SHAPE FEATURE REPRESENTATIONS

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SHAPE RETRIEVAL

REFRESHER

QUERY SHAPE

DATABASE

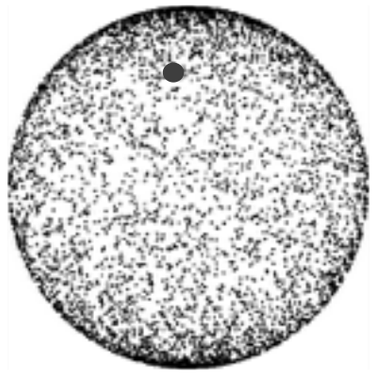
PROBLEM STATEMENT

SHAPE REPRESENTATION

1

FEATURE REPRESENTATION

2



RETRIEVAL MECHANICS

3

ROADMAP FOR FEATURE REPRESENTATION

1 WAVELETS

2 WAVELET DENSITY ESTIMATION

3 OPTIMIZATION

4 SHAPE L'ANE ROUGE

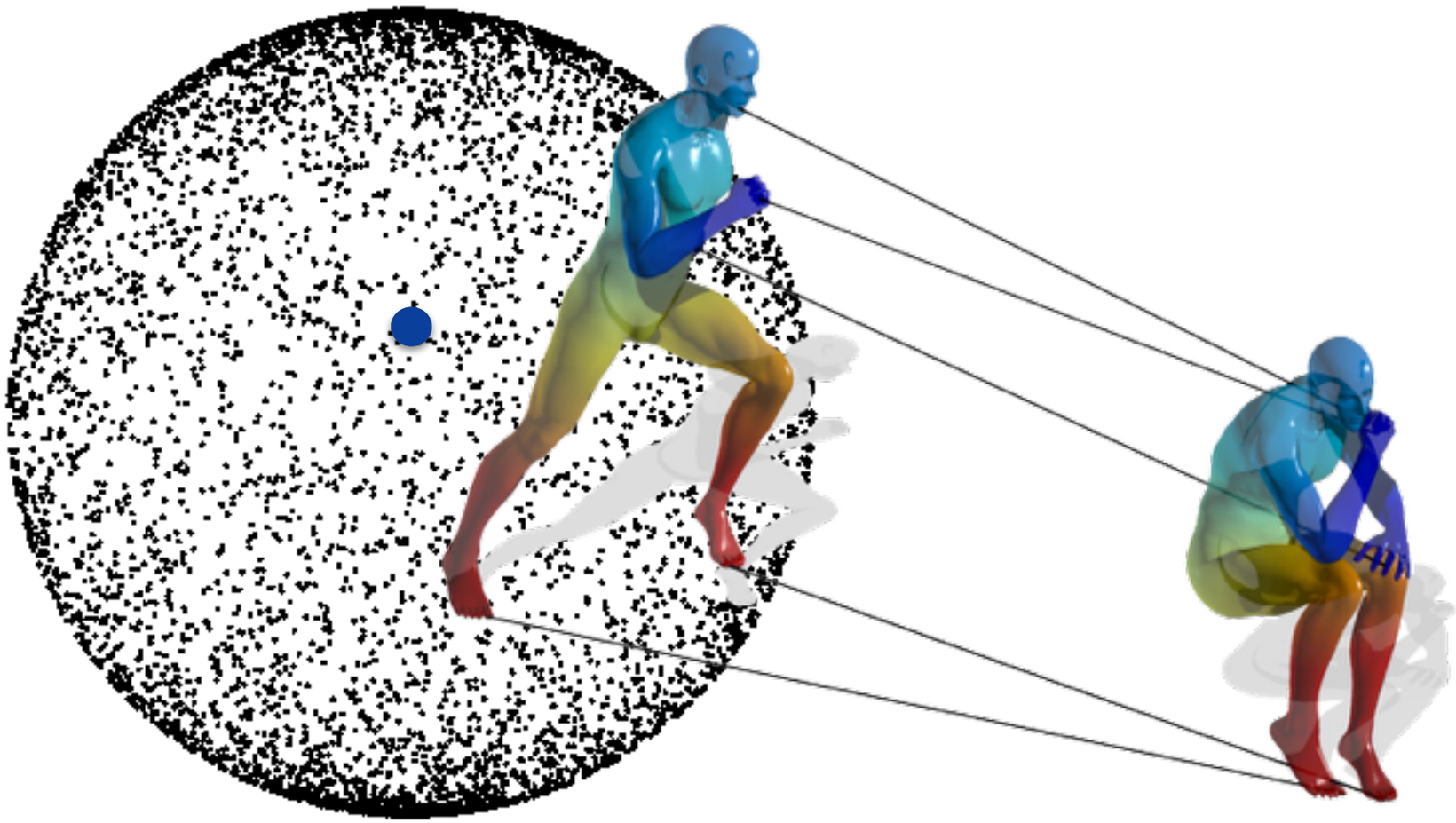
5 LINEAR ASSIGNMENT

6 RESULTS

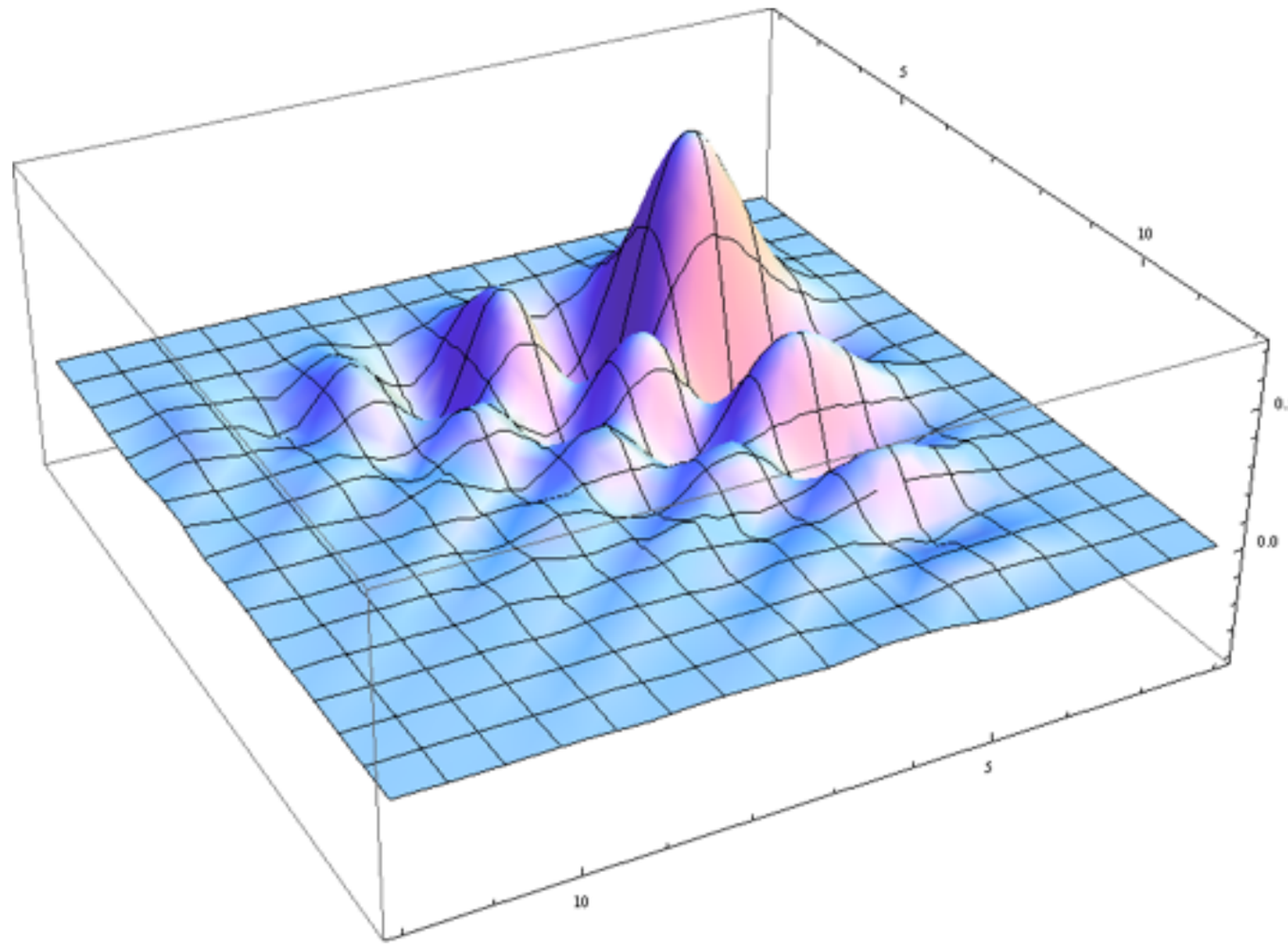
7 TIMELINE

LAPLACE-BELTRAMI OPERATOR

ISOMETRY INVARIANCE

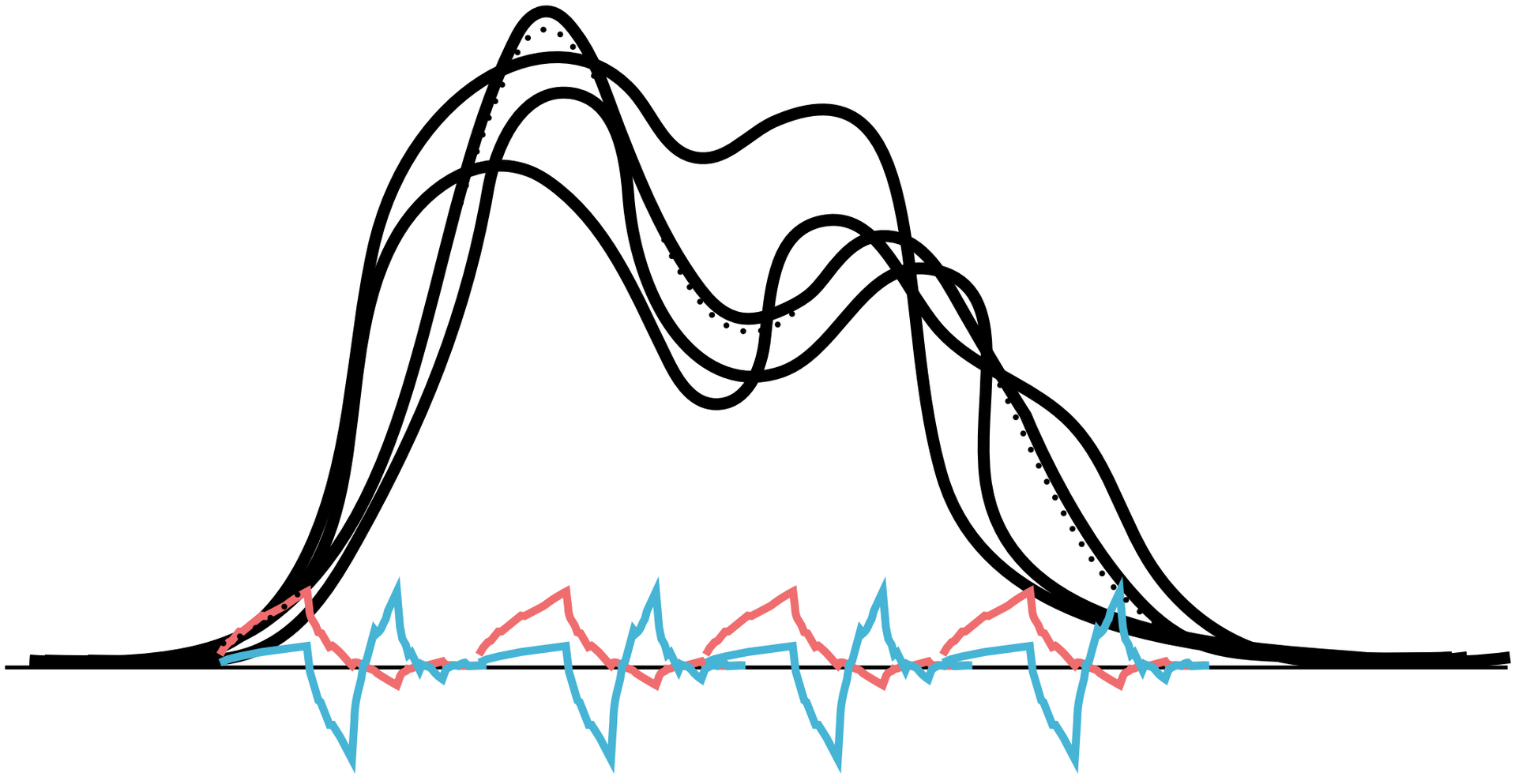


WAVELETS



WHY WAVELETS

WAVELET DENSITY ESTIMATION



WAVELETS FORMALLY

$$\sqrt{p(x)} = \sum_{j_0,k} \underbrace{\alpha_{j_0,k}}_{\substack{\text{Scaling} \\ \text{Coefficient}}} \underbrace{\phi_{j_0,k}(x)}_{\substack{\text{Scaling Basis} \\ \text{Function}}} + \sum_{j \geq