

Swarm intelligence

Ant Colony Optimization



September 7, 2018

The University of Huddersfield

Author: Luke McCann

# Chapter 1: Introduction

In recent years artificial intelligence (AI) and machine learning (ML) have made a comeback, after an initial dark period, in the industry of research and academia regarding computational systems. As such, many researchers have taken an interest in accelerating the growth of specific technologies in these areas including; meta-heuristics, neural networks (NN’s), and evolutionary computing (ECO). Autonomous systems offer a great advantage to many industries, allowing for machines to explore zones or perform tasks which hold a danger to human health, or simply with greater levels of accuracy.

Swarm intelligence (SI) is defined by the emerging complex self-organising behaviours of groups of autonomous agents whom as a single agent sport low level intelligence (*Louis P. Walters, 2011)*. While much of the research in SI is highly theoretical there are a variety of nature-inspired algorithms which have been proposed.

Meta-heuristics, high level procedures designed to search for an adequate solution to some optimisation problem with incomplete datasets, aim to implement some of these algorithms. While globally an optimal solution is not guaranteed to be discovered, many of these algorithms implement stochastic optimisation. Some of the most successful include;

* Ant colony optimisation (ACO)
* Particle swarm optimisation (PSO)
* **TODO: MORE**

## Background

As an emerging area in AI, SI was first inspired by biological systems of social insects. The most famous experiment contributing to the founding of this area is that of The Double Bridge Experiment by S. Goss et al (*Goss et al, 1989*). Goss et al’s findings from experiments with real ants show that a system governed by simple rules can evolve complex emergent behaviours naturally from the use of stigmergic indirect communication, such as ants self-catalysing shortest path optimisation.  
  
Inspired by the findings of S. Goss, Marco Dorigo proposed an algorithm to solve the famous Travelling Salesman problem in 1992, this was known as the ant system (AS). AS has since been redefined in 1999 as the ACO meta-heuristic by Marco Dorigo and Gianni Di Caro to unify the workings of ACO allowing a simpler implementation for solving discrete optimisation problems (*Marco Dorigo, 1999*). ACO is most suited to problems in which the properties of the environment change over time, meaning that the optimisation process must be able to adapt with these changes. Other problems ACO may be applied to include those where computational architecture is distributed, due to the multi-agent nature of the algorithm it is well suited to these environments.

Over the years there have been several implementations of ACO varying in success rates. These problems include but are not exclusive to;

* Scheduling Problems
* Vehicle Routing Problems
* Loud Balancing in Cloud Computing
* Assignment Problems (Generic assignment problem (GAP), Quadratic assignment problem (QAP)
* Set Problems
* Device sizing problems
* Image processing

Currently, research is directed towards multi objective optimisation (MOO). While ACO can effectively be applied to multi-objective problems due to its stochastic nature, there are a variety of dynamic ways in which ACO has been applied to varying problems. Multi-objective ACO (MOACO) attempts to solve multi-objective combinatorial optimisation problems (*Daniel Angus, 2008*).   
  
Other modern implementations of ACO include the load balancing ACO (LBACO) proposed by Kun Li (*Kun Li, 2011)* this form of ACO attempts to take the scheduling optimisation idea one step further, applying it to the problem of load balancing in cloud computing, the results from their experiments show that LBACO can balance network loads effectively.

## Motivation

## Project Outline