University of Regina

In Search of a Perceptual Basis for Interacting with Parametric Images

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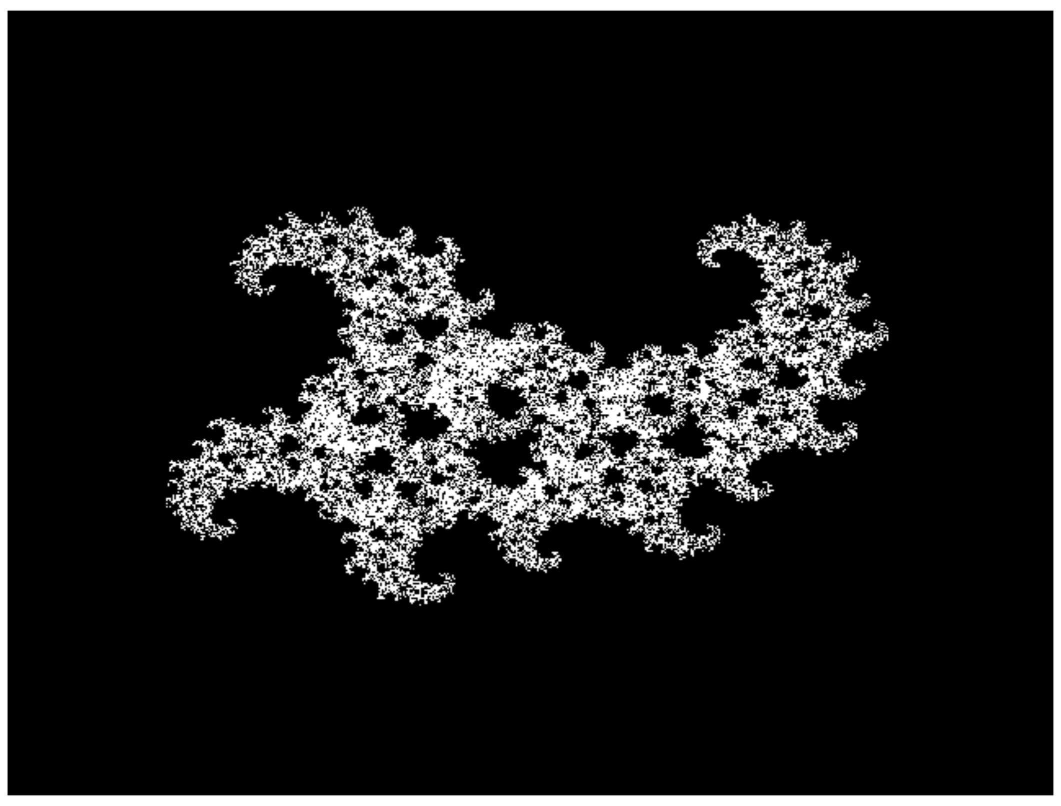
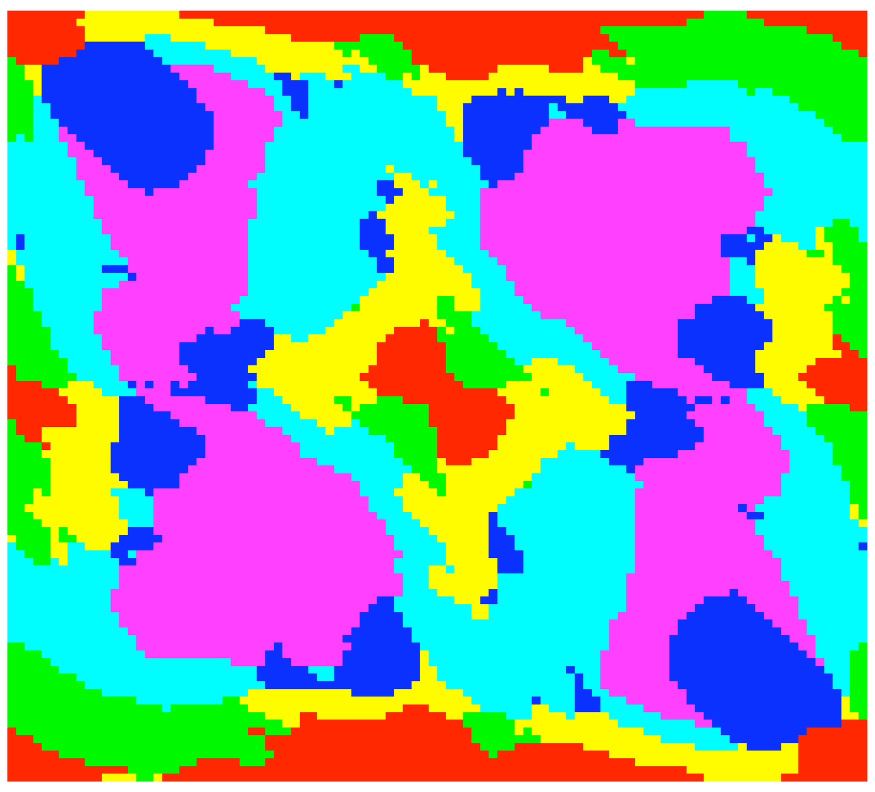
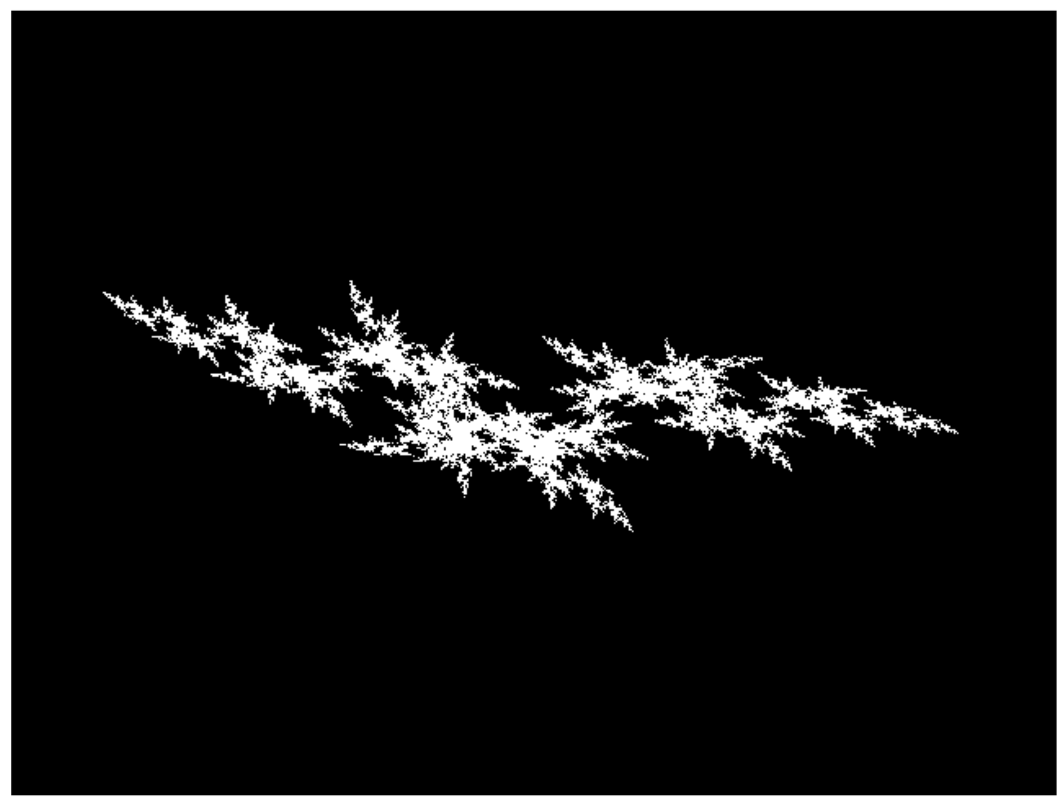
Seahorse?





