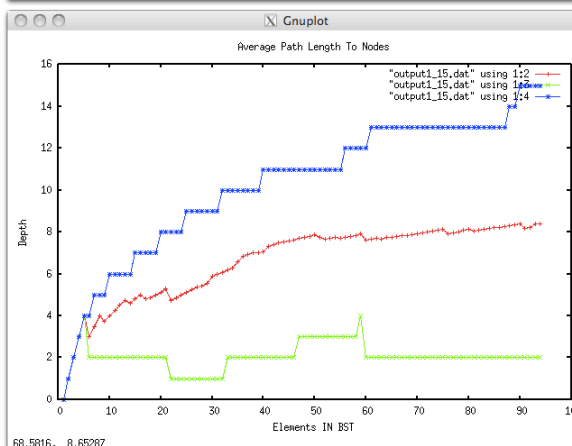
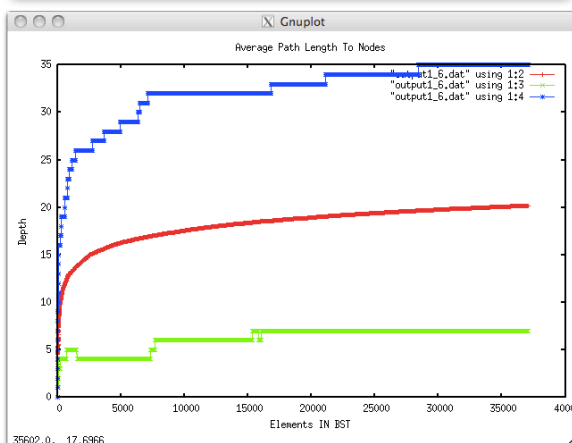
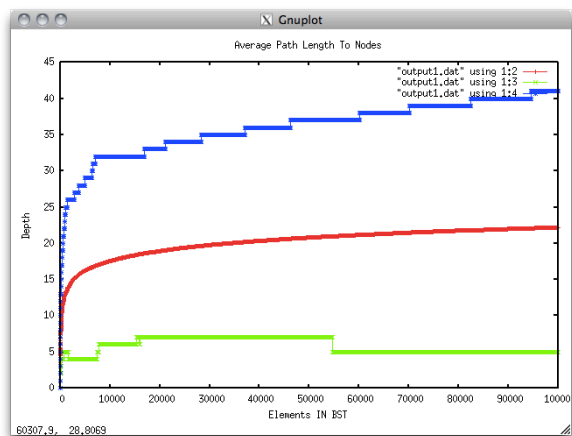


## CS241 Final Homework Assignment

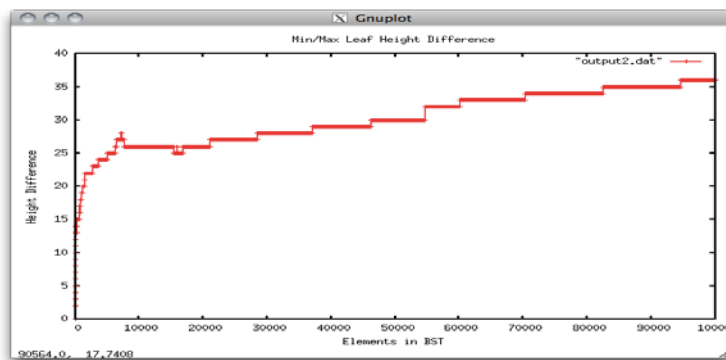
I conducted experiments measuring the asymptotic balance of a binary search tree by testing the average length to all leaf nodes in to minimum and maximum leaf nodes. In the graphs below, the Blue line indicates the depth of the deepest leaf. The green line depicts the depth of the leaf nearest to the root. The red line depicts the average depth of every leaf node in the tree.



The average depth of every leaf node clearly shows asymptotic behavior. If we consider the height of the tree, that is the distance between the root and the deepest leaf, we can see that the average depth of every leaf is approximately half the height of the tree. This trend starts very early on and continues throughout the rounds of insertions.

As elements are inserted into the binary search tree, we can see that it maintains a huge variance between the nearest and farthest (min and max) leaf nodes in the tree. This gap increases significantly in the beginning, and less quickly with successive insertions. I would expect this trend to continue with time. Let it be known that as the tree fills out, I would have not expected to see the minimum leaf stay fixed as depicted in my results. I suspect the minimum leaf would not be fixed over insertions beyond 100,000 elements.

I believe my findings are reasonable, because we know that as the depth of the binary tree increases, the tree gains an exponential number of free nodes. This is shown by the asymptotic behavior of the average depth of every leaf in my graphs. As we gain an exponential amount of space, we also gain an exponential amount of future operations before it's necessary to expand again.



Ideal results, however, would show a tighter coupling between the minimum and maximum leaf nodes. My results portray a tree that is much larger than is necessary for it's working data set.

The variance between leaf extrema in a binary search tree creates the foundation for improvement upon which AVL trees and other tree data structures. I am sure they attempt to reduce the height difference between the deep and shallow leaves to best tighten up the tree. These improvements would result in a fuller tree that would be able to hold the same amount of data in less space and, consequently, improve run-time operations that interact with the tree.