

# Alquerque

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# 1 Introduction

For phase 1 of the project, we have been tasked with implementing the user interface for the board game, Alquerque, by developing a class in accordance with the contract for phase 1. The class has to be executable, meaning it has a main method. The program must start with prompting for the choice of which players are human and which are controlled by the computer. When playing the game, it must prompt the user for a move, and output the moves the computer makes. After each turn it must print the board to the screen. Game continues until a winner is found or there are no valid moves left, resulting in a draw. All the provider classes are precompiled, and thus we should just focus on the interface during this phase.

## 2 Design

This section will give an overview of how the program works, and which design choices has been made while writing the program.

### 2.1 Option menu & game initialization

The program works by first asking the user to select one of three playable game scenarios; (1) Player vs Player, (2) Player vs CPU, and (3) CPU vs CPU, or (0) to exit the program. The game is then initiated according to what the user picked.

If the user chooses to play against another player, they will be prompted to enter the name of player 1 and then player 2. The game will thereafter commence with player 1 being white and player 2 being black. The game will continue, first prompting the current player, starting with white, to input which piece they want to move followed by where they want to move it, updating the position of the pieces and displaying the updated gamestate to the user, then switching to the next player and repeating the same process for that player. This continues until one of three things happen, either black wins, white wins or the game is a draw.

Else, if the player chooses to play against a CPU they are first prompted to pick what color they want to play as. The CPU will then play as the opposite color. The player is then prompted to enter their name followed by the number of moves they want the CPU to look ahead while calculating its

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moves, which determines the level of difficulty. The game will then commence with white making the opening move, may that be either the player or the CPU. Assuming the CPU is white it will calculate its move, in accordance with the number of moves it was allowed to look ahead by the player, and play it. The game state is then updated and displayed, then switching to the player, saying that it is their turn, prompting them to input which piece they want to move followed by where they want to move it. The pieces position are updated and the updated gamestate is displayed, then the CPU makes a move and this cycle continues until either black wins, white wins or the game is a draw.

Alternatively the user can choose to pit two CPUs against each other, picking how many moves the CPUs are allowed to look ahead, being able to spectate their respective moves as they are calculated and executed. Updating the pieces positions and then displaying them to the user. This continues until either black wins, white wins or the game is a draw.

### 2.2 Getters & setters:

Getters and setters have not been implemented because the class is not going to be instantiated, and it is not defined in the contract that another class should be able to use these variables.

### 2.3 Chess notation

For improved QOL/user friendliness, we have chosen to assign coordinates to the visual representation of the board with letters, A through E, above and below the board, as well as numbers, 1 through 5, to the left and to the right of the board. Due to the familiarity from chess, this way of identifying board positions should feel more intuitive.

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Figure 1: Chess Notation

	A		B		C		D		E	
1	[B]	-	[B]	-	[B]	-	[B]	-	[B]	1
		\		/		\		/		
2	[B]	-	[B]	-	[B]	-	[B]	-	[B]	2
		/		\		/		\		
3	[B]	-	[B]	-	[ ]	-	[W]	-	[W]	3
		\		/		\		/		
4	[W]	-	[W]	-	[W]	-	[W]	-	[W]	4
		/		\		/		\		
5	[W]	-	[W]	-	[W]	-	[W]	-	[W]	5
	A		B		C		D		E	

Following this mindset, we decided to represent the board in a two-dimensional array in the size of 6 x 5. The reason we chose this size is that the side of the board which represents the numbers seems more intuitive if the row number corresponds to the rank number on the board, which goes from 1-5. On the other hand the side of the board that represent the letters doesn't have to correspond in the same way, so we kept the column as going from 0-4

## 3 Implementation

This section describes the actual technical implementation of the choices described in Section 2, about design, going in to detail about what methods have been implemented and how they are used.

### 3.1 The init() method

The method init() is the first thing being called when the program starts, when this happens all variables get initialized throughout the method. Firstly the variables which have predefined values get initialized e.g. board becomes a new board, reader becomes a new scanner. Secondly the program greets the user, prints the available options the user can pick from and then prompts the user to pick one of the options, which is then passed through a switch, which is wrapped in a do while loop, which repeats until a valid option is picked. The switch determines which of the available options, if any, the user's input corresponds to. If the user's input does not correspond to a valid option the

### 3 IMPLEMENTATION

switch defaults to telling the users that their inputted option is an invalid option and to try again. This response is followed by the option menu being printed for the user to view the available options again. Depending on which option is chosen, the corresponding variables are defined, and the loop within `init()` is exited, since a valid option was picked, and the program continues to the main game loop.

