Swarm-PI System Overview

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**Overview**:

I. Directory Structure

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**I. Directory Structure**

**Max Patch Files:**

*ControlPanel\_XX-XX.maxpat* – This file contains the Max simulation and contains everything necessary to run the simulation, including the external jitter (which is what we coded) object that is used in the simulation. Instructions on running the simulation can be found in this file in Presentation Mode. For more information about the external object, refer to *jit.boids3d.mxo* under the Other section of Directory Structure.

*FlockParamUI\_XX-XX.maxpat* - This is a max patch that is embedded in the *ControlPanel* patch. Contains the number fields for all the parameters of a flock and packages when a parameter is changed in the Control Panel so it can be sent to the external object. (i.e. Changing the speed of the first flock to 5.0 would produce the message: 'speed 5.0 1', where 5.0 is the new speed for this flock, and 1 is the flock whose speed will be updated.)

**Code:**

*XX-XX\_Code* - This directory contains the code for the jitter external, *jit.boids3d.mxo*, which performs updates to the boids. Opening *jit.boids3d.xcodeproj* will allow you to make changes to the code which can then be compiled into a new external (For compilation instructions, refer to the User Manual in the *Help/* directory)

*Dependencies* - This directory contains various Jitter and Max header files that are required to compile the external. This directory should remain unchanged.

**Help Files:**

*Help ­-* Contains various instructions and help files that are useful for running and understanding the simulation and external object.

*README.md* - A markdown file for GitHub containing general information about anticipated future work.

**Other:**

*jit.boids3d.mxo* - The compiled jitter external object from the code in the *XX-XX\_Code* directory. This file is used in the Control Panel to perform updates on the boids. This is recognized as a Max object in Max, and behaves the same as all Max objects. For more information on how to interact with the object, refer to **Section V: External Outlets**

*paramPreset.json* - A JSON object containing preset flock behaviors. Interacting with this file is not necessary, it is automatically loaded into the presets section of the Control Panel upon startup and presets can be saved within the Control Panel.

**II. Jitter External Data Structures**

This section contains info about the data structures used in the *jit.boids3d.mxo* object. This code can be found in the XCode project in the *XX-XX\_Code/* directory. It is coded in C.

**Flock Parameters:**

The flock-specific parameters for the flocks are stored in arrays of size 6 (an index for each flock) in the jitter object struct.

Example Code:

typedef struct \_jit\_boids3d

{

double minspeed[MAX\_FLOCKS]

double maxspeed[MAX\_FLOCKS]

...

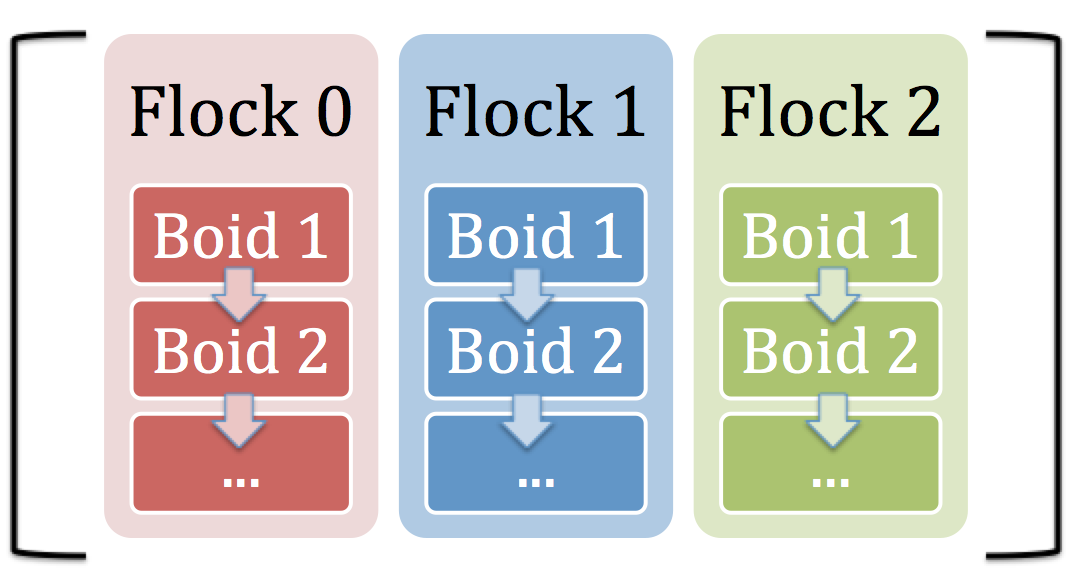
}

Note: the constant MAX\_FLOCKS is set to 6

**Boids:**

Boids are individual structs that are stored in a linked list for each flock. A linked list was used because this allows boids to be added and deleted quickly without the overhead of creating a new array of appropriate size and copying the boids over every time the count changes.