j_0,k}^{\infty} \underbrace{\beta_{j,k}}_{\substack{\text{Wavelet} \\ \text{Coefficient}}} \underbrace{\psi_{j,k}(x)}_{\substack{\text{Wavelet Basis} \\ \text{Function}}}$$

Father Mother

$$\phi\ \alpha_{j_o,\mathbf{k}} = \frac{1}{N} \frac{\sum_{i=1}^{N} \phi_{j_o,\mathbf{k}}(\mathbf{x})}{\sqrt{p(\mathbf{x})}} \quad 2)$$

$$\psi^2_{j,\mathbf{k}}(\mathbf{x}) = 2^j \psi \int \frac{}{\sqrt{p(x)}} \phi_{j_0,k}(x) dx \quad)$$

$$\psi^3_{j,\mathbf{k}}(\mathbf{x}) = 2^j \psi\, \mathcal{E}\left[\frac{\phi_{j_0,k}(x)}{\sqrt{p(x)}}\right]. \quad)$$

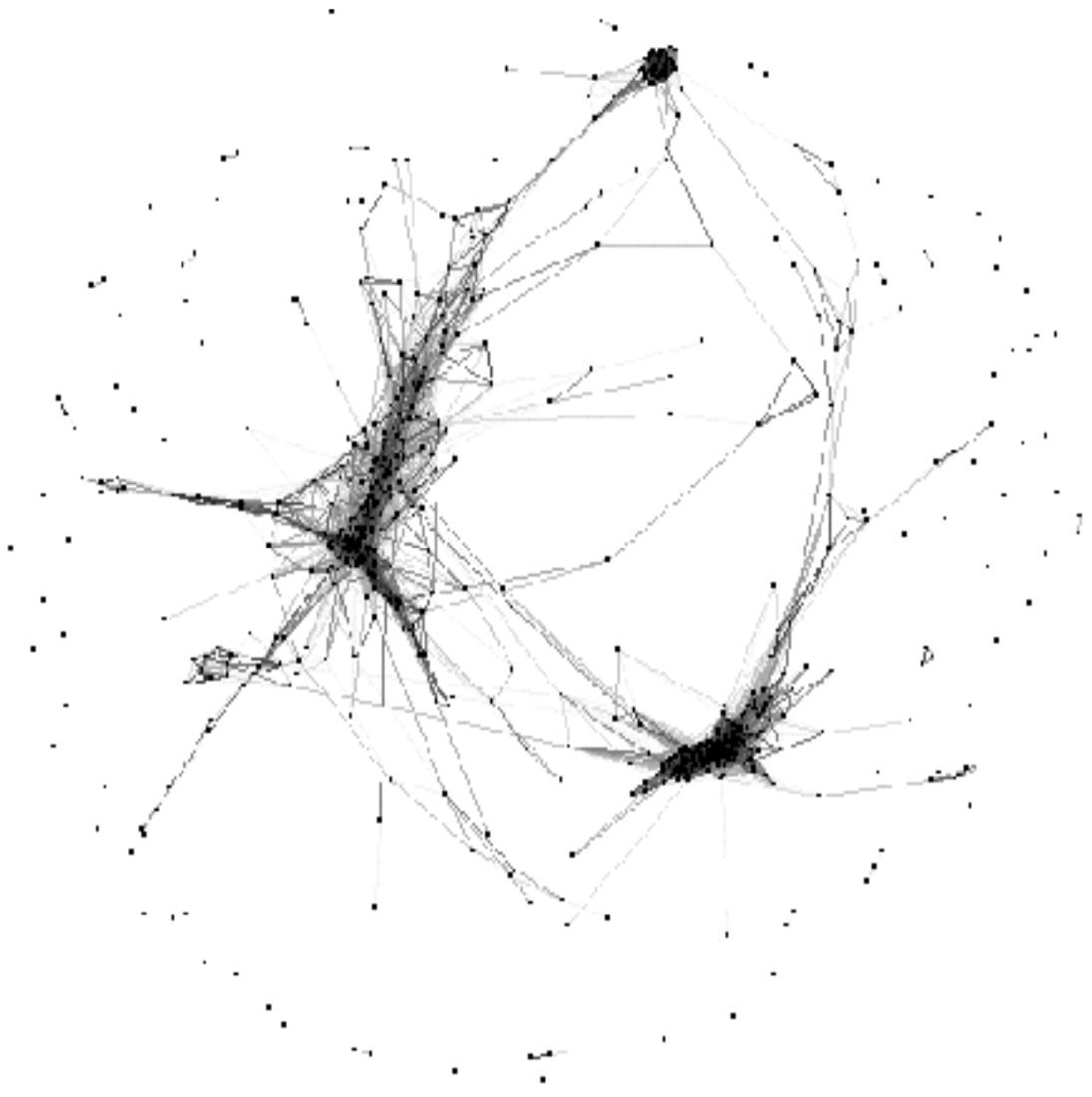
WAVELET DENSITY ESTIMATION

NEGATIVE LOG LIKELIHOOD

$$
\begin{aligned}
-\log p(X;\{\alpha_{j_0,k},\beta_{j,k}\}) &= -\frac{1}{N}\log\prod_{i=1}^{N}\left[\sqrt{p(x_i)}\right]^2 \\
&= -\frac{1}{N}\sum_{i=1}^{N}\log\left[\sum_{j_0,k}\alpha_{j_0,k}\phi_{j_0,k}(x_i)+\sum_{j\geq j_0,k}^{j_1}\beta_{j,k}\psi_{j,k}(x_i)\right]^2
\end{aligned}
$$

