

Exhaustive Backtracking in Hierarchical Wave Function Collapse for Procedural Music Generation

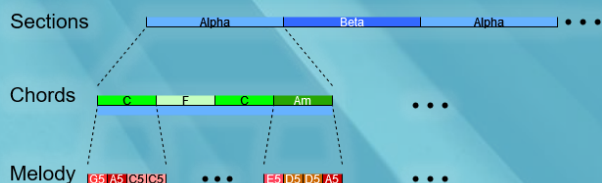
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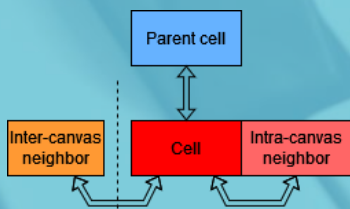
Background & motivation

Wave function collapse (WFC) is a **constraint-based procedural content generation** algorithm. Recent advancements were inspired by this algorithm to model procedural **music** generation, using a **hierarchy** of many canvases [1].

Backtracking the solver over this model is non-trivial, but it would be highly useful.



Basic hierarchy for a music generator



Types of constraints acting on a cell

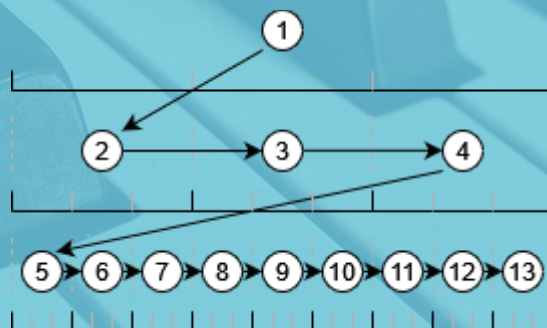
Research questions

- How to deal with constraints that span across multiple canvases?
- How can backtracking be meaningful across several (types of) canvases?
- What makes one backtracking approach better than another?
- When can we say for certain that we have explored all options?

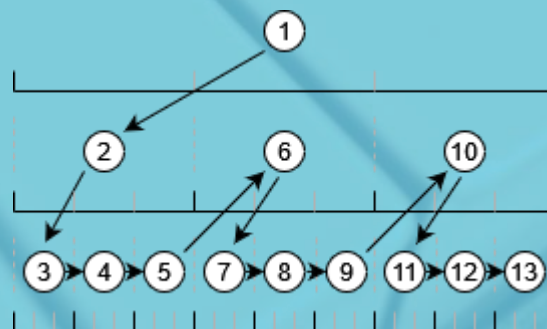
Method

After formalizing the main challenges, we propose two backtracking algorithms, prove that they completely exhaust the solution space, implement them, then compare them based on runtime efficiency.

Proposed algorithms



Breadth-first (BF) traversal of hierarchy



Depth-first (DF) traversal of hierarchy

Results

#sections	BF	DF
2	565.1 ±52.0	73.97 ±6.19
3	63567 ±16275	256.9 ±17.0

Mean runtimes (in ms) of the two algorithms in our experiments (95% confidence interval)

Conclusion

The runtime of the depth-first traversal is much smaller than that of breadth-first traversal. It also scales much better for larger problems.

Limitations

Further research could be conducted on alternative backtracking methods, further optimization of our methods, and evaluation based on additional criteria beside runtime efficiency (suggested in the paper).

References

[1]: Pál Patrik Varga and Rafael Bidarra. 2024. Harmony in Hierarchy: Mixed-Initiative Music Composition Inspired by WFC. Submitted for publication.