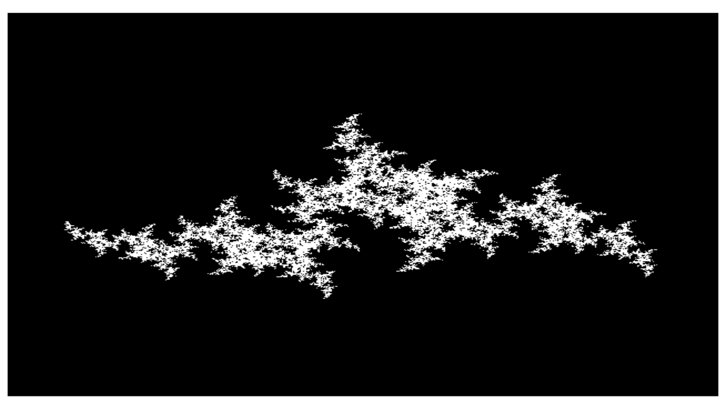


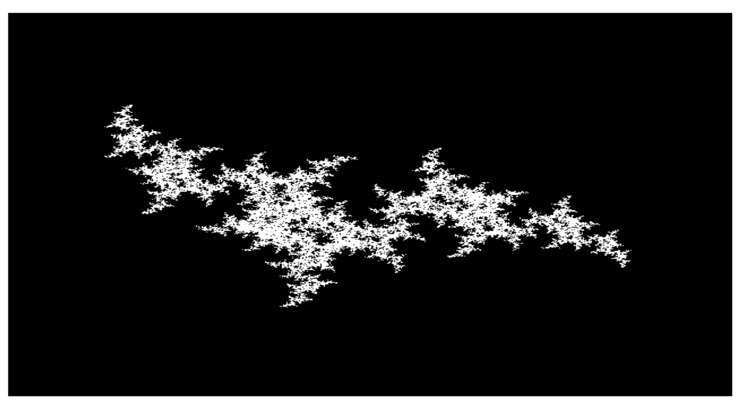
Pterodacytl?

Finding a perceptual basis for interacting with parametric images like fractals could make the parameter space more accessible, which is an important step towards democratizing this creative activity.

Linear Fractal Images

The images that we study are visualizations of the attractor of an iterated function system or a linear fractal , defined by 2 transformations, each of which specifies rotation (1 angle), scaling (2 values, for x and y), and translation (2 values, for x and y). Therefore, 2 transformations have 10 parameters. It is not difficult to imagine wanting to explore a minimum of 10 values for any of these parameters, which yields 10,000,000,000 potential images. Many of these images would be similar to one another, yet this is difficult to determine algorithmically.



