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| |  |  |  | | --- | --- | --- | | **Credit Hours System**  **CMPN402**  **Machine Intelligence**  **Spring 2019** |  | **Cairo University Faculty of Engineering** | |
| Wehrmacht Team |
| Scrabble Game |
|  |
| **Project Supervisor**  Prof. Dr. Nevin Darwish Computer Engineering Department |

|  |
| --- |
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Abstract

The report explains how Wehrmacht Team Designed and implemented the Scrabble game and the programming languages/ technologies used as well as the implementation of the game Graphical user interface tools and the testing and training that was done to the agent that would be used for the upcoming competition with the other team in the Machine Intelligence course.

In the first section we introduce what is the history of the scrabble game and the basic game rules, in order to build the main idea on how the work follow went through the project and the reasons for choosing the mentioned algorithms for Agent implementation. After that we demonstrate a market survey to show our customers who are willing to buy/play our game and the other games of scrabble that are currently in the market.

After the research phase we oved to the methods and algorithms used for implementation; we decided to implemented our board using Bitboard instead of 2D array and used monte carlo for the logic implementation. Then we designed the interface and implemented the Graphical user interface using unity since unity is the current dominate tool used in the game market now a days.

After finishing the implementation and the communication between the logic and the user interface, tests were done to the project units and the project as whole, and the agent successfully managed to beat the human player in the tests after being trained and the game simulate the original scrabble game but with better and quicker logic and interface.

It is hoped that our game will be able to preform as well as it did during the testing and simulations and that it will be considered to be released to the market in the future to be able to compete with the other scrabble games that are currently in the market.

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Team Contacts

|  |  |  |  |
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Section 1: Introduction



1. Introduction

## About Scrabble

Scrabble is a word game in which two to four players score points by placing tiles bearing a single letter onto a board divided into a 15×15 grid of squares. The tiles must form words that, in crossword fashion, read left to right in rows or downward in columns, and be included in a standard dictionary or lexicon.

The name is a trademark of Mattel in most of the world, but of Hasbro, Inc. in the United States and Canada. The game is sold in 121 countries and is available in 29 languages; approximately 150 million sets have been sold worldwide and roughly one-third of American and half of British homes have a Scrabble set. There are around 4,000 Scrabble clubs around the world.

## History of Scrabble

In 1938, American architect Alfred Mosher Butts created the game as a variation on an earlier word game he invented called Lexiko. The two games had the same set of letter tiles, whose distributions and point values Butts worked out by performing a frequency analysis of letters from various sources, including The New York Times. The new game, which he called "Criss-Crosswords," added the 15×15 gameboard and the crossword-style game play. He manufactured a few sets himself, but was not successful in selling the game to any major game manufacturers of the day.

## Game Rules

### Notation System

* In the notation system common in tournament play, columns are labeled with the letters "A–O" and rows with the numbers "1–15".
* A play is usually identified in the format xy WORD score or WORD xy score, where x denotes the column or row on which the play's main word extends, y denotes the second coordinate of the main word's first letter, and WORD is the main word.
* additional words formed by the play are sometimes listed after the main word and a slash. When the play of a single tile forms words in each direction, one of the words is arbitrarily chosen to serve as the main word for purposes of notation.
* When a blank tile is employed in the main word, the letter it has been chosen to represent is indicated with a lower case letter, or, in handwritten notation, with a square around the letter. When annotating a play, previously existing letters on the board are usually enclosed in parentheses.

### Sequence of Play

* Before the game, a resource, either a word list or a dictionary, is selected for the purpose of adjudicating any challenges during the game. The tiles are either put in an opaque bag or placed face down on a flat surface.
* Opaque cloth bags and customized tiles are staples of clubs and tournaments, where games are rarely played without both.
* Next, players decide the order in which they play. The normal approach is for players to each draw one tile: The player who picks the letter closest to the beginning of the alphabet goes first, with blank tiles taking precedence over the letter A.
* In most North American tournaments, the rules of the US-based [North American Scrabble Players Association](https://en.wikipedia.org/wiki/North_American_Scrabble_Players_Association) (NASPA) stipulate instead that players who have gone first in the fewest number of previous games in the tournament go first, and when that rule yields a tie, those who have gone second the most go first. If there is still a tie, tiles are drawn as in the standard rules.
* At the beginning of the game, each player draws seven tiles from the bag and places them on his or her rack, concealed from the other player(s).

