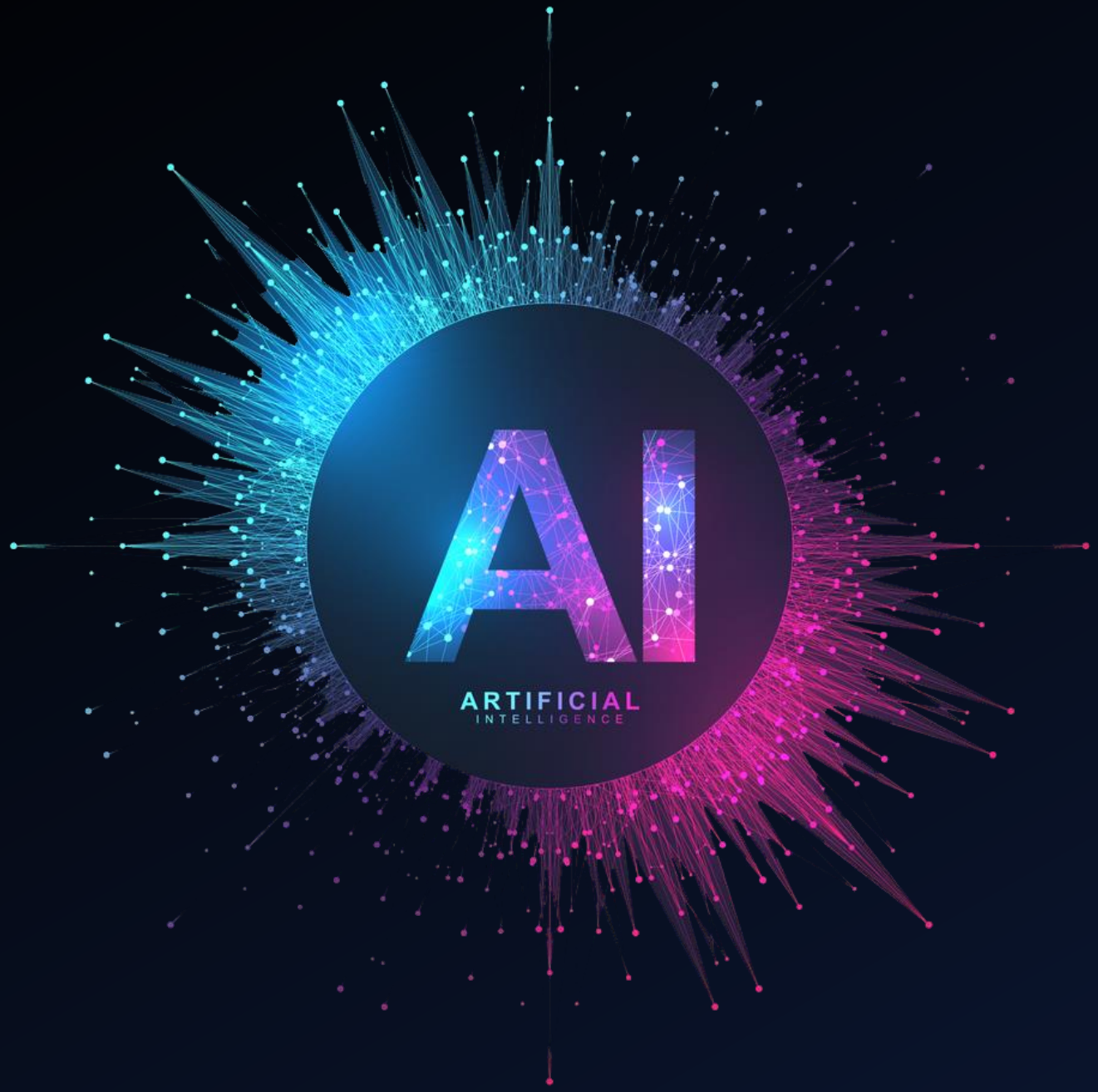
AI
ARTIFICIAL
INTELLIGENCE

Colony Optimization (Swarm Intelligence)

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Swarm Intelligence

ANT COLONY OPTIMIZATION (ACO)

