Evolutionary Algorithms

CS 356N Analysis and Design of Algorithms Third Programming Assignment

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Description

This assignment is related to the Darwinian evolutionary theory. It aims at exploring random mutation using a situation concerning ants and eating food for fitness. Randomly generated Finite State Machines (FSMs) are used to simulate the moves of the ant which are randomly cloned or mutated according to the principle of "Survival of the fittest" in an attempt to generate a population of intelligent ants after a given number of iterations.

Implementation

The simulation of the random iterations depends on five parameters :

1. Maximum number of states allowed.
2. Number of iterations
3. Maximum moves allowed for ant on grid
4. Population of ants
5. Mutation Probability

The code is implemented in C++. A class is written to represent the ant. It contains functions to

1. Initialise the ant with the minimum number of states configured randomly.
2. Change output , Change transition , add/delete states, change initial states.
3. Mutate/Clone a generation of ants to the next generation using the mutation probability. If number of states are already equal to maximum number of states , then no new states are added.
   Similarly of only 1 state is there , then no states are deleted.
4. Move the ant over the grid using its FSM and report the fitness after one series of steps.

An array is declared which stores ants according to the population by instantiating the class ant. Then the array is initialised to generate the ants with randomly configured minimum state FSMs. Then all the ants are moved one by one and the fittest ant is stored. Then the next generation is generated using the mutate() function in the ant class and one of the ants is made the fittest ant in the previous generation to ensure "survival of the fittest".
This process is repeated required number of times and then the fittest ant in the last generation is reported.

Results

Various trials were conducted with the program to experiment with the various parameters and see the effect on the intelligence of the ants.

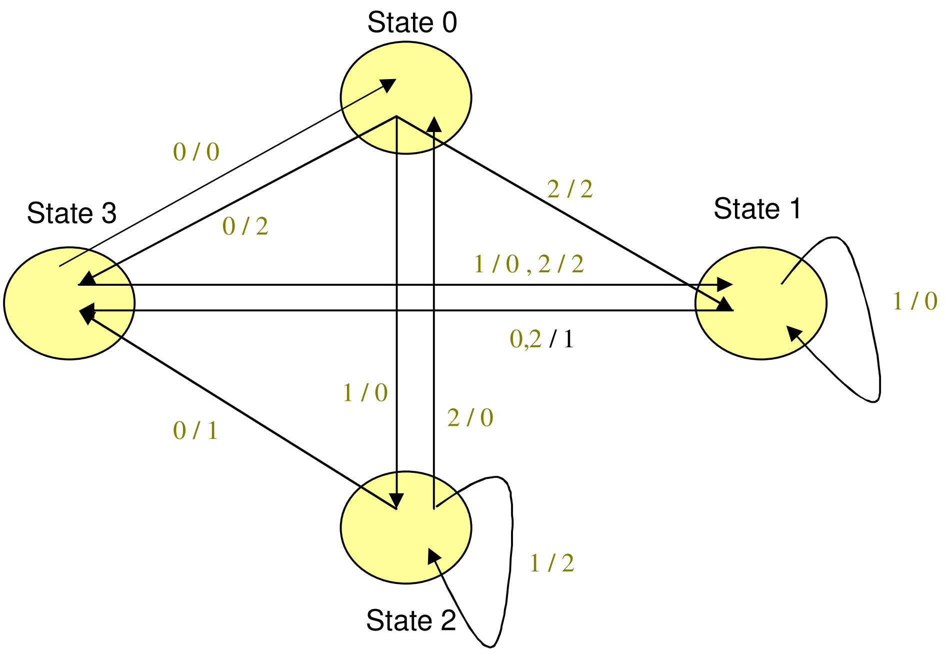
Trial 1

The program was run with the following parameters :
Population : 50
Maximum number of iterations : 100
Maximum number of states : 10
Mutation Probability : 0.5
Maximum number of moves : 100

After conducting the trial , the fittest ant had a fitness level of 31.

