# Route Planning Algorithm based on Ant Colony Optimization Algorithm

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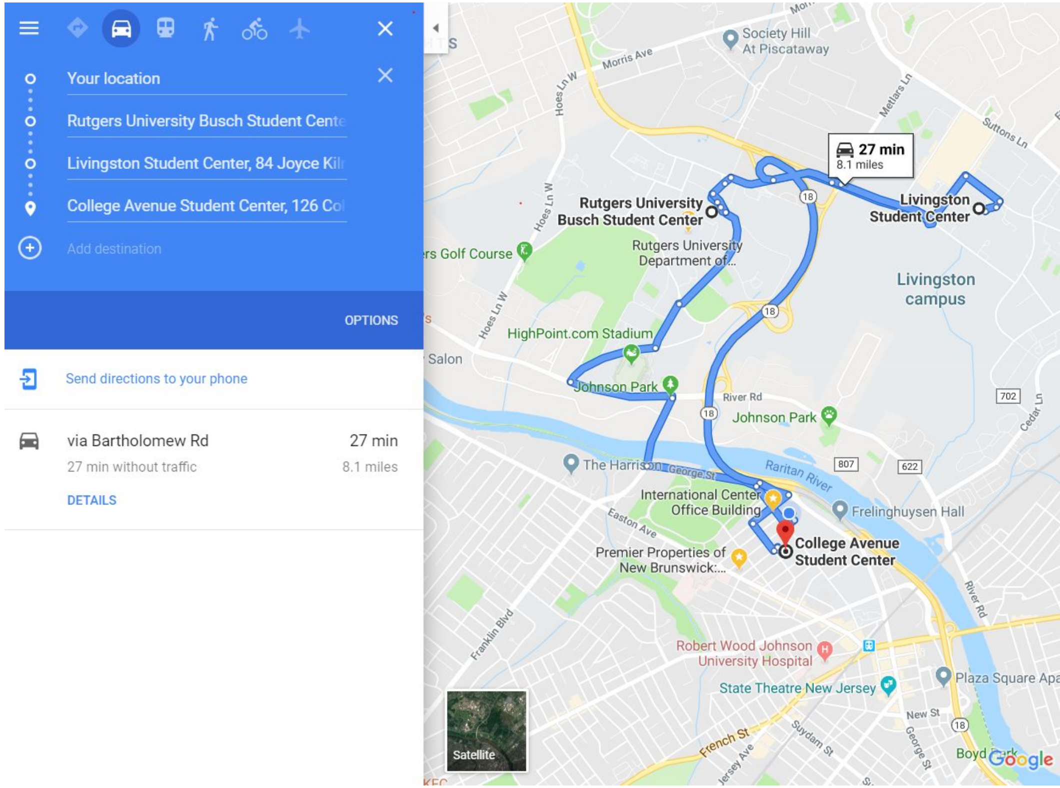
## Motivitation

Multiple destinations in one trip

Route planning saves traveling time

Easily applied to navigation system



Your location

Rutgers University Busch Student Cente

Livingston Student Center, 84 Joyce Kil

College Avenue Student Center, 126 Col

Add destination

OPTIONS

Send directions to your phone

via Bartholomew Rd 27 min

27 min without traffic 8.1 miles

DETAILS

27 min
8.1 miles
Rutgers University Busch Student Center
Livingston Student Center
Livingston campus
College Avenue Student Center
Society Hill At Piscataway
Rutgers University Department of...
HighPoint.com Stadium
Johnson Park
Raritan River
The Harrison
International Center Office Building
Frelinghuysen Hall
Premier Properties of New Brunswick:...
Robert Wood Johnson University Hospital
State Theatre New Jersey
Plaza Square Apa
Satellite
Google

