CMPT 129 Assignment 2

Consider the assignment below and develop an algorithm to solve it based on the information provided.

This Assignment must be completed in groups of one to two students. No groups larger than two students will be permitted.

PLEASE NOTE IF YOUR CODE DOES NOT COMPILE, OR DOES NOT PRODUCE THE CORRECT OUTPUT THE MAXIMUM SCORE YOU WILL RECEIVE IS 20%.

You code will play a game called FlipFlop. FlipFlop is a game similar to Reversi or Go. The rules for this game are a little different from GO or Reversi so please read the rules below carefully.

The FlipFlopA.cpp file should contain the solution for part A of the assignment. In particular the FlipFlopA.cpp file should contain:M
1. main() function
2. CheckLine function (code for this function will be supplied)
3. PlacePiece function
4. InitializeBoard function
5. DisplayBoard function
6. IsAnyMoveValid function
7. IsThisMoveValid function (optional)

These functions MUST have the exact prototypes given at the start of the description of part A of the assignment and must be used in your code.

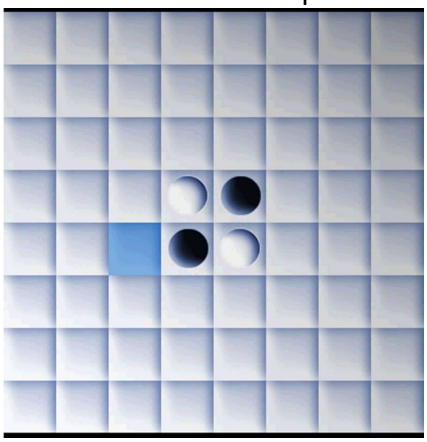
The FlipFlopB.cpp file should contain the solution for part B of the assignment. This will consist of a copy of the FlipFlopA.cpp file modified to use dynamic allocation of the myFlipFlopBoard array. In particular the FlipFlopB.cpp file should contain modified versions of the following functions:
1. main() function
2. CheckLine function
3. PlacePiece function
4. InitializeBoard function
5. DisplayBoard function
6. IsAnyMoveValid function
7. IsThisMoveValid function (optional)

These functions MUST have the exact prototypes given at the start of the description of part B of the assignment.

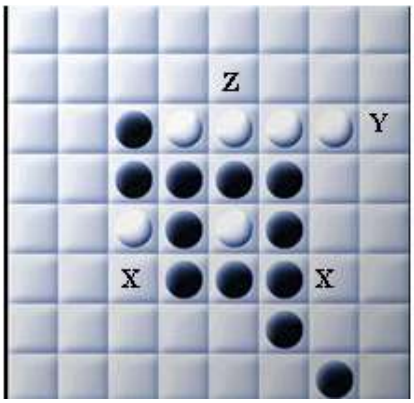
FOR EACH FUNCTION WHO'S PROTOTYPE YOU CHANGE (IN PART A OR PART B) YOU WILL AUTOMATICALLY LOOSE 3 MARKS OF THE 100 MARKS FOR THE ASSIGNMENT.

The Game of FlipFlop is a strategy oriented board game with the following rules:

1. The game begins on a board of N squares by N squares. N must be at least 8 and N must be even,
2. The game is played by two players using game pieces that are placed on the squares of the board. One player uses white game pieces; the other player uses black game pieces.
3. White moves first.
4. The game ends when of the conditions below is true
    a. The black player has taken $N^2/2$ turns
    b. When a player plays 0 game pieces and their opponent then also plays 0 game pieces
5. The initial board will be set up as follows



6. When a player places a game piece on the board it MUST trap at least one of their opponent's game pieces. To understand when a piece is trapped we must think of the board in terms of 'lines'. A line must be straight, but may be horizontal, vertical or diagonal.
    a. To trap an opponent's piece there must be one of your pieces on each side of the piece within a particular line. For example placing a white piece on the blue square in the board above would trap one black piece between two white pieces in a horizontal line.
    b. You may trap any number of your opponent's pieces in a single move. To trap more than one of your opponent's pieces in the same line your opponent must have more than one adjacent piece in that line. In some cases it may be possible to trap opponent's pieces along more than one line with a single move.
    Some examples are shown on the board below. If it is white's move, the X's show two squares where a white piece could be placed to trap two black pieces in a row along a diagonal line. If it is black's move the Y shows where a black piece could be placed to trap 4 white pieces in a horizontal row. An example of this is shown on the board below. Assume that it is black's turn and black has chosen to place a black piece on the square indicated by the Z. This move traps 1 piece along a vertical line and 1 piece along a diagonal line.



