Indian Institute of Technology, Delhi

Design Practices in Computer Science

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Starling Simulation

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ABSTRACT

We are going to design and implement a Starling Simulation that will help us understand the Flocking behaviour of birds. Computer Science term for this simulation is Boids.

The simulation software will have the following functionalities:

1. We will be able to interactively input or read from a file :
   - Degree of Seperation, Cohesion, Alignment.
   - Speed of boids .
2. We can interactively add / remove *boids and obstacles* based on combination of inputs from keyboard and mouse.
3. Get the color of boids based by grouping on speed, flock, direction .
4. Calcuate and display average Velocity and Accleration vector of boid groups and global flock dynamically.
5. Calcuate and display average Kinetic Energy of boid groups and global flock dynamically.

Future scope of the problem may include:

1. Interactively control the Gravity vector and see it's effect on the flock .
2. Adding and measuring the effect of Wind speed / direction and Drag on the flock .

In this design project, we shall work as observers, developers and algorithm enthusiasts to understand the ways and finding different means to approach and tackle the objectives in a more well defined mathematical way.

We shall work with full confidence and zeal to achieve the goal or reach to quite an end of the problem so that using our lemmas, proofs and knowledge, someday a perfect model can be implemented using a software by some other Computer Explorer. As a matter of interest, we just wish to argue that these things can be computed by our brain so we do hope to find a solution to this problem using machine learning algorithms. Since, Machine Learning algorithms are more or less based on Mathematical matrices, with the use of computer graphics, we expect to find a start with matrices that we have dealt with further in this report.

Contents

Chapter 1

Introduction

Boids is an artificial life program, developed by Craig Reynolds in 1986, which simulates the flocking behaviour of birds. His paper on this topic was published in 1987 in the proceedings of the ACM SIGGRAPH con- ference. The name boid corresponds to a shortened version of bird-oid object, which refers to a bird-like object.
As with most artificial life simulations, Boids is an example of emergent behavior; that is, the complexity of Boids arises from the interaction of individual agents (the boids, in this case) adhering to a set of simple rules.
Baseline Rules

The following objectives are aimed to be discussed in this paper:

- Defining the problem.
- Discussing how a simulation is modeled, what are the diffrent padigrams.
- What set of rules govern bird in flocks.
- What model is to be adopted for interplay of starlings with the environment.
- What parameters can be varied to see interesting patterns.
- Intresting Obeservations on varying diffrent parameters in simulation.
- Processing Software

Chapter 2

Defining the problem

2.1 Introduction

2.1.1 Why do we care about bird flocking patterns ?

2.2 How do we study them ?

Chapter 3

Modelling a Simulation

3.1 Introduction

Simulation is the imitation of the operation of a real-world process or system. The act of simulating something first requires that a model be developed; this model represents the key characteristics, behaviors and functions of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.
Simulation is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, and video games. Often, computer experiments are used to study simulation models. Simulation is also used with scientific modelling of natural systems or human systems to gain insight into their functioning, as in economics. Simulation can be used to show the eventual real effects of alternative conditions and courses of action. Simulation is also used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist.
Key issues in simulation include acquisition of valid source information about the relevant selection of key characteristics and behaviours, the use of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation outcomes. Procedures and protocols for model verification and validation are an ongoing field of academic study, refinement, research and development in simulations technology or

practice, particularly in the field of computer simulation.

3.1.1 What's a Computer Simulation ?

A computer simulation (or "sim") is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works. By changing variables in the simulation, predictions may be made about the behaviour of the system. It is a tool to virtually investigate the behaviour of the system under study.
Computer simulation has become a useful part of modeling many natural systems in physics, chemistry and biology, and human systems in economics and social science (e.g., computational sociology) as well as in engineering to gain insight into the operation of those systems. A good example of the usefulness of using computers to simulate can be found in the field of network traffic simulation. In such simulations, the model behaviour will change each simulation according to the set of initial parameters assumed for the environment.
Traditionally, the formal modeling of systems has been via a mathematical model, which attempts to find analytical solutions enabling the prediction of the behaviour of the system from a set of parameters and initial conditions. Computer simulation is often used as an adjunct to, or substitution for, modeling systems for which simple closed form analytic solutions are not possible. There are many different types of computer simulation, the common feature they all share is the attempt to generate a sample of representative scenarios for a model in which a complete enumeration of all possible states would be prohibitive or impossible.
Several software packages exist for running computer-based simulation modeling (e.g. Monte Carlo simulation, stochastic modeling, multimethod modeling) that makes all the modeling almost effortless. Modern usage of the term "computer simulation" may encompass virtually any computer-based representation.

3.2 Input Output to simulations

3.2.1 Input

- Body Tracking.

- Physical Controllers.
- Sound Recognition

3.2.2 Output

- Visual display
- Aural display
- Haptic display
- Vestibular display

So in our starling simluation we are taking interactive user input Physical Contoller : Keyboard and Mouse and computing dynamically the parameters and enviroment changes, then showing results Like starling speed, energy-expenditure, Friend circl etc directly to the user.