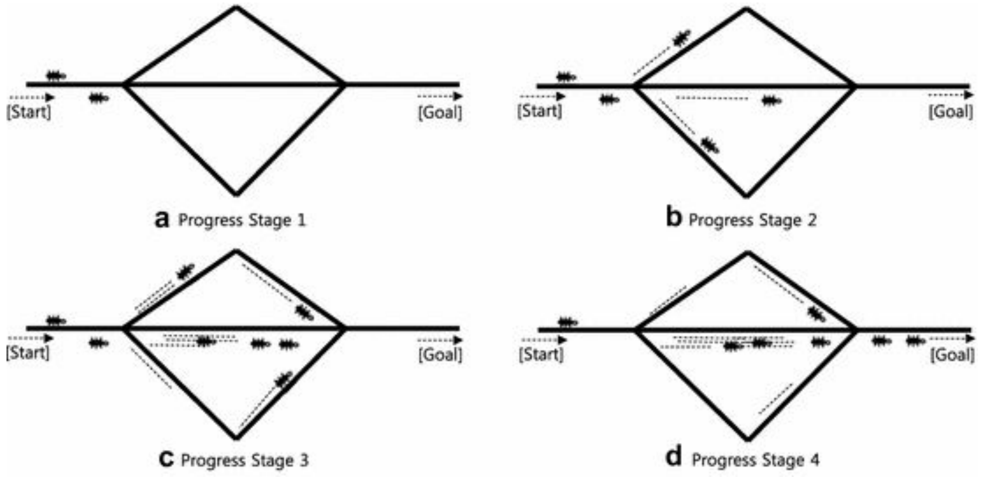
# Ant Colony Optimization Algorithm

Inspired by ant colony's behavior

Ants can always find the best route between nest and food

Ants leave pheromones on the route

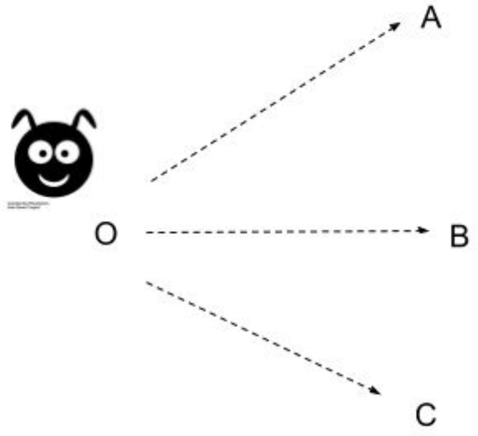
Ants prefer following route with high density of pheromones



## Implementation

2 factors affect its decision:

Pheromones & Distance



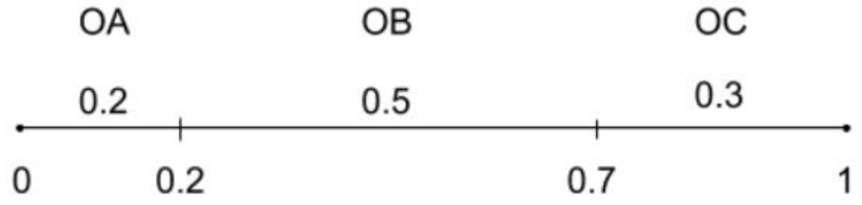
$$\text{Probability}(O\text{->}A)=\frac{\text{phe}(OA)^{\alpha} * (1/\text{dis}(OA))^{\beta}}{\sum_{i=A,B,C}\text{phe}(Oi)^{\alpha} * (1/\text{dis}(Oi))^{\beta}}$$

$\alpha$ & $\beta$ are parameters

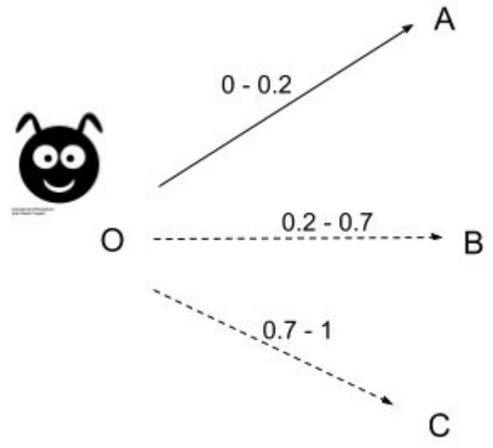
## Implementation

How to make the decision in the program?

| | O->A | O->B | O->C |
|---|---|---|---|
| Probability | 0.2 | 0.5 | 0.3 |
| Cumulative sum | 0.2 | 0.7 | 1.0 |