$$
\sum_{j_0,k}\alpha_{j_0,k}^2+\sum_{j\geq j_0,k}^{j_1}\beta_{j,k}^2=1.
$$

WAVELET DENSITY ESTIMATION

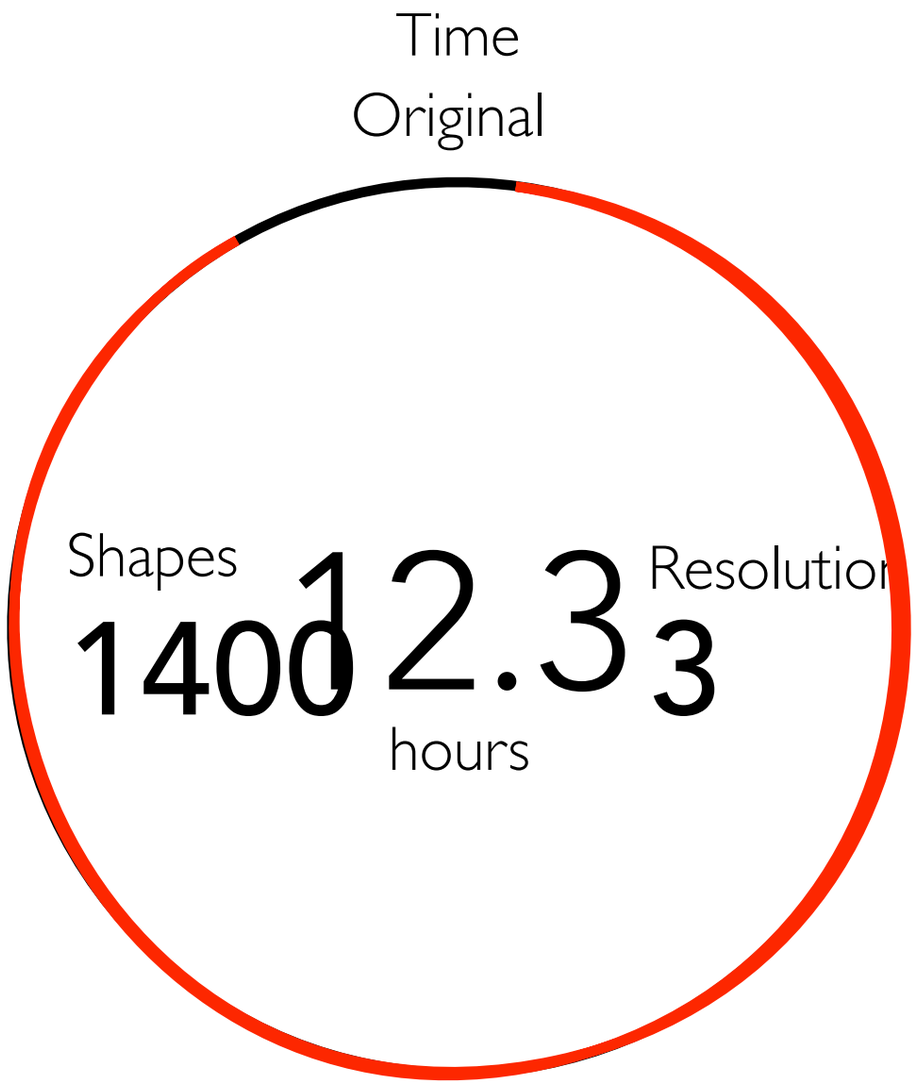


WAVELET-BASED SPECTRAL ESTIMATION

WDE OPTIMIZATION

Database

MPEG7



Translations

576

WDE OPTIMIZATION

INITIALIZE COEFFICIENTS

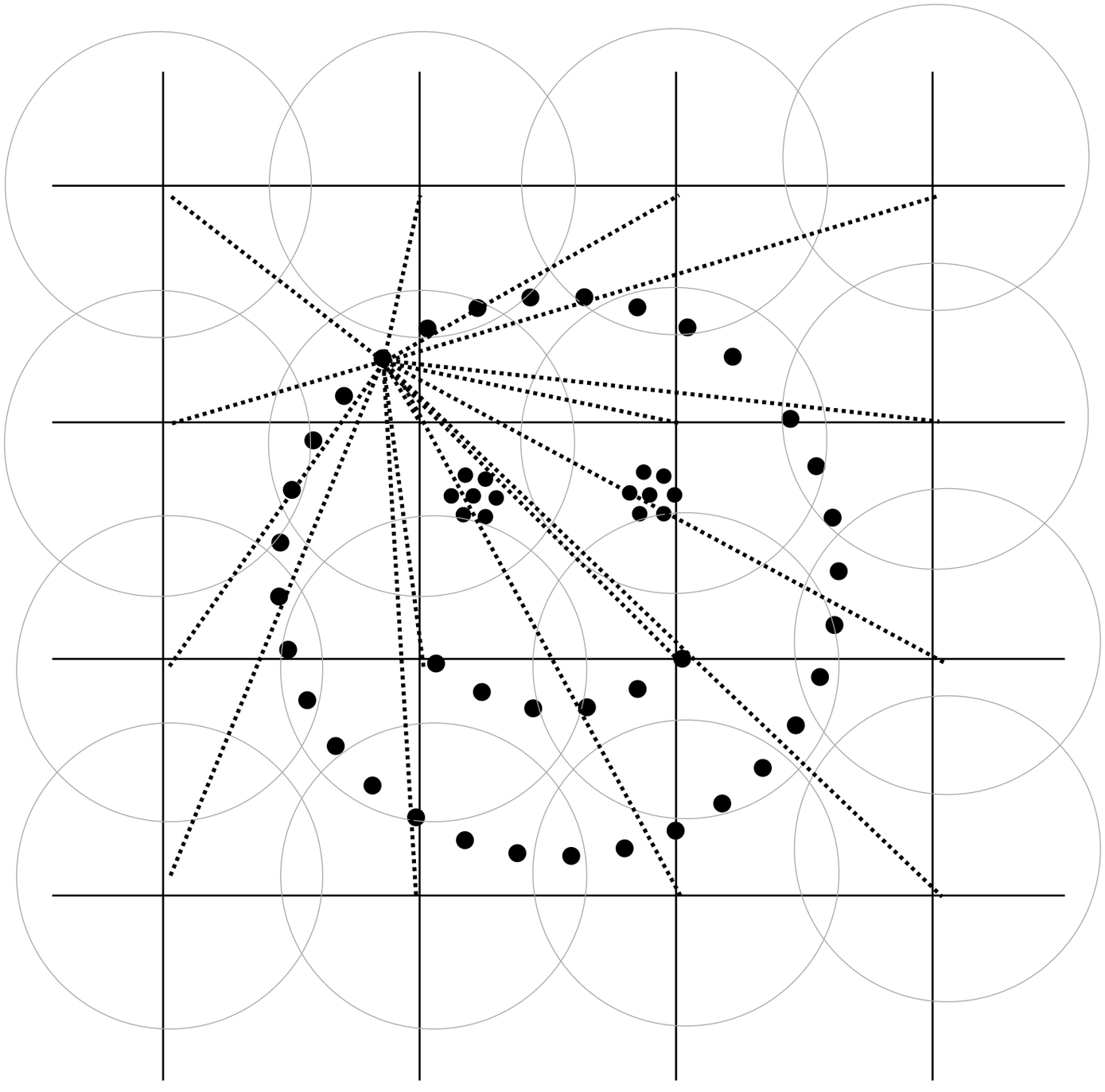
$$\alpha_{j_o,\mathbf{k}} = \frac{1}{N} \frac{\sum_{i=1}^{N} \phi_{j_o,\mathbf{k}}(\mathbf{x})}{\sqrt{p(\mathbf{x})}}$$

Problem

576 basis functions

× 4007 samples

2,308,032 operations



WDE OPTIMIZATION

INITIALIZE COEFFICIENTS

$$\alpha_{j_o,\mathbf{k}} = \frac{1}{N} \frac{\sum_{i=1}^{N} \phi_{j_o,\mathbf{k}}(\mathbf{x})}{\sqrt{p(\mathbf{x})}}$$

