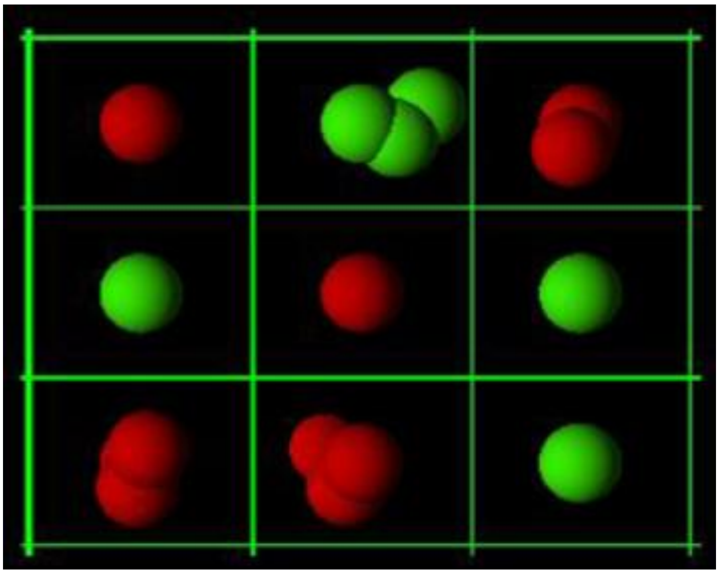
CHAIN REACTION



PROJECT REPORT ON

Chain Reaction Game

UNDER THE GUIDANCE OF

Ms. KRUPA KAMDAR

SUBMITTED BY

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TYCS18

UNIVERSITY OF MUMBAI

T.Y.B.Sc (COMPUTER SCIENCE)

ACADEMIC YEAR: 2021-2022

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CERTIFICATE

This is to certify that **Ms. Tanisha Gondke**, Seat Number **TYCS18** of the class T. Y. B. Sc. Computer Science has satisfactorily completed the practical course in Group 6 as prescribed by the University of Mumbai during the academic year 2021 – 22.

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Computer Science Coordinators

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ACKNOWLEDGEMENT

I would like to express my sincere gratitude towards the Computer Science Department of Bhavan's College.

After months of hard work, finally I am very happy to present my final year Project. The Project making was full of new experiences and learning and difficult one too. Though a difficult job it was made simpler by the timely guidance received, which helped me greatly in the completion of my project. But it wouldn't be right to do so without thanking to those who have helped me in converting our thought into reality. So I would like to take full advantage of this opportunity to thank each and every person who has helped me throughout the completion of our project.

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-Thank you.

TYCS SEM-VI PROJECT INDEX

1. ABSTRACT AND KEYWORDS

Main objective of the game chain reaction is to take control of the entire board by eliminating your opponents' orbs. The cell, when reached its mass critical stage; the orb explodes into its surrounding area adding an extra orb. This claims that particular cell for the player. Interesting part of this game is that it's unpredictable. We should focus to find out the right movements and combinations of chain reactions to win the game. There are 3 types of agents we can play with, this reflects to their difficulty level in the game. Each agent has its own algorithm to play the game.

Keywords:

Chain Reaction, python, pygame, Random, MCTS, Minimax

2. Introduction

2.1 Problem Statement

The game chain reaction is a game where the player has to get rid of all the opponent orbs in the board. The game is usually played with two human players. We should focus to find out the right movements and combinations of chain reactions to win the game.

2.2 Description of the present system / Literature Review

Chain reaction is a board game. The player places the orb in the board to claim that cell. When the maximum cell space is reached, the orbs explodes and moves into the other adjacent cell. Similarly, both the players have to claim their cells on the board and then one who gets rid of all the opponent orbs wins the game. A bot is introduced here.

2.3 Background / Limitation

The traditional chain reaction game is played on the board. The number of players are 2 and both are humans.