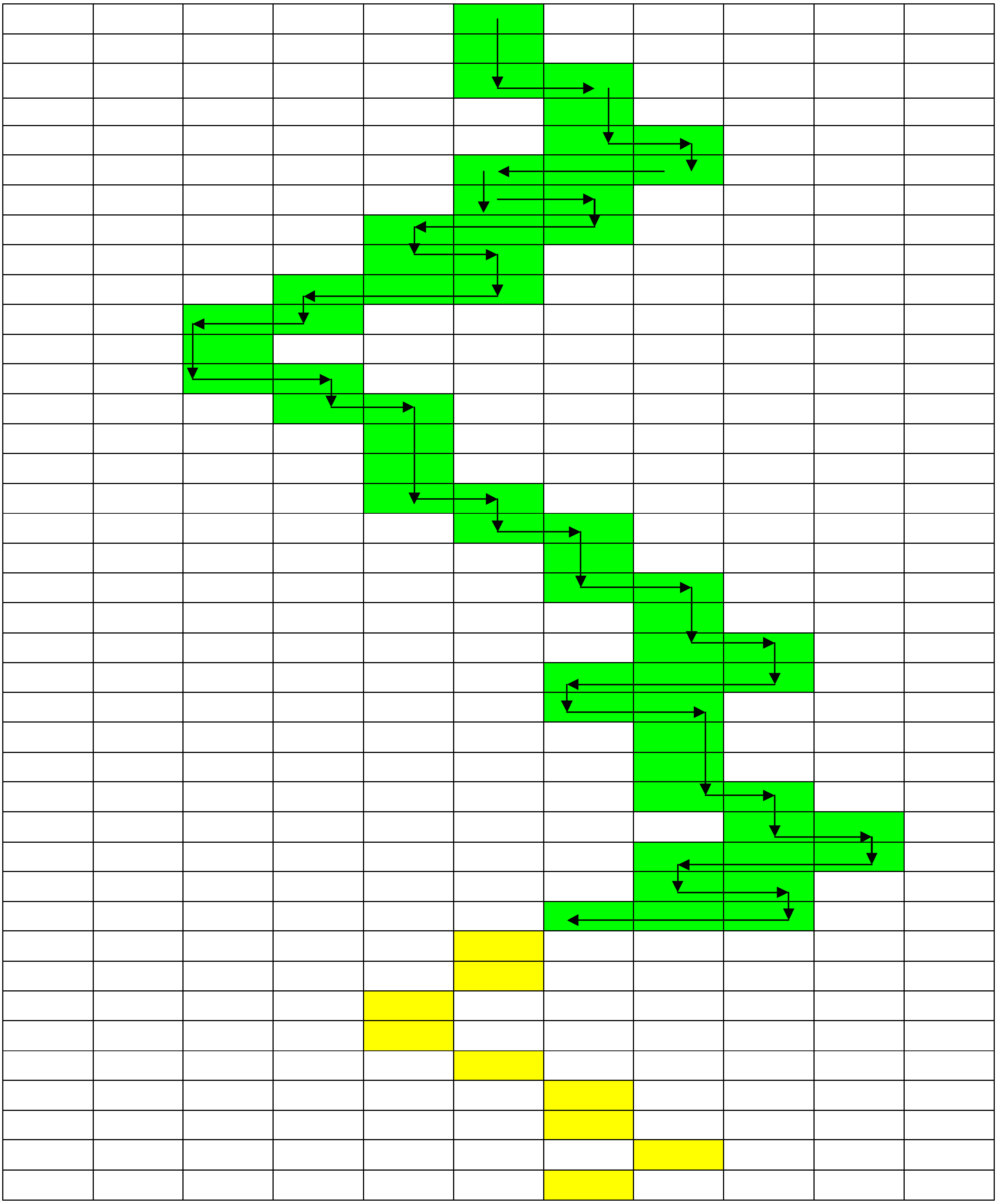
Its Finite State Machine has 4 states.

FINITE STATE MACHINE



Moves of the fittest ant

The following grid shows the moves of the grid of the aforementioned ant.



