Literature Review

# Flocking in Nature - Swarm Behaviour

Flocking algorithms draw a lot of their inspiration from the behaviour of flocks in the natural world \citep{flake1998computational}. As there are many examples of this behaviour in organisms across the planet, there is a lot of information and insight that can be gleaned on how to design these algorithms. Flocks are included in the field of Swarm Behaviour, that is, the study of swarms in the natural world

## Decision Making

The way decisions are made in a flock emerges is varied. The two main ways are via consensus and leadership. An interesting look at this can be found in the behaviour of pigeons. A study conducted into the behaviour of these birds in a flock \citep{Jorge2414} found that leadership initially emerged from younger pigeons in the flock, but as the flight went on older members of the flock led the group, the paper then goes on to discuss how social versus personal information affects the behaviour of the flock. What this displays, is how the extra experience of older members of the flock is taken advantage of in determining leadership and therefore the actions they take as a flock, in this way they build consensus on their leadership through the choices individual flock members make in their group. This is further confirmed in \textit{ 'Misinformed Leaders Lose Influence Over Pigeon Flocks' }\citet{doi:10.1098/rsbl.2016.0544}. What this displays is the interaction between consensus and leadership in making decisions, and demonstrates that they can both be present in the process.

## Eusocial Behaviour

While not specifically flocking as it pertains to biology, this falls under the bracket of swarm behaviour and has interesting relationships which can inform us on how to expand flocking algorithms in beneficial ways. Communication can occur in a variety of ways; ants use pheromones to find shortest paths \citep{DORIGO199773}; bees use a waggle dance to inform others in the hive of food sources and potential new nest sites \citep{AlToufailia2013}; and

## Dynamic Adaptation to Environmental Pressures

## The path from subsocial to eusocial behaviour

% This could be a potentially interesting path to go down here in terms of how it would relate to the evolution in genetic algorithms and potential first steps the genetic algorithm should take in terms of its path towards smart flocking behaviour

## Why this is relevant

This is relevant as it inspires the work done in flocking algorithms and the work of similar fields, which has influence on the design of said algorithms.

# Flocking Algorithm

Flocking algorithms draw inspiration from the natural world, however the design of these algorithms involves mathematical approximations of the behaviours involved, the interactions that take place and the systems overall.

## Reynolds Boids

In the often cited paper when it comes to discussions of flocks: \textit{'Flocks, herds and schools: A distributed behavioral model'} \citet{Reynolds:1987:FHS:37402.37406}, we see that we have the three main forces that make up a basic flock: Separation, Cohesion and Alignment. These are approximative forces that represent the aggregate motion of a collection of boids (representing flock members, which in turn can represent different species in nature).

Expanded Boids

% Potential for adding relevant equations here but they may be more relevant to be placed in the method

## Decision Making

## Learning and Curiosity

# The Interaction of Flocking Algorithms

In the paper \textit{'Simulating Species Interactions and Complex Emergence in Multiple Flocks of Boids with GPUs'} \citet{husselmannsimulating}, multiple flocks, each a different type of boid, are run in a closed environment to see what aspects of species interaction could be reproduced. Th

# Genetic Algorithm

# The Effect of AI on Flocking Algorithms

# The Interaction of an AI Flock with another Flock