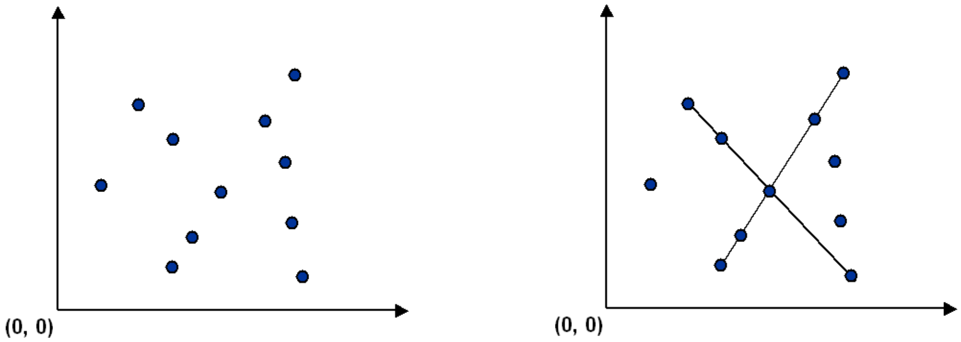
COS 226 Programming Assignment

Pattern Recognition

Write a program to recognize line patterns in a given set of points.

Computer vision involves analyzing patterns in visual images and reconstructing the real world objects that produced them. The process in often broken up into two phases: *feature detection* and *pattern recognition*. Feature detection involves selecting important features of the image; pattern recognition involves discovering patterns in the features. We will investigate a particularly clean pattern recognition problem involving points and line segments. This kind of pattern recognition arises in many other applications, for example statistical data analysis.

The problem. Given a set of *N* feature points in the plane, draw every line segment that connects 4 or more distinct points in the set.



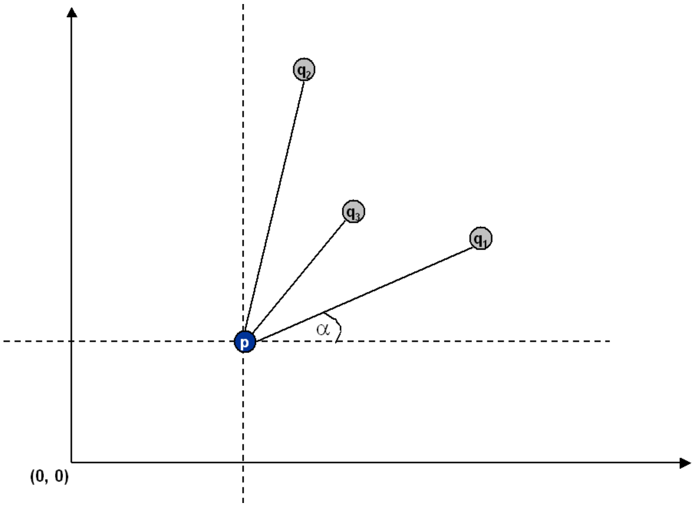
Brute force. Write a program `Brute.java` that examines 4 points at a time and checks if they all lie on the same line segment, printing out any such line segments to standard output and plotting them using `StdDraw`. To get started, you may use the data type Point.java and the client program PointPlotter.java which reads in a list of points from standard input and plots them. You will need to supply additional methods in `Point.java` in order to support the brute force client, e.g., checking whether three or four points lie on the same line.

A sorting solution. Remarkably, it is possible to solve the problem much faster than the brute force solution described above. Given a point `p`, the following method determines whether `p` participates in a set of 4 or more collinear points.

- Think of `p` as the origin.
- For each other point `q`, determine the angle it makes with `p`.
- Sort the points according to the angle each makes with `p`.

- Check if any 3 (or more) adjacent points in the sorted order have equal angles with `p`. If so, these points, together with `p`, are collinear.

Applying this method for each of the *N* points in turn yields an efficient algorithm to the problem. The algorithm solves the problem because points that make the same angle with `p` are collinear, and sorting brings such points together. The algorithm is fast because the bottleneck operation is sorting.



Write a program `Fast.java` that implements this algorithm using `Arrays.sort()` and a user-defined `Comparator` for `Point` objects.

Input format. The data file consists of an integer *N*, followed by *N* pairs of integers (*x*, *y*) between 0 and 32,767.

```
% more input6.txt       % more input8.txt
6                       8
19000  10000             10000      0
18000  10000                 0  10000
32000  10000              3000   7000
21000  10000              7000   3000
 1234   5678             20000  21000
14000  10000              3000   4000
                         14000  15000
                          6000   7000
```

Output format. Print to standard output the line segments that your program discovers in the format below (number of collinear points in the line segment, followed by the points).

```
% java Brute < input8.txt
4: (10000, 0) -> (7000, 3000) -> (3000, 7000) -> (0, 10000)
4: (3000, 4000) -> (6000, 7000) -> (14000, 15000) -> (20000, 21000)

% java Fast < input6.txt
5: (14000, 10000) -> (18000, 10000) -> (19000, 10000) -> (21000, 10000) -> (32000, 10000)
```

Also, plot the points and the line segments using standard draw. Using the `Point` data type supplied, `p.draw()` draws the point `p` and `p.drawTo(q)` draws the line segment from `p` to `q`. Before drawing, scale the coordinate system so that coordinates between 0 and 32,767 fit in the graphics window.

For full credit, `Fast.java` must print and plot a *minimal representation*: that is, only print one representation of each line segment and don't print subsegments. It's ok if `Brute.java` does not produce a minimal representation.

Analysis. Estimate (using tilde notation) the running time (in seconds) of your two programs as a function of the number of points N. Provide empirical and mathematical evidence to justify your hypotheses.

Deliverables. Submit the files: `Brute.java`, `Fast.java`, `Point.java`. Also submit any other auxiliary files, if any, that your program needs (excluding our standard libraries). Finally, submit a readme.txt file and answer the questions.

This assignment was developed by Kevin Wayne.