Report On:

Scrabble Game Using Artificial Intelligence

By

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OBJECTIVE

- **Use Artificial Intelligence to make a virtual player i.e computer as an opponent of Human player.**
- **The computer will try to make word that has maximum by scanning all moves made by human player.**
- **This would increase the vocabulary of the player if he/she is a regular player as computer will act as tough competitor to human player.**

History of scrabble

Originally called Criss Cross, the game, which was based on the crossword puzzle and anagrams, was developed by Alfred M. Butts, an architect, in 1931. It was redesigned, renamed as Scrabble, and marketed by James Brunot in 1948. It was first sold in Great Britain in 1954.

Scrabble was later produced in many foreign languages, Braille, and magnetic editions and continued to be one of the leading board-and-tile games in the United States. Tournaments have been held in the United States since 1973.

In 2005 Scrabulous, an unauthorized online version of Scrabble, was released, and two years later it debuted on the social-networking site Facebook. The online version's immense popularity on the site soon caught the attention of Hasbro, owner of Scrabble's North American rights. Facing a lawsuit by Hasbro, Scrabulous creators Rajat Agarwalla and Jayant Agarwalla in 2008 released Wordscraper, a Scrabble-like game that allows players to design their own board, and later that year Facebook disabled Scrabulous for their North American users.

INTRODUCTION

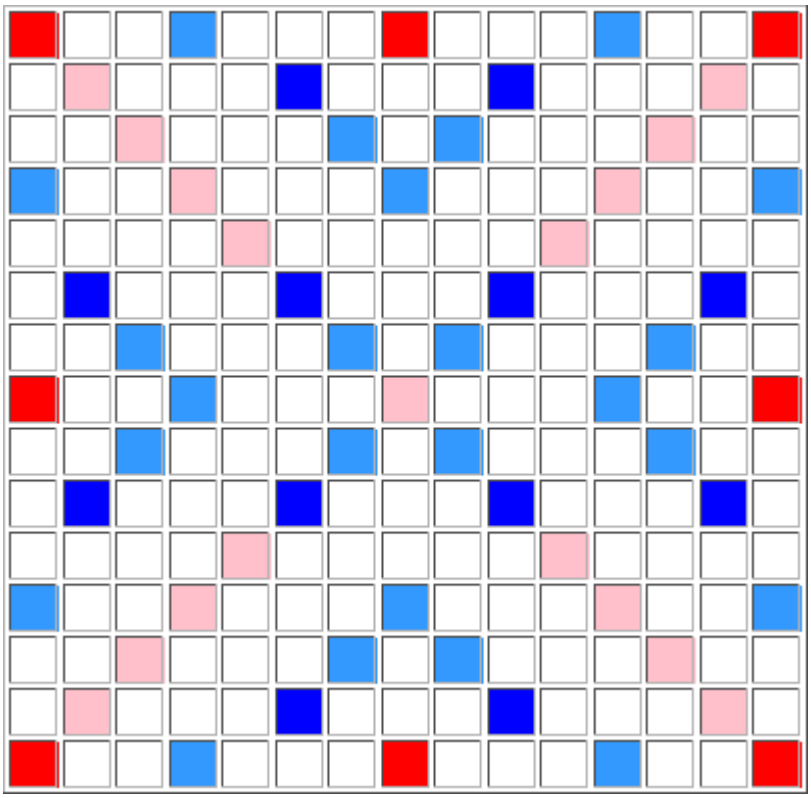
Rules of scrabble game: -

- The board offers 15 cells high and 15 cells wide i.e the size of the board is 15x15
- There are 100 tiles that are used in the game and 98 of them will contain letters and point values and two of them are blank tiles.
- Human player will make word in **horizontal way** and computer will make word in **vertical way.**

- **Double Letter Scores** - The light blue cells in the board
- **Triple Letter Score** - The dark blue cell in the board
- **Double Word Score** - When a cell is light red cells in the board
- **Triple Word Score** - The dark red square is where the high points can be earned as this will triple the word score.
- **Number of tiles of each letter**:-

  A-**9**, B-2, C-2, D-**4**, E-12, F-2, G-3, H-2, I-**9**, J-1, K-1, L-**4**, M-2, N-6, O-8, P-2, Q-1, R-6, S-**4**, T-6, U-**4**, V-2, W-2, X-1, Y-2, Z-1 and Blanks-2.

- **Structure of a scrabble board**:-



Structure of game:-

- A list representing the tiles available to the human player.
- After each move the empty tiles will be updated with the new letters.
- After each move by the human player computer matches it with its dictionary to find whether the entered word is genuine or not.
- The game executes in multiplayer mode between computer and user.
- If the human player doesn't find any letter present in the list matching the he could replace it but his turn will be passed to the computer.
- If the human player cannot find a suitable word the he could pass his turn to the computer.

