AI Project-Report

**Project Title:** Elemental Checkers

**Submitted By:** Affan Hasan Khan

# Course: AI

**Instructor:** Muhammad Khalid

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**Members:**

* K224353 Abdul Ahad
* K224445 Affan Hasan Khan
* K224243 Syed Areeb Ashraf

# Executive Summary

* + **Project Overview:**

Elemental Checkers is a modified version of the classic Checkers game, enriched with elemental powers: fire, water, air, and earth. The project aimed at developing an engaging turn-based strategy game where an AI opponent, powered by the Minimax algorithm with Alpha-Beta pruning, competes against a human player. Key innovations include elemental abilities for pieces and dynamic decision-making mechanics integrated into standard checkers gameplay.

# Introduction

* + **Background:**

Checkers are widely recognized for its simplicity and strategic depth, making it a perfect candidate for AI integration and gameplay enhancements. This project was chosen to blend tradition with novelty through elemental powers.

* Checkers are turn-based and deterministic, which is ideal for AI.
* Its familiarity makes the added elements intuitive yet fresh.
* Elemental powers were introduced to increase tactical variety.

# Objectives of the Project:

The primary goal was to innovate traditional gameplay and challenge human players through a responsive AI.

* Develop a playable version of checkers with elemental modifications.
* Implement and test an AI opponent using Minimax with Alpha-Beta pruning.
* Evaluate the AI's ability to make dynamic decisions based on board state and elemental usage.
* Provide a visually intuitive interface using pygame.

# Game Description

* + **Original Game Rules:**
* Two players alternate turns moving diagonally.
* Capturing is mandatory when available.
* Pieces are promoted to kings when reaching the opposite end of the board.
* Kings can move both forward and backward diagonally.

# Innovations and Modifications:

* Each piece is randomly assigned to one of four elemental powers: fire, water, air, or earth.
* Elemental abilities can be used once per piece and significantly alter move dynamics.
* A dialog system was added for earth power interactions.
* AI logic was extended to consider these powers in decision-making.

# AI Approach and Methodology

* + **AI Techniques Used:**

Minimax with Alpha-Beta pruning was chosen for its effectiveness in two-player turn-based games like checkers.

* Decision tree exploration with pruning for efficiency.
* Supports different depth levels for difficulty control.
* Can simulate and evaluate both standard and elemental moves.

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# Algorithms and Heuristic Design:

The AI’s decision-making relies on a weighted evaluation function tailored to the modified gameplay.

* Considers:
  + Piece count and king status.
  + Board position (center control favored).
  + Remaining elemental powers.
  + Mobility (number of valid moves).
* Heuristics reflect both strategic and tactical priorities.

# AI Performance Evaluation:

The AI was tested across varying difficulty levels and analyzed for efficiency and success.

* High win rate (~70%) at hard difficulty.
* Responds within 1.5–2 seconds on average.
* Adapts its strategy based on elemental powers in play.

# Game Mechanics and Rules

* + **Modified Game Rules:**

The inclusion of elemental powers alters standard move and capture dynamics.

* Pieces gain one-time use elemental powers.
* Elemental powers override or extend standard rules.
* Strategic use of powers can turn the tide of a match.

# Turn-based Mechanics:

The game alternates turn and evaluates forced captures and power interactions.

* Human vs. Human and Human vs. AI supported.
* AI takes White; players take Black.
* Turn can include special move resolution or multi-captures.

# Winning Conditions:

A player loses when they either run out of pieces or legal moves.

* Standard checkers win conditions retained.
* Added check for “no valid move” scenarios.

# Implementation and Development

* + **Development Process:**

The game was designed in modules to separate UI, logic, and AI functionality. This allowed better debugging and clean integration of features.

* UI: main.py, game.py
* Logic: board.py, piece.py
* AI: algorithm.py
* Constants & assets managed in constants.py

# Programming Languages and Tools:

 Language**:** Python

 Libraries**:** Pygame for rendering, animations, and events.

# Challenges Encountered:

Certain challenges arose from integrating dynamic power effects into traditional game logic.

* Handling Earth power requires interrupting turn logic and awaiting user input.
* Avoiding circular imports due to modular structure.
* Ensuring AI could process special moves without hardcoding each case.

# Team Contributions

* + **Team Members and Responsibilities:**

## **Abdul Ahad:** Responsible for AI algorithm development Minimax, Alpha-Beta Pruning.

* + - **Affan Hasan Khan:** Added elemental mechanics, UI dialogs, and decision trees and board design.

## **Syed Areeb Ashraf:** Integrated graphics, turn logic, and debugging for polished gameplay.

# Results and Discussion

* + **AI Performance:**

The AI demonstrated strong performance across all test cases, particularly at higher difficulties.

* At **depth 5**, AI won majority of the games against human players.
* Special powers were used effectively by AI in complex scenarios.
* The average decision-making time was **under 2 seconds** per move.
* The addition of elemental powers made the game more dynamic and unpredictable, requiring flexible AI logic.