

Research Proposal Rhys Hughes

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Enhancing Complexity of Maze Generation Using a Hybrid Approach of Pathfinding Algorithms and Influence Maps

RESEARCH PROPOSAL
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Introduction

This project will be looking at if combining both pathfinding algorithms and influence maps can make more complex mazes than using just one of the techniques. To test this an application will be created to generate the mazes and to compare them. The reasoning for doing this specific project is to explore the different ways of generating mazes and how the different ways of navigating environments are used in industry such as video games or how autonomous robots. As someone with a passion in software development, developing an application that both generates the maze and tests it automatically interests me and the difficulty of understanding the algorithms and how they work will improve my skills as a software developer. For this project to be a success an algorithm must be made that combines both A* pathfinding and influence maps and it must be able to generate an output maze.

SMART objectives

Specific

Design a hybrid maze generation algorithm that uses both A* pathfinding algorithm and influence maps.

Test the new algorithm against just using A* pathfinding or influence maps for maze generation.

Measurable

Have users test the mazes to compare the difficulty between the different techniques

Achievable

Complete the algorithm and the application by the deadline of the independent project.

Relevant

The creation of the project requires software development which is both of interest and a skill of the researcher.

Time-Bound

Have a detailed project timeline with each of the requirement's deadlines described.

Background to the Proposed Research

Much of the recent research into maze generation uses machine learning and AI in order to create and solve mazes. One interesting piece of research [1] has AI to generate a maze and then to test the mazes using different algorithms such as A*. It tests the maze based on current position and how many times the agent has moved. For the purposes of the test the researcher didn't consider time for finding out the maze efficiency. The reason for this is that they are not attempting to measure the efficiency of the algorithms they are testing the AI itself. A* algorithm appears to be average to below average for nodes created to complete the mazes. This should mean that a combination could improve the efficiency of the mazes. One important part of that paper is how it determines the difficulty of mazes. It uses the McClendon's difficulty model [2]. It is a complex model that considers the correct path, the branching paths, and paths not connected to the solution. This could be useful for this research to be able to quantifiably show how difficult the generated mazes are instead of the possible subjectivity of human participants attempting the maze.

Another work compares different maze generating algorithms and the time it takes to create them [3]. Some algorithms such as Kruskal's algorithm appear to take exponentially more time to generate larger mazes whereas simpler maze generation techniques such as recursive backtrack don't have much of an increase in maze generating time. This could cause an issue for the hybrid approach if the combination causes the generating time to become exponential as it wouldn't be useful in the real world nor would it be easy to test. But another part of the research also states that a lot of the algorithms used to attempt to pass the maze struggled the most with Kruskal's algorithm. Therefore, while the simpler algorithms take less time to generate a maze, the mazes they generate can be a lot simpler to solve. But later after taking into consideration other parts of solving a maze such as how many dead ends the agents encountered the Aldous-Broder was ranked the most difficult to solve in general. This is interesting for this project as there are multiple ways to classify difficulty, this can be included in this project such as measuring how many times a participant runs into a dead end or how many intersections they reach.

Another paper compares different pathfinding algorithms and shows their paths on a grid [4]. One part which is relevant to this research is the discussion on the A* algorithm. A* algorithm is based off Dijkstra's algorithm. It was developed by Peter Hart, Nils Nilsson, and Bertram Raphael in 1968 [5]. As A* algorithm attempts to look at points which are closer to the goal rather than spreading out it is more efficient than Dijkstra's. There are also different heuristics that can be used such as Manhattan or Euclidean. The research shows that Manhattan distance is more efficient.

Aims & Objectives

- Output the generated mazes onto a display
- Develop a hybrid algorithm that combines A* pathfinding and influence maps.
- Successfully use A* pathfinding to generate mazes
- Successfully use Influence maps to generate mazes
- Research into maze generation
- Test the efficiency of the 3 chosen ways to generate mazes
- Test users time to complete the different generated mazes
- Question them on what they think about the different mazes.
- Ensure that the project adheres to the ethical guidelines of the university and other relevant authorities.

Methodology

Research Methodology

Philosophy

The research philosophy that will be used is positivism. Positivism has many benefits to this type of project and suits the project better than a different philosophy such as phenomenology. One benefit is the number of quantifiable metrics and measurements that can be used on this project such as the efficiency of the algorithms and how long it takes for a user to solve the generated mazes. Positivism encourages a structured methodology which is useful for software development to understand what is important and necessary for the project such as how to structurally develop the algorithm. Another part of positivism that helps software development is its reductionism, this is essential for software development as it allows for breaking down of the complex process of making an application into smaller pieces

Approach

The approach used will be a deductive approach. This approach suits this project as it uses research to test a hypothesis. It uses hypothesis testing which can be used to test whether a hybrid algorithm is better for generating mazes than using one set algorithm. It also means the development of the application can proceed in a sequence that is logical such as starting with the theories and hypotheses first and then the development and finally the testing. This sequence makes developing software easier. A deductive approach also allows for theory-driven development which is beneficial because the A* and influence algorithms already exist with a lot of research already done which will help guide this project.

Strategies

Literature Review

A literature review will significantly benefit this project for multiple reasons. The first is by understanding existing approaches. A literature review will help the researcher understand both the A* algorithm and influence maps and their advantages and disadvantages which will help in integrating them to make them more efficient together. It will also help with optimizing the two techniques individually to truly be able to compare between a hybrid approach and a single algorithm approach. It also allows for comparison to past attempts; the researcher can see how their implementations compare against how others in the field attempted to generate mazes.

