Story-Based Map Generation

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Abstract

Procedural content generation refers to the creation of content automatically through algorithmic means.
Designing a virtual environment for action, adventure or role-playing computer games is a complex process. Some computer game genres require meaningful stories and complex worlds in order to successfully engage players.
Existing work has been done in spatial and narrative procedural generation, separately from one anther in most cases, neglecting the interconnection between spatial and narrative requirements.
We look at a procedural approach to story-based map generation for computer games focusing on the tight relationship between stories and the virtual environments where those stories will unfold. We present an approach that takes, as input, the specification of a story space as a collection of plot points. Causal relations between these plot points and spatial relationships between locations define different story and spatial structures. Our system generates multiple configurations of a game map, determines the stories that are actually supported in each map, and evaluates their quality, in order to find maps that provide the best player experience from a storytelling perspective.

Computer Games and Game Maps

A computer game map is a virtual environment a player can interact with in order to accomplish some goal. Examining a game map, two different structures emerge that both describe the map.

- **The space:** The geometrical layout of the virtual environment.
- **The narrative**: The series of events the player needs to complete in order to accomplish the given goal.

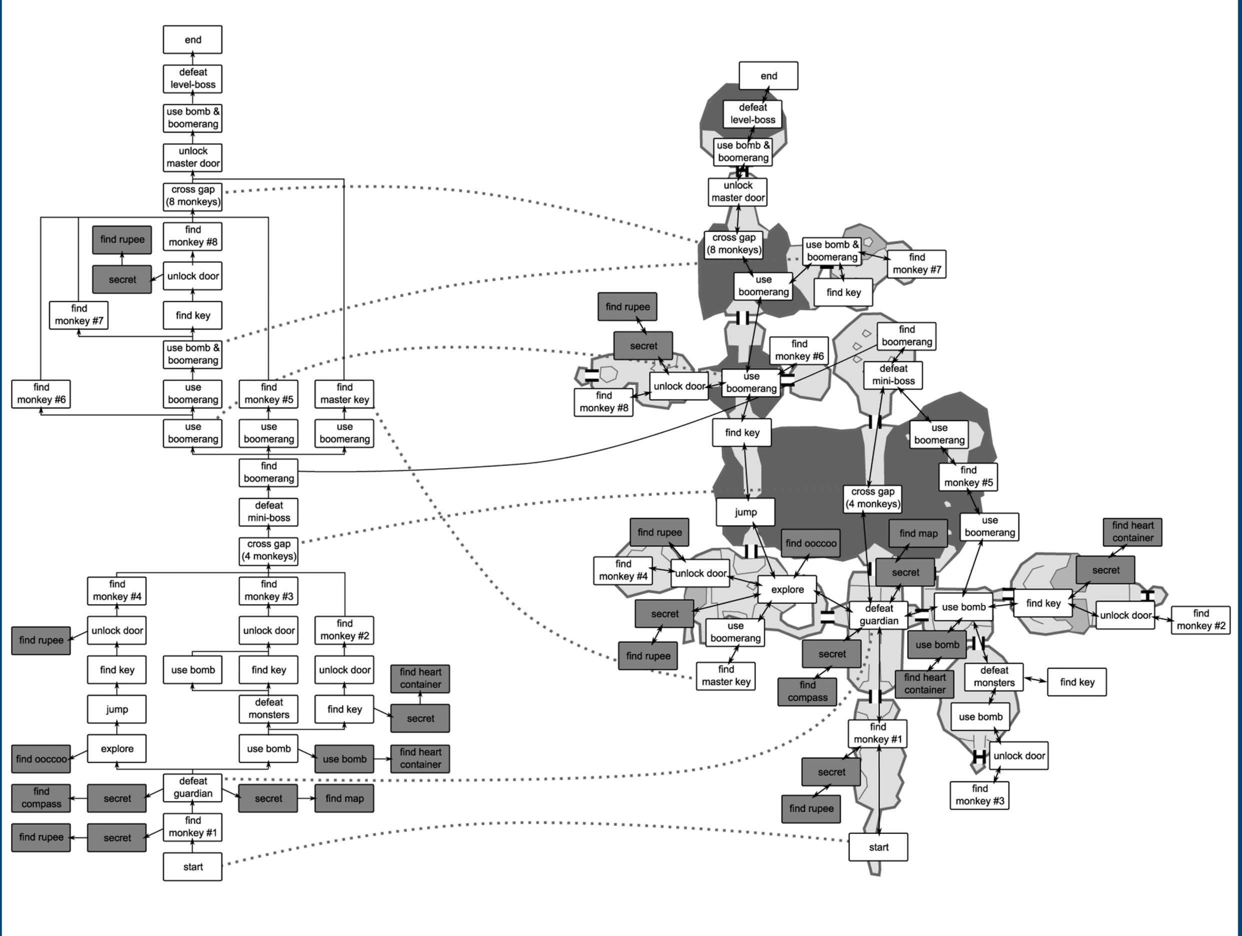


Fig. 1: Narrative and space in the *Forest Temple* map of *The Legend of Zelda: The Twilight Princess*