Approach used by computer player :-

- Universe of this game is unpredictable because both the player doesn't know which word is going to be made by other player.
- So, to solve this computer will explore all moves previously made to find its next best move.
- The computer explores all the letter present on the board and calculate their heuristic value.
- The letter with maximum heuristic value will be chosen and word that will yield maximum score is chosen from scrabble dictionary.
- If no such word is present then computer backtracks and select next best move.

Libraries used:-

- **Tkinter**

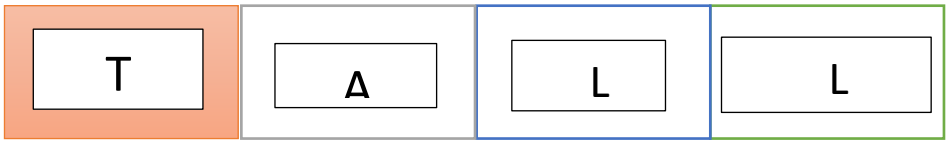
Github repository Link :-

https://github.com/Amritesh21/ScrabbleGameUsingAI.git

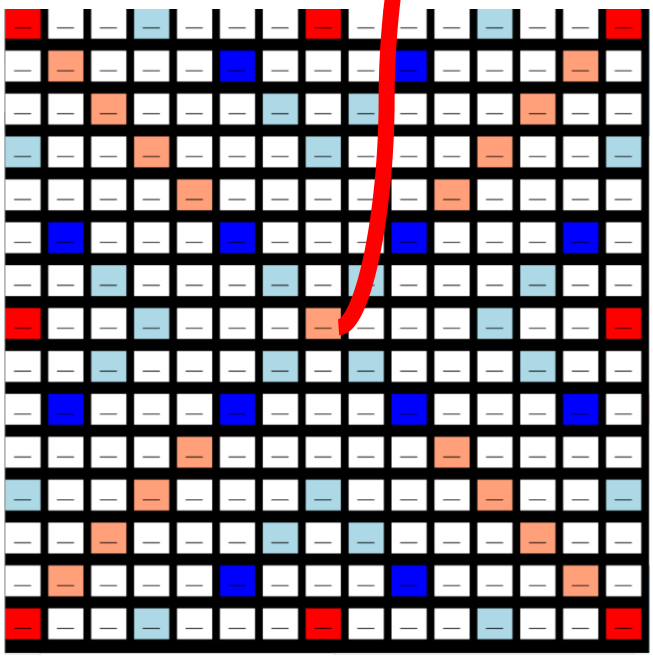
Approach in details :

- In universe of scrabble game is unpredictable as we don't know which alphabet we are going to draw from the bag and which next word my opponent will form.
- So based on the move made by opponent computer will decide what will be its best move that will give it maximum score.
- As in this game all the words formed by computer will be horizontally whereas human will form the word in vertical fashion.

