PROCEDURAL GENERATION
BASICS OF RANDOMNESS
GENERATING RANDOM BITS

• Random bits are generated from pseudorandom number generators, or algorithms that generate a sequence of bits that appears random
  • Sequence based on a "seed" that starts the algorithm off
  • Set of bits are composed and manipulated to interpret higher level types, e.g., integers or floating-point numbers

• Numbers can also be generated through quasi-random or truly random generation (quantum computers)
VARIOUS DISTRIBUTIONS

• Random numbers are manipulated so that they then reflect a probability distribution

• Uniform distribution – all values equally likely in a range (or discrete set)

• Gaussian distribution – values near a mean are more likely than far away from a mean
VARIOUS DISTRIBUTIONS

• Binomial distribution – series of coin flips
• Poisson distribution – expresses probability of a given number of events occurring within a time interval
• Exponential distribution – represents time between different Poisson events
• Etc.
EXERCISE

• With a partner
  • Define an algorithm to generate points uniformly within a disc of radius $r$
  • Define an algorithm to generate velocities biased towards a target velocity for a series of objects
  • Where in games you have played have you seen this most basic form of generation?
GENERATIVE GRAMMARS
WHAT'S A GRAMMAR?

- A set of production rules for strings in a language
- Example: all strings containing at least one "a" followed by the same number of "b"s
  - "ab", "aabb", etc
  - Production rules:
    \[ S \leftarrow aSb \]
    \[ S \leftarrow ab \]
HOW CAN THESE BE USEFUL FOR GENERATING CONTENT?

- Expressed as a **generative grammar**, they define rules to generate strings in a language, vs "accept" strings in the language.
- Simple procedure could be to uniformly pick a production rule repeatedly to generate a random string from the language.
  - Essentially forms a random grammar tree.
  - Can apply constraints and non-random decision making as well.
LINDENMAIER SYSTEM

- Combines generative grammar of strings with a translation system to translate the string into geometric structures.
SHAPE GRAMMAR

- Production system to generate a geometric shape
- Rules describe how an existing part of a shape
ADVANCED METHODS FOR PROCEDURAL GENERATION

- Image filtering
- Spatial algorithms
  - Fractals
- Simulation and modeling
  - Cellular automata
- AI
  - Genetic algorithms
  - Neural networks
HOW DOES PROCEDURAL GENERATION COME INTO PLAY IN YOUR GAME CONCEPTS?
SUMMARY

• Procedural generation can greatly enhance the user experience and replayability of a game

• Many methods can be employed at all levels of game content
EXAM

• Closed note/book exam
• No questions on Unity

• Format – five sections and a bonus
  • Q1 – T/F – Definitions/Concepts from FGD
  • Q2 – Fill-in-the-blank – Definitions/Concepts from GPAT
  • Q3 – Free response – Game programming (Game loop, input, sound)
  • Q4 – Free response – Game programming (Graphics, camera models, and procedural generation)
  • Q5 – Free response – Analyze design decisions
  • Bonus – ?