The linked lists for each flock are stored in an array of size 6 (an index for each flock). Refer to Fig. 1 for the organization of flocks/boids.



**flockPtr flockLL[MAX\_FLOCKS] =**

**Fig. 1: Organization of the boids linked lists**

The boids struct contains the following data about a boid:

- Flock ID (which flock this boid is a part of)

- Age (int, in timesteps)

- Old Position (double[3], xyz)

- New Position (double[3], xyz)

- Old Direction (double[3], xyz)

- New Direction (double[3], xyz)

- Speed (double)

- Neighbors (long[kMaxNeighbors])

- Neighbor Distance Squared (double[kMaxNeighbors])

- Pointer to the next boid in the flock

**Attractors:**

Attractors are also structs which are stored in a linked list (called attractorLL) in the \_jit\_boid3d object. The attractors serve as points to which the boids are attracted based on two factors: their flocks’ “attract” value and the attractor’s radius value. The attractor struct contains the following:

- Attractor ID (int)

- Location of the attractor (double[3], xyz)

- Radius of the attractor (note: this is called attractorRadius)

- Pointer to the next attractor in the LL

**Neighborhood Lines:**

Neighborhood lines display the connections between boids within a neighborhood. All of the neighborhood lines (a maximum of kMaxNeighborLines lines) are stored in the array:

NeighborLinePtr neighborhoodConnections[kMaxNeighborLines];

Each neighbor line in this array is a struct that contains the following data:

- Position of the first boid (float[3], xyz) - this is an endpoint of the line

- Position of the second boid (float[3], xyz) - this is the other endpoint

- Flock ID - neighborhood lines are only drawn between boids of same flock

**Other:**

- Birth location, which is where boids appear when the simulation begins or the population is increased, is stored in an array - double birthLoc[3]

- The center point of the current flock being updated is stored in an array - double tempCenterPt[3]

- The boundaries of the simulation are stored in an array - double flyrect[6]

**III. General Code Structure**

Note: The external object is primarily coded in C, but contains some code that is used to communicate with Max that is similar to C.

**1. Lines 0-375: Global variables, structs, and function definitions**

This section contains code for the above components. It also contains the initializer for the \_jit\_boids3d object which is called on startup and initializes all of its attribute methods

**2. Lines 375-725: Boids attribute methods**

This section contains all the attribute methods for the external. When a message is passed to the external to change a parameter, the cooresponding attribute method in this section is called, which then updates the global variable for this parameter stored in Section 1.

**3. Lines 725-990: Matrix output methods**

After every timestep, these methods are called to prepare the matricies that will be outputted in the 4 outlets of the external object back to the Max Patch.

jit\_boids3d\_matrix\_calc(): Prepares the matricies, populates matricies 2-4 with data, and outputs all of them to the max patch.

jit\_boids3d\_calculate\_ndim(): Called by the matrix\_calc method, populates the 1st matrix with data

For more information on the contents of each matrix going back to the Max Patch, refer to *Help/Swarm-PI\_Parameters.docx*

**4. Lines 990-1445: Boid update methods**

These lines contain all the functions that are used to update each boids direction and position every timestep.

FlightStep(): Calculates the new velocity and position of each boid. Calls the other methods in this section to get each component of the boids new velocity

**5. Lines 1445-end: Memory management methods**

Methods in this section are intializers for the various structs and objects in the external. Allocation and freeing of memory for all of these objects occurs in this section.

**V. External Outlets**

Outlets are used to send information from the external object to the Max patcher so the simulation can be visualized. The contents of each outlet is the following:

**Outlet #1 - Boid Info Matrix**

Note: The dimensions of this matrix and its contents depend on the mode, which is documented in the max patch. This is what the planes are for Mode 0:

Plane 0 - X position

Plane 1 - Y position

Plane 2 - Z position

Plane 3 - Flock ID

**Outlet #2: Boid Counts**

Outputs the number of boids in each flock (one per plane)

**Outlet #3: Attractor Info**

Format:

Plane 0 - X position

Plane 1 - Y position

Plane 2 - Z position

Plane 3 - Attractor ID

Plane 4 - Attractor Strength

**Outlet #4: Matrix with lines connecting neighboring boids**

Format:

Plane 0 - boid1, X position

Plane 1 - boid1, Y position

Plane 2 - boid1, Z position

Plane 3 - boid2, X position

Plane 4 - boid2, Y position

Plane 5 - boid2, Z position

Plane 6 - Flock ID

Note: connecting lines are only drawn between boids of the same flock