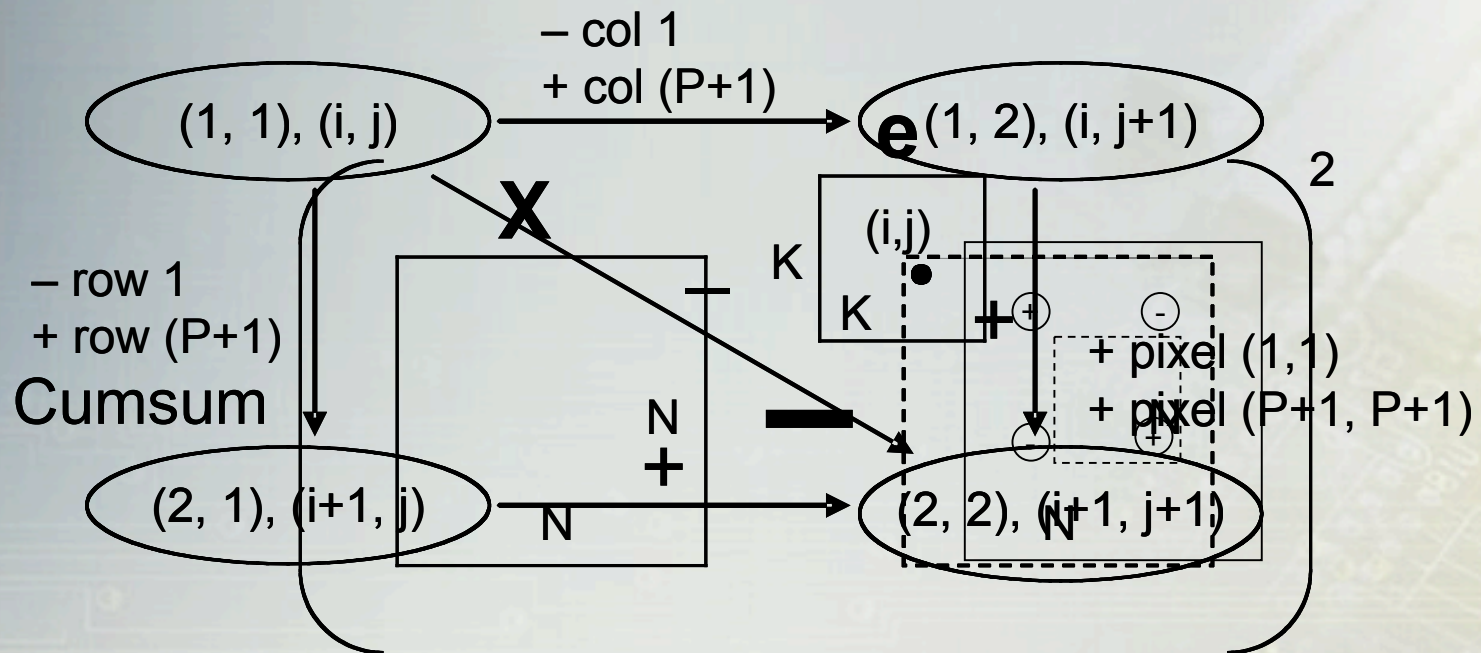
Collecting Sufficient Statistics

$$\hat{\mu}_j \equiv \frac{\sum_k \sum_{i, i \in S_k} \sum_{T_k, T_k(i)=j} g(T_k) z_{i,k}}{\sum_k \sum_{i \in S_k} \sum_{T_k, T_k(i)=j} g(T_k)}$$

$$\hat{\phi}_j = \frac{\sum_k \sum_{i, i \in S_k} \sum_{T_k, T_k(i)=j} g(T_k) z_{i,k}^2}{\sum_k \sum_{i \in S_k} \sum_{T_k, T_k(i)=j} g(T_k)} \mu_j^2 - \hat{\mu}_j^2$$