2.4 Aim and Objective

To enhance the game's performance, the opponent player will be a bot based on AI. So, a single human player can play against AI. There is a freedom of playing against an AI or a human. The game will have 3 agents (bot) each based on 3 algorithms each. The algorithms will be made such that the level of difficulty of the game increases as we play with the respective agent. This makes the game more interesting as were playing with the bot.

2.5 Project Motivation

The motivation of this project is to boost / increase the competition of the players in the game called chain reaction.

3. Description of the Proposed Work / Project

3.1 Number of Modules

1. Chain reaction basic game: This consists of the traditional chain reaction game having 2 human players.

2. Random: This contains a bot (agent) which plays its move on the board at random.

3. MCTS: This contains a bot (agent) which plays its move on the board using MCTS algorithm.

4. Minimax: This contains a bot (agent) which plays its move on the board using Minimax algorithm.

3.2 Algorithm

1. Random

This is made using random module which was imported in the code. It uses the normal valid board moves logic but just plays them at random.

2. MCTS

Monte Carlo Tree Search is a method usually used in games to predict the path (moves) that should be taken by the policy to reach the final winning solution. It is a slow learner. It has to observe all the states in present and chooses the optimal one not knowing if the state will really lead to an optimal solution or not. It follows a sequence of steps until it reaches the final solution, also learning the policy of the game; and those steps are: Selection, Expansion, Simulation, Back Propagation.

