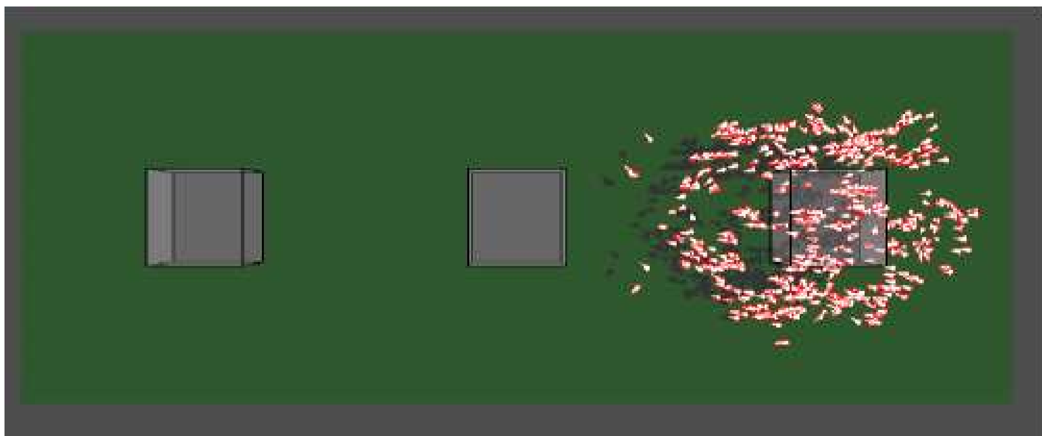
E.B.P.L. USER GUIDE AND LANGUAGE REFERENCE



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Chapter 1

Introduction

ebpl is a development environment for the production of animations using multiple Agents within a user-specified environment, additionally ebpl also allows for the production of particle systems with user programmable particles.

1.1 ebpl structure

The ebpl system is split into two parts, the AgentBrain programming language and the simulation environment. The Agents brain is programed using a simple script language which is compiled to an object file. This object file is then loaded into the Agent brain within the ebpl system with additional environment configuration handled by a separate script file.

1.2 BrainCompiler

The Brain compiler is used in the following way

```
BrainComp [SourceFile].bs [compiledfile].comp
```

Although the example above uses a .bs and .comp extension the compiler does not require any specific file names.

If the compilation is successful the compiler will report that everything is OK and save to a .comp

file. If there is an error the compiler will report the problem and what source line number the problem occurred on.

On occasion the program will hang, this is due to the parser getting stuck, to stop the compiler the **ctr + c** keys can be pressed to terminate the program. This error is usually due to a misplaced **;** in the source file.

1.3 ebpl program.

The ebpl program loads in an ebpl .fl script and runs the simulation. The .fl script is responsible for configuring the environment and the placement of the Agents within the environment.

The environment is responsible for containing all the Objects within the scene, as well as calling all of the Agent's brain routines as shown in Figure 1.1.

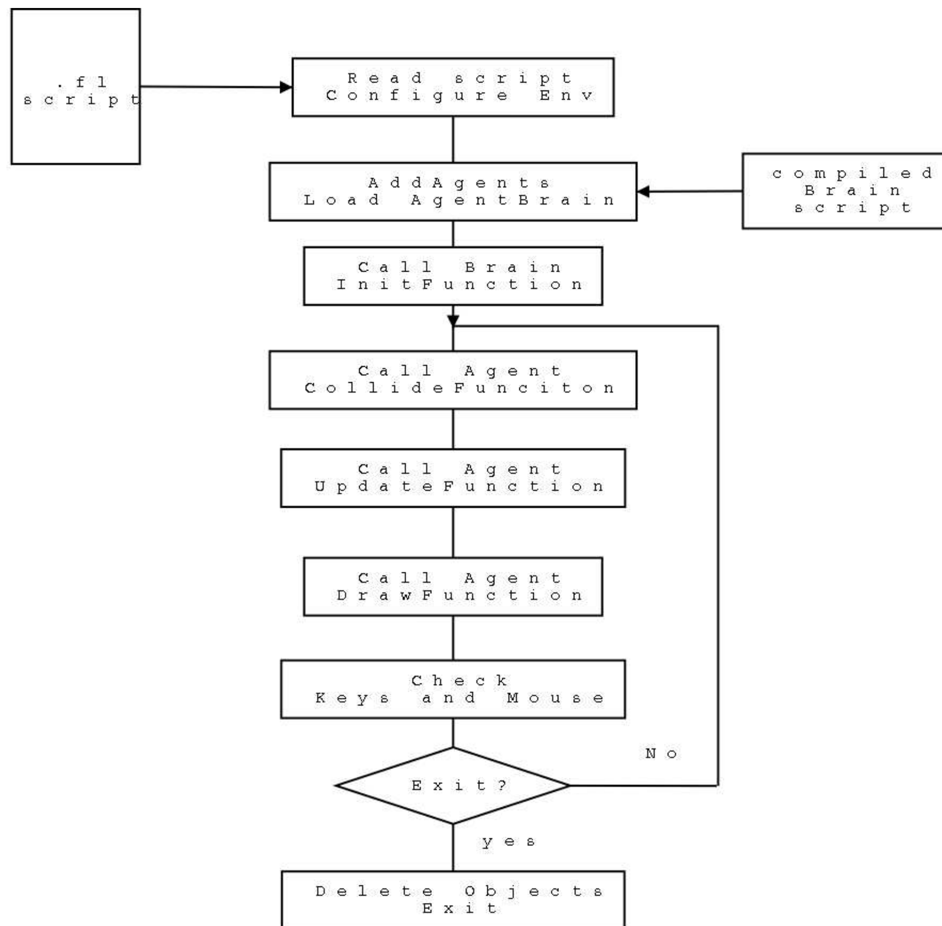


Figure 1.1: EBPL environment flow chart

1.4 Getting started

The following section shows a simple ebpl program to place and render 50 random spheres in the environment as shown in Figure 1.2.

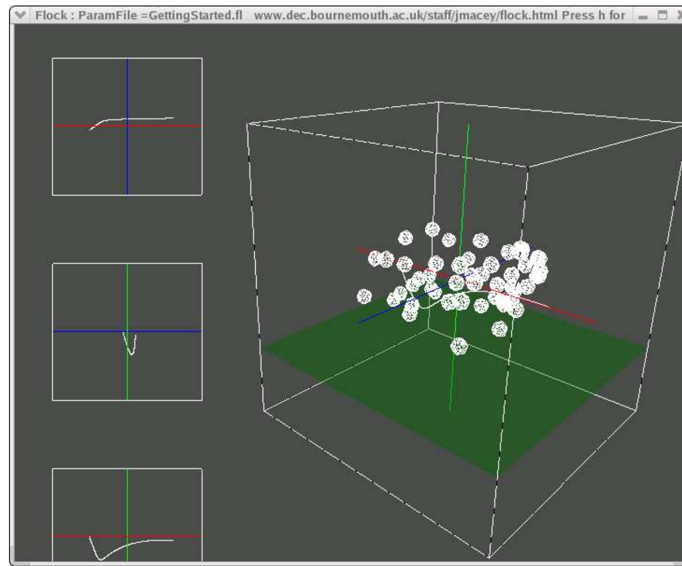


Figure 1.2: Getting Started 50 Random Spheres

The Agent brain for this simulation is shown in Program 1. When the *InitFunction* is called on the creation of the Agents brain the position of each of the Agents is calculated as a random number seeded with the value 20 10 20 for the x, y and z position.

The Agent is drawn using the *Sphere* opcode by first setting the colour using the *Colour* opcode then translating it to the random position using the *Translate* command.

Program 1: GettingStarted.bs 50 Random Spheres

```
// the Agents position
Point Pos=[0,0,0];
InitFunction
  // create a random position for the Sphere
  Randomize Pos 20 10 20;
End;
DrawFunction
 Colour 1.0 1.0 1.0
 // save the gl transformation matrix
 PushMatrix;
 // Translate to the Agents Position
    Translate Pos;
    // Draw a sphere of radius 2
    Sphere 2.0 8 8;
    // restore the gl transformation matrix
 PopMatrix;
End;
UpdateFunction
// do nothing
End;
CollideFunction
// do nothing
End ;
```

The script to configure the environment is detailed below. First the world bounding box is setup to be centered at 0,0,0 with a width height and depth of 80.

The *AgentEmitter* is then set to load the Agents with the *GettingStarted.comp* compiled brain script.

```
// Configure the bounding box for the simulation
WorldBBox 0 0 0 80.0 80.0 80.0 2 2 2 50
// specify the output file to read to
outputfile outfile.out
// create a camera to view the scene
Camera 0 80 40 0 0 0 0 1 0 800 660 45.0 1.33 0.1 450.0
// Create an emitter for the Agent with 50 Agents
AgentEmitter 0.0 0.0 0.0 50 0 0 0.0 0.0 0 0 GettingStarted.comp
// Specify a path
PathFollow 0 -20 0 2 -10 -30 -5 -20 1 -4 25 -2 -5
// Specify the ground plane
GroundPlane -20 0 0.4 0 0.5
```

1.4.1 Running the simulation.

To run the simulation first the brain script needs to be compiled as follows

```
BrainComp GettingStarted.bs GettingStarted.comp
```

Then the simulation is run by using the following commands

```
ebpl GettingStarted.fl
```

Chapter 2

ebpl Language

2.1 Agent Characteristics

The initial Agent is shown in the class diagram in Figure 2.1.

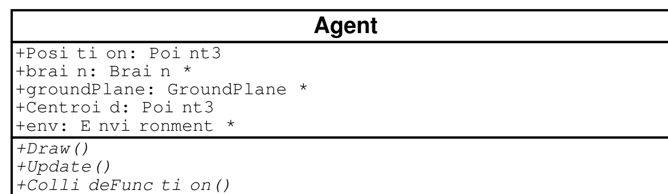


Figure 2.1: Agent Class Diagram.

The main element of the Agent is the brain. This is a separate class which contains the brains instructions as well as the "memory" for the agent. This will be discussed in more detail in Section 2.2.

All the Agents must also be aware of the *Environment* which is created within the main development system from the *.fl* script. This script is responsible for setting the number of Agents created, the volume of the environment, what objects live in the environment and any Terrain.

Although the system is designed to be flexible there are still a few built in variables for the Agent to allow quick access to environmental variables. The Position attribute allows the current Agents position to be stored. This may then be used to calculate the flock center within the main environment.

The current flock center (Centroid) is calculated as the average position of all the Agents in the Environment for each cycle of the system. Each Agent is then made aware of this. It is up to the user if these variables are used within a EBPL program and they do not actually have to be set.

2.2 Agent Brain

At the heart of the Agent brain is a series of Stacks and the Opcode interpretor. The main function of the Brain is to execute the opcodes and produce output. The basic structure of the brain is shown in Figure 2.2.

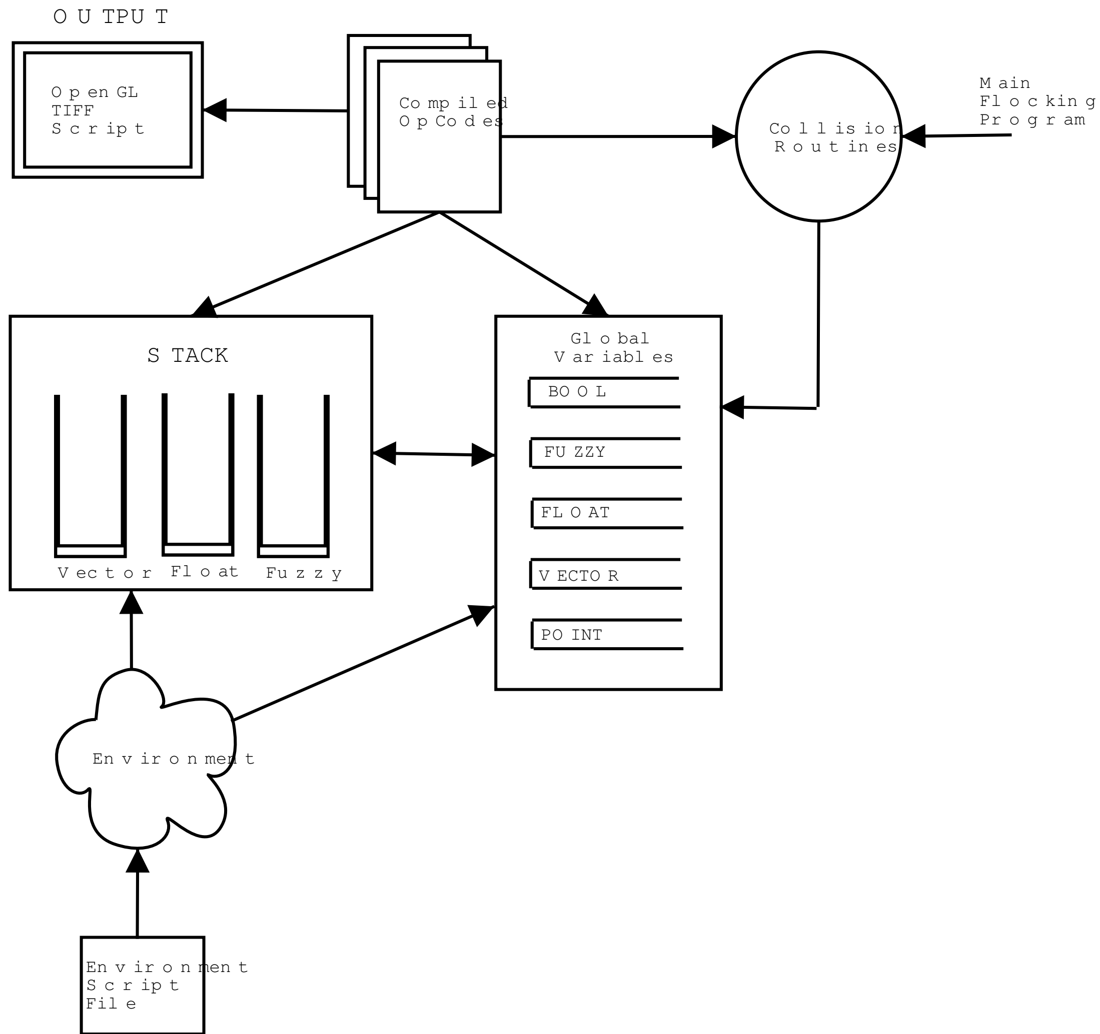


Figure 2.2: Agent Brain Structure

2.2.1 Brain Stacks

The Agent Brain has four built in stacks as follows :-

Float	A floating point stack.
Vector	A stack for operation on the Vector class.
Bool	A boolean stack.
Fuzzy	A stack for operation on the Fuzzy object class.

Unlike most interpretive languages EBPL operations are not entirely dependent upon the stack architecture. Most data types can be accessed, queried and modified directly, however some operation such as access to tuple data types still rely upon the stack. These stack operations are outlined in Section 2.3.1.

2.2.2 Global Variables

When the Brain is loaded the variables defined in the brain script file are loaded in the form of a Variable list. Each element of this list is a class called a VarObj as shown in Figure 2.3.

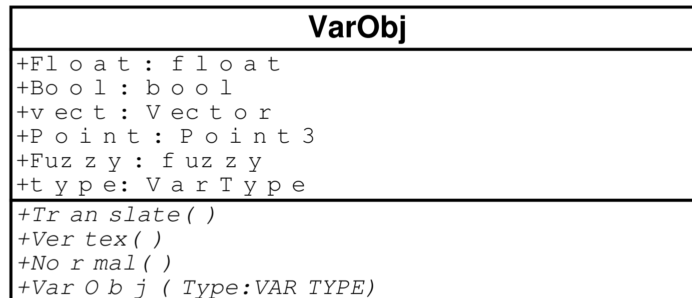


Figure 2.3: VarObj Class diagram

This object can assume any of the data type shown in Table 2.1 and has built in methods for specialist OpenGL functions such as Vertex, Normal and Translate. These OpenGL operations only execute for the Vector and Point classes.

2.2.3 Variables

At present five variable types are supported in EBPL, as shown in Table 2.1.

Variable Type	Description	Example
Float	A signed floating point value	Float CentroidWeight=50.0;
Bool	A boolean value	Bool HitAgent=false;
Vector	A four tuple vector class [x,y,z,w]	Vector Dir=[0,-1,0,0];
Point	A three tuple Cartesian point class [x,y,z]	Point Pos=[0,0,0];
Fuzzy	A full fuzzy logic class with fuzzy operators	Fuzzy NearAgent=0.2;

Table 2.1: EBPL variable types

The syntax of the variable definitions is tightly specified as shown in the Examples column of Table 2.1. All variables must be initialized when declared and all have global scope to the Brain. This means that all variables are available to all functions in the source file as well as accessible by other Agents.

2.2.4 Functions

EBPL has two types of Function these are built-in and user defined. There are 4 default built-in functions which must be present in every EBPL script. The user may additionally create any number of Functions within the program which act as procedure calls.

Built In Functions	Description
InitFunction	Called when the Agent brain is created and used to initialize variables etc.
UpdateFunction	Called every iteration of the system to update the Agents position
DrawFunction	Called every iteration of the system to Draw the Agent
CollideFunction	Called every iteration to do collision detection

Table 2.2: EBPL variable types

The built-in functions are shown in Table 7.1 and are called for every Agent in the system for each iteration of the environment.

User defined functions are generated by the *Function* keyword and can be called from within any of the main built-in functions.

2.2.5 Call Lists

Call lists are a way of creating switchable function calls depending upon an ordinal variable value similar to the C/C++ *switch* - *case* construct. The creation of a call list is a two stage process as follows :-

```
DefineCallList TestList;
CallListItem TestList foo;
CallListItem TestList bar;
```

First a call list name is defined to make storage for the Function pointers to be allocated to the list. Next list items may be added to the list. To use a CallList within a *Function* the following code is used

```
float ListValue=0;
// function foo called
CallList TestList ListValue;
AddD ListValue 1;
// Function bar called
CallList TestList ListValue;
```

2.3 EBPL language structure

The EBPL language is split into four distinct parts, these are

- Stack Based Operations.
- Variable Operations.
- Collisions.
- Drawing.

2.3.1 Stack Operations

Each stack has a series of opcodes which can access the stack data. The operations are based upon the stack data type and results from the operations are always placed back upon the stack. All stack operations are prefixed with the stack type name as shown in Table 2.3.

Operator Prefix	Description
F	*Float* stack operator pre-fix
FZ	*Fuzzy* stack operator pre-fix
B	*Boolean* stack operator pre-fix
V	*Vector* stack operator pre-fix

Table 2.3: Stack Operation Prefix

For example to push an element of a vector onto the floating point stack the following code would be used.

```
Vector Dir=[0,-1,0,0];
Fpush Dir y;
```

2.3.1.1 Float Stack Opcodes

The floating point stack operates in a First in Last Out principle, any operations on the stack use Reverse Polish Notation (RPN). For example 2+3 will be executed in the script by *Fpushd 3 Fpushd 2 Fadd* which will result in 5 being placed onto the top of the stack.

2.3.1.2 Fpush

The *Fpush* opcode pushes a floating value onto the stack. Any variable type may be pushed onto the stack, however with tuple data types the element of the tuple to be pushed must be specified as shown in the following example.

```
Fpush Pos x; // pushes the x component of the Point pos
Fpush yrot ; // pushes the float variable yrot;
Fpushd 10 ; // places 10 directly onto the stack
```

2.3.1.3 Fpop

The *Fpop* opcode takes the value from the top of the stack and places it into the variable, if a tuple data type is used the *x*,*y* or *z* destination must be specified.

```
Fpop ypos; // places the tos value into ypos
Fpop tempPos y; places the tos value into tempPos.y
```

2.3.1.4 Fadd

The *Fadd* opcode takes the top two values from the stack adds them and places the sum back onto the stack

2.3.1.5 Fsub

The *Fsub* opcode takes the top two value from the stack subtracts them and places the result back on the stack. Note if the stack contains 2 and 4 the result will be 2 - 4 = -2

2.3.1.6 Fmul

The *Fmul* opcode takes the two top values from the stack and multiplies them and places the product back on the stack.

2.3.1.7 Fdiv

The *Fdiv* opcode takes the two top values from the stack and divides them and places the result back on the stack. Division by 0 is trapped by changing any 0 value with a 1 (and printing a warning to the console in debug mode).

2.3.1.8 Fdup

The *Fdup* opcode takes the top of stack value and duplicates it.

2.3.1.9 Fsqrt

The *Fsqrt* opcode takes the top of stack value and places the square root of that value onto the stack.

2.3.1.10 Frad2Deg

The *Frad2deg* opcode is a helper function to convert radians to degrees as most C++ math operations use radians.

2.3.1.11 Fatan

The *Fatan* opcode takes the two top values from the stack and calculates the arc tangent. The code used is atan2(x,y) where X is the top of stack value and y is the next value.

2.3.1.12 Fsin

The *Fsin* opcode takes the top most value from the stack and puts back the sine of the value.

2.3.1.13 Fasin

The *Fasin* opcode takes the top most value from the stack and puts back the arc sine of the value.

2.3.1.14 Fcos

The *Fcos* opcode takes the top most value from the stack and puts back the cosine of the value.