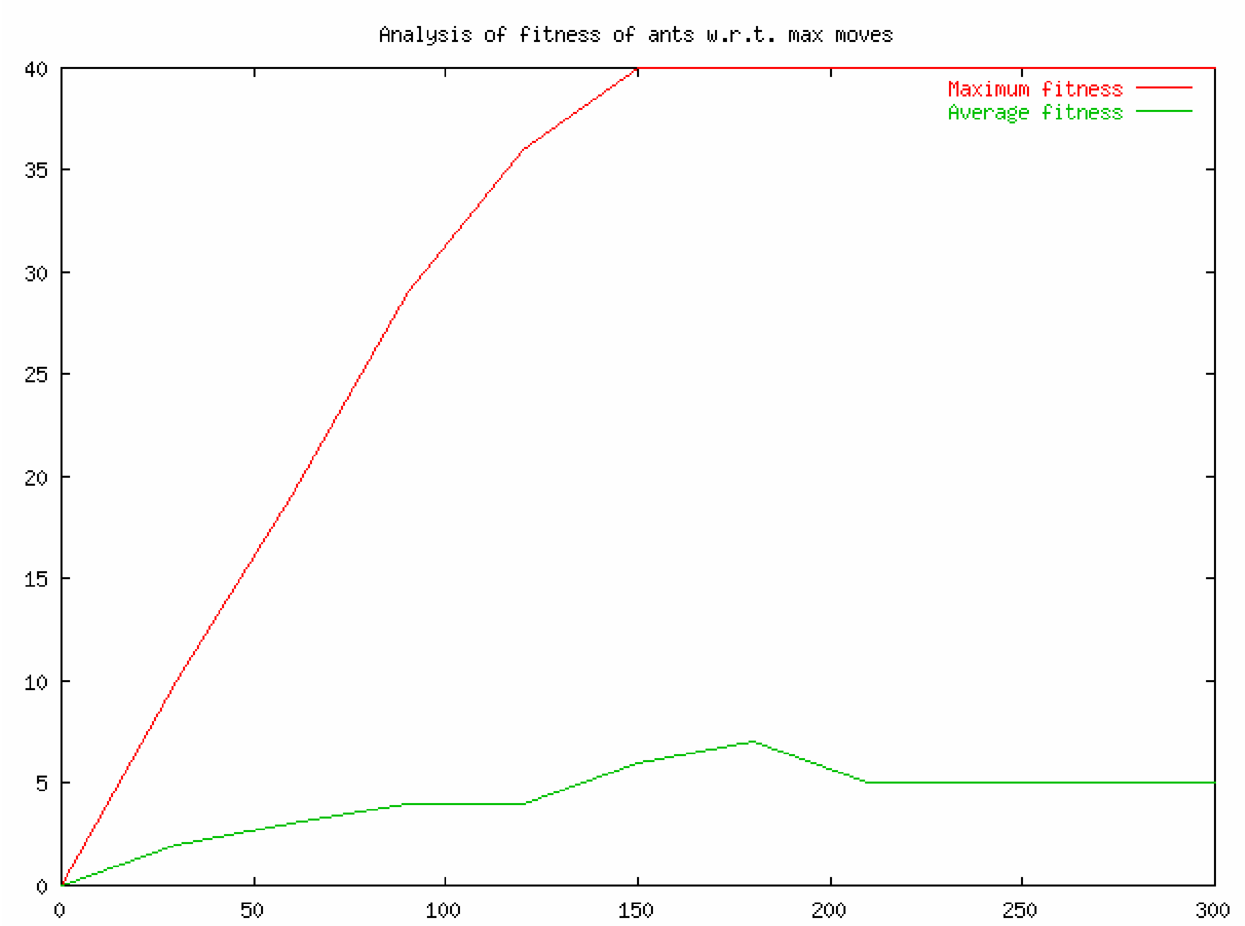
Fitness = 31

Other Results

Effect of number of moves on the fitness of ants

The number of moves drastically allows the maximum fitness of ants. It basically determines how many steps an ant can take before dying. Obviously , more moves it can make , greater is the probability that its fitness is more.