3.3 Types of Simulation

3.3.1 Key Aspects

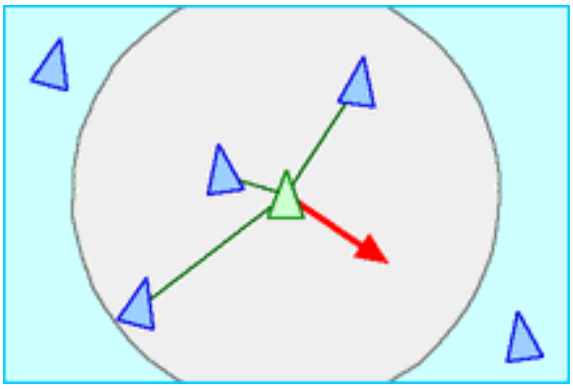
Chapter 4

Flocking Rules

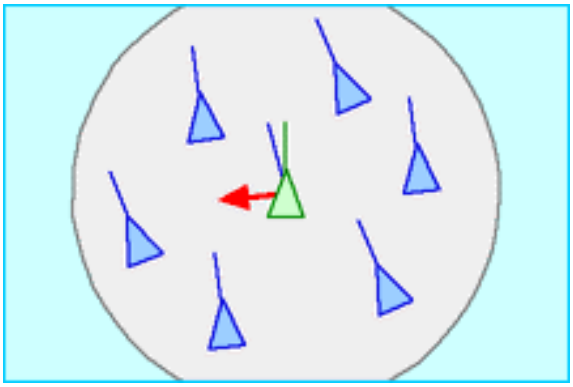
4.1 Baseline

The rules applied in the simplest Boids world are as follows:

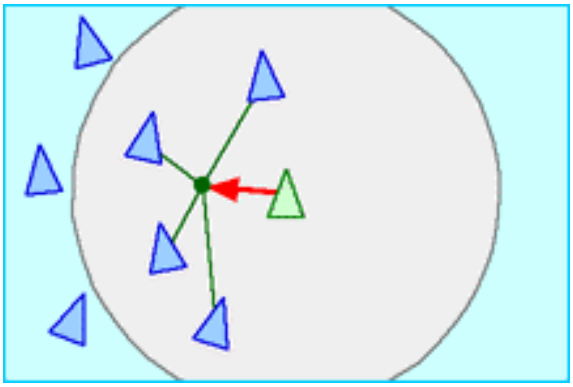
- ***Seperation*** : Steer to avoid crowding of local flockmates



- ***Alignment*** : Steer towards the average heading of local flockmates.



- ***Cohesion*** : Steer to move toward the average position (Center of Mass) of local flockmates.



4.2 Additional Behaviour

More complex rules can be added, such as:-

- Obstacle avoidance: Avoiding the obstackles
- Goal Seeking: Starlings actively move towards a specifically designed object and after reaching there, do a predefined behavior like encirclement.
- Alone Behaviour : What does a starling do when it's alone, and not part of a group.

- Wind Behaviour : What do the starlings do as a group when the wind blows in a particular direction.
- Speed Regulation : The speed of starlings should be regulated as a group.

Chapter 5

Environment Parameters

5.1 Parameters varied in Software

Here is a list of parameters which we have dynamically varied in out simlulation.

- Placing Obstacles : Circular, Rectangular.
- Placing Starlings : Place Single or as a Batch. At a point or randomized .
- Removal : Erasing the unwanted starlings and obstacles, part by part or as a whole group by certain key presses .
- Selection : Selecting a starling to observe it's dynamic group parameters like Speed, Kinetic Energy, Friends in group.
- Graph : We can view the connections in a graph , an edge representing that two starlings are friends.
- Interactions : We can toggle the interactions between the starling to see the results of graph.
- Wind Simulation : Add wind in a particular direction and observe how the starlings fly with/against the wind, in the flock/alone.
- Obstacle Avoidance : We can toggle obstacle avoidance on or off and according to it , starlings will pay heed to the obstacles .

- Alignment : We can toggle flock alignment on or off and according to it , starlings will run streamlined or randomly.
- Noise : We can toggle noise on or off and according to it , starlings will run with some randomeness or completly in harmony.
- Cohesion Radius : We can mannualy vary the cohesion radius in between the starlings and see what effect does it have on the intra and inter group distance and other starling realtions.
- Seperation Radius : We can mannualy vary the seperation radius in between the starlings and see what effect does it have on the intra and inter group distance and other starling realtions.
- Speed : Changing the max speed capacity of starlings, and observing at what flock conditions is it reached.

Note :- Press H to get exact keys and full Legend in the Software.

5.2 Observations

- A starling alone cannot reach the maximum speed capacity and in real starling groups this is often the case.

Chapter 6

Processing Software

6.1 How does it work?

How does it work ? How does it handle threading ? Explicit / Implicit / Automatic multi threading ? Arduion loops ?

Chapter 7

Conclusion

After this simulation we learn a lot about starling behaviour and had the chance to observe different behaviour of starlings in different environments.