Ant Recruitment

New Mexico

Supercomputing Challenge

Final Report

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Team 3

The Albuquerque Institute for Math and Science

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Executive Summery

Ants are a source of great interest among biologists. They have what appears to be a complex, intelligent system involving the organization and work of every member of the ant colony. A study was recently conducted by the University of New Mexico that studied the foraging techiques of several ant spices, one of which being the *Pogonomyrmex rugosus*. Our team created a simplified version of the field test performed by the study group so we can compare our results with data collected from the field through an ANOVA test. We ran the simulation ten times, six of which indicated that the ants had advanced foraging techniques. The results being lower in the simulation than expected could be a result from the program taking in worst-possible circumstances. The majority of the data supports the data however from the field stating that the ants do indeed have a system for gathering food.

Problem Definition

Ants remain a great mystery and a source of fascination to the biological community. They still have many riddles unsolved by science, their process of working together as a clan for tasks such as hive building, foraging , social structure, among many other tasks ants use complex organization to achieve. Over the summer, a member on the team conducted a study with a group through the University of New Mexico to study the foraging techniques of several ants, among them the species *Pogonomyrmex rugosus*, a species of large black ants. They are the most widespread species of ants in North America. The study was based off of the theory that the ants use pheromone trails to communicate the location of food. The theory says that when they find a source of food, like a cluster of seeds, the ants lay an alcohol-like pheromone trail as they make their way back to the hive acting like a trail of breadcrumbs for other ants to follow allowing them to bring more food from that source. In the field test, seeds were placed in piles equidistant from the anthill; the seeds were marked with different colors depending on what type of pile they came from. There was 1 pile of 256 red seeds, 4 piles of 64 purple seeds, 16 piles of 16 green seeds, and 256 randomly scattered blue seeds, but still equidistant from the hive. This project is to create a computer model of the same circumstances with the parameters fit to match the theory and to compare the computer test results with the actual results from the field.

Problem solution

The computer model was made using Java. The program, when started, creates one pile of 256 red seeds and 256 individual seeds at random angles on a radius around the anthill. The program then creates 3000 ants that would leave the hill at a random angle, if there were no seed on that angle the ant dies, if that angle does contain a seed, the ant will leave a 'pheromone' which with give that angle a higher probability chance of being picked. To simulate the evaporation of the pheromone, the increased chance of that angle being chosen decreases with a half life $P_o(e^{-rt})$. If more ants however find more seeds on this angle, their pheromones are going to reinforce and further increase the chance of that angle being chosen by another ant. the ants die after they return to the hill.

The data collected was put through an ANOVA (An Analysis Of Variance) test to compare the results in the program to the results from the field. Depending on the value of P, the scientific standard for probability, determined if the foraging was organized or random. If the p value is less than 5% P, this represents the probability that the rate at which the larger pile of seeds is brought back to the colony is random, and not related to the pheromone trails. Having a value lower than 5% would mean that the ants exhibit a characteristic of having an intelligent system for gathering seeds and that is also what was found in the field observation.

Results:

To prove that the laying of pheromones is significant, all scale factors have been set to 1. Then, to search for the pile of 256 seeds, at the bottom of the output is a line that reads: loc (the degree the pile was on in the circle): orig=256 is now: (The number left.) Go to the numerically ordered list of 0-359, and fine the degree the pile was on in the circle. The percentage at that position is the percentage of ants that went to that location.

While running the simulation 10 times, we obtained the following results:

Red seeds left:	Blue Piles left:	% That went to the red:
Run 1: 234	1	%0.73
Run 2: 60	1	%6.53
Run 3: 4	2	%8.40
Run 4: 89	3	%5.57
Run 5: 0	4	%11.07
Run 6: 256	2	%0.00
Run 7: 169	2	%2.90
Run 8: 228	2	%0.93
Run 9: 67	2	%6.30
Run 10:51	4	%6.83

Summery & Conclusions

In the 10 runs, only 6 out of the 10 had a P <5%. This is, however, based upon the model is under worst-case conditions, where the ants die after they return to the colony and does not search for another seed. We also found, though we ran out of time to analyze the data fully enough to put it into the report, that if the number of ants increased, P also increased to give us approximately 8 out of 10 with 4000 ants, thus suggesting that a higher population leads to a better support of the theory. The data shown does, if not significantly, that the *Pogonomyrmex rugosus* does utilize a system for efficiently gathering food for its colony.

Bibliography

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Achevements

Our project finds a solution to the thing that has bothered biologists to find how ants are so knowledgable about foraging even though individually they don’t display very much intellect.

We get to see how the group mind works as an extremely efficient foraging system.

Acknowledgements

Tatiana Paz: Who one of our members volunteered for to do this project then she helped with the technical information.

Mark Johnson: Who helped with the Programming of the code.