2.3.1.15 Facos

The *Facos* opcode takes the top most value from the stack and puts back the arc cosine of the value

2.3.1.16 Fnegate

The *Fnegate* opcode takes the top most value from the stack and puts back the negated value.

2.3.1.17 FStackTrace

The *FStackTrace* opcode prints out the current contents of the stack.

2.3.2 Variable Operations

All variables within EBPL have global scope and can be accessed within any *Function*. They can be set directly or assigned a value based upon another variable.

The setting of individual tuple values can only be accomplished via the float stack as outlined in Section 2.3.1.

Variables may also be used in comparison *if* and *ifelse* operations. These may only be carried out with variables of the same type and relies upon the overloaded comparison operators of Point and Vector classes.

As the comparison of the operators >, >=, <, <=, is ambiguous for Points and Vectors they have be defined to work for all tuple values for example the Point >= operator is defined as

```
bool Point3 :: operator>=(Point3& v)
{
if(x>=v.x && y>=v.y && z>=v.z)
    return true;
else return false;
}
```

2.3.3 Variable Opcodes

Most variables can be accessed directly by the use of opcodes and values can be set and retrieved. The following section show the basics, full examples of all opcodes are shown in Section 7.11.

2.3.3.1 Add

The *Add* opcode works on any data type but care must be taken with the mixing of types. For example tuple data types can be added together easily but a tuple to float will cause problems.

```
Add Pos Dir; // add a point to a vector
Add yrot zrot; // add two float variables
```

2.3.3.2 AddD

The *AddD* opcode adds a value directly to a variable for example

```
AddD yrot 180.0;
```

2.3.3.3 Length

The *Length* opcode returns the length of a *Vector* or *Point* Variable onto the stack.

2.3.3.4 Normalize

The *Normalize* opcode normalizes the current Vector or Point Variable.

2.3.3.5 Randomize

The *Randomize* opcode sets the variable to a random value within a range based on the seed value passed.

The *RandomizePos* opcode only returns positive values.

```
Randomize Dir 2.1 0.1 1.1;
RandomizePos yrot 4.0;
```

2.3.3.6 Debug

The *Debug* opcode prints to the console the variable argument

```
Debug Pos;
```

The *DebugOpOn* and *DebugOpOff* enable and disable the printing of the current opcode name to the console.

2.3.4 Collisions

Each time the system is updated the Brain's *CollideFunction* is called. This is the only time within an EBPL program that the an Agent can access another Agent's data.

Within the ebpl system all Agents are contained within a number of bins (see Section **??**. for more details). It is possible to loop through the Agents within the bins and test for collisions. This is implemented using the *LoopBin* EBPL function.

Whenever the *LoopBin* structure is encountered the current Agent value is used and the rest of the Agents within the bin are compared with the current Agent.

For convenience and speed EBPL has two built-in collision detection routines, however these and others may also be implemented within the EBPL language itself. These routines take as parameters variables from the EBPL script.

2.3.4.1 SphereSphereCollision

The *SphereSphereCollision* opcode takes five parameters as outlined below

```
SphereSphereCollision bool Hit Point3 Pos1 float Rad1
                              Point3 Pos2 float Rad2 ;
```

The collision detection is calculated using the Position of the Current Agent and any other Agents in the current lattice bin. Each Agent has a Radius for the bounding sphere and if the spheres collide the *Hit* flag will be set to true.

2.3.4.2 CylinderCylinderCollision

The *CylinderCylinderCollision* opcode takes seven parameters as outlined below

```
CylinderCylinderCollision bool Hit Point3 Pos1 float Rad1 float Height1
                          Point3 Pos2 float Rad2 float Height2;
```

The collision detection is calculated using the Position of the Current Agent and any other Agents in the current lattice bin. Each Agent has a Radius and Height for the bounding cylinder and if the cylinders collide the *Hit* flag will be set to true.

2.3.5 Environment Collisions

Collisions with objects within the environment are processed by two built-in functions. At present only *Planes* and *Cubes* are supported.

2.3.5.1 Env Object Collisions

EnvObjects as shown in Figure 2.4. are represented as a cube with a bounding sphere. When the *SphereEnvObjectCollision* Opcode is used the parameters passed to the routine are checked against all of the *EnvObjects* contained within the environment.

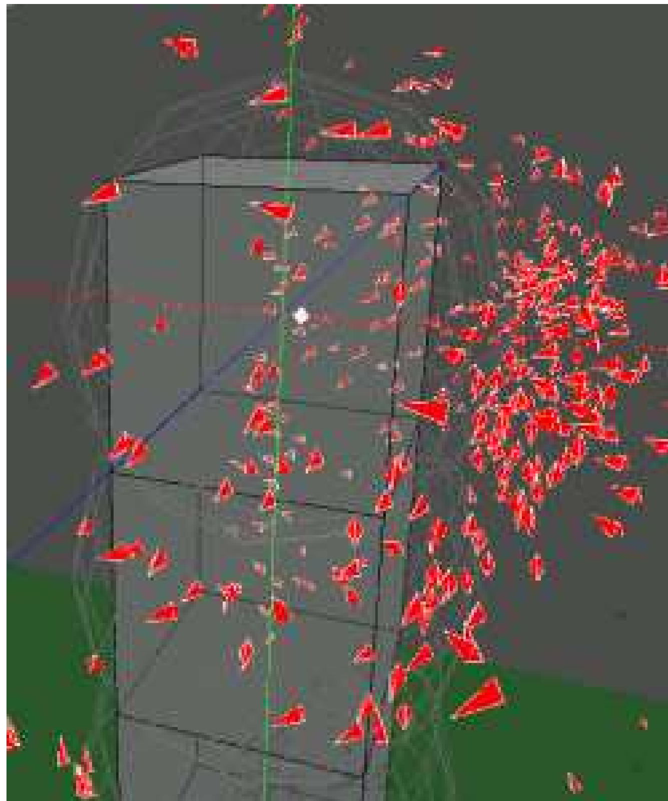


Figure 2.4: Agents avoiding an EnvObj

Detection of collision with *EnvObjects* is a two stage process, first the Agent is tested using Sphere-Sphere collision as shown in Section 7.3.0.1. to determine if the Object has been hit. Next Sphere Plane collision as shown in Section **??**. is used to determine which face of the object has been hit. At present the Normal of this face is returned to the Agent and collision avoidance is calculated on this value.

2.3.5.2 EnvObject Example

EnvObj's are added to the environment using the following *.fl* script.

```
EnvObj float Pos.x float Pos.y  float Pos.z
       float Width float Height float Depth
       float Radius
```

The radius parameter is used to determine the bounding sphere of the object for the collision detection used in the *SphereEnvObjCollision* opcode.

The *SphereEnvObjCollision* opcode takes four parameters as outlined below

```
SphereEnvObjCollision bool Hit Point3 Pos
                      float Radius2 Vector Normal;
```

The collision detection is calculated using the Position of the Current Agent and its bounding sphere Radius, each EnvObject is tested in turn against the Agent and if a hit is detected the *Hit* flag is set to true and the Normal to the face hit is returned in the *Normal* parameter.

2.3.6 Structure Opcodes

The structure opcodes are used to define and call functions and make decisions.

2.3.6.1 Function

The *Function* Opcode defines the beginning of a function block. It must be terminated by use of an *End* opcode as shown below

```
Function CalcAngle
 Fpush yrot;
 Fpop yrot;
End;
```

2.3.6.2 Call

The *Call* opcode will call a function within the script.

```
Call CalcAngle;
```

2.3.6.3 If

The *if* structure can be used on all data types and is constructed as shown below

```
if dist > MinCentroidDist
 {
  // do something
 }
```

All *if* statements must use the open and closed braces, however *if* statements may be nested.

2.3.6.4 ifelse

The *ifelse* structure can be used on all data type and is constructed as shown below

```
ifelse dist > MinCentroidDist
 {
  // do something
 }
 {
 // else do something else
 }
```

All *ifelse* statements must use the open and closed braces. At present the *ifelse* statement may not be nested, however *if* statements may be placed within an *ifelse* structure. If multiple *ifelse* type structures are required use the *CallList* mechanism as outlined in Section 7.5.

2.4 Drawing

The EBPL *DrawFunction* is a built-in function to allow the rendering of Agents for previewing of the simulation. The system has two main methods for drawing either using a cut-down version of OpenGL or a built in AgentRender system.

2.4.1 MiniGL Opcodes

The MiniGL Opcodes are split into 2 main areas

- Affine Transforms
- Drawing

2.4.2 Affine Transforms

The following Opcodes are responsible for transforms within the environment, all transforms are based on a transformation matrix which can be preserved for each drawing routine.

2.4.2.1 PushMatrix / PopMatrix

The *PushMatrix* and *PopMatrix* opcodes preserve the affine transformation stack an operate in a similar way to the OpenGL matrix stack. Care must be taken when using these operations and *PushMatrix* / *PopMatrix* opcodes must be matched else the outcome is undefined.

```
// create an empty transform stack
PushMatrix;
  // draw stuff
// restore the transform stack
PopMatrix;
```

2.4.2.2 Rotations

The rotation opcode set the current rotation in the X, Y and Z axis, all drawable objects called after a rotation opcode will be rotated by the amount of degrees specified. The Rotate opcodes are defined as follows

```
RotateX float Degrees;
RotateY float Degrees;
RotateZ float Degrees;
```

At present the Rotate opcode only accepts a *Float* variable and not a direct floating value.

2.4.2.3 Scale

The *Scale* opcode scales in the X, Y and Z axis any drawable objects specified after the *Scale* is used. At present the *Scale* opcode only accepts direct floating point values and not variables as shown in the example below

```
//scale in X y and Z
Scale 5.0 6.0 5;
```

2.4.2.4 Translate

The *Translate* opcode translates the current drawing position from the current point of the transformation matrix to a new point specified by either a *Vector* or *Point* variable as shown below

```
Translate Point NewPos;
Translate Vector NewPos;
```

2.4.3 Drawing Primitives

EBPL has three geometric drawing primitives these are *Sphere*, *Cube* and *Cylinder*.

2.4.3.1 Sphere

The *Sphere* and *SolidSphere* opcodes draw a sphere using the current *Colour*. The syntax for these opcodes are as follows

```
Sphere Float Radius Float slices Float Stacks;
SolidSphere Float Radius Float slices Float Stacks;
```

The Radius value may be either a EBPL variable or a direct floating point value as shown in the following examples

```
Float Radius=2.0;
Sphere Radius 12 12;
SolidSphere 10 12 12;
```

2.4.3.2 Cube

The *Cube* opcode will draw a wire-frame cube of width, height and depth *d* where *d* is either a *Float* variable or a direct float value as shown in the following examples

```
float Width=1.0;
Cube Width;
Cube 4.3;
```

2.4.3.3 Cylinder

The *Cylinder* opcode draws a wire-frame cylinder of Radius *r* and Height *h* where *r* and *h* are either a *Float* variable or a direct float value as shown in the following examples

```
float Width=1.0;
float Height=0.5;
Cylinder Width Height;
Cylinder 4.3 2.5;
```

2.4.4 Line Drawing

The line drawing elements of the MiniGL opcodes allow for the setting of line style, colour and the drawing of verticies.

2.4.4.1 Colour

The *Colour* opcode sets the current drawing colour for lines and primitives, it can take either a *Point* data type using the *x*,*y* and *z* tuple values for Red, Green, and Blue or direct *Float* values as shown in the following examples

```
// set colour to red
Point  ColourValue=[1,0,0];
Colour ColourValue;
// set colour to white
Colour 1 1 1;
```

2.4.4.2 Line and Point Size

The current line and point size can be set using the *PointSize* and *LineSize* opcodes these only take direct float values and are valid until another call to *PointSize* and *LineSize.* The default value for both is 1.0.

```
// set the pointsize to 5.0
PointSize 5.0;
// set the linesize to 2.0
LineSize 2.0;
```

2.4.4.3 Drawing Styles

MiniGL supports five line drawing style as shown in Table 2.4

Value	Meaning
Points	individual points
Lines	pairs of verticies interpreted as individual line segments
LineLoop	same as above, with a segment added between last and first verticies
Polygon	boundary of a simple convex polygon
Quads	quadruples of verticies interpreted as four sided polygons

Table 2.4: Line Drawing styles[MW99]

These are shown in Figure 2.5.

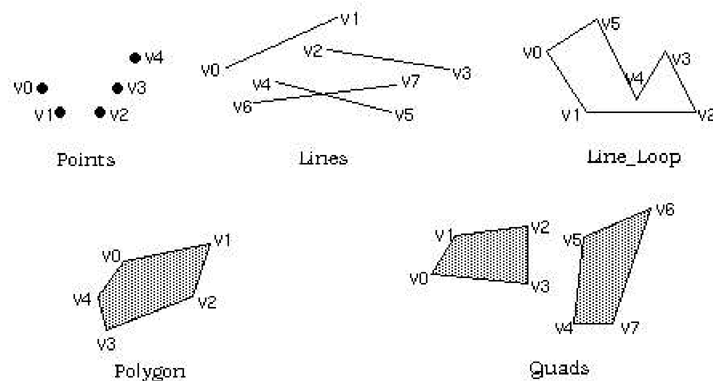


Figure 2.5: MiniGL Line Drawing types

Each of these opcodes are called to specify the line drawing style for the verticies which follow, each of the drawing styles must be ended by the use of the *glEnd* opcode as shown in the following example

```
// Draw using points
Points
  Vertexf 0 0 0;
  Vertexf 0 10 0;
glEnd;
```

2.4.4.4 Vertex Commands

The drawing of individual verticies is carried out using the *Vertex* and *Vertexf* opcodes. The *Vertex* opcode takes a *Point* or *Vector* variable as the argument whereas the *Vertexf* takes a direct floating point value for the *x*, *y* and *z* values. These are shown in the following examples

```
// Draw a triangle using direct values
LineLoop
  Vertexf 0 0 0;
  Vertexf 1 0 0;
  Vertexf 1 -1 0;
glEnd;
```

```
// Draw a triangle using variables
Point P1=[0,0,0];
Point P2=[1,0,0];
Point P3=[1,-1,0];
LineLoop
  Vertex P1;
  Vertex P2;
  Vertex P3;
glEnd;
```

2.4.4.5 Lighting

The current OpenGL lighting may be turned on and off using the *LightingOn* and *LightingOff* opcodes. At present only the default OpenGL light *GL_LIGHT0* (see [MW99] for more details) is enabled in the system. Later version will allow for the full scripting of all available OpenGL lights.

2.4.5 MiniGL Example

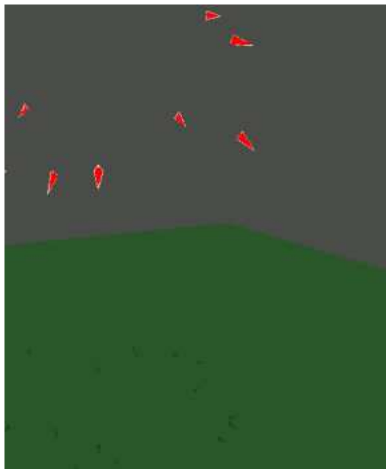


Figure 2.6: Mini GL drawing

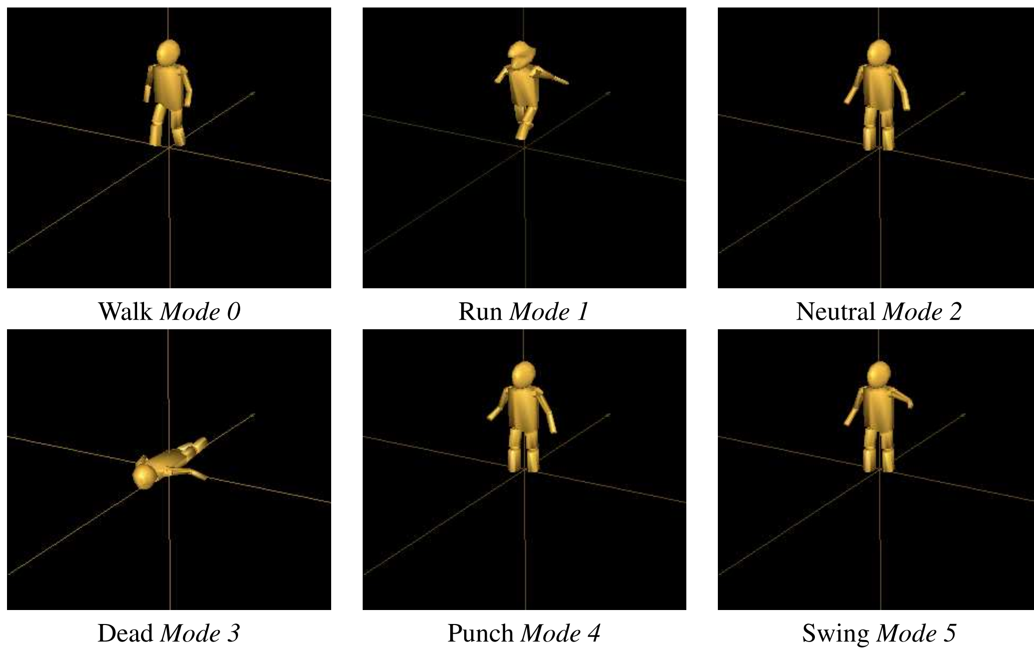
Figure 2.6. shows MiniGL in action rendering both the Boid type Agents and the ground shadows with the ebpl code shown in Algorithm 1.

Algorithm 1 MiniGL Drawing Example - Reynolds Boids [Rey87].

```
DrawFunction
PushMatrix;
// Translate to the Agents Position
    Translate Pos;
        //Rotate the Agent to the correct orientation
        RotateX  xrot;
        RotateY  yrot;
        RotateZ  zrot;
        //Set the Colour
        Colour 1.0 0.0 0.0;
       //Now draw the agent poly's
      Polygon ;
            Vertexf 0.5 -0.2 -0.2;
            Vertexf 0.5 0.2 0.0;
            Vertexf -0.5 -0.2 0.0;
            Vertexf 0.5 -0.2 0.2;
            Vertexf 0.5 0.2 0.0;
            Vertexf -0.5 -0.2 0.0
       glEnd ;
 // Now draw the Poly's as Lines to give the agent an outline shape
        LineSize 1.0;
        Colour 1.0 1.0 1.0;
        LineLoop
            Vertexf 0.5 -0.2 -0.2 ;
            Vertexf 0.5 0.2 0.0 ;
            Vertexf -0.5 -0.2 0.0 ;
            Vertexf 0.5 -0.2 0.2 ;
            Vertexf 0.5 0.2 0.0 ;
            Vertexf -0.5 -0.2 0.0 ;
        glEnd;
PopMatrix ;
// Now Draw Shadows
PushMatrix;
       // preserve y value
        Fpush Pos y;
        PushGPYlevel;
        Fpop Pos y;

        Translate Pos;
        RotateX  xrot;
        RotateY  yrot;
        RotateZ  zrot;
        Scale 0.5 0.5 0.5;
        Colour 0.2 0.2 0.2;
        Polygon ;
            Vertexf 0.5 -0.2 -0.2 ;
            Vertexf 0.5 0.2 0.0 ;
            Vertexf -0.5 -0.2 0.0 ;
            Vertexf 0.5 -0.2 0.2 ;
            Vertexf 0.5 0.2 0.0 ;
            Vertexf -0.5 -0.2 0.0 ;
        glEnd;
PopMatrix;
// restore the Y value
Fpop Pos y;
End;
```

2.4.6 AgentRender

The AgentRender module allows for a series of key-framed Alias-wavefront .obj [Ali03] files to be loaded as separate animation sequences which can be triggered within the system.



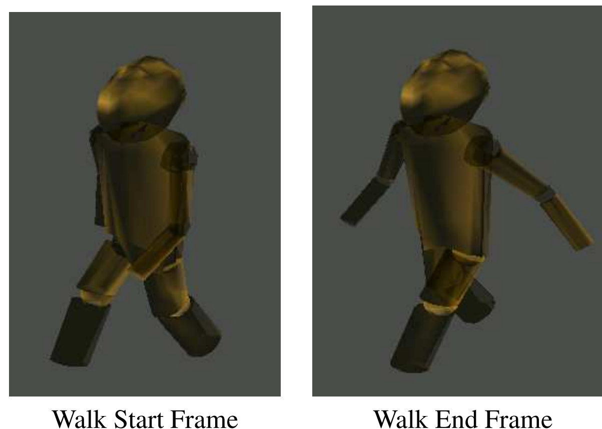
Walk *Mode 0* | Run *Mode 1* | Neutral *Mode 2*

Dead *Mode 3* | Punch *Mode 4* | Swing *Mode 5*

Figure 2.7: AgentRender module with 6 animations cycles

At present the AgentRender module is hard coded with the six animation cycles shown in Figure 2.7. However in future versions of the system this will be fully scripted within the .fl script system. Each time the AgentRender module is loaded a series of OpenGL display lists are created to speed up the execution of the renderer. If a non-accelerated OpenGL graphics card is used the system will resort back to software rendering which slows down the loading and rendering of Agents.

When the AgentRender module is created the six animation cycles are created by loading in two .obj models and creating a series of frames by the use of linear interpolation. Each model loaded in must have the same vertex, face and normal layout but the verticies may be in different positions to create the animation.