Experiment

Experimentation will help this project as it is a software development project with no guaranteed outcome. Software development allows for rapid changes and testing without much difficulty which makes experimenting easier. As it is a blend of 2 different techniques to get the hybrid outcome experimenting between how they interact with each other to make the final algorithm

Software Development

Software development is essential for this project as the research topic is algorithms used in software. Software development also makes testing more manageable as it is possible to create the tests in software and get the results and data out from the software.

Risks and Limitations

Ethical Issues

There are very few ethical issues, but some can be highlighted. One could be mental or physical harm to the researcher due to overwork. This will be mitigated by limiting the scope of the project and ensuring there are enough redundancies within the plan to allow for rest and for certain parts of the project taking longer than expected. The users for testing the algorithms will be students of the University which means there could be some ethical issues if it isn't treated correctly. To mitigate this the researcher will be complying with the University ethical guidelines. For example, everyone that will be tested will require consent and can retract their consent at any time.

Validity

As the project uses the philosophy of positivism the validity of the project will be low.

Reliability

As the project uses the philosophy of positivism the reliability of the project will be high.

Generalisability

While it is possible for the research to be generalisable, as it is only going to be tested on one machine and one programming language it is possible for the results to change depending on those variables which would mean it isn't very generalisable

Data Evaluation Methods

Data Collection

There will be multiple different data collection methods. The first will be from the software itself, this will primarily be how long it takes for the maze to generate and how many possible ways to complete it there is. There will also be a human data collection by getting users to attempt to solve the mazes and timing how long it takes them. There will also be a questionnaire on how they feel about the different algorithms used to generate the mazes.

Development Methodology

Feature Driven Development

Feature driven development methodology will be used for this project as it is a software development project. It is an agile development methodology that is suitable for single developer projects such as this one. Feature driven development has incremental development which will be very beneficial for breaking down the software project into more manageable pieces which can be tested individually

Resources and Planning

Hardware Resources

This project doesn't require any specialized hardware and only a networked computer. This is because the majority of the project is a software application that isn't very resource intensive, nor does it have any difficulty to render graphics. The only consideration is that the application will be developed on a high-end networked computer as it is the researcher's personal computer.

Software Resources

This project doesn't require any specialist software as it is primarily a programming project. The only software required on top of that which comes with a standard operating system is an IDE for creating the code. There are many free IDE's available and VSCode will be used as it is versatile with support for many different programming languages, and it has ample support for extensions, which makes developing the software easier.

References

- [1] L. Peachey, "Parameterized Maze Generation Algorithm for Specific Difficulty," Earlham, Richmond, 2022.
- [2] M. S. McClendon, "The Complexity and Difficulty of a Maze," University of Central Oklahoma, Edmond, 2001.
- [3] P. Gabrovsek, "Analysis of Maze Generating Algorithms," *IPSI Transactions on Internet Research*, vol. 15, no. 1, pp. 23-30, 2019.
- [4] M. Adaixo, "Influence map-based pathfinding algorithms in video games," University of Beira Interior, Covilha, 2014.
- [5] P. Hart, N. Nilsson and B. Raphael, "A formal Basis for the Heuristic Determination of Minimum Cost Paths," IEEE, New York, 1968.

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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

60/100

Intro / A&O (400 words)		
Project title; Identification of a specific problem to be investigated; Well-defined aims and SMART objectives; Explaining why this project is worth doing; Discussion of what the project needs to do in order to be a success; Description any deliverables that will be produced at the end of the project The title needs simplifying and a clear aim provided. Currently there appears to be some confusion/conflict in some sections of the proposal regarding what you hope to achieve in this project. Implementing and comparing two methods then evaluating them seems like a reasonable approach but you need to be clearer in explaining how the methods you identify can achieve this.	20	12
Background to the Project / Literature Review (400 words)		
Description of how the work to be done by in the project relates to the work identified in the literature review; Discussion	20	15.5

of any ethical issues raised by the project Identifying what has already been done within the field; Topic familiarity; Brief literature review using appropriate sources – 6-8 journal papers and book chapters rather than just websites; Selection of relevant models & concepts Review of related work undertaken evidenced by use of seminal papers in the field. Well done. Refs in general are used appropriately. Key ideas identified and I am pleased you were able to identify a numerical method to score maze complexity. Relevant algorithms identified and metrics considered too. Good. Try to be clearer on your aims in this project. In order to help in this, define your terms/concepts clearly, early on and clearly explain them.		
Project Design (500 words)		
Clear statement of which development methods are to be used and why they are appropriate; Clear statement of which tools are to be used and why they are appropriate; Clear description of how data collected will be analysed You've identified important topics to consider and discuss methodologies that could be applied. Some detail is missing here – this will become evident as you	30	16

progress and re-evaluate the scope and aim of the project.		
Resources / Planning (200 words)		
List of any deliverables; Clear diagram showing both timing and resource use; Completed ethics form; Limited and relevant appendices You do not provide a Gannt chart – you will consider project resources and timings to be successful in this project. Some resources, etc. are identified here but these are, in general, lacking detail. You need to include a more detailed risk assessment regarding access to resources – including time for development	15	7
Document Presentation		
Correct spelling, grammar and punctuation; Flow of narrative/fluency; Coherence; Word processed ; Correct use of referencing with bibliography; Strict word limit Well structured. References provided and used appropriately. Some diagrams and further clear explanation would help.	15	9

TOTAL	100	59.5
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