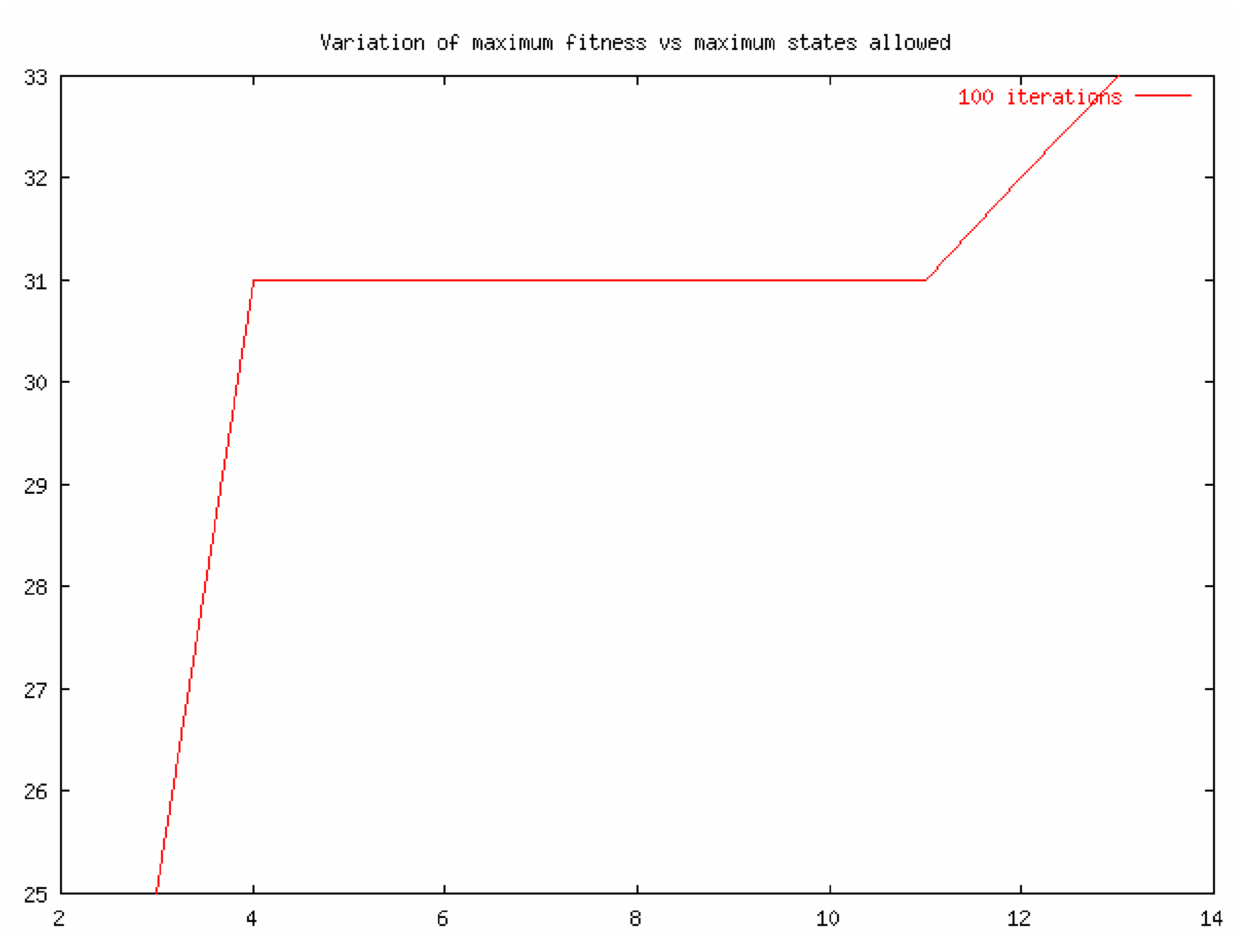
The following graph shows that the fitness of the fittest ant rises sharply as the maximum number of moves allowed to the ant are increased. It reaches the maximum of 40 around at 150 moves.
However , it is interesting to note that the average fitness of the ants doesn't increase with the number of maximum moves and remains constant around 5 which is quite far from the highest which is 40.



Effect of the maximum number of states allowed on fitness

The number of maximum states basically determines the size of the FSM which an ant can posses. Obviously , if more states are allowed , the ant can make a much greater variety of moves and hence its fitness should be more.

The following graph shows that the fitness of the fittest ant increases as the maximum number of states are increased. This seems to be obvious as the number of states are increased , the FSM of ants can become more complex and allow for more complex and intelligent movement patterns across the grid.

