Computational Intelligence

Evolutionary Art

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1 Problem: Evolutionary Art

1.1 Problem

Objective: The core objective is to leverage our evolutionary algorithm to evolve an image, in our case the iconic "Mona Lisa." The process involves the initiation of a population of random 'chromosome' representations of images, which then undergo iterative selection, crossover, and mutation with the aim of minimizing the difference between the evolved image and the original image.

1.2 Chromosome Representation

In the context of this question, chromosome represent a potential solution. Specifically, each chromosome is an image, itself a collection of polygons with varying vertices, color, and position. The representation takes the form of a dictionary in Python, where each dictionary key corresponds to an attribute relevant to the image:

- 'height' and 'width' define the dimensions of the image.
- 'fitness' holds the fitness score, a measure of how close this image is to the target image
- 'image' is the actual PIL Image object consisting of polygons that form the chromosome's visual representation.
- 'array' consists of the pixel data converted to a NumPy array for fitness computation.

This abstract representation is essential for the genetic algorithm as it allows manipulation through crossover and mutation functions and facilitates the evaluation of likeness to the target image.

1.3 Fitness Function

The fitness function quantitatively evaluates how close a given solution (chromosome) is to the optimal solution. In this code, the fitness function computes the visual difference between the chromosome's image and the target image using the CIE76 delta E color difference function, provided by the 'colour' library – this is a scientifically grounded metric used to compare color differences between images.

The rationale for using the delta E CIE76 formula for the fitness function lies in its ability to mimic human perception of color differences, which is crucial when the goal is to approximate a human-made painting like the "Mona Lisa." (**reference:** https://medium.com/@sebastian.charmot/genetic-algorithm-for-image-recreation-4ca546454aaa) A lower fitness score indicates a higher resemblance to the target, guiding the evolutionary process towards more accurate representations as the generations progress. The use of this fitness function ensures the selection pressure during the genetic algorithm's run pushes the population to enhance the visual fidelity relative to the "Mona Lisa."

1.4 Results

1.4.1 Parameters:

- Population Size: 100
- Number of Polygons: 50
- Number of Vertices: 3
- Number of Generations: 10,000

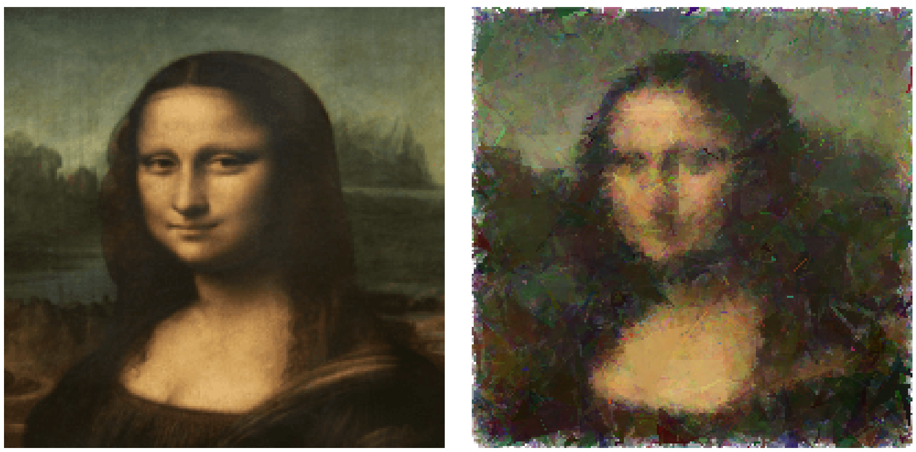

Figure 1: Target Image vs Evolved Image (according to the parameters mentioned above)

1.4.2 Analysis and Evolution Visualization

Implementing a genetic algorithm to approximate the intricate details of the "Mona Lisa" through image evolution presented a formidable challenge, due to the broad search space and nuanced color variations. We employed a larger population and increased generational iterations to refine the produced images; these modifications enhanced the outcomes but demanded higher computational time. Crucially, the adoption of elitism—retaining a subset of top-performing chromosomes in each generation—ensured that high-quality traits persisted, fostering incremental improvements without sacrificing diversity. Our Mutation and Crossover operators, as well as the function to initialize chromosomes was carefully experimented using preexisting techniques to come up with our own modified functions to yield better results. We experimented with different selection schemes and found tournament selection (with a tournament size of 4) to be particularly effective, striking a balance between exploring the search space and honing in on promising solutions, thus successfully progressing toward a recognizably evolved "Mona Lisa."

