Project report

Student ID's: 220026574, 180000870

Introduction

Our game, Murder at Belmont Manor, is a detective game with procedurally generated stories. We aim to use a combination of simple random number generation with SAT formulae to produce varied and interesting stories which still follow consistent rules.

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Design

Design Decisions

This project aims to deliver a compromise between procedurally generated content and static hand-made content in order to deliver the replay-ability without compromising on a consistent theme. We decided to start by limiting procedurally generated content to the roles of a fixed rota of characters, clues and weapons. We have also prioritised modularity of code in order to permit the project to be scaled in future. In particular the implementation of Characters, Clues, Motives, and Weapons are designed to be easy to extend with a clear template for new items.

The gameplay is closely tied to the complexity of the facts involved in the plot, and the evidence required to deduce the murderer. We chose to aim for shorter and easier rounds, rather than aim for high complexity because this more accessible arcade style gameplay is more appropriate for a range of audiences. This has also made enforcing rules on the procedurally generated facts easier, and allowed us to spend time on other areas.

In the game's current state there are several potentially immersion breaking elements, such as characters never telling a lie. We decided to embrace this and use a fantasy style for our game. This is also designed to abstract from the darker side of the game and encourage our players to focus on the puzzle solving aspect.

Early in the project we considered permitting suicides. This would improve the potential complexity of the plot and allow some interesting interactions if the Murderer is allowed to lie – where they may attempt to suggest their victim's death was suicide. However, we chose not to include this because it would not be appropriate for the tone we wish to set.

In order to handle procedural generation for elements with a high degree of inter-dependence we chose to use SAT for its ability to efficiently find satisfying solutions to complex logic problems. The core issue we need SAT for is ensuring that each bystander (a character who is neither murderer, nor victim) does not have all three of motive, opportunity, and method. Using SAT has also made the project very

scalable both in terms of the number of elements, and adding new factors such as permitting the murderer to lie, while still ensuring that there exists counter evidence so the game is still fair.

What was fun

As a team our common interests are detective stories and puzzle solving. Our game aims to satisfy this, while making the game more approachable by reducing the complexity and time needed for each game.

When testing our game, we have enjoyed navigating our player around the map, exploring and investigating the clues. We have also enjoyed the sudoku-like aspect of deducing which characters may be the murderer.

Similar Games

The game was initially inspired by the board game Cluedo, with a similar system of randomly assigning cards for the suspect, room and weapon to the murderer. The games have significantly diverged, however. We have focused on a single-player approach, and benefit from our digital medium due to how well it lends itself to scaling the variety of our content.

Point and click adventures are a genre of games where the player needs to explore environments, interacting with items and people until they achieve their goal. The difficulty usually comes from a variety of abstract puzzles, and well hidden secrets. These are similar to our game, because both follow a similar process of systematic discovery. While our game lacks the depth of a traditional point and click adventure, we also support much shorter games, and guarantee a logical and fair problem.

Implementation

Procedural generation of content uses two main components, a random number generator and a SAT solver using random walk. The SAT solver is used to assert conditions on the murder plot, such as: no bystander may have all three of motive, opportunity (alibi), and method (access to the murder weapon). These conditions ensure that the game is fair, and that there is always a solution. However, they have the inevitable effect of reducing the number of valid plans where many characters have several suspicious attributes (motive, opportunity or alibi), and therefore the SAT solver generally produces more simple plans. The random number generator allows us to guide the process by forcing more randomly chosen attributes on bystanders to increase the difficulty of distinguishing the murderer.

Expressing the murder mystery plot using SAT required adapting techniques from automated planning via SAT. This technque requires the creation of Fluents, boolean variables which express a binary relationship in the planning problem. For example, the Fluent has_alibi_a_b may express whether Characters a and b share an alibi.

