Pixar’s “A Bug’s Life” (with procedural models abounding)

**CNM 190**

**Advanced Digital Animation**

**Lec 06 : Advanced Procedural Modeling**

Dan Garcia, EECS (co-instructor)

Greg Niemeyer, Art (co-instructor)

Jeremy Huddleston, EECS (TA)

Sanjay Bakshi, Pixar (guest lecturer)
Overview

- Dan on Advanced Procedural Modeling
  - Randomness revisited
  - Particle systems
  - Genetic algorithms
  - How do we do it?
  - Set dressing
  - Character generation
  - Hair & Fur
  - Conclusion

- Sanjay on what is done at Pixar
Randomness revisited

What if we want a characters distribution to resemble demographics of Cal ugrads?

Gender

- Men: 46%
- Women: 54%

Ethnicity

- American Indian
- Asian
- African-American
- Hispanic
- Caucasian
- Other
- No Data
- International

How can we use random()?
Simple, slice up [0,1]!

- Just use range = to that of distribution!

  ```python
  >>> g = random()  # [0, 1) gender
  >>> e = random()  # [0, 1) ethnic
  ```

- And then use if … else from data!

  ```python
  >>> if g < .46:  # 46% male
  ... MakeCharacter(male)
  ... else:
  ... MakeCharacter(female)
  ```

- …and similarly for ethnicity, height, etc
I must program to randomize?

- Maya has randomness at many levels
  - Demo of Maya’s help, specifically Functions49.html
- It has most of the functions built-in!
  - seed()
  - rand()
  - gauss()
  - noise()

---

Procedural Modeling Basics

Field Annex: 642-9920

http://inst.eecs.berkeley.edu/~selfpace/

 gauss(5)
Particle systems

Typically used to simulate fuzzy phenomena
- Smoke, Explosions, Water, Sparks, Dust, Stars

Emitter controls particle generation, simulation

What is involved with the geometry?
- Typically output as textured billboard quad
- Or, single pixel
- Or, metaball (for gooey materials)

pixar cosmic voyage
Genetic Algorithms

- Karl Sims blew away his colleagues with his seminal 1994 work on evolved creatures

(evolved virtual creatures)

C15 Hearst Field Annex: 642-9920

CNM190  Procedural Modeling Basics
Genetic Algorithms

- **Genotype** is the genetic information that codes the creation of an individual
- **Phenotype** is the individual
- **Selection** is the process by which fitness of phenotypes is determined
- **Reproduction** is the process by which new genotypes are generated from existing ones
- There must be probabilistic **mutations** with some frequency

Procedural Modeling Basics
How do we do it in Renderman?

renderman.pixar.com/products/whatsrenderman/
www.cs.berkeley.edu/~ddgarcia/renderman/

- Easy!
- Renderman supports a library that you can compile with your C program that will help you output RIB
- RIB is the intermediate file that Renderman reads
- The result of a render is a tiff file (or multiple tiff files)
  - Demo of simple.c and hard.c

Procedural Modeling Basics 9/17
How do we do it in Maya?

- Easy!
- Every action you perform in Maya is available in the Script Editor.
- You can generate this text explicitly through a program using the techniques we just discussed. E.g., Name it Foo.mel.
- Or you can use MEL as a programming language (it looks like C) and do all your scripting there!
- Open this in Maya (double-click, or use the Script Editor).
  - Demos of makeAntenna.mel and makeMenger.mel.
Set Dressing

http://en.wikipedia.org/wiki/Set_dressing

“The process of selecting, designing, adapting to, or modifying the performance space for a given purpose. This includes the use of stagecraft elements as well as the structure of the stage and its components.”
Which elements of the scene below were placed by hand and which were placed procedurally?

In general, when would you author code to place set elements? How much randomness would you allow?
Consider the problem of placing trees in a forest in a natural way

- How would you place them so that they don’t overlap?
- What are some ideas?
Random Trees
- Pick random points and remove if new tree is too close to existing tree
- Start with trees regularly spaced and then perturb (wiggle)
- Add “relax” step which treats each point as having “negative gravity” to push away nearby points
- Find out what “right” answer is (check forestry research) or by looking at real forests and simulate

Voronoi diagram of random points
Procedural Character Generation

- Create a procedural character model that has enough parameters to capture what you want
- Find out what distribution you would like (see first slides) of the parameters
- Populate your world (for each character, assign the properties, including location)
Hair and Fur

- Used to be a hard problem
- Algorithms now exist to allow animators to either let dynamics control it completely OR to animate “control hairs” (which control a patch)
  - It’s even built into Maya!
- See the work in Monsters, Inc and Narnia
Conclusion

- Set dressing grounds scene in believable surroundings
- Crowds need lots randomness with character selection
- Next week:
  - Skeletons & Rigging