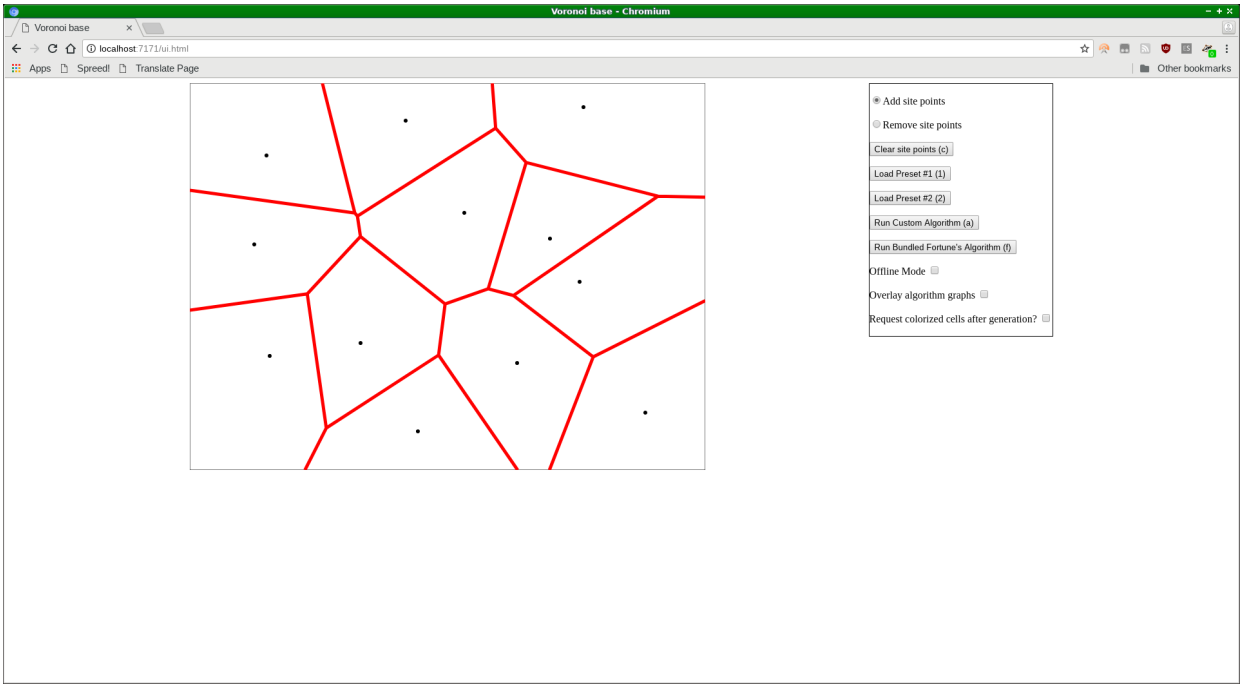
Main Problem Statement

We want you to write your own algorithm to generate a Voronoi Diagram.



Background Info

The above graphic shows a complete diagram. There are several dots in the diagram – these represent control points, or Sites. n of these are inputted arbitrarily by a user, you are guaranteed at least 2. The Voronoi "diagram" is the unique set of line segments (or pixels) that are red in the graph.

Around each Site point is a set of colored edges, or line segments, that define the Site's Cell or polygon. The formal definition of the Voronoi diagram is such that for each (x, y) point within a Cell, the corresponding Site point is the closest (by Euclidean distance) Site point. If two or more Site points are equidistant, then that represents a boundary location for the Cells and is therefore colored as part of a line in the diagram above.

Stating the same thing but more mathematically,

Site $S := (S_x, S_y)$
Sites $:= \exists\{S_i\},\ 2 \leq i \leq n$
Cell in site $:= \forall S_i \exists C_i$
Relationship of points $:= \forall (x, y) \in C_i$ and $\forall i \neq j \rightarrow distBetween((x, y), S_i) \leq distBetween((x, y), S_j)$

Framework Details

You should have received a README file with this project which covers how to setup the project. If you have not gone through that yet, please do so now, then come back to this document.

We've provided a framework in order to make your primary task as straightforward as possible but also to support supplementary tasks as needed. From the README you should have learned you can use either Java or JavaScript. If opting for Java, you should have opened and launched `Application.java` and have `http://localhost:7171/ui.html` open in a browser window. If opting for JavaScript instead, you just need to open the `ui.html` file with the browser directly (most will open it if you drag and drop).

Included is a known-correct implementation of Fortune's Algorithm, an efficient method of generating these diagrams. (We do not expect you to derive and write your own version of that algorithm; fortunately there are many ways of generating these diagrams!) It will draw the diagram in red for you to compare your own output against. You can toggle which algorithm to use from the client.

