Nature of Code

Patrick Dwyer
Fall 2005
patrick@digilutionary.com
http://www.digilutionary.com/classes/nature

Class Hours

- Tuesdays 3:30pm - 6:00pm

Office Hours

- Tuesdays 2:00pm - 3:00pm
- Thursdays 1:00pm - 2:00pm
- By appointment

Description

Can we capture the unpredictable evolutionary and emergent properties of nature in software? Can understanding the mathematical principles behind our physical world world help us to create digital worlds? This class will focus on the programming strategies and techniques behind computer simulations of natural systems. We'll explore topics ranging from basic mathematics and physics concepts to more advanced simulations of complex systems. Subjects covered will include forces, trigonometry, fractals, cellular automata, self-organization, and genetic algorithms. Examples will be demonstrated using the processing (http://www.processing.org) environment with a focus on object oriented programming.

Homework

Students are required to complete a programming exercise each week (assignments to be specified in the weekly handouts). The assignment's source code and accompanying applet should be uploaded to a web server and linked to from the Homework upload page.

Presentations

Each student is required to make a "research" presentation once during the course of the semester to supplement the material presented in class the previous week. 2-3 people should sign up for each week (and can present as a group or separately.) The format for the presentations is extremely open (feel free to think creatively here). They should be brief (10-20 minutes, longer for 3 people) and could include any of the following: information on related projects, live physics demonstrations, instructional videos, links to online sources and tutorials, book reviews, source code examples, diagrams, etc. You should include a link to documentation of your talk on the sign up wiki.

Part I: Motion

Week 1 — September 6th

Class Introduction

Class Overview
Processing review
Object Oriented Programming review
Vectors - Basics of Motion (Acceleration & Velocity)

Week 2 — September 13th

Forces

Attraction, Repulsion, Friction and Drag

Readings

- *Essential Mathematics for Games* - Vectors pg. 12 - 37
- *Physics for Game Developers* - Kinematics & Force pg. 25 - 68

Resource

- GameDev - Math and Physics: http://www.gamedev.net/reference/list.asp?categoryid=28

Week 3 — September 20th

No More Random Numbers

Understanding Probability
Distribution of Random Numbers (Uniform, Non-Uniform, Normal)
Perlin Noise

Readings

- http://mathworld.wolfram.com/NormalDistribution.html
- http://mathworld.wolfram.com/UniformDistribution.html

Resource

- Perlin Noise Tutorial: http://freespace.virgin.net/hugo.elias/models/m_perlin.htm

Week 4 — September 27th

Making Waves

Trigonometry
Oscillations and Pendulum
Graphing waves
2D trigonometry graphing

Readings

- *Essential Mathematics for Games* - Trigonometry Review pg. 623 - 633

Week 5 — October 4th

Particle Systems

Advanced Object Oriented programming
Inheritance and Polymorphism

Readings

- *Physics for Game Developers* - Kinetics & Particle Systems pg. 69 - 81, 271 - 284

Week 6 October 11th — **Review**

Part II: Life

Week 7 October 18th — **Simple Rule-based Systems**

Recursion and Fractals
1D Cellular Automata - Wolfram Automata
2D Cellular Automata - Conway's Game of Life

Readings

- *Computational Beauty of Nature* - Fractals pg. 59 - 127
- *Computational Beauty of Nature* - Cellular Automata pg. 231 - 258

Week 8 October 25th — **Autonomous Agents**

Steering
Craig Reynold's Boids - Alignment, Cohesion and Separation

Readings

- *Computational Beauty of Nature* - Complex Systems pg 231 - 304

Week 9 November 1st — **Genetic Algorithms - Part I**

Readings

- *Computation Beauty of Nature* - Genetics and Evolution pg. 339 - 380

Week 10 November 8th — **Genetic Algorithms - Part II**

Readings

- *Computational Beauty of Nature* - Genetics and Evolution pg. 383 - 424

Week 11 November 15th — **Propose Final Projects**

Week 12 November 22nd — **Final Projects in Progress**

Week 13 November 29th — **Final Projects in Progress**

Week 14 December 6th — **Show Final Projects**

Reading Materials

Readings for each week are listed in the syllabus. The readings are chosen from all of the course books; you are only required to read sections from *The Computation Beauty of Nature*, the remainder of the readings are suggested aides to the material for the week.

Required Materials

- *The Computational Beauty of Nature*, Gary William Flake

Suggested Materials

- *Physics for Game Developers*, David M. Bourg

Optional Materials

- *Algorithmic Beauty of Plants*, Przemyslaw Prusinkiewicz
- *Essential Mathematics for Games & Interactive Applications*, Verth, Bishop
- *Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds (Complex Adaptive Systems)*, Mitchel Resnick
- *Creative Code*, John Maeda

Grading

Grades will be determined according to the following breakdown:

- Homework Assignments 50%
- Participation and Attendance 20%
- Final Project 30%