Analysis of Render Algorithm

1) Characterize Input: The input is a vector of points that make up the graph. The algorithm also has a set of points as input, but these are simply copies of certain points in the vector. Specifically, the function grows based on the size of the points in the vector. The larger the points, the more times the basic op executes. It is not based on the number of points. I will consider n to be the maximum of the x-coords and m to be the maximum of the y-coords.

2) The Basic Op: I would consider the basic op to be <<. It appears throughout the algorithm and is the operator that is used the most.

3) Same Count?: As long as the points have the same max x-coord and max y-coord as a previous instance, then the count will be the same.

4) Summation Exp.: This is a little hard to compute. I put each piece of the graph into a stringstream object. This object is then outputted to std::cout and, if applicable, a file stream. This way, I don't have to have the same code twice or some gross check each time << appears to make sure the file is open and exists. I have written the summation a bit differently than it would actually appear for simplicity.
$\left(\sum_{1}^{m}\left(1+\sum_{1}^{n}1\right)\right)+\left(\sum_{1}^{n}\left(1+\sum_{1}^{digits(n)}1\right)\right)+5$. Kind of gross, but it should be obvious what the closed form is. The first loop does the y label and the actual graph, and it does it starting a n and doing down to 1. The second does the x labels. The 5 is some stuff like actually outputting it or drawing the first line of the graph (an extra line to look nice and match your output).

5) Closed Form: A closed form for this mess would be $m + mn + n + n \cdot (floor(log_{10}n) + 1) + 5$. I find the digits by a different method, but this is the best way to represent it in a summation. For simplicity, let's assume this is a square graph, or that the max x-coord and y-coord are the same, or that $n = m$. That gives the easier to look at $n^2 + n \cdot (floor(log_{10}n) + 1) + 2n + 5$. Still a little gross, but clearly it is in the field of n^2.

6) Growth Function: $m + mn + n + n \cdot (floor(log_{10}n) + 1) + 5 \in O(n^2)$, or quadratic