Walk Start Frame | Walk End Frame

Figure 2.8: Sample Agent Render model frames

Figure 2.8 shows the two obj models used for generating the walk cycle. These are loaded as the start and end frames for the animation cycle then the linear interpolation function shown below is used on each Vertex to calculate the in-between frames

```
glVertex3f( lerp(StartObj.Verts[V].x,EndObj.Verts[V].x,t),
            lerp(StartObj.Verts[V].y,EndObj.Verts[V].y,t),
            lerp(StartObj.Verts[V].z,EndObj.Verts[V].z,t));
```

Where t is the blend function set from 0, the start frame and 1 the end frame. The *lerp* function used is shown below

```
GLfloat lerp(GLfloat A,GLfloat B, GLfloat t)
{
   GLfloat p;
   p=A+(B-A)*t;
   return p;
}
```

2.4.6.1 Using the AgentRender

To use the AgentRender module both the .fl and brainscript files need to have the following instruction added

```
UseAgentRender ;
```

This tells the environment and the Brain that the AgentRender is being used. If this is not present in the scripts and any other AgentRender calls are made the system will crash. In the brain script this call is generally placed in the *InitFunction* as it only needs to be set once.

There are four Opcodes used for configuring the AgentRender as follows

Value	Meaning
SetAnimCycle	sets the animation cycle to be drawn as indicated by the Mode values in Figure 2.7
RenderFrame	Selects which frame of the AgentRender sequence to draw
RenderAgent	Draws the Agent configured by the above two opcodes
RenderMaterial	Set the current material for the Agent (see Table 7.3)

Table 2.5: AgentRender Opcodes

All these opcodes can take either *Float* variables or direct float values as shown in the example below :-

```
// set to agent walk cycle
float DrawMode=0;
float Frame=4;
SetAnimCycle DrawMode;
// set material to chrome
RenderMaterial 3;
//render the 3rd frame of the cycle
RenderFrame Frame;
```

The material types currently used in EBPL are shown in Table 7.3.

Material Number	Material Type
0	BLACKPLASTIC
1	BRASS
2	BRONZE
3	CHROME
4	COPPER
5	GOLD
6	PEWTER
7	SILVER
8	POLISHEDSILVER

Table 2.6: Material Types

Chapter 3

Programmable Particles

As well as emergent behaviour ebpl can generate user programmable particles for simple simulations. This chapter presents a number of example ebpl brain scripts for generating a simple particle system and highlight some of the basic principles of the ebpl language.

3.1 Simple Particles

One of the earliest method of controlling large amounts of objects in a scene is the Particle System introduced by Reeves [Ree83, Ree85] in 1983. When viewed as a whole the particles create the impression of a single, dynamic, complex object [Par02] as shown in Figure 3.1.

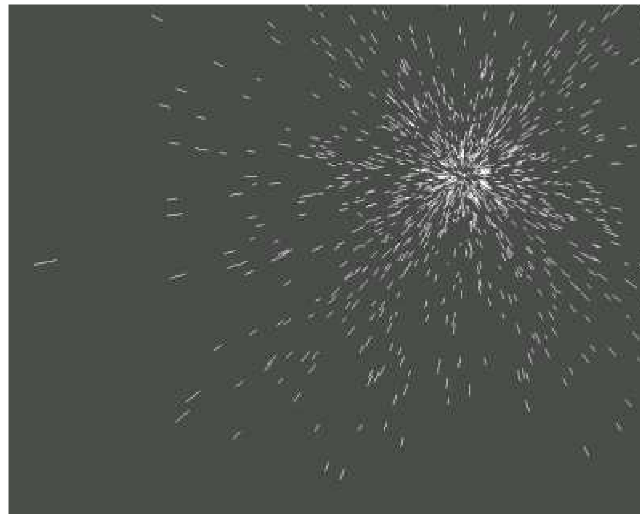


Figure 3.1: Simple Particle system Created in EBPL

For a simple omni-directional particle system only a few variables are required as follows

- **Position** - the particles current position.
- **NextPosition** - the position where the particle will be next.

- **Direction** - the direction of emission.
- **LifeSpan** - the life of the particle.

For each iteration of the system the Direction is added to the current Position to give the particle movement. The NextPosition is calculated by setting the current position after this calculation and then adding the Direction again.

The Life variable is incremented by one each iteration and if it reaches the EndLife value the particle is reset and re-emitted.

For each particle a random life and direction is created and the particles are drawn as lines as shown in the following ebpl script.

Program 2: Particle.bs Simple Particle System

```
// the Particles Position
Point Pos=[0,0,0];
// Particles Direction
Vector Dir=[0.0,0.0,0.0,0.0];
// The Particles Next Position
Vector NextPos=[0.0,0.0,0.0,0.0];
// The Lifespan of the particle
float Life=0.0;
// When the particle is to Die
float EndLife=10.0;
// Default init function for the Agent Brain
InitFunction
  Call InitParticle ;
End;
// Initialize the particle
Function InitParticle ;
  // Create a random direction
  Randomize Dir 1.0 1.0 1.0;
  // Set the particles life value to 0
  SetD Life 0.0;
  // Set the initial position of the particle to 0,0,0
  SetD Pos 0.0 0.0 0.0;
  SetD NextPos 0.0 0.0 0.0;
  // Randomize the particles life span
  Randomize EndLife 20;
End;
// just draw the particle as a line from current pos to next pos
DrawFunction
  PushMatrix;
  // Translate to the Agents Position
  Translate Pos;
  Colour 1.0 1.0 1.0;
  Lines ;
  Vertex Pos;
  Vertex NextPos;
  glEnd;
  PopMatrix;
End;
// update the particles position based on the Dir vector
UpdateFunction
  Add Pos Dir;
  Set NextPos Pos;
  Add NextPos Dir;
  AddD Life 1.0;
  // if we have reached the end of the particle's life reset it
  if Life >= EndLife
```

```
    {
    Call InitParticle;
    }
  End;
  // No collision detection
  CollideFunction
  End ;
```

3.2 Cone Emit Particles

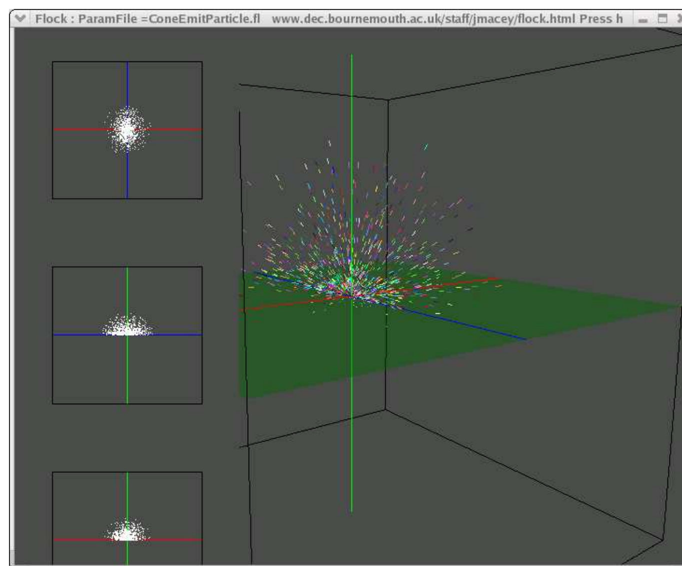


Figure 3.2: Cone Emit Particles

The following example (Figure 3.2.) shows a particle system using a directional cone as the emitter. The algorithm used is shown in Algorithm 2.

Algorithm 2 ConeEmitter modified from[jr01]

To emit a particle in a cone we define the EmitAngle to be in the range $0 - \pi$
Generate two random numbers θ and ϕ based on the EmitAngle.
The Direction vector $\mathbf{D}$is then calculated as follows :-
$\mathbf{D_x} = \sin(\theta) * \cos(\phi)$
$\mathbf{D_y} = \sin(\theta) * \sin(\phi)$
$\mathbf{D_z} = \cos(\theta)$

This can be converted into ebpl code as follows

Program 3: ConeEmitParticles.bs Particles Emitted in a Cone

```
float phi=0.0 ;
float theta=0.0 ;
float EmitAngle=3.1415926;
Function Emit ;
   RandomizePos theta EmitAngle ;
   RandomizePos phi EmitAngle ;
   fpush theta ;
   fsin ;
   fpush phi ;
   fcos ;
   fmul ;
   fpop EmitDir x ;
   fpush theta ;
   fsin ;
   fpush phi ;
   fsin ;
   fmul ;
   fpop EmitDir y ;
   fpush theta ;
   fcos ;
   fpop EmitDir z ;
End ;
```

3.2.1 Wind vector

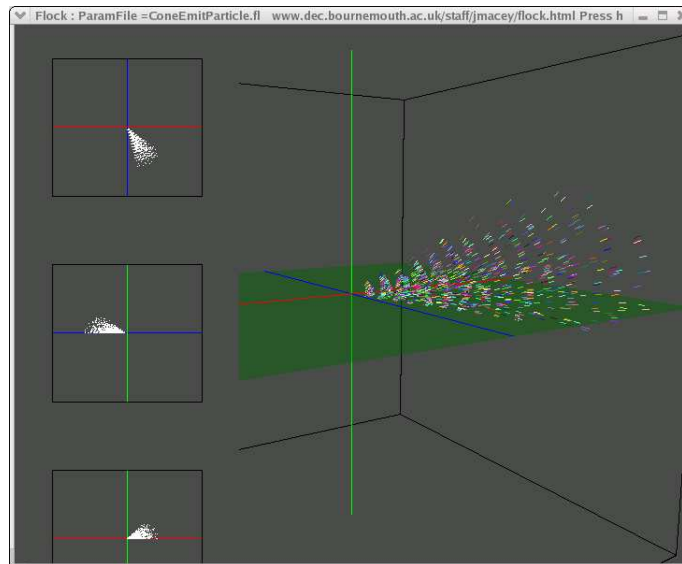


Figure 3.3: Cone Emit Particles with wind and different cone angle

Figure 3.3 shows the same system with a different EmitAngle and a Wind vector added to the x and y value of each particle. The full source for this example is shown below

Program 4: ConeEmitParticles.fl Full Listing

```
// the particles position
Point Pos=[0,0,0] ;
Point NextPos=[0,0.0,0.0] ;
// life of the particle
float Life=0.0 ;
// particle end life
float EndLife=10.0 ;
//colour value for the particle
Point PColour=[1,1,1] ;
// the direction to emit the particle
Vector EmitDir=[0,0,0,0] ;
// wind vector to add to the particle
Vector Wind=[0.4,0,0.6,0] ;
// variable used to calculate emit direction
float phi=0.0 ;
float theta=0.0 ;
float EmitAngle=1.14159276 ;
//to emit we use the following algorithm
// D.x=cos(theta)*sin(phi)
//D.y =sin(theta)*sin(phi)
//D.z = cos(theta)
Function Emit ;
  RandomizePos theta EmitAngle ;
  RandomizePos phi EmitAngle ;
  fpush theta ;
  fsin ;
  fpush phi ;
  fcos ;
  fmul ;
  fpop EmitDir x ;
  fpush theta ;
  fsin ;
  fpush phi ;
  fsin ;
  fmul ;
  fpop EmitDir y ;
  fpush theta ;
  fcos ;
  fpop EmitDir z ;
End ;
//initialise the particle
InitFunction ;
    Call InitParticle ;
End ;
Function InitParticle ;
    //set initial position to 0
    SetD Pos 0 0 0 ;
    SetD NextPos 0 0 0;
    SetGlobalPos Pos ;
    // create a random colour
    RandomizePos PColour 1.0 1.0 1.0 ;
    // reset the life
    SetD Life 0.0 ;
    // create a random life for the particle
    RandomizePos EndLife 15 ;
    // calculate the emit direction
    Call Emit  ;

End ;
DrawFunction ;

 PushMatrix;
```

```
      // Translate to the Agents Position
         Translate Pos;
         // set the colour
         Colour PColour;
         // draw the particle as a line
         Lines ;
           Vertex Pos;
           Vertex NextPos;
         glEnd;
       PopMatrix;
     End;
     UpdateFunction ;
         // move the particle
         Add Pos EmitDir;
         // add the wind
         Add Pos Wind;
         Set NextPos Pos;
         Add NextPos EmitDir;
         AddD Life 1.0;
         // set the global pos so the particles get draw in all views
         SetGlobalPos Pos;
         // are we dead yet
         if Life >= EndLife
         {
         // create a new particle
         Call InitParticle ;
         }
     End ;
     CollideFunction ;
     End ;
```

3.3 Projectile Motion Particles

Figure 3.4 shows a series of spheres using the equations for projectile motion outlined in Algorithm 3.

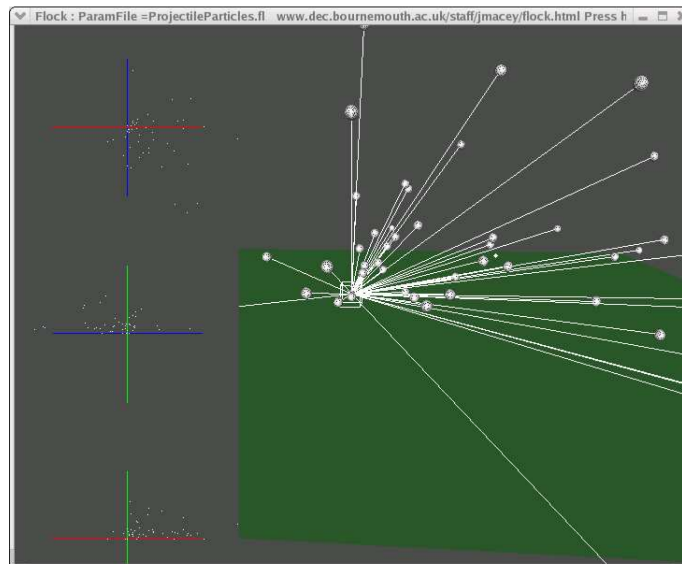


Figure 3.4: Projectile particles

Algorithm 3 Projectile Motion modified from [Len01]

The position $\mathbf{P}(t)$of a projectile having initial position $\mathbf{I}_o$and initial velocity $\mathbf{v_o}$at time t=0 is given by $\mathbf{x}(t) = \mathbf{I_o}$+$\mathbf{v}_o t + \frac{1}{2}\mathbf{g}t^2$ where gravity $\mathbf{g} = [0 - g, 0]$ assuming the Y axis is upward and $g = 9.8m/s^2$
From the above equation values for the x, y and ‡ components of $\mathbf{x}$ may be calculated at any time t by the following expressions :-
$x(t) = \mathbf{I_x} + \mathbf{v_x}t$
$y(t) = \mathbf{I}_y + \mathbf{v_y}t - \frac{1}{2}\mathbf{g}t^2$
$z(t) = \mathbf{I_z} + \mathbf{v_z}t$

This can be implemented using the following ebpl code

```
// pre-calculate 1/2 G for speed
float Gravity=-4.9;
Function CalcProjectileMotion ;
  //calc x
  fpush Pos x;
  fpush Velocity x;
  fpush Time;
  fadd;
  fadd;
  fpop Pos x;
  //calc z
  fpush Pos z;
  fpush Velocity z;
  fpush Time;
  fadd;
  fadd;
  fpop Pos z;
  // do t^2
  fpush Time;
  fdup;
  fmul;
  fpush Gravity;
  fmul;
  fpush Time;
  fpush Pos y;
  fmul;
  fsub;
  fpop Pos y;
End;
```

And the full program listing is as follows

Program 5: ProjectileParticle.bs Projectile particles

```
// the particles position
Point Pos=[0,0,0] ;
// wind vector to add to the particle
Vector Wind=[0.0,0,0.0,0] ;
float Time=1.0;
float EndTime=0.4;
Vector Velocity=[0,0,0,0];
//initialise the particle
InitFunction ;
    Call InitParticle ;
End ;
Function InitParticle ;
    //set initial position to 0
    SetD Pos 0 0 0 ;
```

```
    SetGlobalPos Pos ;
    RandomizePos Time 1.0;
    Randomize Wind 1 1 1;
    Randomize Velocity 1 1 1;
End ;
DrawFunction ;
  PushMatrix;
    Colour 1 1 1;
    Cube 2.0;
   // draw a line from the origin to the particle
   Lines;
     Vertex Pos;
     Vertexf 0 0 0;
   glEnd;
// Translate to the Agents Position
   Translate Pos;
     EnableLights;
     Colour 1.0 1.0 0.0;
     Sphere 0.4 12 12;
     DisableLights;
 PopMatrix;
End;
// half gravity
float Gravity=-4.65;
Function CalcProjectileMotion ;
  fpush Pos x;
  fpush Velocity x;
  fpush Time;
  fadd;
  fadd;
  fpop Pos x;
  fpush Pos z;
  fpush Velocity z;
  fpush Time;
  fadd;
  fadd;
  fpop Pos z;
  // calculate y  do t^2
  fpush Time;
  fdup;
  fmul;
  fpush Gravity;
  fmul;
  fpush Time;
  fpush Pos y;
  fmul;
  fsub;
  fpop Pos y;
End;
UpdateFunction ;
    // move the particle
    SubD Time 0.01;
    Call CalcProjectileMotion;
    Add Pos Wind;
    // set the global pos so the particles get draw in all views
    SetGlobalPos Pos;
    // are we dead yet
    if Time <= EndTime
    {
    Call InitParticle ;
    }
End ;
CollideFunction ;
End ;
```

Chapter 4

Flocking

In 1987 Reynolds [Rey87] extended the original Reeves [Ree83, Ree85] particle system into a *"sub-object system"* where each particle, represented by a point in the Reeves system, is replaced by an animated object. Each of these objects which Reynolds refers to as "Bird-oids" or "*Boids"* are given limited intelligence which when combined into a collective whole produces the flocking behaviour.

The original Boids have three simple rules :-

1. **Collision Avoidance** : avoid collisions with nearby flock mates.
2. **Velocity Matching** : attempt to match velocity with nearby flock-mates
3. **Flock Centering** : attempt to stay close to nearby flock-mates.

Combining these rules produce a simple flocking behaviour as shown in figure 4.3

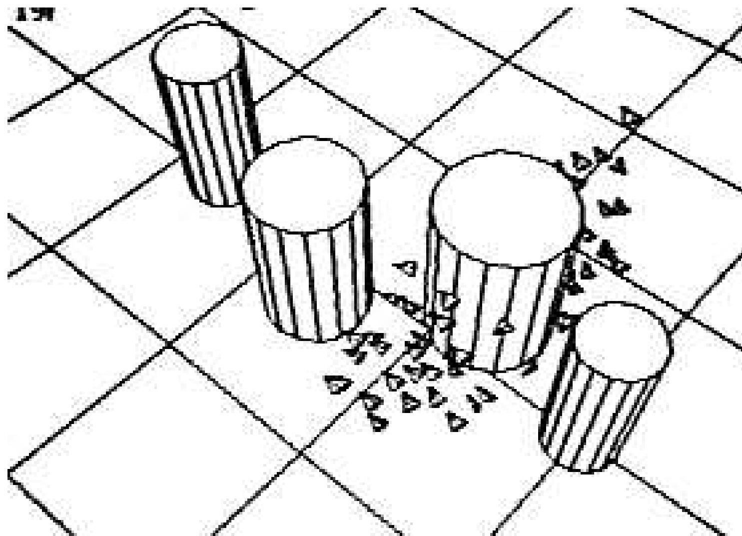


Figure 4.1: A simple Flock [Rey87]

In more recent papers Reynolds has introduced slightly different rules for his flocking behaviours calling them “steering behaviours” [Rey99]. The new rules are

- **Separation** : steer to avoid crowding local flock mates.
- **Alignment** : steer towards the average heading of local flock mates.
- **Cohesion** : steer to move toward the average position of local flock mates.

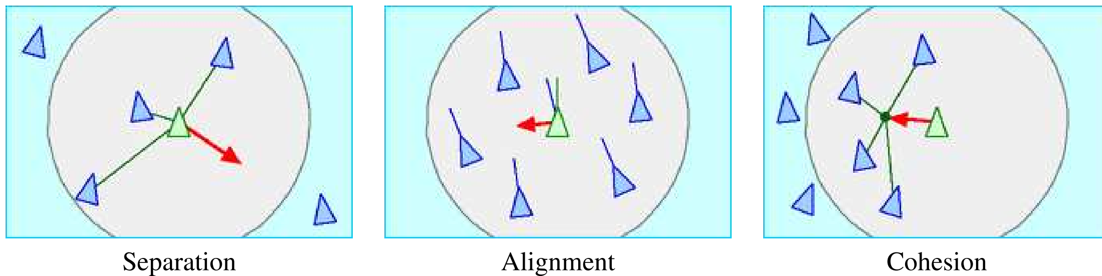


Figure 4.2: Steering Flocking rules [Rey99]

These behaviours are shown in Figure 4.2 and create a different type of flocking to the original rules.

4.1 A simple Flock in ebpl

Figure 4.3 shows a simple flock using the rules outlined in the previous section.