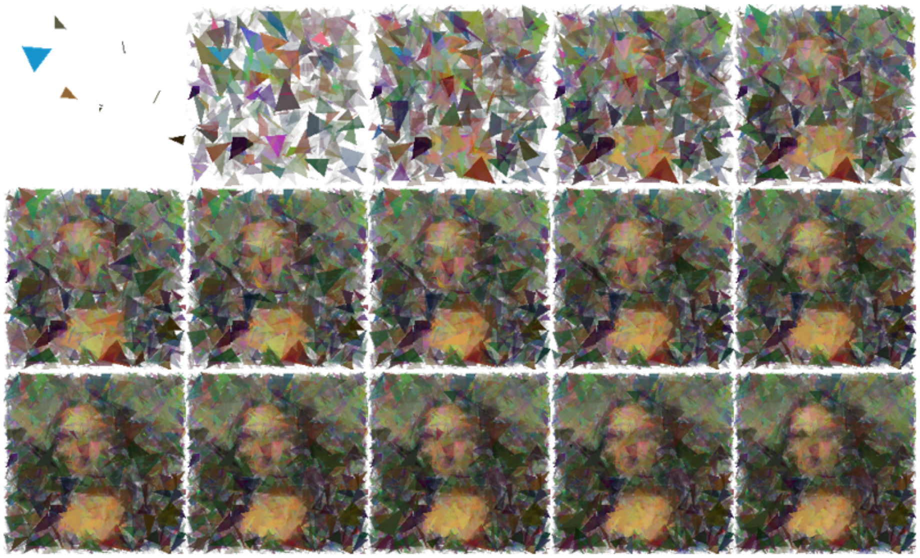

Figure 2: A - Mona Lisa Evolution - Every 100 generations - Left to Right

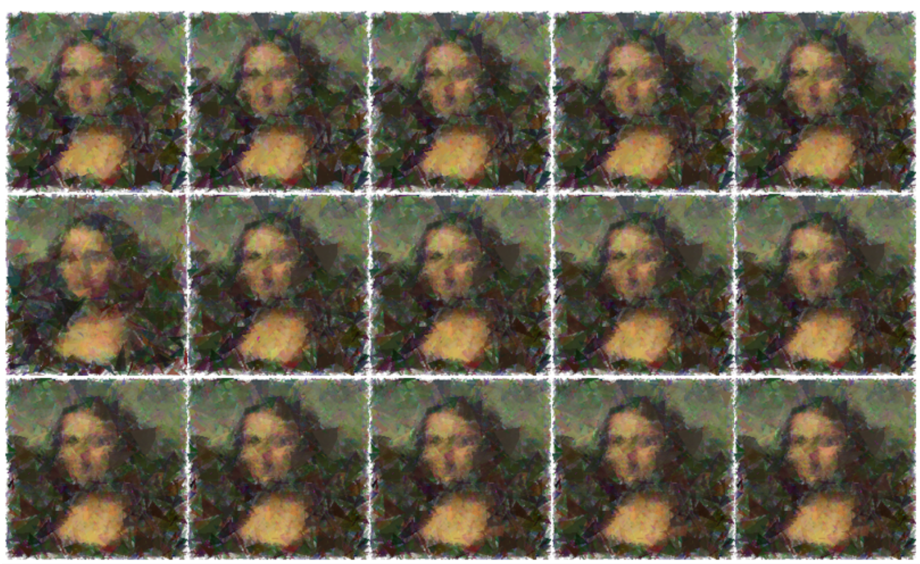

Figure 3: B - Mona Lisa Evolution - Every 100 generations - Left to Right

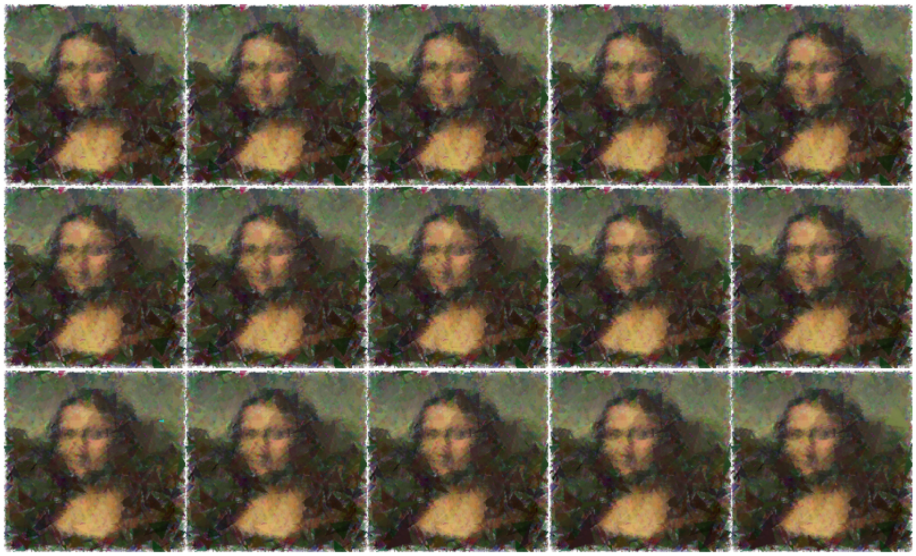