Story-Based Map Generation

Game World Specification

The input to our system is a game world specification containing a list of locations, an initial state, one or more goals and a set of plot points. Our plot point representation is based on those used in planning systems. A story consists of the sequence of plot points generated by the planner for reaching the specified goal from the initial state.

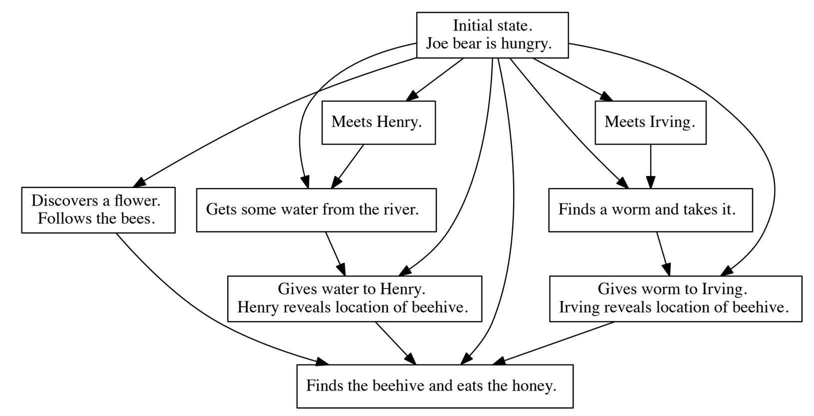


Fig. 2: Example plot point dependency graph.
Boxes represent plot points and arrows dependencies between plot points.

Spatial configuration

A spatial configuration must be provided to the planner. A spatial configuration is represented as a graph where the nodes represent locations and edges between nodes represent locations that are accessible from each other.

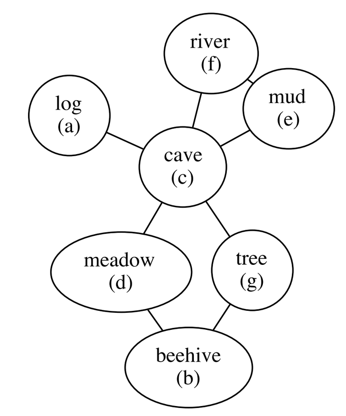


Fig. 3: Example spatial configuration with 7 locations.

Story Search

The planner performs an exhaustive enumeration of all the possible stories that can unfold in the given spatial configuration. Each story is represented as a plan or a sequence of plot points.

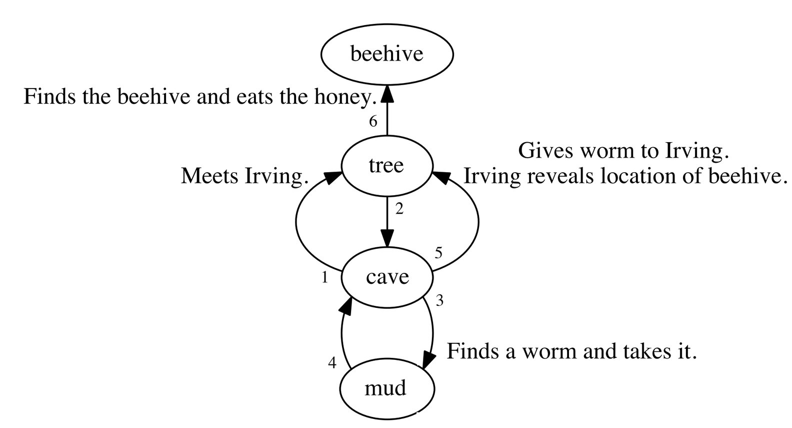


Fig. 4: Example story for the narrative space in Fig. 2 and the spatial configuration in Fig. 3.

Story Evaluation

The plot point representation is extended with annotations in order to enable story evaluation. Our evaluation function is a weighted sum of a set of simpler normalized feature values. The selected features try to evaluate certain logical and aesthetic properties that characterize story quality from a storytelling point of view.