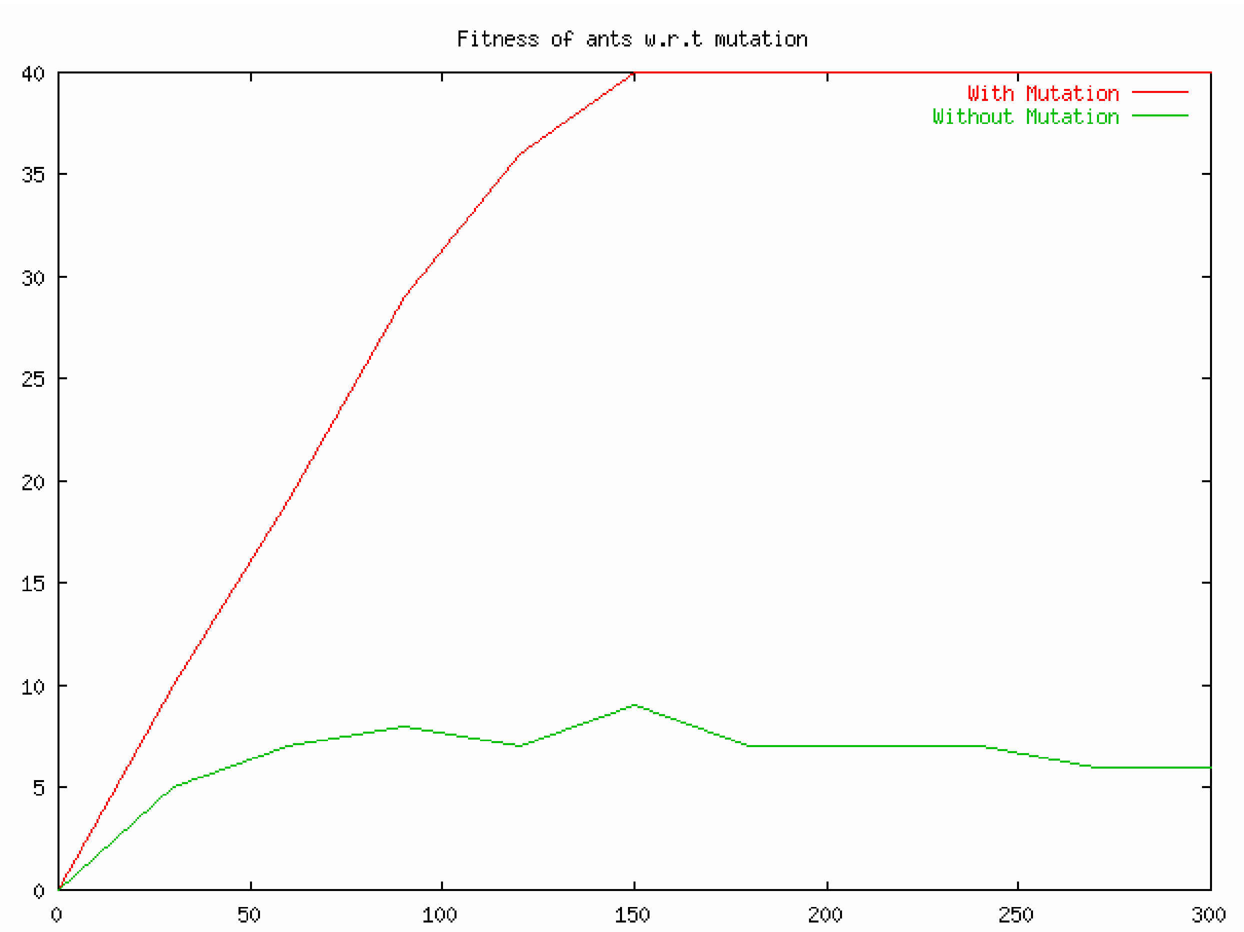


Effect of “Survival of the fittest” principle on the fitness of ants

The “survival of the fittest” principle is an important part of the Darwinian theory of evolution. This trial investigates , how this principle affects the maximum fitness among the ants

The following graph clearly shows that the principle of “survival of the fittest” is necessary to get a fit ant at the end of the simulation. Without “survival of the fittest” , the fitness of the best ant doesn’t increase much and is almost constant. However with “survival of the fittest” , the fitness rises sharply with increasing number of moves allowed.

Theoretically also , the maximum fitness should increase if the fittest member of the previous generation is preserved in the current generation. However the difference in results is remarkable , hence this principle seems to be crucial for the increasing fitness of the fittest ant.