Explanation through example



Human player scores :- (1+1+1+1)*4=16

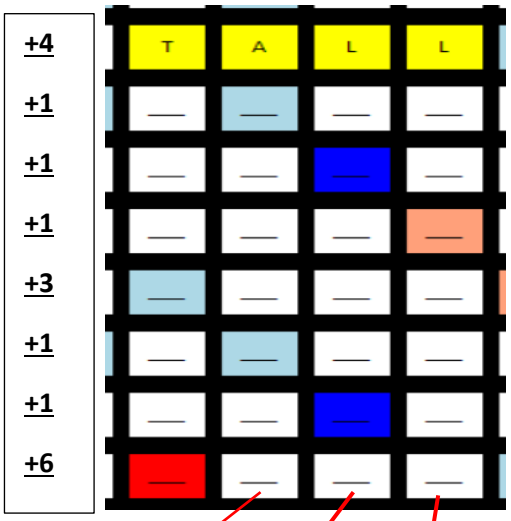


- Now heuristic value of each cell filled by human player is calculated,

  Process of calculation of heuristic value:-

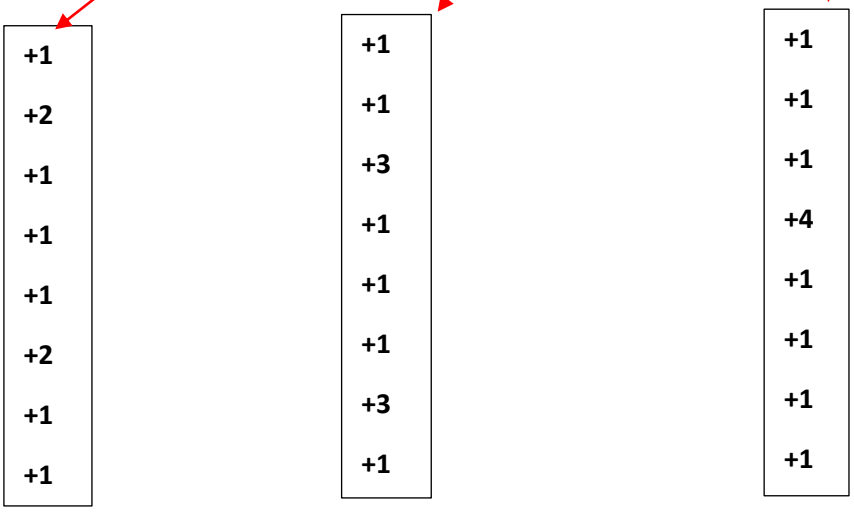
Number of cells present below that cell in that particular column =n
Weight of each cell :

- Light blue=2
- Light red=4
- Dark blue=3
- Dark red =6
- **White =1**



- **So for first cell 'T' in column 1 heuristic value is:**
  There are 3 color tiles :
  Dark red, light blue and light red
  and it has 5 white tiles
  So heuristic value of column containing 'T ' =18

Column containing 'A': **1st Column containing 'L'** **2nd Column containing 'L'**

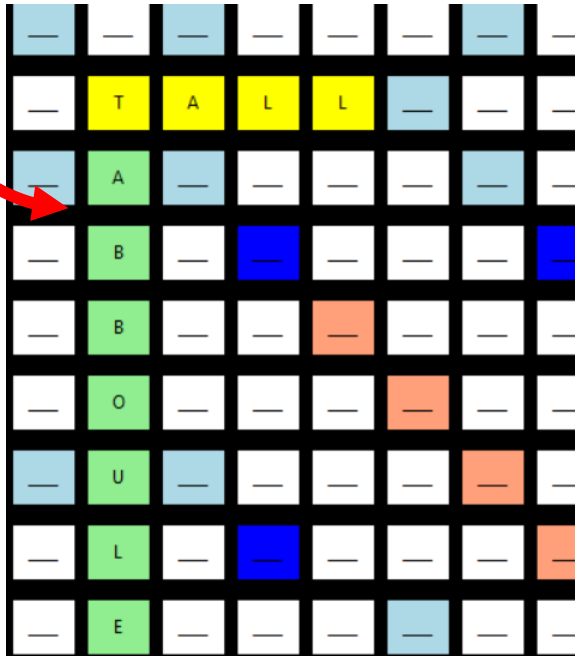


Total heuristic value=10 **Total heuristic value = 12** **Total heuristic value=11**

As first column has maximum heuristic value i.e 18 so filling that column will yield it maximum score.

Now computer searches for word of length n(for abbreviation see above)

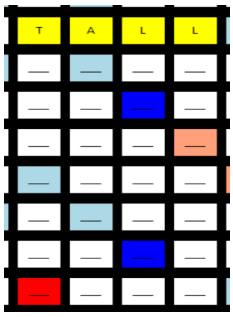
- If it finds a word of length n then it is fine
- but if it is not able to find word of length n then it finds word of length less than n
- Then heuristic value of new word is calculated and if it is greater than then heuristic value of rest of column then it is permitted to fill the cells
- Otherwise the word with its heuristic value is saved in memory and waits for next greater heuristic value word.
- If a word having heuristic value greater than previously saved word is found then cell are filled by that word.
- The process repeats for each entry.



Game Flow :

Forward flow →

Backtracking →



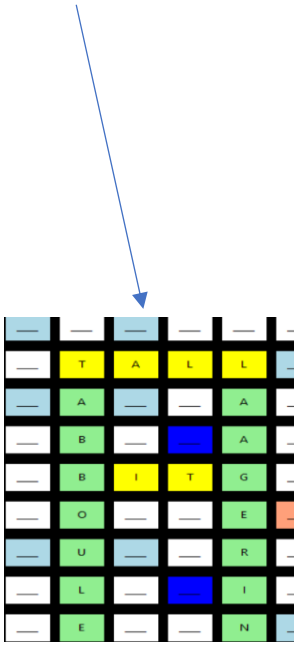
Human=16

Computer **18** **10** **12** **11**

Human

‘A’ **‘L1’** **‘L2’** **‘I’** **‘T’**

4 **5** **11** **6** **7**



And so on until letter bag of one of the player is empty……

Future use of Scrabble

- It might be used by various MNC in recruiting process to test candidates vocabulary and word forming speed.
- It can be used by various school to motivate children in increasing their vocabulary and word forming speed.

References:-

- **Research paper :-**

  A Scrabble Artificial Intelligence Game by Priyatha Joji Abraham (San Jose State University)

- northwestern.edu
- www.britannica.com/sports/Scrabble