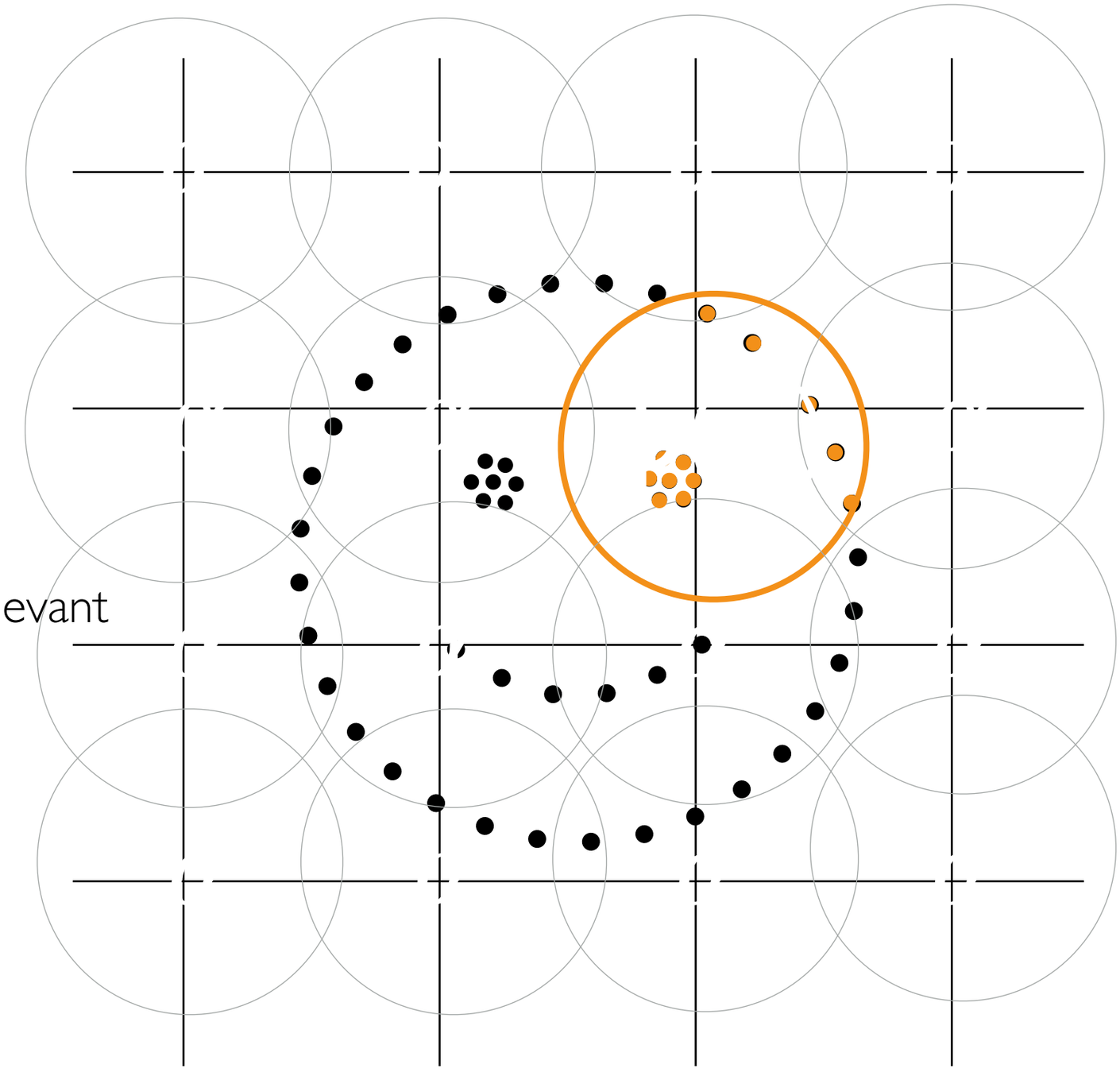
Solution

loops over each function

determine which points fall under it

calculate scaling function for only relevant points

save scaling values for each point

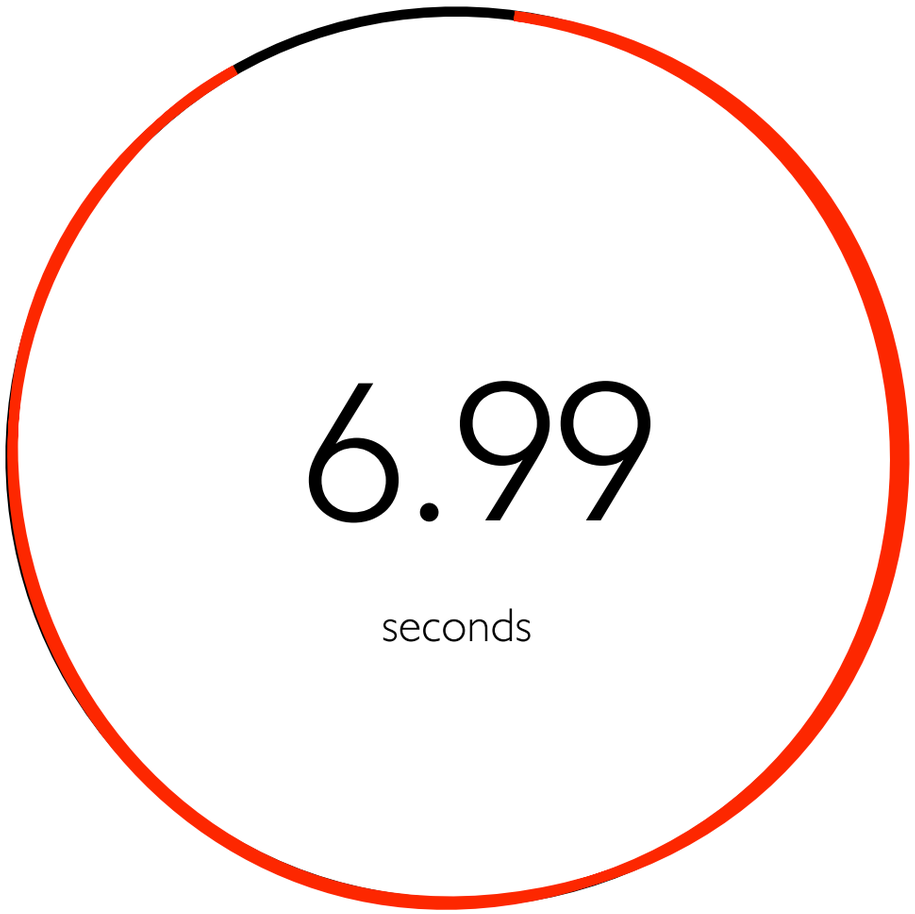


WDE OPTIMIZATION

INITIALIZE COEFFICIENTS

Time

Original



Time

Optimized

99.2%

faster

WDE OPTIMIZATION

NEGATIVE LOG LIKELIHOOD

$$-\log p(X;\{\alpha_{j_0,k},\beta_{j,k}\})$$

$$= -\frac{1}{N}\sum_{i=1}^{N}\log\left[\sum_{j_0,k}\alpha_{j_0,k}\phi_{j_0,k}(x_i)\right]^2$$

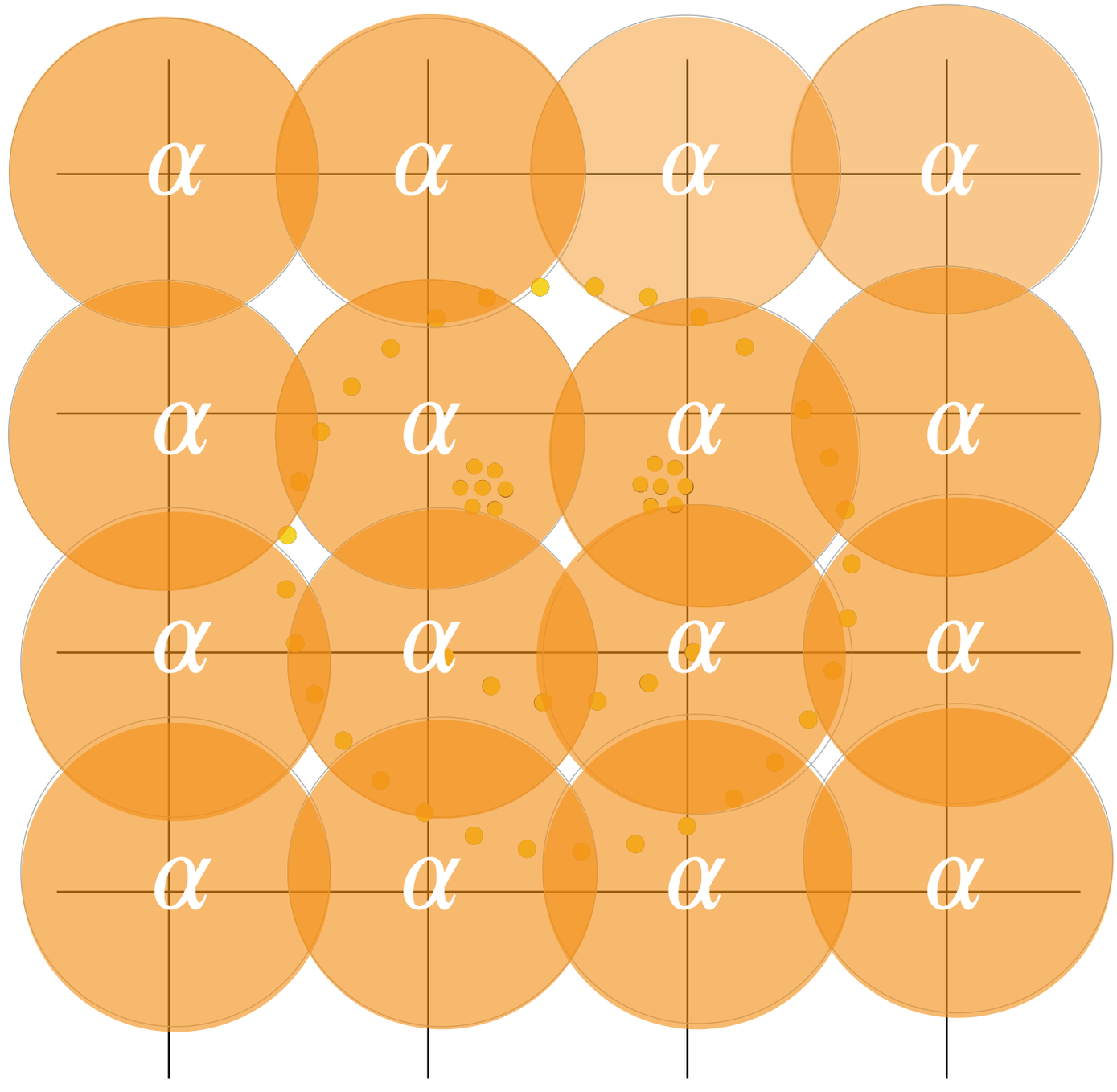
Problem

ran the same as initializeCoefficients to find the scaling basis value for each sample

