Procedural Generation

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What is procedural generation?

Procedural generation is a method of creating data algorithmically as opposed to manually.
Deterministic -> same inputs = same output.

Many uses, more to discover!
What is procedural generation?

Composed of two things:

1. **Randomizer** - modifies values using some random input
2. **Constraint system** - sets constraints to the randomizer to make the output logically correct or visually appealing.
Common things to be made procedurally

**Procedural Items** - usually combinations of pre-made objects

Borderlands and Fallout 4 both create weapons procedurally
Common things to be made procedurally

**Procedural characters** - Mostly known by Spore and No Man Sky aliens.
Common things to be made procedurally

Procedural characters - Many RPG games allow character customizations.

Often business secret!
Common things to be made procedurally

Procedural characters - [https://www.mixamo.com/](https://www.mixamo.com/)

But you can’t have unlimited ammount of those characters!
Common things to be made procedurally

Procedural characters
Common things to be made procedurally

Procedural characters -
https://drive.google.com/open?id=0B232TQYJs91cbTFSOE1WYk56Qzg
Common things to be made procedurally

Procedural characters - **how it was done**
Common things to be made procedurally

Procedural color palettes - alter the look of the whole game!
Common things to be made procedurally

Procedural color palettes - How it’s made?

Some theories of color harmony in use!
Common things to be made procedurally

Procedural color palettes - **How it’s made?**

Transform the color space using a lookup texture made procedurally.
Procedural level generation

Number of techniques is unlimited!

http://www.nullpointer.co.uk/content/research-info-in-ruins/
Procedural level generation

1. Carcassonne a city building board game
Procedural level generation

Procedural level generation

2. World Remade - my own game :) -> Connect the dots puzzle
Procedural level generation

2. **World Remade** - my own game :) -> **Connect the dots puzzle**
Fundamentals of procedural generation

1. Multi-level procedural generation - https://www.youtube.com/watch?v=GJWuVwZO98s
2. Procedural geometry

2. Either for altering models or making new models from ground up
2. Procedural geometry

1. Superformula - nature like structures
2. Procedural geometry

2. Lindmayer system (L-system)
2. Procedural geometry

3. **Voronoi diagram** - cut 3D meshes or create artistic structures
3. Noises

2. Noise - mathematical function -> noise(coordinate) = value
3. Noises

1. White Noise

Ordered Bayer  Ordered Blue Noise  Floyd Steinberg  Atkinson
3. Noises

1. **Perlin noise** - it has multiple alternatives like Simplex noise, but the result looks the same
3. Noises

1. Voronoi noise - uses voronoi pattern, cell points are scattered uniformly

The real knowledge is how to combine and modify those noises.
Working with noises

Example of heightmap generated in GPU using noises:
Working with noises

Another example:
Working with noises

This is how it’s done

\[ \text{simplex}(p) \rightarrow \text{Turbulance} \rightarrow | \text{simplex}(p) | \]
Working with noises

This is how it’s done

\[ \text{billow} \]

\[ \text{ridged} \]

\[ \text{abs} (\text{simplex}(p)) \]

\[ 1 - (\text{abs} (\text{simplex}(p))) \]
Working with noises

This is how it’s done
Working with noises

This is how it’s done

Another simplex noise to distort
Working with noises

This is how it’s done

Or use rigged noise instead

- ->
Working with noises

This is how it’s done

Or don’t go rigged, use billow
Working with noises

Allright what about Voronoi?
Procedural tools

Advanced landscapes

Sometimes noise is not enough! - thermal, hydraulic, wind erosion?

http://codeflow.org(entries/2011/nov/10/webgl-gpu-landscaping-and-erosion/)
Procedural generation

What else can you do?
Procedural generation

You have to find it out! Yourself