7. When a player makes a move they must place zero, one, or two pieces on the board. Each piece placed on the board must trap an opponent's game piece.
    a. If it is not possible to trap an opponent's game piece along a horizontal line or along a vertical line (your program needs to check this and end the turn if necessary) then the player places zero game pieces on the board and ends their turn.
    b. If it is possible to trap an opponent's game piece along a horizontal line or along a vertical line then the player must try to play their first game piece. If the player does not trap two or more of their opponent's pieces when they play their first game piece the player's turn is over.
    c. If the player traps two or more of their opponent's game pieces when they place their first game piece on the board then the player may choose to place a second game piece on the board. If the second game piece is placed it MUST be placed so that it traps at least one of the opponent's game pieces along a diagonal line.
8. Immediately after a game piece has been placed on the board ALL trapped opponent's game pieces will be "captured". This includes game pieces trapped in ALL possible directions (horizontally, vertically, or diagonally). When a game piece is captured the color of the game piece is changed. In the examples above the black game pieces trapped by placing the new white game pieces on one X would become white game pieces or the white game pieces trapped by the new black game piece places on the Y would be changed to black game pieces.

PART A (90% of the grade for the assignment)

To implement your version of FlipFlop you will write a main program and the following functions. The main program and the functions will be written inside a file called FlipFlopA.cpp. You must use the exact prototypes given as we may test your functions without your main program. You may use additional function if you wish. The prototypes of your functions are given below. The purpose of each of the functions is explained after the description of the main program

bool InitializeBoard(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard);

bool DisplayBoard(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard);

bool PlacePiece(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard,
int player, int squarePlayed, int whichPiece, int& numberCaptured);

bool IsAnyMoveValid((int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard,
int player, int whichPiece);

bool IsThisMoveValid(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard,
int player, int squarePlayed, int whichPiece);

THE FOLLOWING FUNCTION IS PROVIDED FOR YOU IN THE POSTED FRAMEWORK

bool CheckLine(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard,
int player, int squarePlayed, int xDirection, int yDirection, int& numCaptured);

DO NOT DECLARE THE FlipFlopBoard ARRAY AS A GLOBAL VARIABLE
DO NOT DECLARE THE myFlipFlopBoard ARRAY AS A GLOBAL VARIABLE
DO NOT USE GLOBAL VARIABLES (GLOBAL CONSTANTS ARE OK)
You will be given the code for function CheckLine

Your main program should

1. Declare an array myFlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE] as a local automatic variable in the main program. MAX_ARRAY_SIZE should be a declared constant with global scope and with a value 24.

2. Prompt for and read the size of the board (***numRowsInBoard*****).** Use the following prompt
   Enter the number of squares along each edge of the board
   a) Check the board size entered by the user.
   The correct range for board size is ***8 <= numRowsInBoard <= 24, numRowsInBoard*** must be even**.** If the board size is not valid one of the following error messages should be printed
   ERROR: Board size too large
   ERROR: Board size too small
   ERROR: Board size odd
   ERROR: Board size is not an integer
   b) If the user enters an invalid value or a value that is out of range, tell the user what legal values are by printing the message
   8 <= number of squares <= 24
   and reprompt for and reread a new value. Read the value a maximum of 3 times, if the value is still invalid or out of range print the message below and terminate the program.
   ERROR: Too many errors entering the size of the board