Random = 0.1



A random number between 0 and 1 decides which way to go

## Implementation

After the ant finished traveling to all the destinations

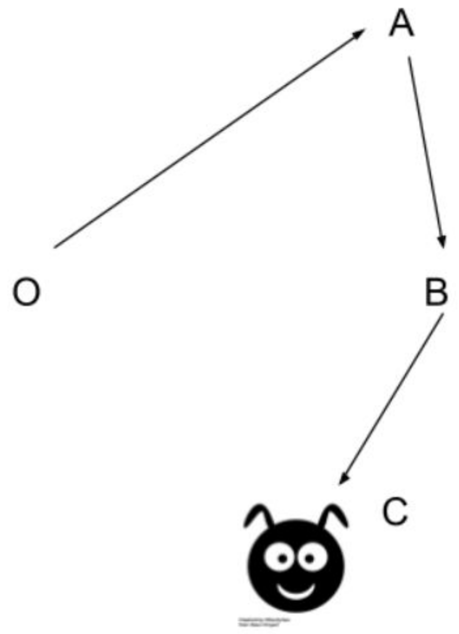
Old pheromones may evaporate

New pheromones will be left on the route the ant passed by

Pheromone density = ρ*phe + Q/total_dis

total_dis = dis(OA) + dis(AB) + dis(BC)

ρ & Q are parameters



## Implementation

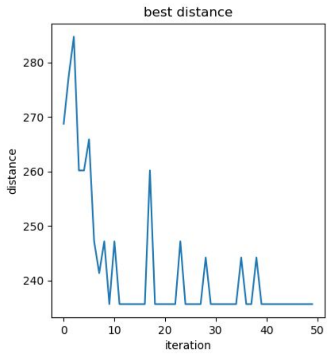
Program process:

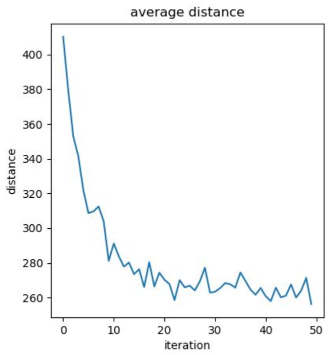
1. Put some ants at random positions as their starts
2. Every ant starts traveling until it finishes all the destinations
3. Record every ant’s route and find the shortest one
4. Update the pheromones of every route
5. Step 1 - 4 as one iteration, repeat this for some times

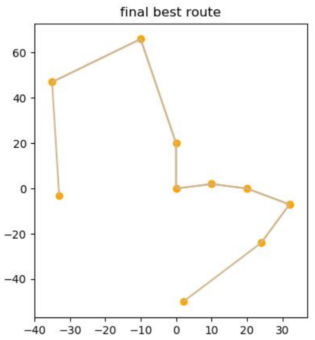
# Results

In each iteration, 20 ants are created to travel all the destinations

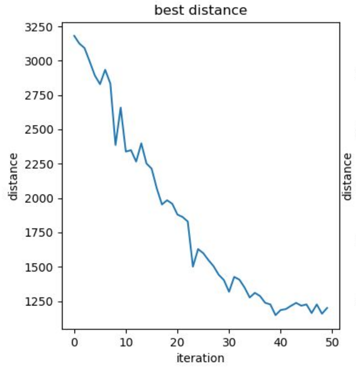
10 destinations:

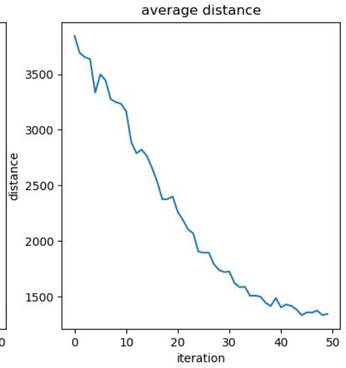


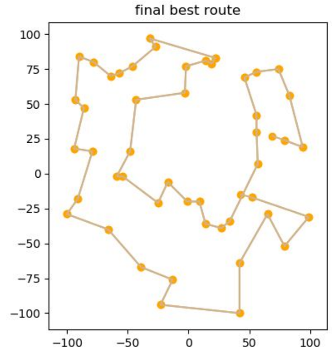




50 destinations:

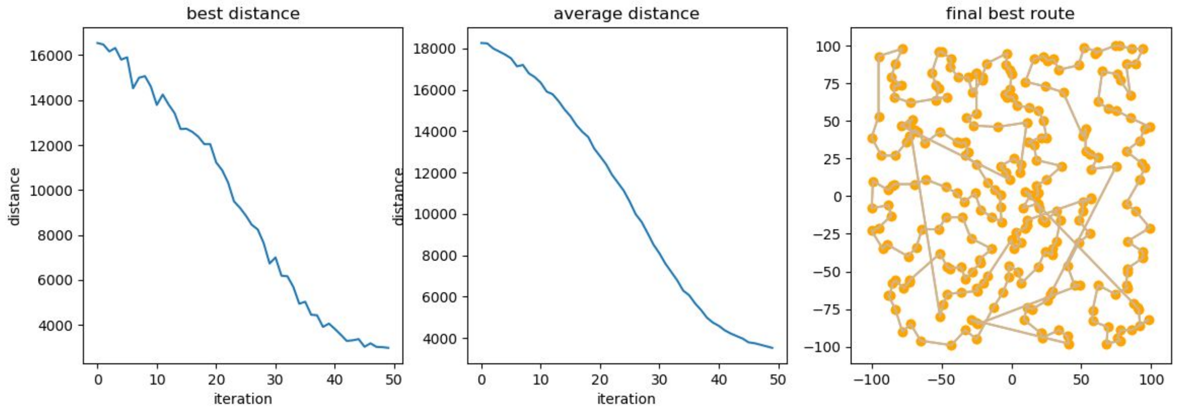






# Results

256 destinations:



## Algorithm Prediction/Intuition

Define the following parameters:

**i**: number of iterations

**a**: number of ants

**n**: destinations to visit, **n-1** after first visit

Prediction of overall complexity: $O(\mathbf{i} * \mathbf{a} * \mathbf{n} * (\mathbf{n-1})) = O(\mathbf{i} * \mathbf{a} * \mathbf{n}^2)$

## Experiment - Input and Testing

- Input: a csv file
  - First line: specify number of dimensions
  - Subsequent: positions (coordinates) of destination points
- Testing conditions
  - 3 parameters: **n**, **a**, **i**
  - Tested by fixing two of them and changing the third
  - When varying **n**: up to 256 lines, **a** fixed to 100, **i** to 50
  - When varying **a**: up to 256 ants, **n** fixed to 10, **i** to 50
  - When varying **i**: up to 256 iterations, **n** fixed to 10, **a** to 50