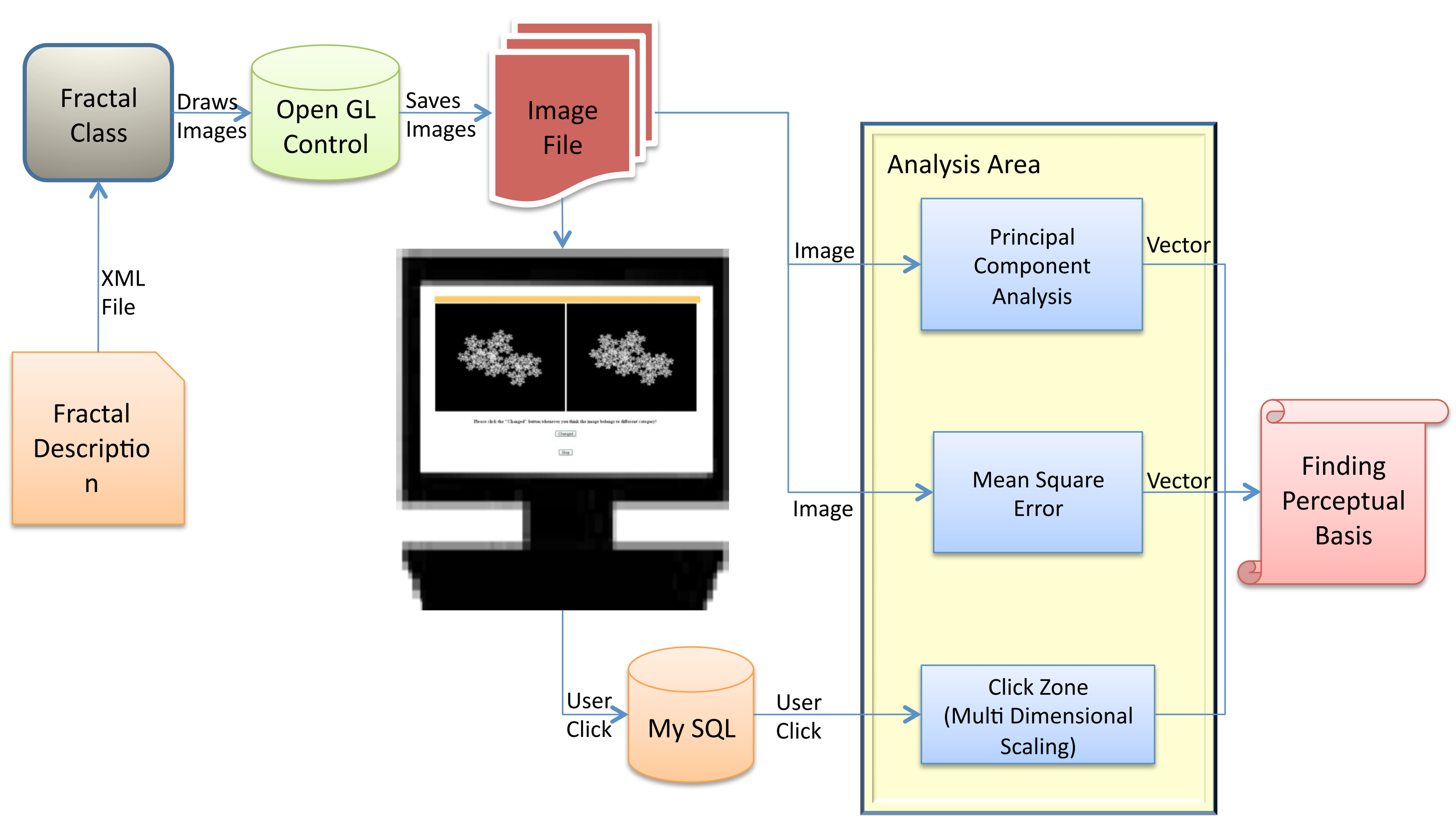


Human Perception of Similarity

In order to make our stimulus set manageable, we chose to just increment the rotation angles by 3.6 degrees, leaving a stimulus set containing 10,000 images (100x100).

Each one of 25 participants saw 1600 images, divided into 16 sequences of 100 continuously-varying images (8 unique sequences, shown forward and backward). Following the method of limits, each participant was asked to make judgments about when the change was noticeable, in each of two directions.

