

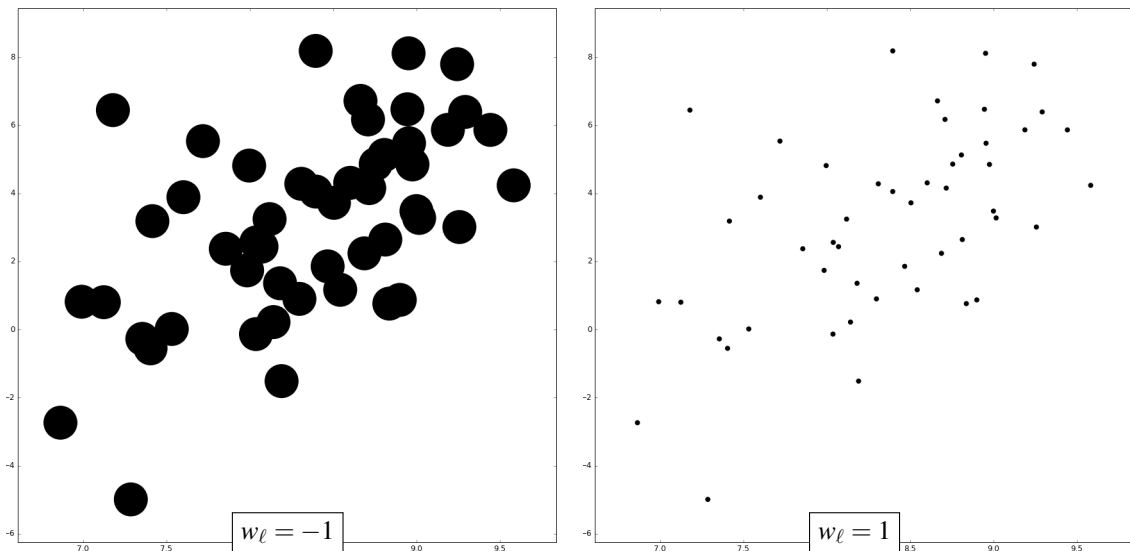
Towards Perceptual Optimization of the Visual Design of Scatterplots

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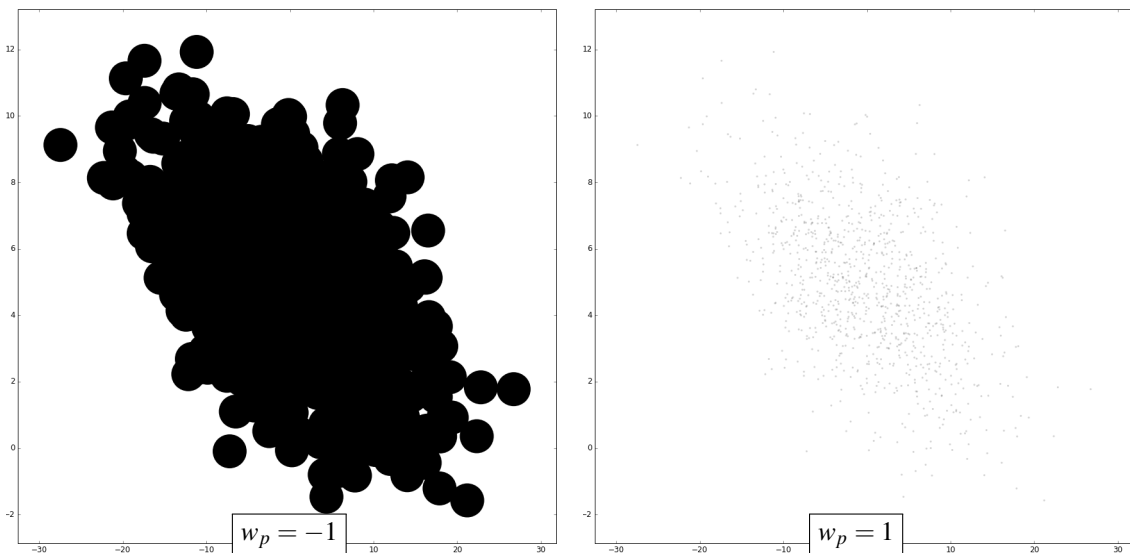
In this supplement, we provide example figures for the perceptual metrics of our method. This refers to Section 5 of the paper.

1 Overlapping and overplotting measures

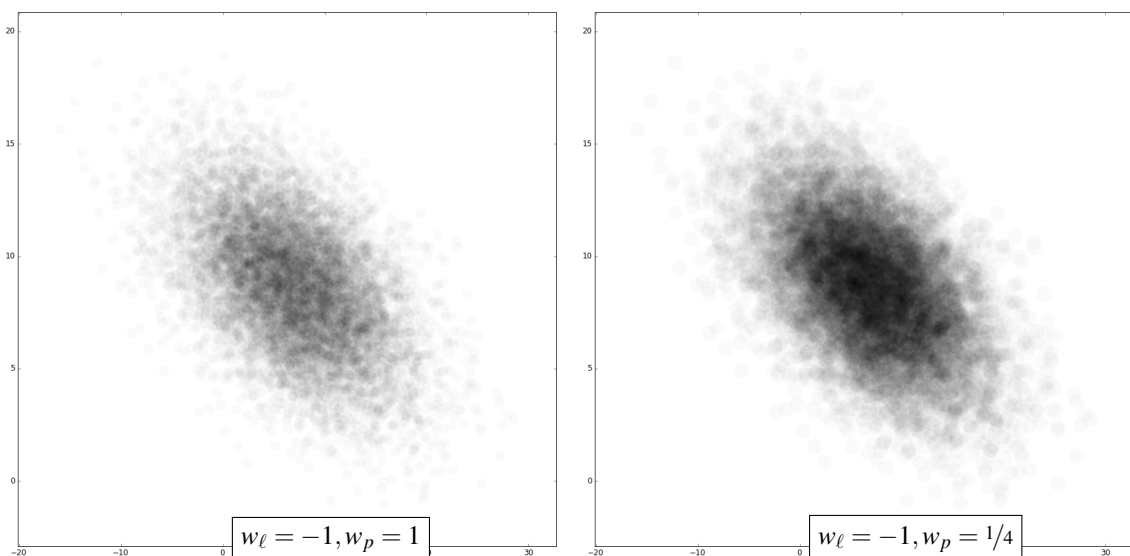
Figure 1 shows examples for overlap and overplotting.



(a) Maximized (left) and minimized (right) overlap measure I_ℓ .



(b) Maximized (left) and minimized (right) overplotting measure I_p .



(c) Balancing I_ℓ and I_p such that overlapping markers are desired, but overplotting is penalized to a varying degree. This leads to smoother, less extreme results.

Figure 1: Examples for the overlapping and overplotting measures.

2 Class and Outlier Perceivabilities

Figure 2 shows examples with minimized and maximized perceivability of classes and outliers. Note how the perceivability becomes minimal when the plots are essentially white due to low marker opacity and small marker size.

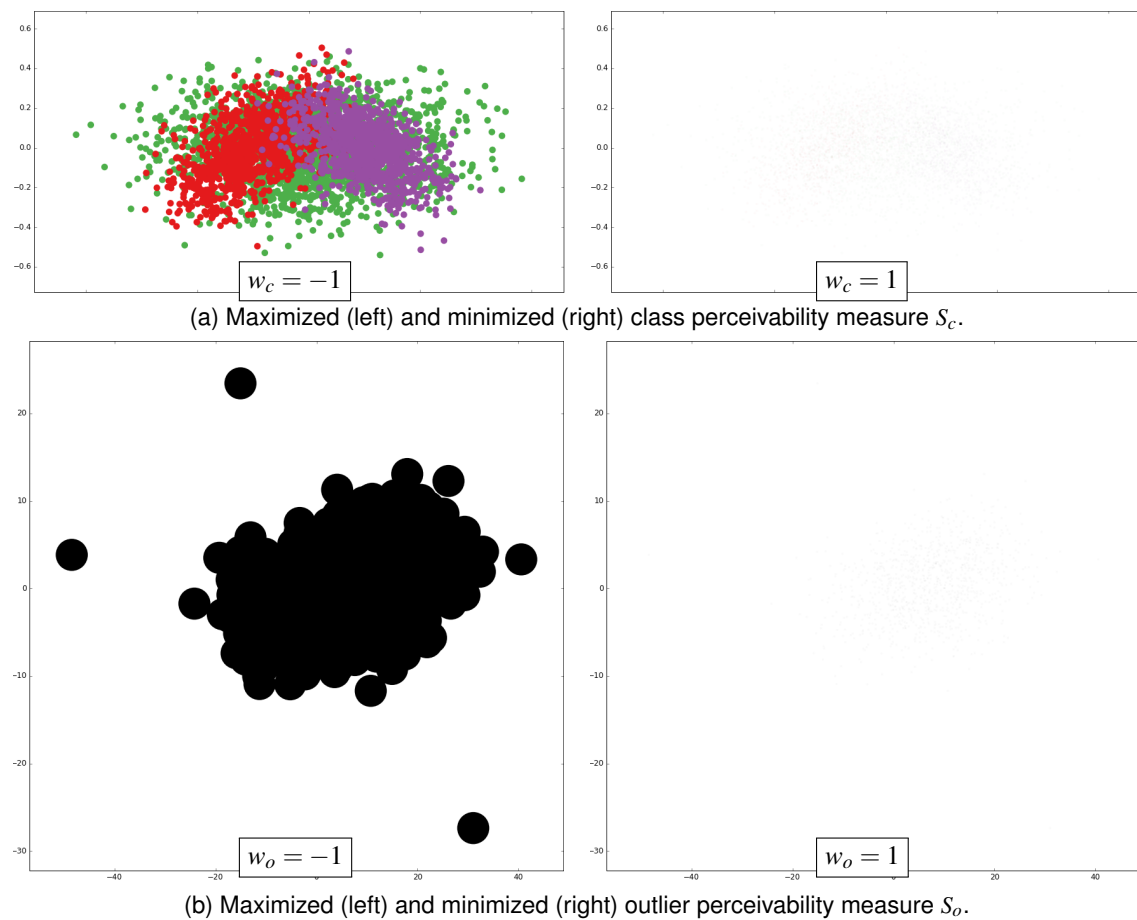


Figure 2: Examples for the class and outlier perceivabilities S_c, S_o .

