Mathematical Model of Starlings

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1 Introduction

As starlings gather in the evenings to roost, often they will participate in what is called a murmuration — a huge flock that shape-shifts in the sky as if it were one swirling liquid mass. Often the behavior is sparked by the presence of a predator like a hawk or peregrine falcon, and the flock's movement is based on evasive maneuvers. There is safety in numbers, so the individual starlings do not scatter but rather are able to move as an intelligent cloud, feinting away from a diving raptor, thousands of birds changing direction almost simultaneously. The question that has had scientists stumped is how each bird, most of them tens or hundreds of birds away from the danger, senses the shift and moves in unison?

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2 Objectives

-To model and simulate the fascinating phenomenon of starling murmurations.
-Computationally simulate the phenomenon by modelling each bird as an independent agent communicating and cooperating with other neighbouring agents.
-To measure from a realistic simulation the average energy spend by each bird, the angular momentum and the force that each bird has to withstand in a typical flight ritual.

3 Overall Approach

Flocking behavior is the behavior exhibited when a group of birds, called a flock, are foraging or in flight.
Each boid has direct access to the whole scene's geometric description, but flocking requires that it reacts only to flockmates within a certain small neighborhood around itself. The neighborhood is characterized by a distance (measured from the center of the boid) and an angle, measured from the boid's direction of

flight. Flockmates outside this local neighborhood are ignored. The neighborhood could be considered a model of limited perception (as by fish in murky water) but it is probably more correct to think of it as defining the region in which flockmates influence a boids steering.
Basic models of flocking behavior are controlled by three simple rules:
Separation - avoid crowding neighbors (short range repulsion)
Alignment - steer towards average heading of neighbors
Cohesion - steer towards average position of neighbors (long range attraction)

4 separation

steer to avoid crowding local flockmates .

5 alignment

steer towards the average heading of local flockmates .

6 cohesion

steer to move toward the average position (center of mass) of local flockmates .