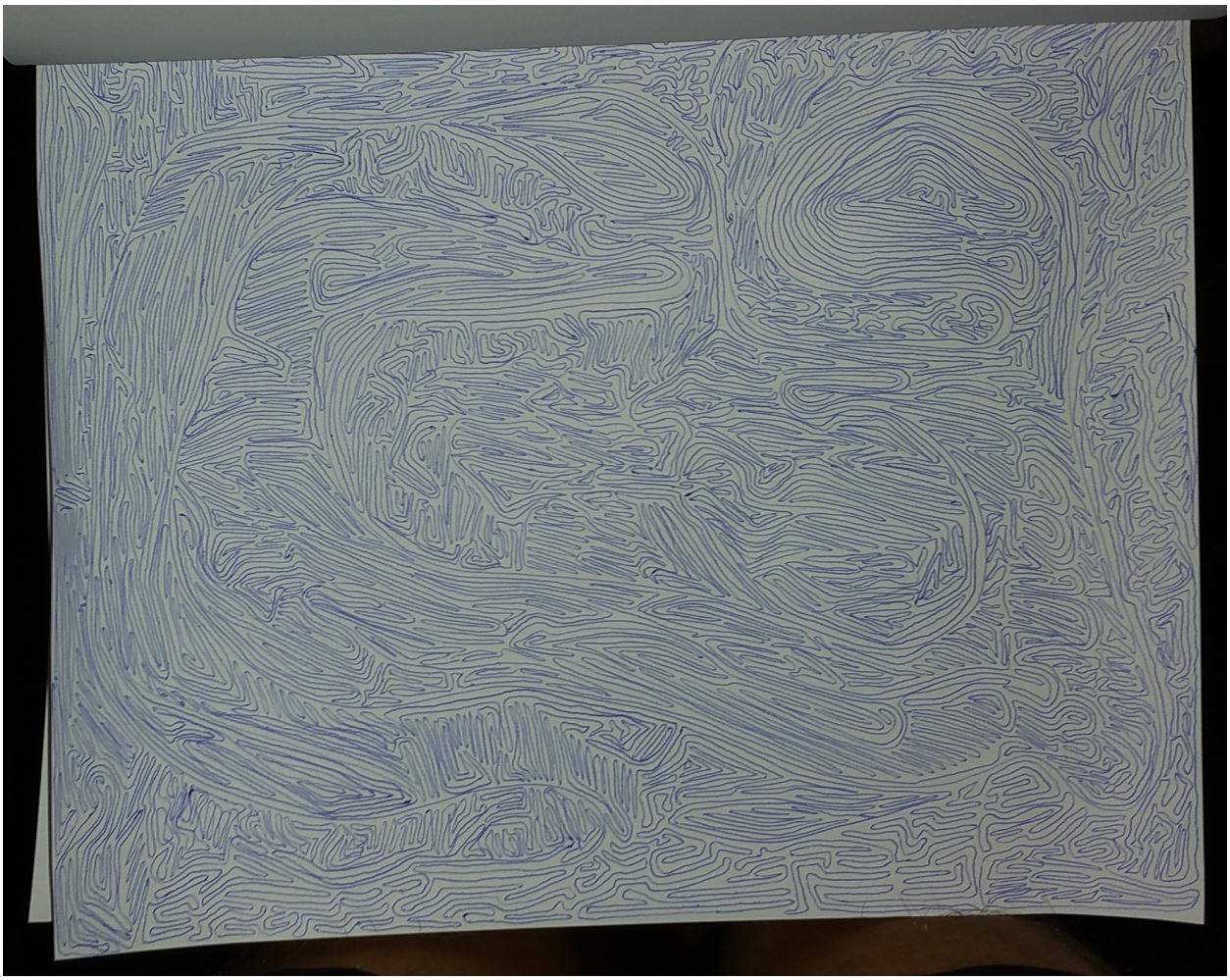
Wavy Line Search Problem
CS 221 Final Project — Final Report
Fall 2017

Mateo Garcia



Task Definition
My system generates a "wavy line." Shown above is a wavy line drawn with a pen. It covers the entire page with a single line. To approximate this, my system draws a single line through a grid of points. The task of my system is to fill as much of the grid as possible with this line. As the merit of this work is artistic, resulting outputs are evaluated by humans.

Infrastructure
I chose to use Processing in Python for my project.

Approach
As my project title suggests, I chose to model this task as a search problem. I defined the search problem as follows:

- *Start state:* 2-D array of grid locations, starting point
- *Actions:* Move forward, left, or right
- *Cost:* Based on several deterministic factors, as well as some randomness to make the path interesting (explained below)
- *Successor state:* A new 2-D array of grid locations, with the last current point updated to point to the new current point
- *End state:* True if all surrounding points have been visited

The element of experimentation in this project came with composing the cost function for the search problem. /* TODO */ This is further discussed in this paper's Error Analysis section.