Implementation Difficulties

We were able to find two SAT solvers compatible with Java, SAT4J and Kissat. However, both required formulae in DIMACS format (requiring boolean formulae in CNF format). Expressing the problem with CNF and bug testing took significant time. It is future work to investigate using non-Java libraries which do not require CNF in order to make the boolean formula more readable and more easily implemented. Changing to a non-DIMACS based library would also increase the readability of the SAT based code.

Playtesting revealed the repetitiveness of the default SAT plans, even using a random walk heuristic, and few interesting plots. To improve the gameplay, we needed to ensure that characters other than the murderer had several suspicious attributes so the game didn't become trivial. This is accomplished in three ways. First, every character must have access to at least one weapon. This is designed to avoid situations where only the murderer has access to a weapon, which both makes the murderer weapon and murderer obvious. Second, we introduce 'red herrings'. Red herrings are characters who have exactly two out of three suspicious traits. In addition, each has a different combination so there will be a minimum of two characters (including the murderer) with a motive, no alibi, or access to the murder weapon. Finally, we ensure that every character has at least one suspicious trait, so there are no characters who can be immediately dismissed.

Critical Appraisal

The design of the floor layout was one of the biggest difficulties we ran across while making our game. With '0' standing for floor area and '1' for walls, we created a number system to outline the design of our in-game rooms. Other numerals, such as "8," were assigned to different items in the rooms, such the images of lamps. For our game world to be coherent and functional, this strategy required rigorous design and precise implementation. Player movement was yet another difficulty we ran into. Integrating sprite sheet graphics to produce seamless player motion turned out to be a time-consuming and difficult undertaking. To improve the entire gaming experience as well as make certain the player character moves naturally and attractively, it was necessary to get beyond this obstacle.

In the early phases of development, we debated including randomly generated rooms to give our game a sense of variety and unpredictability. Due to the potential issues this feature could cause, we eventually opted against it. We understood that random generation can provide illogical or useless room arrangements. Additionally, using the text file to create tile maps would have presented considerable challenges, perhaps lowering the level of playability and quality of our game. We chose a more limited method of space design as a result, which allowed us to maintain a high level of quality while minimizing pointless complexity.

The layout of the rooms themselves was another meticulous detail. In particular, the placement of doorways and furniture within a room in a video game must resemble real-world architecture. Furthermore, we had to make sure that the aesthetics of the space complemented the general subject and mood of our game. This called for the research and selection of photos that would enhance the player's immersion and go along with our game concept. In addition to taking a lot of time, this method required careful attention to detail and original thought.

The use of SAT for procedural generation was both a benefit and a weakness in the project. Through SAT formulae we were able to express complex relationships and efficiently find satisyfing plans. However, this took time, and the use of DIMACS format has made the code creating the SAT problem difficult to debug. There is currently an unresolved bug causing the SAT problem to be unsatisfyable when the final weapon in the weapons list is chosen as the murder weapon (then asserted as a clause in the SAT formula).

As described in the Implementation difficulties section we mistakenly believed that SAT's random walk heuristic would be sufficient to produce interesting plans. Through playtesting we discovered that direct guidance was requried to increase the complexity of the problem to a fun level.

Future Work

- Rewriting the project to use a different SAT solver so the format can be made more intuitive. There is currently a bug when the third weapon in the Weapons list is set as the murder weapon before SAT (regardless of which clue it actually is).
- Procedurally generated rooms
- Moving characters
- More Clues, Weapons, Motives and Characters
- Consider allowing multiple victims and murderers
- The player to interact with the food items and eat them to show more realism
- Adding sound for example, for the footsteps of the player

Reference

ClipartMax.com. (n.d.). *Gold Candlestick Png Clip Art In Category Candles Png - Candle - Free Transparent PNG Clipart Images Download. ClipartMax.com*. [online] Available at: https://www.clipartmax.com/middle/m2i8b1A0H7G6K9N4_gold-candlestick-png-clip-art-in-category-candles-png-candle/.

