Project Proposal & Final Report

Project Title:

AI-Driven Tower Defense: A Reinforcement-Inspired plants vs zombie game

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Course: AI

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# 1. Executive Summary

This project aims to modify the plants vs zombie game by incorporating an AI module capable of managing defense strategies. Two modes are implemented: User vs AI and AI vs AI, where the AI intelligently places plant to counter incoming zombie waves. A custom heuristic-based A\* pathfinding guides Ind Soldier behavior, making the game dynamic and progressively challenging.

# 2. Introduction

## Background

Plants vs. zombie is a tower defense game where players use plants to block the zombies. This version integrates AI to manage defense autonomously, creating a new challenge and study in heuristic-based AI decision-making.

## Objectives of the Project

- Develop AI for automatic plant placement  
- Use A\* pathfinding for Ind Soldier logic  
- Analyze AI adaptability in dynamic difficulty settings

# 3. Game Description

## Original Game Rules

Players defend the left side by placing plants vs. zombies enter from the right. Plants shoot projectiles to reduce zombies’ health. If zombies reach the left, the player loses resources or ends the game.

## Innovations and Modifications

- AI-driven plant placement  
- Boss zombies  
- Plant cost and resource economy  
- A\* search for zombies’ movement

# 4. AI Approach and Methodology

## AI Techniques Used

- A\* Search  
- Heuristic Penalty System  
- Rule-based Decision AI

## Algorithm and Heuristic Design

The A\* pathfinding used Manhattan distance with additional penalties for Plants proximity to simulate smarter zombie paths.

## AI Performance Evaluation

Evaluated by survival duration, resource usage, and wave count. Performance was consistent across tests, with AI sustaining multiple waves without human input.

# 5. Game Mechanics and Rules

## Modified Game Rules

- Plants cost 30 resources  
- Boss zombie appear every 10s  
- AI or user places plants under constraints

## Turn-based Mechanics

Game runs in real-time. In AI mode, AI places plants every 2s. In User mode, players place manually by clicking the mouse.

## Winning Conditions

Game ends if resources drop below -100.

# 6. Implementation and Development

## Development Process

Implemented in Python using Pygame. Designed classes for plants, zombies, and AI. A\* search manages Ind Soldier routing. AI decision tree handles plants placement.

## Programming Languages and Tools

- Language: Python  
- Libraries: Pygame  
- Tools: Git

## Challenges Encountered

- Managing real-time pathfinding with A\*  
- Optimizing AI plants decisions  
- Balancing difficulty dynamically

# 7. Team Contributions

- Areeb Hussain (22k-4042): AI plant placement and logic implementation.  
- M Sheharyar Baig (22k-4085): A\* pathfinding and zombies movement logic.  
- Arbaz Hasan (22k-4031): Game rendering, interface, and user interaction.  
- Hamza Yaqoob (21K-3011): Performance testing, debugging, and final integration.

# 8. Results and Discussion

AI handled plant placement effectively in over 70% of simulations. Zombies took intelligent paths avoiding dense plant areas. Boss waves tested AI adaptability, showing successful defense for more than 15 waves in most runs.

# 9. References

- Pygame Documentation: https://www.pygame.org/docs/  
- A\* Pathfinding Theory: https://theory.stanford.edu/~amitp/GameProgramming/AStarComparison.html  
- StackOverflow  
- PopCap Games (PvZ Reference)