3 Correlation Cost Measures

Figure 3 shows an example for which E_α, E_r have been maximized and minimized.

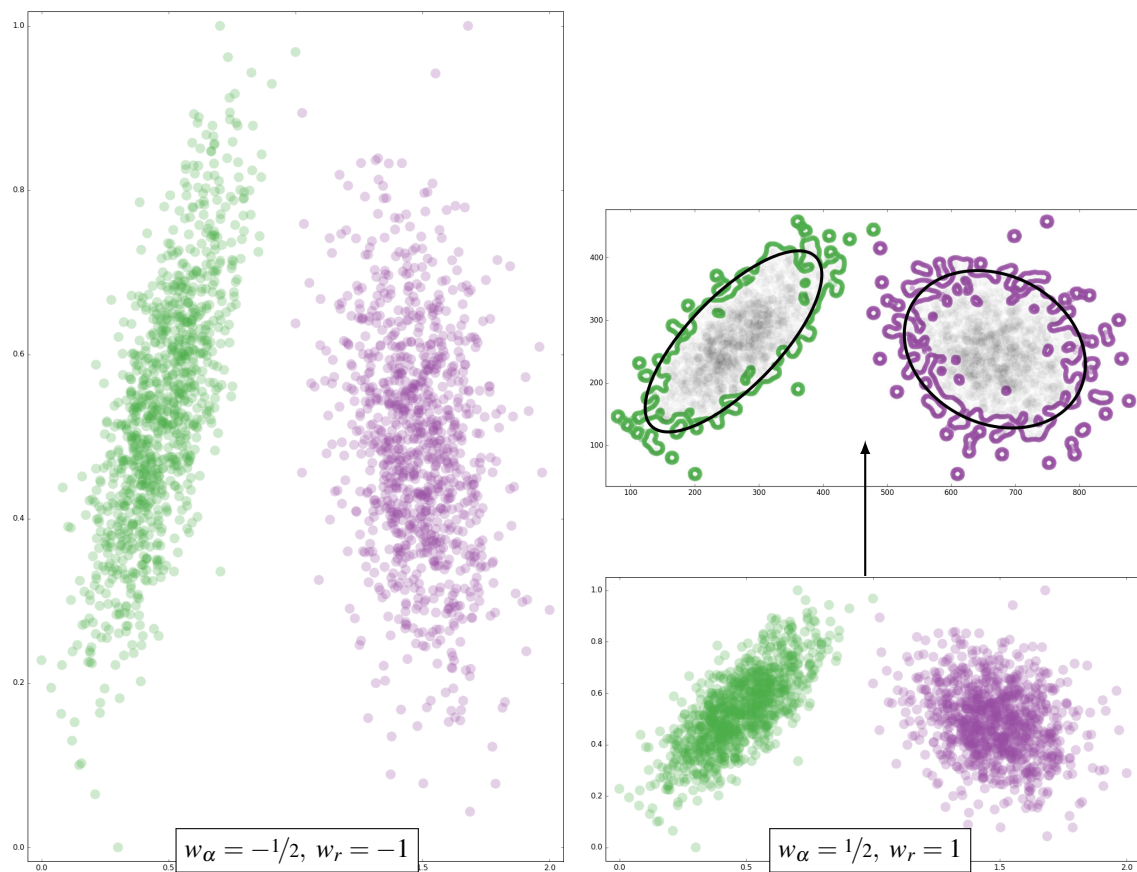


Figure 3: Maximized (left) and minimized (right) correlation cost measures E_α, E_r . The minimized version allows to better perceive the linear correlation. The upper right image shows the perceived border points after applying the Canny edge detector. The fitted ellipses estimate the perception of the classes following unit formation theory.

4 Canny Edge Detector

We use the Canny edge detector [1] with $\sigma = 4px$ to detect edges in the scatterplot image. σ refers to the size of the Gaussian blur filter. The smaller the size, the less blurring and the more detail and small edges are detected. In the following, we examine σ values in the range $[0, 14]$ for two different scatterplots. We note that the edges detected with $\sigma = 4px$ align best with the edges perceived by the 4 authors. This value of σ is consistent with design recommendations (www.wintopo.com/help/html/canny-opt.htm). Note also that minor differences in σ do not produce remarkably different results.

4.1 Example 1

Figure 1 shows the scatterplot in Example 1 with 1000 data points and 2 classes. Figures 2-16 show the edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma \in [0, 14]$.

4.2 Example 2

Figure 17 shows the scatterplot in Example 2 with 10000 data points and 3 data classes. Figures 18-32 show the edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma \in [0, 14]$.

References

- [1] J. Canny. A computational approach to edge detection. *IEEE TPAMI*, (6):679–698, 1986.