3. Initialize the game board using the ***InitializeBoard*** function.
   a) Declare the array to hold the game board in the main program
   b) Do not initialize the array in the main program
   c) If the board does not initialize correctly (***InitializeBoard*** returned false) print the error message below and then terminate the main program
   ERROR: Could not initialize the game board

4. Print the initial board to the screen using the ***DisplayBoard*** funtion

5. Check to see that the board displayed correctly (***DisplayBoard*** returned true)

a) If the board does not display correctly print and error message and continue
ERROR: Could not print the game board

6. For each turn
   a) Check if the player can play their first piece by calling function IsAnyMoveValid. This function determines if there is any legal square on which the player can place their first piece. If function IsAnyMoveValid returns false then there is no available move. If there is no available move print one of the following messages.
   White is unable to move
   Black is unable to move
   b) If the player can place their first game piece on the board print one of the following single line message to the screen
   White takes a turn
   Black takes a turn
   c) Give the player three attempts to select a legal square to place their first game piece on. If the player does not select a legal square in three tries he forfeits his turn. If the player forfeits their turn print one of the following messages
   White has forfeited a turn
   Black has forfeited a turn
   d) For each attempt at placing the first game piece on the game board
      i. If three attempts to make a legal move have already failed forfeit the turn then print one of the messages in c) then go to the start of step 6 and let the opponent take their turn.
      ii. Request the number of the square on which the player wishes to place his piece. The number of the square will be displayed on the gameboard. For example the initial gameboard for an 8x8 board would be like that shown below. The square number of the square is shown for each empty square. W is shown for each white piece. B is shown for each black piece.

```
 0   1   2   3   4   5   6   7
 8   9  10  11  12  13  14  15
16  17  18  19  20  21  22  23
24  25  26   W   B  29  30  31
32  33  34   B   W  37  38  39
40  41  42  43  44  45  46  47
48  49  50  51  52  53  54  55
56  57  58  59  60  61  62  63
```

      When requesting the number use the prompt
      Enter the square number of the square you want to put your first piece on
      iii. If the chosen square is not on the board print the error message below and continue to the next attempt at a legal mover (this attempt was not legal)
      ERROR: that square is not on the board.

Try again
Proceed to the next try

iv. If the chosen square is already occupied, print an error message below and continue to the next attempt at a legal move (this attempt was not legal)
ERROR: that square is already occupied
Try again
Proceed to the next try

v. Attempt to place the first piece by calling function ***PlacePiece***.

vi. If ***PlacePiece*** returns false (the requested move is illegal) then print the error message below
ERROR: illegal move
Try again
Proceed to the next try

vii. If ***PlacePiece*** returns true and the first piece captured exactly one opponent's piece print the board to the screen using the ***DisplayBoard*** funtion

1. Check to see that the board displayed correctly (***DisplayBoard*** returned true)**.** If the board does not display correctly print and error message and continue

e) Print a message indicating how many pieces were captured in the move
Your first piece captured N opponent's pieces
where N is the number of pieces you captured

f) If the move was legal and the first piece captured more than one opponent's piece ask the player if they wish to play a second piece.

g) If the player does not wish to play a second piece then go to the start of step 6 and let the opponent take a turn.

h) Otherwise check if the player has a legal move (using IsThisMoveValid). If there is no legal move print one of the messages in a), go to the beginning of step 6 and let the opponent take a turn.

i) for each try at placing the second piece in the turn

i. If three attempts to make a legal move have already failed forfeit the turn then print one of the messages in c) then go to the start of step 6 and let the opponent take their turn.

ii. Request the number of the square on which to place the second piece using the prompt
`Enter the square number of the square you want to put your second piece on`

iii. If the chosen square is not on the board print the error message below and continue to the next attempt at a legal move (this attempt was not legal)
ERROR: that square is not on the board.
Try again

iv. If the chosen square is already occupied, print an error message below and continue to the next attempt at a legal move (this attempt was not legal
ERROR: that square is already occupied
Try again

v. Attempt to make a move by calling function ***PlacePiece***. If ***PlacePiece*** returns false go back to step iii. (this attempt was not legal)

vi. If ***PlacePiece*** returns true, print the board to the screen using the ***DisplayBoard*** funtion

1. Check to see that the board displayed correctly (***DisplayBoard*** returned true). If the board does not display correctly print and error message and continue

vii. Print a message indicating how many pieces were captured in the move
Your second piece captured N opponent's pieces
where N is the number of pieces you captured

7. Terminate the program if the maximum number of turns have been taken (N^2) or if both players are unable to move. When the game finishes print the messsages
GAME OVER
Please enter any character to close the game window
Then wait till the player enters a character, then terminate the program.

