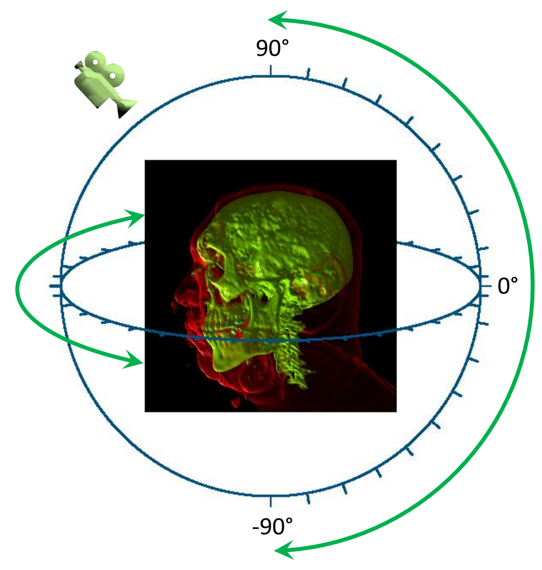
Volume Rendering Using Principal Component Analysis

Salaheddin Alakkari and John Dingliana
Email: alakkars@tcd.ie | John.Dingliana@tcd.ie
Graphics Vision and Visualisation Group (GV2), School of Computer Science and Statistics, Trinity College Dublin (Ireland)

Principal Component Analysis

- Find a set of orthogonal bases (eigenvectors) that best describe the variability in a set of input samples.
- These eigenvectors are ordered based on the variability covered by each individual eigenvector (defined by its eigenvalue).
- In our case the input samples are pre-rendered images using a standard raycaster from spherically distributed camera positions.
- Samples can be reconstructed efficiently at run-time based on their scores (projection values onto the first significant eigenvectors).
- Novel-views can be derived by interpolation of scores.



Given data samples $X = [x_1\ x_2 \ldots x_n] \in R^{d \times n}$
and eigenvector, $v \in R^d$ and, eigenvalue λ

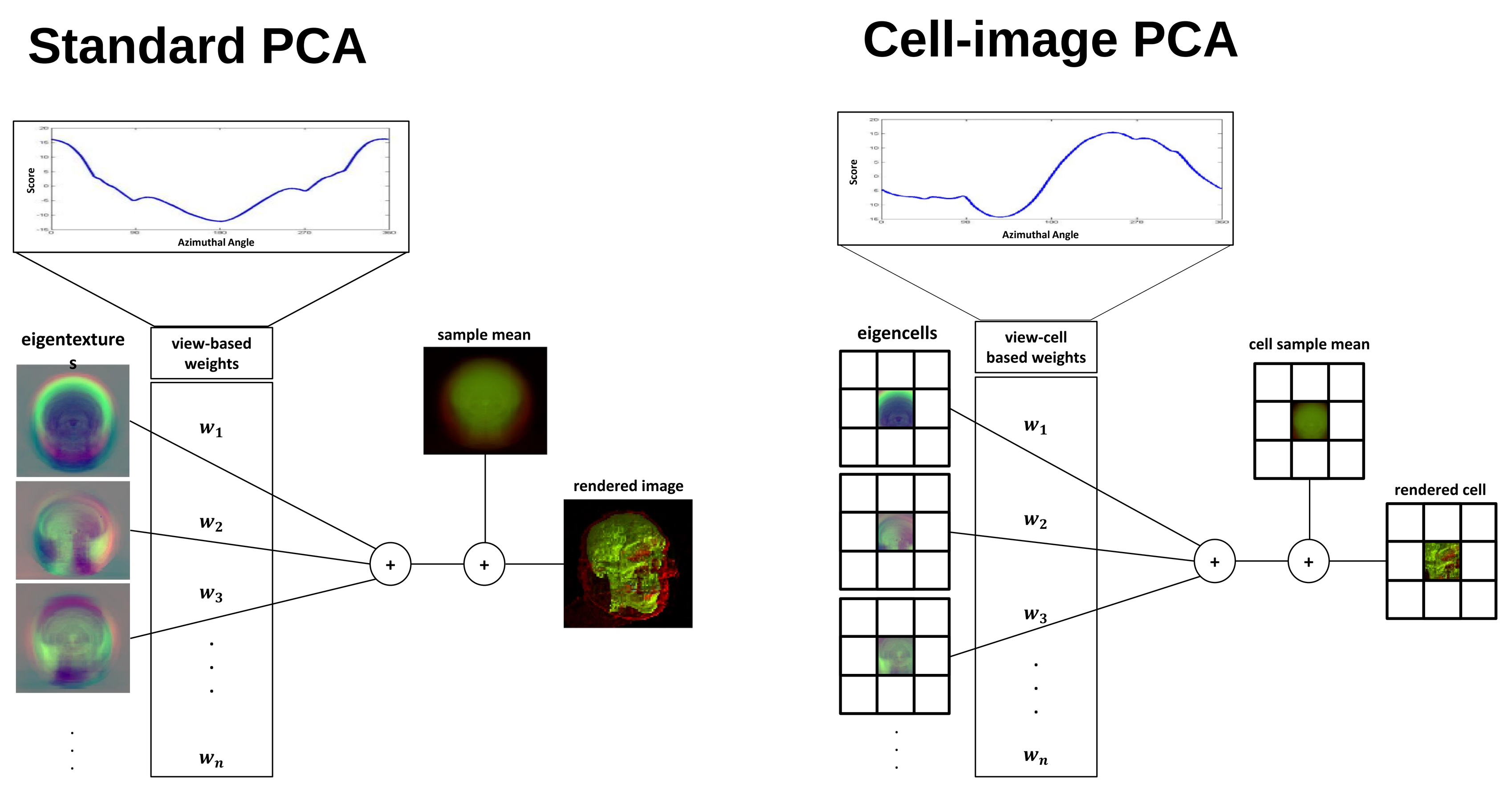
the COVARIANCE MATRIX is defined as:

$$C = \frac{1}{n-1} X X^T = \frac{1}{n-1} \sum_{i=1}^{n} x_i x_i^T$$

$$(C - \lambda I)v = 0; \quad v^T v = 1$$

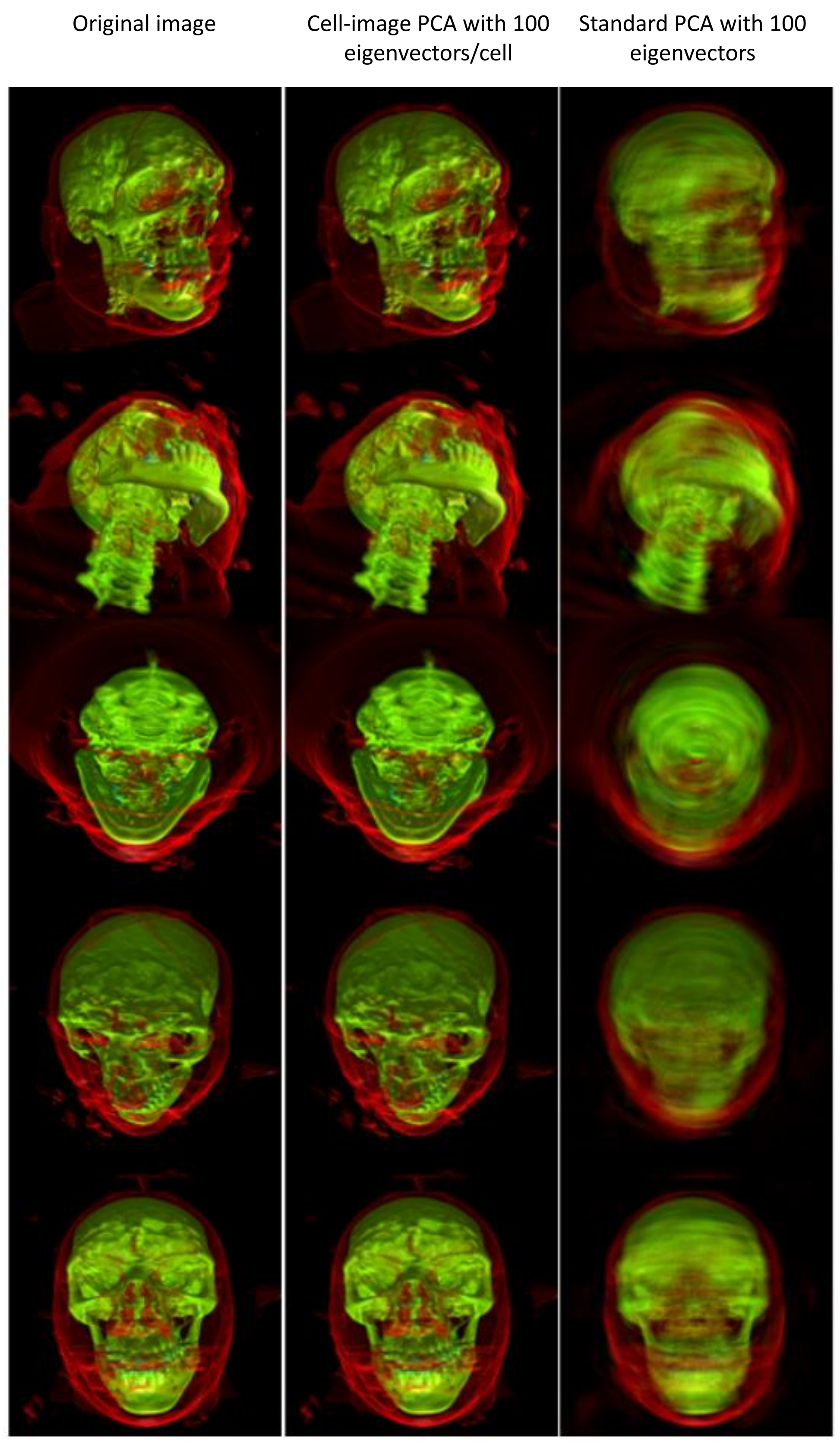
Standard PCA VS. Cell-Image PCA

PCA for Volume Rendering

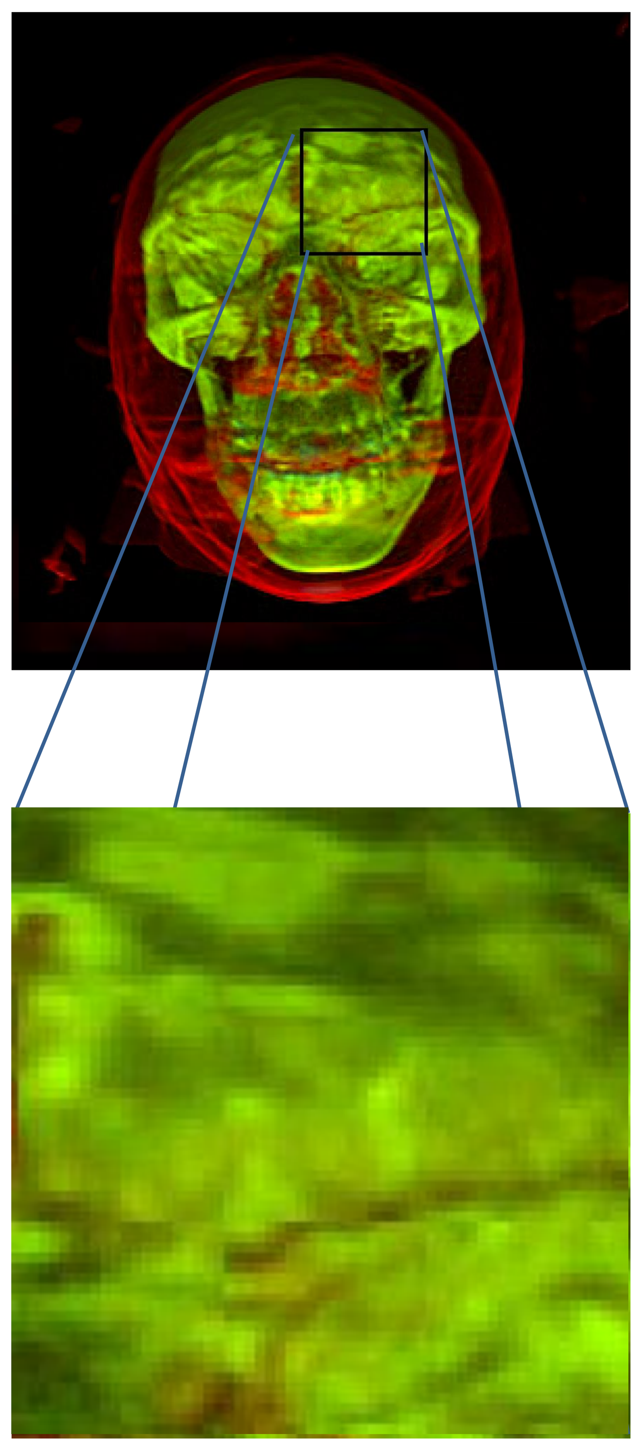


- We applied PCA to RGB images with resolution of 300x300 pixels.
- In ***Cell-image PCA*** the images are divided into equally sized cells and then apply PCA to each cell region individually.
- We applied cell size of 20x20 RGB pixels in *Cell-image PCA*.
- We used 100 eigenvectors per cell to encode the computed eigenspace.
- We then synthesize a novel view image by interpolating the scores in the eigenspace.

Results



Subtle Discontinuity Artefacts with Cell-based PCA



Main Findings

1. **The *Cell-image PCA* approach leads to much better quality results compared to the standard PCA.**
2. **The *Standard PCA* results in somewhat blurry images for the same distribution of training samples.**
3. **Cell-image PCA results in subtle discontinuity artefacts at the cell boundaries in the reconstructed images.**
4. **A disadvantage of both PCA approaches is that changes in transfer function require recomputing the eigenspace.**
5. **The main advantage is efficient image generation from any viewpoint. This is independent of rendering complexity, which is decoupled in the pre-processing stage.**

Future Work

- Conduct perceptual studies to measure the conspicuity of artefacts under different viewing and training configurations.
- Investigate strategies to ameliorate the subtle artefacts appearing in the cell boundaries for Cellimage -PCA.
- Investigate potential benefits to client-server schemes for interactive volume visualization

Acknowledgements

- This research has been conducted with the financial support of Science Foundation Ireland (SFI) under Grant Number 13/IA/1895.

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Science Foundation Ireland

ARTIVVIS

gv2 graphics • vision • visualisation