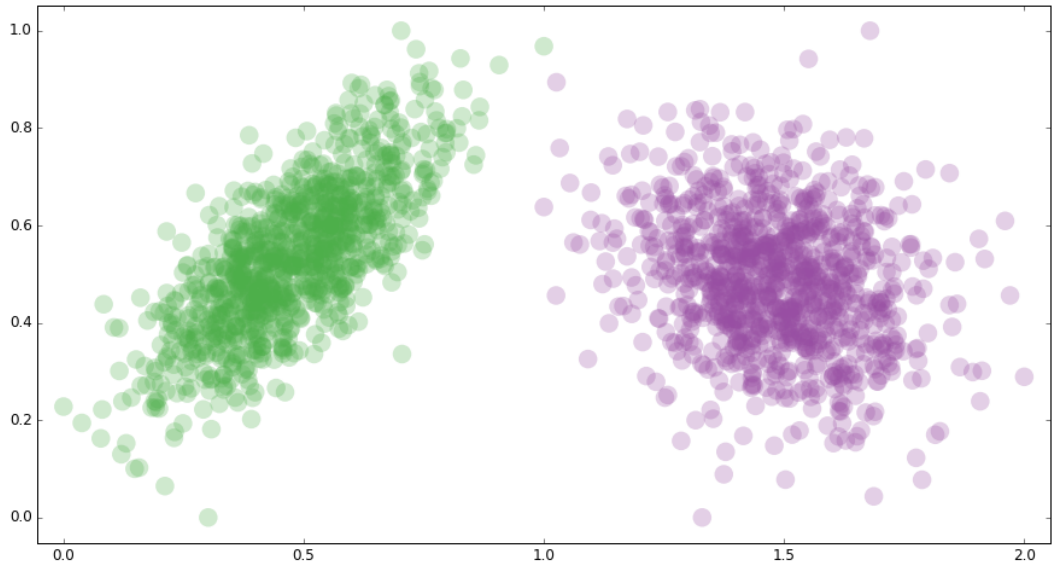


Figure 4: Scatterplot in Example 1

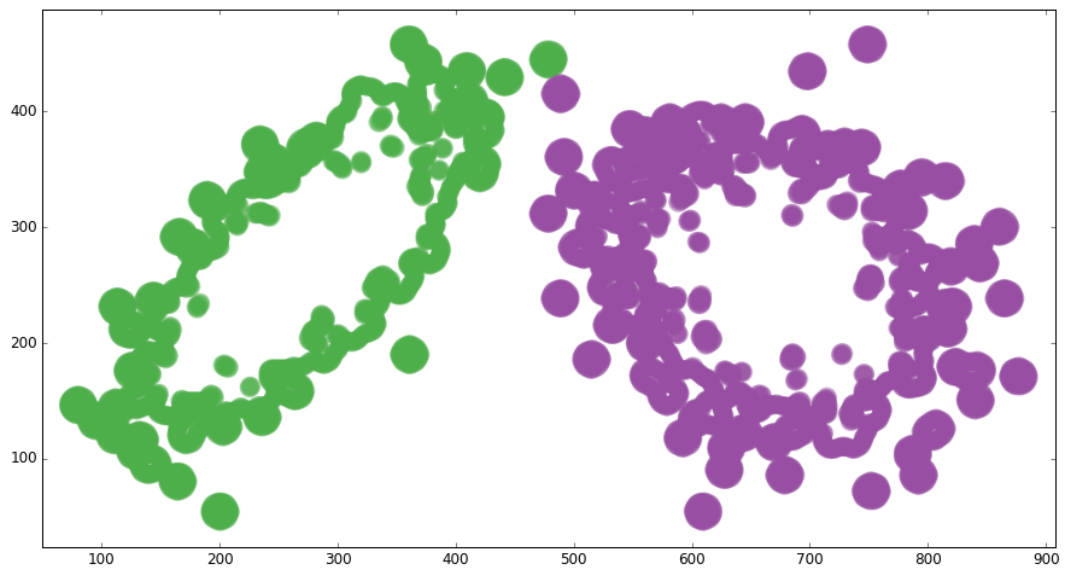


Figure 5: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 0$ px

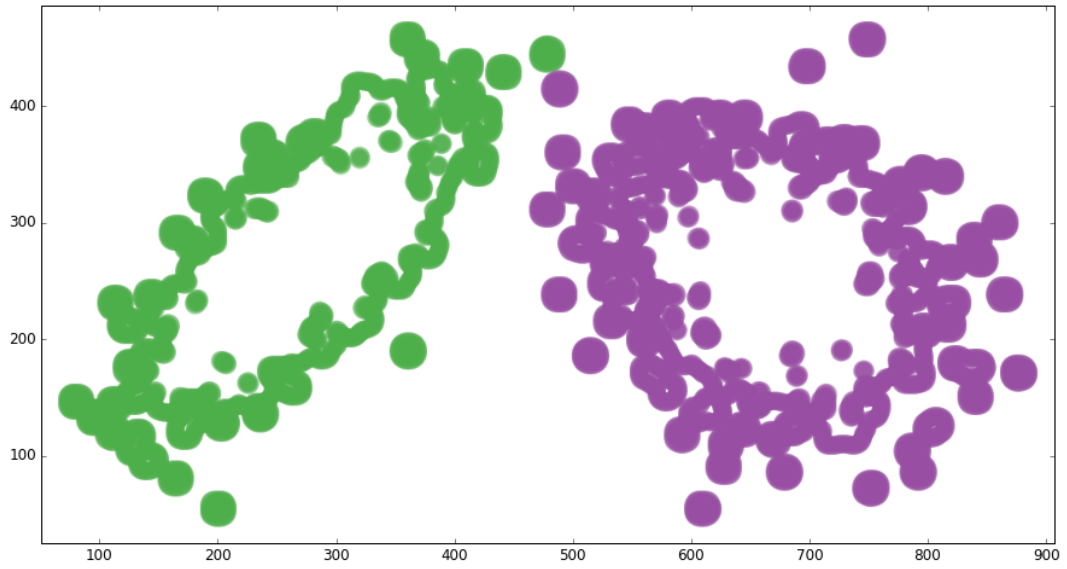


Figure 6: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 1\text{px}$

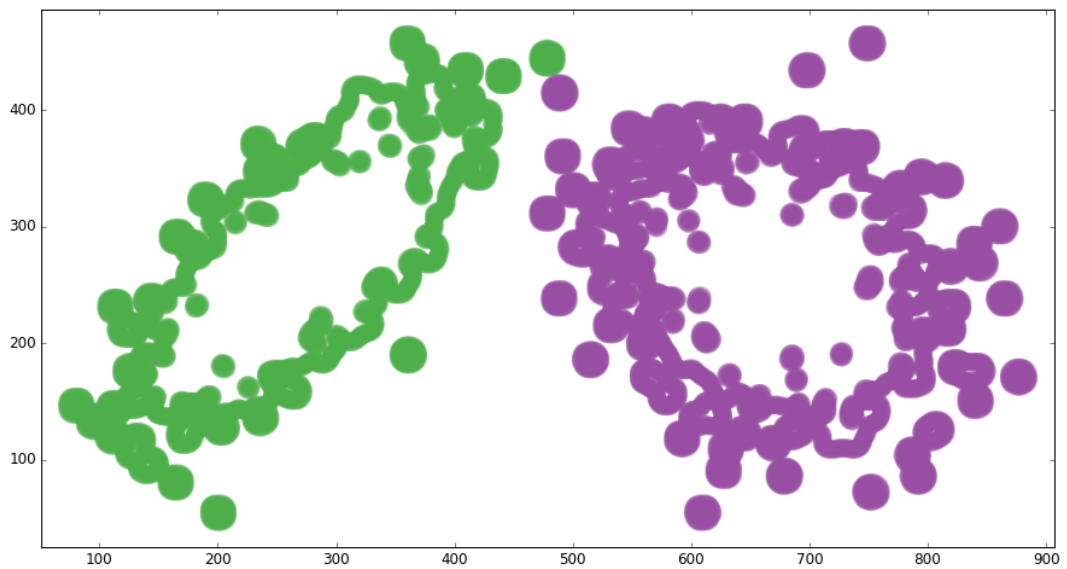


Figure 7: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 2\text{px}$

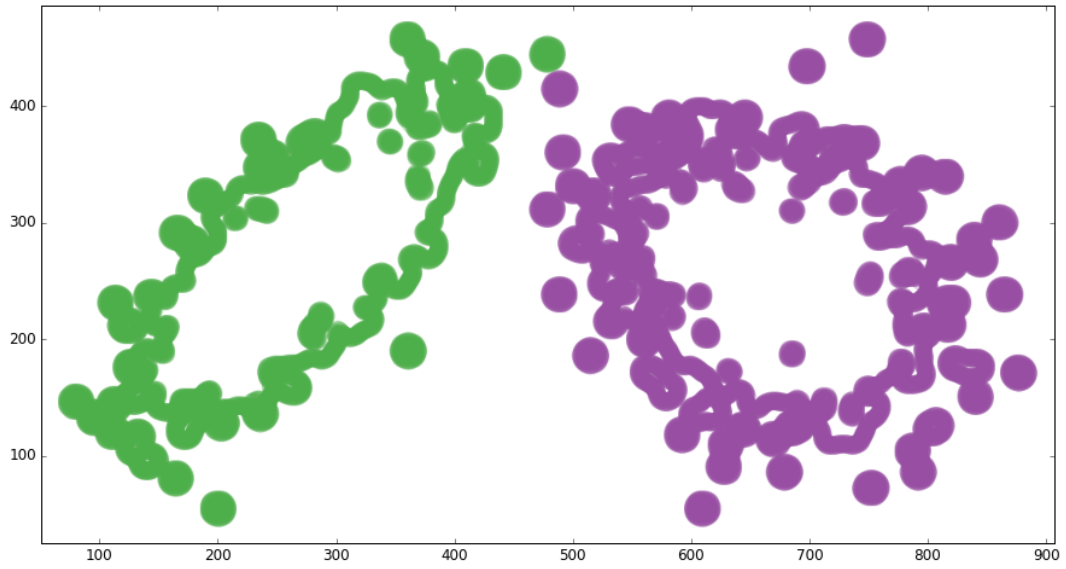


Figure 8: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 3\text{px}$

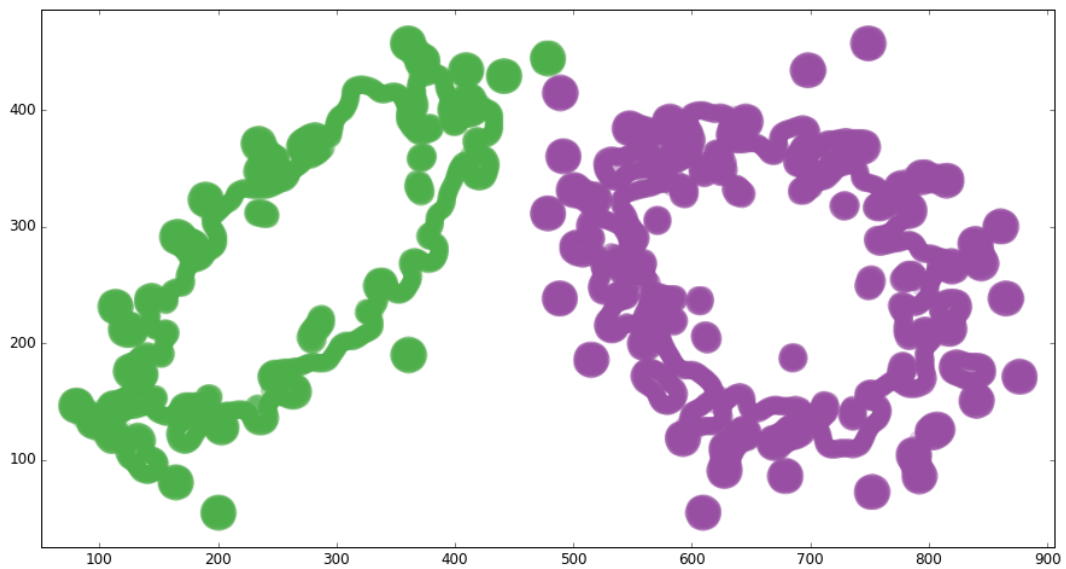


Figure 9: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 4\text{px}$

