Visualising Ant Colony Optimisation

Major Project

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Aims of the Project

- Provide a visual representation of an Ant Colony Optimisation algorithm
- To be used in an educational environment
  - Teaching resource
- The algorithm's parameters can be changed by the user
  - Number of cities
  - Number of ants
  - Alpha value
  - Beta value
  - Decay rate
  - etc

Ant Colony Optimisation

- Family of Swarm Intelligence methods
  - SI typically involves a population of simple agents
- Probabilistic path finding technique
  - Return the optimal path in a graph
- Based on real-world ant behaviors
  - Ants always find the shortest path between nest + food
  - Work together based on pheromone trails
- Currently this project focuses on the TSP
  - Travelling salesman problem

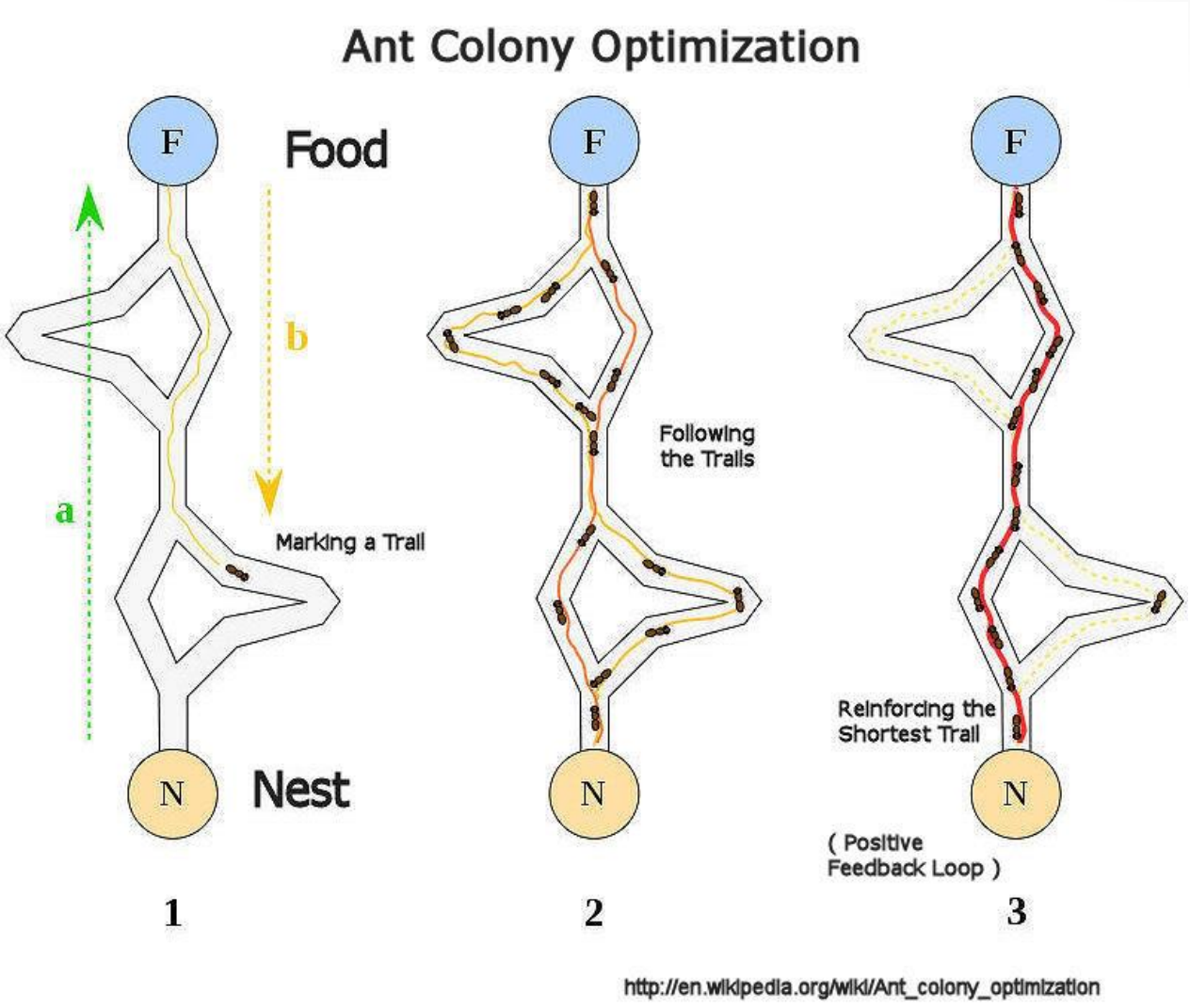

Image: http://s158.photobucket.com/user/OnlyObvious/media/ants/Aco_branches_svg_800_Notes.jpg.html