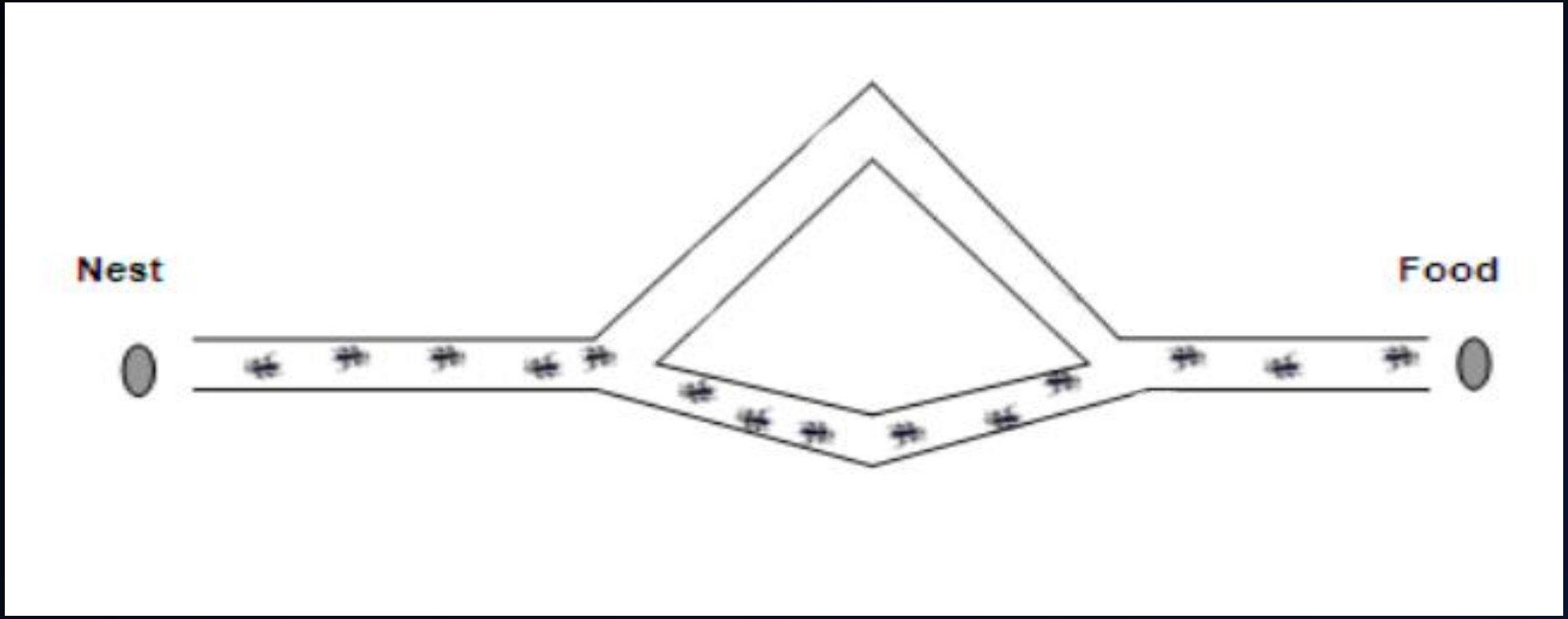
Outline

- Introduction
- Overview
- Swarm Intelligence (ACO)
- ACO Pheromone Definition
- ACO Algorithm
- ACO Pseudo code
- Advantages and Disadvantages of ACO
- Applications
- References

Introduction

- It is a part in the field of artificial intelligence. swarm intelligence adopts the collective behavior of decentralized, self-organized systems like (group of animals) ,as they strive to survive.
- Birds, bees, fish and ants all of these creatures have evolved methods of amplifying their intelligence by thinking together in systems.
- This is why birds flock and bees swarm, they are smarter together than alone.

Naturally observed ant behavior



Overview on ACO

- This algorithm is a member of the ant colony algorithms family, in swarm intelligence methods, and it constitutes some metaheuristic optimizations.
- In COMPUTER SCIENCE and OPERATION RESEARCH, the **ant colony optimization algorithm**(ACO) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs.