#### 3.2 The main game loop

In the main game loop the first thing that happens is that the initialized board is presented to the user. After this a check is run determining how the next move should be made. If the next one to play is a player they are prompted to choose a piece corresponding to the color of the player, which turn it is, that they want to move, and then where they want to move the piece, in accordance with standard chess notation. This move is then validated as a valid coordinate. An instance of the move class is then created and passed to `isLegal` to see if it is a legal move that can be played on the board in the current boardstate. And if that is not the case the user is told that the entered move was invalid and a do-while repeatedly asks the user to input what piece they want to move and where to, until a valid and legal move is entered by the user. While the game is not over this process is repeated switching between black and white. If the player is a CPU, a new move is created in accordance with the calculations done by `MiniMaxTree`. If the do-while guard, encapsulating the player's moves, registers whether the game is over. An if-statement then checks whether black has won, white has won or if it is a draw between the two. This is then printed to the console for the player to view.

#### 3.3 Construction of the visual board

The board is represented in the program by a two-dimensional array, which is constructed in the `boardWithPieces()` method. First it initiates the array, and fills it with empty spaces, defined by the `EMPTY` constant. It then uses the methods `black` and `white` from the `Board` class, to fill in the spaces occupied by black and white pieces.

The `printBoard()` method, which is used in the main game loop to display

### 3 IMPLEMENTATION

the board on the screen, makes an array from `boardWithPieces()` and prints it out, along with letters from A - B in the top and bottom, numbers from 1-5 in the sides and the guiding lines between the squares.

#### 3.3.1 Chess notation and functionality

As mentioned in the design-section, we chose to represent the board with letters for columns and numbers for rows. However, this gives us a String coordinate rather than an integer in the preconditioned range of 1 through 25. So in order to satisfy the precondition for `Move`, we made the method `convertCoordinate` that converts an input coordinate to the corresponding positional number, so that it may be used by methods `from()` and `to()` in `Moved`. The method works by assigning a numerical value to the coordinate letters, then adding it to a multiplum by 5, which is determined by the coordinate-numbers corresponding array-index.

```
1 private static int convertCoordinate(String coord){
2     int position = 0;
3     switch(Character.toUpperCase(coord.charAt(0))){
4         case 'A': //value of each column is added to the row-↵
5                 //determined multiplum of 5 (e.g. D is 4'th, so positional ↵
6                 //value is +4)
7                 position = (1+(5*((Integer.parseInt(coord.substring(1))-1)↵
8                 ));
9                 break;
10        case 'B':
11            position = (2+(5*((Integer.parseInt(coord.substring(1))-1)↵
12            ));
13            break;
14        case 'C':
15            position = (3+(5*((Integer.parseInt(coord.substring(1))-1)↵
16            ));
17            break;
18        case 'D':
19            position = (4+(5*((Integer.parseInt(coord.substring(1))-1)↵
20            ));
21            break;
22        case 'E':
23            position = (5+(5*((Integer.parseInt(coord.substring(1))-1)↵
24            ));
25            break;
26        default:
27            return 0;
28    }
29    return position;
30 }
```

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Since the `convertCoordinate` method has a precondition that it can only accept coordinates that correspond to a number 1-25, we also wrote a method `isValidCoords` that returns a boolean true/false if the coordinates is a valid place on the board or not. It uses regex to check that it is a two letter string from A1 to E5, which, by the logic used in `convertCoordinate`, will only translate to numbers between 1 - 25, which therefore satisfies the precondition.

```
1 private static boolean isValidCoords(String coords){
2     return (coords.matches("[A-Ea-e][1-5]")); // Regex for ↔
3     matching
}
```

For a move to be printed as a coordinate, rather than as the positional integer which the CPU returns when a move is calculated, we had to make a method that would convert Move objects returned from MinMaxTree to the corresponding letters for files and numbers for ranks. The method functions by subtracting 1 from the positional integer, before subtracting 5 until the integer is between 0 and 4, which for each number corresponds to a letter for each file on the board.

