A Flock of Crows, How Scarce Resources Affect Group Behavior and the Effects of Personalities and Strategy Influence Distribution Patterns

Travis Scrimshaw
Department of Mathematics
tscrim@ucdavis.edu

The flocking of birds has been a focus of study for many years and results from such have lead to many innovations in the computer animation industry, the primary example is Boids by Craig Reynolds. Yet I see more potential in studying the different aspects of flocks, such as feeding patterns and different behaviors, then applying this to real life scenarios. By studying the way these birds move and react based upon a few parameters, I hope to use the information to create a simpler model for how countries of the world interact and quantifying reasons. A few birds flying around trying to eat should translate into how human beings move around trying to feed all of their interests.

Introduction:

I pulled into the gas station and could only shake my head as I looked at the gas prices, getting so high up that I can barely make payments of everything which I need: food, bills, etc. So I got to thinking what made these prices keep going up and up, and despite my cynical nature, instead of just merely attributing it to price gauging, I remembered the price of crude oil kept on going up, and one of the reasons for having an active presence in the Middle East is to remove our dependence on foreign oil. I could only but wonder what allowed the U.S. to move so aggressively against the world.

I knew trying to model the strategy, politics, and internal workings of the individual countries of the world would be a nearly impossible task so I had to think of a simpler model which to then extrapolate upon to how the countries of the world go after the scarce resources of the world. I had remembered the Boids which someone had referenced me to while trying to develop a simple AI system, which made my think of using that premise and birds going after food as my model.

Understanding the reasoning behind the thought process of countries, and how this affects warfare and international politics is a key issue in today's economy. This knowledge could have a profound impact to change how the countries operate in an effort to reduce the prices of goods and help ensure a stable and peaceful world. This project was also interesting for me on a development level because I enjoy programming, specifically Artificial Intelligence, and applying mathematics to many different systems.

I wanted to have my birds not only act on basic instincts such as hunger and aggression, but to develop strategies and relationships with others in the flock to try and overall improve their chances of becoming fully fed. The basic instincts were to go towards their target, the feeder, which had only finite perches normally less than the number of birds, and then avoid other birds in their vicinity, but how much depended upon their aggression factor.

However, the overall scope of my project was too much for my time which I could work on the coding and all I was able to develop were the basic instincts. In my initial trials during development, I came upon another use of my model, which was modeling simple chemical compounds, such as methane (CH_4) because as I was trying different birds, but hadn't included how hunger and aggression affected their behaviors. Yet once I included these aspects and adjusted the equations, I was able to get the birds to feed and return to an orbit distance waiting to feed again.

Background:

The basic instincts which my birds operate is based upon two factors, a desire to go towards the feeder which the strength of this desire is relative to the amount of hunger the bird currently has; the other desire they have is to avoid the other birds which is inversely proportional to the amount of aggression of the bird. There are various other parameters which were initially built into the system that due to modifying the program to get certain characteristics to work became obsolete and others were never used because I did not have time to implement them.

Dynamical System:

Summing over all birds, vectors which a bird avoids others

tempVec= Current_Position – Other_Bird_Position
Avoidance = tempVec / ((1 + 4 * aggression)*(tempVec_Length – Other_Bird_Size*.6))

Target_Directon = (Current_Position – Feeder_Position)*(hunger + .5)

Move_Direction = Sum_Avoidance + Target_Direction
Move_Direction could never be more than the max speed

New_Velocity = Current_Velocity + Move_Direction

New_Position = Current_Position + New_Velocity * timestep

Method:

The basic method I used to study was by using Visual Python and using spheres to show the size of the birds and the feeder using colors blue and red respectively, as well as having lines representing the pathways which they had traveled, and when the bird had been fed completely (its hunger was 0), then turn it's sphere color to green. The other alternative that I had encoded was more statistical instead of continuous time was by defining how long for the simulation to run and then by displaying the hunger of birds through a separate menu command. It was this time based simulation was what I used as my primary method to study my dynamical system.

Results:

When I had equal amounts of hunger that was equal, no fluctuation, as well as aggression being all 0's as well, I had the same system as I started with in the alpha stages of building my simulation, which modeled the states of simple chemical compounds and mapped out their symmetries, showing the principle behind the VSEPR theory (Valence Shell Electron Pair Repulsion) to be valid, as the "molecules" moved to the maximum distance and retained this equal separation in low "molecule" system, 4 "molecules" is when the system always reaches various equilibria. This also is sufficient to explain the various structures and symmetries which occur in these chemical compounds because in the 4 "molecule" systems, I had all of the "molecules" either reach a vibration around a constant state up to none of the molecules coming to any cycle.

Regardless, with all aggression and hunger variables in complete randomness, shells formed as the simulation ran for long amounts of time, the outermost was composed of those birds whose hunger and aggression were high enough to have them force their way into the feeder to remove their hunger. Even just with one of the two primary variables varying between the birds, some of the birds were able to force their way into the feeder and eat.

Conclusion:

I was not able to complete nearly what I had originally set out to do as far as behavioral modeling, forming groups, and strategy building. However, I had multiple of bugs in my system which I could not work out, such as the near instantaneous feeding

time, which one major roadblock being that I could not get proper self-modifying code, but I managed to get a workable system to extrapolate data from. The chemical molecule model could prove useful in future applications, but there many more things which I want to expand upon, such as multiple feeders and choosing different goals.

As far as applying the data gathered from the simulation tool which I had developed helped me comprehend why some things happen in the way they do in this world. How people who are desperate enough and aggressive enough will be able to get away with the resources which they because they lack the fear which keeps away the other people.

Reference:

http://www.red3d.com/cwr/boids/ "Boids (Flocks, Herds, and Schools: a Distributed Behavioral Model)", Craig Reynolds