The client front-end defines a bounding box rectangle 800x600 pixels and this information is passed along to the code you will write, however the UI is resilient to drawing out of bounds. For instance, if you returned an edge from $(-400, -300)$ to $(1600, 1200)$, you will still see a visible line as if your edge was from $(0, 0)$ to $(800, 600)$.

Framework Details (Java)

The Java file `CustomAlgorithm.java` in the package `com.thejach.voronoi.custom` is the primary file you will need to edit in order to complete the problem statement. You are of course free to introduce new files (and tests) as you see fit. Open source dependencies are also allowed if you think it appropriate, but note the intent is to see what you can do directly, not just what other software you can manipulate.

You should open `CustomAlgorithm.java` now. It has a method `generate()` whose role is to populate the object's `graph` variable with new `Edge` objects. An Edge represents a line segment, with a start point (x_0, y_0) and an end point (x_1, y_1). The file contains further comments on the usage of the existing code.

Framework Details (JavaScript)

The JS file `custom_algorithm.js` is the primary file you will need to edit in order to complete the problem statement, the area to edit is at the bottom of the file.

Just like the Java version, there is a `generate` method whose role is to add edge points. This is where you will write your code, but you can add any other functions or methods you need. The file contains further comments on the usage of the existing code.

Scoring Criteria

Our intent is to keep any candidate busy for the allotted time, not to make a single pass/fail type of problem. As such **there are many ways you can make a positive impression, even if you can't complete the primary problem statement as given.** You should attempt the problem statement for maximum effect, but here are some suggestions for other things you can do instead / in addition, and you're free to try wowing us with your own ideas here.

1. Try solving a simpler subproblem first; for example what is the diagram when you only have two Site points?[1] What about only 3 points? **Make sure you include any partial or incremental work even if it doesn't end up in the final code path!**
2. The UI is robust to out-of-bounds edges, but what if it wasn't? Would your code work? Can you verify that it would work? Are there other edge cases?
3. We are a dev/QE hybrid team. The provided `FortuneAlgorithm.java` class results in a known-correct set of edges, but is it actually correct? How might you assess its quality? Feel free to provide an optional commentary text file if you have anything interesting to say about the existing code or your own code.
4. A dual graph of a Voronoi diagram is a Delaunay triangularization. Can you generate the dual? Can you output its edges so that it draws?
5. Can you color the graph Cells such that no two adjacent cells share the same color, and so you never have to use more than the minimum necessary unique colors? (See `GraphColorizer.java` or `graph_colorizer.js` for hints on where to start if you decide to try this.)
6. If you generate the graph by plotting a bunch of points, can you take your set of points and construct a minimum set of edges that pass through all of them?
7. How do other distance metrics besides Euclidean distance impact the graph?
8. Is your code straightforward to follow?
9. Do you understand the performance profile?
10. If this is child's play, you can attempt your own version of Fortune's Algorithm, just be ready to explain it to us!
11. Do you really hate Java/JS? Well, that's what we mostly do here! But you're free to write your own stuff from scratch in whatever language and stack you like (for instance an android app done in Kotlin), but it must allow us to interactively add points and generate a diagram.

[1] Some testing has shown that even this simpler subproblem can take good candidates over half an hour to make a clean and robust solution, so if you are considering this near the end, make sure you've paced yourself.

Potentially Useful Formulas

Distance formula for the distance between two points (x_0, y_0) and (x_1, y_1):

$$distance = \sqrt{(x_0 - x_1)^2 + (y_0 - y_1)^2)}$$

Midpoint formula for the midpoint between two points:

$$(x_m, y_m) = (\frac{x_0 + x_1}{2}, \frac{y_0 + y_1}{2})$$

Formula of a line:

$$y = mx + b$$

where m is the line slope, b is the y-intercept, and so given x you can calculate y.

Alternate formula of a line:

$$y = m(x - a) + b$$

where m is the line slope, and the point (a, b) is any known point on the line.

Slope between two points:

$$slope = \frac{\Delta y}{\Delta x} = \frac{y_1 - y_0}{x_1 - x_0}$$

Perpendicular slope:

$$slope_{perp} = \frac{-1}{slope}$$

If you need a refresher on how to represent and graph a line: `https://www.youtube.com/watch?v=IL3UCuXrUzE`

This is open book / internet, just be prepared to deeply explain everything you do including how you arrived at writing any particularly piece of code. Marking commented out sections / otherwise dead code can be illuminating for our end in understanding how you develop software.