Figure 4: C - Mona Lisa Evolution - Every 100 generations - Left to Right

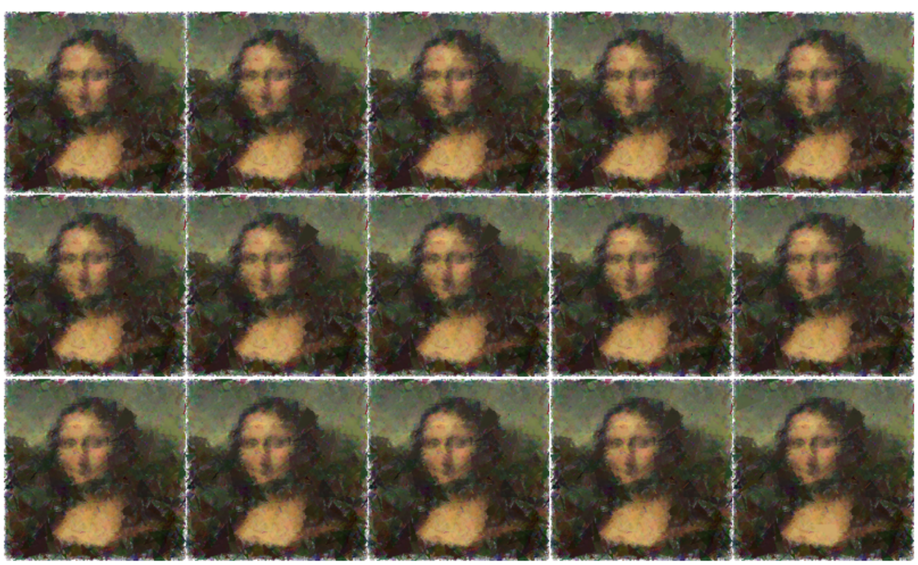

Figure 5: D - Mona Lisa Evolution - Every 100 generations - Left to Right

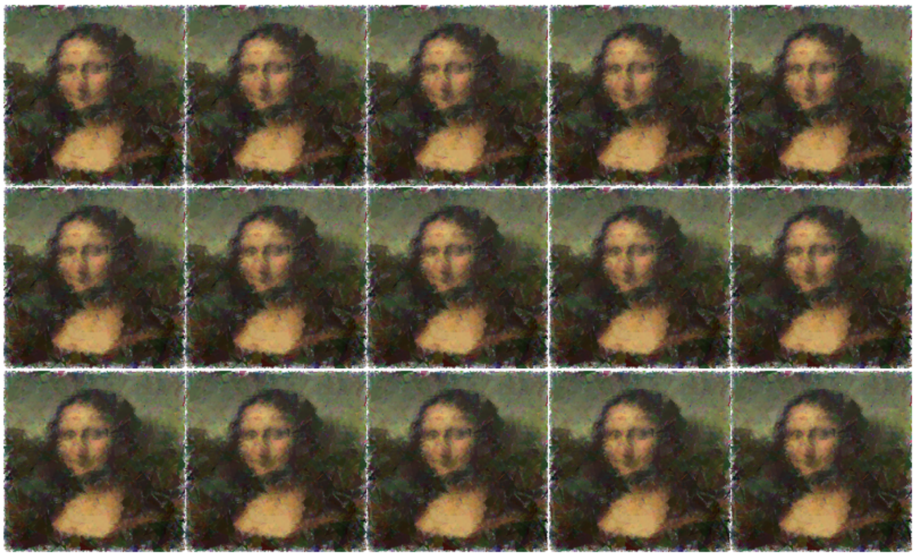

