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Genetic Algorithm Experiment Report: Mutation Rates

**Introduction and Objective**

In Muric’s example of a genetic algorithm for pathfinding to a goal[1], the mutation rate is set at 20 percent. In this experiment, the mutation rate will be varied to see if higher rates lead to a lower average number of generations before the goal is reached.

**Solution Description**

The boundary lines of the playing field were set to the same as in Muric’s example[1]. The boundaries were defined as being 32 units wide and 18 units tall. The starting location and goal location were both fixed 20 units apart. The initial population consisted of 50 chromosomes “snakes” that contained a list of 25 randomly generated alpha pairs (x, y). The alpha pair values were generated such that and . These alpha values are then used to calculate the path of the line that the chromosomes take. For example, given the starting point , would be calculated as . After generation of the initial population, the algorithm will run until either the stopping condition is met, or 1000 generations have passed. The algorithm is defined by the following steps.

1. **Evaluation:**

All segments of the path each chromosome took are checked such that if the ith segment crossed outside of the playing field, an evaluation of i+38 is assigned. If the ith segment did not leave the playing field and it came within 0.5 units of the goal, an evaluation of i is assigned. If neither of the previous conditions occur, an evaluation of is assigned.

1. **Survivor Selection:**

Survivors are selected based on the chromosomes’ selection probability. Selection probabilities are calculated using the evaluation values by . The survival rate was fixed at 4%. With a population of 50, that means 2 survivors. Selection is based off of a randomly generated threshold between 0 and 1. Chromosomes are ranked, with higher selection probabilities being prioritized during survivor selection. Each chromosome is checked and if the threshold is lower than the chromosome’s selection probability, it is added to the survivors. If no chromosomes are added during this process, the two chromosomes with the best selection probabilities are immediately placed in the next generation.

1. **Crossover Selection:**

Using the selection probability again, chromosomes are processed in order starting at the highest probability and are selected based on a random threshold that the selection probability must meet. If after the process is done there are not 48 chromosomes in the crossover list, the process is repeated.

1. **Crossover**

Crossover is accomplished by pairing chromosomes from the crossover list. A random value between 2 and 23 is selected as the split point for each pair of chromosomes as the point where the alphas will be split and crossed.

1. **Mutation**

The mutation rate is varied. However, if the mutation rate were at 10%, there would be a 10% chance that each individual regenerates a random one of its alpha values. All chromosomes have an equal chance at mutating.

1. **New Population**

At this point the old population “dies” and the new population becomes the current population.

The code was developed in Python 3.7.x

**Hypothesis**

The higher the mutation rate, the lower number of generations it will take to reach the goal, up to a certain threshold. Null hypothesis: the mutation rate will not affect the number of generations that it takes to reach the goal.

**Experiment Design**

The mutation rate was varied from 0% up to 100%. All other hyperparameters were kept static. For every 1 percent up to 25, 100 independent trials were run. For every 5th percent past 25, 100 independent trials were run. The length of each trial was determined by the stopping condition of coming within 0.5 units of the goal.

**Results and Conclusions**

The average number of generations for each mutation rate can be found in the attached data file. A summary and graph of the data can be found here. Just as the hypothesis made suggested, the higher likelihood of a mutation occurring, the less generations it takes in order to reach the goal. Once the mutation rate reaches a certain threshold, however, it no longer benefits the chromosomes and improves their pathfinding abilities very little, if at all. This is likely due to the fact that during the survivor selection and crossover phases, the best chromosomes are picked first. Since mutation only modifies a single random alpha value, it allows for slight modifications to chromosomes that are nearest to reaching the goal. Ones that are improved during mutation are then going to be ranked higher during selection and are more likely to get picked as survivors and/or parents. Since there are progressively more and more chromosomes that are getting closer to the goal, mutation rates will only go so far because the probability of, say, 30/50 chromosomes close to the goal having one get mutated and reaching the goal is higher than only 5/50 near the goal. This theory is quantified by the mostly leveling out of the generations required beyond a 15% mutation rate.

**References**

[1]G. Muric, “Genetic Algorithm Example,” youtube.com, Feb. 25, 2017. [Online]. Available: https://www.youtube.com/watch?v=XcinBPhgT7M. [Accessed Oct. 4, 2019].