To determine the ranks, the positional integer is divided by 5, whereafter 1 is added to compensate for index 0 in the array. However, during testing we discovered a minor issue with this method, although, for the most part, it worked as intended, we found the need to subtract 1 from the position before dividing; this will be elaborated in the test section of this report.

```
1 private static String convertPosition(int position){
2     String coord = "";
3     switch ((position - 1) % 5){
4         case 0:
5             coord = "A";
6             break;
7         case 1:
8             coord = "B";
9             break;
10        case 2:
11            coord = "C";
12            break;
13        case 3:
14            coord = "D";
15            break;
16        case 4:
17            coord = "E";
18            break;
19    }
```



## 4 TEST

```
20     coord = coord + ((position - 1) / 5 + 1);  
21     return coord;  
22 }  
23
```

## 4 Test

This section describes some of the errors and challenges we faced during the construction of the program, either from challenges arising from the calculations, or by limitations of the methods used.

### 4.1 Error when inputting non-integers in menus

The game crashes when a non-integer input is typed in the menu, or when choosing the CPU depth, as the Scanner method `nextInt` is used. This causes the program to throw an `inputMismatchException`.

### 4.2 Mistake in B/W input, fixed with regex

During testing we found that, when choosing to play white or black, the user could type any characters after the B or W and it would still accept it. For example you could write Bwhite, and it would be accepted as black. When this error occurred the program would accept a string as input for what color the player wanted to play. The input string would then be passed to a switch where the character at index 0 would be checked and all characters after index 0 was ignored. To fix this error, we changed it to an if-else statement, using regex to match B and W specifically, but case insensitive.

### 4.3 CPU moves being printed incorrectly

When the CPU made a move, we discovered that whenever it was to or from the E file, regardless of rank, the move, although correctly executed, would be printed as a rank 1 higher than intended. An example of this would be the move D1 to E1 being misprinted as “White/Black(CPU) moved D1 to E2”. To fix this, we found that in our method to convert a position represented

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by an integer to a position represented by a coordinate, we would have to subtract 1 from the position integer before dividing by 5 to get the rank. This meant that position 5 would accurately be converted to 1, instead of 2. The same thing applied to 10, 15, 20, and 25.

## 5 Conclusion

We didn't encounter a lot of issues in this phase. We went in to the design phase with a clear picture in our minds, which was a movement system, similar to a chess game, with coordinates instead of numbers, and this proved to be a challenge to implement.

In hindsight this might have made our code a bit more complicated, but we were committed to solving this issue, and implemented several methods to overcome the challenge, without breaching the contract.

We managed to construct a working program without any major issues. The only thing left unsolved is the exception thrown if anything other than an integer is entered when the program expects an integer.

## 6 Appendix

### 6.1 Program Code

```
1 import java.util.Scanner;
2 public class Alquerque {
3     private static Scanner reader;
4     private static Board board;
5     private static final char EMPTY = ' ';
6     private static String whiteName, blackName;
7     private static int cpuDepth;
8     private static boolean isWhiteCPU, isBlackCPU, isWhite;
9
10    public static void main(String[] args) {
11        String coordsFrom;
12        String coordsTo;
13        Move nextMove = new Move(0,0);
14        init();
15        do { // main game loop
16            printBoard();
17            if (!isWhiteCPU && isWhite || !isBlackCPU && !isWhite) {
18                boolean inputWithinRange = false;
19                do { // loop for validating the players input
```