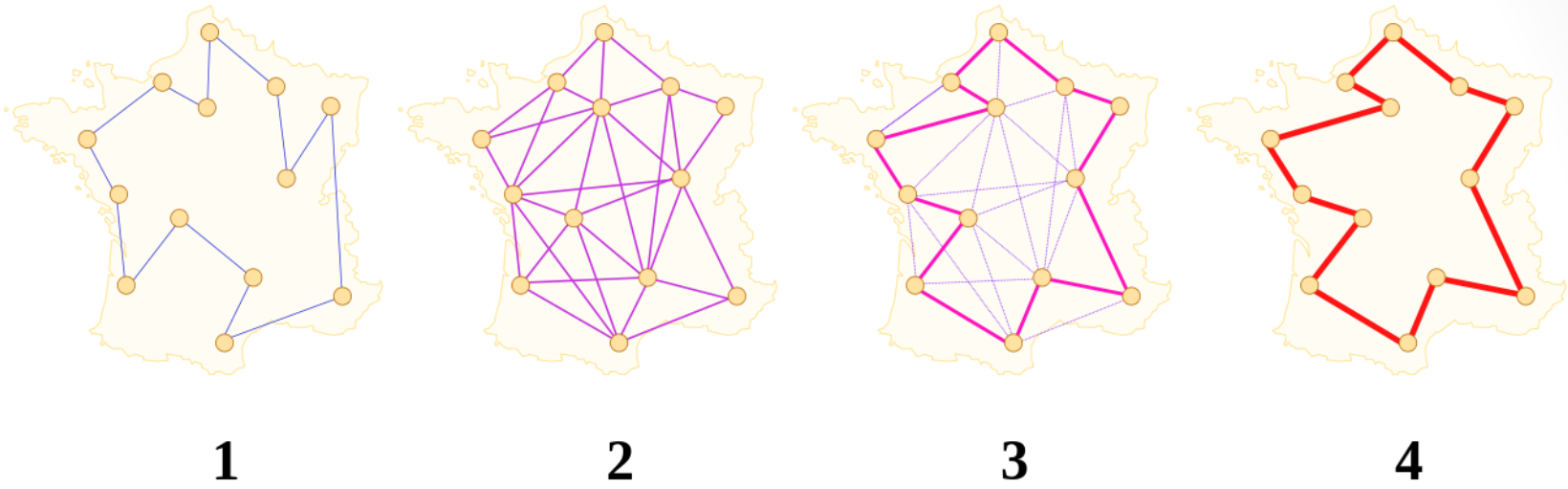

Image: http://upload.wikimedia.org/wikipedia/commons/thumb/2/2a/Aco_TSP.svg/1280px-Aco_TSP.svg.png

Probabilistic property

- An agents next location is calculated using the following probability:

$$p_{xy}^{k} = \frac{(\tau_{xy}^{\alpha})(\eta_{xy}^{\beta})}{\sum(\tau_{xy}^{\alpha})(\eta_{xy}^{\beta})}$$

  - α: Meta heuristic value relating to the favoring of pheromone
  - β: Meta heuristic value relating to the favoring of shorter distance
  - η: 1/distance from current to node xy

Pheromone deposit

- The pheromone trails are updated as the agents traverse the graph
- The equation to model this behavior is:

$$p_{xy}^{k} = (1-\rho)\tau_{xy}^{k} + \Delta\tau_{xy}^{k}$$

$$\Delta\tau_{xy}^{k} = \begin{cases} Q/L_k & \text{if Agent } k \text{ uses curve } xy \text{ in its tour} \\ 0 & \text{otherwise} \end{cases}$$

  - This correctly factors in decay and allows for any ant moving through node xy to add to the pheromone concentration at node xy

Technical Implementation

- Implemented in Java and its Swing packages
  - Cross-platform
  - JUnit tests
- Visualising the algorithm is difficult
  - Easy to implement, difficult to visualise
    - Showing pheromone levels to the user
    - Showing the agents moving
    - Show the best route
- Do all this in a reasonable time

Technical Challenges

- Use of SwingWorker to execute the algorithm in its own thread
  - Allows updates of the view without it ‘freezing up’

- Simulate ants moving on the ‘paths’
  - Get the location the ant started and its destination
  - Use linear interpolation
    - Given the x /y co-ordinate of the start and finish
    - get the value of any x/y co-ordinate on the path between these two points
    - value1*(1-μ)+value2* μ);
      - value1/2 is the X or Y value (e.g value1 = start x, value2 = destination x)
      - μ is how far on that path you want (e.g μ 0.5 = half way between the points)

Current algorithm

- To update the view to reflect the current state
- For every ant(agent)
  - Draw the ant at their current location
  - If they aren't finished, move them
    - During this move, get their current X and the destination
      - Linearly interpolate these two locations to show the ant moving
      - Update pheromone
    - If the ant has the current best path, set its path as best
      - Loop through the cities visited in order and draw a line between them
      - paint the updated pheromone
  - Once all ants have finished
    - Remove all pheromone trails and only show the best path
- This is the general form there are other intricacies

Future work

- Display how many ants are at each city
  - Currently shows 1 ‘ant’ regardless
- Experiment with correct limits to add to text fields
- Potentially add variations of the algorithm
  - Elitist ants, Min-Max system etc.
- Test the application thoroughly
- Potentially set up an nest-food style of problem
- Potentially extend the application to visualise BCO as well

Demonstration

- Current features:
  - load configurations from a file
  - Save configurations to a file
  - Set the speed
  - Modify algorithm parameters
  - Error checking on all fields
  - Display the best route and distance
  - See the ants move
  - Visualise pheromone