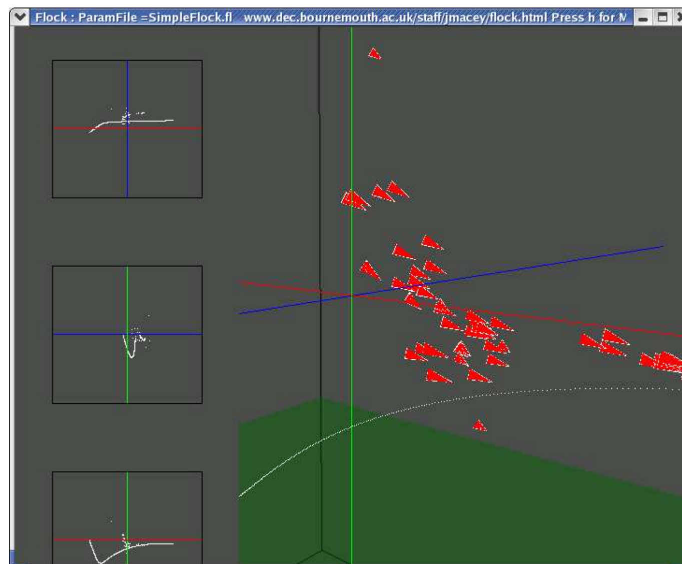


Figure 4.3: A simple Flock

The flock is programmed to follow the flock center attached to the path but to avoid collisions with each other and match speed.

Each Agent has a number of variables used to determine it’s Position and orientation. These are as follows

- **Pos** - The agents position
- **NextPos** - Where the Agent will be in the Next cycle (used for collision detection and orientation)
- **CentroidWeight** - how much the agent should try to move to the flock center
- **MinCentroidDist** - how far the Agent should move away from the flock center before turning back
- **FlockAvoidWeight** - how much the Agent should try to avoid the other Agents
- **Radius** - the bounding sphere radius of the Agent used for collision detection
- **HitAgent** - a flag to indicate if the Agent has collided

When the simulation is executed the Agents are emitted in a random direction, once the flocking mode is turned on using the space key the Agents will try to head towards the flock center.

Next the Agents are tested for collisions, if there is a collision the Average direction of both Agents is calculated and the Agents new direction is set to this. This allows the Agents to merge together and match velocity.

Finally the orientation of the Agent is calculated using Spherical geometry as shown in Section 4.1.0.1

4.1.0.1 Using spherical geometry to calculate Agent orientation

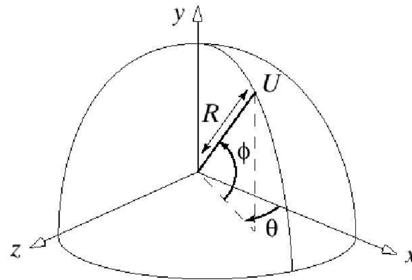


Figure 4.4: Spherical Geometry[jr01]

Figure 4.4 shows how a point U is defined in spherical coordinates.

R is the radial distance of U from the origin, and ϕ is the angle that U makes with the xz-plane, know as the latitude of the point U.

θ is the azimuth of U, the angle between the xy-plane and the plane through U and the y-axis.

ϕ lies in the interval $-\pi/2 \leq \phi < \pi/2$ and θ lies in the range $0 \leq \theta < 2\pi$

Using trigonometry we can work out a relationship between spherical coordinates and Cartesian coordinates (u_x, u_y, u_z) for U the equations are

$u_x = Rcos(\phi)cos(\theta)$, $u_y = Rsin(\phi)$, and $u_z = Rcos(\phi)sin(\theta)$

Using trigonometry we can work out a relationship between Cartesian coordinates and spherical coordinates as follows

$R = \sqrt{u_x^2 + u_y^2 + u_z^2}$; $\phi = sin^{-1}\left(\frac{u_y}{R}\right)$; $\theta = arctan(u_z, u_x)$

The function arctan(,) is the two argument form of the arctangent, defined as (atan2 in C++)

$$arctan(y,x) = \begin{cases} tan^{-1}(y/x) & if\, x > 0 \\ \pi + tan^{-1}(y/x) & if\, x < 0 \\ \pi/2 & if\, x = 0\, and\, y > 0 \\ -\pi/2 & if\, x = 0\, and\, y < 0 \end{cases}$$

This may be implemented in C++ using the following code

```
void Agent::CalcAngle(void)
{
  GLfloat X,Y,Z;
  X=NextPos.x-Pos.x;
  Z=NextPos.z-Pos.z;
  Y=Pos.y-NextPos.y;
  //using spherical geometry we calculate the rotation based on the New Point
  yrot=atan2(Z,X); // Now convert from radians to deg
  yrot=-((yrot/TWO_PI)*360.0f); //now align the geometry to our world
  yrot+=180;
  // Now for the zrot
  GLfloat r=sqrt(X*X+Y*Y+Z*Z);
  zrot=asin(Y/r);
  //convert from radians to deg
  zrot=((zrot/TWO_PI)*360.0f);
}
```

The following code does the same using the ebpl language

```
Vector tmpPos=[0,0,0,0];
Vector tmpPos2=[0,0,0,0];
Function CalcAngle;
 // fist set the vectors to subtract
 Set tmpPos NextPos ;
 Sub tmpPos Pos;
 Fpush tmpPos x ;
 Fpush tmpPos z ;
 // use atan2 to calc the angle
 fatan ;
 // this gives us the angle in radians so we convert it
 Frad2deg ;
 // finally we align it with the world geometry
 Fnegate ;
 Fpop yrot ;
 AddD yrot 180.0 ;
 // now we align the z rotation
 //Y=Pos.y-NextPos.y;
 Set tmpPos NextPos ;
 Set tmpPos2 Pos ;
 // swap the y components
 Fpush Pos y ;
 Fpop tmpPos y;
 Fpush NextPos y ;
 Fpop tmpPos2 y ;
 // now subtract the two
 Sub tmpPos tmpPos2 ;
 //zrot=asin(Y/r);
 Length tmpPos ;
 Fpush tmpPos y ;
 Fdiv ;
 fasin ;
 // convert it to degrees
 frad2deg;
 Fpop zrot;
End;
```

4.1.0.2 Simple Flock program using ebpl

The following code is used to control the Agent for the simple flock example

Program 6: SimpleFlock.bs Simple flocking system

```
// the Agents position
Point Pos=[0,0,0];
Vector Dir=[0.0,-0.2,-0.1,0.0];
Point NextPos=[0,0.0];
bool TRUE=true;
bool FALSE=false;
// The rotation of the Agent in the X plane
float xrot=0.0;
float yrot=0.0;
// The rotation of the Agent in the Z plane
float zrot=0.0;
// Vector ADir is the Average direction of the Agent calculated from hits with any agents
//in the current bounding sphere radius. This is used with the FlockAvoidDir
// weight to set the Flock avoid Direction
Vector ADir=[0,0,0,0]; //flock avoid dir
// Vector CentroidDir is the direction to the flock center from the current agent position.
//This is multiplied by the Centroid weight */
Vector CentroidDir=[0,0,0,0];
// bool HitAgent boolean flag set to indicate that the Agent has hit another Agent */
bool HitAgent=false;
// GLfloat GPYlevel the ground plane level of the Agent */
float GPYlevel=-18;
// GLfloat CentroidWeight The weight the CentroidDir vector is multiplied by to calculate
//the new direction of the Agent so it can flock center */
float CentroidWeight=20.0;
//GLfloat FlockAvoidWeight The Weight the FlockAvoidDir vector is multiplied by to calculate
//the new direction of the Agent when it has hit a member of it's own flock */
  float FlockAvoidWeight=99.0;
float Radius=4.1;
// GLfloat Hunger will be used to make Agent hunt for food when hungry
float MinCentroidDist=10.0;
Vector CentroidDist=[0,0,0,0] ;
Point Centroid=[0,0,0] ;
InitFunction
  Randomize Dir 2.0 2.0 2.0;
  SetGlobalPos Pos;
  RandomizePos MinCentroidDist 28;
End;
DrawFunction
  PushMatrix;
  // Translate to the Agents Position
    Translate Pos;
     //Rotate the Agent to the correct orientation
      RotateX  xrot;
      RotateY  yrot;
      RotateZ  zrot;
      //Set the Colour
      Colour 1.0 0.0 0.0;
      Polygon ;
        Vertexf 0.5 -0.2 -0.2;
        Vertexf 0.5 0.2 0.0;
        Vertexf -0.5 -0.2 0.0;
        Vertexf 0.5 -0.2 0.2;
        Vertexf 0.5 0.2 0.0;
        Vertexf -0.5 -0.2 0.0
      glEnd ;
      // Now draw the Poly's as Lines to give the agent an outline shape */
```

```
      LineSize 1.0;
      Colour 1.0 1.0 1.0;
      LineLoop
        Vertexf 0.5 -0.2 -0.2 ;
        Vertexf 0.5 0.2 0.0 ;
        Vertexf -0.5 -0.2 0.0 ;
        Vertexf 0.5 -0.2 0.2 ;
        Vertexf 0.5 0.2 0.0 ;
        Vertexf -0.5 -0.2 0.0 ;
      glEnd
PopMatrix ;
End;
float Ylevel=0.0;
UpdateFunction
    Set HitAgent FALSE;
    Call UpdateAgainstCentroid ;
    Mul ADir FlockAvoidWeight;
    Mul CentroidDir CentroidWeight;
    Add Dir ADir;
    Add Dir CentroidDir;
    Normalize Dir;
    fpush Pos y ;
    fpop Ylevel ;
    Add Pos Dir ;
    Set NextPos Pos ;
    Add NextPos Dir ;
    Call CalcAngle ;
    SetGlobalPos Pos;
    SetD ADir 0 0 0;
    SetD CentroidDir 0 0 0;
    if Ylevel <= GPYlevel
    {
    SetD Dir y 1;
    }
End;
float dist=0.0;
Function UpdateAgainstCentroid;
  GetGlobalCentroid Centroid;
  Set CentroidDist Centroid;
  Sub CentroidDist Pos;
  Length CentroidDist ;
  fpop dist ;
  if dist >= MinCentroidDist;
    {
     Set CentroidDir Centroid ;
     Sub CentroidDir Pos;
    }

End;
// This function calculates the Agents orientation based on the pos
// and the NextPos
// use these for temp storage in the calc angle function
Vector tmpPos=[0,0,0,0];
Vector tmpPos2=[0,0,0,0];
Function CalcAngle;
    // fist set the vectors to subtract
    Set tmpPos NextPos ;
    Sub tmpPos Pos;
    Fpush tmpPos x ;
    Fpush tmpPos z ;
    // use atan2 to calc the angle
    fatan ;
    // this gives us the angle in radians so we convert it
    Frad2deg ;
    // finally we align it with the world geometry
    Fnegate ;
    Fpop yrot ;
```

```
        AddD yrot 180.0 ;
        // now we align the z rotation
        //Y=Pos.y-NextPos.y;
        Set tmpPos NextPos ;
        Set tmpPos2 Pos ;
        // swap the y components
        Fpush Pos y ;
        Fpop tmpPos y;
        Fpush NextPos y ;
        Fpop tmpPos2 y ;
        // now subtract the two
        Sub tmpPos tmpPos2 ;
        //zrot=asin(Y/r);
        Length tmpPos ;
        Fpush tmpPos y ;
        Fdiv ;
        fasin ;
        // convert it to degrees
        frad2deg;
        Fpop zrot;
    End;
    CollideFunction
      LoopBin ;
        SphereSphereCollision HitAgent Pos Radius NextPos Radius;
        if HitAgent == TRUE;
           {
             // calc average
            GetAgentI ADir Dir;
            Add ADir Dir;
            DivD ADir 2;
            Normalize ADir;
            Set Dir ADir;
            SetAgentI Dir ADir;
            }

         LoopBinEnd;
    End ;
```

And the ebpl .fl script for the configuration of the environment

```
// Configure the bounding box for the simulation
WorldBBox 0 0 0 80.0 80.0 80.0 2 2 2 20
// specify the output file to read to
outputfile outfile.out
// create a camera to view the scene
Camera 0 80 40 0 0 0 0 1 0 800 660 45.0 1.33 0.1 450.0
// Create an emitter for the Agent with 50 Agents
AgentEmitter 0.0 0.0 0.0 50 0 0 0.0 0.0 0 0 SimpleFlock.comp
// Specify a path
PathFollow 0 -20 0 2 -10 -30 -5  -20 1 -4 25 -2 -5
// Specify the ground plane
GroundPlane -20 0 0.4 0 0.5
```

4.2 Advanced Flocking

Figure 4.5 shows a flock of fifty Agents using a different Agent avoid algorithm and Perlin noise [eta98] turbulence based on the Agents Position.

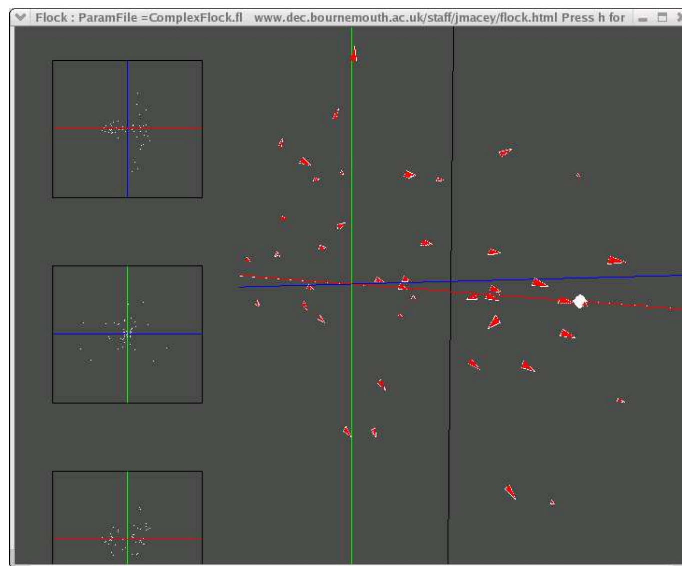


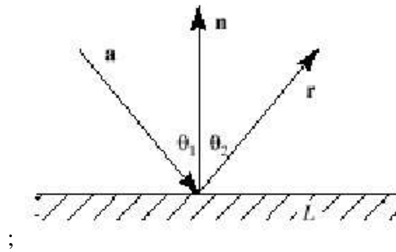
Figure 4.5: A flock using complex avoidance and noise functions

The Agents have a number of built in weights and vectors as in the previous example. However the Agents use a different avoid function as shown in the following section.

4.2.0.3 Agent Avoidance routine

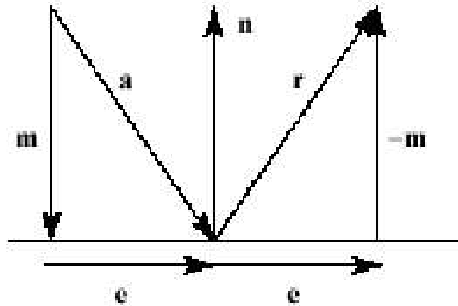
Algorithm 4 shows the new collision avoidance algorithm used in the new flocking system based on the calculation of reflected rays normal to a surface. Algorithm 5 shows the ebpl code for the routine.

Algorithm 4 Collision avoidance algorithm adapted from [jr01, Len01]



;

The above figure shows the movement of an Agent having a direction $\mathbf{a}$ hitting the Agent Normal L and reflecting in (an as yet unknown) direction $\mathbf{r}$. The vector $\mathbf{n}$ is perpendicular to the line. Angle θ_1 must equal angle θ_2



The above figure shows $\mathbf{a}$ resolved into a portion $\mathbf{m}$ along $\mathbf{n}$ and a portion $\mathbf{e}$ orthogonal to $\mathbf{n}$. Because of symmetry, $\mathbf{r}$ has the same component $\mathbf{e}$ orthogonal to $\mathbf{n}$ but the opposite component along $\mathbf{n}$, so $\mathbf{r} = \mathbf{e} - \mathbf{m}$
Because $\mathbf{e} = \mathbf{a} - \mathbf{m}$ it follows that $\mathbf{r} = \mathbf{a} - 2\mathbf{m}$. Now $\mathbf{m}$ is the orthogonal projection of $\mathbf{a}$ onto $\mathbf{n}$ so we can get $\mathbf{m} = \frac{\mathbf{a} \bullet \mathbf{n}}{|\mathbf{n}|^2}\mathbf{n} = (\mathbf{a} \bullet \widehat{\mathbf{n}})\widehat{\mathbf{n}}$ remember that $\widehat{\mathbf{n}}$ is a unit vector in the direction of $\mathbf{n}$
From this we obtain the result $\mathbf{r} = \mathbf{a} - 2(\mathbf{a} \bullet \widehat{\mathbf{n}})\widehat{\mathbf{n}}$ which is the direction of the reflected Agent.
This is then repeated for Agent 2 to determine the new direction for the other Agent.

Algorithm 5 ebpl Code for Agents reflection

This is shown in the following ebpl code

```
Point TempP=[0,0,0];
Vector Norm=[0,0,0,0];
Point P1=[0,0,0,0];
Point P2=[0,0,0,0];
float x=0.0;
float two=2.0;
Vector d=[0,0,0,0];
Vector NDir=[0,0,0,0];
CollideFunction
   LoopBin ;
    SphereSphereCollision HitAgent Pos Radius2 NextPos Radius2;
      ifelse HitAgent == TRUE;
        {
         GetAgentI  P1 Pos ;
         GetAgentI   P2 NextPos ;
         Set Norm P2;
         Sub Norm P1;
         Dot x P1 P2;
         Mul x two;
         Set d Norm;
         Mul d x;
         Set NDir Dir;
         Sub d NDir;
         Set ADir NDir;
         Set P1 Pos;
         Set P2 NextPos ;
         Set Norm P2;
         Sub Norm P1;
         Dot x P1 P2;
         Mul x two;
         Set d Norm;
         Mul d x;
         GetAgentI NDir Dir;
         Sub d NDir;
         SetAgentI NDir ADir;
         SetD CentroidWeight 0;
         SetD CentroidDir 0 0 0;
         SetD FlockAvoidWeight 100;
         }
         {
         SetD CentroidWeight 100;
         SetD FlockAvoidWeight 50;
         }
   LoopBinEnd;
End ;
```

4.2.0.4 Noise Function

Each Agent has the ability to access a noise function based on Perlin Noise [eta98]. This value is generated by a built-in noise function and can be calculated from any tuple data type. There are five built in noise functions as shown in Table 7.4

Noise Type	Noise Index Value
turbulence	0
marble	1
undulate	2
noise3	3
turbulence2	4

Table 4.1: ebpl Noise functions

To use noise the noise generator must be initialized as follows

```
float NoiseType=5.0;
float NoiseScale=0.0;
RandomizePos NoiseType 5;
Randomize NoiseScale 2000;
UseNoise NoiseType NoiseScale;
```

The *GetNoiseValue* opcode is used to access the noise table, it is passed a value to return to and a seed value to generate the noise from this is shown in the following example.

```
Point Pos=[0,0,0];
Vector NoiseValue=[0,0,0,0];
GetNoiseValue NoiseValue Pos;
```