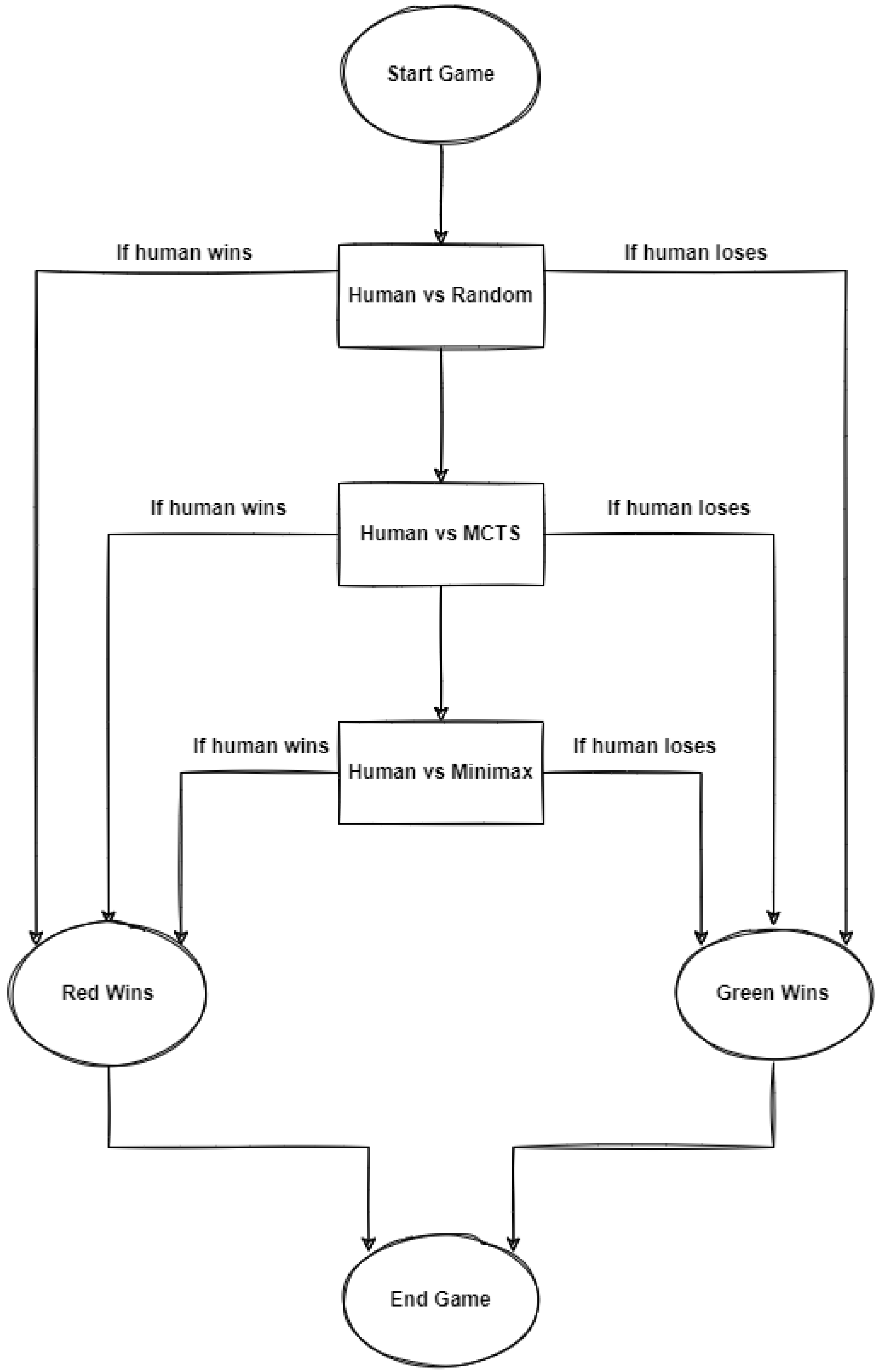
3. Minimax

This algorithm follows the look ahead decision strategy. It assumes that the opposite player is playing optimally, thus it tries to play even better with the intention of defeating the enemy player. This algorithm is used when there are two player games this type of game is called zero sum game concept. It contains a minimizer and maximize. They choose the best move and worst move for the agent respectively. It also consists of Alpha Beta Pruning where the tree branch that is useless is eradicated. It traverses in a DFS fashion down the tree. It selects the move which gives the best utility value.