Your function *InitializeBoard* should

1. Have the prototype
bool InitializeBoard(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard);
2. ***InitializeBoard*** will fail (return false) if the numRowsInBoard is out of range or if an unallocated dynamic array is passed to the function.
3. The meanings of the values that will be placed into the FlipFlopBoard when it is initialized are
   a) 0 in an element of ***FlipFlopBoard*** indicates there is no game piece on the square
   b) 1 in an element of ***FlipFlopBoard*** indicates there is a white game piece on the square
   c) 2 in an element of ***FlipFlopBoard*** indicates there is a black game piece on the square
4. Begin by initializing the FlipFlopBoard to be an empty board
5. Place the first four tiles on the center 4 squares of the board. (see the example in the example of the rules at the start of this lab)
6. For example after initialization a 8X8 or 10X10 board would have the following values in the array ***FlipFlopBoard***

```
0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0
0  0  0  1  2  0  0  0
0  0  0  2  1  0  0  0
0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0
```

```
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  1  2  0  0  0  0
0  0  0  0  2  1  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
```

Your function *DisplayBoard* should

1. Have the prototype
   bool DisplayBoard(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard);
2. The meanings of the values tin the FlipFlopBoard are
   a) 0 in an element of ***FlipFlopBoard*** indicates there is no game piece on the square
   b) 1 in an element of ***FlipFlopBoard*** indicates there is a white game piece on the square
   c) 2 in an element of ***FlipFlopBoard*** indicates there is a black game piece on the square
3. Step through the ***FlipFlopBoard*** array
   a) For the nonzero elements of the ***FlipFlopBoard***
      i. Print a B if a there is a black game piece on the square (FlipFlopBoard element = 2)
      ii. Print a W if there is a white game piece on the square (FlipFlopBoard element =1)
   b) For zero elements (empty squares) of FlipFlopBoard print the square number
      i. An example of the square numbers for a 8x8 board is given above (in the discussion of the main program), here is an additional example for a 10x10 board

```
 0   1   2   3   4   5   6   7   8   9
10  11  12  13  14  15  16  17  18  19
20  21  22  23  24  25  26  27  28  29
30  31  32  33  34  35  36  37  38  39
40  41  42  43  44  45  46  47  48  49
50  51  52  53  54  55  56  57  58  59
60  61  62  63  64  65  66  67  68  69
70  71  72  73  74  75  76  77  78  79
80  81  82  83  84  85  86  87  88  89
90  91  92  93  94  95  96  97  98  99
```