## Experiment - Environment

Programming language: Python 3.7

Libraries: numpy 1.16.0

matplotlib 3.0.3

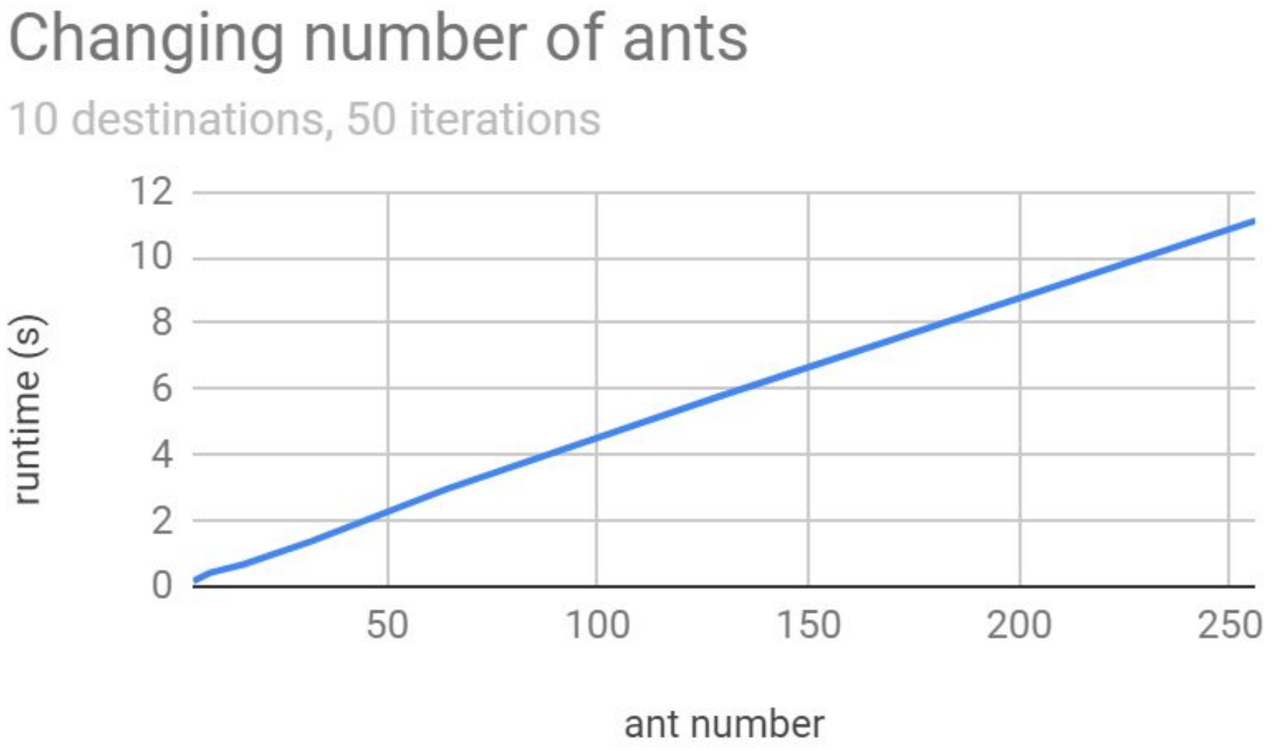
Environment: Microsoft Windows 10 17134

Visual Studio Code 1.33.1

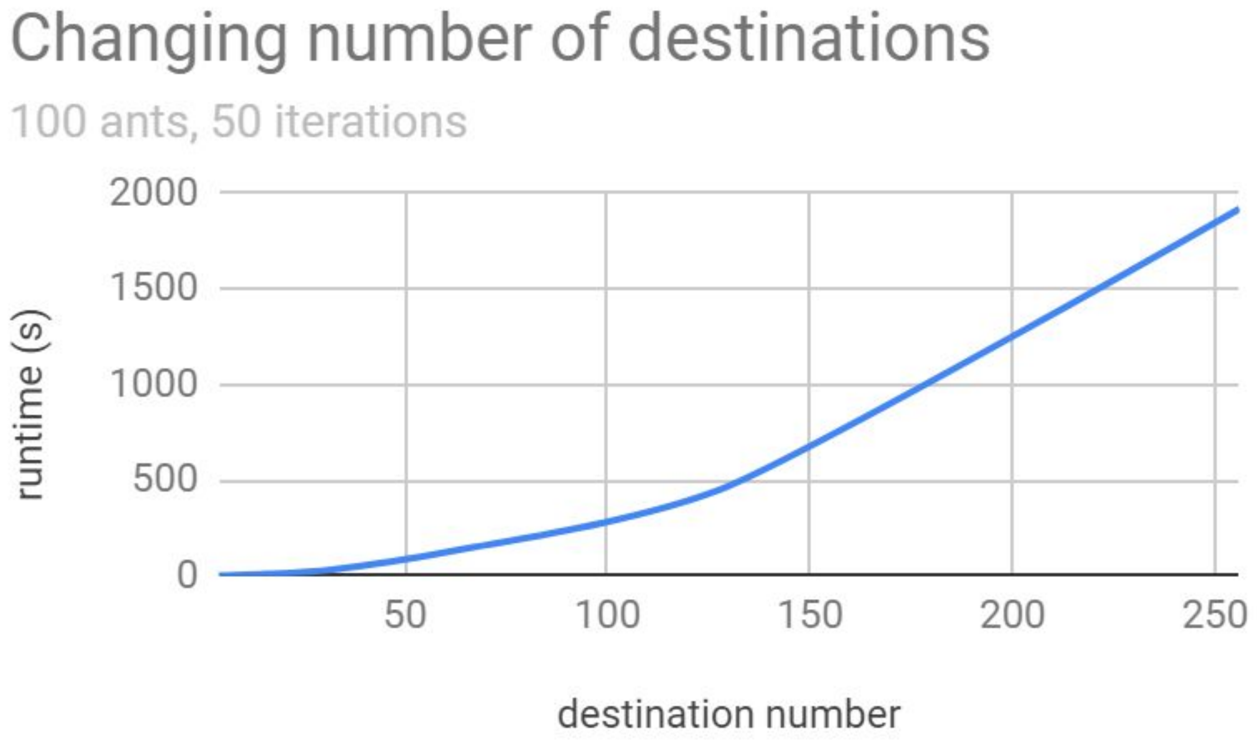
Processor: Intel Core i5-7200U @2.50GHz

RAM: 8.00 GB

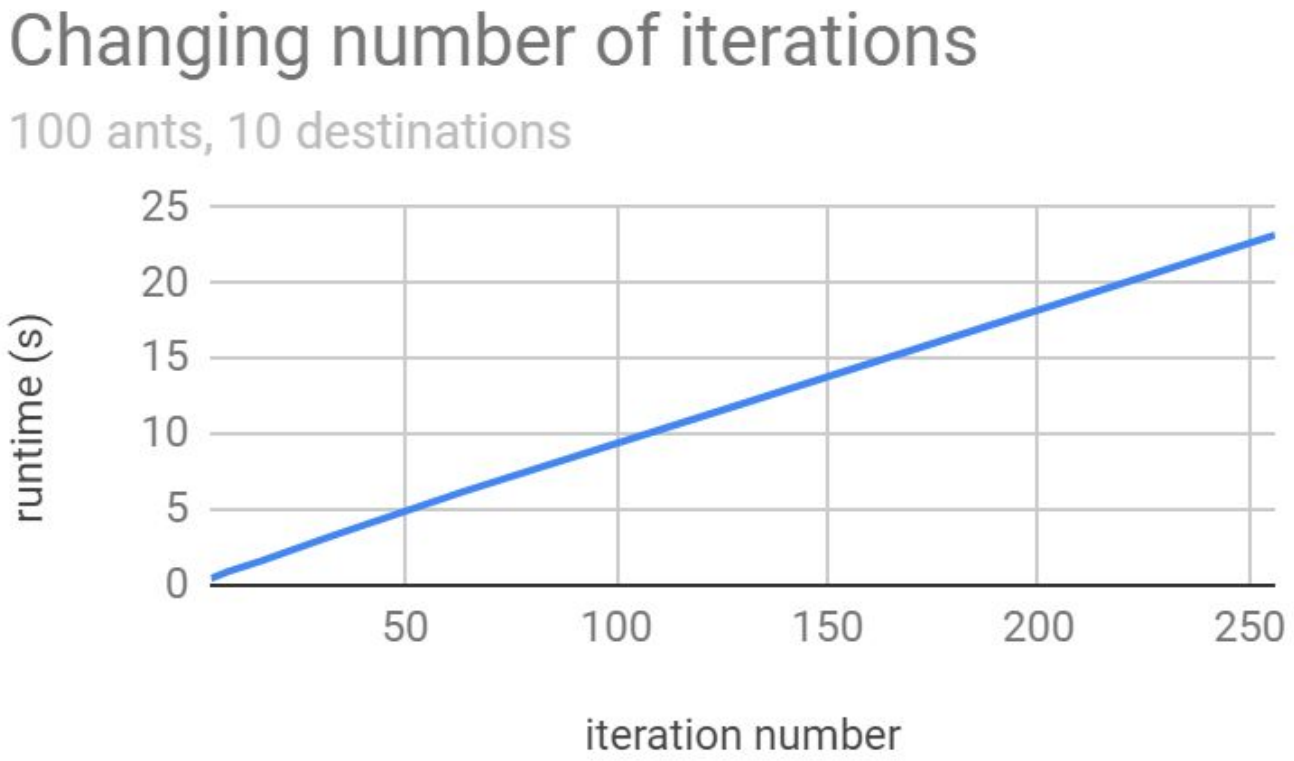
## Testing number of ants



## Testing number of destinations



## Testing number of iterations



## Conclusions

Runtime = O($\mathbf{n}^2$***a*****i**)

The randomness of decision making for each ants ensures stability of best path calculation given more ants and iterations.

Fixing around 20 ants, about 50 iterations for any number of destinations ensure correctness

Questions?

Thank You!