4.2.0.5 Complex Flock ebpl code

The following code shows the Agent brain code for the Complex Flock example

Program 7: ComplexFlock.bs Flock using Noise

```
// the Agents position
Point Pos=[0,0,0];
Vector Dir=[0.0,-0.2,-0.1,0.0];
Point NextPos=[0,0.0];
bool TRUE=true;
bool FALSE=false;
// The rotation of the Agent in the X plane
float xrot=0.0;
float yrot=-90.0;
// The rotation of the Agent in the Z plane
float zrot=0.0;
// Vector ADir is the Average direction of the Agent calculated from hits with
//any agents
//  in the current bounding sphere radius. This is used with the FlockAvoidDir
// weight to set the
// Flock avoid Direction */
Vector ADir=[0,0,0,0]; //flock avoid dir
// Vector CentroidDir is the direction to the flock center from the current agent
//position.
//This is multiplied by the Centroid weight */
Vector CentroidDir=[0,0,0,0];
// bool HitAgent boolean flag set to indicate that the Agent has hit another
// Agent
```

```
bool HitAgent=false;
// GLfloat GPYlevel the ground plane level of the Agent
float GPYlevel=-38;
// GLfloat CentroidWeight The weight the CentroidDir vector is multiplied by to
// calculate
//the new direction of the Agent so it can flock center
float CentroidWeight=100.0;
//GLfloat FlockAvoidWeight The Weight the FlockAvoidDir vector is multiplied by
//to calculate
//the new direction of the Agent when it has hit a member of it's own flock
float FlockAvoidWeight=100.0;
float Radius=2.0;
float Radius2=1.5;
// GLfloat Hunger will be used to make Agent hunt for food when hungry
float MinCentroidDist=10.0;
Vector CentroidDist=[0,0,0,0] ;
Vector nVel=[0,0,0,0];
Vector acceleration=[1,1,1,0];
Vector force=[0,0,0,0];
Vector mass=[150,150,150,0];
Vector EnvAvoidDir=[0,0,0,0];
Vector Velocity=[0,0,0,0];
Vector VelDiv=[1,1,1,0];
float NoiseType=2.0;
float NoiseScale=1230.0002;
Point Centroid=[0,0,0] ;
float Ylevel=0.0;
float dist=0.0;
InitFunction
    Randomize Dir 2.0 2.0 2.0;
    SetGlobalPos Pos;
    RandomizePos MinCentroidDist 28;
    AddD MinCentroidDist 4;
    RandomizePos CentroidWeight 50;
    RandomizePos NoiseType 5;
    Randomize NoiseScale 2000;
    UseNoise NoiseType NoiseScale;
End;
DrawFunction
  PushMatrix;
  // Translate to the Agents Position
    Translate Pos;
        //Rotate the Agent to the correct orientation
        RotateX  xrot;
        RotateY  yrot;
        RotateZ  zrot;
        //Set the Colour
        //Now draw the agent poly's
        Colour 1.0 0.0 0.0;
        Polygon ;
            Vertexf 0.25 -0.1 -0.1;
            Vertexf 0.25 0.1 0.0;
            Vertexf -0.25 -0.1 0.0;
            Vertexf 0.25 -0.1 0.1;
            Vertexf 0.25 0.1 0.0;
            Vertexf -0.25 -0.1 0.0
        glEnd ;
        // Now draw the Poly's as Lines to give the agent an outline shape */
        LineSize 1.0;
        Colour 1.0 1.0 1.0;
        LineLoop
            Vertexf 0.25 -0.1 -0.1 ;
            Vertexf 0.25 0.1 0.0 ;
            Vertexf -0.25 -0.1 0.0 ;
            Vertexf 0.25 -0.1 0.1 ;
            Vertexf 0.25 0.1 0.0 ;
            Vertexf -0.25 -0.1 0.0 ;
```

```
        glEnd;
PopMatrix ;
PushMatrix;
            // preserve y value
        Fpush Pos y;
        PushGPYlevel;
        Fpop Pos y;

        Translate Pos;
        RotateX  xrot;
        RotateY  yrot;
        RotateZ  zrot;
        Scale 0.5 0.5 0.5;
        Colour 0.2 0.2 0.2;
        Polygon ;
            Vertexf 0.25 -0.1 -0.1 ;
            Vertexf 0.25 0.1 0.0 ;
            Vertexf -0.25 -0.1 0.0 ;
            Vertexf 0.25 -0.1 0.1 ;
            Vertexf 0.25 0.1 0.0 ;
            Vertexf -0.25 -0.1 0.0 ;
        glEnd;
PopMatrix;
fPop Pos y;
End;
Function UpdateAgainstCentroid;
 GetGlobalCentroid Centroid;
 Set CentroidDist Centroid;
 Sub CentroidDist Pos;
 Length CentroidDist ;
 fpop dist ;

 ifelse dist >= MinCentroidDist;
    {
     GetGlobalCentroid CentroidDir ;
    Sub CentroidDir Pos;
    }
    {
     SetD CentroidDir 0 0 0;
    }

End;
// This function calculates the Agents orientation based on the position
// and the NextPos
// use these for temp storage in the calc angle function
Vector tmpPos=[0,0,0,0];
Vector tmpPos2=[0,0,0,0];
Function CalcAngle;
    // fist set the vectors to subtract
    Set tmpPos NextPos ;
    Sub tmpPos Pos;
    Fpush tmpPos x ;
    Fpush tmpPos z ;
    // use atan2 to calc the angle
    fatan ;
    // this gives us the angle in radians so we convert it
    Frad2deg ;
    // finally we align it with the world geometry
    Fnegate ;
    Fpop yrot ;
    AddD yrot 180.0 ;
        // now we align the z rotation
    //Y=Pos.y-NextPos.y;
    Set tmpPos NextPos ;
    Set tmpPos2 Pos ;
    // swap the y components
    Fpush Pos y ;
```

```
        Fpop tmpPos y;
        Fpush NextPos y ;
        Fpop tmpPos2 y ;
        // now subtract the two
        Sub tmpPos tmpPos2 ;
        //zrot=asin(Y/r);
        Length tmpPos ;
        Fpush tmpPos y ;
        Fdiv ;
        fasin ;
            // convert it to degrees
        frad2deg;
        Fpop zrot;
    End;
    Point TempP=[0,0,0];
    Vector Norm=[0,0,0,0];
    Point P1=[0,0,0,0];
    Point P2=[0,0,0,0];
    float x=0.0;
    float two=2.0;
    Vector d=[0,0,0,0];
    Vector NDir=[0,0,0,0];
    CollideFunction
        LoopBin ;
         SphereSphereCollision HitAgent Pos Radius2 NextPos Radius2;
         ifelse HitAgent == TRUE;
           {
            GetAgentI   P1 Pos ;
            GetAgentI   P2 NextPos ;
            Set Norm P2;
            Sub Norm P1;
            Dot x P1 P2;
            Mul x two;
            Set d Norm;
            Mul d x;
            Set NDir Dir;
            Sub d NDir;
            Set ADir NDir;
            Set P1 Pos;
            Set P2 NextPos ;
            Set Norm P2;
            Sub Norm P1;
            Dot x P1 P2;
            Mul x two;
            Set d Norm;
            Mul d x;
            GetAgentI NDir Dir;
            Sub d NDir;
            SetAgentI NDir ADir;
            SetD CentroidWeight 0;
            SetD CentroidDir 0 0 0;
            SetD FlockAvoidWeight 100;
            }
            {
            SetD CentroidWeight 100;
            SetD FlockAvoidWeight 50;
            }
            LoopBinEnd;
    End ;
    float gpy=0.0;
    UpdateFunction
        SetGlobalCollideFlag FALSE;
        SetGlobalPos Pos;

        Call Move;
        Call UpdateAgainstCentroid;
        Call CalcDir;
```

```
    Call CalcAngle;

    PushGPYlevel;
    fpop gpy;
    fpush Pos y ;
    fpop Ylevel ;
    SetGlobalPos Pos;
    SetD ADir 0 0 0;
    SetD CentroidDir 0 0 0;
    SetD EnvAvoidDir 0 0 0;
End;
vector NoiseValue=[0,0,0,0];
Function Move;
Set acceleration force;
Div acceleration mass;
Add Velocity acceleration;
Set nVel Velocity;
Div nVel VelDiv;
Add Pos Dir;
Mul Pos nVel;
Set NextPos Pos;
Add NextPos Dir;
Mul NextPos nVel;
Set ADir Dir;
End;
Function CalcDir;
Mul ADir FlockAvoidWeight;
Mul CentroidDir CentroidWeight;
Set Dir ADir;
Add Dir CentroidDir;
GetNoiseValue NoiseValue Pos;
Add Dir NoiseValue;
Normalize Dir;
//Set the force to be the current Direction so we can calculate the new
//acceleration
//in the next iteration
Set force  Dir;
//Store the Average dir to be the current dir
//Set ADir Dir;
End;
```

4.3 Avoiding Objects

Figure 4.6 shows five hundred Agents avoiding a series of *EnvObj* objects. The environment is configured using the following .fl script.

```
WorldBBox 0 0 0 80.0 80.0 40.0 5 2 5 520
OutputFile birds.out
OutFileFrameSkip 1
UpdateRate 1
Camera 0 80 0 0 0 0 0 0 1 800 660 45.0 1.33 0.1 450.0
Randomize
GroundPlane -20 0 0.4 0 0.7
EnvObj 0.0 0.0 0.0 6.0 6.0 6.0 5.0
EnvObj -20.0 0.0 0.0 6.0 6.0 6.0 5.0
EnvObj 20.0 0.0 0.0 6.0 6.0 6.0 5.0
EnvObj 0.0 -6.0 0.0 6.0 6.0 6.0 5.0
EnvObj -20 -6.0 0.0 6.0 6.0 6.0 5.0
EnvObj  20.0 -6.0 0.0 6.0 6.0 6.0 5.0
EnvObj 0.0 -12.0 0.0 6.0 6.0 6.0 5.0
EnvObj -20 -12 0.0 6.0 6.0 6.0 5.0
EnvObj 20.0 -12.0 0.0 6.0 6.0 6.0 5.0
EnvObj 0.0 -18.0 0.0 6.0 6.0 6.0 5.0
EnvObj -20 -18 0.0 6.0 6.0 6.0 5.0
EnvObj 20.0 -18.0 0.0 6.0 6.0 6.0 5.0
AgentEmitter -30.0 0 0 520 0.7 0.3 0.33 0.6 0 0 EnvObj.comp
PathFollow 0 -20 0 0 -10 0 0 10 0 0  20 0 0
lockedCentroid 0 0 0 0
```

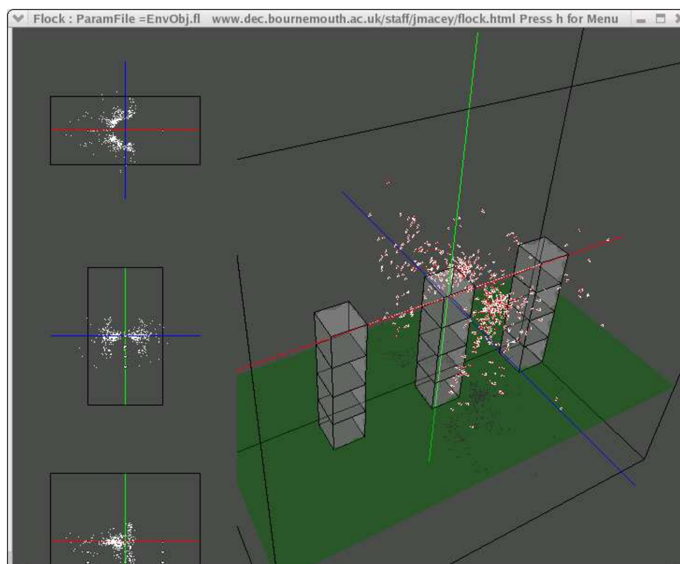


Figure 4.6: Agents Avoiding Objects

The Agents again have a series of Variables as in the previous examples but the interaction with the EnvObj objects are handled by the function CollideAgainstEnvOb

```
Function CollideAgainstEnvObj;
   SphereEnvObjCollision HitEnvObj NextPos Radius2 EnvAvoidDir;
   if HitEnvObj == TRUE;
      {
       SetD CentroidWeight 0;
       SetD FlockAvoidWeight 10.0;
       SetD EnvAvoidWeight 6129.0;
       Randomize EnvNoise 0.2 0.2 0.2;
       Add EnvAvoidDir EnvNoise;
      }
   if HitEnvObj == FALSE;
      {
       SetD CentroidWeight 72.9;
       SetD FlockAvoidWeight 5100.0;
       SetD EnvAvoidWeight 6120.0;
      }
End;
```

Program 8: EnvObj.bs Avoiding Environment Objects

```
// the Agents position
Point Pos=[-30,0,0];
Vector Dir=[0.0,0.0,0.0,0.0];
Point NextPos=[0,0.0];
bool TRUE=true;
bool FALSE=false;
// The rotation of the Agent in the X plane
float xrot=0.0;
float yrot=-90.0;
// The rotation of the Agent in the Z plane
float zrot=0.0;
// Vector ADir is the Average direction of the Agent calculated from hits with any agents
//  in the current bounding sphere radius. This is used with the FlockAvoidDir
// weight to set the  Flock avoid Direction
Vector ADir=[0,0,0,0]; //flock avoid dir
// Vector CentroidDir is the direction to the flock center from the current agent position.
//This is multiplied by the Centroid weight
Vector CentroidDir=[0,0,0,0];
// bool HitAgent boolean flag set to indicate that the Agent has hit another Agent
bool HitAgent=false;
bool HitEnvObj=false;
// GLfloat GPYlevel the ground plane level of the Agent
float GPYlevel=-20;
// GLfloat CentroidWeight The weight the CentroidDir vector is multiplied by to calculate
//the new direction of the Agent so it can flock center
float CentroidWeight=72.9;
//GLfloat FlockAvoidWeight The Weight the FlockAvoidDir vector is multiplied by to calculate
//the new direction of the Agent when it has hit a member of it's own flock
float FlockAvoidWeight=5100.0;
float EnvAvoidWeight=6129.0;
float Radius=0.6;
float Radius2=2.1;
float MinCentroidDist=6.0;
Vector CentroidDist=[0,0,0,0] ;
Vector nVel=[0,0,0,0];
Vector acceleration=[1,1,1,0];
Vector force=[0,0,0,0];
Vector mass=[150,150,150,0];
Vector EnvAvoidDir=[0,0,0,0];
Vector Velocity=[0,0,0,0];
Vector VelDiv=[1,1,1,0];
float NoiseType=2.0;
```

```
float NoiseScale=1230.0002;
vector NoiseValue=[0,0,0,0];
InitFunction
    Randomize Dir 2.0 2.0 2.0;
    SetGlobalPos Pos;
    RandomizePos NoiseType 5;
    Randomize NoiseScale 2000;
    UseNoise NoiseType NoiseScale;
End;
Point Centroid=[10,10,0] ;
DrawFunction
PushMatrix;
// Translate to the Agents Position
    Translate Pos;
     //Rotate the Agent to the correct orientation
     RotateX  xrot;
     RotateY  yrot;
     RotateZ  zrot;
      //Set the Colour
     Colour 1.0 0.0 0.0;
     Polygon ;
       Vertexf 0.25 -0.1 -0.1;
       Vertexf 0.25 0.1 0.0;
       Vertexf -0.25 -0.1 0.0;
       Vertexf 0.25 -0.1 0.1;
       Vertexf 0.25 0.1 0.0;
       Vertexf -0.25 -0.1 0.0
     glEnd ;
                // Now draw the Poly's as Lines to give the agent an outline shape */
     LineSize 1.0;
      Colour 1.0 1.0 1.0;
      LineLoop
        Vertexf 0.25 -0.1 -0.1 ;
        Vertexf 0.25 0.1 0.0 ;
        Vertexf -0.25 -0.1 0.0 ;
        Vertexf 0.25 -0.1 0.1 ;
        Vertexf 0.25 0.1 0.0 ;
        Vertexf -0.25 -0.1 0.0 ;
      glEnd;
  PopMatrix ;
  PushMatrix;
        // preserve y value
        Fpush Pos y;
        PushGPYlevel;
        Fpop Pos y;

        Translate Pos;
        RotateX  xrot;
        RotateY  yrot;
        RotateZ  zrot;
        Colour 0.2 0.2 0.2;
        Polygon ;
           Vertexf 0.25 -0.1 -0.1 ;
           Vertexf 0.25 0.1 0.0 ;
           Vertexf -0.25 -0.1 0.0 ;
           Vertexf 0.25 -0.1 0.1 ;
           Vertexf 0.25 0.1 0.0 ;
           Vertexf -0.25 -0.1 0.0 ;
        glEnd;
 PopMatrix;
fPop Pos y;
End;
float Ylevel=0.0;
float gpy=0.0;
UpdateFunction
    SetGlobalCollideFlag FALSE;
    Call UpdateAgainstCentroid;
```

```
    Call Move;
    Call CalcDir;
    Call CalcAngle;
    PushGPYlevel;
    fpop gpy;
    fpush Pos y ;
    fpop Ylevel ;
    if Ylevel <= gpy
     {
      SetD Dir y 1;
     }
    SetGlobalPos Pos;
    SetD ADir 0 0 0;
    SetD CentroidDir 0 0 0;
    SetD EnvAvoidDir 0 0 0;
End;
float dist=0.0;
Function UpdateAgainstCentroid;
  GetGlobalCentroid CentroidDir;
  Sub CentroidDir Pos;
  Length CentroidDir ;
  fpop dist ;
  ifelse dist > MinCentroidDist;
   {
    GetGlobalCentroid CentroidDir ;
    Sub CentroidDir Pos;
   }
   {
    SetD CentroidDir 0 0 0 ;
   }

End;
// This function calculates the Agents orientation based on the position
// and the NextPos
// use these for temp storage in the calc angle function
Vector tmpPos=[0,0,0,0];
Vector tmpPos2=[0,0,0,0];
Function CalcAngle;
    // fist set the vectors to subtract
    Set tmpPos NextPos ;
    Sub tmpPos Pos;
    Fpush tmpPos x ;
    Fpush tmpPos z ;
    // use atan2 to calc the angle
    fatan ;
    // this gives us the angle in radians so we convert it
    Frad2deg ;
    // finally we align it with the world geometry
    Fnegate ;
    Fpop yrot ;
    AddD yrot 180.0 ;
        // now we align the z rotation
    //Y=Pos.y-NextPos.y;
    Set tmpPos NextPos ;
    Set tmpPos2 Pos ;
    // swap the y components
    Fpush Pos y ;
    Fpop tmpPos y;
    Fpush NextPos y ;
    Fpop tmpPos2 y ;
    // now subtract the two
    Sub tmpPos tmpPos2 ;
    //zrot=asin(Y/r);
    Length tmpPos ;
    Fpush tmpPos y ;
    Fdiv ;
    fasin ;
```

```
        // convert it to degrees
    frad2deg;
    Fpop zrot;
End;
CollideFunction
  Set HitAgent FALSE;
  Set HitEnvObj FALSE;
  Call CollideAgainstEnvObj;
  LoopBin ;
     SphereSphereCollision HitAgent NextPos Radius2 NextPos Radius2;
     if HitAgent == TRUE;
       {
        // calc average
        SetGlobalCollideFlag TRUE;
        GetAgentI ADir Dir;
        Add ADir Dir;
        DivD ADir 2;
        SetAgentI ADir ADir;
        }
    LoopBinEnd;

End ;
Vector EnvNoise=[0,0,0,0];
Function CollideAgainstEnvObj;
SphereEnvObjCollision HitEnvObj NextPos Radius2 EnvAvoidDir;
      if HitEnvObj == TRUE;
      {
       SetD CentroidWeight 0;
       SetD FlockAvoidWeight 10.0;
       SetD EnvAvoidWeight 6129.0;
       Randomize EnvNoise 0.2 0.2 0.2;
       Add EnvAvoidDir EnvNoise;
      }
      if HitEnvObj == FALSE;
      {
      SetD CentroidWeight 72.9;
      SetD FlockAvoidWeight 5100.0;
      SetD EnvAvoidWeight 6120.0;
      }

End;
Function Move;
 Set acceleration force;
 Div acceleration mass;
 Add Velocity acceleration;
 Set nVel Velocity;
 Div nVel VelDiv;
 Add Pos Dir;
 Mul Pos nVel;
 Set NextPos Pos;
 Add NextPos Dir;
 Mul NextPos nVel;
 Set ADir Dir;
End;
Function CalcDir;
 Mul ADir FlockAvoidWeight;
 Mul CentroidDir CentroidWeight;
 Mul EnvAvoidDir EnvAvoidWeight;
 Set Dir ADir;
 Add Dir CentroidDir;
 Add Dir EnvAvoidDir;
 GetNoiseValue NoiseValue Pos;
 Add Dir NoiseValue;
 Normalize Dir;
//Set the force to be the current Direction so we can calculate the new acceleration
//in the next iteration
 Set force  Dir;
```

```
End;
```

Chapter 5

Agent Render

The following chapter highlights the AgentRender module. At present the AgentRender has six built in animation cycles to demonstrate the use of the AgentRender these are shown in Figure 2.7. Future versions of the AgentRender module will allow the loading of any .obj file with user definable animation loop cycles.

5.1 Agent Resource File (ARF)

The Agent Resource File allows the user to define and load the positions of the Agents and their initial orientation. The file format is as follows

```
Number Of Agents to load
Pos.x Pos.y Pos.z Dir.x Dir.y Dir.z
```

All the values in the file are separated using a space and the newline terminates the record. When the *LoadARF* .fl command is encountered the arf file is loaded and the Agents *InitFunction* is called. The position value is loaded into the Agents global variable Pos and the direction to the Dir variable. These may then be accessed using the following Opcodes

```
Vector Dir=[0,0,0,0];
Point Pos=[0,0,0];
GetGlobalPos Pos;
GetGlobalDir Dir;
```

Figure 5.1 shows the **Layout** program in action. This allows the user to interactively place agents in the environment and save the results to an arf file.

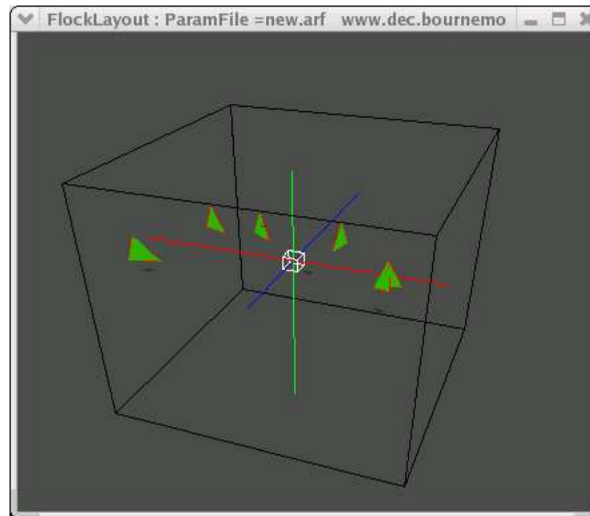


Figure 5.1: Agent Layout program

The following examples all use an arf file to configure the initial position of the Agents. The file used is as follows

```
25
 4 -20 30 0 0 -0.4
 2 -20 30 0 0 -0.4
 0 -20 30 0 0 -0.4
-2 -20 30 0 0 -0.4
-4 -20 30 0 0 -0.4
 4 -20 28 0 0 -0.4
 2 -20 28 0 0 -0.4
 0 -20 28 0 0 -0.4
-2 -20 28 0 0 -0.4
-4 -20 28 0 0 -0.4
 4 -20 26 0 0 -0.4
 2 -20 26 0 0 -0.4
 0 -20 26 0 0 -0.4
-2 -20 26 0 0 -0.4
-4 -20 26 0 0 -0.4
 4 -20 24 0 0 -0.4
 2 -20 24 0 0 -0.4
 0 -20 24 0 0 -0.4
-2 -20 24 0 0 -0.4
-4 -20 24 0 0 -0.4
 4 -20 22 0 0 -0.4
 2 -20 22 0 0 -0.4
 0 -20 22 0 0 -0.4
-2 -20 22 0 0 -0.4
-4 -20 22 0 0 -0.4
```

5.2 Using the AgentRender

The following example shows a series of Agents configured using an arf file. When the simulation starts the Agents all move in the same direction. When they reach a certain point the animation cycles changes to a run cycle and the Agents speed up as shown in Figure 5.2.