At one point, per the suggestion of CA Steven Mussman, I attempted to formulate the problem as having two actions: Move clockwise or move counterclockwise around the starting point. At each step taken, with some probability the line would begin moving in the opposite direction. The idea was that this would cause the line to emanate from the starting point by wrapping back and forth around itself in a circular fashion. To encourage the line to fill the rectangular page, costs could be assigned based on how square the resulting line pattern would be after taking an action. I unfortunately did not get around to fully implementing the search problem in this way.

After several discussions with the CAs I found the most appropriate search algorithm to be depth-first search with iterative deepening (DFS-ID). My implementation composes a wavy line of segments found using DFS-ID with a fixed depth. The search runs to a depth d, selects the lowest-cost path of those with the greatest length (at most d), and then repeats, beginning at the endpoint of the selected path.

I should also mention that the size of the state for my search problem was prohibitive to the use of certain algorithms. Because the state includes the entire grid of points, my search problem does not lend itself well to, for example, uniform cost search, which would need to compare entire grids in order to check whether a state has already been explored.

The oracle for this task is a hand-drawn line that fills an entire page and achieves aesthetic beauty. The baseline is a basic line that is aesthetically interesting, but does not fill the entire page.

Literature Review
From what I could find, this is the first attempt to build such a system. There is work on maze generation, but the mazes generated are not composed of a single, non-branching line, which is what distinguishes my system's task.

Procedural generation is an umbrella term used in game development and other related spheres to randomly generate graphics that appear as if they were created by a human. I could not find any work within procedural generation that related specifically to my system's task of working with a single line.

Error Analysis
// discuss my findings w.r.t. my attempts at search optimization

- **Task definition**: What does your system do (what is its input and output)? What real-world problem does this system try to solve?Make sure that the **scope** of the project is not too narrow or broad. For example, building a system to answer any natural language question is too broad, whereas answering short factoid questions about movies is more reasonable. This is probably the most important part of the project, but is also the part that you will not get practice doing from homeworks.
  The first task you might come up with is to apply binary classification on some standard dataset. This is probably not enough. If you are thinking in terms of binary classification, you are probably thinking too narrowly about the task. For example, when recommending news articles, you might not want to make predictions for individual articles, but might benefit from choosing a diverse set of articles.
  An important part of defining the task is the **evaluation**. In other words, how will you measure success of your system? For this, you need to obtain a reasonably sized **dataset** of example input-output pairs, either from existing sources, or collecting one from scratch. A natural evaluation metric is accuracy, but it could be memory or running time. How big the dataset is depends on your task at hand.

- **Infrastructure**: In order to do something interesting, you have to set up the infrastructure. For machine learning tasks, this involves collecting data (either by scraping, using crowdsourcing, or hand labeling). For game-based tasks, this involves building the game engine/simulator. While infrastructure is necessary, try not to spend too much time on it. You can sometimes take existing datasets or modify existing simulators to save time, but if you want to solve a task you care about, this is not always an option. Note that if you download existing datasets which are already preprocessed (e.g., Kaggle), then you will be expected to do more with the project.

- **Approach**: Identify the challenges of building the system and the phenomena in the data that you're trying to capture. How should you model the task (e.g., using search, machine learning, logic, etc.)? There will be many ways to do this, but you should pick one or two and explain how the methods address the challenges as well as any pros and cons. What algorithms are appropriate for handling the models that you came up with, and what are the tradeoffs between accuracy and efficiency? Are there any implementation choices specific to your problem?Besides your primary approach(es), you should have two types of other ones, **baselines** and **oracles**. These are really important as they tell you how significant the problem you're solving is. Baselines are simple algorithms, which might include predicting the majority label, using a small set of hand-crafted rules, training a simple classifier, etc. Baselines are meant to be extremely simple, but you might be surprised at how effective they are. Oracles are algorithms that "cheat" and look at the correct answer or involve humans. If your problem has two components (identifying entities and classifying them), an oracle uses the correct answer for one of the components so that we can see how well the other can do. Baselines give lower bounds and oracles give upper bounds on your performance. If this gap is too small, then you probably don't have an interesting enough task.

- **Literature review**: Have there been other attempts to build such a system? Compare and contrast your approach with existing work, citing the relevant papers. The comparison should be more than just high-level descriptions. You should try to fit your work and other work into the same framework. Are the two approaches complementary, orthogonal, or contradictory?

- **Error analysis**: Design a few experiments to show the properties (both pros and cons) of your system. For example, if your system is supposed to deal with graphs with lots of cycles, then construct both examples with lots of cycles and ones without to test your hypothesis. Each experiment should ask a concise question, such as: *Do we need to model the interactions between the ghosts in Pac-Man?* or *How well does the system scale up to large datasets?* Analyze the data and show either graphs or tables to illustrate your point. What's the take-away message? Were there any surprises?

.