First introduced by Marco Dorigo in 1992 . Originally applied to traveling salesman problem.

Swarm Intelligence

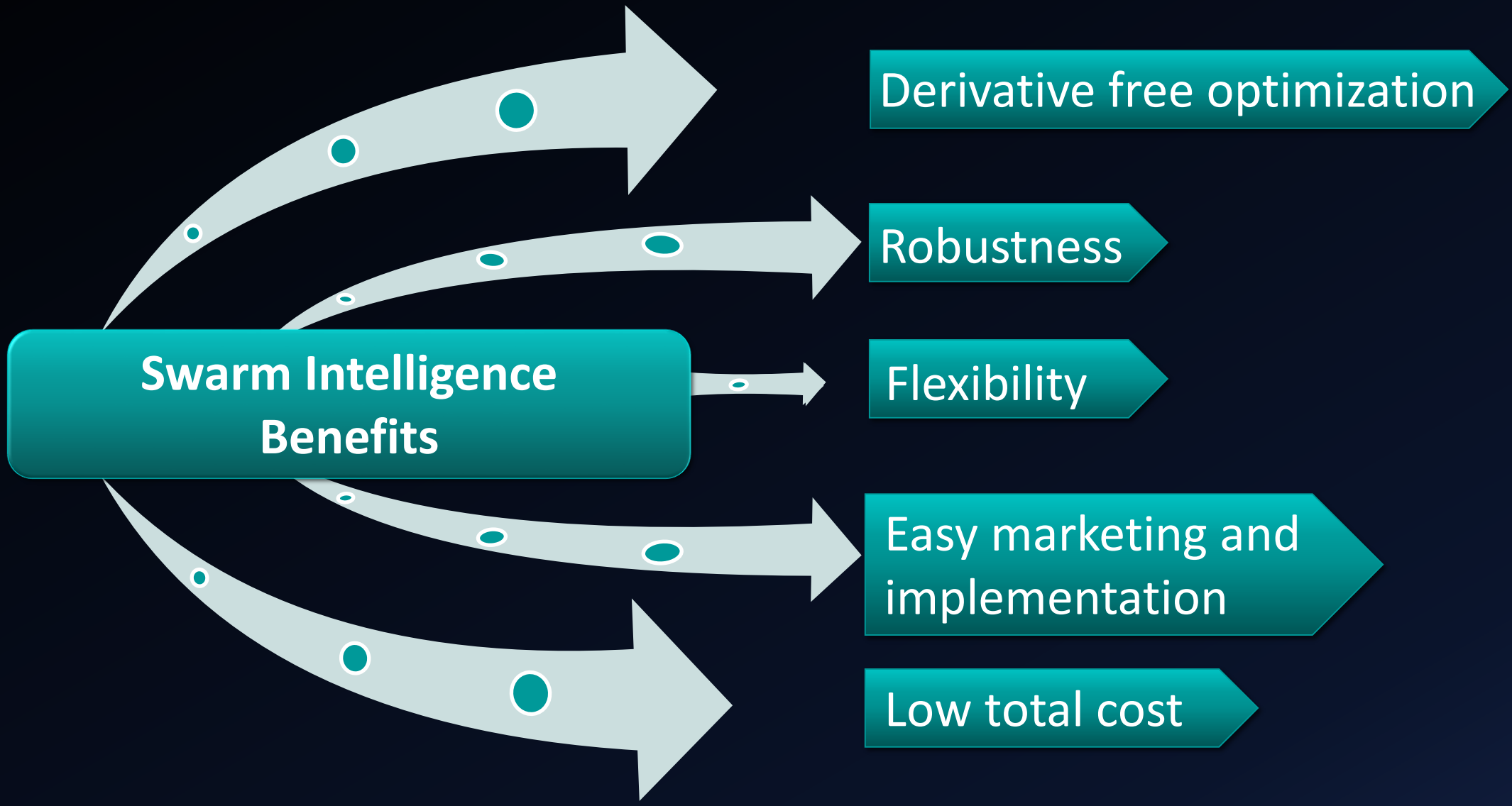
Main Idea ..

