

Computer Games based on Procedural Content Generation

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- Day by Day people playing the computer games are increasing tremendously.
- **Definition:** Procedural Content Generation can be defined as the algorithmical creation of game content with limited or indirect user input [1].
- It can also be referred as a computer software in which it creates its own game content or makes together with more than one or many human designers or players.
- **Content:** It means what the game usually contains such as stories, textures, maps, game rules, music, weapons, vehicles, characters etc.
- And the term “**procedural**” and “**generation**” means that to deal with algorithms or computer procedures that create some specific output.

1. Following are the things that are considered to be a PCG :-

- Middleware of game engine in which it quickly populates a game of world with the vegetation.
- Specific program that produces playable and complete board games on its own.
- Tool for graphical design in which strategy games are mapped by the user design and simultaneously evaluating that map for gameplay properties, giving improvements for the designed map in order to make it interesting and more balanced.
- Game of space shooter in which system creates the new weapons in accordance with what the collectives of players do.

2. Things that are not considered to be a PCG :-

- A board game that has an artificial player.
- Any strategy game in which a map editor simply lets the user remove and place items and without doing any generation on its own and not taking any initiatives.
- Automatically amalgamation of generated vegetation by the game engine.

3. Why to adapt PCG?

- Obviously the main reason for content generation is that it eradicates the necessity for having an artist that generates the content.
- As humans are slow and very expensive, it seems that we require them most of the time.
- It's very common now for a game that is developed by thousands of people over a period of more than one year, and hence situation arises where fewer or less games get profit and less number of developers can manage to develop a game which in turn results into less diversity in the game marketplace.
- So if the developer could replace the artists or designers by algorithms then that would be an advantage as games can be generated faster and cheaper.
- Another reason for using PCG is that it helps us to be more creative and helps us to understand the different design constraints more effectively.

4. Games that use PCG :-

- **Spore** [2] uses the concept of PCG in which player designs and creates an animation using procedural animation techniques.
- **Diablo** [3] is an action role-playing hack and slash video game that features procedural generation for creating the maps, type, placement and number of items and monsters.

- **Civilization IV** [4] is a turn based strategy game that allows gameplay experience uniquely by generating random maps.
- **Minecraft** [5] is an indie game that uses extensive PCG techniques that generates the whole world and its content.
- **Spelunky** [6] is a 2D platform indie game that uses PCG to automatically generate variations of game levels. Fig 1 is shown below.



Fig 1[6] Image from Spelunky

5. PCG Visions:-

The 3 visions for procedural content generation are as follows [7]

i. Multi-level, Multi-content PCG :

- Refers to a content generator in which there is a game engine and its own set of rules and they will generate all content such that the content is of high quality and fits exactly together with each other. Example is role playing game **Skyrim**, this unreal software will be generating quests, vegetation, backstory, graphics etc. in such a way that it all becomes a believable new world and an enjoyable gameplay.

ii. PCG based game design :

- Refers for creating the games that is not only dependent on procedural content generation. But as PCG is a central part of the gameplay, and if we took the content generation fragment away then there would not be left anything that is recognizable. Example *Endless Web* [8] or *Galactic Arms Race* [9] are still based on game genres.

iii. Generating complete games :

- Refers to a generator that is capable of generating the game itself and not only the content of the game. That includes graphical representation, rules and reward structures.

6. Properties of a PCG solutions :-

- Speed:** Speed requirements vary drastically and it depends on whether the content generation is done during gameplay or during the development of the game.
- Controllability:** There is an indeed a need for content generators that are controllable, so that an algorithm or human user can identify the details of the content generation. There are multiple possible elements of control e.g. one might ask for a car that has ability to take sharp bends and also has numerous colours, a small set of rules in which chances plays no role, specific level that causes a perception of mystery and honors perfectionists.
- Expressivity and diversity:** There is frequently a requirement to produce a diverse set of content. For example, consider the case of non- expressivity,

a level generator always gives the same level but in between the level, it randomly transforms the colour of a single stone. Whereas on the other side, level generator gathers the components fully but randomly, thereby giving unplayable and insensible levels.

- iv. **Creativity and believability:** In most of the cases, we don't like our content to look like as if it has been designed and developed by procedural content generator. There are multiple ways to produce the generated content as opposite to humanly created design content.

7. PCG Taxonomies: Following are taxonomies[10] of procedural content generation:-

- i. **Online versus Offline:-** To generate the content online, procedural content generation techniques are used as the player plays the game and thereby produces endless variations, making game replayable and generating the possibility of player-adapted content. The usage of PCG is particularly useful for offline content generation when we have complicated contents such as maps and environments.
- ii. **Necessary versus Optional:-** Procedural content generation can be used to produce essential game contents that are needed for the accomplishment of a level, or it can be used as an optional content that can be eliminated or removed for other content. The main difference between optional and necessary contents is that necessary content should always be accurate while this condition does not satisfy for optional content.
- iii. **Generic versus Adaptive:-** Generic content generation is a prototype of procedural content generation where content is generated without taking the behavior of player. Whereas in adaptive content generation,

interaction of the player with the game is examined and content is created based on player's previous behavior.

- iv. **Stochastic versus Deterministic:-** Stochastic PCG means that recreating or regenerating the similar content is not possible whereas in deterministic PCG allows to recreate the same content.
- v. **Constructive versus Generate-and-test:-** In constructive PCG, content produced once cannot be modified. Generate-and-test PCG follows a loop of generate-test several times until a solution is created.

8. Recommendations for future research:-

- i. **Evaluation of generated content:-** Still a lot of work remains to be done in characterizing the **playability** [Smith et al. 2010], **quantity** [Smith and Whitehead 2010], **freshness** [Iosup 2011], **utility** [Li and Riedl 2010] etc. for the experience of users. Increasing the attributes of generated content leads to more parameters that are essential to restrain the process of procedural content generation. The study of trade-off between detail and content generation **controllability** [Smelik et al. 2010] leads to the development of new different procedural techniques.

- 9. **Conclusion:** The research for procedural content generation is increasing at an alarming rate nowadays. In this work, I have showed an inclusive research on Procedural Content Generation (PCG). I found that many real games that use PCG techniques are often limited to a specific type of game content.

10. References:-

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