CSCI570 Final Project Summary

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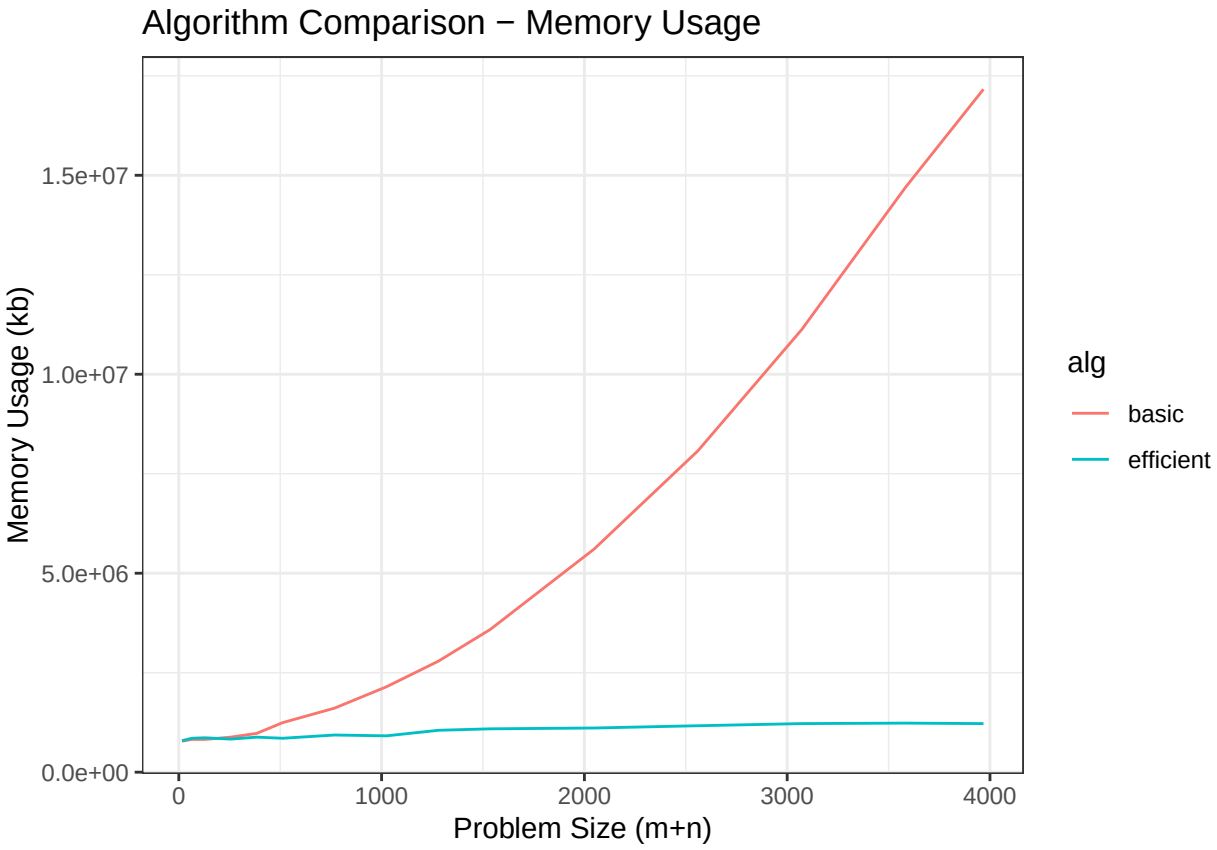
Datapoints:

Problem Size (m+n)	CPU Time (ms) - Basic	Memory Usage (kb) - Basic	CPU Time (ms) - Efficient	Memory Usage (kb) - Efficient
16	1.523	778240	1.280	790528
64	1.266	823296	1.125	851968
128	1.688	823296	1.793	864256
256	2.906	880640	3.738	831488
384	4.084	974848	9.673	880640
512	6.829	1245180	13.024	851968
768	11.754	1609730	28.129	933888
1024	17.981	2146300	45.377	913408
1280	28.244	2789380	69.414	1052670
1536	40.523	3588100	96.606	1089540
2048	69.781	5607420	179.091	1110020
2560	106.092	8077310	273.913	1167360
3072	154.958	11124700	374.422	1220610
3584	205.714	14700500	528.854	1232900
3968	271.369	17162200	680.967	1220610