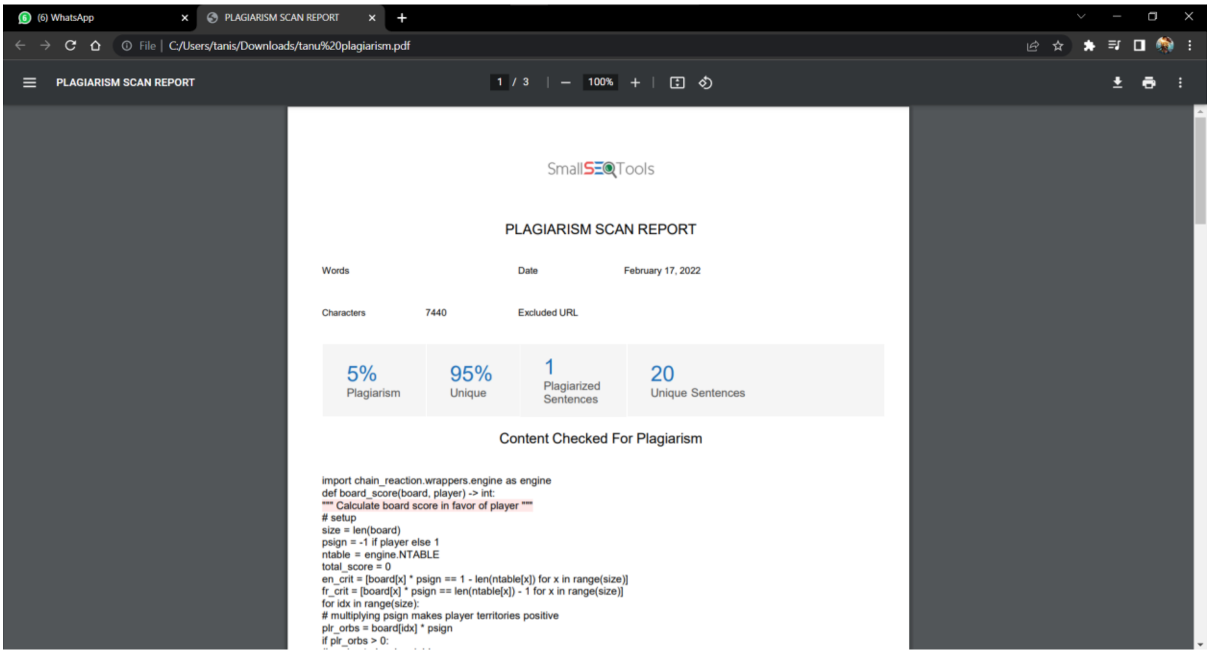
3.3 Working

The user can change the grid dimensions by changing the shape attribute in the code. The player1 and player2 can have values: “human, random, mcts, minimax”. The game then starts by the settings you’ve set. The difficulty increases as the levels increase. Level 1 is the random agent. Level 2 is MCTS and level 3 is Minimax. The players have to place their atoms in the grid in alternate turns and try to eliminate the atoms of the other players. These atoms have valency upto 3 but it depends on what position they’re placed in. If it’s a corner the atom has valency 1; if an edge then valency is 2, if in between then the valency is 3. When these valency get full, these atoms burst in the board in x and y plane (2d). The player (we) have to defeat the ai agent by placing our atoms on the board and eliminating all the enemies' atoms. The atoms burst and occupy adjacent cells leading to a chain reaction. Finally, a wintext frame will appear at the end of the game when a player wins.

3.4 Design / Block diagram / flowchart / graph / deployment diagram / architectural design



3.5 Plagiarism Report



3.6 Coding

1. MCTS

```
import time
import math
import random
import chain_reaction.wrappers.engine as engine
def uct_score(node, c_param) -> int:
    exploit = node.qscore / node.visits
    explore = math.sqrt(math.log(node.parent.visits, 10) / node.visits)
    return exploit + c_param * explore
def forward_roll_once(state, player) -> tuple:
    valid_moves = engine.valid_board_moves(state, player)
    chosen_move = random.choice(valid_moves)
    next_state = state[:]
    game_over = engine.interact_inplace(next_state, chosen_move, player)
    if game_over:
        return (None, player)
    else:
```

```
        return (next_state, 1 - player)


class MCTSVisitedNode:
    def __init__(self, state, parent, index, player):
        self.state = state
        self.index = index
        self.player = player
        self.parent = parent
        self.children = []
        self.unvisited = engine.valid_board_moves(state, player) if state else []
        self.is_terminal = False if state else True
        self.visits = 0
        self.qscore = 0

    def is_fully_expanded(self):
        return len(self.unvisited) == 0

    def expand(self):
        action = self.unvisited.pop()
        next_state = self.state[:]
        game_over = engine.interact_inplace(next_state, action, self.player)
        next_state = None if game_over else next_state
        child = MCTSVisitedNode(next_state, self, action, 1 - self.player)
        self.children.append(child)
        return child

    def best_child(self, c_param):
        b_score = -math.inf
        b_child = None
        for child in self.children:
            score = uct_score(child, c_param)
```

```
            if score > b_score:
                b_score = score
                b_child = child
        return b_child

    def simulate(self):
        state = self.state
        player = self.player
        while state is not None:
            state, player = forward_roll_once(state, player)
        return player

    def backpropagate(self, reward):
        node = self
        while node is not None:
            node.visits += 1
            node.qscore += 1 if node.player == reward else -1
            node = node.parent



class MCTSRootNode(MCTSVisitedNode):
    def __init__(self, state, player):
        super().__init__(state, None, None, player)

    def best_action(self):
        return self.best_child(c_param=0.0).index

    def tree_policy(self, c_param):
        node = self
        while not node.is_terminal:
            if not node.is_fully_expanded():
```

```
                return node.expand()
            else:
                node = node.best_child(c_param)
        return node


def best_action(board: list, player, time_limit, c_param) -> int:
    time_start = time.perf_counter()
    rootnode = MCTSRootNode(board, player)
    while time.perf_counter() - time_start < time_limit:
        leafnode = rootnode.tree_policy(c_param)
        reward = leafnode.simulate()
        leafnode.backpropagate(reward)
    return rootnode.best_action()
```