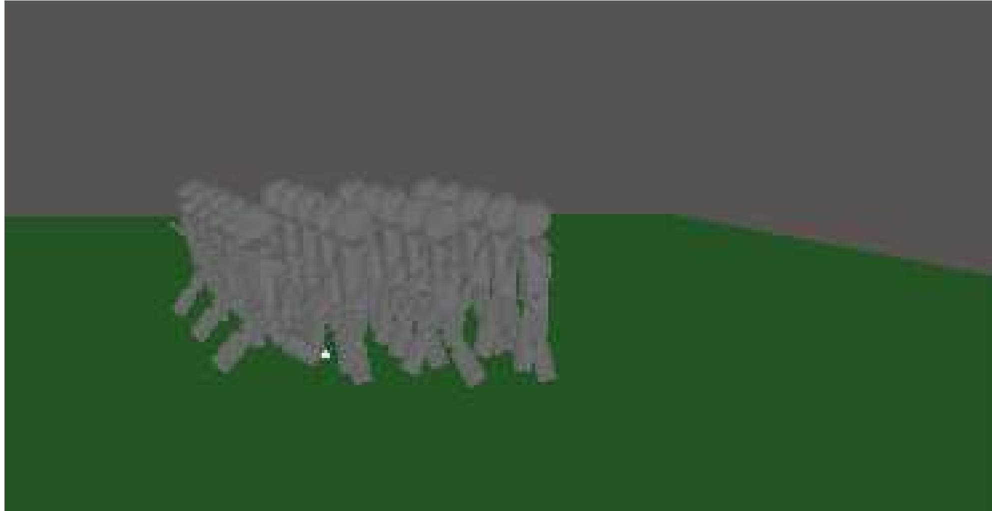


Figure 5.2: AgentRender Agents with different animation cycles

Once the Agents reach the end of the world they are reset to their original position and start the cycle over again.

The system is configured using the following .fl script

```
WorldBBox 0 0 0 80.0 80.0 80.0 2 2 2 120
OutputFile agents.out
OutFileFrameSkip 1
UpdateRate 1
UseAgentRender
GroundPlane -20 0.0 0.2 0.0 1.0
Camera 0 2 100 0 0 0 0 1 0 800 660 45.0 1.33 0.1 450.0
AgentEmitter -30.0 0 0 25 0.7 0.3 0.33 0.6 0 0 Agent1.comp
PathFollow 0 -20 0 0 -10 0 0 10 0 0  20 0 0
LoadArf 0 AgentLayout.arf
lockedCentroid 0 0 -20 0
```

The arf file is loaded using the *LoadArf* .fl keyword.

5.2.0.6 Setting the Agents original position

When the the *LoadArf* instruction is called the Agent brain *InitFunction* is called and the Position and Direction variables are loaded as follows :-

```
InitFunction
    GetGlobalPos Pos;
    GetGlobalDir Dir;
    Set StartPoint Pos;
    UseAgentRender;
    RandomizePos Frame 8;
End;
```

The *GetGlobalPos* and *GetGlobalDir* opcodes are used to access the data from the arf file and store the initial Agent position and Direction. Next the system is told to use the AgentRender module and the start frame for the Agent is determined using the *RandomizePos* opcode.

The full listing of the Example is shown below.

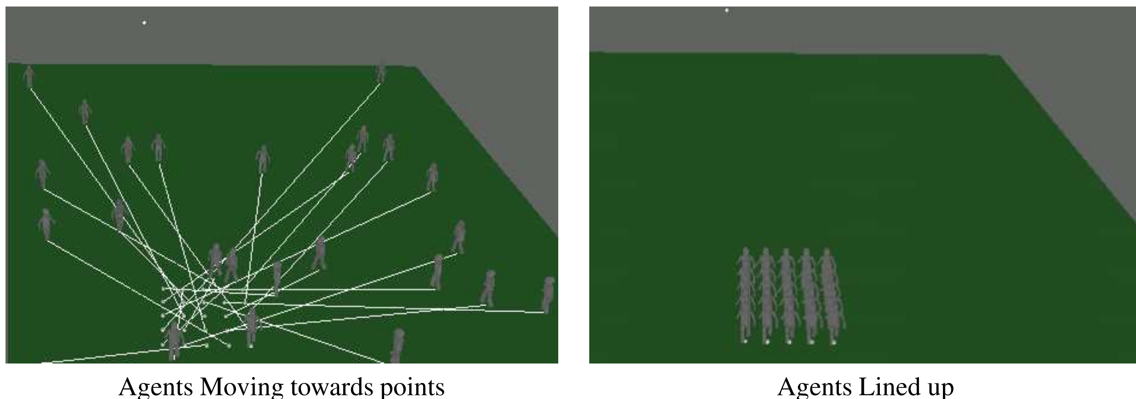
Program 9: Agent1.bs Using Agent Render

```
// the Agents position
Point Pos=[-30,0,0];
// The Agents direction
Vector Dir=[0.0,0.0,0.0,0.0];
// Where the agent start from set from arf
Point StartPoint=[0,0,0];
// Agent Render Modes
float WALK=0.0;
float RUN=1.0;
float DrawMode=0.0;
float Frame=0.0;
float Zpos=12.0;
float ZposEnd= -40.0;
float CurrZpos=0.0;
float NewSpeed=-1.5;
float MaxFrame=8.0;
float StartWalk=30.0;
float Yrot=-180;
// The Agents normal speed
Vector NormalSpeed= [0,0,-0.6,0];
InitFunction
    // get the values from the Agent class
    GetGlobalPos Pos;
    GetGlobalDir Dir;
    Set StartPoint Pos;
    // use the agent render
    UseAgentRender;
    // set a start frame for the animation cycle
    RandomizePos Frame 8;
End;
DrawFunction
PushMatrix;
// Translate to the Agents Position
    Translate Pos;
    // make the Agent bigger
    Scale 5.0 5.0 5.0;
    // turn on lights
    EnableLights;
    // set material to silver
    RenderMaterial 8;
    // render the Agent
    SetAnimCycle DrawMode;
    RenderFrame Frame;
    RotateY Yrot;
    RenderAgent;
    DisableLights;
PopMatrix;
End;
UpdateFunction
    // calculate the new position
    SetGlobalPos Pos;
    Add Pos Dir;
    fpush Pos z;
    fpop CurrZpos;

    // if we have reach the run point set agent to run
    if CurrZpos <= Zpos
    {
    fpush NewSpeed;
    fpop Dir z;
```

```
        Set DrawMode RUN;
        }

        // if we have reached the end set agent back to start
        if CurrZpos < ZposEnd
        {
        Set Pos StartPoint;
        Set DrawMode WALK;
        Set Dir NormalSpeed;
        }
        // incriment the frame for animation cycle
        AddD Frame 1;
        if Frame >= MaxFrame
        {
        SetD Frame 0;
        }
    End;
    // no collisions
    CollideFunction
    End ;
```

5.3 Using arf to set Agent target points

In the following example the arf file is used to configure target points for each of the Agents as show in Figure 5.3. These points are loaded in from the arf file and the Agents are assigned a random starting point.



Agents Moving towards points Agents Lined up

Figure 5.3: Agents moving to position set in arf file

When the simulation starts the Agents move to find their start point and then stop on the spot. The simulation then resets to a new random start position and starts again.

This is shown in the following ebpl program

Program 10: Agent2.bs Using arf to set Agent Target Positions

```
    // the Agents position
```

```
Point Pos=[-30,0,0];
// the Agent direction
Vector Dir=[0.0,0.0,0.0,0.0];
//where to line up
Point TargetPoint=[0,0,0];
//the direction to the target
Vector TDir=[0,0,0,0];
bool TRUE=true;
bool FALSE=false;
// flag to say were resting
bool Resting=false;
// frames
float MaxFrame=15.0;
float EndTime=75.0
float MinDist=1.0;
float dist=0.0;
// zero vector to stop agent moveing
Vector ZERO=[0,0,0,0];
// The rotation of the Agent in the X plane
float yrot=180.0;
// The rotation of the Agent in the Z plane
float WALK=0.0;
float RUN=1.0;
float DrawMode=0.0;
float Time=0.0
float Frame=0.0;
float Ypos=-20.0;
InitFunction
  // get the target point from the arf file
  GetGlobalPos TargetPoint;
  // cal random position
  Randomize Pos 40 1 40;
  UseAgentRender;
  SetGlobalPos Pos;
  // lock to the groundplane
  fpush Ypos;
  fpop Ypos y;
  RandomizePos Frame 15;
End;
// function to reset the Agent
Function ResetFunc ;
  SetD Time 0;
  Set Resting FALSE;
  Randomize Pos 40 1 40;
End;
DrawFunction
  // turn on lights
  EnableLights;
  PushMatrix;
    // draw the target spheres
    Translate TargetPoint;
    SolidSphere 0.2 12 12;
  PopMatrix;
// draw the Agent
  PushMatrix;
    Translate Pos;
     PushMatrix;
       Scale 5.0 5.0 5.0;
       RotateY yrot;
       SetAnimCycle DrawMode;
       RenderMaterial 3;
       RenderFrame Frame;
       RenderAgent;
     PopMatrix;
  PopMatrix;
 DisableLights;
  // draw the path line for the Agent
```

```
  PushMatrix;
    Lines;
       Colour 1 1 1;
       Vertex TargetPoint;
       Vertex Pos;
    glEnd;
  PopMatrix;
End;
UpdateFunction
  AddD Time 1.0;
  AddD Frame 1.0;
  // if were at the max frame set frame to 0
  if Frame >= MaxFrame;
    {
     SetD Frame 0.0;
     }
  // if the simulation has run too long reset
  if Time >= EndTime ;
    {
    Call ResetFunc;
    }
  // if were not at point continue to move
  ifelse Resting != TRUE
    {
    fpush Ypos;
    fpop Pos y;
    Call UpdateAgainstTargetPoint;
    Call CalcDir;
    Call CalcAngle;
    Add Pos Dir;
    }
    {
    // else align the agent the right way
    SetD yrot 180;
    }
End;
CollideFunction
End ;
Vector tmpPos=[0,0,0,0];
Vector tmpPos2=[0,0,0,0];
// calculate the correct agent direction
Function CalcAngle;
  // fist set the vectors to subtract
  Set tmpPos TargetPoint ;
  Sub tmpPos Pos;
  Fpush tmpPos x ;
  Fpush tmpPos z ;
  // use atan2 to calc the angle
  fatan ;
  // this gives us the angle in radians so we convert it
  Frad2deg ;
  // finally we align it with the world geometry
  Fnegate ;
  Fpop yrot ;
  AddD yrot 90.0 ;
End;
// find the target point and set the direction
Function UpdateAgainstTargetPoint ;
  Set TDir TargetPoint;
  Sub TDir Pos;
  Length TDir ;
  fpop dist ;
  // if were on the target point stop
  if dist <= MinDist;
    {
     Set TDir ZERO;
     Set Dir ZERO;
```

```
      Set Pos TargetPoint;
      Set Resting TRUE;
     }
End;
// move the agent
Function CalcDir;
  Set Dir TDir;
  Normalize Dir;
End;
```

5.4 Agents with Collisions

The following example takes the code from section 5.2.0.6 and adds collision detection.

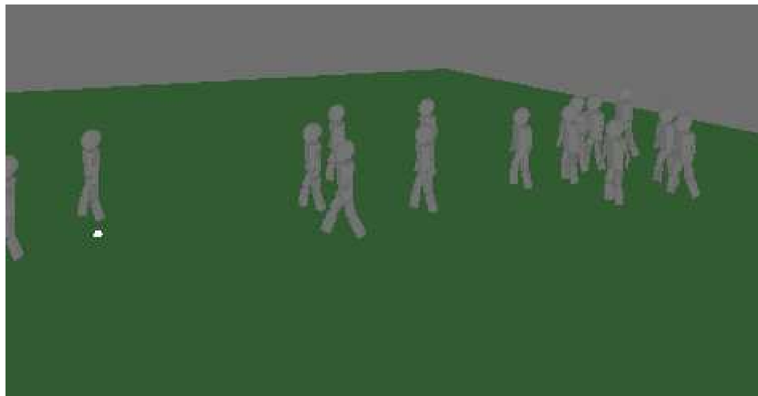


Figure 5.4: Agents with Collision detection

The Agents look for the nearest Agent and if the Agent is going to collide the Agent in front Speeds up and the Agent behind slows down. This produces a simple crowd simulation. The ebpl code for this example is as follows

Program 11: Agent3.bs Agents AgentRender with collisions

```
// the Agents position
Point Pos=[-30,0,0];
Vector Dir=[0.0,0.0,0.0,0.0];
Point NextPos=[0,0.0];
bool TRUE=true;
bool FALSE=false;
// The rotation of the Agent in the X plane
float yrot=180.0;
// The rotation of the Agent in the Z plane
float WALK=0.0;
float RUN=1.0;
float DrawMode=0.0;
float Frame=0.0;
Point StartPoint=[0,0,0];
```

```
bool HitAgent=false;
float Radius=1.5;
float ZposEnd= -40.0;
float CurrZpos=0.0;
float NewSpeed=-1.5;
float MaxFrame=15.0;
float StartWalk=30.0;
Vector NormalSpeed= [0,0,-0.6,0];
InitFunction
    GetGlobalPos Pos;
    GetGlobalDir Dir;
    Set StartPoint Pos;
    UseAgentRender;
    RandomizePos Frame 15;
End;
DrawFunction

PushMatrix;
// Translate to the Agents Position
    Translate Pos;
    Scale 5.0 5.0 5.0;
    RotateY yrot;
    RenderMaterial 3;
    SetAnimCycle DrawMode;
    RenderFrame Frame;
    RenderAgent;
PopMatrix;
End;
UpdateFunction
    SetGlobalPos Pos;
    Add Pos Dir;
    Set NextPos Pos;
    Add NextPos Dir;
    fpush Pos z;
    fpop CurrZpos;

   if CurrZpos < ZposEnd
    {
    Set Pos StartPoint;
    Set DrawMode WALK;
    Set Dir NormalSpeed;
    }

    AddD Frame 1;
    if Frame >= MaxFrame
    {
    SetD Frame 0;
    }

    //Call CalcAngle;
End;
Point AiPos=[0,0,0];
CollideFunction
Set HitAgent FALSE;
LoopBin ;

     SphereSphereCollision HitAgent Pos Radius NextPos Radius;
     // if we have hit
     if HitAgent == TRUE;
            {
        // get the position
        GetAgentI AiPos Pos;
        // if were in front move faster
        ifelse AiPos < Pos ;
        {
        SetD Dir 0 0 -1.7 ;
        SetAgentI Dir Dir;
```

```
        SetD Dir 0 0 -0.2;
        }
        // otherwise slow down
        {
        SetD Dir 0 0 -0.2 ;
        SetAgentI Dir Dir;
        SetD Dir 0 0 -1.7;
        }
        SetAgentI HitAgent HitAgent;

        }
      LoopBinEnd;

End ;
Vector tmpPos=[0,0,0,0];
Vector tmpPos2=[0,0,0,0];
Function CalcAngle;
    // fist set the vectors to subtract
    Set tmpPos NextPos ;
    Sub tmpPos Pos;
    Fpush tmpPos x ;
    Fpush tmpPos z ;
    // use atan2 to calc the angle
    fatan ;
    // this gives us the angle in radians so we convert it
    Frad2deg ;
    // finally we align it with the world geometry
    Fnegate ;
    Fpop yrot ;
    AddD yrot 90.0 ;
        // now we align the z rotation
End;
```

Chapter 6

Terrain Interaction

Figure 6.1 shows Agents interacting with a terrain model loaded from an Alias-Wavefront obj file.

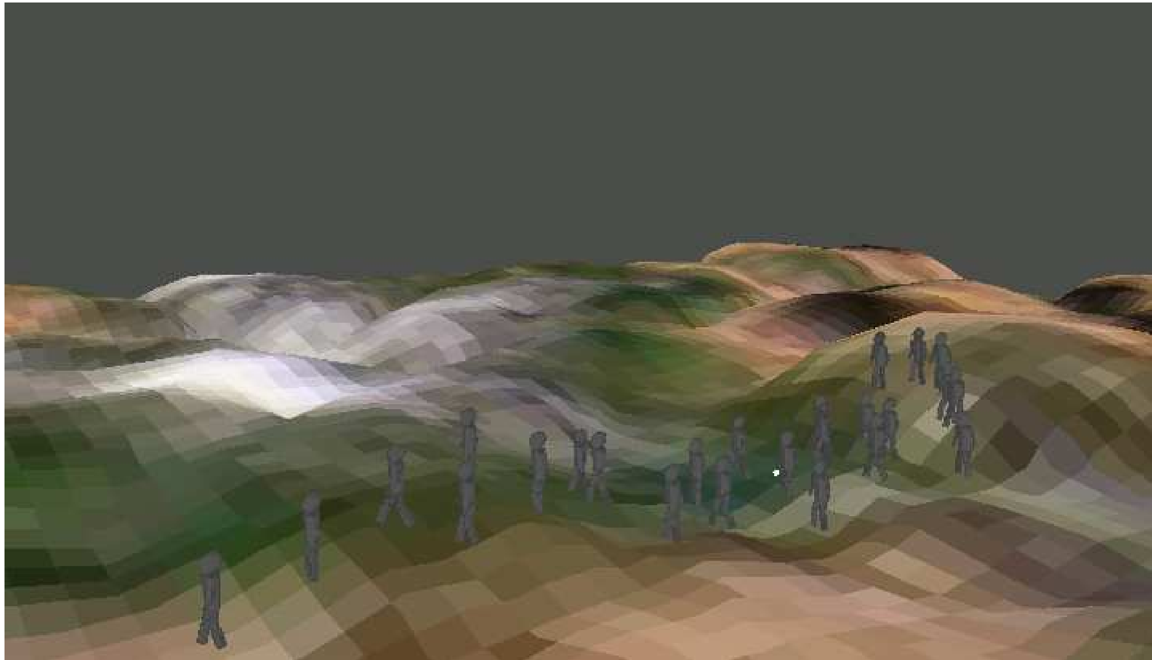


Figure 6.1: Agents Interacting with the Terrain

To calculate the current Y height value of the Agent within the terrain the GetHeight method is used. This is based on calculating the point normal for each of the faces in the obj file and determining if the point passed is withing the triangle. The method used is modified from [jr01] as shown in Algorithm 6.

Algorithm 6 Calculating if a point is within a triangle

Given each Triangle within the .obj file extract the Points T_0, T_1, T_2 and construct the Lines b_1, b_2, b_3 by subtracting the the Triangle Points as follows :-
$b_1 = T_1 - T_0$, $b_2 = T_2 - T_1$ and $b_3 = T_0 - T_2$
The point Normal of each line is constructed by negating the y value and swapping it for the x so
$PN_1 = [-b_{1y}, b_{1x}, 0]$, $PN_2 = [-b_{2y}, b_{2x}, 0]$ and $PN_3 = [-b_{3y}, b_{3x}, 0]$
Next the Point to be tested P is subtracted from each of the original triangle points so
$b_1 = T_0 - P$, $b_2 = T_1 - P$ and $b_3 = T_2 - P$
To determine if the Point is within a triangle we calculate the dot product of the triangle points with their point normals
$Test_1 = b_1 \bullet PN_1$, $Test_2 = b_2 \bullet PN_2$ and $Test_3 = b_3 \bullet PN_3$
If all the Test values are $<= 0$ then the point is within the triangle and the Y height offset value is calculated using linear interpolation of the triangle points.

6.0.1 Loading Terrain

Terrain is loaded using the ObjTerrain .fl command. The parameters used are as follows

```
ObjTerrain (f)Ylevel (s)Filename.obj (s) TextureName.bmp
              (f)AgentHeightOffset (f)Scale X (f) ScaleY
              (f) ScaleZ
```

Ylevel : The level of the groundplane

Filename.obj The name of the obj file to load

TextureName.bmp : The name of the file to use as a texture for the groundplane.

AgentHeightOffset : The value to add to the Agents Y value

Scale X,Y,Z : The scale in X,Y and Z for the obj file. This pre-scales the obj file before loading.