Solution

pass scaling basis value for each sample from initializeCoefficients

simply perform appropriate operates for the cost function and gradient



WDE OPTIMIZATION

NEGATIVE LOG LIKELIHOOD

Time

Original

94.5%

faster

Time

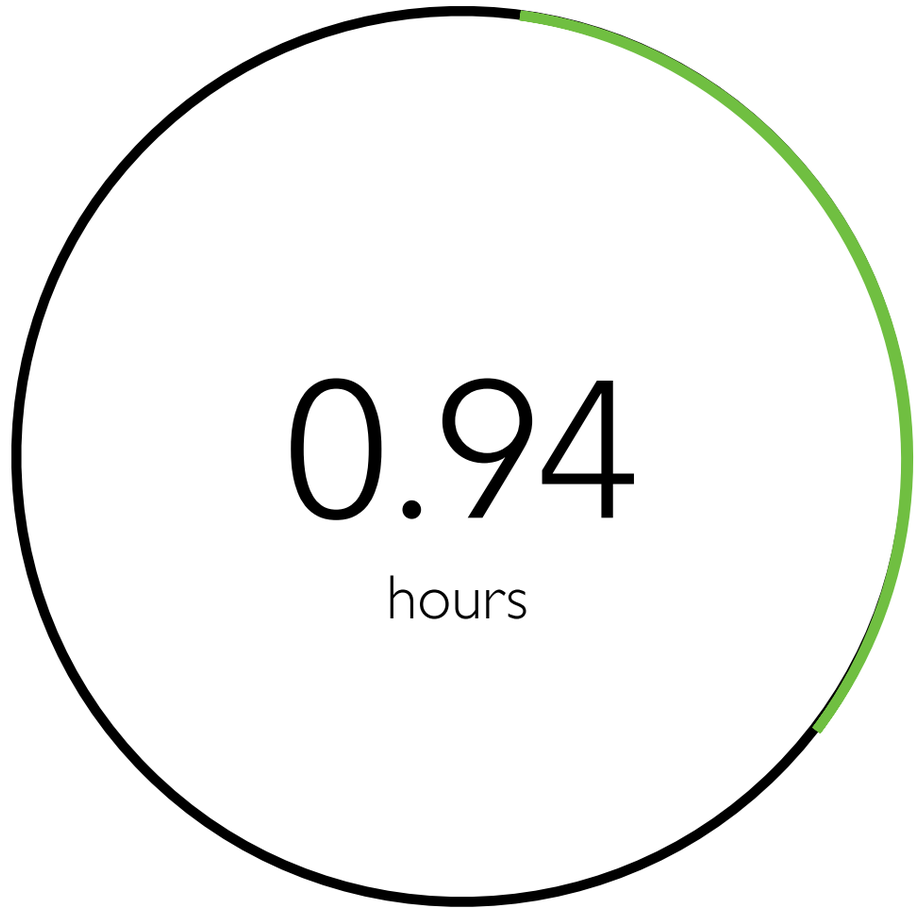
Optimized

WDE OPTIMIZATION

Time
Original

92.4%
faster

Time
Optimized



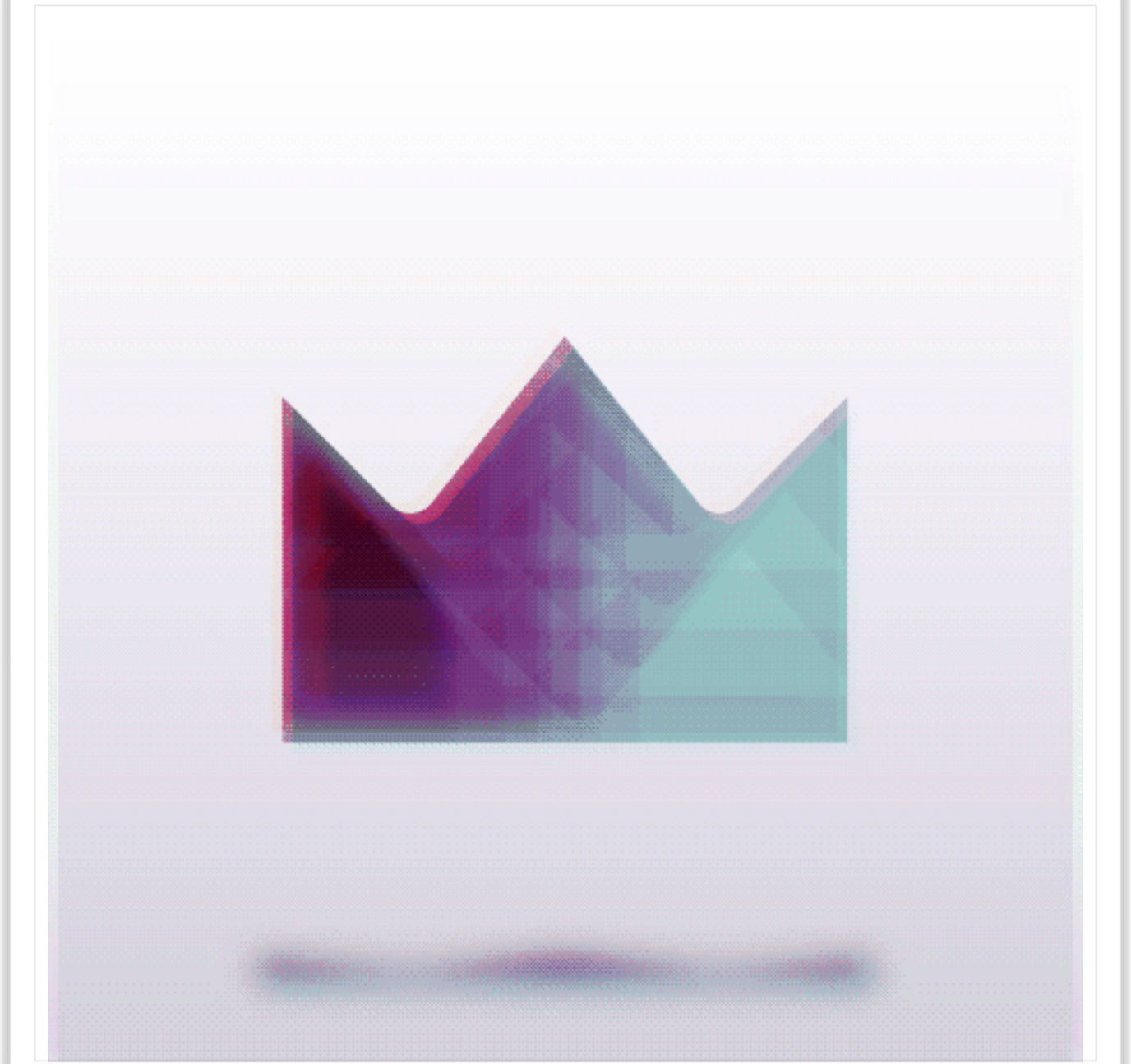
Database
MPEG7

Shapes
1400

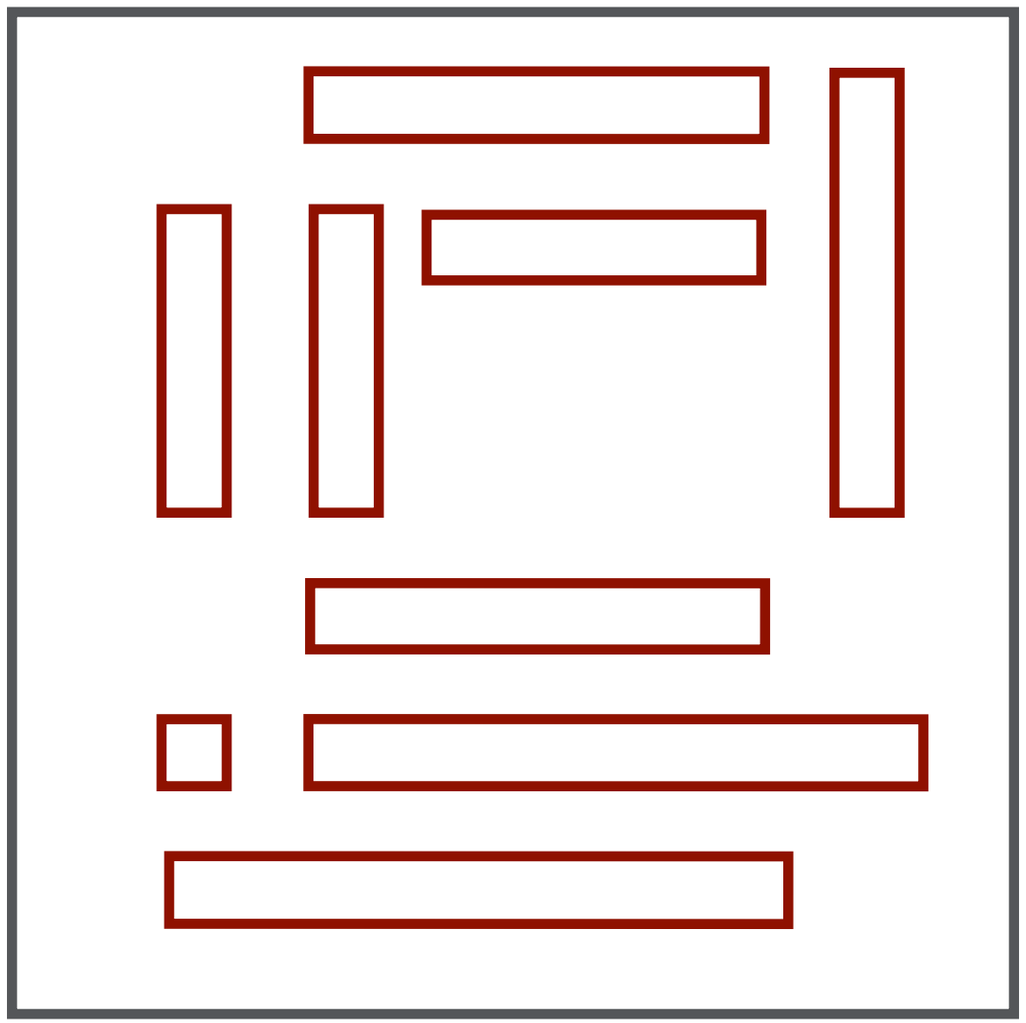
Resolution
3

Translations
576

SHAPE L'ANE ROUGE