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```

20         System.out.print("It's " + (isWhite ? whiteName : ↵
21             blackName) + "'s turn" + ", please enter which " +
22             "piece you want to move: ");
23         coordsFrom = reader.nextLine().trim();
24         System.out.print("Please enter where you want to move ↵
25             the piece: ");
26         coordsTo = reader.nextLine().trim();
27         if (isValidCoords(coordsFrom) && isValidCoords(↵
28             coordsTo)) { //Checks if input is a valid letter+↵
29             number
30             nextMove = new Move(convertCoordinate(coordsFrom),↵
31                 convertCoordinate(coordsTo)); //Converts ↵
32                 coordinate to int position
33             if (board.isLegal(nextMove))
34                 inputWithinRange = true;
35         }
36         if (!inputWithinRange)
37             System.out.println(coordsFrom + " to " + coordsTo ↵
38                 + " is " +
39                 "not a valid move, please enter a ↵
40                 coordinate A-E 1-5.");
41         } while (!inputWithinRange);
42         board.move(nextMove);
43     } else if (!board.isGameOver()) {
44         nextMove = new Minimax().nextMove(board, cpuDepth, isWhite↵
45             );
46         System.out.println((isWhite ? whiteName : blackName) + " ↵
47             played " +
48             convertPosition(nextMove.from()) + " to " + ↵
49             convertPosition(nextMove.to()));
50         board.move(nextMove);
51     }
52     isWhite = !isWhite; // changes who's turn it is at the end of ↵
53     a turn
54 } while (!board.isGameOver());
55 System.out.println("This is the final state of the board");
56 printBoard(); // prints the state of the board when game over
57 if (board.black().length > 0 && board.white().length <= 0)
58     System.out.println(blackName + " is the winner!");
59 else if (board.black().length <= 0 && board.white().length > 0)
60     System.out.println(whiteName + " is the winner!");
61 else
62     System.out.println("It's a draw!");
63 }
64
65 /**
66  * Initializes the program and runs the start menu.
67  */
68 private static void init() {
69     reader = new Scanner(System.in);
70     board = new Board();
71     whiteName = "White(CPU)";
72     blackName = "Black(CPU)";
73     isWhite = true;
74     int option;
75     System.out.println("*****");
76     System.out.println("Greetings Master! And welcome to Alquerque.");
77     System.out.println("*****");
78     do {
79         printOptions();
80         option = reader.nextInt();
81         switch (option) {

```

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```
70         case 0:
71             System.out.println("You have chosen option " + option +
72                 + ": Exit program");
73             System.out.println("Thank you for playing, have a nice
74                 day!");
75             break;
76         case 1: // Player vs Player
77             System.out.println("You have chosen option " + option +
78                 + ": Player vs Player");
79             System.out.print("Please enter the name of player 1: ");
80             reader.nextLine(); // clears input
81             whiteName = reader.nextLine().trim();
82             System.out.print("Please enter the name of player 2: ");
83             blackName = reader.nextLine().trim();
84             break;
85         case 2: // Player vs CPU
86             System.out.println("You have chosen option " + option +
87                 + ": Player vs CPU");
88             String color;
89             reader.nextLine(); // clears input
90             do {
91                 System.out.print("Please enter the color you want
92                     to play " +
93                     "black or white (B/W): ");
94                 color = reader.nextLine();
95                 if (color.matches("[Bb]")){
96                     System.out.println("\nYou have chosen to play
97                         black.\n" +
98                         "The CPU will therefore play white");
99                     System.out.print("Please enter the name of the
100                         player: ");
101                     blackName = reader.nextLine().trim();
102                     isWhiteCPU = true;
103                 } else if (color.matches("[Ww]")){
104                     System.out.println("\nYou have chosen to play
105                         white.\n" +
106                         "The CPU will therefore play black");
107                     System.out.print("Please enter the name of the
108                         player: ");
109                     whiteName = reader.nextLine().trim();
110                     isBlackCPU = true;
111                 } else {
112                     System.out.println("'" + color + "'" + " is
113                         not a valid color " +
114                         "option, please try again.\n");
115                 }
116             } while (!color.matches("[BbWw]"));
117             System.out.print("How far ahead do you want the CPU to
118                 analyze: ");
119             cpuDepth = reader.nextInt();
120             reader.nextLine(); // clears input
121             break;
122         case 3: // CPU vs CPU
123             System.out.println("You have chosen option " + option +
124                 + ": CPU vs CPU");
125             System.out.print("How far ahead do you want the CPU's
126                 to analyze: ");
127             cpuDepth = reader.nextInt();
128             isWhiteCPU = true;
129             isBlackCPU = true;
```