The following .fl file shows the loading of terrain for the example in Figure 6.1 .

```
WorldBBox 0 0 0 80.0 80.0 80.0 2 2 2 120
OutputFile agent.out
OutFileFrameSkip 1
UpdateRate 1
UseAgentRender
Camera 0 2 100 0 0 0 0 1 0 800 660 45.0 1.33 0.1 450.0
AgentEmitter -30.0 0 0 25 0.7 0.3 0.33 0.6 0 0 Agent4.comp
PathFollow 0 -20 0 0 -10 0 0 10 0 0  20 0 0
LoadArf 0 AgentLayout.arf
ObjTerrain -20 NewTerrainTri.obj MountainHMC.bmp 0.4 3 1.2 3
```

The ebpl program for this example is as follows

Program 12: Agent4.bs Agents interacting with terrain

```
// the Agents position
Point Pos=[-30,0,0];
Vector Dir=[0.0,0.0,0.0,0.0];
Point NextPos=[0,0.0];
```

```
bool TRUE=true;
bool FALSE=false;
// The rotation of the Agent in the X plane
float yrot=180.0;
// The rotation of the Agent in the Z plane
// DrawMode flags
float WALK=0.0;
float RUN=1.0;
float DrawMode=0.0;
float Frame=0.0;
// The Agent Start Point
Point StartPoint=[0,0,0];
bool HitAgent=false;
float Radius=1.5;
float ZposEnd= -40.0;
float CurrZpos=0.0;
float NewSpeed=-1.5;
float MaxFrame=15.0;
float StartWalk=30.0;
Vector NormalSpeed= [0,0,-0.6,0];
InitFunction
    // configure initial Agent position
    GetGlobalPos Pos;
    GetGlobalDir Dir;
    Set StartPoint Pos;
    UseAgentRender;
    RandomizePos Frame 15;
End;
DrawFunction

PushMatrix;
// Translate to the Agents Position
    Translate Pos;
    Scale 5.0 5.0 5.0;
    RotateY yrot;
    RenderMaterial 3;
    SetAnimCycle DrawMode;
    RenderFrame Frame;
    RenderAgent;
PopMatrix;
End;
UpdateFunction
    SetGlobalPos Pos;
    Add Pos Dir;
    Set NextPos Pos;
    Add NextPos Dir;
    fpush Pos z;
    fpop CurrZpos;

   if CurrZpos < ZposEnd
    {
    Set Pos StartPoint;
    Set DrawMode WALK;
    Set Dir NormalSpeed;
    }

    AddD Frame 2;
    if Frame >= MaxFrame
    {
    SetD Frame 0;
    }
    SetGPYlevel Pos;
 End;
Point AiPos=[0,0,0];
CollideFunction
Set HitAgent FALSE;
LoopBin ;
```

```
        SphereSphereCollision HitAgent Pos Radius NextPos Radius;
        // if we have hit
        if HitAgent == TRUE;
               {
           // get the position
           GetAgentI AiPos Pos;
           // if were in front move faster
           ifelse AiPos < Pos ;
           {
           SetD Dir 0 0 -1.7 ;
           SetAgentI Dir Dir;
           SetD Dir 0 0 -0.2;
           }
           // otherwise slow down
           {
           SetD Dir 0 0 -0.2 ;
           SetAgentI Dir Dir;
           SetD Dir 0 0 -1.7;
           }
           SetAgentI HitAgent HitAgent;

           }
         LoopBinEnd;

  End ;
  Vector tmpPos=[0,0,0,0];
  Vector tmpPos2=[0,0,0,0];
  Function CalcAngle;
      // fist set the vectors to subtract
      Set tmpPos NextPos ;
      Sub tmpPos Pos;
      Fpush tmpPos x ;
      Fpush tmpPos z ;
      // use atan2 to calc the angle
      fatan ;
      // this gives us the angle in radians so we convert it
      Frad2deg ;
      // finally we align it with the world geometry
      Fnegate ;
      Fpop yrot ;
      AddD yrot 90.0 ;
          // now we align the z rotation
  End;
```

6.1 Complex Agent Interactions using CallLists

Figure 6.2: Agents Fighting

The following example shows complex Agent interactions using the AgentRender module and terrain as shown in Figures 6.2 and 6.3. This example uses CallLists as well as an arf file to load in the initial Agent positions.

Figure 6.3: Agents Fighting (close up)

The environment is configured using the following .fl script.

```
WorldBBox 0 0 0 80.0 80.0 80.0 2 2 2 24
OutputFile fight.out
OutFileFrameSkip 1
UpdateRate 1
UseAgentRender
ObjTerrain -20 NewTerrainTri.obj MountainHMC.bmp 0.4 3 1.2 3
Camera 0 2 100 0 0 0 0 1 0 800 660 45.0 1.33 0.1 450.0
AgentEmitter -30.0 0 0 26 0.7 0.3 0.33 0.6 0 0 Fight.comp
PathFollow 0 -20 0 0 -10 0 0 10 0 0  20 0 0
LoadArf 0 Fight.arf
```

With the Agents initial position loaded using the following arf file

```
26
 -18  -20 -34 0 0 0.4
 -15  -20 -34 0 0 0.4
 -12  -20 -34 0 0 0.4
 -9  -20 -34 0 0 0.4
 -6  -20 -34 0 0 0.4
 -3  -20 -34 0 0 0.4
  3  -20 -34 0 0 0.4
  6  -20 -34 0 0 0.4
  9  -20 -34 0 0 0.4
 12  -20 -34 0 0 0.4
 15   -20 -34 0 0 0.4
 18   -20 -34 0 0 0.4
 -18  -20 34 0 0 -0.4
 -15  -20 34 0 0 -0.4
 -12  -20 34 0 0 -0.4
 -9  -20 34 0 0 -0.4
 -6  -20 34 0 0 -0.4
 -3  -20 34 0 0 -0.4
  3  -20 34 0 0 -0.4
  6  -20 34 0 0 -0.4
  9  -20 34 0 0 -0.4
 12  -20 34 0 0 -0.4
 15   -20 34 0 0 -0.4
 18   -20 34 0 0 -0.4
 0   -20 -34 0 0 0.4
 0  -20 34 0 0 -0.4
```

When the program starts the Agents are assigned a position based on the arf file. The Agent direction is then used to determine which colour the AgentRender material is set to.

The Agents then move towards each other and when they collide the Agents decide upon a punch or swing animation cycle. The Agent is also given a Life value and each time the Agent interacts with another Agent this value is decremented. If the life reaches zero the Agent is set to Dead and the other Agent assumes the Neutral position.

The code for this program is as follows.

Program 13: Fight.bs Complex Agent interactions using call lists and AgentRender

```
// the Agents position
Point Pos=[-30,0,0];
Vector Dir=[0.0,0.0,0.0,0.0];
bool TRUE=true;
bool FALSE=false;
```

```
// The rotation of the Agent in the X plane
float xrot=0.0;
float yrot=-90.0;
// The rotation of the Agent in the Z plane
float zrot=0.0;
float Material=0.0;
float Radius=1.4;
float ZERO=0.0;
bool HitAgent=false;
float SpeedZ=1.0;
float Life=10.0;
float DrawCallListindex=0.0;
bool ALIVE=true;
float WALK=0.0;
float RUN=1.0;
float SWING=5.0;
float PUNCH=4.0;
float DEAD=3.0;
float NEUTRAL=2.0;
float DrawMode=0.0;
Point NextPos=[0,0,0];
Vector ZeroVect=[0,0,0,0];
float Choice=0.0;
float ChoiceVal=50.0;
float AgentILife=0.0;
float EndFrame=8.0;
DefineCallList DrawFunctions;
CallListItem DrawFunctions Walk;
CallListItem DrawFunctions Punch;
CallListItem DrawFunctions Swing;
CallListItem DrawFunctions Neutral;
CallListItem DrawFunctions Dead;
Function Walk;
  Set DrawMode WALK;
End;
float Frame=0.0;
Function Punch;
  Set DrawMode PUNCH;
  SetAnimCycle DrawMode;
  RenderFrame Frame;
  RenderMaterial Material;
  RenderAgent;
End;
Function Swing;
  Set DrawMode SWING;
  SetAnimCycle DrawMode;
  RenderFrame Frame;
  RenderMaterial Material;
  RenderAgent;
End;
Function Neutral;
 Set DrawMode NEUTRAL;
 SetAnimCycle DrawMode;
  RenderFrame Frame;
  RenderMaterial Material;
  RenderAgent;
End;
Function Dead;
 Set DrawMode DEAD;
 SetAnimCycle DrawMode;
 RenderFrame Frame;
 RenderMaterial Material;
 RenderAgent;
End;
InitFunction
    UseAgentRender;
    GetGlobalPos Pos;
```

```
    GetGlobalDir Dir;
    Fpush Pos z;
    Fpop Material;
    Randomize Frame 8;
    Set NextPos Pos;
    Add NextPos Dir;
    Call CalcAngle;
    // get a random speed value;
    RandomizePos SpeedZ 2.0 ;
    fpush SpeedZ;
    fpushd 0.1;
    Fadd;
    ifelse Material > ZERO
    {
    SetD Material  1.0;
    fNegate;
    fpop Dir z;
    }
    {
    SetD Material 4.0;

    fpop Dir z;
    }
    SetD DrawCallListindex 0.0;
    RandomizePos Life 10.0;

End;
DrawFunction
SetGPYlevel Pos;
PushMatrix;
EnableLights;
// Translate to the Agents Position
    Translate Pos;
    Scale 10.0 10.0 10.0;
    RotateY yrot;
    CallList DrawFunctions DrawCallListindex;
DisableLights;
PopMatrix;
End;
UpdateFunction
    //Set HitAgent FALSE
    Add Pos Dir;
    Set NextPos Pos;
    Add NextPos Dir;
    AddD Frame 2.0;
     if Frame >= EndFrame
     {
     SetD Frame 0;
     }
End;
float EL=100.0;
bool AgentILifeFlag=false;
CollideFunction
if ALIVE == TRUE
{
   LoopBin;
     SphereSphereCollision HitAgent NextPos Radius NextPos Radius;
     if HitAgent == TRUE;
     {
     SetD Dir 0 0 0;
     SetAgentI Dir Dir;
     RandomizePos Choice 100.0;
     SubD Life 4.0;
     GetAgentI AgentILife Life;

     if AgentILife != ZERO
     {
```

```
       if Choice >= ChoiceVal
         {
         SetD DrawCallListindex 1.0
        }
       if Choice < ChoiceVal
         {
         SetD DrawCallListindex 2.0
         }

         if Life <= ZERO
         {
         Set ALIVE FALSE;
         SetD DrawCallListindex 4.0;
         SetAgentI Life EL;
         SetGlobalCollideFlag TRUE;
         }
       }

      }

LoopBinEnd;
}
 if AgentILife == ZERO
   {
   SetD Life 10;
   SetD DrawCallListindex 3.0;
   SetD Frame 0;
   }
End ;
// This function calculates the Agents orientation based on the poistion
// and the NextPos
// use these for temp storage in the calc angle function
Vector tmpPos=[0,0,0,0];
Vector tmpPos2=[0,0,0,0];
Function CalcAngle;
    // fist set the vectors to subtract
    Set tmpPos NextPos ;
    Sub tmpPos Pos;
    Fpush tmpPos x ;
    Fpush tmpPos z ;
    // use atan2 to calc the angle
    fatan ;
    // this gives us the angle in radians so we convert it
    Frad2deg ;
    // finally we align it with the world geometry
    Fnegate ;
    Fpop yrot ;
    AddD yrot 90.0 ;
End;
```

Chapter 7

Language Reference

The following Chapter describes the syntax of the EBPL programming language.

7.1 Variable syntax

7.1.1 Float

A floating point variable may be defined as shown below, it must be defined in the script before it used.

```
float xrot=0.0;
```

7.1.2 Point

The *Point* data type is used to represent a 3D point for drawing, it must be defined in the script before it is used. The point is defined as a 3 tuple with *x*,*y* and *z* components

```
Point Pos=[0,0,0];
```

7.1.3 Vector

The *Vector* data type is used to represent a 4D mathematical vector, it must be defined in the script before it is used. The point is defined as a 4 tuple with *x*,*y*,*z* and *w* components

```
Vector Dir=[0.0,-0.2,-0.1,0.0];
```

7.1.4 Bool

The *Bool* data type is used to represent **true** and **false** values, it must be defined in the script before it is used.

```
bool HitAgent=false;
```

7.1.5 Fuzzy

The *Fuzzy* data type represents a class of fuzzy object. It is defined as a floating point value (usually clamped between 0.0 - 1.0) and is capable of having fuzzy set operations applied to it, it must be defined in the script before it is used.

```
Fuzzy CloseEnough=0.03;
```

7.2 Agent Global Variables

There are five built in Agent Global variables these may be used to either set or get values from the Agent Class.

7.2.1 SetGlobalPos GetGlobalPos

The global position opcodes are used to set and get the global position of the Agent. The position value is used to calculate the flock center (Centroid) and if this is to be used in the simulation the GlobalPos variable must be set. It is used in the following way :-

```
// set the global pos flag
Point Pos=[0,0,0];
GetGlobalPos Pos;
// get the global pos flag
SetGlobalPos Pos;
```

7.2.2 SetGlobalDir GetGlobalDir

The global dir opcodes are used to set and get the global direction of the Agent. The direction value is not used within the simulation system, but the Dir value is from the arf file so getting this value can be used to configure the initial Agent direction.

```
// get a direction value
Vector Dir=[0,0,0,0];
GetGlobalDir Dir;
```

7.2.3 SetGlobalCentroid GetGlobalCentroid

The global Centroid opcodes are used to set and get the global Centroid of the Agent. The Centroid is calculated every frame by finding the average position of all the Agents. If the Centroid is required the user can access the flock center by these opcodes

```
// get the flock center
Point Centroid=[0,0,0];
GetGlobalCentroid Centroid;
```

7.2.4 SetGlobalCollideFlag GetGlobalCollideFlag

The global collide flags are used to indicate if an Agent has already been hit in a collision detection routine. If the global collide flag is set the collision detection will not be executed for the Agent.

```
// get the flock center
Bool TRUE=true;
// set glob collide flag
SetGlobalCollideFlag TRUE;
```

7.2.5 SetGPYlevel

The setgpylevel opcode is used to query the groundplane and set the y value of a tuple data type.

```
// get the flock center
Point Pos=[0,0,0];
// set the y value based on the gp from the agents position
GetGPYLevel Pos;
```

7.2.6 PushGPYLevel

This opcode pushes the y value of the groundplane onto the float stack. No variables are required for this function.

```
PushGPYLevel;
```

7.3 Collisions

Each time the system is updated the brain's CollideFunction is called, this is the only time within an EBPL program that the An Agent can access another Agents data. Within the system all agents are contained within a number of bins It is possible to loop through the Agents within the bins and test for collisions. This is implemented using the *LoopBin* and *LoobBinEnd* EBPL opcodes.

Whenever the *LoopBin* structure is encountered the current Agent value is used and the rest of the Agents within the bin are compared with the current Agent.

For convenience and speed EBPL has two built-in collision detection routines, however these and others may also be implemented within the EBPL language itself. These routines take as parameters variables from the EBPL script.

7.3.0.1 SphereSphereCollision

The SphereSphere collision opcode takes five parameters as outlined below

```
SphereSphereCollision bool Hit Point3 Pos1 float Rad1
                               Point3 Pos2 float Rad2 ;
```

The collision detection is calculated using the Position of the Current Agent and any other Agents in the current lattice bin. Each Agent has a Radius for the bounding sphere and if the sphere collide the Hit flag will be set to true.

7.3.0.2 CylinderCylinderCollision

The CylinderCylinder collision opcode takes seven parameters as outlined below

```
CylinderCylinderCollision bool Hit Point3 Pos1 float Rad1 float Height1
                          Point3 Pos2 float Rad2 float Height2;
```

The collision detection is calculated using the Position of the Current Agent and any other Agents in the current lattice bin. Each Agent has a Radius and height for the bounding cylinder and if the cylinders collide the Hit flag will be set to true.

7.3.1 Environment Collisions

Collisions with Objects within the environment are processed by two built in functions. At present only Planes and Cubes are supported but the environment has been designed to be extensible and add more object types including .obj objects.

7.3.1.1 Env Object Collisions

EnvObjects are represented as a cubes with a bounding sphere. When the *SphereEnvObjectCollision* Opcode is used the parameters passed to the routine are checked against all of the EnvObjects contained within the environment.

Detection of collision is a two stage process, first the Agent is tested using Sphere-Sphere to determine if the Object has been hit. Next Sphere Plane collision is used to determine which face of the object has been hit. At present the Normal of this face is returned to the Agent and collision avoidance is calculated on this value.

The SphereEnvObjCollision opcode takes four parameters as outlined below

```
SphereEnvObjCollision bool Hit Point3 Pos
                      float Radius2 Vector Normal;
```

The collision detection is calculated using the Position of the Current Agent and its bounding sphere radius, each EnvObject is tested in turn against the Agent and if a hit is detected the Hit flag is set to true and the Normal to the face hit is returned in the Normal parameter.

7.4 Functions

EBPL has two types of functions, there are 4 default built in functions which must be present in every EBPL script and user defined functions which act as procedure calls.

Built In Functions	Description
InitFunction	Called when the Agent brain is created and used to initialize variables etc.
UpdateFunction	Called every iteration of the system to update the Agents position
DrawFunction	Called every iteration of the system to Draw the Agent
CollideFunction	Called every iteration to do collision detection

Table 7.1: EBPL variable types

The built in functions are shown in Table 7.1 and are called for every Agent in the system for each iteration of the environment. User defined functions are generated by the *Function* keyword and can be called from within any of the main built in functions.

7.5 Call Lists

Call lists are a way of creating switchable function calls depending upon an ordinal variable value. The creating of a call list is a two stage process as shown below

```
DefineCallList TestList;
CallListItem TestList foo;
CallListItem TestList bar;
```

First a call list name is defined to make storage for the Function pointers to be allocated to the list. Next list items may be added to the list. To use a CallList within a function the following code is used

```
float ListValue=0;
// function foo called
CallList TestList ListValue;
AddD ListValue 1;
// Function bar called
CallList TestList ListValue;
```

7.6 Bins and Other Agent Access

The only time other Agents value may be accessed is within the LoopBin structure. There are two methods of accessing the data of other agent by use of the *SetAgentI* and *GetAgentI* methods as follows

```
// Set NDir to be the ADir of the other Agent
SetAgentI NDir ADir;
// Get the Dir of AgentI and set it to NDir
GetAgentI Dir Ndir
```

7.7 MiniGL Opcodes

A simple subset of the OpenGL drawing commands have been implemented in the script to allow the Draw function to produce images. These allow for simple line, point and 3D primitives to be drawn and are intended as a simple method to visualize the Agents behaviour.

7.7.1 RotateX

The RotateX opcode calls *glRotatef(d,1,0,0);* and rotates the current transformation matrix by degrees in the X axis. It takes as its argument either a direct floating point value or a Floating point variable.

```
RotateX xrot; // using a variable
RotateX  -90.0; //using a direct value
```

7.7.2 RotateY

The RotateY opcode calls *glRotatef(d,0,1,0);* and rotates the current transformation matrix by degrees in the Y axis. It takes as its argument either a direct floating point value or a Floating point variable.

```
RotateY yrot; // using a variable
RotateY  -90.0; //using a direct value
```

7.7.3 RotateZ

The RotateZ opcode calls *glRotatef(d,0,0,1);* and rotates the current transformation matrix by degrees in the Z axis. It takes as its argument either a direct floating point value or a Floating point variable.

```
RotateZ zrot; // using a variable
RotateZ  -90.0; //using a direct value
```

7.7.4 PushMatrix

The PushMatrix opcode calls *glPushMatrix();* to store the state of the current OpenGL transformation matrix.

7.7.5 PopMatrix

The PopMatrix opcode calls *glPopMatrix();* to re-store the state of the current OpenGL transformation matrix.

7.7.6 Translate

Translate calls *glTranslate3f(x,y,z)* where the x,y and z values come from either a Point or Vector data type. It is used as shown below

```
Translate Pos; // where Pos is a point
Translate Dir; // where dir is a vector
```

7.7.7 Polygon

The Polygon opcode calls *glBegin(GL_POLYGON);* to start drawing with polygons

7.7.8 Quad

The Quad opcode calls *glBegin(GL_QUADS);* to start drawing with quads.

7.7.9 Point

The Point opcode calls *glBegin(GL_POINTS);* to start drawing with points.

