



Procedural Content Generation for Computer Games

What is Procedural Content Generation?

- ▶ Procedural Content Generation is a field with no widely agreed definition:
 - ▷ “the application of computers to generate game content, distinguish interesting instances among the ones generated, and select entertaining instances on behalf of the players.” - Hendrikx et al. [1].
 - ▷ “the algorithmical creation of game content with limited or indirect user input.” - Togelius et al. [2].
- ▶ PCG techniques often make use of approaches from the related fields of dynamic difficulty adjustment, particle systems, evolutionary algorithms, cellular automata and AI.

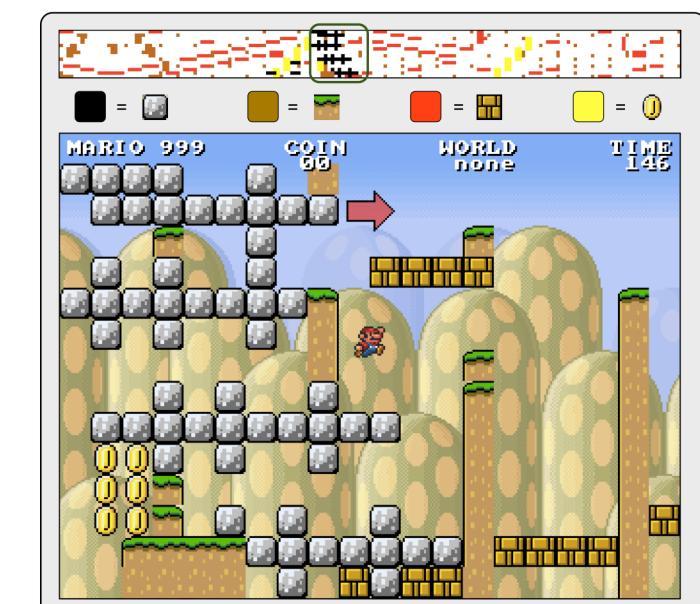


Figure 1: PCG Mario [3]

Online vs. Offline PCG

	Traditional	Offline	Online
Reduced Workload	✓	✓	
Reduced Storage	✓	✓	
More Variety	✓	✓	
Responsive		✓	

PCG for Artists

Artists use PCG techniques to make the production of multiple content types more efficient & varied:

- ▶ Textures
 - ▷ Perlin noise and PRNGs
 - ▷ Image Filtering techniques
- ▶ Models
 - ▷ Component-Assembly method using generative grammars
- ▶ Music
 - ▷ Responsive generated music
- ▶ Animations
 - ▷ Offline automatic completion
 - ▷ Online reactive generation
 - ▷ Player-driven generation
- ▶ Effects
 - ▷ Procedural particle systems
 - ▷ Procedural rendering effects (see figure 2)