ClipartMax.com. (n.d.). *Jpg Free Library Png Images Free Download - Poison Bottle Clip Art - Free Transparent PNG Clipart Images Download. ClipartMax.com*. [online] Available at:

https://www.clipartmax.com/middle/m2H7G6K9G6N4N4H7_jpg-free-library-png-images-free-download-poison-bottle-clip-art/.

Creative Fabrica. (n.d.). *Haunted House SVG Cut file by Creative Fabrica Crafts · Creative Fabrica*. [online] Available at: https://www.creativefabrica.com/product/haunted-house-10/.

Flaticon. (n.d.). *Candlestick free icons designed by Freepik*. [online] Available at: https://www.flaticon.com/free-icon/candlestick_210617?term=candlestick&page=1&position=19&origin=search&related_id=210617.

Flaticon. (n.d.). *Notebook free icons designed by Jesus Chavarria*. [online] Available at: https://www.flaticon.com/free-icon/notebook_2157751?term=notebook&page=1&position=13&origin=search&related_id=2157751.

Flaticon. (n.d.). *Photo Frame free icons designed by BZZRINCANTATION*. [online] Available at: https://www.flaticon.com/free-icon/photo-frame_4957215?term=frame+picture+family&page=3&position=91&origin=search&related_id=4957215.

Flaticon. (n.d.). *Poison free icons designed by Freepik*. [online] Available at: https://www.flaticon.com/free-icon/poison_238299?term=poison&page=1&position=13&origin=search&related_id=238299.

Freepik. (n.d.). *Free Photo | A red background with waves and a pattern of waves.* [online] Available at: https://www.freepik.com/free-photo/red-background-with-waves-pattern-waves_40873679.htm#query=carpet%20catroon&position=21&from_view=search&track=ais.

Freepik. (n.d.). *Free Photo | Orange cloth with seamless crocheted pattern*. [online] Available at: https://www.freepik.com/free-photo/orange-cloth-with-seamless-crocheted-pattern_5471716.htm#page=2&query=carpet%20catroon&position=2&from_view=search&track=ais.

Freepik. (n.d.). *Free Photo | White cotton carpet textures and surface*. [online] Available at: https://www.freepik.com/free-photo/white-cotton-carpet-textures-

surface_4011611.htm#page=3&query=carpet%20catroon&position=14&from_view=search&track=ais.

iStock. (n.d.). *Seamless cartoon stone texture. Vector illustration.* [online] Available at: https://www.istockphoto.com/vector/seamless-cartoon-stone-texture-vector-illustration-gm512453168-87160367.

PNGitem.com. (n.d.). *8 Bit Clipart Explosion - Top Down Walk Animation, HD Png Download , Transparent Png Image - PNGitem*. [online] Available at: https://www.pngitem.com/middle/hTboxib_8-bit-clipart-explosion-top-down-walk-animation/.

PNGitem.com. (n.d.). *Paper Clip Art Free Free Clipart Image Clipartcow 3 - Writing Paper Clipart, HD Png Download , Transparent Png Image - PNGitem*. [online] Available at: https://www.pngitem.com/middle/wThmob_paper-clip-art-free-free-clipart-image-clipartcow/.

Pngtree. (n.d.). *Floor Lamps Hd Transparent, Floor Lamp, Lamp Clipart, Household, Yellow PNG Image For Free Download*. [online] Available at: https://pngtree.com/freepng/floor-lamp_780195.html.

Shutterstock. (n.d.). *Cartoon Wood Texture Seamless Vector Pattern Stock Vector (Royalty Free) 2283084553*. [online] Available at: https://www.shutterstock.com/image-vector/cartoon-wood-texture-seamless-vector-pattern-2283084553.

Character sprites sourced from: https://deepdivegamestudio.itch.io/monstergiantassetpack

sat4j library sourced from: http://www.sat4j.org/

Original code based on our submissions for CS4303 P2