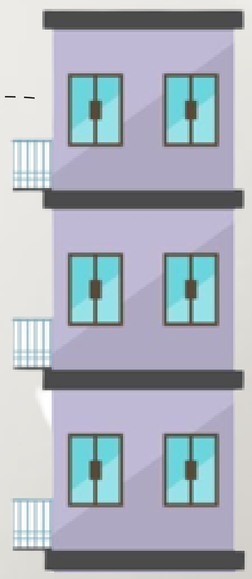
Egg Dropping Problem



CS 412 -
Algorithms & Analysis
Team Average-Problem

1 PROBLEM STATEMENT

Suppose we have a certain number of eggs and some floors in a building. The physical properties of an ideal egg is such that it will break if it is dropped from floor F or above, and will have no damage if it is dropped from floor F-1 or below. Given that an unbroken egg can be dropped from any of the floors, what is the minimum number of egg drops D needed in order to find the threshold floor F in the worst case?

2 DESIGN TECHNIQUES

- Recursion
- Dynamic Programming
- Binomial Coefficients And Binary Search

3 THEORETICAL TIME COMPLEXITIES

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Floors = k
Eggs   = n
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SLOWEST TO FASTEST

Recursive	$O(2^k)$
Dynamic	$O(nk^2)$
Binary Search & Binomial Coefficient	O(nlogk)

The recursive solution is a straightforward approach and can be implemented with ease. But it is also the slowest, taking exponential time due to the same sub-problems being solved again and again.

The Dynamic Programming Approach is similar to the recursive one, but it's much faster with polynomial complexity. It does so by avoiding recalculation of the same subproblems by storing them in a table for future reference. It may be used to solve the problem for medium or small values of k and n.

However, using binomial coefficients with binary search is the fastest as can be observed in the table, the complexity becomes O(nlogk), so this approach performs really well, even with large values of k and n.

4 EMPIRICAL FINDINGS

In Figure 1, for small values of eggs and floors, all the algorithms are almost at par with each other. But as the function was called with increased floors, the time of recursion spiked up, with the dynamic approach taking much less time and the binomial approach the least. These agree with the trend observed in theoretical time complexities.

In base cases, for example, when floors = 1 in Figure 2, recursion performs the best. This is because the base cases are checked at the start of the algorithm in the recursion approach. While the binomial and dynamic show their usual trend.

With much larger values of eggs and floors, the difference between time complexities of dynamic and binomial is clearly visible in Figures 3 & 4. The binomial graph shows execution time close to zero, while the execution time for the dynamic approach continues to increase as the input size becomes larger.

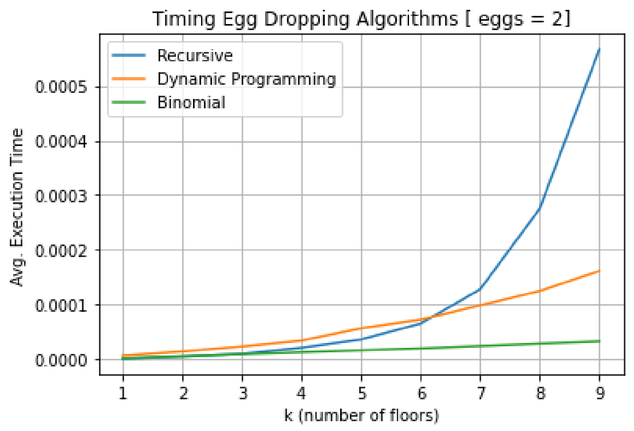

Figure 1 : Constant Eggs = 2, Floors increased

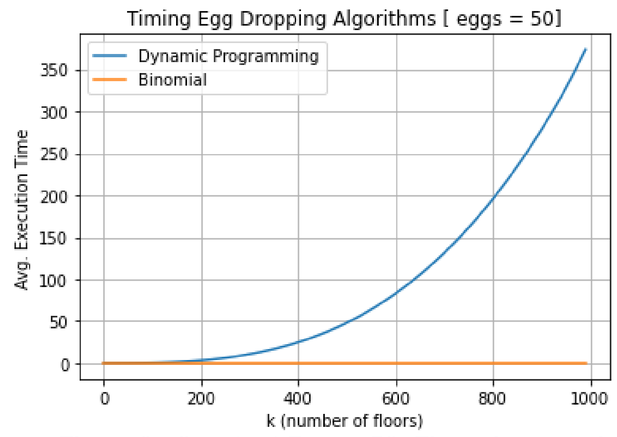

Figure 3 : Constant Eggs = 50, Floors increased

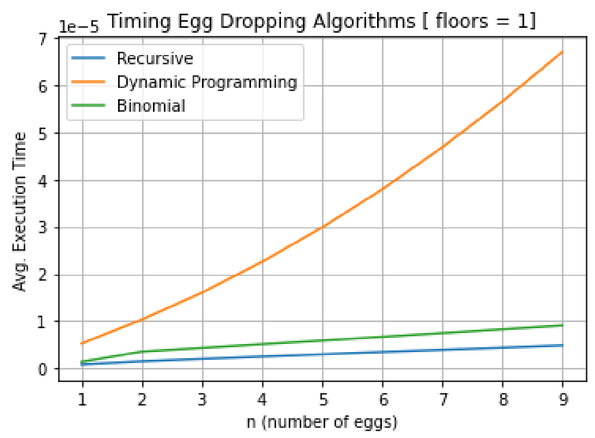

Figure 2 : Constant Floors = 1, Eggs increased

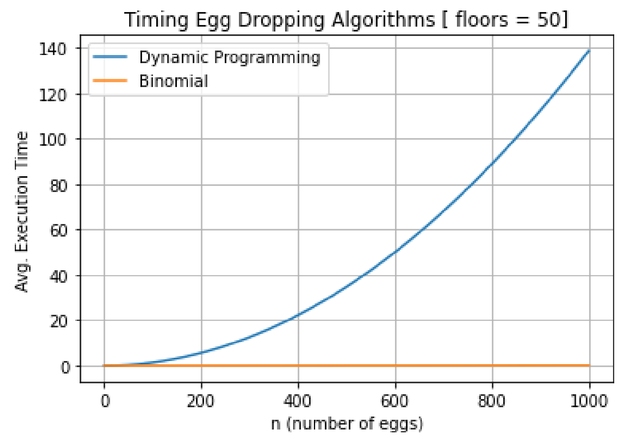

Figure 4 : Constant Floors = 1000, Eggs increased

REFERENCES

[1] Egg Dropping. Brillieant.org.
[2] Ew-Nutrition, 2020.How producers keep the egg supply chain going amid COVID-19.