   c) Each number or character should be printed in a field 4 characters wide

Your function *PlacePiece* should

1. Have the prototype
   bool PlacePiece(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard, int player, int squarePlayed, int whichPiece, int& numberCaptured);
2. Begin at a square indicated by the ***squarePlayed*** (the place the player is trying to put a piece this turn). The value of ***squarePlayed*** will be the square number as displayed in the ***DisplayBoard*** function. The value of ***squarePlayed*** should be translated to the location in the ***FlipFlopBoard***.
3. If whichPiece indicates the first piece is being played, then make four calls to ***CheckLine*** for horizontal and vertical lines.
   a) If none of the the four calls to ***CheckLine*** for horizontal and vertical lines returns true then the move is not a valid move
      i. Print a line of text to the screen that says
         Illegal move
      ii. Return false
   b) If any of the four calls to CheckLine returns true then the chosen square is a square into which the piece may be placed.
      i. Place the piece on the board
      ii. Determine how many of the opponent's game pieces will be captured. It is possible the trap opponent's pieces in more than one direction when placing a single piece on the board. To determine which pieces are captured you must consider all directions (including diagonal horizontal and vertical directions). The number captured pieces sent to the calling program includes all pieces captured in all directions.
      iii. Change the colour of all the captured pieces
      iv. Print a line of text to the screen that says either
         White has placed the first piece
         Black has placed the first piece
      v. return true
4. If whichPiece indicates the second piece is being played then make four calls to ***CheckLine*** for diagonal lines
   a) If none of the the four calls to ***CheckLine*** for diagonal lines returns true then the move is not a valid move
      i. Print a line of text to the screen that says
         Illegal move
      ii. Return false
   b) If any of the calls to CheckLine returns true then the chosen square is a square into which the piece may be placed.
      i. Place the piece on the board
      ii. Determine how many of the opponent's game pieces will be captured.
      iii. Change the colour of all the trapped pieces
      iv. Print a line of text to the screen that says either
         White has placed the second piece
         Black has placed the second piece
      v. Return true

The function IsThisMoveValid

1.Has the prototype

bool IsThisMoveValid(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard, int player, int squarePlayed, int whichPiece);

2. For the square squarePlayed find the x and y coordinates in the ***FlipFlopBoard***
3. Determine from whichPiece if this a a piece being played in the first turn or the second turn
   i. If the piece is being played in the first piece played in a turn, call ***CheckLine*** for each of the four horizontal and vertical directions.
      a) If none of the four calls to ***CheckLine*** then return false
      b) If any of the four calls to **CheckLine** return true then return true
   ii. If the piece is being played in the second piece played in a turn then call ***CheckLine*** for each of the four diagonal directions
      a) If none of the four calls to ***CheckLine*** then return false
      b) If any of the four calls to ***CheckLine*** return true then return true

The function IsThisMoveValid

1. Has the prototype

   bool IsAnyMoveValid((int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard, int player, int whichPiece);

2. Checks every possible location in the FlipFlopBoard to see if there is a valid move starting at that location.
3. Returns true as soon as it finds a location that can be the start of a valid move
4. Returns false if there are no locations that can be used as the start of a valid move.

You should either call ***IsThisMoveValid*** for each location in the ***FlipFlopBoard*** until a location returns 0. Or implement the description of ***IsThisMoveValid*** within loops in this function.

The provided function *CheckLine*

1. Has the prototype
   bool CheckLine(int FlipFlopBoard[MAX_ARRAY_SIZE][MAX_ARRAY_SIZE], int numRowsInBoard, int player, int squarePlayed, int xDirection, int yDirection, int& numCaptured);
2. Begins at a square indicated by the ***squarePlayed*** (the place the player is trying to put his piece this turn). The value of ***squarePlayed*** will be the square number as displayed in the ***DisplayBoard*** function. The value of ***squarePlayed*** should be translated toan the location in the ***FlipFlopBoard*** array (the indices x and y in FlipFlopBoard[x][y]).
3. The values o***f xDirection*** and ***yDirection*** will indicate which direction to check for possible 'trapping' of opponents pieces. If the piece is being placed at location (x,y) in the board (row x, column y) then we can check in any one of eight directions. If ***xDirection=1*** and ***yDirection=0*** you are checking along a horizontal line toward the right. If ***xDirection = 0 yDirection*** = -1 you are checking along a vertical line to the bottom. If ***xDirection*** = -1 and ***yDirection***=1 then your are checking along a diagonal line upwards and to the left. Etc.
4. The value of ***player*** is 1 if this is a white player's turn, and 2 if this is a black player's turn.
5. If the first square in the selected direction is empty, return false
6. If the first square in the selected direction contains one of the player's pieces, return false
7. If the first square int the selected direction contains one of the opponent's pieces then we must consider addition squares further along the line in the same direction. For each successive square along the line in the direction being considered
   a. if the square is empty return false.
   b. If the square contains an opponent's piece continue to the next square along the line
   c. If you reach the edge of the board without finding one of the player's pieces return false
   d. If the square contains one of the player's pieces then return true