

Implementing City Generation With Wave Function Collapse

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Introduction

This project explores the use of Wave Function Collapse to generate dynamic, modular city layouts.. While methods like Perlin noise and cellular automata work well for natural generation such as terrain and caves, they lack the control needed for tightly structured environments. WFC offers a rule-based system that ensures tiles like roads and buildings connect logically. This project investigates how effective WFC is for generating playable, coherent city maps compared to other procedural techniques.

Methodology

The project was developed in C++, using a custom implementation of the Wave Function Collapse algorithm to generate modular city layouts. A set of tiles with predefined adjacency rules was created to ensure consistent placement of roads, buildings, and empty spaces.

What is Wave Function Collapse?

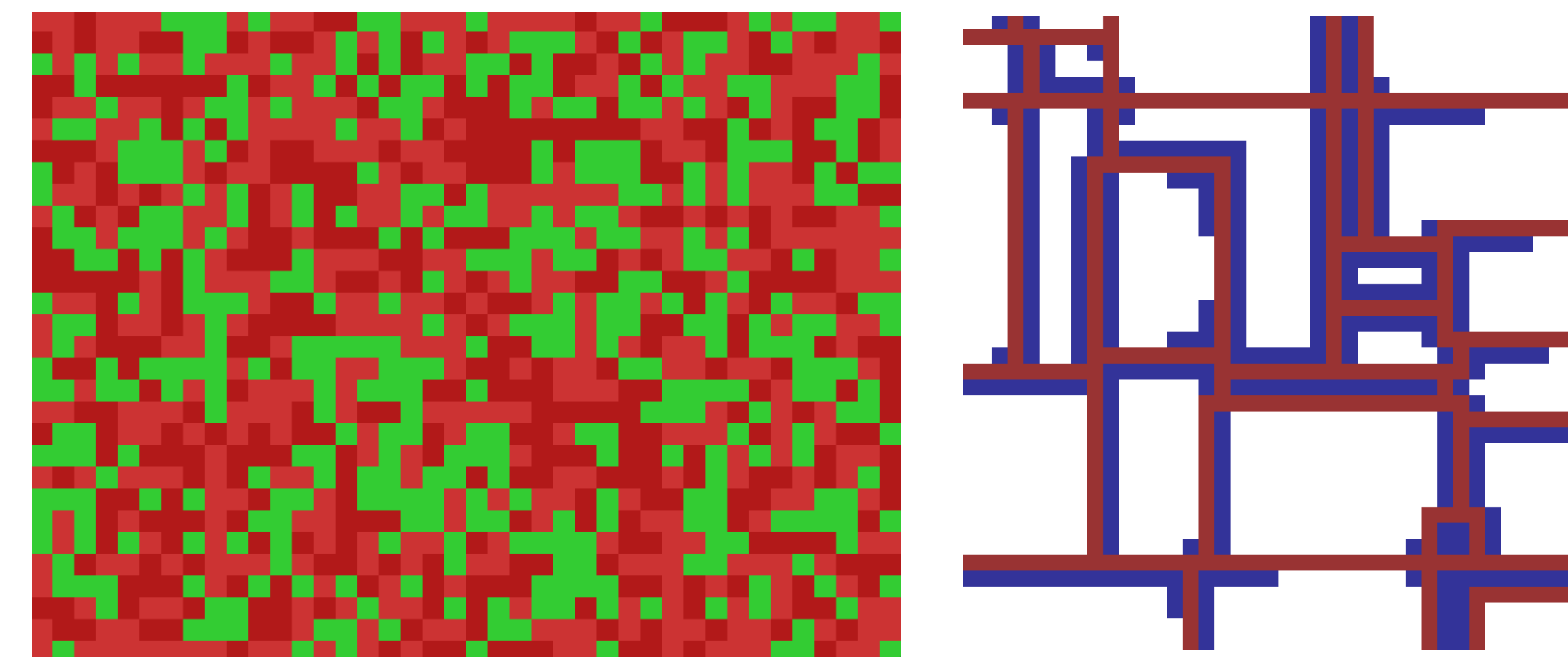
Wave Function Collapse is a constraint-based procedural generation algorithm inspired by quantum superposition,, each grid cell starts in a state of superposition—holding all possible tiles. Tiles are selected (collapsed) based on adjacency rules, which define what tiles can neighbour each other[1].

Results and Conclusions

Why use Wave Function Collapse to generate cities?

Wave Function Collapse (WFC) is ideal for procedural city generation because it respects constraints between adjacent tiles or modules, allowing it to produce complex, believable layouts from a small set of input patterns. Cities benefit from this approach since they are made up of interconnected systems—roads, buildings, parks, and infrastructure—that must follow rules (e.g., roads connecting logically, buildings not overlapping). WFC encodes these spatial rules into its generation process, ensuring outputs that are both varied and structurally coherent. This makes it particularly powerful for generating diverse yet believable urban environments without hand-authoring every layout[2].

How does WFC compare to Perlin noise and cellular automata?



Example of Cellular Automata vs WFC city generation

WFC created more coherent and controlled layouts, while Perlin noise lacked structure and cellular automata produced chaotic, organic results that failed to meet the structure required of a city on the left you can see an example while it's not a totally fair comparison you can see that WFC is far superior when dealing with larger structures outside of neighbourhoods

Citations

- [1]R. Heaton, “The wavefunction collapse algorithm explained very clearly,” Robert Heaton, Dec. 17, 2018. <https://robertheaton.com/2018/12/17/wavefunction-collapse-algorithm/>
- [2]L. Voisard, “Procedural Generation: Wave Function Collapse,” Ptidej Team Blog, Jul. 10, 2024. <https://blog.ptidej.net/procedural-generation-using-wave-function-collapse/>.



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