Ahmed Nouralla – AI Assignment 2 Report

Algorithm description:

- The program takes a 512x512 pixel bitmap (*.bmp) image and applies genetic programming (evolutionary algorithm) to generate another image (generated art), using a triangle brush (i.e., the generated image is composed of triangles of different colors, positions, sizes, each has an opacity value (alpha channel))
- **Dependencies**
  - C++ OpenGL Utility Toolkit (GLUT) for visualizing the generation process.
  - A modified version of RgbImage to support reading bitmap images.
  - The code will compile and run **only under Linux** as it uses some functions that are only available on Linux (check README file for testing instructions).

Genetic algorithm components:

- **Chromosome representation:**
  - A chromosome is a set of N triangles (each having a specific color and position), representing one of the possible solutions for the problem.
  - Each chromosome object contains an array $point[N][3][2]$ for positions on the screen, and another array $color[N]$ containing the RGB color values for each triangle in the chromosome, it also contains a field fit_val containing the fitness value for that chromosome, and a couple of functions for mutating, representing, and drawing the chromosome.

- **Fitness function:**
  - The Pixel-wise Mean-Squared-Error (MSE) value between the input (reference) image RGB data and the chromosome to be evaluated (test image RGB data read from the screen) is used as a key for sorting population.
  - A comparator function based on fit_val is used to decide which chromosome should come earlier in order.

- **Mutation technique**
  - Two variants for mutation are being used: $mutate\_disturb()$, and $mutate\_change()$

- The first one (usually used) introduces small changes (uniformly chosen deltas) to the position/color of the chromosome being mutated, while making sure values do not go off-bounds.
- The second one (less used) completely changes the position/color values, generating new random values that are uniformly bounded.

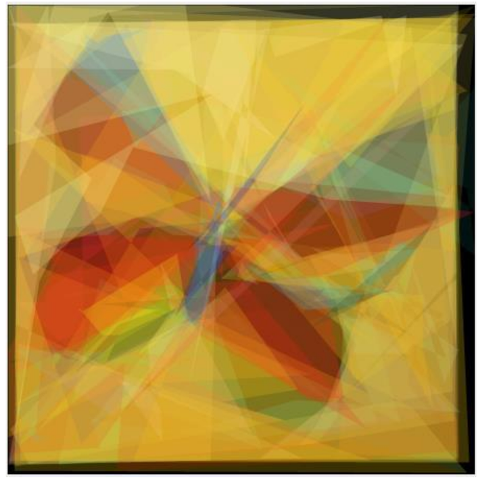
- **Crossover technique**
  - Two variants for crossover are being used: $one\_point\_co()$ and $n\_points\_co()$.
  - The first one chooses a random point to be the crossover point, and swaps all triangles before it, leaving the rest unmodified.
  - The second one essentially does the same but decides whether to swap or not based on a randomly chosen value, thus modifying multiple subsets of triangles.

- **Population size and selection technique**
  - **Population size** is a macro POP_SIZE defined at the beginning of the code that can be increased or decreased.
    - A low value will make the algorithm slower as it will require more generations to approach a good fitness.
    - On the other hand, a high value will hinder performance, as it will require more calculations per second.
    - A value of **30** that balances this trade-off is used for testing.