7.7.10 LineLoop

The LineLoop opcode calls *glBegin(GL_LINE_LOOP);* to start drawing a line loop

7.7.11 glEnd

The glEnd Opcode calls *glEnd()* to end the current drawing mode

7.7.12 Vertex

The vertex Opcode takes either a point or a vector data type and uses the x,y and z values to produce a vertex using *glVertex3f(x,y,z);*

```
Vertex Pos; // draw a vertex using a point
Vertex Dir; // draw a vertex using a vector
```

7.7.13 Vertexf

The vertexf opcode draws a vertex using direct floating point values for the x,y and z values as shown below

```
Vertexf -0.5 -0.2 0.0;
```

7.7.14 PointSize

The PointSize opcode sets the current point drawing size

```
PointSize 2.0; //set the point size to 2.0
```

7.7.15 LineSize

The LineSize opcode sets the current line drawing width

```
LineSize 4.0; // set the line width to 4.0
```

7.7.16 Sphere

The Sphere opcode draws a sphere using either a floating point variable or direct value for the radius of the sphere, the other two arguments are stacks and slices which can not be changed once set.

```
Sphere radius 12 12 ; // sphere using a variable value
Sphere 0.02 20 20 ; // sphere using direct float values
```

A solid version of the sphere may also be drawn using the *SolidSphere* opcode as follows

```
SolidSphere radius 12 12 ; // sphere using a variable value
SolidSphere 0.02 20 20 ; // sphere using direct float values
```

7.7.17 Cylinder

The Cylinder opcode draws a cylinder using either floating point variable of direct value for the radius and height of the cylinder, the other two arguments are stacks and slices which can not be changed once set.

```
Cylinder Rad Height 12 14; // using variables
Cylinder 0.4 1.0 20 20 ; // using direct values
```

7.7.18 Colour

The colour opcode sets the current drawing colour, it takes 3 floating point values for red, green and blue or a Point variable type

```
Colour 0.3 0.2 1.0 ;
Point colour=[0,1,0]
Colour colour;
```

7.7.19 Lighting

At present only the *GL_LIGHT0* light is enabled in the system. This has a default position of 0,0,0 and a default colour of white.

To enable and disable the lighting in the system the following opcodes are used.

```
// turn lights on
EnableLights;
// turn lights off
DisableLights;
```

The shade models used for rendering may also be set. The default value is smooth shading which is slower. To change the shade model use the following opcodes

```
// turn on smooth shading (slower)
Smooth;
// turn on flat shading (faster)
Flat;
```

7.8 AgentRender

To use the AgentRender module both the .fl and brainscript files need to have the following instruction added

```
UseAgentRender ;
```

This tells the environment and the brain that the AgentRender is being used. If this is not present in the scripts and any other AgentRender calls are made the system will crash. In the brain script this call is generally placed in the *InitFunction* as it only needs to be set once.

There are four Opcodes used for configuring the AgentRender as follows

Value	Meaning
SetAnimCycle	sets the animation cycle to be drawn as indicated by the Mode values in Figure 2.7
RenderFrame	Selects which frame of the AgentRender sequence to draw
RenderAgent	Draws the Agent configured by the above two opcodes
RenderMaterial	Set the current material for the Agent (see Table 7.3)

Table 7.2: AgentRender Opcodes

All these opcodes can take either floating point variables or direct float values as shown in the example below :-

```
// set to agent walk cycle
float DrawMode=0;
float Frame=4;
SetAnimCycle DrawMode;
// set material to chrome
RenderMaterial 3;
//render the 3rd frame of the cycle
RenderFrame Frame;
```

The material types currently used in EBPL are shown in Table 7.3.

Material Number	Material Type
0	BLACKPLASTIC
1	BRASS
2	BRONZE
3	CHROME
4	COPPER
5	GOLD
6	PEWTER
7	SILVER
8	POLISHEDSILVER

Table 7.3: Material Types

7.9 Float Stack Opcodes

The floating point stack operates in a First in Last Out principle, any operations on the stack use reverse polish notation for example 2+3 will be executed in the script by push 3 push 2 fadd which will result in 5 being put onto the top of the stack.

7.9.1 Fpush

The fpush opcode pushes a floating value onto the stack any variable type may be pushed onto the stack but with tuple data types which element to be pushed must be specified.

```
Fpush Pos x; // pushes the x component of the Point pos
Fpush yrot ; // pushes the float variable yrot;
```

7.9.2 Fpushd

The *fpushd* opcode allows a direct floating point value onto the stack as follows

```
Fpushd 23.2; // pushes 23.2 onto the float stack
```

7.10 Fpop

The fpop opcode takes the value from the top of the stack and places it into the variable, if a tuple data type is used the x,y or z destination must be specified.

```
fpop ypos; // places the tos value into ypos
fpop tempPos y; places the tos value into tempPos.y
```

7.10.1 Fadd

The fadd opcode takes the top two values from the stack adds them and places the sum back onto the stack

7.10.2 Fsub

The fsub opcode takes the top two value from the stack subtracts them and places the result back on the stack. Note if the stack contains 2 and 4 the result will be 2 - 4 = -2

7.10.3 Fmul

The fmul opcode takes the two top values from the stack and multiplies them and places the product back on the stack.

7.10.4 Fdiv

The fdiv opcode takes the two top values from the stack and divides them and places the result back on the stack. Division by 0 is trapped by changing any 0 value with a 1 (and printing a warning to the console in debug mode)

7.10.5 Fdup

The fdup opcode takes the top of stack value and duplicates it.

7.10.6 Fsqrt

The Fsqrt opcode takes the top of stack value and places the square root of that value onto the stack.

7.10.7 Frad2Deg

The Frad2deg opcode is a helper function to convert radians to degrees as most C++ math operations use radians.

7.10.8 Fatan

The fatan opcode takes the two top values from the stack and calculates the arc tangent. The code used is atan2(x,y) where X is the top of stack value and y is the next value

7.10.9 Fsin

The fsin opcode takes the top most value from the stack and puts back the sine of the value

7.10.10 Fasin

The fasin opcode takes the top most value from the stack and puts back the arc sine of the value

7.10.11 Fcos

The fcos opcode takes the top most value from the stack and puts back the cosine of the value

7.10.12 Facos

The facos opcode takes the top most value from the stack and puts back the arc cosine of the value

7.10.13 Fnegate

The Fnegate opcode takes the top most value from the stack and puts back the negated value.

7.10.14 FStackTrace

The FstackTrace opcode prints out the current contents of the stack.

7.11 Variable Opcodes

Most variables can be accessed directly by the use of opcodes and values can be set and retrieved.

7.11.1 Add

The *Add* opcode works on any data type but care must be taken with the mixing of types. For example tuple data types can be added together easily but a tuple to float will cause problems. The opcode is used as follows

```
Add Pos Dir; // add a point to a vector
Add yrot zrot; // add two float variables
```

7.11.2 Sub

The *Sub* opcode works on any data type but care must be taken with the mixing of types. For example tuple data types can be subtracted easily but a tuple to float will cause problems. The opcode is used as follows

```
Sub Pos Dir; // subtract Dir from Pos
Sub yrot zrot; // subtract two float variables
```

7.11.3 Mul

The *Mul* opcode works on any data type but care must be taken with the mixing of types. For example tuple data types can be multiplied easily but a tuple to float will cause problems. The opcode is used as follows

```
Mul Pos Dir; // multiply Pos by Dir
Mul yrot zrot; // multiply two float variables
```

7.11.4 Div

The *Div* opcode works on any data type but care must be taken with the mixing of types. For example tuple data types can be subtracted easily but a tuple to float will cause problems. The system automatically traps division by zero errors by setting the divisor to 1 if it is a zero value. The opcode is used as follows

```
Div Pos Dir; // divide Dir from Pos
Div yrot zrot; // divide two float variables
```

7.11.5 Set

The *Set* opcode is used to assign one variable from another it may only be used with variable of the same type as follows

```
Point Pos=[1,0,1];
Point Pos2=[0,0,0]
Set Pos Pos2;  // Set Pos = Pos2;
```

7.11.6 AddD

The AddD opcode adds a value directly to a variable for example

```
// using a float
AddD yrot 180.0;
// using a point
AddD Pos 0 1 0;
```

7.11.7 SubD

The SubD opcode subtracts a value directly from a variable for example

```
// using a float
SubD yrot 180.0;
// using a point
SubD Pos 0 1 0;
```

7.11.8 MulD

The MulD opcode multiplies a value directly from a variable for example

```
// using a float
MulD yrot 180.0;
// using a point
MulD Pos 0 1 0;
```

7.11.9 DivD

The DivD opcode divides a value directly from a variable. If the divisor is zero the value will be set to 1 for example

```
// using a float
DivD yrot 180.0;
// using a point
DivD Pos 0 1 0;
```

7.11.10 SetD

The SetD opcode assigns a direct value to a variable as follows

```
// using a float
SetD yrot 180.0;
// using a point
SetD Pos 0 -1 0;
```

7.11.11 Length

The Length opcode returns the length of a Vector or Point Variable onto the stack

```
Vector Dir=[1,0,-2,0];
Length Dir;
```

7.11.12 Normalize

The Normalize opcode set the variable to unit size

```
Vector Dir=[1,0,-2,0];
Normalize Dir;
```

7.11.13 Dot

The *Dot* opcode returns the dot product of two Point or Vector data types, these types may be mixed but the return type is always a float. It is used as follows

```
Float DotResult=0.0;
Vector Dir=[1,0,-2,0];
Vector Dir2=[1,0,1,0];
// return the result DotResult = Dir • Dir2
Dot DotResult Dir Dir2;
```

7.11.14 Reverse

The Reverse opcode reverses (negates) the current variable.

```
Vector Dir=[1,0,-2,0];
Reverse Dir;
```

7.11.15 Randomize

The randomize opcode sets the variable to random values within a range based on ±seed value passed.

```
Randomize Dir 2.1 0.1 1.1;
Randomize yrot 4.0;
```

7.11.16 RandomizePos

The randomizepos opcode sets the variable to random positive value within a range based on zero to the seed value passed.

```
RandomizePos Dir 2.1 0.1 1.1;
RandomizePos yrot 4.0;
```

7.12 Structure Opcodes

The structure opcodes are used to define functions and call functions and make decisions.

7.12.1 Call

The Call opcode will call a function within the script.

```
Call CalcAngle;
```

7.12.2 Function

The Function Opcode defines the beginning of a function block. It must be terminated by use of an End opcode as shown below

```
Function CalcAngle
 fpush yrot;
 fpop yrot;
End
```

7.12.3 If

The if structure can be used on all data types and is constructed as shown below

```
if dist > MinCentroidDist
 {
  // do something
 }
```

All if statements must use the open and closed braces, however if statements may be nested. At present if only works with two defined variable types so if a comparison against a static value is required the static value must be define as a variable.

7.12.4 Ifelse

The ifelse structure can be used on all data types and is constructed as shown below

```
ifelse dist > MinCentroidDist
 {
  // do something
 }
 {
 // do something else
 }
```

All if statements must use the open and closed braces and at present ifelse statements may not be nested, however if statements may be placed within an ifelse construct. At present ifelse only works with two defined variable types so if a comparison against a static value is required the static value must be define as a variable.

7.13 Debug

The Debug opcode prints to the console the variable argument.

```
Debug Pos;
```

The *DebugOpOn* and *DebugOpOff* opcodes turn on and off the printing of the current opcode to the console.

7.14 Noise Function

Each Agent has the ability to access a noise function based on Perlin Noise [eta98]. This value is generated by a built in noise function and can be calculated from any tuple data type. There are five built in noise functions as shown in Table 7.4.

Noise Type	Noise Index Value
turbulence	0
marble	1
undulate	2
noise3	3
turbulence2	4

Table 7.4: ebpl Noise functions

To use noise the noise generator must be initialized as shown below

```
float NoiseType=5.0;
float NoiseScale=0.0;
RandomizePos NoiseType 5;
Randomize NoiseScale 2000;
UseNoise NoiseType NoiseScale;
```

The *GetNoiseValue* opcode is used to access the noise table, it is passed a value to return to and a seed value to generate the noise from this is shown in the following example

```
Point Pos=[0,0,0];
Vector NoiseValue=[0,0,0,0];
GetNoiseValue NoiseValue Pos;
```

Chapter 8

.fl Script reference

To run the program type in the console ebpl <paramfile.fl> where <paramfile.fl> is the name of the file to load.

Once the program runs it is best to leave the agents moving in random for a while so the system can reach a suitable chaotic state.

To run full screen use ebpl <paramfile.fl> f

8.0.1 Keys

Key	Action
[space]	turns the flocking on and off
c	toggles the curve following for the agents
p	Pause simulation
d	Dump agent debug info to console
h	Toggle on screen menu
Mouse	rotates view Left Button x-y Right button x-z
0[zero]	toggle write agent points to file mode
ArrowKeys	Move Camera
PGUP/PGDN	Zoom Z in and out.
1	Toggle Camera follow Centroid
g	Toggle Agent Follow goals mode
p	Pause Simulation
l	Toggle Locked Centroid mode
4	Draw bin lattice structures
q	Toggle draw Environment details
t	Toggle write frames as tiff files (will be placed in the directory ../Frames/

8.1 Flocking System Script File Format

The flocking system reads a file to configure the various elements of the system. Two initial parameters must be set and after that the parameters may be set in any sequence.

All variables are assumed floats *(f)* except index values which are integer values *(i)* and the file name for the Output file *(s)*. Comments can be added to the file using the standard C comment block //. also white space on lines is also ignored.

All keywords are case insensitive and capitalizations are only used for ease of reading the script.

8.1.1 Environment Parameters

The Environment parameters are used to set up the initial parameters for the world.

8.1.1.1 BBox

The first script element of the file must be a BBox which sets up the world bounding box.

```
WorldBBox (f)Pos.x (f)Pos.y (f)Pos.z (f)Width (f)Height
(f)Depth (i)Xdiv (i)Ydiv (i)Zdiv (i)BinSize
```

Pos : sets the initial position of the bounding box center

Width, **Height Depth** : the extents of the box calculated from the center (as $\pm$Width/2 etc)

Xdiv,Ydiv,Zdiv : The subdivision of the Lattice bin structure for agent containments

BinSize : the max size of bins, this is usually set to be the number of Agents in the system

8.1.1.2 EnvObj

Any number of EnvObj can be added to the Environment, they are added sequentially from 0 and any subsequent operations of these objects refer to the index.

```
EnvObj (f)Pos.x (f)Pos.y (f)Pos.z (f)Width (f)Height
(f)Depth (f)Radius
```

Pos : sets the central position of the Object

Width Height Depth : set the extents of the Object

Radius : the radius of the object used for collision detection, it is best to set it slightly larger than the biggest extent of the object.

8.1.1.3 RotateObj

This is used to rotate an object around it's own axis in x,y or z.

```
RotateObj (i)Index (f)angle (f)xAxis (f)yAxis (f)zAxis
```

Index : the index of the object to rotate, this is based on the sequence that the objects are added in the script file starting at 0

angle : the angle to rotate in degrees

xAxis,yAxis zAxis : are flags to indicate which axis to rotate around. setting any of these to 1.0 will rotate around the axis specified, all can be set in one go i.e *RotateObj 0 25 1 1 1* will rotate 25°in all 3 axis.

8.1.1.4 Goal

Goals are timer based objects which can attract the flock. Any number can be added to the AgentEmitter they are drawn in Red in the display

```
Goal (i)index (f)Pos.x (f)Pos.y (f)Pos.z (f)TimeToActivate
```

Index : which AgentEmitter to attach the goal to

Pos : sets the central position of the goal

TimeToActivate : The time when the goal is active.

8.1.1.5 OutputFile

This sets the name for the output file to save Agent data to

```
OutputFile (s)Filename
```

Filename : file to save to

8.1.1.6 OutFileFrameSkip

The set the number of frames to skip between writes to the file. This value defaults to 5.

```
OutFileFrameSkip (i)skip
```

skip : the frame skip rate.

8.1.1.7 UpdateRate

Set how many times the simulation is update per redraw. This value will run the agent update but not display the results until all the updates have been done.

```
UpdateRate (i)rate
```

rate : how many times to update per display update

8.1.1.8 RandomSeed

The tells the simulation to set the seed to a random value (using *srand(time(NULL));*) to generate random values for the simulation, otherwise srand(2) is used to give the same values each time.

8.1.1.9 Camera

Allows the user to override the camera

```
Camera (f)eyeX (f)eyeY (f)eyeZ (f)lookX (f)lookY (f)lookZ
(f)upX (f)upY (f)upZ (i)W (i)H (f)va (f)asp (f)near
(f)far
```

eyeX,eyeY,eyeZ : eye Position

lookX,lookY,lookZ : look at point

upX,upY,upZ :a vector to indicate which axis is the up direction

W,H : the width and height of the screen area

va : the view angle

asp : the aspect ration

near,far : the near far clip planes

8.1.1.10 CamFollowCentroid

This command allows the Camera to be attached to one of the AgentEmitters centroids.

```
CamFollowCentroid (i)index (f)Xoff (f)Yoff (f)Zoff
```

Index : the index of the AgentEmitter for the camera to attach the look point to

Xoff : the X offset from the centroid for the Eye point of the camera

Yoff : the Y offset from the centroid for the Eye point of the camera

Zoff : the Z offset from the centroid for the Eye point of the camera

8.1.1.11 FrameOffset

This sets the frame offset for the output file, by default frames start at 0

```
FrameOffset (i)offset
```

offset : the offset added to the frame numbers in the output file.

8.1.1.12 RandomSeed

Sets the seed for the random number generator to the value time(NULL) which is the current system time. In theory this should make each run of the system different but this will change depending upon the random number generator used.

8.1.1.13 VectObj

Vector objects are objects in the environment which act like winds. Each vector Obj has a bounding sphere which will become active if the Agents collide with them.

```
VectObj (f)Pos.x (f)Pos.y (f)Pos.z (f)Width (f)Height (f)Depth
(f)Radius (f)X (f)Y (f)Z
```

Pos : the position of the Vector Object

Width,Height,Depth : The width height and depth of the object

Radius : The radius of the Objects bounding sphere for agent collision detection

X,Y,Z : The vector direction for the Vector object.

8.1.1.14 GroundPlane

The ground plane is the default ground level for the Agents in the Environment

```
GroundPlane (f)Level (f)Red (f)Green (f)Blue (f)Alpha
```

Level : The ground plane level

Red : The red colour component for the gp

Green : The green colour component for the gp

Blue : The blue colour component for the gp

Alpha : The transparency for the gp.

8.1.1.15 ImageGroundPlane

This allows the groundplane to be loaded from an image file. The extents of the ground plane are calculated from the WorldBBox size and the number of triangle strips used are dependent upon the size the image loaded.

```
ImageGroundPlane (f)Ylevel (s)Filename.bmp (f)Ydivisor
```

Ylevel : The level of the groundplane

Filename.bmp The name of the bmp file to load

Ydivisor : The value to scale the heightmap by.

8.1.1.16 GroundPlaneTex

This allows the groundplane to be loaded from an image file. The extents of the ground plane are calculated from the WorldBBox size and the number of triangle strips used are dependent upon the size the image loaded. The second filename is the name of the texture to use.

```
GroundPlaneTex (f)Ylevel (s)Filename.bmp (s) TextureName.bmp
               (f)Ydivisor
```

Ylevel : The level of the groundplane

Filename.bmp The name of the bmp file to load

TextureName.bmp : The name of the file to use as a texture for the groundplane.

Ydivisor : The value to scale the heightmap by.

8.1.1.17 ObjTerrain

This allows the groundplane to be loaded from an obj file with textured support from a bitmap file

```
ObjTerrain (f)Ylevel (s)Filename.obj (s) TextureName.bmp
               (f)AgentHeightOffset (f)Scale X (f) ScaleY
               (f) ScaleZ
```

Ylevel : The level of the groundplane

Filename.obj The name of the obj file to load

TextureName.bmp : The name of the file to use as a texture for the groundplane.

AgentHeightOffset : The value to add to the Agents Y value

Scale X,Y,Z : The scale in X,Y and Z for the obj file. This pre-scales the obj file before loading.

8.1.2 Emitters

The Environment can have any number of AgentEmitter. These are the source for each of the agents and are responsible for all the agent collision detection , updates and rendering.

There must be at least one AgentEmitter in the file and this is set to index 0, each subsequent one is then incremented by one. These numeric values are then referred to by the other elements of the script to attach something to the Emitter .

8.1.2.1 AgentEmitter

The simplest emitter is shown below and is used for most systems

```
AgentEmitter (f)Pos.x (f)Pos.y (f)Pos.z (i)NumAgents
             (f)Width (f)Height (f)Depth (f)Radius (i)SpeciesTag
             (b)EmitType (s) BrainFile
```

Pos : sets the initial position of the emitter.

NumAgents : the number of Agents to Emit.

Width, **Height** ,**Depth** set the size of the agents

Radius : the bounding sphere radius of the Agent used for collision detection

SpeciesTag : indicates which species the Agents are.

EmitType: set to 0 for point emitter 1 for random distribution around the world BBox

BrainFile : The name of the compiled brain for the Agent to use.

8.1.2.2 PathFollow

This is used to set a spline curve for the agents to follow at present this is a 4 point Bezier curve.

```
PathFollow (i)Index (f)P1.x (f)P1.y (f)P1.z (f)P2.x (f)P2.y
(f)P2.z (f)P3.x (f)P3.y (f)P3.z (f)P4.x (f)P4.y (f)P4.z
```

Index : which AgentEmitter to attach the curve to

P[n].x P[n].y P[n].z : the points for the curve.

8.1.2.3 PathStep

This sets the speed at which the Centroid path step is updated each time default value 0.02

```
PathStep (f)steprate
```

steprate : The update speed for the centroid

8.1.2.4 LoadARF

This allows for the loading of an AgentResoure file generated from the Layout program.

```
LoadARF (i)Index (s)Filename
```

Index the index of the AgentEmitter to load

Filename The name of the ARF file to load.

Index

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