Assignment 2: Survival of the Fittest

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***Abstract*—Given three sets of people - Pike men, Archers and Knights, it is required to determine the group that survives,assuming that the probability of any two people running into each other is equal. No two people from the same group can kill each other. Archers kill Pikemen, who kill Knights. Knights kill Archers.**

***Index Terms*—Probability**

I. Introduction

The problem of determining the probability given a set of conditions can be approached in three ways.

The first two methods - Las Vegas and Monte Carlo simulation can be used to approximate the probability by repeatedly simulating the event and calculating the probability.

The simulation stops when the values converge. This method does not necessarily guarantee that the result obtained is accurate. This paper explores using dynamic programming as an approach to solve the problem.

II. Approach

A. Recurrence Relation

The first step is to determine the probability of one of the groups surviving the battle. Let us start with archers. In this section, I will arrive at the recurrence relation that describes the probability of archers surviving given "a" number of archers, "p" number of pike men and "k" number of knights.

$$den = ((a * p) + (p * k) + (k * a)) \tag{1}$$

$$ap = (a * p)/den \tag{2}$$

$$ak = (a * k)/den \tag{3}$$

$$pk = (p * k)/den \tag{4}$$

$$P(a) = ap * P(p-1) + ak * P(a-1) + pk * P(k-1) \tag{5}$$

By symmetry, P(p) and P(k) can be calculated in a similar manner.

B. Dynamic Programming

The main issue with naive approach to solve the problem is redundant recursions that calculate the same terms over and over again. The cost of repeated recursions is unacceptable as the program takes too long for small values.

To resolve this issue, memoization has been utilized.

III. Memoization

The problem recursively calculates the probability of a group of n members surviving by calculating the probability of n-1 members of the said groups.

Rather than calling the recursion, we assume that the probability of a group of n-1 members is constant and therefore use the pre- calculated values, which are stored in a memoize table, reducing the number of recursions and significantly improving the time taken for large values of a, p and k.

The memoize table is a four dimensional array where the first three subscripts refer to a, p and k values at the current iteration and the fourth subscript refers to the probability index of a, p and k.

if the table contains non-negative values for a, p and k, these values are returned, otherwise, the table is populated by explicitly calculating the probabilities.

The base condition is when one or more of the groups contains zero members, in which case, the probability of the other group surviving is 1.

If there are equal number of members in each group, the probability of any othem surviving is 0.3333

IV. Conclusion

Dynamic Programming with memoize tables is used to determine the probability of occurrence of events both accurately and in a reasonable amount of time for large values of input.