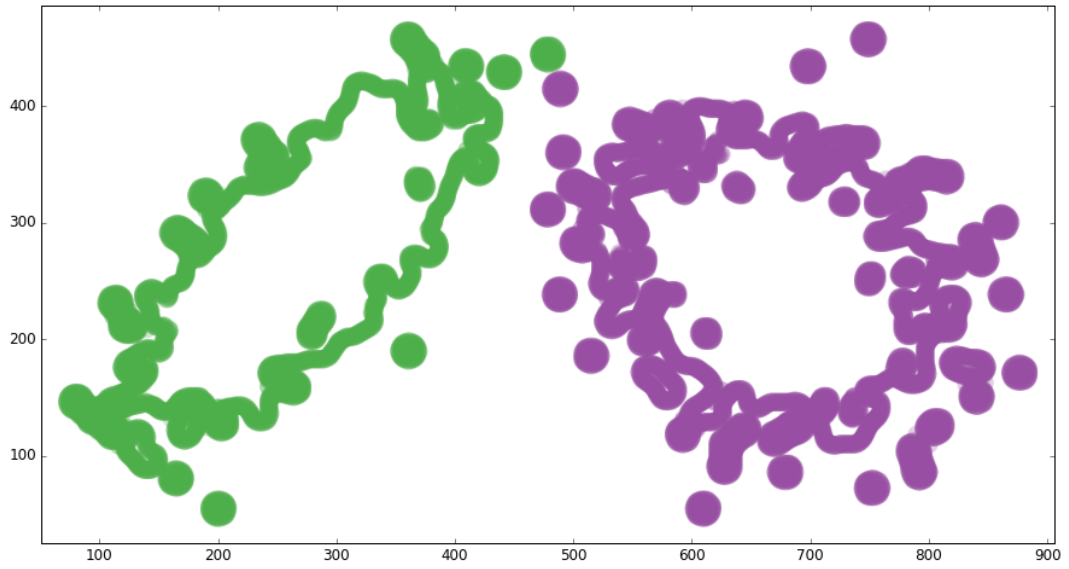


Figure 10: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 5\text{px}$

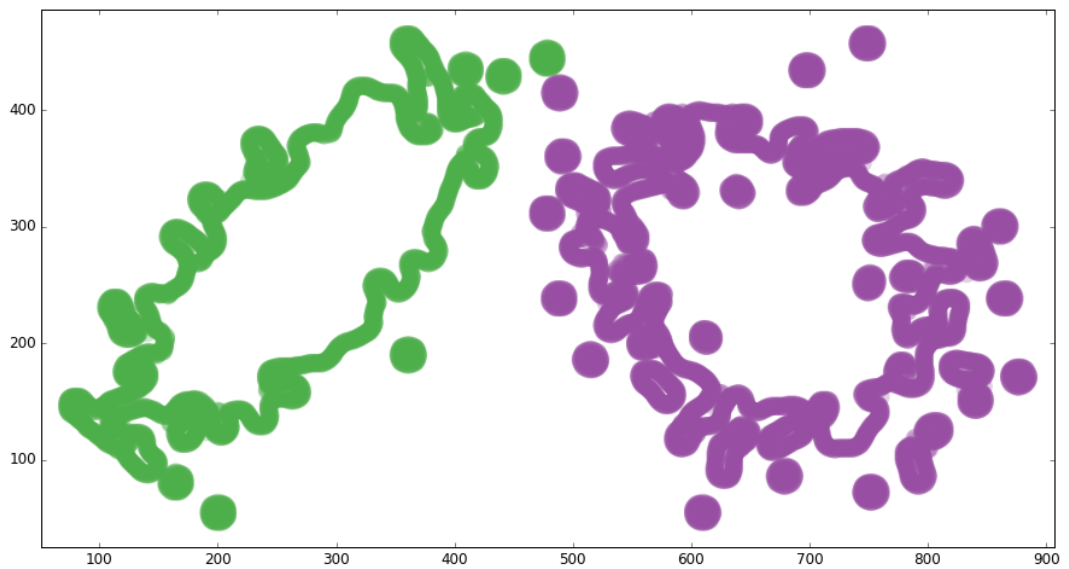


Figure 11: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 6\text{px}$

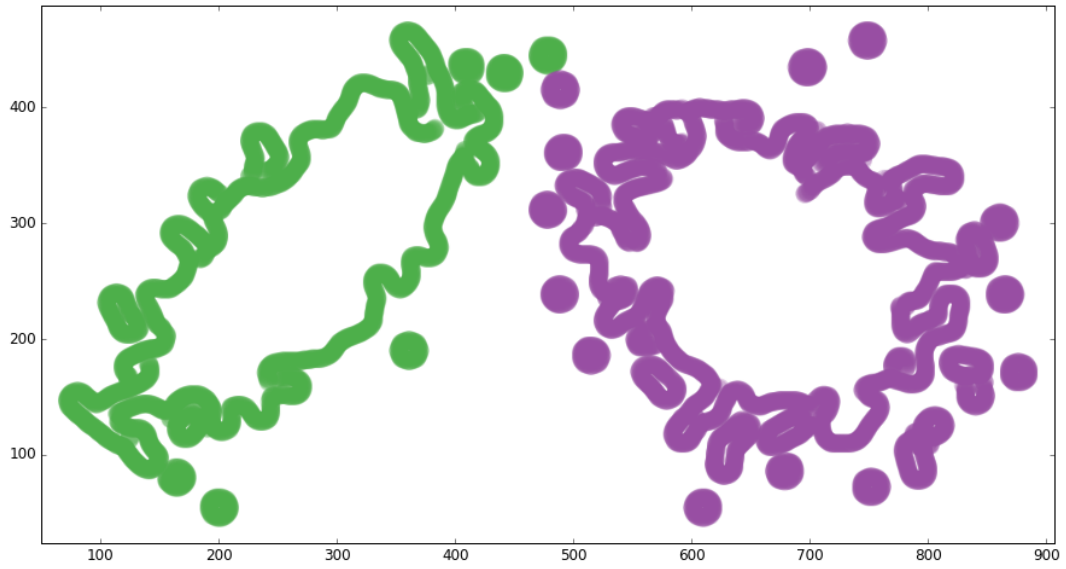


Figure 12: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 7\text{px}$

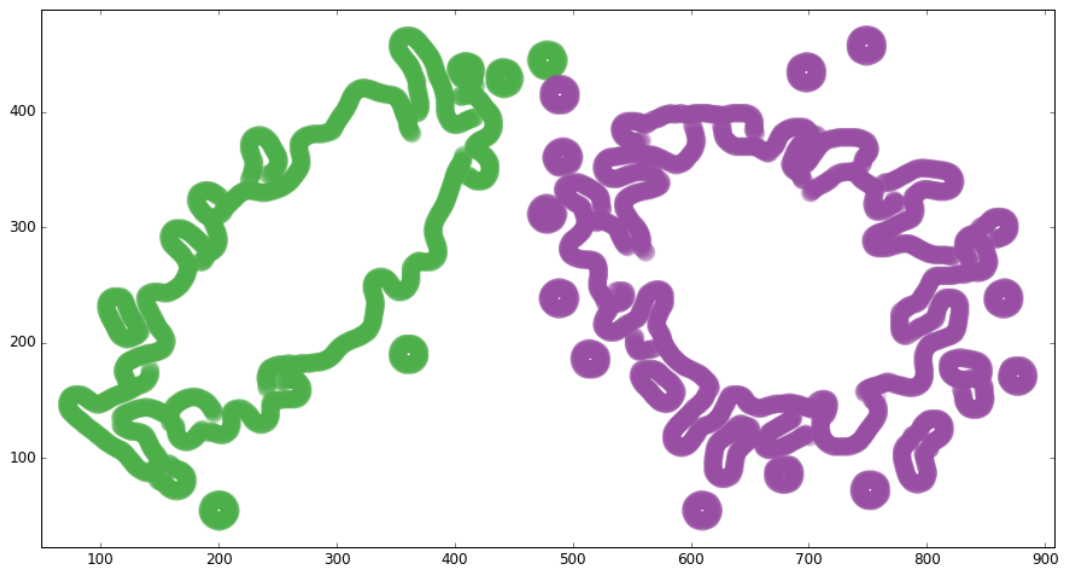


Figure 13: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 8\text{px}$

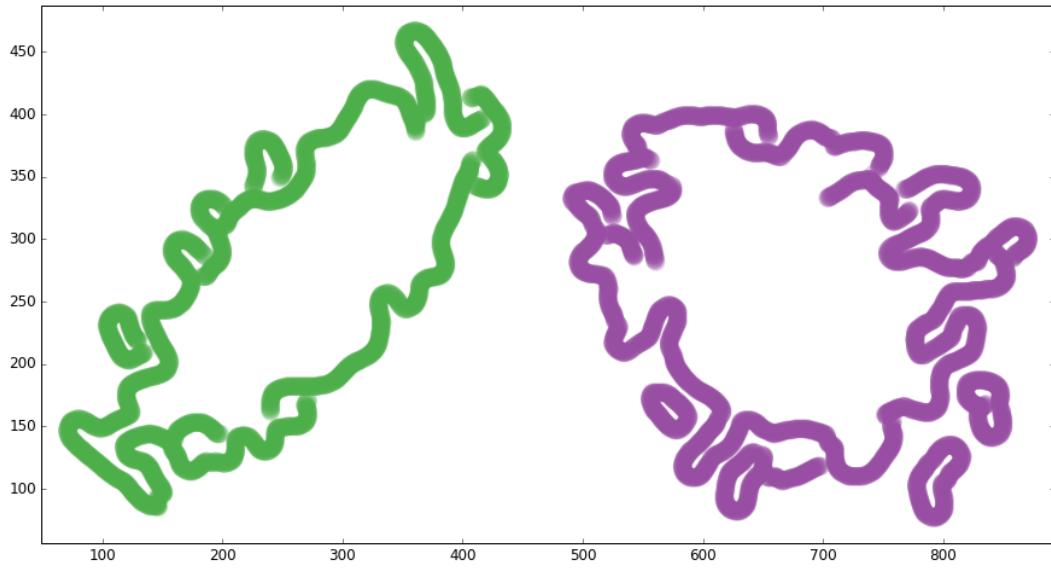


Figure 14: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 9\text{px}$