2. Minimax

```
import chain_reaction.wrappers.engine as engine
def board_score(board, player) -> int:
    size = len(board)
    psign = -1 if player else 1
    ntable = engine.NTABLE
    total_score = 0
    en_crit = [board[x] * psign == 1 - len(ntable[x]) for x in range(size)]
    fr_crit = [board[x] * psign == len(ntable[x]) - 1 for x in range(size)]
    for idx in range(size):
        plr_orbs = board[idx] * psign
        if plr_orbs > 0:
            neighbrs = ntable[idx]
            is_critc = fr_crit[idx]
            maxcp = len(neighbrs)
            crit_enemies = sum([en_crit[nid] for nid in neighbrs])
            crit_friends = sum([fr_crit[nid] for nid in neighbrs])
```

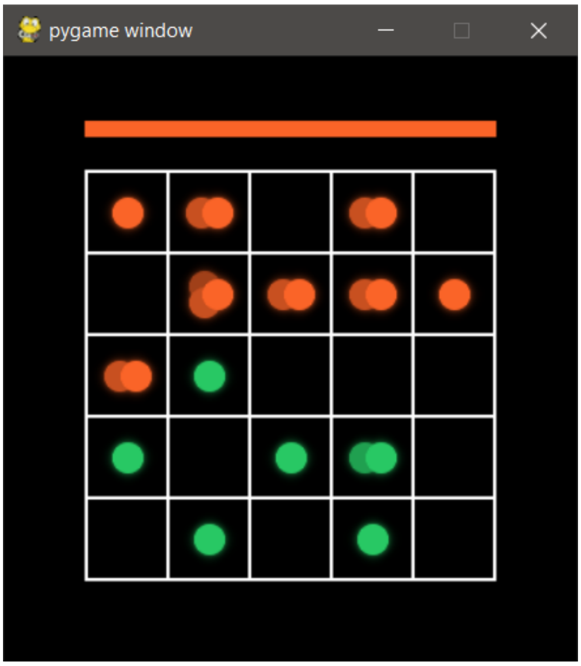
```
            total_score += plr_orbs
            total_score -= (5 - maxcp) * crit_enemies
            if not crit_enemies:
                total_score += 3 if maxcp == 2 else 0
                total_score += 2 if maxcp == 3 else 0
                total_score += 2 if is_critc else 0
            if is_critc and crit_friends:
                total_score += 2

    return total_score



def score_minimizer(board, player, alpha, beta) -> int:
    enemy = 1 - player
    esign = -1 if enemy else 1
    score = 10000
    for idx in range(len(board)):
        if board[idx] * esign < 0:
            continue
        cboard = board[:]
        if engine.interact_inplace(cboard, idx, enemy):
            return -10000
        cscore = board_score(cboard, player)
        score = min(score, cscore)
        beta = min(beta, score)
        if alpha >= beta:
            return score

    return score
```