Search Process

The search process generates new spatial configuration candidates which are evaluated by the quality of the stories supported.
The search process uses an iterative approach using ε-greedy search.
Two tables are initialized, one with the number of paths between locations in a spatial configuration and another with the individual value for each specific path. The values in the tables are used to generate a spatial configuration candidate.

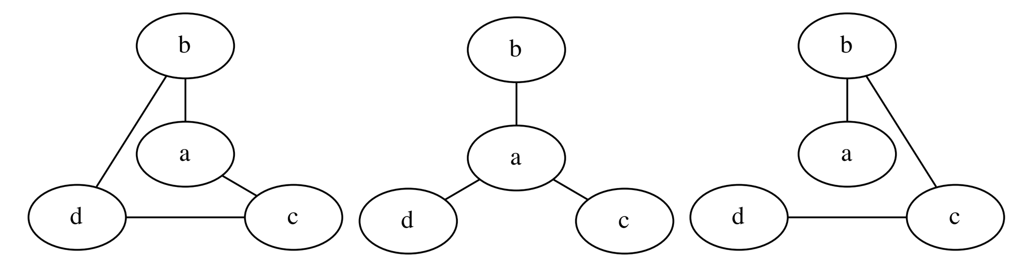
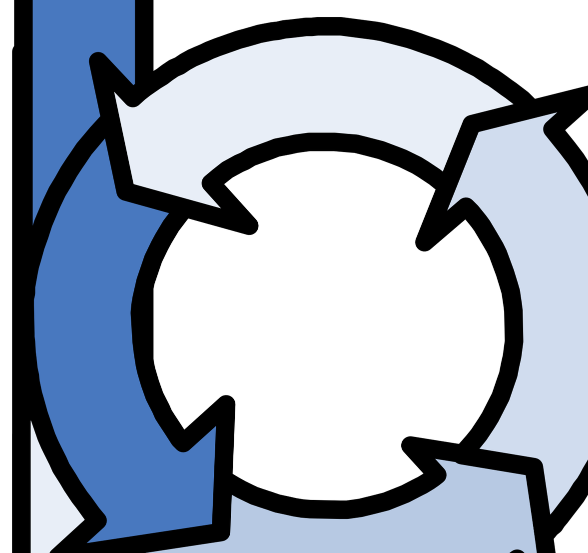


Fig. 5: Different spatial configurations with 4 locations.

Iterative Search



1. Generate a spatial configuration candidate.
2. Generate all possible stories.
3. Evaluate each story.
4. Aggregate the individual story evaluations to obtain an evaluation for the spatial configuration.
5. If the evaluation is below a threshold, update the search tables, otherwise, break the loop.

Embedding and Graphical Realization

Graph Embedding

Our graph embedding procedure only considers planar embeddings based on a rectangular grid layout. Allowing two edges to cross would allow the player to access locations that should not be accessible.

Graphical Realization

We instantiate grid cells with a bitmap representation for rooms, doors for connected rooms and areas for split nodes.

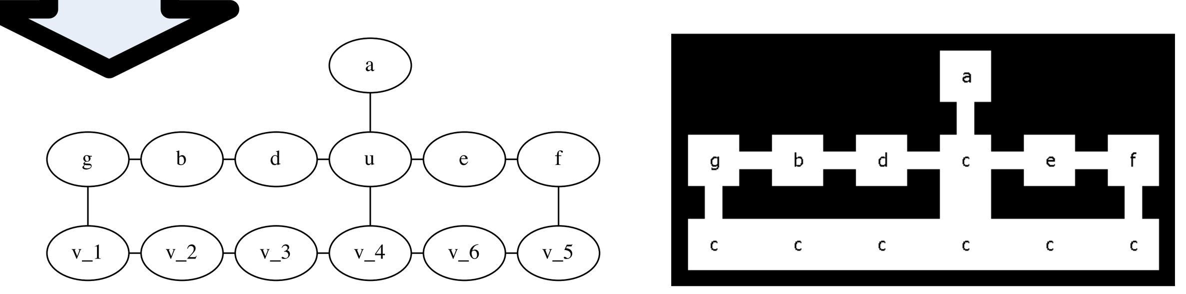
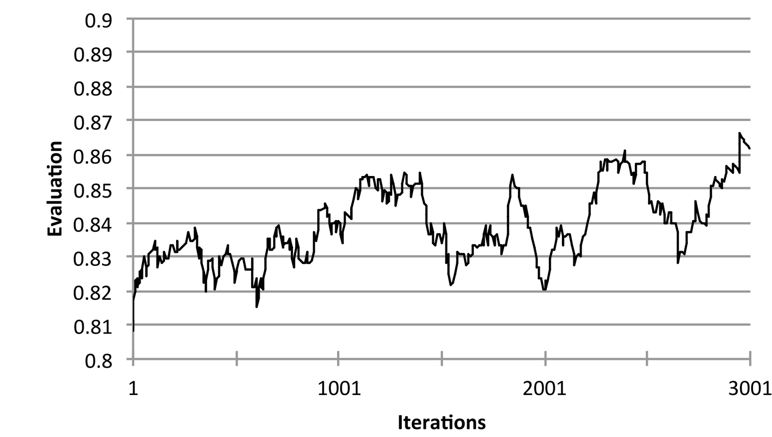