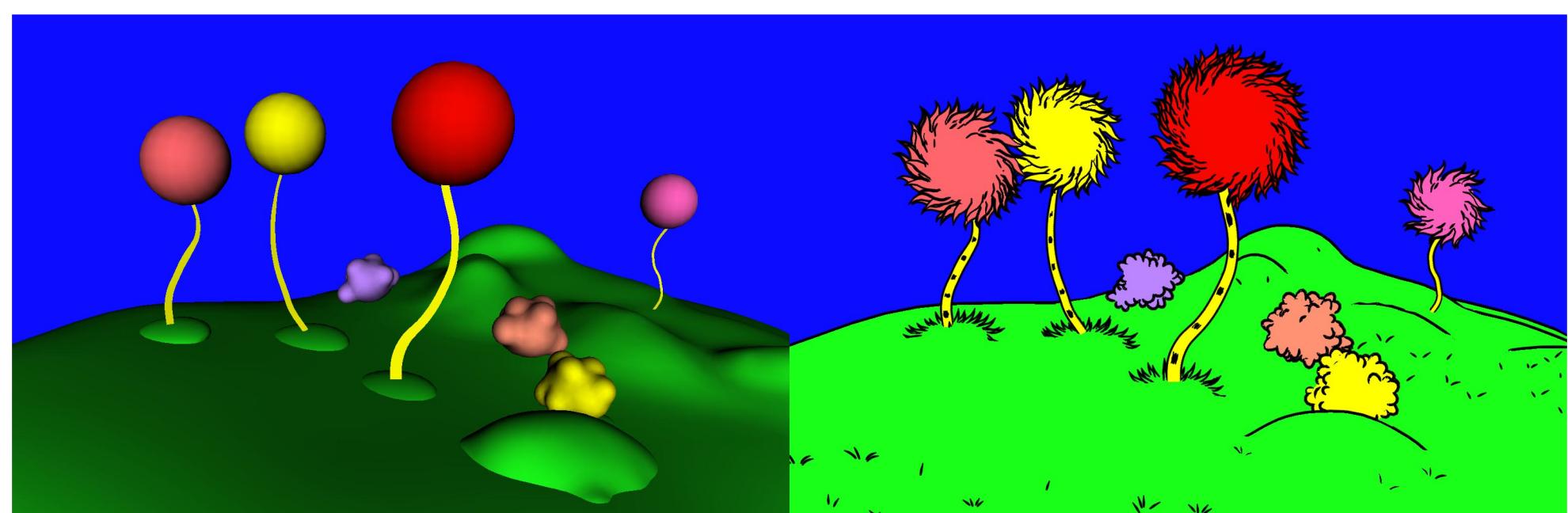


Figure 2: Procedural rendering of Seussian grass and trees, from [4].

Conclusions & Future Work

PCG methods can improve the process of content creation, providing:

- ▶ Increased efficiency
- ▶ Greater variation
- ▶ Tailored content

Commercially successful games use PCG for many purposes. However:

- ▶ Implementations are bespoke
- ▶ No standard approaches exist

This hinders research into the use of PCG with other fields by dividing focus between incompatible methods. Further work is needed to:

- ▶ Develop domain-independent methods to standardise approaches
- ▶ Investigate combination with related research areas: DDA, AI, etc

PCG for Designers

The use of PCG methods bring several benefits to developers, enabling:

- ▶ Content Scale enhancements
 - ▷ PCG approaches can populate large handcrafted areas
 - ▷ Near-limitless areas can be generated from scratch
- ▶ Replay Value improvement
 - ▷ Generated content can vary between playthroughs
- ▶ Challenge Adjustment systems
 - ▷ Online algorithms can use player metrics to adjust the challenge of procedurally generated content

Two particularly active research areas are:

- ▶ Search-based PCG techniques
 - ▷ Fitness functions evaluate generated content
- ▶ Mixed-Initiative content creation
 - ▷ Developer and PCG algorithm work in tandem

PCG for Consumers

Some games use information about the player to tailor content at runtime, to improve:

- ▶ Experience of gameplay overall
 - ▷ Valve’s ‘AI Director’ – maintains emotional intensity
 - ▷ Bethesda’s ‘Radiant Story’ – encourages exploration
- ▶ Agency available to players
 - ▷ ‘Weapons Lab’ in Galactic Arms Race – custom weapons
 - ▷ ‘Creature Creator’ in Spore – procedural creatures

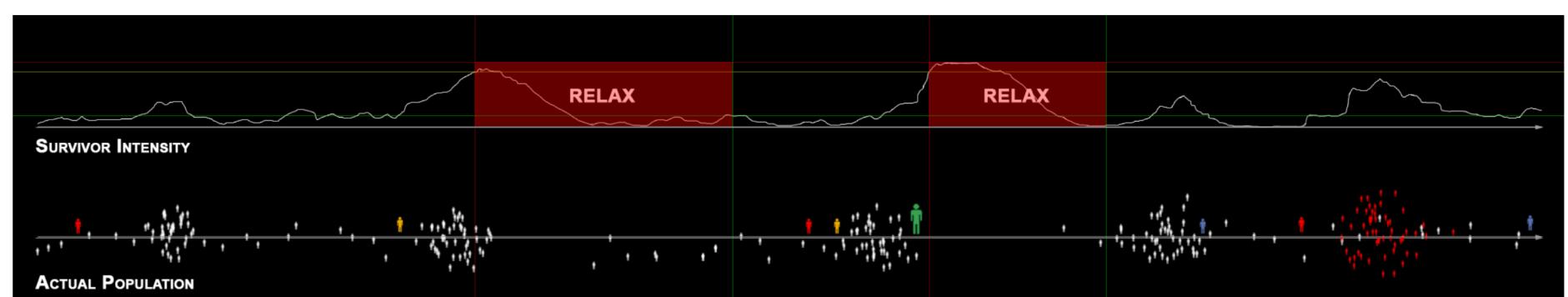


Figure 2: Generation of opponent population by AI Director [5]

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