### Making a Play

* The first played word must be at least two letters long, and cover H8 (the center square). Thereafter, any move is made by using one or more tiles to place a word on the board. This word may use one or more tiles already on the board and must join with the cluster of tiles already on the board.
* On each turn, the player has three options:
  1. Pass, forfeiting the turn and scoring nothing.
  2. Exchange one or more tiles for an equal number from the bag, scoring nothing, an option available only if at least seven tiles remain in the bag.
  3. Play at least one tile on the board, adding the value of all words formed to the player's cumulative score.
* A proper play uses one or more of the player's tiles to form a continuous string of letters that make a word (the play's "main word") on the board, reading either left-to-right or top-to-bottom. The main word must either use the letters of one or more previously played words or else have at least one of its tiles horizontally or vertically adjacent to an already played word. If any words other than the main word are formed by the play, they are scored as well, and are subject to the same criteria of acceptability. See [Scoring](https://en.wikipedia.org/wiki/Scrabble#Scoring) for more details.
* A blank tile may represent any letter, and scores zero points, regardless of its placement or what letter it represents. Its placement on a double-word or triple-word square causes the corresponding premium to be applied to the word(s) in which it is used. Once a blank tile is placed, it remains that particular letter for the remainder of the game.
* After making a play, the player announces the score for that play, and then, if the game is being played with a clock, starts his or her opponent's clock. The player can change his play as long as his or her clock is running, but commits to the play when he or she starts the opponent's clock. The player then draws tiles from the bag to replenish his or her rack to seven tiles. If there are not enough tiles in the bag to do so, the player takes all the remaining tiles.
* If a player has made a play and has not yet drawn a tile, the opponent may choose to [challenge](https://en.wikipedia.org/wiki/Challenge_(Scrabble)) any or all words formed by the play. The player challenged must then look up the words in question using a specified word source (such as [OTCWL](https://en.wikipedia.org/wiki/Official_Tournament_and_Club_Word_List), the [Official Scrabble Players Dictionary](https://en.wikipedia.org/wiki/Official_Scrabble_Players_Dictionary), or [CSW](https://en.wikipedia.org/wiki/SOWPODS)) and if any one of them is found to be unacceptable, the play is removed from the board, the player returns the newly played tiles to his or her rack and the turn is forfeited. In tournament play, a challenge may be to the entire play or any one or more words, and judges (human or computer) are used, so players are not entitled to know which word(s) are invalid. Penalties for unsuccessfully challenging an acceptable play vary in club and tournament play, and are described in greater detail below.

### End of Game

* Under North American tournament rules, the game ends when either

1. one player plays every tile on his or her rack, and there are no tiles remaining in the bag (regardless of the tiles on his or her opponent's rack)
2. at least six successive scoreless turns have occurred and either player decides to end the game
3. either player uses more than 10 minutes of overtime. (For several years, a game could not end with a cumulative score of 0–0, but that is no longer the case, and such games have since occurred a number of times in tournament play, the winner being the player with the lower total point value on his or her rack).

* When the game ends, each player's score is reduced by the sum of his or her unplaced letters. In addition, if a player has used all of his or her letters (known as "going out" or "playing out"), the sum of the other player's unplaced letters is added to that player's score; in tournament play, a player who goes out adds twice that sum, and his or her opponent is not penalized.