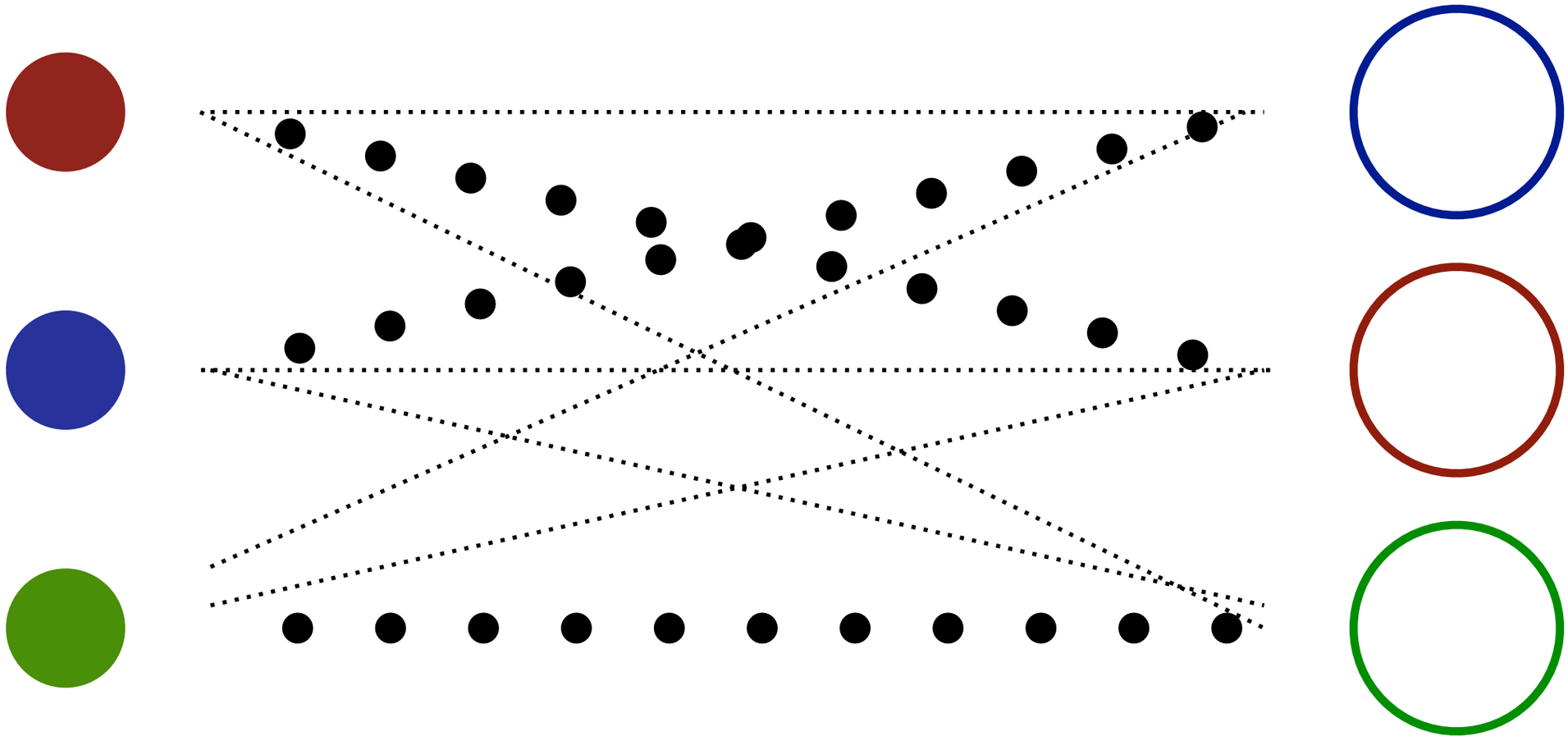


SHAPE L'ANE ROUGE



SHAPE L'ANE ROUGE

LINEAR ASSIGNMENT



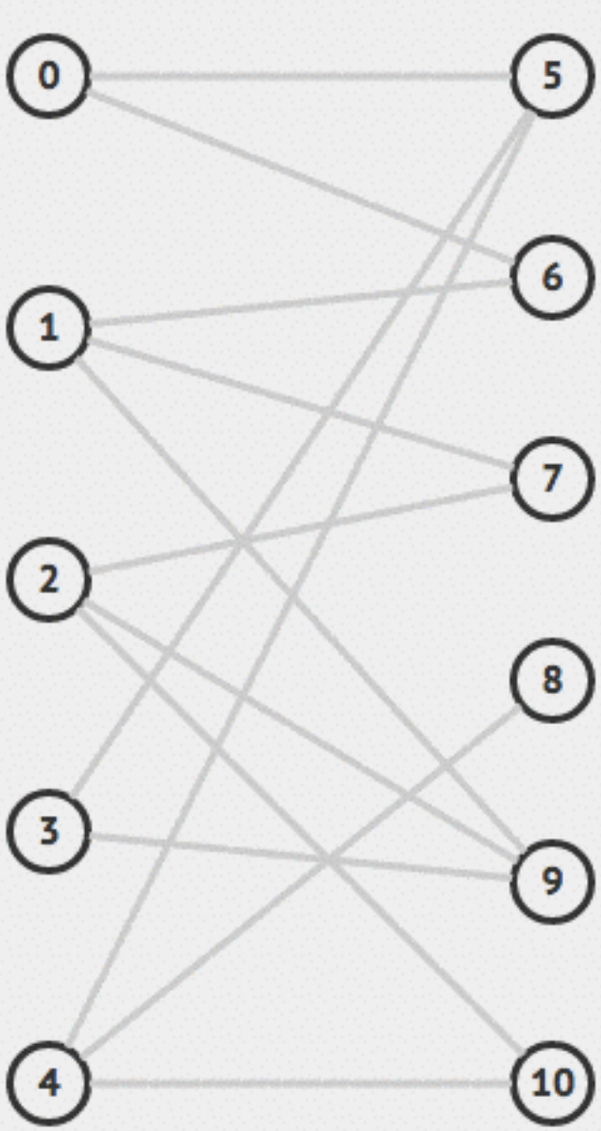
SHAPE L'ANE ROUGE

LINEAR ASSIGNMENT, INFORMALLY

$$\mathrm{s}X, Y[| = |Y|$$

$$C : X \times Y \to \mathbb{R}$$

$$X \to Y$$



SHAPE L'ANE ROUGE

JONKER-VOLGENANT

SHAPE L'ANE ROUGE

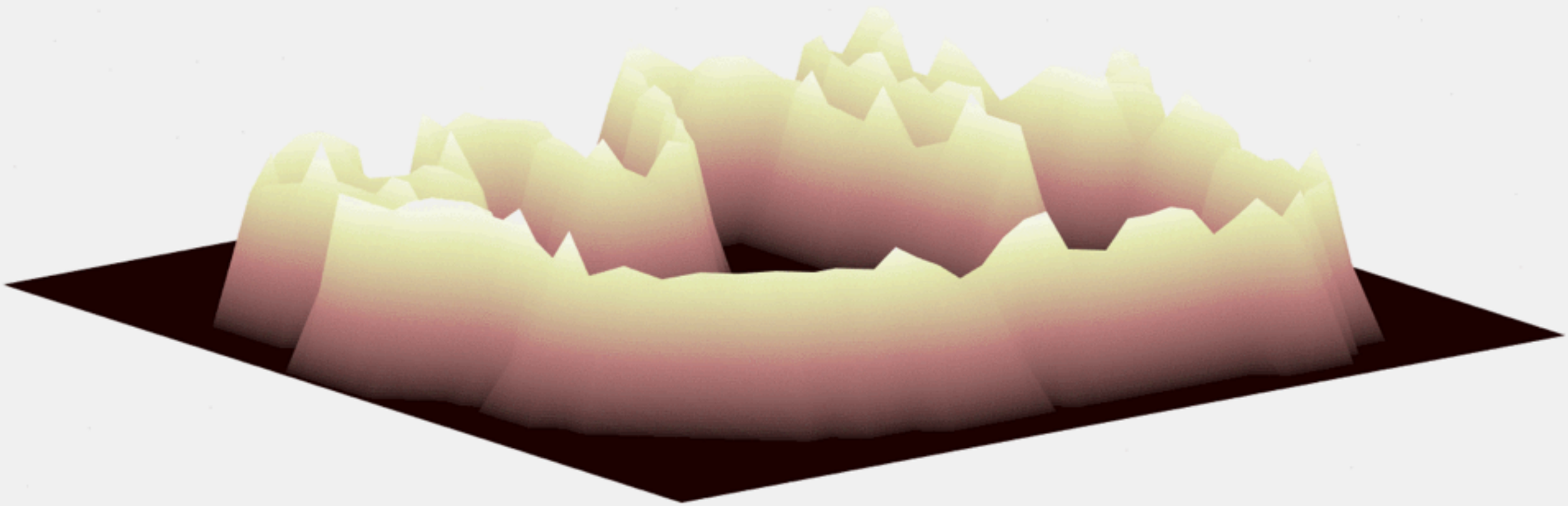
SHAPE L'ANE ROUGE

COST MATRIX

$$C = -(\boldsymbol{c_1} \otimes \boldsymbol{c_2}) + \lambda$$

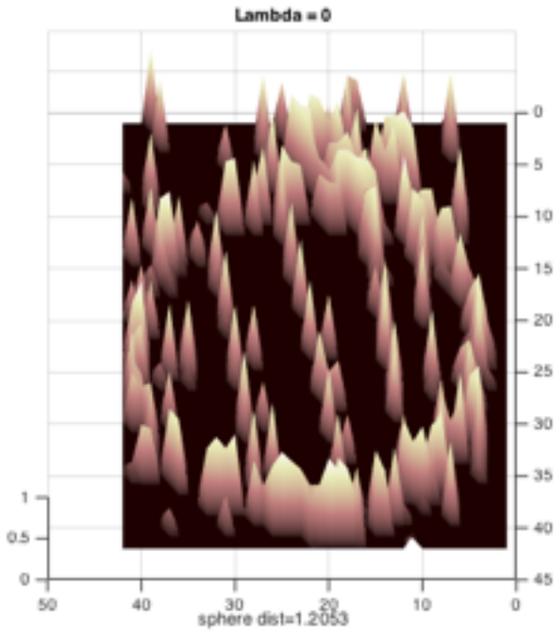