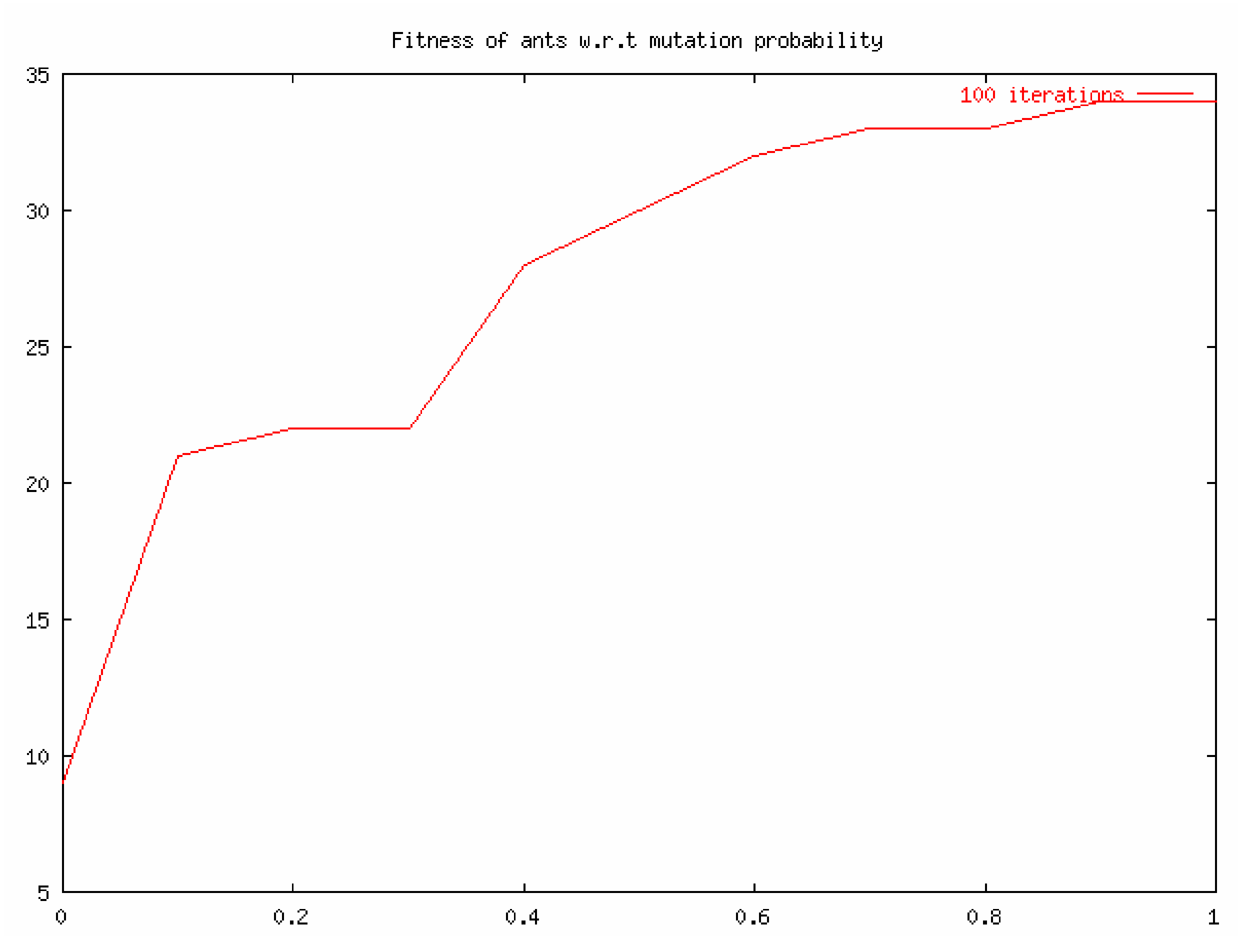


Effect of mutation probability on the fitness of ants

The mutation probability determines , how many members of the previous generation will be randomly mutated to the current generation and the rest will be cloned.

The following graph shows that the fitness of the fittest ant is directly related to the mutation probability. Higher is the probability , higher is the fitness of the fittest ant.
Hence cloning doesn't seem to be as effective as random mutation. As mutation probability increases from 0 to 1 in the graph , the maximum fitness increases sharply.

Intuitively, the result seems to be correct as mutation allows the ants to wander in new directions in search of more intelligent ants while cloning preservers the "dumbness" of the ants.