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```

117         break;
118     default:
119         System.out.println("Invalid option, " + option + " is ↵
120                             not a valid option.\n");
121     }
122 } while (option > 3 || option < 0);
123 }
124
125 /**
126  * Prints the option menu to the terminal.
127  */
128 private static void printOptions() {
129     System.out.println("Now, what do you wish to do?");
130     System.out.println("*****");
131     System.out.println("Option 0: Exit program");
132     System.out.println("Option 1: Player vs Player");
133     System.out.println("Option 2: Player vs CPU");
134     System.out.println("Option 3: CPU vs CPU");
135     System.out.println("*****");
136     System.out.print("Please enter the number corresponding " +
137                     "to the option you want executed: ");
138 }
139
140 /**
141  * Creates a representation of the game board with the pieces ↵
142  * correctly placed
143  * in the form of a two dimensional array.
144  * Precondition: Relies on method black() and white() to return valid ↵
145  * positions numbered from 1-25
146  * @return a two dimensional array 5 x 5 with the game pieces placed ↵
147  * correctly
148  */
149 private static char[][] boardWithPieces() {
150     char[][] boardArr = new char[6][5]; //A-E & (no 0) 1-5
151     for (int j = 1; j < boardArr.length; j++)
152         for (int i = 0; i < boardArr[j].length; i++)
153             boardArr[j][i] = EMPTY; // Fills board with empty spaces
154     for (int i = 0; i < board.black().length; i++)
155         boardArr[((board.black()[i] - 1) / 5) + 1][((board.black()[i] ↵
156             - 1) % 5)] = 'B'; // Places black pieces
157     for (int i = 0; i < board.white().length; i++)
158         boardArr[((board.white()[i] - 1) / 5) + 1][((board.white()[i] ↵
159             - 1) % 5)] = 'W'; // Places white pieces
160     return boardArr;
161 }
162
163 /**
164  * prints a representation of the board to the terminal
165  */
166 private static void printBoard() {
167     System.out.println(); // new line
168     int i = 0, j = 1;
169     System.out.println("  A   B   C   D   E"); //upper-coordinate ↵
170     line (A-E)
171     char[][] boardWithPieces = boardWithPieces();
172     while (j < 6) {
173         System.out.print(j + " "); //left-hand coordinate (1-5)
174         while (i < 5) {
175             System.out.print "[" + boardWithPieces[j][i] + ""];
176             if (i < 4)
177                 System.out.print("-");
178         }
179     }
180 }

```

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```

172         i++;
173     }
174     System.out.print(" " + (j)); //right-hand coordinate (1-5)
175     System.out.println("");
176     i = 0;
177     if (j % 2 == 1 && j < 5)
178         System.out.println("  | \\ | / | \\ | / |");
179     else if (j % 2 == 0)
180         System.out.println("  | / | \\ | / | \\ |");
181     j++;
182 }
183 System.out.println("  A  B  C  D  E"); //bottom-coordinate ←
    line (A-E)
184 System.out.println(""); // new line
185 }
186
187 /**
188  * Test whether an entered coordinate is a valid coordinate
189  * @param coords, a coordinate to be tested
190  * @return true if the coordinate entered is a valid coordinate else ←
191  *         returns false
192  */
193 private static boolean isValidCoords(String coords){
194     return (coords.matches("[A-Ea-e][1-5]")); // Regex for matching
195 }
196
197 /**
198  * Converts an input coordinate to the corresponding position on the ←
199  * board, determined by numbers 1-25
200  * @param coord move coordinate input from user
201  * @return position on board, represented by an integer (1-25)
202  */
203 private static int convertCoordinate(String coord){
204     int position = 0;
205     switch(Character.toUpperCase(coord.charAt(0))){
206         case 'A': //value of each column is added to the row ←
207             //determined multiplicity of 5 (e.g. D is 4'th, so positional ←
208             //value is +4)
209             position = (1+(5*((Integer.parseInt(coord.substring(1))-1) ←
210             )));
211             break;
212         case 'B':
213             position = (2+(5*((Integer.parseInt(coord.substring(1))-1) ←
214             )));
215             break;
216         case 'C':
217             position = (3+(5*((Integer.parseInt(coord.substring(1))-1) ←
218             )));
219             break;
220         case 'D':
221             position = (4+(5*((Integer.parseInt(coord.substring(1))-1) ←
222             )));
223             break;
224         case 'E':
225             position = (5+(5*((Integer.parseInt(coord.substring(1))-1) ←
226             )));
227             break;
228         default:
229             return 0;
230     }
231     return position;
232 }

```

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```
224  /**
225   * Converts an input position, represented by a number 1-25 to the ↵
226   * corresponding coordinates in form [A-E][1-5]
227   * @param position position represented by an int
228   * @return coord position represented by coordinates [A-E][1-5]
229   */
229  private static String convertPosition(int position){
230      String coord = "";
231      switch ((position - 1) % 5){
232          case 0:
233              coord = "A";
234              break;
235          case 1:
236              coord = "B";
237              break;
238          case 2:
239              coord = "C";
240              break;
241          case 3:
242              coord = "D";
243              break;
244          case 4:
245              coord = "E";
246              break;
247      }
248      coord = coord + ((position - 1) / 5 + 1);
249      return coord;
250  }
251 } // end of alquerque class
```