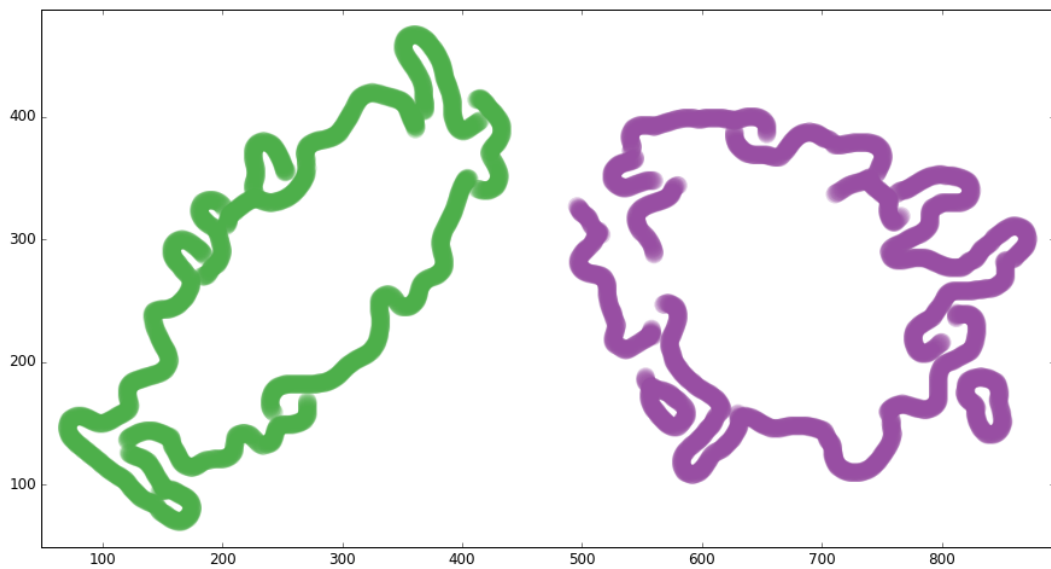


Figure 15: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 10\text{px}$

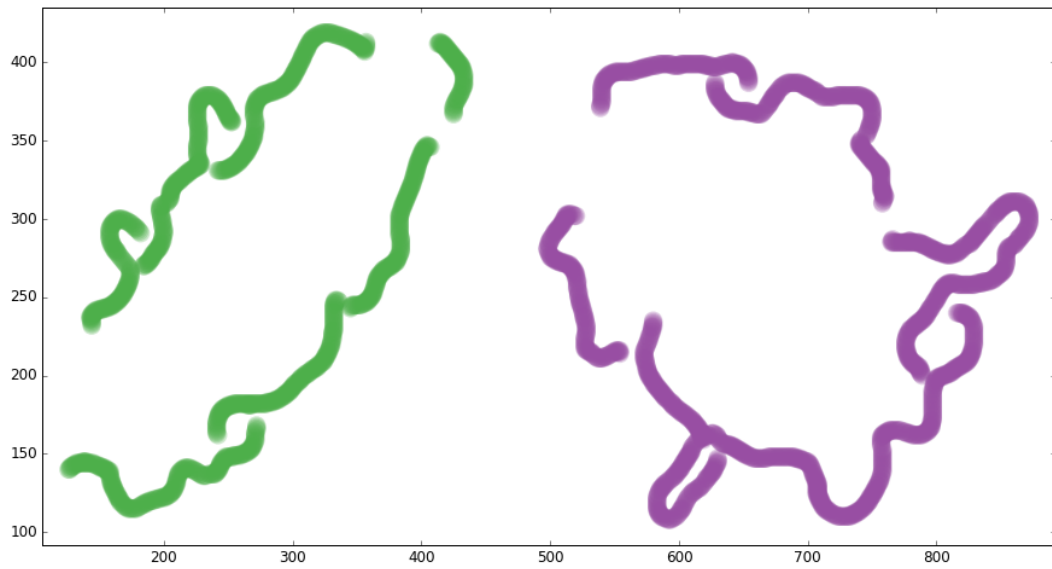


Figure 16: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 11$ px

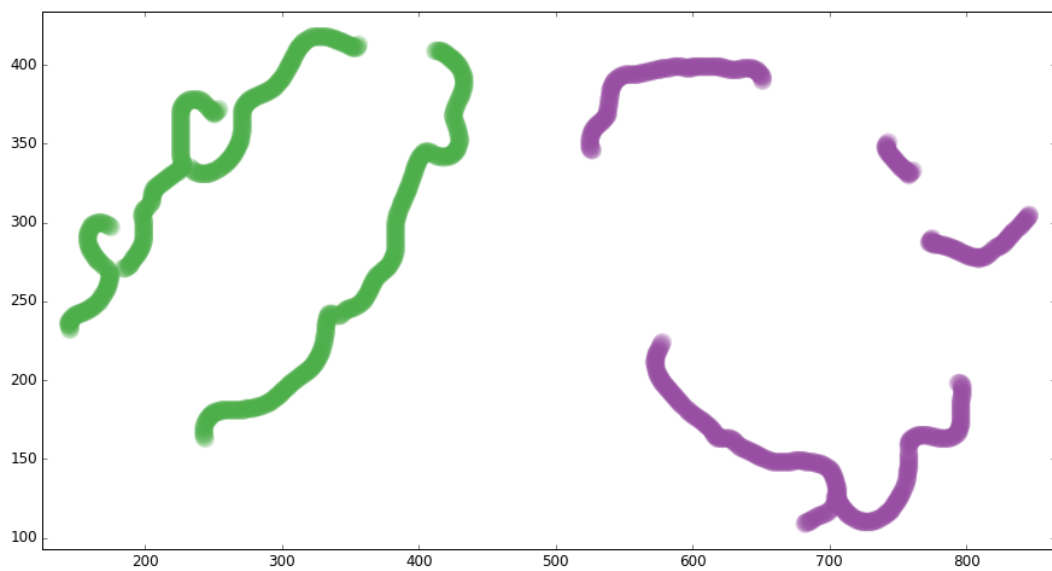


Figure 17: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 12$ px

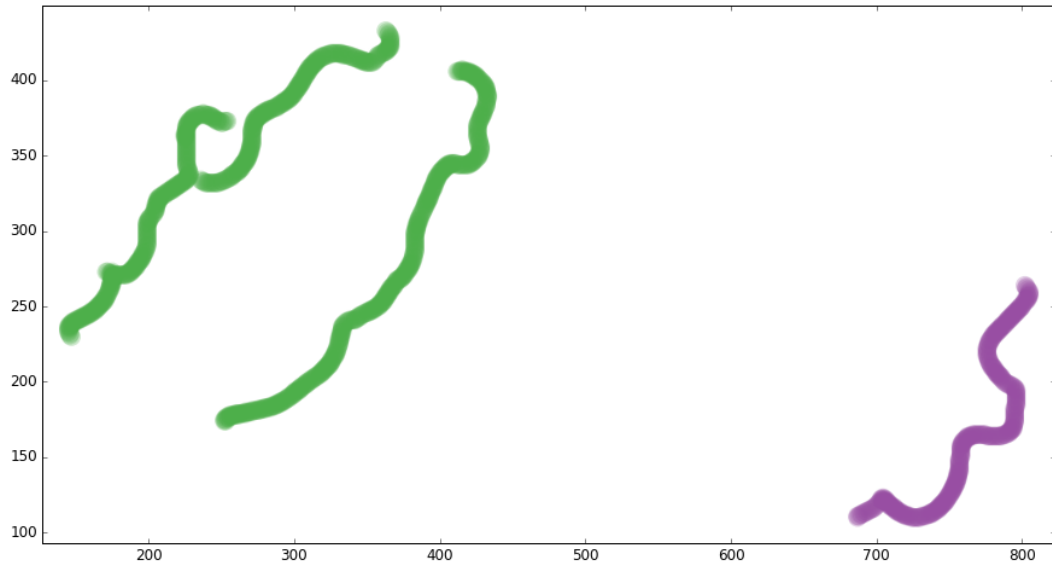


Figure 18: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 13\text{px}$

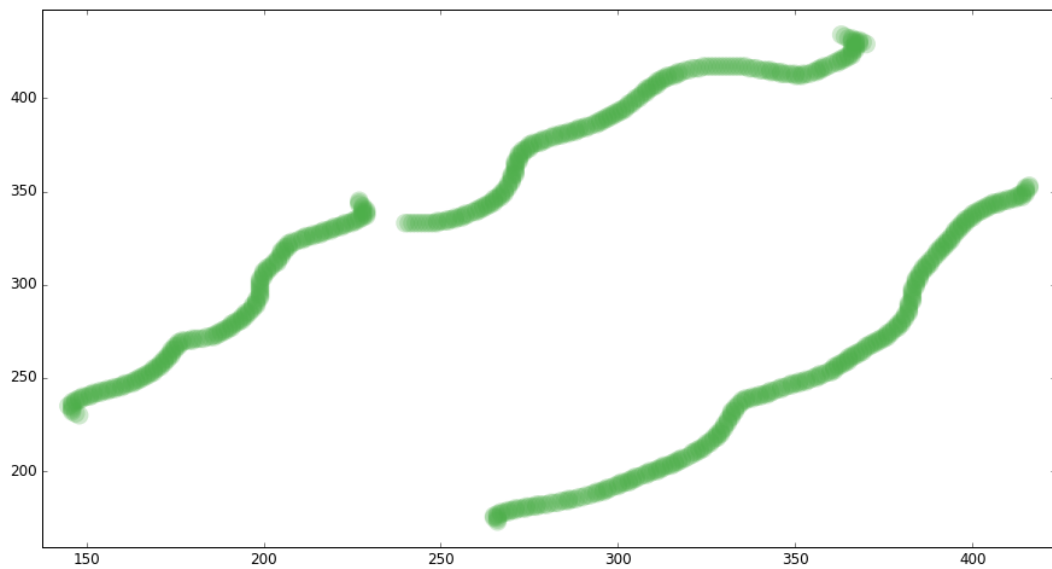


Figure 19: Edges detected for the scatterplot in Figure 1 by the Canny edge detector with $\sigma = 14\text{px}$

