Starlings Murmuration Simulation

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1 Introduction

2 Modelling the Starling

We seek to model each bird as an individual agent which reacts to its surroundings in order to determine its flying direction. In the most simple model, its environment consists only of other birds. The bird must therefore negotiate three types of constraints in order to determine its flying direction: External forces, Internal forces and Personal limitations.

2.1 External Forces

External forces are the forces of mother nature which the bird act on the bird. We assume that the bird does not need to spend energy to generate these forces, and also cannot have any direct control over them. While there are many such forces, we seek to model only the major ones(this selection is similar to what is done for modelling airplanes):

- **Gravity:** Gravity is perhaps the simplest yet most significant force to model. The concept of flight is fascinating essentially since it seems to overcome gravity.
- **Buoyancy:** Buoyancy may not be too important in air, but it is extremely easy to adjust within gravity. It can become significant for birds with very low density, so it cannot harm to model it.
- **Lift:** The lift force is the main contributor towards overcoming gravity. In fact the bird can maintain its altitude only if the sum of Lift and Buoyancy is same as Gravity.
- **Drag:** The drag force arises due to air resistance which tries to prevent the motion of any body travelling through a fluid. But for this force, the bird could keep flying without applying any effort.

Birds, unlike airplanes can flap their wings in order to generate upward force. This force is more like a buoyant force, but needs the bird to spend energy to

get it and can also control its magnitude to some extent. Therefore, we do not include it here.

2.2 Internal Forces

Once the external forces have been decided, the bird may decide to fly in a certain direction. It is somewhat misleading to call this decision a force, these are actually factors based on which the bird decides what kind of force to apply on itself(actually the bird applies the force on the environment and it gets it force by Newtons Third Law). These, however are all vector quantities and it is rather intuitive to consider them as components of the net force that the bird applies.

In the current model, we consider three forces, which are commonly used to simulate flocking behaviour:

- **Cohesion:** The cohesive force is the attractive force that a bird experiences towards other members of the flock. It ensures that the flock stays together and does not start moving in random directions.
- **Separation:** The separative force acts opposite to the cohesive force and ensures that the birds keep a minimum distance between them and don't start colliding with each other
- **Alignment:** This force tries to coordinate the direction of motion of the entire flock. Each bird has the urge to fly in the same direction as its neighbours.

The above mentioned factors present a somewhat idealistic view of how a certain bird desires to fly. However, there are other factors effecting how the bird really flies.

To start off, a bird is not likely to know about another bird which is flying right behind it. In fact, it can only see those birds which are in its **field of view**, ie the maximum angle from its line of motion which it can see. This is actually quit large for birds since they have eyes on the sides of their heads. Further, two birds which are far off from each other are less likely to affect each other than two birds that are close by. This phenomenon is modelled by the (near)**sightedness** of the bird. Finally, some birds may be more **adventurous** than others, giving them urges to fly off in random directions rather than those specified by the above forces.

Finally, a bird can apply only a limited amount of force, in which it would try to overcome the External forces and move in its desired direction. This limit would be determined both by an overall **maximum acceleration** andthe individual **strength** of the bird.