Flocks, Herds, and Schools : A Distributed Behavioural Model

Contribution

* Simulation as alternative to scripting the path of each bird individually
* The simulated group (flock) is an elaboration of the system’s parts (simulated birds)
* Ensure that obstacles, collisions and predators are avoided
* Simulation related to particle systems such as fire, clouds, smoke, etc.
* Flock model is sub-object system of particle system
* Boids and flocks behaviours are rules or programs
* Boids objects and their flying paths identical to the 3D turtles
* Boids have desire to stay close but avoid collision with flock mates
* Paper provides visual representation of the boids
* Parameters of the flock simulation can be changed by the animator to achieve variations of the flock-like behaviour

Framework

Use-Case

* Actor - each simulated bird that navigates according to its understanding of the environment
* Rules of motions and behaviours are inputted by the animator
* Each bird interacts with its neighbours
* Consider bird’s flying speed
* The whole flock of birds is to move in directions that ignore obstacles, predators and collisions
* The flock is a result of the birds interacting among each other and the behavioural rules
* Flock motion is aggregated results of the combined individual bird actions each behaving based on its own understanding of the world
* Actor - virtual computer communicates with other virtual computers by passing messages

Tools / Techniques

* Animation
* Computer graphics portrayal
* Control Structure – simulations of the portions of the bird’s understanding mechanism and features of the aerodynamic flight
* Build instances of simulated bird model and let them interact with one another, as this will create a flock
* The Force Field Animation System different to Build instances of simulated bird model interaction
* Animator is actually meta-animator – designer of behaviour
* There are cased where boids have mind of their own causing for uncooperative flocks
* Geometric database that consists of position, orientation and velocity of all objects in the environment
* When flocks change direction the boids do so in synchronisation
* User-supplied software invocation frame by frame
* Flocks directions changes could be thought of as shock wave as this does not happen simultaneously but starts with a single boid and spreads to the others
* Collision avoidance for polyhedral obstacles is being developed
* Boids software developed in Symbolics Common Lisp and Flavours – object oriented extensions

Theories

* Flock is a result of the combined interaction of the behaviours of the individual birds
* Computer animation models character’s properties
* Character based animation models behaviour – learn as much as possible about characters actions, motions and emotional interactions
* By birds building bigger flocks and creating traffic jams help survival from predators
* A bird is normally interested in itself, nearest neighbours (centering) and the rest of the flock
* Boid perception model is ad-hoc and avoids simulating vision – boids have limited vision (only 10 – 15 degrees due to zone overlap from both eyes), so if they could get better visualisation of the environment, they could plan their paths better
* When simulation first starts flock’s first reaction is reaction to initial conditions – i.e. analyse whether too close to one another or distant
* Smaller flocks tend to join together to make bigger flock and big flocks can split to smaller ones
* Pass global position parameter to flock which is then passed to each boid to alter their position
* Boid need to realise where it is flying towards : if a wall, then ensure that boid does not hit it and need to fly in the opposite direction ; if along side a wall, then wall can be ignored
* Flocks can be thought of as cars on motor way

Critic

* Paper way too long for the points made – author repeats the same issues about speed, collision avoidance, distance from neighbours, centering and obstacles (environmental and position compared to flock mates) avoidance way too many times in different words but actually referring to the same theory repeatedly
* References to other groups such as humans and fish is mentioned but not discussed in detail and compared to the birds flock in proportion
* Boids behaviours is more complicated (for the flock to be correct due to strong interactions) vs. particles (as particles do not interact with one another) – this assumption might not always be correct for all particle systems !
* Particles do not rely on external state whereas boids rely on both internal and external state – assumption might not be correct for all particle systems !
* Boid minimum flying speed defaults to zero – I would say use, greater than 0 because 0 is non-movement
* Gravity is considered in flock modelling but not in detail and weather conditions not at all - those could affect the flocks behaviour results completely
* Simulation of boids and flocks does not take into consideration real life living birds needs such as tiredness, hunger, fear of predators etc.
* Flock centre relates to being surrounded by a few birds – the paper says as long as individual boid stays close to its neighbours, it does not care in case the rest of the flocks flies away. But what about the ones in the boundaries ?
* The mathematical references in the article appear only in the second half, i.e. too late and therefore overwhelm reader
* Paper mentions that a boid can be taught to navigate independently – but the whole point of the simulation is to study boids interaction and simulate their behaviour as flock. Thus, paper addresses irrelevant points.

New Terminology

* Control Structure
* Force Field
* Phase Portrait in the force field
* Rejection forces surrounding birds
* Particle System – dynamic fuzzy (noisy) object each having own behaviour and characteristics of creation, age and death which each state can change during lifetime
* Geometric flight – motion along a path in a 3D space

Citations

Maciejewski, A. A., Klein, C. A., "Obstacle Avoidance for Kinematically Redundant Manipulators in Dynamically Varying Environments," to appear in International Journal of Robotic Research (745 citations)

Moon, D. A., "Object-oriented Programming with Flavors," in Proceedings of the First Annual Conference on Object-Oriented Programming Systems, Languages, and Applications, ACM, 1986. (473 citations)

Reynolds. C. W., "Computer Animation with Scripts and Actors," Computer Graphics, V16 #3, July 1982, (acm SIGGRAPH `82 Proceedings), pp. 289-296 (278 citations)