- Actually, the main idea is to collaborate together and behave as single entity which performs better than individuals .
- The principles was inspired from collective insect societies which is helping in developing computer algorithms and motion control principles for robotics

SI Algorithms

- Particle swarm optimization (PSO)
- Ant colony optimization (ACO)
- Artificial Bee Colony (ABC)
- Genetic **Algorithms** (GA)
- Differential Evolution (DE)
- Glowworm **Swarm Optimization** (GSO)

Benefits of SI



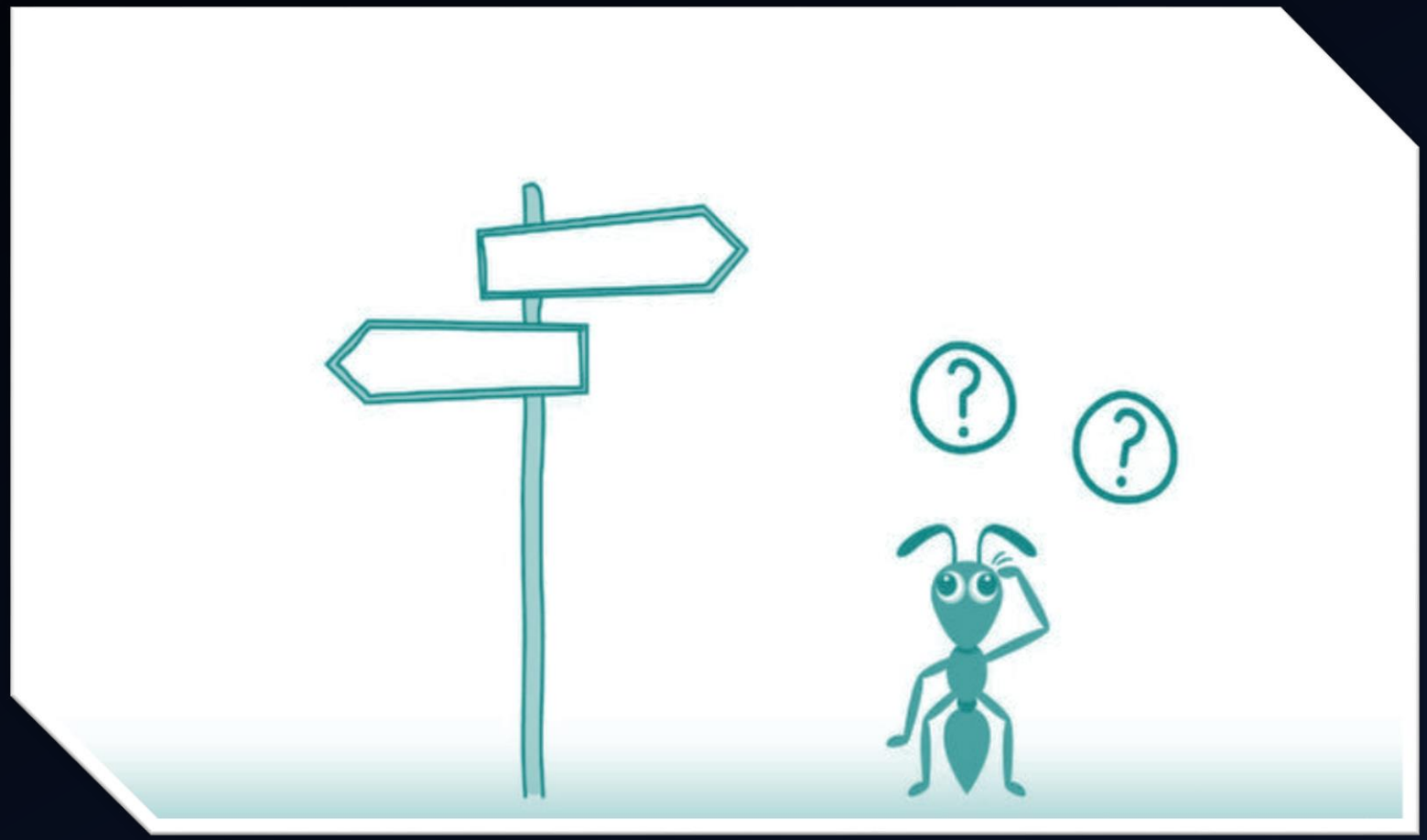
Capabilities of Swarm Intelligence :