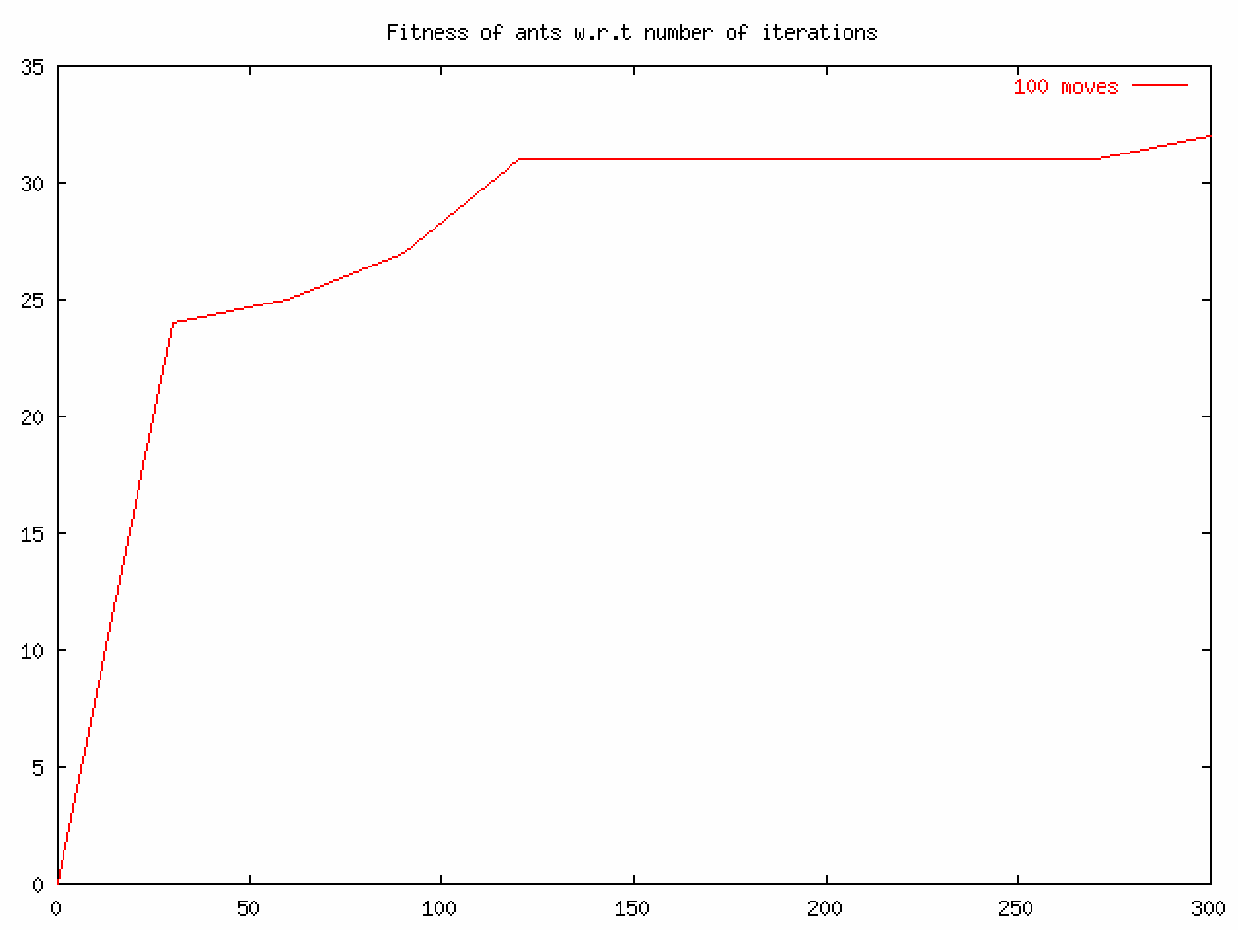


Effect on fitness with number of iterations

The maximum number of iterations decide , how many times new generations will be generated using the principles of cloning and mutation.

The following graph shows that the number of iterations for which the generation of ants is mutated and cloned greatly effects the maximum fitness of ants.
Theoretically also , similar results are predicted , as the number of iterations increase , ability to improve greatly increases for the fittest ant.

Intuitively also , the fitness should increase as number of iterations are increased.



Conclusion

Various interesting results were reported above. On the whole it was noticed that on the average the ants do not get intelligent. However , due to "survival of the fittest" principle (which is deliberately programmed) increases the maximum fitness of the ants. Variation of other parameters brings change in the maximum fitness but hardly seems to affect the average fitness of the ants.