Extending Epitomes to Videos

- Desire a miniature, condensed version of a video sequence

- Want it to accurately account for the interesting properties of the video

- Applications
  - ▶ optic flow
  - ▶ segmentation
  - ▶ texture transfer
  - ▶ layer separation
  - ▶ compression
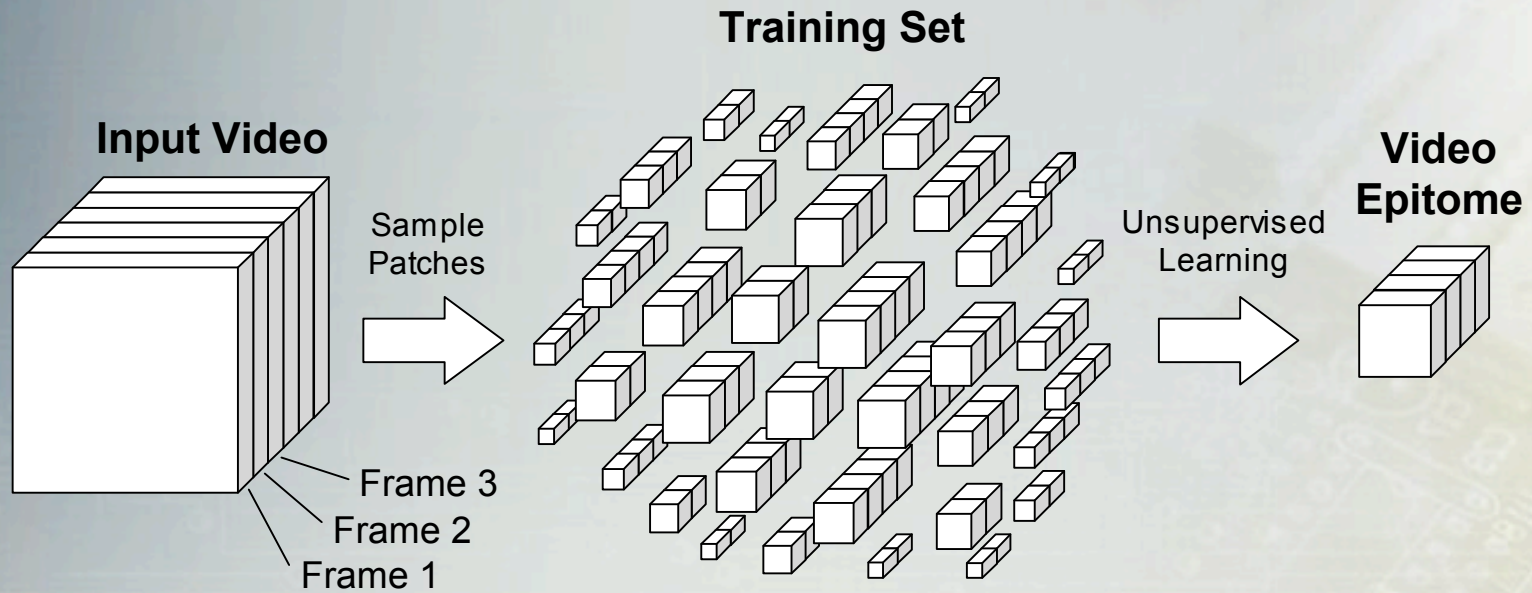 - ▶ noise reduction
  - ▶ inpainting

Video Epitome

Image

Learning

Video

Input Video

Sample
Patches

Frame 3
Frame 2
Frame 1

Training Set

Unsupervised
Learning

**Video
Epitome**

Video Epitome Example
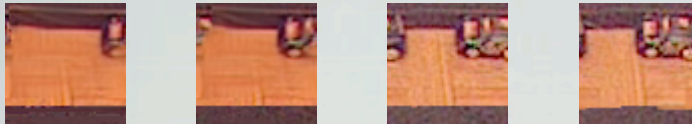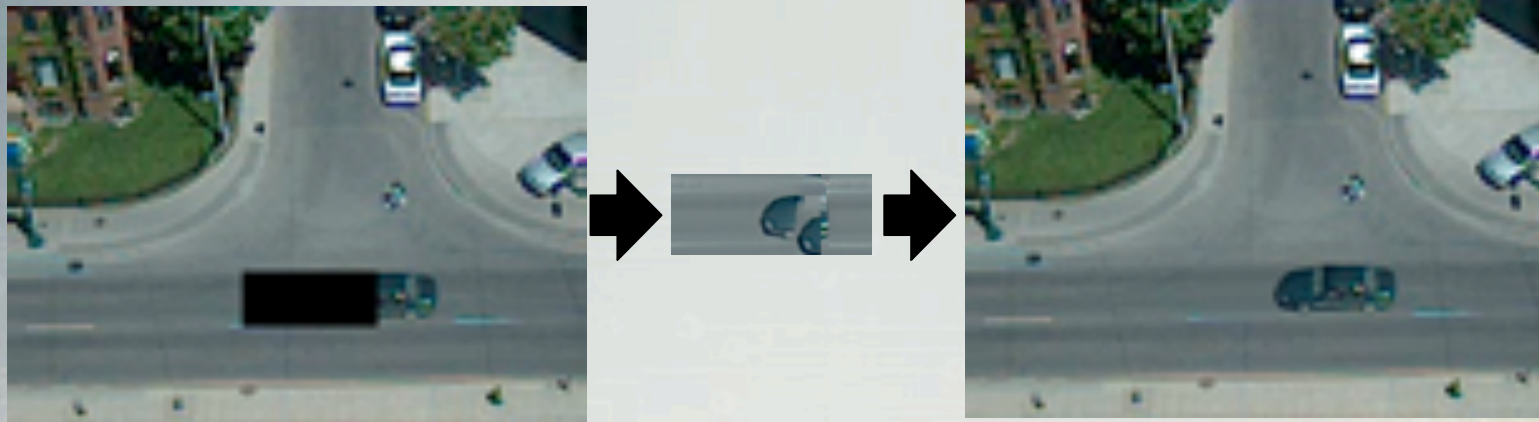

Spatially Compressed

Temporally Compressed

Video Inpainting (1)

- Fill in missing portions of a video
  - ▶ damaged films
  - ▶ occluding objects

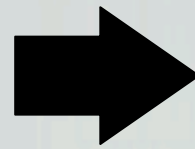- Reconstruct the missing pixels from the video epitome

Video Inpainting (2)

Image

Learning

Video

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Conclusion

- Improved the efficiency of learning image epitomes

- Extended the concept of epitomes to video sequences

- Demonstrated the ability of video epitomes to model motion patterns through video inpainting