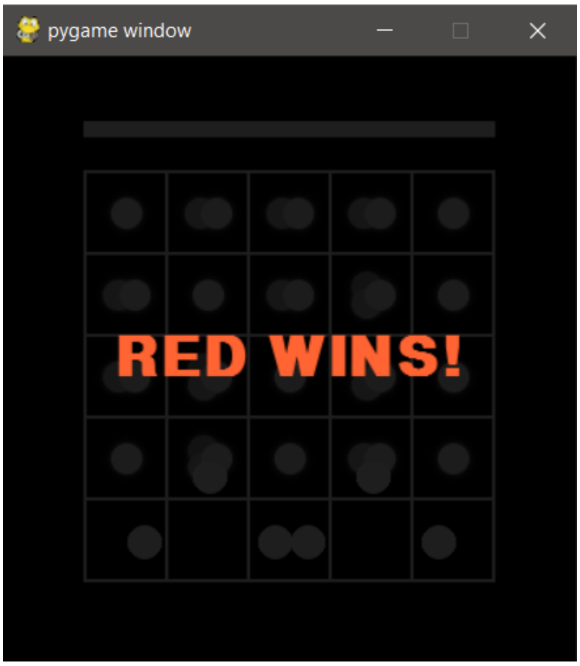
```
def pruned_minimizer(board, player, alpha, beta, depth) -> int:
    enemy = 1 - player
    esign = -1 if enemy else 1
    score = 10000
    if depth == 0:
        return score_minimizer(board, player, alpha, beta)
    for idx in range(len(board)):
        if board[idx] * esign < 0:
            continue
        cboard = board[:]
        if engine.interact_inplace(cboard, idx, enemy):
            return -10000
        cscore = pruned_maximizer(cboard, player, alpha, beta, depth)
        score = min(score, cscore)
        beta = min(beta, score)
        if alpha >= beta:
            return score

    return score



def pruned_maximizer(board, player, alpha, beta, depth) -> int:
    score = -10000
    psign = -1 if player else 1
    for idx in range(len(board)):
        if board[idx] * psign < 0:
            continue
        cboard = board[:]
        if engine.interact_inplace(cboard, idx, player):
            return 10000
        score = max(
```

```
            score, pruned_minimizer(cboard, player, alpha, beta, depth - 1)
        )
        alpha = max(alpha, score)
        if alpha >= beta:
            return score
    return score


def load_scores(board, player, depth) -> list:
    alpha = -10000
    psign = -1 if player else 1
    score_list = [0] * len(board)
    for idx in range(len(board)):
        if board[idx] * psign < 0:
            score_list[idx] = -20000
            continue
        cboard = board[:]
        game_over = engine.interact_inplace(cboard, idx, player)
        if game_over:
            score_list[idx] = 10000
            return score_list
        score = pruned_minimizer(cboard, player, alpha, 10000, depth - 1)
        score_list[idx] = score
        alpha = max(alpha, score)
    return score_list
```