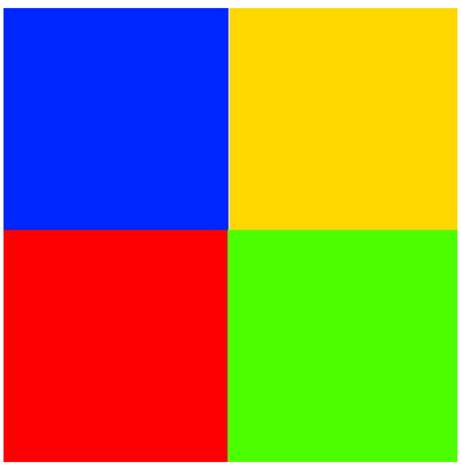
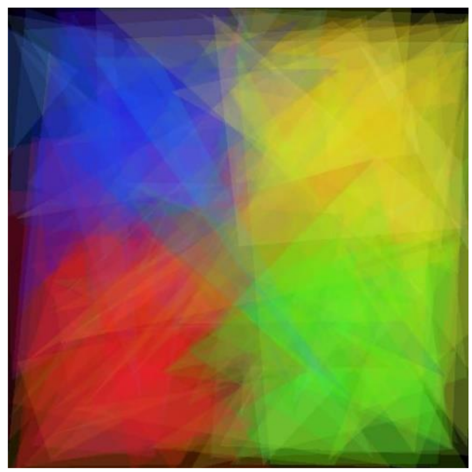
  - **Selection** is uniformly random, the algorithm applies tournament selection, it selects the best **25%** of the population to remain, the other **75%** are modified via mutation or crossover to generate a new population that evolve.
    - The best 25% are chosen based on the fitness value, the population is sorted based on fit_val for each chromosome.
    - To mutate or to crossover a chromosome is decided randomly, 95% of the cases we crossover, and the remaining 5% of the cases are mutated.
      - **50%** of the population to be crossover-ed are using one-point crossover, the rest uses n-points crossover, n is also uniformly chosen.
      - **95%** of the population to be mutated uses $mutate\_disturb()$, the rest uses a $mutate\_change()$, both described above.

I/O examples

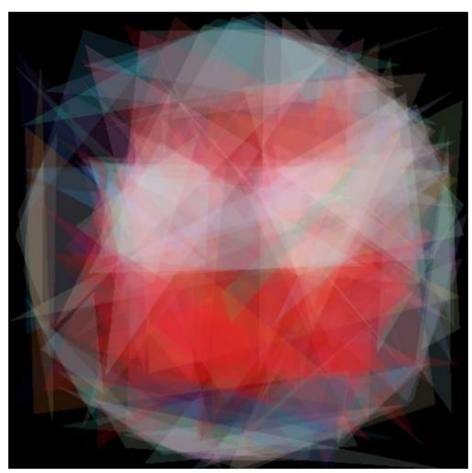
1. **Test image with many details, Generation time:** approximately 5 hours

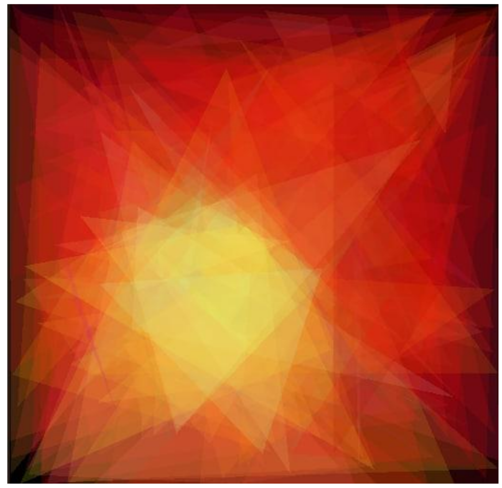
2. **Test image with minimal details, Generation time:** 10 minutes

3. **Generation time:** 10 minutes

4. **Generation time:** 5 minutes

Definition of Art

- There is no generally accepted definition of art, and personally I do not agree with the statement "Computers can generate art". The code described above essentially uses an input image, without which it cannot produce any result, the computer used a human-created art as a reference and defines the quality of its own art based on that reference through the means of fitness function and fitness value.
- The implementation used above considers the input image as a masterpiece, the best generated art it can get to, is to generate a clone to that reference ($fit\_val = 0$) via the genetic algorithm.
- The output images from I/O example above can be considered art in the sense that it represents the original image in a new way, abstracting it, or adding an effect/flavor that gives a different impression to the observer, who may admire it in the same way people like glitch-art or pixel-art for example, although they might look like - for other observers - a low-quality version of some original image.