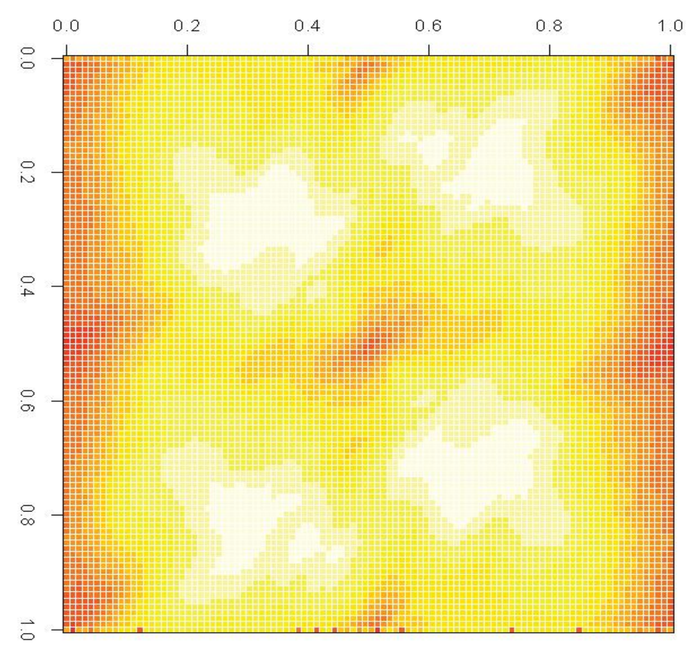
Program Architecture



Computational Approach

Local

Mean squared error (MSE), one of the most popular methods for image comparison, was used to measure the pixel by pixel variation between 2 adjacent images.



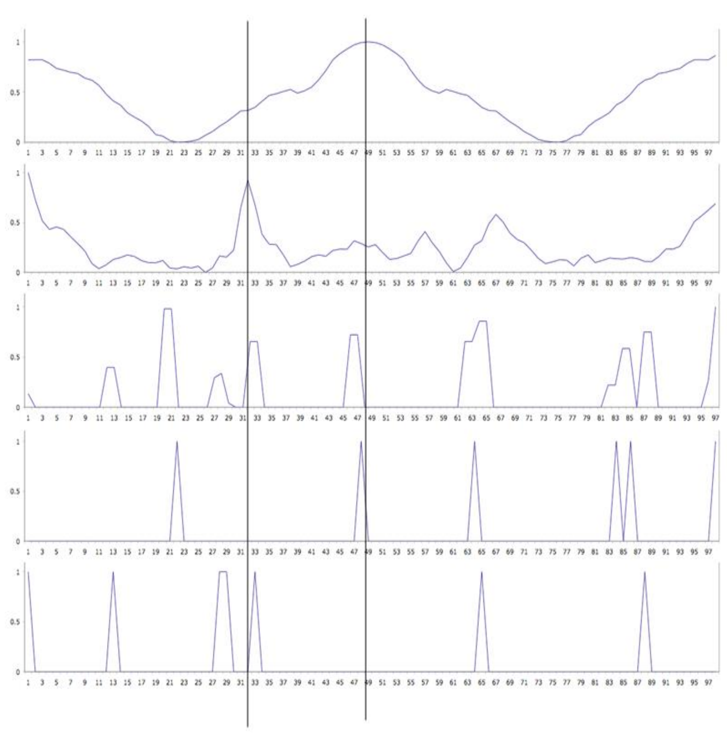
$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|I(i,j)-K(i,j)\|^2$$

Global

A principle component analysis of the images was performed. A procedure took the two diagonals of the 100x100 image grid as input. From the vectors output, the top 40 were used and accounted for 85% of the variance in the images. All 10,000 images were then expressed as coordinates in this 40 dimensional space. Clustering was done to produce the map at the top (middle). Also, within each image sequence, Euclidean distance between neighbouring images was computed. Values were normalized over the entire sequence.

Analysis

For each sequence of images, we are comparing the local and global metrics (as described above) with the users' judgements of noticeable change between images. We have combined the judgements from both viewing directions into an indication of where change is likely. In the example below, we see that the user has clicked near the maxima of the local and global metrics.



1st line: MSE values (local)
2nd line: PCA values (global)
3rd line: change locations, computed from lines 4 & 5
4th line: clicks in forward direction
5th line: clicks in backward direction.

Vertical lines placed at maxima for PCA (left) and MSE (right).

Future Work

More data for the perceptual study will be collected in the lab to better understand the possible roles of individual differences, different rating strategies, and other factors in determining perceived relationships between images. Do some people see with more detail than others, or do they see differently than others? It is hoped that results here can 10,000,000,000 image set and beyond.

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