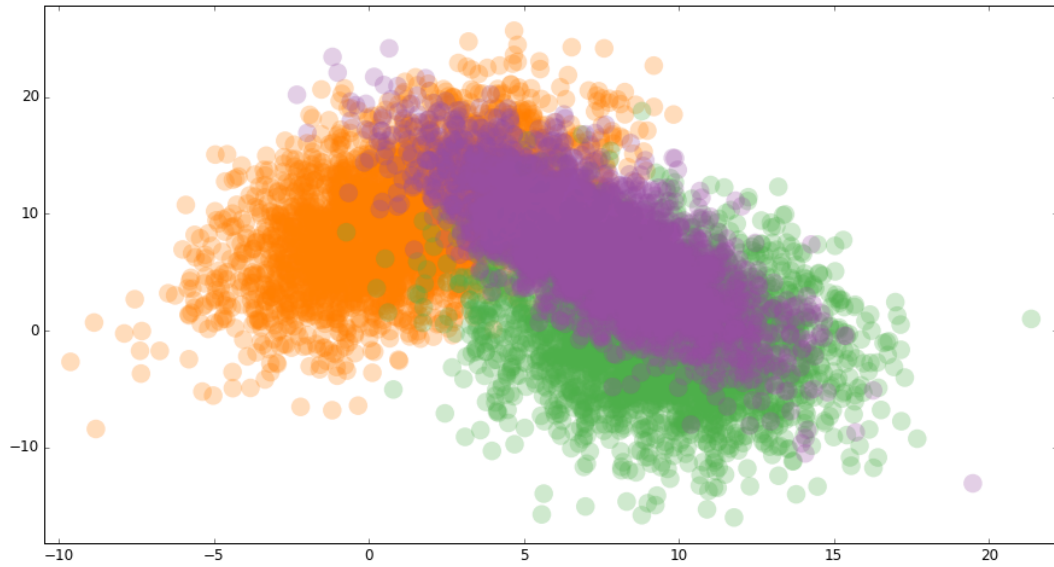


Figure 20: Scatterplot in Example 2

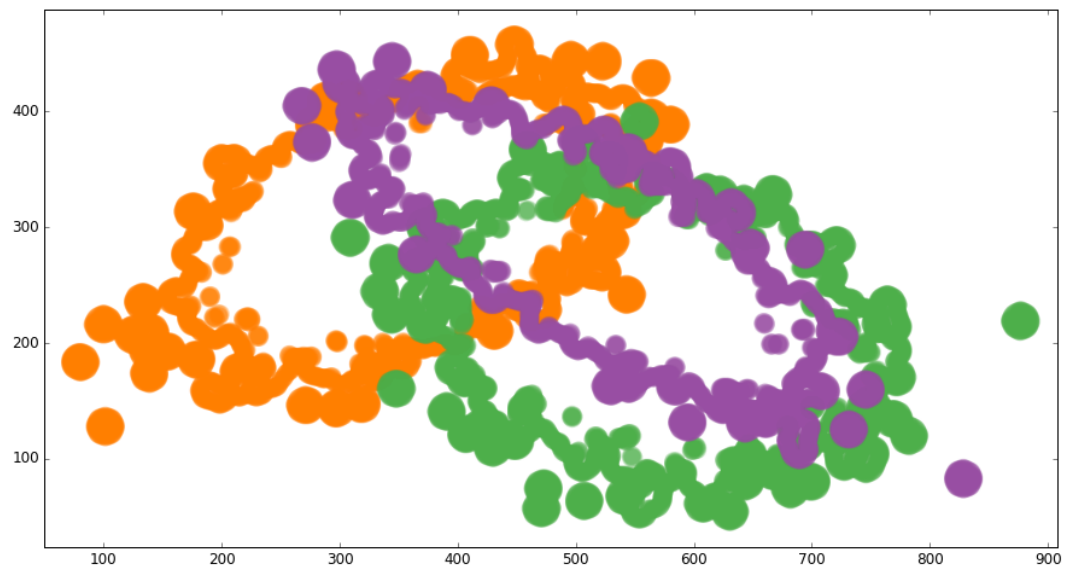


Figure 21: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 0$ px

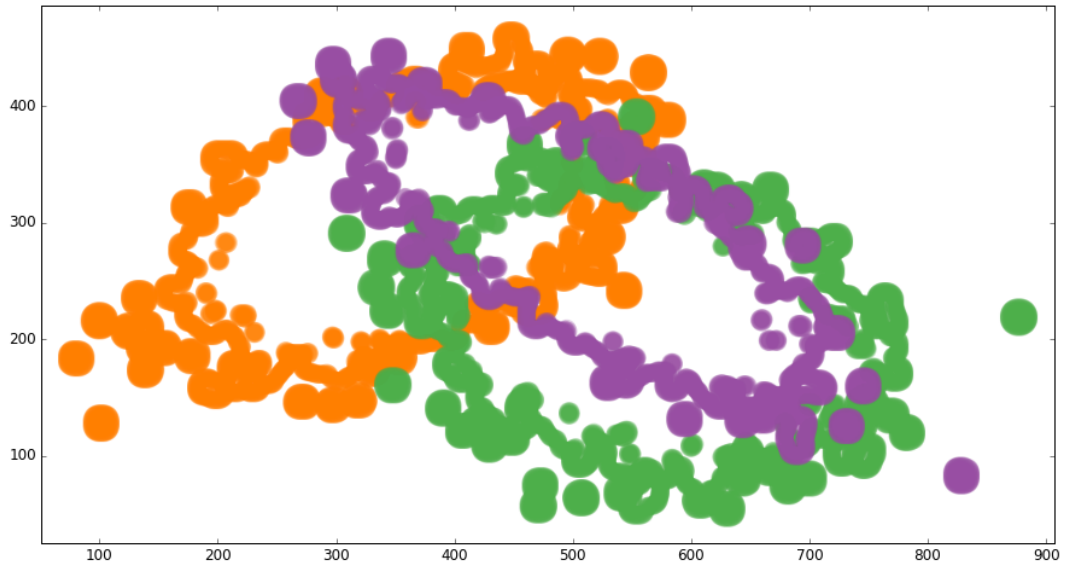


Figure 22: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 1\text{px}$

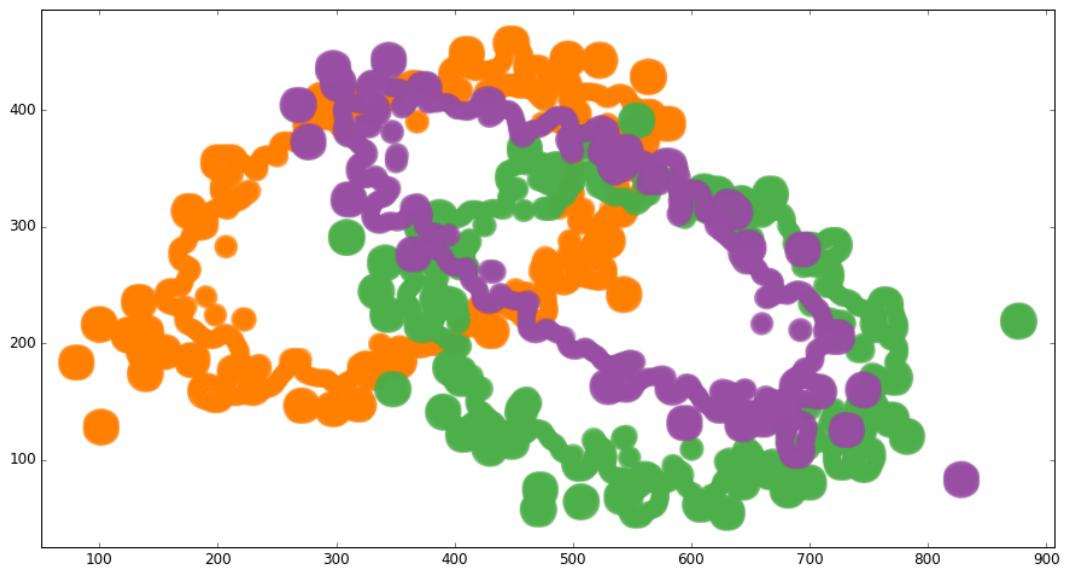


Figure 23: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 2\text{px}$

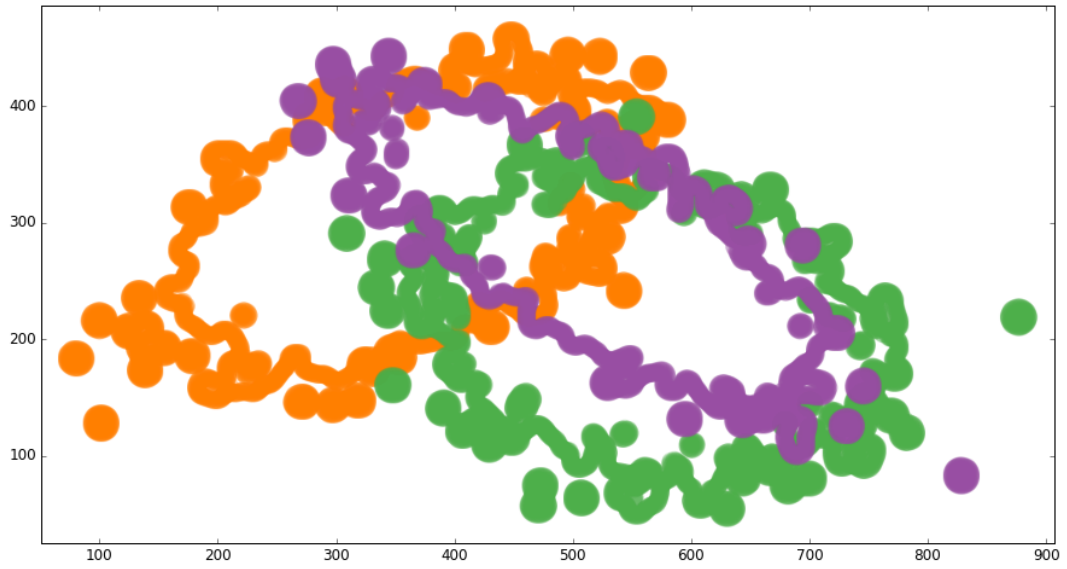


Figure 24: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 3\text{px}$

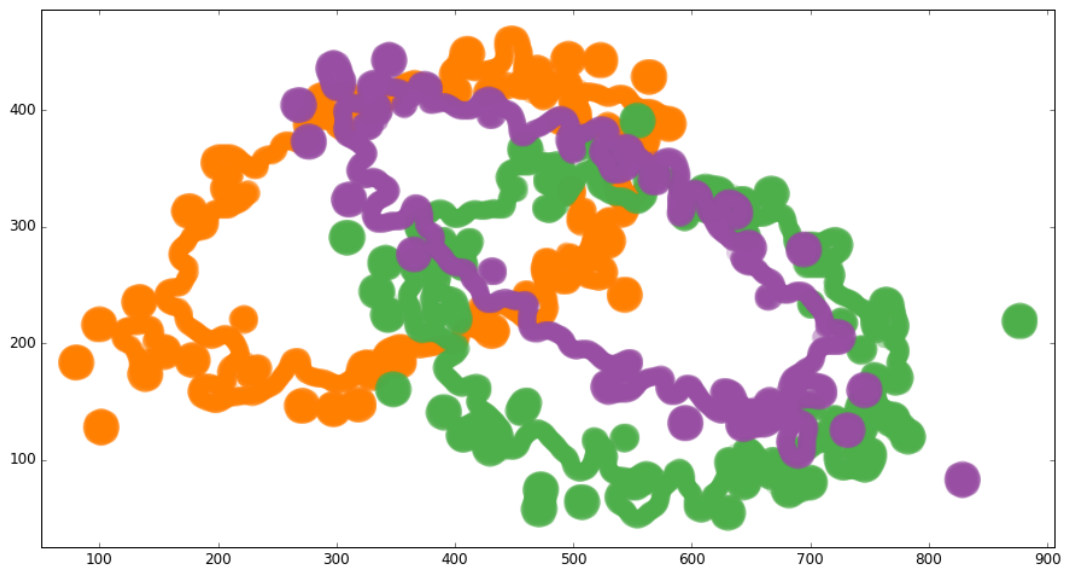