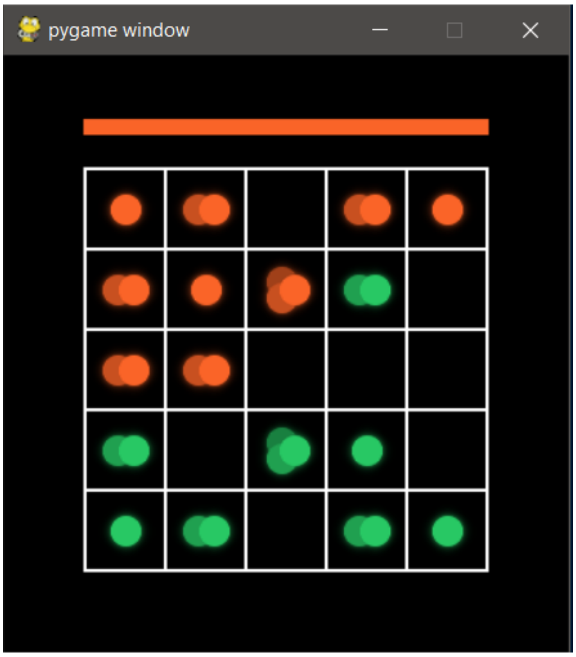
3.7 Screen Layouts

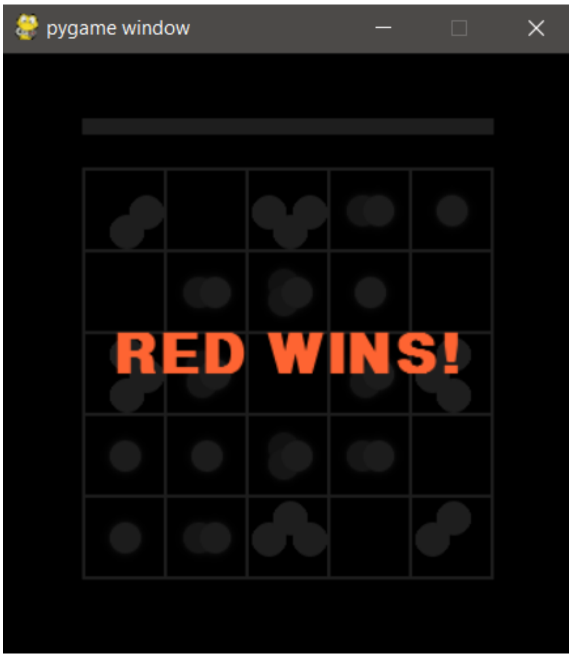
1. Human (Red) vs Random (Green) – Easy to defeat random



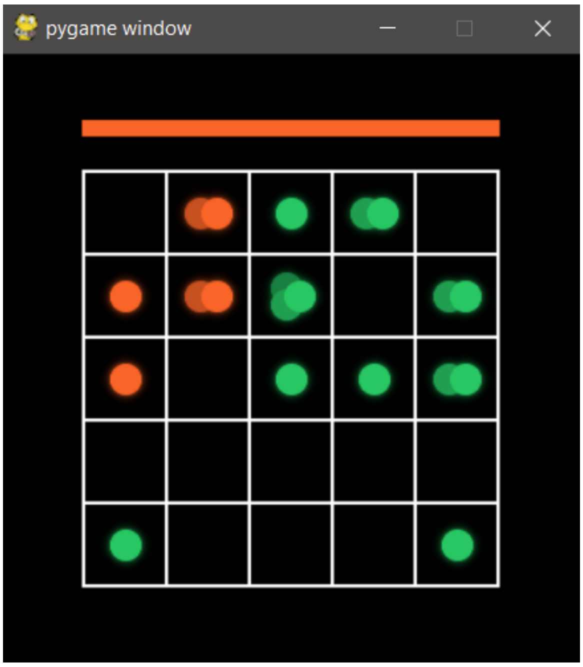


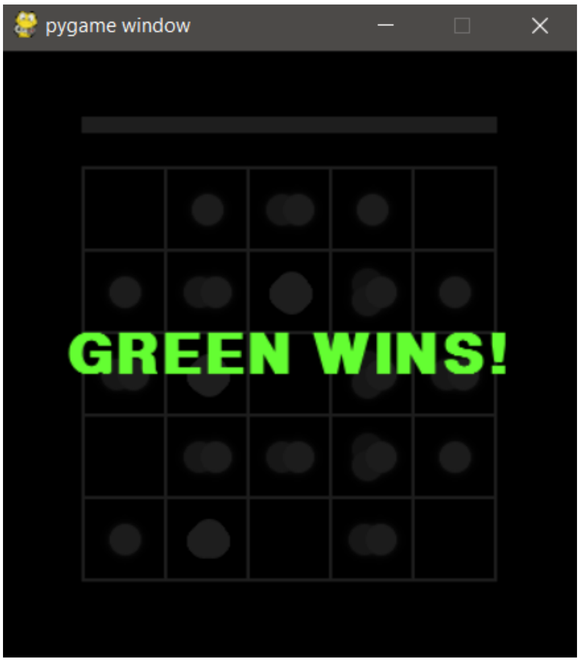
2. Human (Red) vs MCTS (Green) – Slow learner





3. Human (Red) vs Minimax (Green) – Difficult to defeat minimax





4. Technology / Language / Development Tools / Hardware

1. Python - Pygame

5. Conclusion and Future Report

The traditional chain reaction game is modified and upgraded where we can have an ai agent playing against us human. There are 3 agents and each play with their own strategy in this game. In future, we can have an increased number of players in the board and can also play it online. Other entertainment utilities like song can also be added.

6. References / Resource Material / Data collection

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