Procedural Generation

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What Is Procedural Generation?

Creating content based on algorithms instead of manually doing it.
Small Introduction
What can procedural generation be used for?

- Video Games
- 3D Renders
- Simulations
Examples of procedural generation

- Textures
  - Terrains

World/Terrain
  - Voxel based
  - Grid based
  - Tile based

- Animations

- Single Object Generation
  - Trees
  - Weapons

- Life forms
Which Games use procedural generation?

- Minecraft
- Diablo
- Binding of Isaac (Rebirth)
- Borderlands
- Black Mesa (Half-Life fan remake)
- and almost every rogue like...
Textures
Perlin Noise

- Type of Gradient noise
- Commonly used as procedural texture in computer graphics
- Easy to control the parameters
- Vast variety of different outcomes
Perlin Noise

- **Pros for perlin noise:**
  - Fast in generating
  - Easy to control

- **Cons for perlin noise**
  - Tends to create same patterns all over again
Examples of Perlin Noise
Example Of Procedural Terrain Texturing

[ Live Demo ]
World And Terrain Generation

There are three commonly used ways of generating worlds.

- Grid based terrains
Grid Based Terrains

- Using a plane in 3D space to generate a terrain
- Each vertex gets a height assigned
- Height is calculated with perlin noise
- Texturing is done with procedural texturing
World And Terrain Generation

There are three commonly used ways of generating worlds.

- Grid based terrains
- Voxel based worlds
Voxel Based Worlds

- Created with voxels
  - Point in 3D environment grid
  - Mostly represented with cubes

- Split up into “Chunks”
  - $X \times X \times Y$ areas

- Can it be infinite?
  - yes and no at the same time
  - limited space for saving chunks
  - overwriting chunks when it gets too big
Voxel Based Worlds

- How to generate the actual world?
  - Using 3D perlin noise
  - everything < 0 is air
  - everything >= 0 is ground

- The right resolution is crucial
  - Too high of a resolution can cause:
    - Performance issues
    - Floating “boxes”

- Split the world into the chunks
  - e.g. use one noise map per chunk
  - e.g. split one noise map into multiple chunks
World And Terrain Generation

There are three commonly used ways of generating worlds.

- Grid based terrains
- Voxel based worlds
- Tile based worlds
Tile Based Worlds

- Based on predefined tiles that can make up the landscape
  - Walls, Forest, Houses etc.

- Tile information, which tiles fit together?
  - Different wall parts, grass, sky
  - Where is a passage?

- Created with recursive algorithm
  - Each tile spawns new tiles for their openings
  - Each tile checks if a tile can be placed
  - Internal integer can define if the world is big enough
Tile Based worlds

But is it that simple?
No there needs to be a lot taken care of!

- Just checking for a point to attach new tile to is not enough

- Checking the area for other parts
  - e.g. there is a gap between two tiles → find a tile which fits for both ends.

- Make sure that it has an end
  - don’t let it generate forever!
World Generation In General

- Has to be fast
- Should not take too much processing power
- Combination of random and crafted
  - Create random worlds with a charm to explore
- Hard to prevent glitches
Single Object Generation

- Pick an Object
  - Houses, Trees, Rocks, Weapons

- Define those Object
  - How does the Object look like
  - Limit the range of the parameters
  - Describe the textures that can be used

- Predefine parts
  - One way to achieve the generation is to create different parts that match together (similar to tiles)
Example For Object Generation (Borderlands)
Single Object Generation
Animations

- Animation based on the Terrain and the possibilities of the Character

- Dynamical moving instead of predefined
  - walking up and down stairs/slopes
  - climbing

- Many games use a simple variant of procedural animation
  - Even turning a characters head to a specific point is procedural animated
Animations

- Even particles are procedural animations
  - Fire
  - Cloth,
  - Fur

- Water can be generated this way as well
  - Morrorwind used that technology
  - Raimonds water simulation is part of this as well
Animations
Life Forms

- A bit like object generation
  - predefined races and rough looks
  - different body parts
  - textures that match the races body parts

- A rigged body
  - for every body part there needs to be a rig that already works

- generated on the fly
Example Of The Use Of Life Forms

- Starbound (Game)
  - Creating unique monsters the player has to encounter

- Black Mesa (Game / Half-Life remake)
  - Zombie and character parts are provided and used to create unique characters

- No Man’s Sky (Game)
  - Create every life form from scratch on run time
Examples Of Life Forms (Starbound)
A Look Into The Future