Applications of SI

- Ant-based routing: The use of swarm intelligence in telecommunication networks has also been researched, in the form of ant-based routing.
- Crowd simulation
- Human swarming
- Swarmic art
- Flying robots
- Kilobot

ACO Definition

What is Ant Colony Optimization ?



ACO Definition

History

- ACO studies artificial systems that take inspiration from behavior of real ant colonies.
- Natural behavior of ants have inspired scientists to mimic insect operational methods to solve real life complex optimization problems.
- It constitutes some metaheuristic optimizations.
- The inventors are Frans Moyson and Bernard Manderick. Initially proposed by Marco Dorigo in 1992 in his PhD thesis, The first ACO algorithm was called the Ant system and it was aimed to solve the travelling salesman problem, in which the goal is to find the shortest round trip to link a series of cities. At each stage, the ant chooses to move from one city to another according to some rules.

ACO Definition

Concept ..

THE WHOLE CONCEPT OF ANT COLONY OPTIMIZATION IS TO MINIMIZE THE PATH AND POWER CONSUMPTION

ACO Definition

What is ACO ?

- Artificial Ants stand for multi-agent methods inspired by the behavior of real ants.
- Combinations of Artificial Ants and local search algorithms have become a method of choice for numerous optimization tasks involving some sort of graph, e.g., vehicle routing and internet routing.
- A colony is a population of simple, independent, and asynchronous agents that cooperate to find a good solution to the problem.

Pheromone Definition

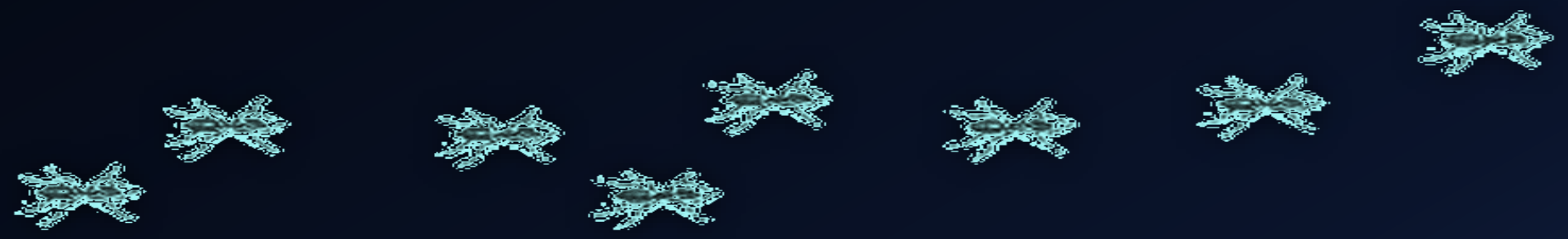
Shortest path is discovered via **pheromone** trails.

Pheromone : is an organic compound Ants deposit while tracing a path.

- Methodology is based on the ant's capability of finding the shortest path from the nest to a food source.
- More **pheromone** on path increases probability of path being followed.

Ant Colony Optimization Algorithms

- Ant Colony Optimization is a swarm intelligence technique and a metaheuristic which is inspired by the behavior of real ants in their search for food.
- The ants in ACO are stochastic solution construction procedures that probabilistically and iteratively build complete solutions from smaller components.
- It is this cooperation on a colony level that gives the members of the ACO algorithm family their distinctive flavor.



Ant Colony Optimization Algorithms

- Amount of pheromone is updated according to the equation

$$\tau_{i,j} = (1- \rho)\, \tau_{i,j} + \Delta\tau_{i,j}$$

where

$\tau_{i,j}$ is the amount of pheromone on a given edge i, j

ρ is the rate of pheromone evaporation

$\tau_{i,j}$ is the amount of pheromone deposited, typically given by

$$\Delta\tau_{i,j}^{k} = \begin{cases} 1/L_k & \text{if ant } k \text{ travels on edge } i,j \\ 0 & \text{otherwise} \end{cases}$$

where L_k is the cost of the k^{th} ant's tour (typically length).