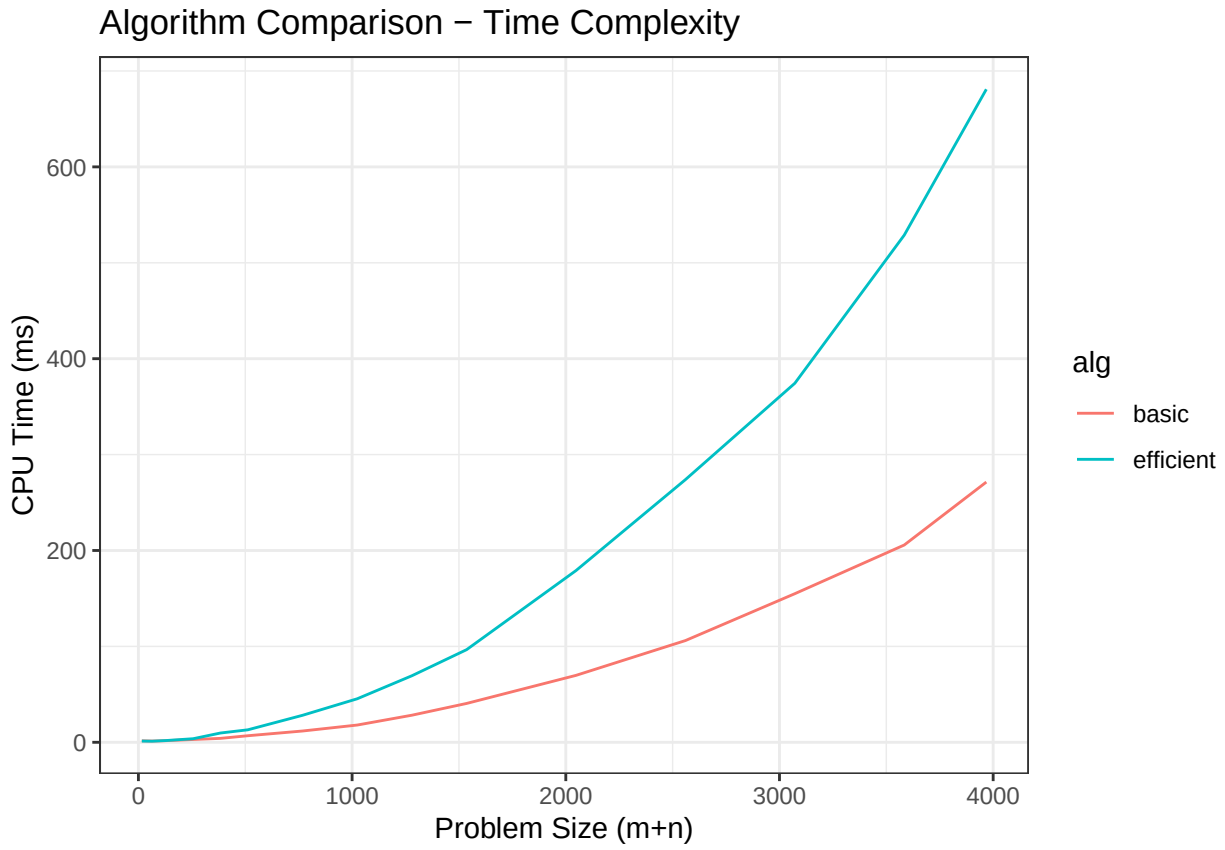
Before addressing the data, it is important to first acknowledge the expectations of the resuluts. The "basic alignment" algorithm, utilizing a purely dynamic programming solution, should have quadratic growth for both time and memory complexity. The "efficient soltuion", utilizing a combination of divide-and-conquer and dynamic programming, should have a quadratic growth for tiem complexity, but linear growth for memory complexity. Despite having comparable growth rates, the time complexity of the efficient soltuion should grow faster than the basic solution by a factor of 2, which we determined in lecture by diriving the Big-O time complexities of the basic and efficient solutions to be O(mn) and O(2mn) respectively. Determining the rate of growth from a data table is not ideal, especially since the problem size does not increase by a constant factor. However looking at specific datapoints (i.e. problem sizes 64, 128, 256, 512, and 1024) can allow us to roughly evaluate some of the changes. The time complexities both appear to follow the exponential growth with the problem size, but only the memory usage of the basic algorithm seem to follow this pattern. It is very clear that the memory usage of the efficient algorithm grows at a rate much slower than the basic alignment. Also, the CPU time of the efficient algorithm seems to be roughly 2x that of the basic alignment. This onlys strays slightly at lower problem sizes where the efficient alignment is actually faster than the basic alignment (this is consistent with the definition of asymptotic runtime analysis).

Discussion: Memory Complexity



Though not clear from the data, the graph of memory usage against problem size clearly shows the difference in growth rates between the basic and efficient algorithms. The basic alignment follows strongly quadratic growth, while the efficient algorithm follows linear growth. This is because the bulk of the memory usage comes from the dynamic programming solutions. The basic algorithm must use the full m*n matrix to backtrace the proper alignment, and as a result must use at least m*n memory. The efficient solution does not, only ever using two columns of the m*n matrix at a time, leaving us with linear (O(m) or O(n)) memory usage. However, it is worth noting that the efficient algorithm appears slightly more variable in memory useage. These inconsistencies are likely a result of the divide-and-conquer recursive calls. When we split strings X and Y into two substrings during the division step of the D&C, we are not guaranteed to get equal size subproblems. Depending on the input itself, these division may be more or less efficient at breaking down the problem size, and less efficient divisions will lead to more recursive calls and therefore a greater memory overhead. Again, despite being more variable, the memory usage of the efficient algorithm grows much slower (linear vs. quadratic) than the basic algorithm.

Discussion: Time Complexity



Unlike the memory complexity, both the basic and efficient solutions run in (quadratic) polynomial time, neither algorithm operates in linear time. The most important note to make is that the growth rate of the basic algorithm is lower than that of the efficient algorithm. At larger problem sizes, the basic algorithm is able to run much faster. Looking at the individual datapoints, we can see that the efficient solution was more than slightly more than 2x slower than the basic solution at large problem sizes. This is very close to what we would expect, and I believe that the reason it appears more than twice as slow is because of the additional time it takes to generate and run through the recursive calls. Had I taken the (lots of) extra time to implement a purely iterative solution for the efficient alignment the growth rate would more closely match 2x than of the basic solution.

Contributions

This was an individual project, completed entirely by Alex Hill (Duval Hill on DEN) (USCID#7074816555)