Fig. 6: Example embedding and graphical realization for the spatial configuration in Fig. 3.

Results

Search Process

The search process shows a positive evolution in the evaluation result as the number of iterations in the ε-greedy search increases.



Map Support for Stories

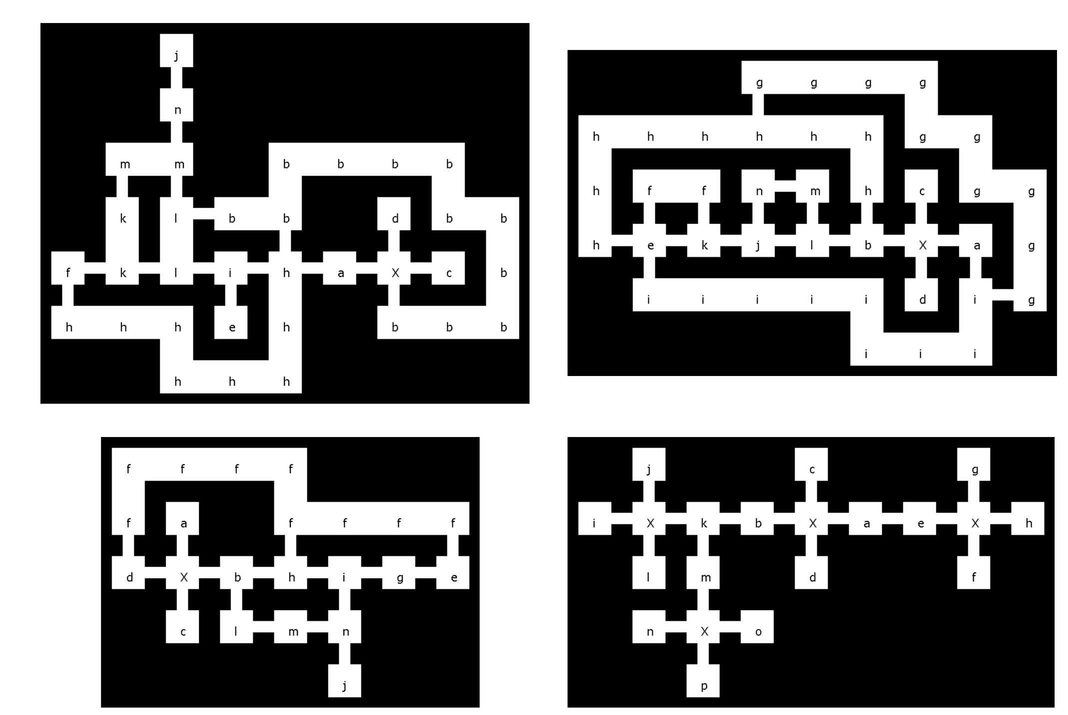
Our experimental results support the claim that we can generate substantial amount of content (stories) with a relatively small input.

# Plot Points	8	8	8	6	8	19	26
# Locations	7	7	7	5	6	4	11
# Paths	6	0	21	4	6	3	55
# Stories	10	0	100	2	21	192	384

Table 1: Number of stories given by different configurations

Embedding and Graphical Realization

Our embedding process manages to successfully find a planar layout for complex spatial configuration graphs.



Conclusions

We have described and implemented a prototype of a system that can generate stories and design a map supporting those stories.
Our system can effectively explore the space of spatial configurations, searching for those that support high quality stories from the story space.
Especially interesting is the capability of our system to generate game maps that support multiple stories, or that contain cycles.

Procedural content generation has the potential to increase the variability and replayability of computer games. This in turn can lead to an increase in player interest in these games, as it will take longer for the player to see or complete everything in the game.
Although it cannot substitute human designers, it can provide assistance in the creative process with tools to explore and assess new ideas.