Figure 25: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 4\text{px}$

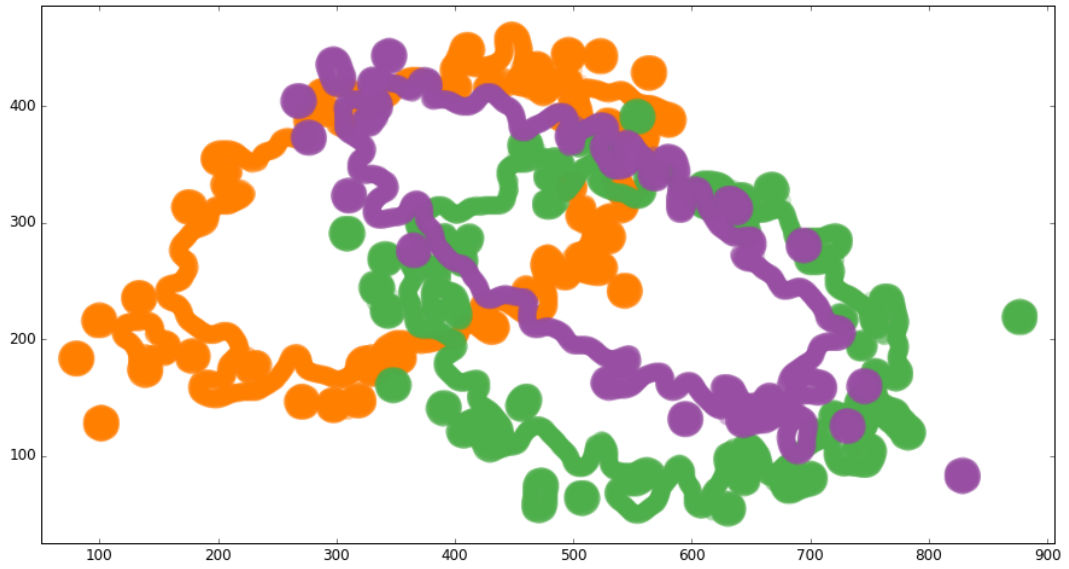


Figure 26: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 5\text{px}$

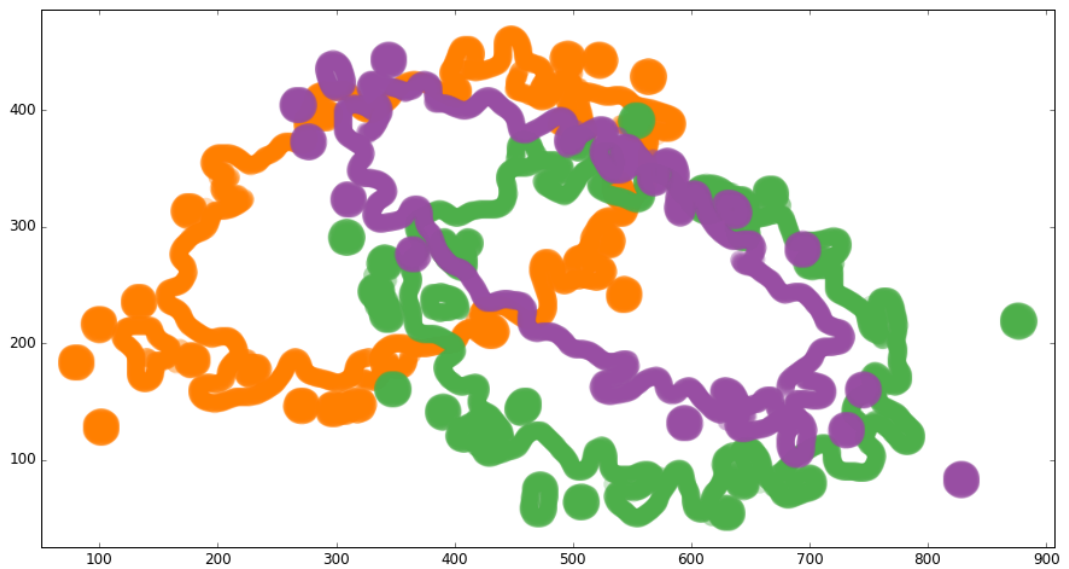


Figure 27: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 6\text{px}$

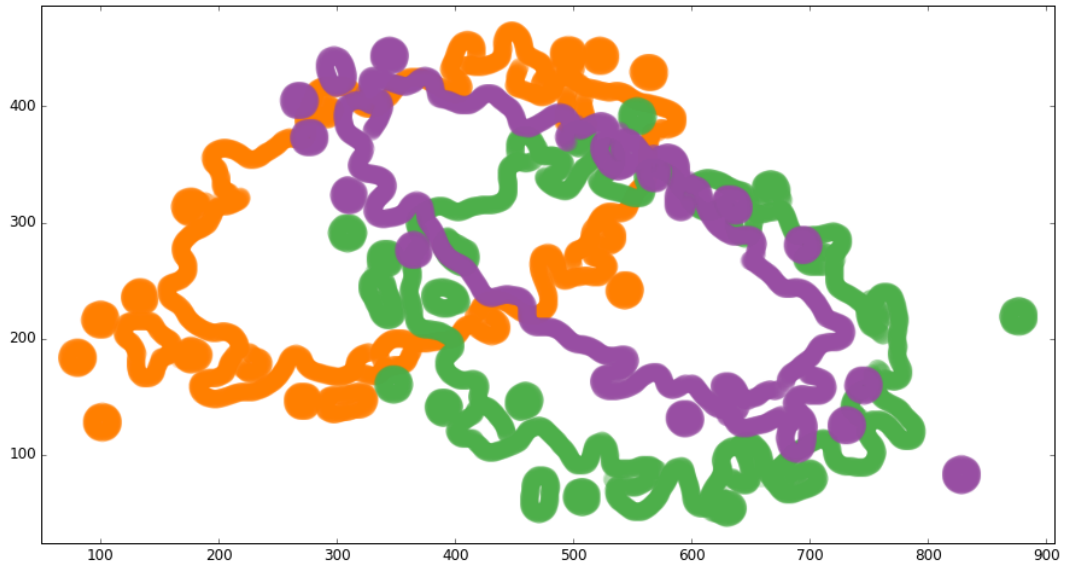


Figure 28: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 7\text{px}$

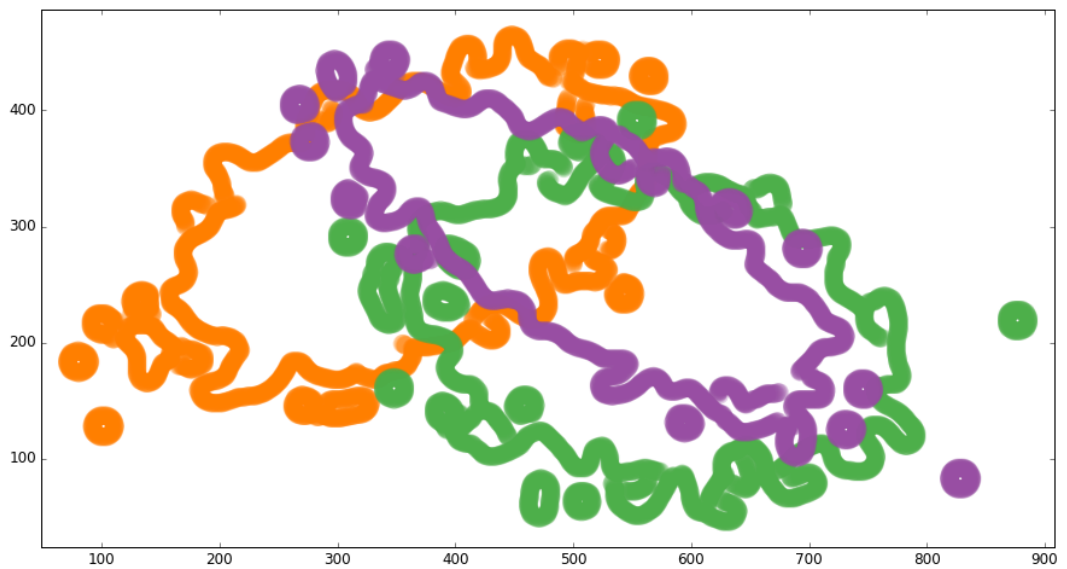


Figure 29: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 8\text{px}$

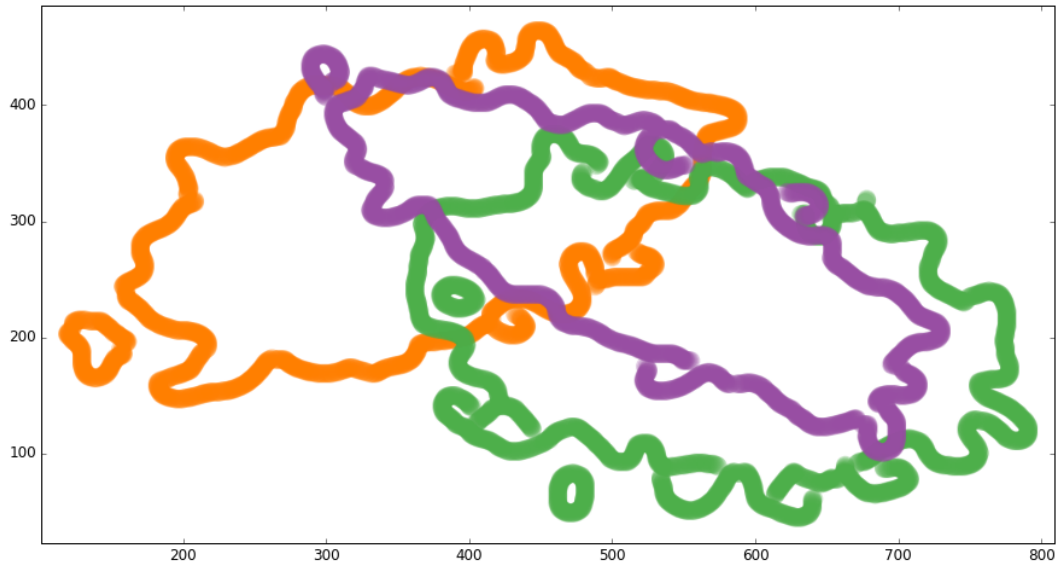


Figure 30: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 9\text{px}$