SHAPE L'ANE ROUGE

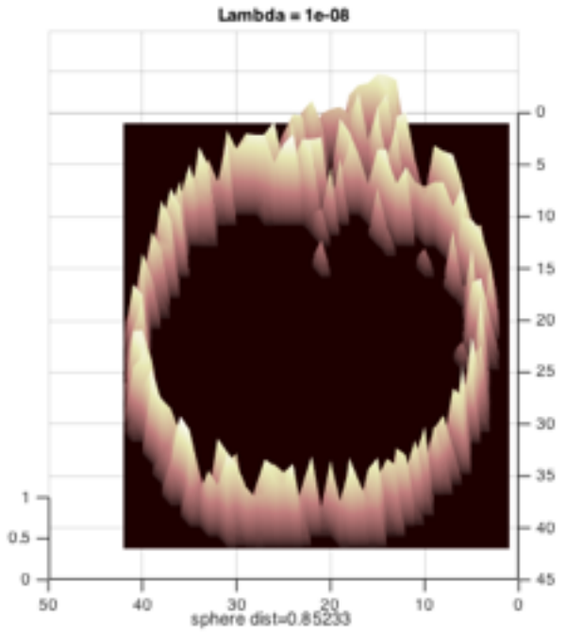
OPTIMIZATION FOR JONKER-VOLGENANT

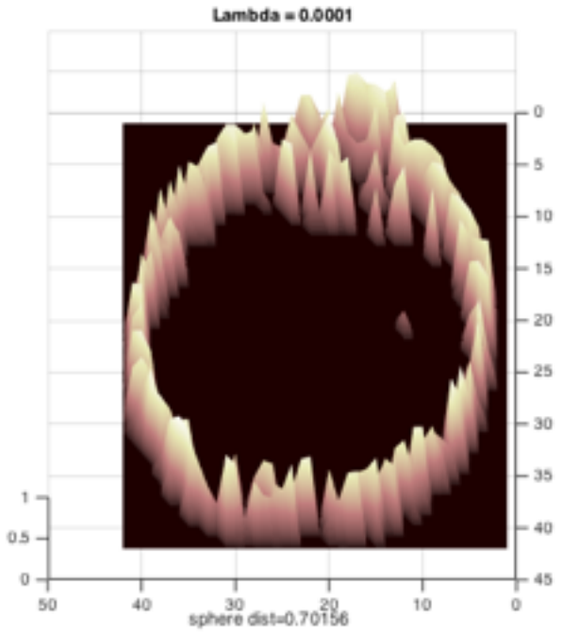


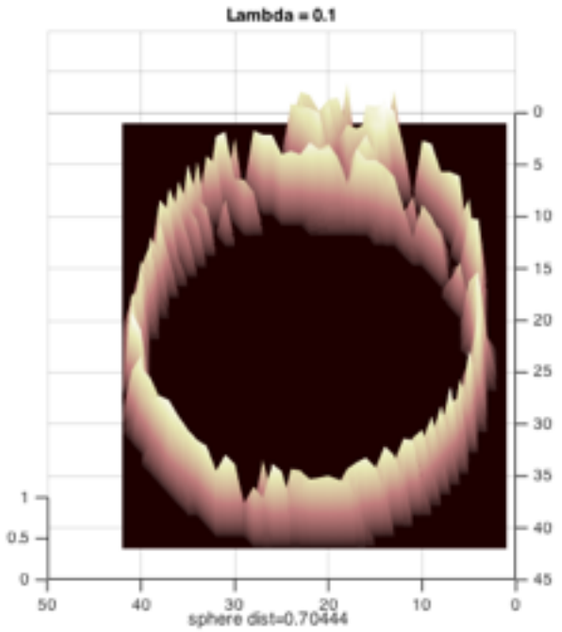
SHAPE L'ANE ROUGE

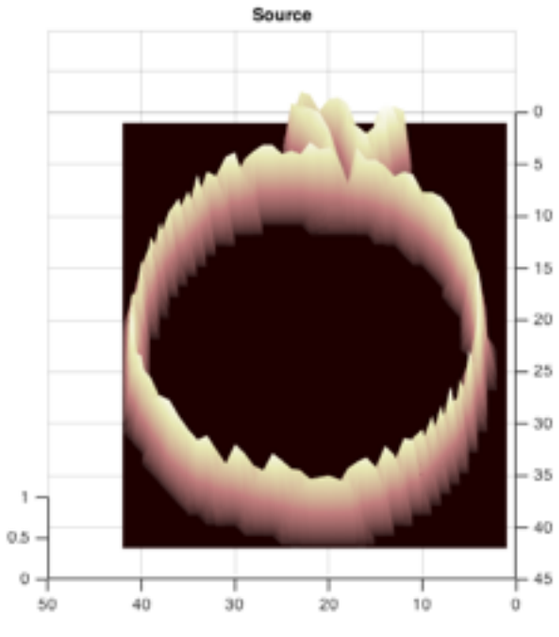
SAME SHAPE WARP

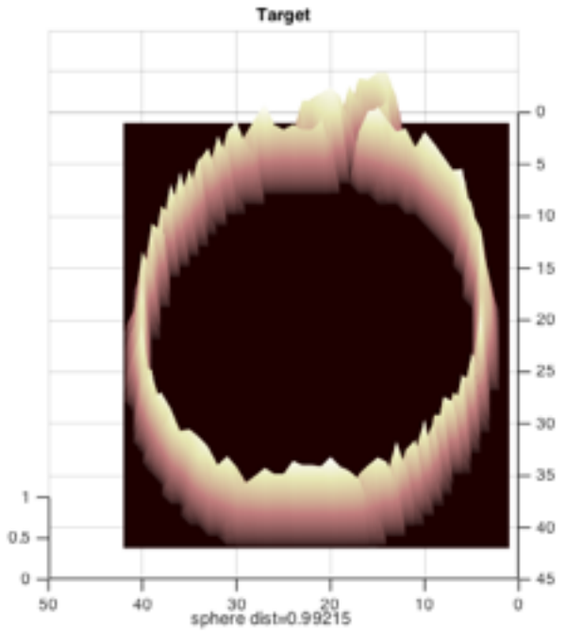






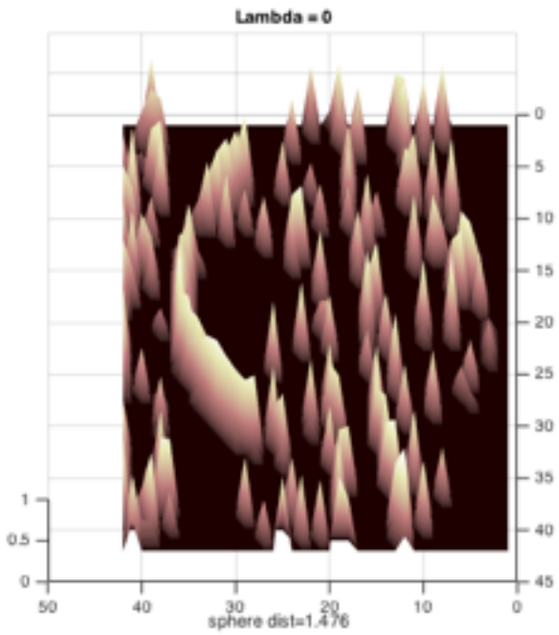


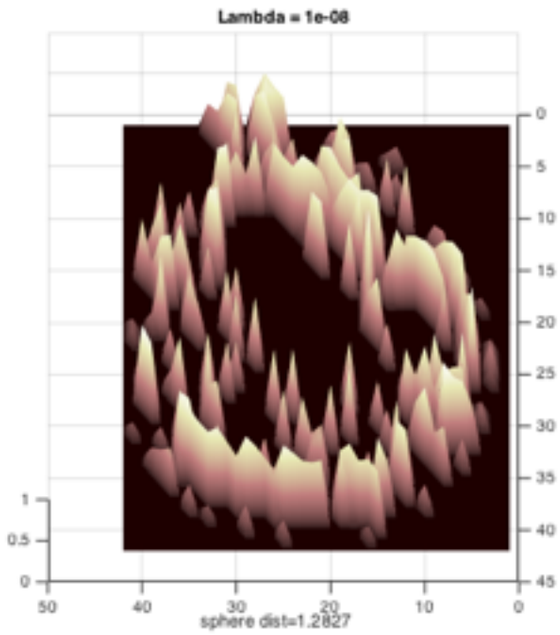


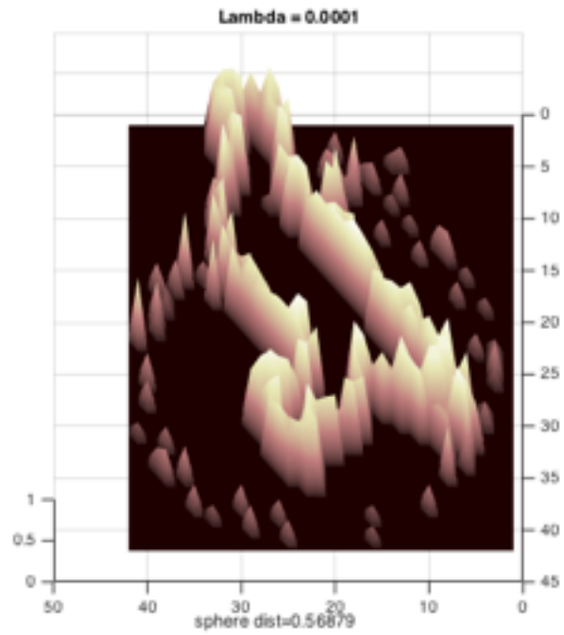


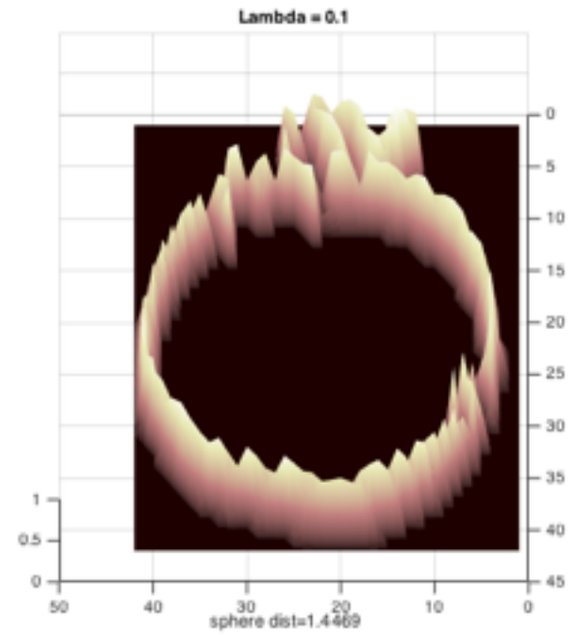
SHAPE L'ANE ROUGE