Ant Colony Optimization Algorithms

- An ant will move from node i to node j with probability

$$p_{i,j} = \frac{(\tau_{i,j})^{\alpha} (\eta_{i,j})^{\beta}}{\sum (\tau_{i,j})^{\alpha} (\eta_{i,j})^{\beta}}$$

T: Taw
η: eetaa

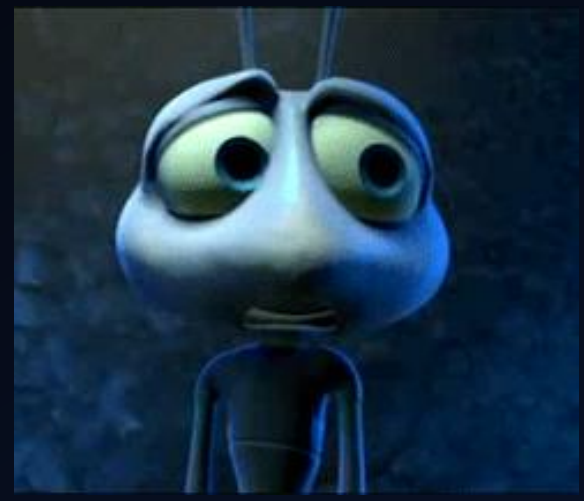
where

$\tau_{i,j}$ is the amount of pheromone on a given edge i, j

β and **α** are parameters which are used to arrange to influence of local trail values and visibility $(0 \leq \alpha , \beta \leq 1)$

$\eta_{i,j}$ is the desirability of edge i, j (typically 1 / Li,j)

Ant Colony Optimization Pseudo code



- ✓ Algorithm in Pseudo code:
  - **Initialize** Trial
  - **Do while** (Stopping Criteria Not Satisfied) - Cycle Loop
    - **Do Until** (Each Ant Completes a Tour) - Tour Loop
    - Local Trial Update
    - **End Do**
    - Analyze Tours
    - Global Trial Update
  - **End Do**

ACO Advantages:

- Distributed computation avoids premature convergence
- Early solution in the early stages of the search process.
- The collective interaction of a population of agents.
- Retains memory of the entire colony instead of the previous generation only
- Less affected by poor initial solutions
- Has been applied to a wide variety of applications
- Inherent parallelism
- Positive Feedback accounts for rapid discovery of good solutions
- Efficient for Traveling Salesman Problem and similar problems
- Can be used in dynamic applications (adapts to changes such as new distances, etc.)

ACO Disadvantages:

- Theoretical analysis is difficult
- Sequences of random decisions (not independent)
- Probability distribution changes by iteration
- Research is experimental rather than theoretical
- Time to convergence uncertain (but convergence is guaranteed!)
- Slower convergence than other Heuristics
- Performed poorly for TSP problems larger than 75 cities

ACO Applications:

Network routing problem

- ACO algorithm is applied in the network routing problems to find the shortest path
- A set of artificial ants (packets) are simulated from a source to the destination
- The forward ants are selecting the next node randomly for the first time taking the information from the routing table
- Ants who are successful in reaching the destination are updating the pheromone deposit at the edges visited by them
- The next set of the ants can now learn from the pheromone deposit feedback left by the previously visited successful ants and will be guided to follow the shortest path

ACO Applications:

Traveling Salesman Problem

The **goal** is to find the **shortest** round trip to link a series of cities.

At each stage, the Salesman chooses to move from one city to another according to some rules:

- Salesman has to start from one place .
- It must visit each city exactly once .
- come back to original city .

ACO Applications:

- Data mining
- Discounted cash flows in project scheduling
- Grid Workflow Scheduling Problem
- Image processing
- Intelligent testing system
- Power Electronic Circuit Design

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THANKS ..

Any Questions ?!

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