Figure 6: E - Mona Lisa Evolution - Every 100 generations - Left to Right

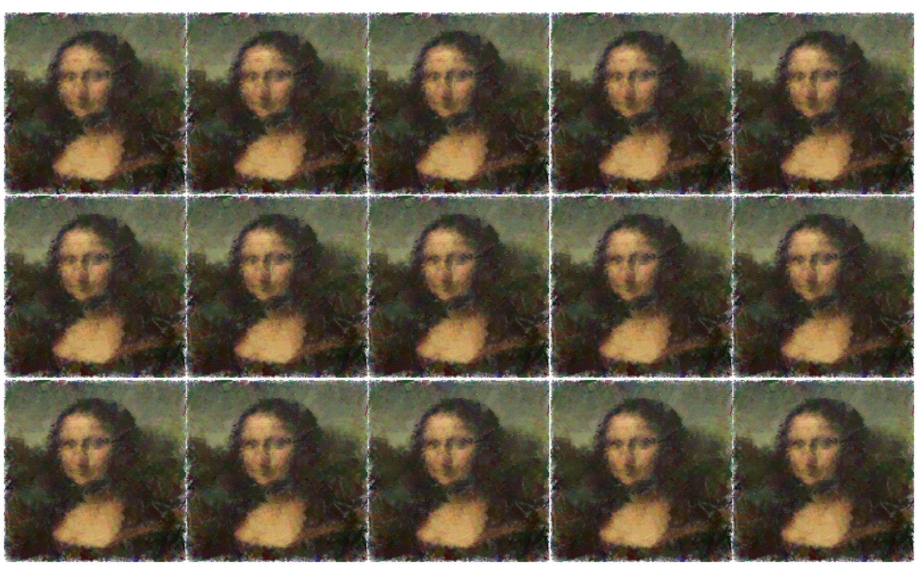

Figure 7: F - Mona Lisa Evolution - Every 100 generations - Left to Right

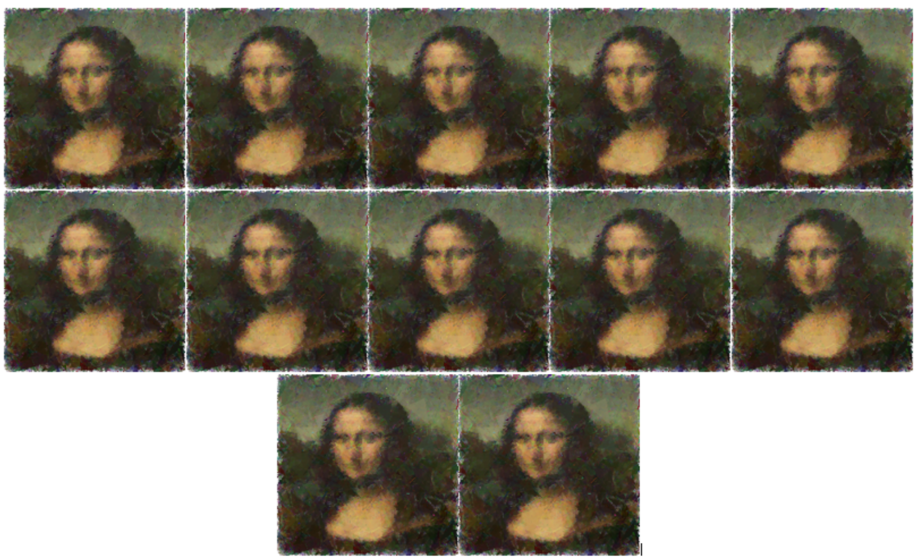

Figure 8: G - Mona Lisa Evolution - Every 100 generations - Left to Right