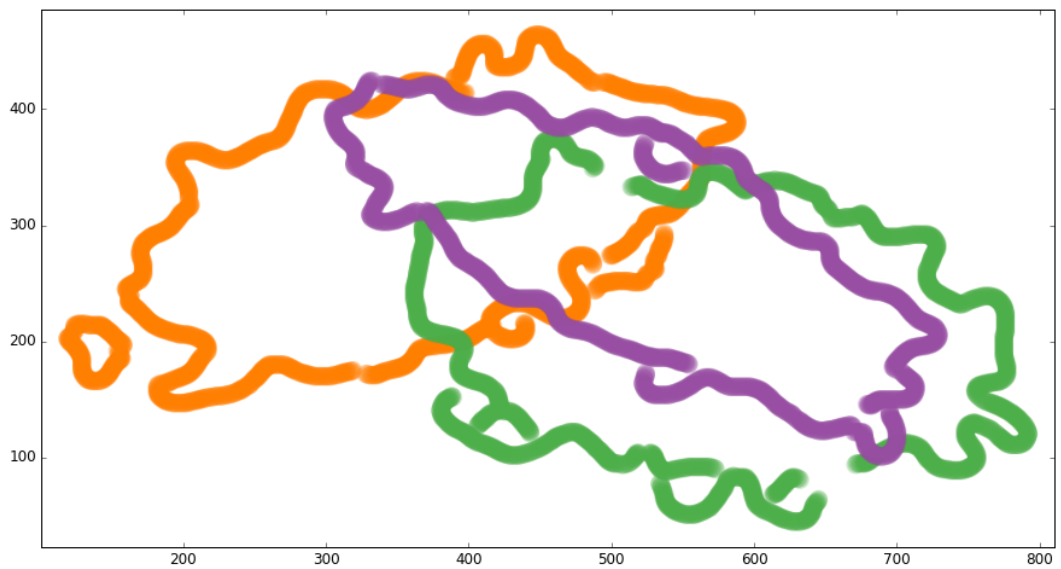


Figure 31: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 10\text{px}$

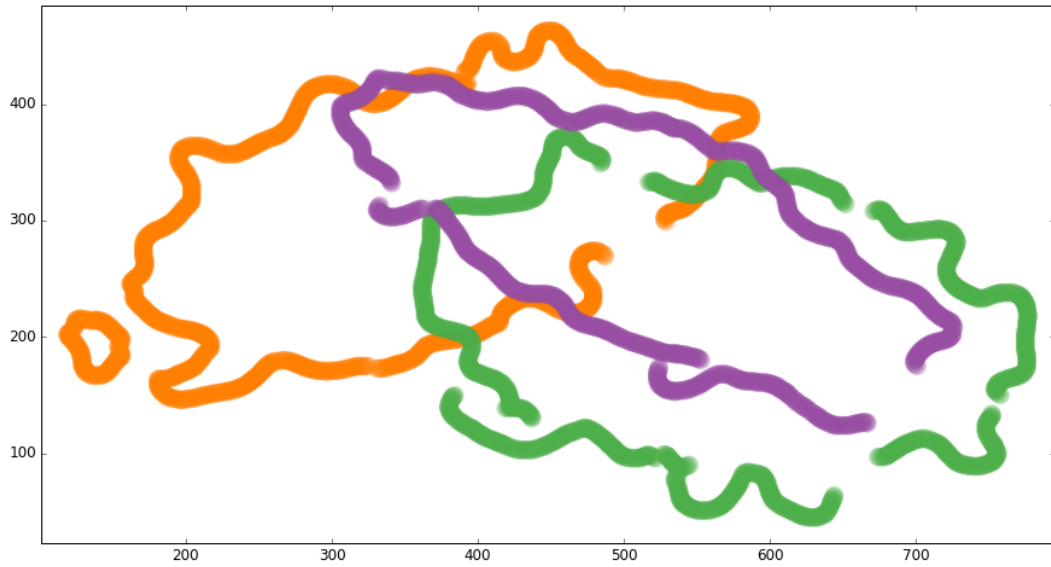


Figure 32: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 11$ px

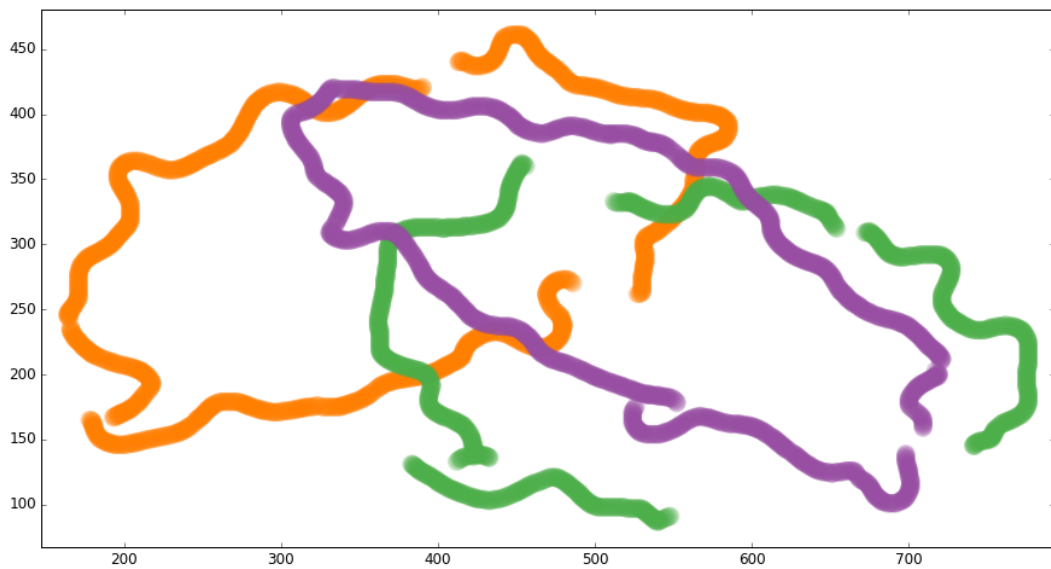


Figure 33: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 12$ px

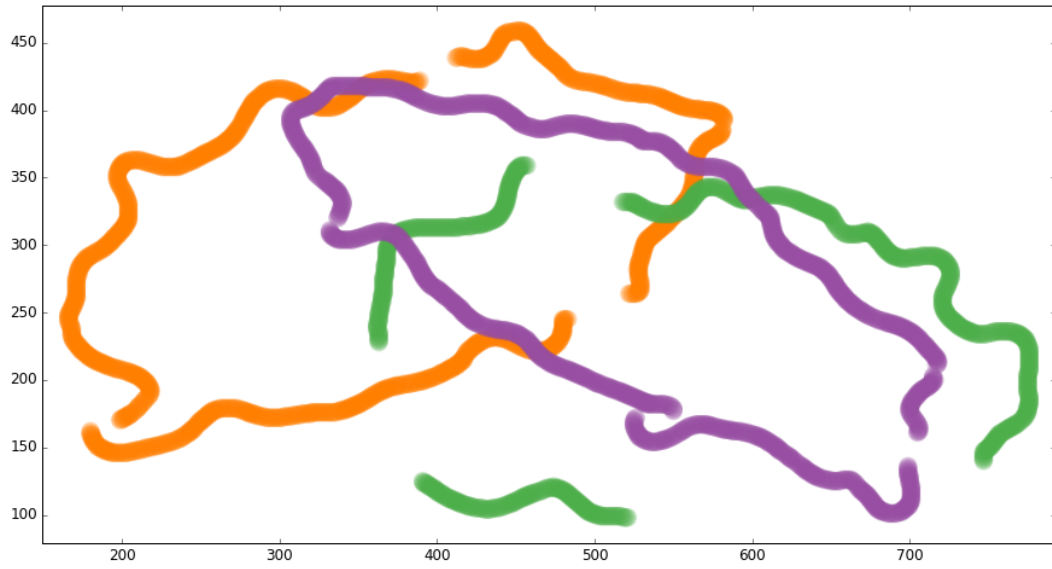


Figure 34: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 13$ px

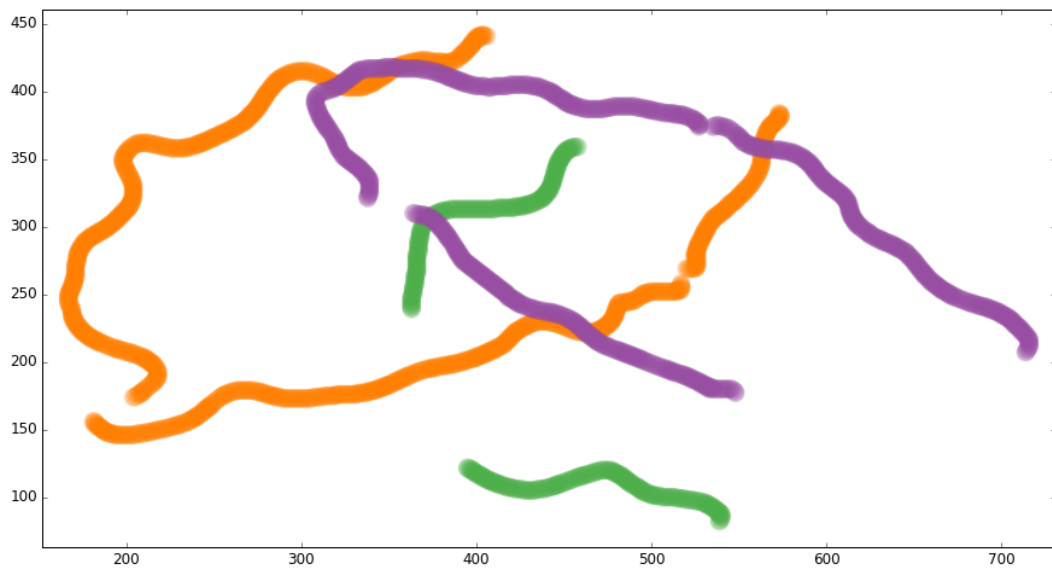


Figure 35: Edges detected for the scatterplot in Figure 17 by the Canny edge detector with $\sigma = 14$ px