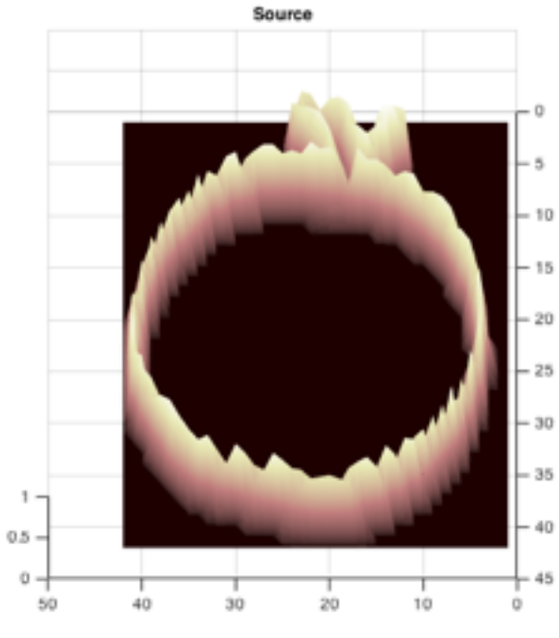
DIFFERENT SHAPE WARP

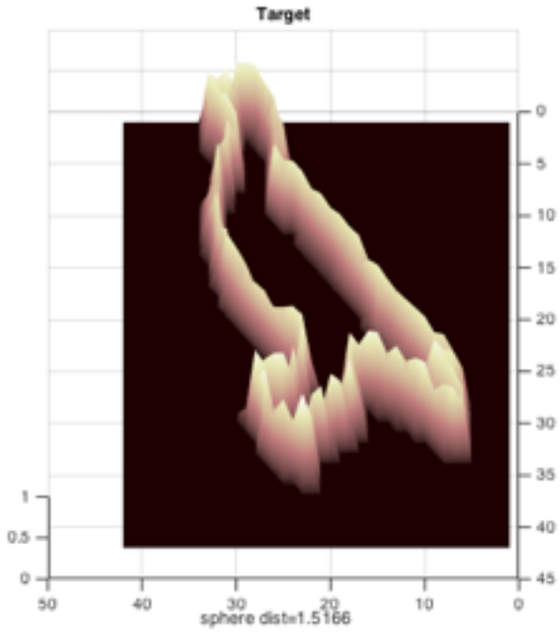






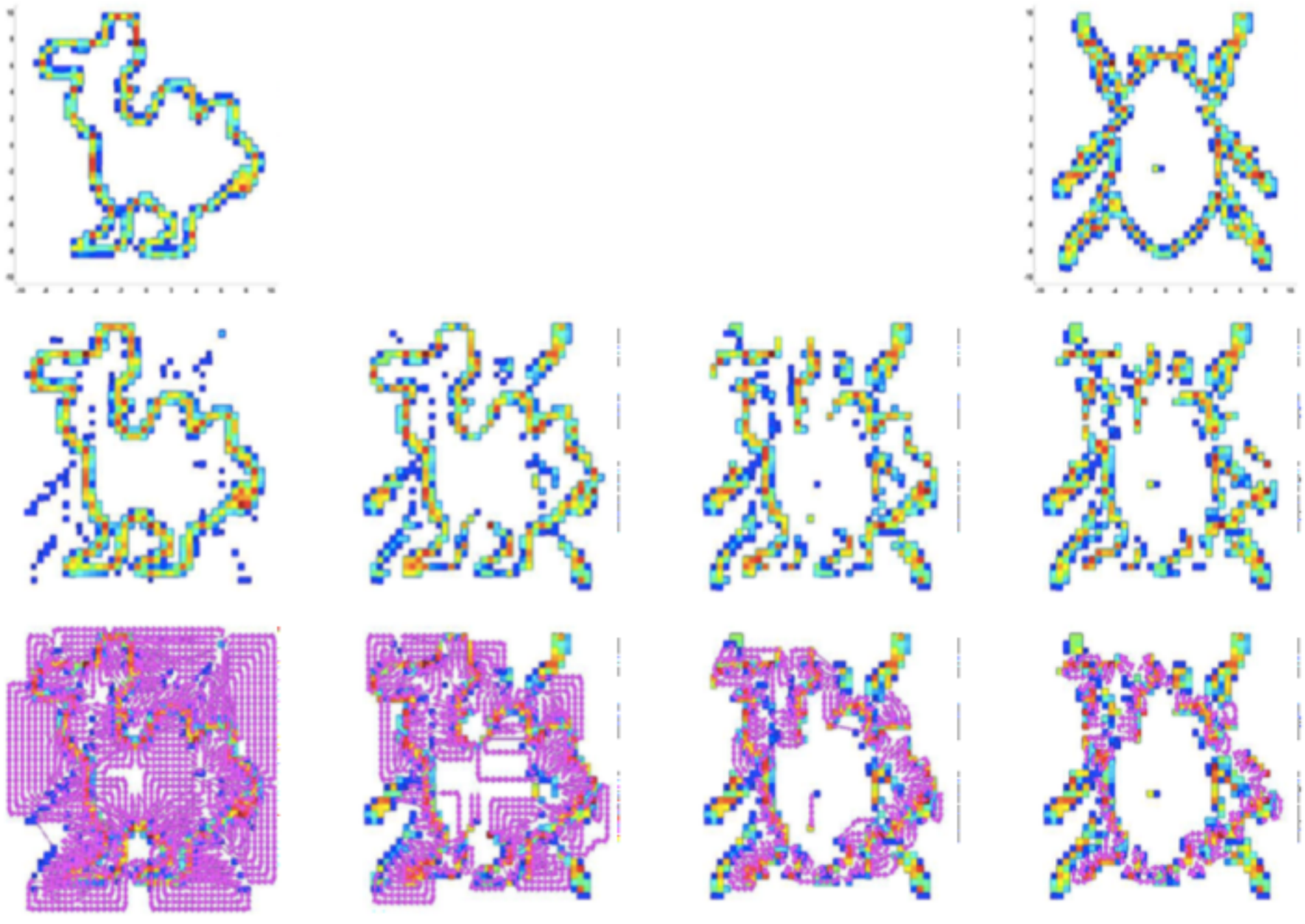






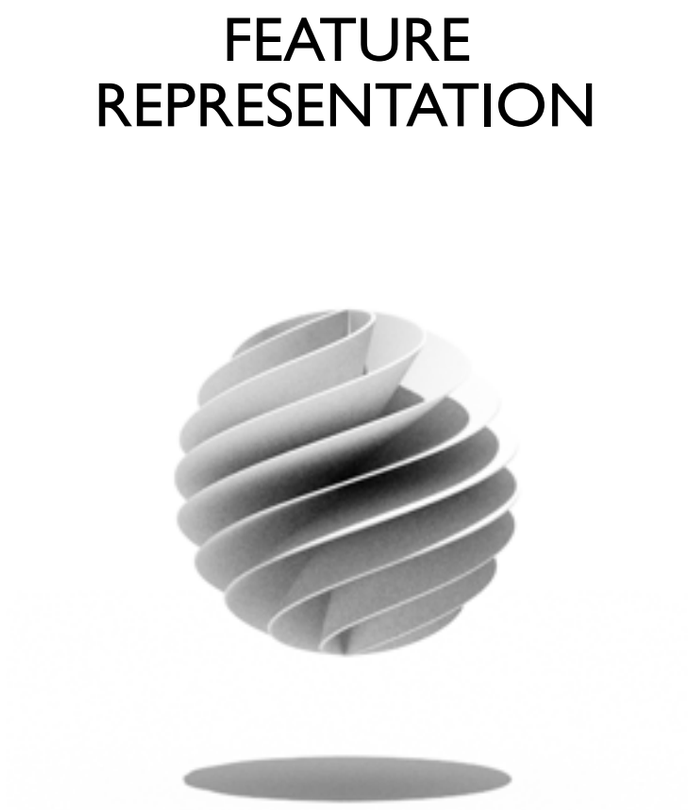
SHAPE L'ANE ROUGE

RESULTS ON DATASETS



FUTURE RESEARCH

- Optimize multi-resolution, 1D, 3D
- Find better feature representations instead of LBO signatures
- Investigate ways to visualize these high dimensional feature representations
- Find the best lambda to get the best results and test on multi resolution



THANK YOU