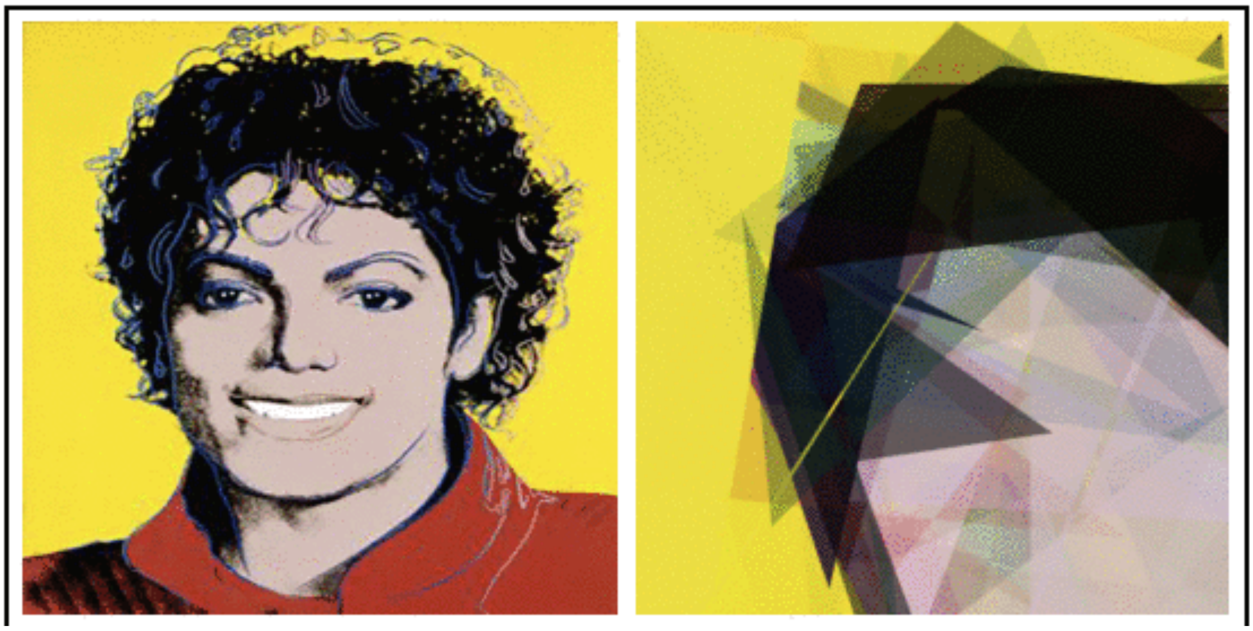
Assignment II

Computers Can Do Art!

Dragos Strugar - 5 April 2019



Introduction & Different Approaches

Using a programming language of your choice you will be given a several test input images of 512x512 pixels. You will produce via any evolutionary algorithm another 512x512 from a single test image your computational artist which will be presented to your peers and a distinguished judging panel!

The goal of this assignment was to come up with an evolutionary/genetic algorithm to produce an image with another 512x512px image as an input. All other parameters were left unknown, leaving the freedom to the writer.

To tackle the problem, I was thinking of using numerous methods, fitness criteria, and shapes. Some of them are: pixel-by-pixel, rectangles, triangles, ovals, lines, 2d/3d spatial nodes, and in general polygons. I have implemented some of these approaches, analysed the result and decided to finally go with the approach of polygons (more specifically, hexagons). Below is the rationale and reasoning on choosing hexagons as my main building block.

As the goal of this assignment is not necessarily to produce an exact replica of the source image, it was obvious to me that the pixel-by-pixel approach is not going to produce the most creative/artistic outcome there is. Especially when the colour sampled from the image provided as an input.

Similar thing happened when I tried with rectangles. I got a more interesting result, but the image looked very similar to the source image, and in addition, it was all in pixels, it looked unprofessional and not artistic at all.

2d/3d spatial node approach was very interesting to me. I wanted to try it out. The idea was to map the lines (straight or curve) to the 2d/3d space. Both ends of these lines would serve as nodes. Then other lines would get appended to the ends of previously generated lines. 3d case is also possible as we can randomly pick the 3rd, Z axis point for the picture and map our line to that point. After some time spent thinking about the implementation, I was not sure I could effectively implement this algorithm, especially in my language of choice - JavaScript. I wanted something a bit less performance-heavy, something that can be executed in a traditional web-browser, and finally something that works quite well - i.e. still produces an artistic outcome. It was too hard to implement.

Ovals (including circles) would have looked way better than the pixel-by-pixel & rectangle approach. I was thinking of using the BFS graph algorithm to determine the fitness criterion. Overall the solution in my opinion would look like a piece of art, but I choose not to go with this approach as the next one (polygons) looked way better and it is more straightforward to implement.

Polygons were my final choice for several reasons. First was the ease of implementation. Second, I liked in particular how hexagons looked like when combined with one another. And third, the image I chose as a source image has quite a bit of detail, and polygonal shapes model such shapes very nicely. This is not to say that my approach is exclusive to the input image, but rather that it fits the source image the best.

Fitness Function of the polygonal approach

The first thing I needed to figure out was how to determine what outcome is better than another. In the pixel-by-pixel example it was very easy. As each colour can be represented in the RGB spectrum, I basically just took the absolute value of the difference between the source image's red, green and blue values with the corresponding generated image's values. Smaller deviations means that the fit is better.

However, in the polygonal case, the case is a bit different. We still want to use colours to determine the fitness. I needed to sum all the pixels within the hexagon and sum them all up. Smaller total deviation means that it is the better fit. Here is the pseudocode for my idea:

```
fitness = 0
for i = 0 to width
    for j = 0 to height
          color C1 = get_pixel_colour(sourceImage, i, j)
          color C1 = get_pixel_colour(generatedImage, i, j)

          // get colour deviation
          del_red       = red(C1)    - red(C2)
          del_green     = green(C1) - green(C2)
          del_blue      = blue(C1)   - blue(C2)

          // euclidian distance
          double pixelFitness = del_red * del_red +
                                del_green * del_green +
                                del_blue * del_blue

          // lower better
          fitness += pixelFitness
    end
end

return fitness
```

It is a fairly simple idea. Just sum all of these in the polygon and we get our result. The crossing pixels have 50-50% chance of being included and excluded from the consideration.

Genetic Programming

After completing the fitness function, the next step is to come up with a complete genetic programming algorithm which would generate new individuals and compare them to the source using the fitness function.

The algorithm models a population, with each individual containing DNA that can be depicted using an image. We start off with a randomly generated gene pool, and compare each and every one of them to the source image. Then we apply the fitness function to the results, and we get the best one. Then, the one that beat all the others is naturally selected as the winner.

Essentially, the algorithm does the following steps:

1. Get and replicate the current individual's DNA sequence and slightly modify it (mutation)
2. Use the new DNA to actually render hexagons on the screen
3. Compare the obtained result with the source (reference) image
4. If the new result looks like the source more than the previous one (using the criteria of the fitness function), make the newly generated image the best one
5. Repeat the process.

Implementation

The implementation of this algorithm is done in the JavaScript (JS) programming language. As I stated above, I chose it for a few reasons:

- My familiarity with the language and tools surround JS
- Straightforward image manipulation
- JS built with changes (including changes to pictures) in mind
- Easily deployed as a website so results can be shared with others (like you, the TA or the professor reading this)

I feel like the little nuts and bolts of the implementations do not matter that much for the report, especially because the report should be cca. 5 pages long. Thus I leave you with the final results of my project, as well as the GIF and resources to try it out yourself.

Thank you,
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