Appendix

```
/**************************
 SUPERCOMPUTING PROJECT 2010
 AIMS@UNM
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 ----
 ANT RECRUITMENT */

import java.io.*;
import java.util.*;
import javax.swing.*;
import java.math.*;

public class mainAnts {

	public static void main(String[] args) {

		//Declaration of basic integers and arrays
		final int numAnts = 5000;
		final double pherWeight = 1.0;
		final double pherHalfLife = 1.0;
		final double pherDecay = -Math.log(1.0)/pherHalfLife;
		final double dirWeight = 1.0;
		final int numRedPiles = 1;
		final int numBluePiles = 256;
		final int redPileSize = 256;
		final int bluePileSize = 1;

		final int DEGREES = 360;

		Random rnd = new Random();

		int[] seeds = new int [DEGREES];

		//Make the red pile
		int[] redPileLocs = new int [numRedPiles];
		for ( int i = 0; i < numRedPiles; ++i )
		{
			int loc = rnd.nextInt(seeds.length);
			while (seeds[loc] > 0){
				loc = rnd.nextInt(seeds.length);
			}
			seeds[loc] = redPileSize;
```

```
            redPileLocs[i] = loc;
        }

        // and the blue piles
        int[] bluePileLocs = new int [numBluePiles];
        for (int i = 0; i < numBluePiles; i++){
            int loc = rnd.nextInt(seeds.length);
            while (seeds[loc] > 0){
                loc = rnd.nextInt(seeds.length);
            }
            seeds[loc] = bluePileSize;
            bluePileLocs[i] = loc;
        }

        // copy the seeds array for output comparison:
        int[] origSeeds = (int[]) seeds.clone();

        //Array to hold pheromone trails
        double[] trails = new double [DEGREES];

        // keep track of how many ants go in each direction
        int[] trips = new int [DEGREES];

        int nErrors = 0;

        //Actual simulation of ants
        for (int ant = 0; ant < numAnts; ant++){
            // System.out.println( "ant=" + ant );

            //Finding total weight of pheromones, and decay on
each step
            double totalPher = 0;
            for (double pher : trails){
                totalPher += pher;
                pher *= pherDecay;
            }

            //Determine actual direction of ant
            int antDir = -1;
            final double totalLoc = DEGREES*dirWeight;
            final double weightedLoc = rnd.nextDouble()*(totalLoc
+ totalPher);
            // System.out.println("totalPher=" + totalPher + ",
weightedLoc=" + weightedLoc );
            if (weightedLoc < totalLoc){
```

```
                    antDir = (int) (weightedLoc / dirWeight);
                } else {
                    double curTotal = totalLoc;
                    for (int i = 0; i < trails.length; i++){
                        double nextTotal = curTotal + trails[i];
                        // System.out.println("    i=" + i + ", 
curTotal=" + curTotal);
                        if (curTotal <= weightedLoc && weightedLoc 
< nextTotal){
                            antDir = i;
                            break;
                        }
                        curTotal = nextTotal;
                    }
                }

                if (antDir == -1){
                    // System.out.println("totalPher=" + totalPher + 
", weightedLoc=" + weightedLoc );
                    // System.out.println("  antDir not set.");
                    ++nErrors;
                    continue;
                }

                // System.out.println("  antDir=" + antDir + ", 
seeds[antDir]=" + seeds[antDir] );

                //Check for seeds at antDir
                if (seeds[antDir] > 0){
                    seeds[antDir]--;
                    trails[antDir] += pherWeight;
                }

                trips[antDir]++;


            } // end of actual simulation



            //Results
            //It is unnecessary when presenting, but can be utilized if 
the judges ask.
            //Only important pieces are Blue Piles and number of Red 
Seeds
```

```
            System.out.println("Seeds and Ants:");
            System.out.println("  loc  orig  left  ants");
            for ( int i = 0; i < DEGREES; ++i )
            {
                  System.out.printf( "  %3d  %4d  %4d  %4d (%6.2f%%)\n",
                                                  i, origSeeds[i], seeds[i],
trips[i],
                                                  100.0*trips[i]/numAnts );
            }

            System.out.println("The amount of blue seeds left " );
            int bluePilesRemaining = 0;
            for ( int loc : bluePileLocs )
            {
                  System.out.println("  loc " + loc + ": orig=" +
bluePileSize + " is now: " + seeds[loc] );
                  if ( seeds[loc] > 0 )
                        bluePilesRemaining++;
            }

            System.out.println("The amount of red seeds left " );
            for ( int loc : redPileLocs )
            {
                  System.out.println("  loc " + loc + ": orig=" +
redPileSize + " is now: " + seeds[loc] );
            }


            System.out.println("The number of blue seed piles
remaining: " + bluePilesRemaining );

            System.out.println("Errors: " + nErrors );


      }
}
```