### Scoring

* The score for any play is determined this way:
  + Each new word formed in a play is scored separately, and then those scores are added up. The value of each tile is indicated on the tile, and blank tiles are worth zero points.
  + The main word (defined as the word containing every played letter) is scored. The letter values of the tiles are added up, and tiles placed on Double Letter Score (DLS) and Triple Letter Score (TLS) squares are doubled or tripled in value, respectively. Tiles placed on Double Word Score (DWS) or Triple Word Score (TWS) squares double or triple the value of the word(s) that include those tiles, respectively. In particular, the center square (H8) is considered a DWS, and the first play is doubled in value.
  + If any "hook" words are played (e.g. playing ANEROID while "hooking" the A to BETTING to make ABETTING), the scores for each word are added separately. This is common for "parallel" plays that make up to eight words in one turn.
  + Premium squares apply only when newly placed tiles cover them. Any subsequent plays do not count those premium squares.
  + If a player covers both letter and word premium squares with a single word, the letter premium(s) is/are calculated first, followed by the word premium(s).
  + If a player makes a play where the main word covers two DWS squares, the value of that word is doubled, then redoubled (i.e. 4× the word value). Similarly, if the main word covers two TWS squares, the value of that word is tripled, then re-tripled (9× the word value). Such plays are often referred to as "double-doubles" and "triple-triples" respectively. It is theoretically possible to achieve a play covering three TWS squares (a 27× word score), although this is extremely improbable without constructive setup and collaboration. Plays covering a DWS and a TWS simultaneously (6× the word value, or 18× if a DWS and two TWS squares are covered) are only possible if a player misses the center star on the first turn, and the play goes unchallenged (this is valid under North American tournament rules).
  + Finally, if seven tiles have been laid on the board in one turn, known as a "[bingo](https://en.wikipedia.org/wiki/Bingo_(Scrabble))" in North America and as a "bonus" elsewhere, after all of the words formed have been scored, 50 bonus points are added.
  + When the letters to be drawn have run out, the final play can often determine the winner. This is particularly the case in close games with more than two players.
  + Scoreless turns can occur when a player passes, exchanges tiles, or loses a challenge. The latter rule varies slightly in international tournaments. A scoreless turn can also theoretically occur if a play consists of only blank tiles, but this is extremely unlikely in actual play.

### Acceptable Words

* Acceptable words are the primary entries in some chosen [dictionary](https://en.wikipedia.org/wiki/Dictionary), and all of their [inflected](https://en.wikipedia.org/wiki/Inflection) forms. Words that are hyphenated, capitalized (such as [proper nouns](https://en.wikipedia.org/wiki/Proper_noun)), or apostrophized are not allowed, unless they also appear as acceptable entries; JACK is a proper noun, but the word [JACK](https://en.wiktionary.org/wiki/jack) is acceptable because it has other usages as a common noun (automotive, [vexillological](https://en.wikipedia.org/wiki/Vexillology) etc.) and verb that are acceptable.
* Acronyms or abbreviations, other than those that have acceptable entries (such as [AWOL](https://en.wikipedia.org/wiki/AWOL), [RADAR](https://en.wikipedia.org/wiki/RADAR), [LASER](https://en.wikipedia.org/wiki/LASER), and [SCUBA](https://en.wikipedia.org/wiki/Scuba_diving)) are not allowed.
* Variant spellings, slang or offensive terms, archaic or obsolete terms, and specialized jargon words are allowed if they meet all other criteria for acceptability, but archaic spellings (e.g. NEEDE for NEED) are generally not allowed.
* Foreign words are not allowed in English-language Scrabble unless they have been incorporated into the English language, as with PATISSERIE, KILIM, and QI. Vulgar and offensive words are generally excluded from the OSPD4 but allowed in club and tournament play.
* Proper nouns and other exceptions to the usual rules are allowed in some limited contexts in the spin-off game [Scrabble Trickster](https://en.wikipedia.org/wiki/Trickster_(board_game)). Names of recognized computer programs are permitted as an acceptable proper noun (For example, WinZip).
* The memorization of two-letter words is considered an essential skill in this game.
* There are two popular competition word lists used in various parts of the world:
  + [TWL](https://en.wikipedia.org/wiki/Tournament_Word_List) (also known as OTCWL, OWL, or TWL).
  + [SOWPODS](https://en.wikipedia.org/wiki/SOWPODS) (also called "Collins" or "CSW").

The first is used in America, Canada, Israel and Thailand, and the second in all other English-speaking countries.

### Challenges

* The penalty for a successfully challenged play is nearly universal: the offending player removes the tiles played and forfeits his or her turn. (In some online games, an option known as "void" may be used, wherein unacceptable words are automatically rejected by the program. The player is then required to make another play, with no penalty applied.)
* The penalty for an unsuccessful challenge (where all words formed by the play are deemed valid) varies considerably, including:
  + "Double Challenge", in which an unsuccessfully challenging player must forfeit the next turn. This penalty governs North American (NASPA-sanctioned) OWL tournament play, and is the standard for North American, Israeli, and Thai clubs. Because loss of a turn generally constitutes the greatest risk for an unsuccessful challenge, it provides the greatest incentive for a player to "bluff", or play a "phony" – a plausible word that they know or suspect to be unacceptable, hoping his or her opponent will not call him on it. Or a player can put down a legal word that appears to be a phony hoping the other player will incorrectly challenge it and lose their turn.
  + "Single Challenge"/"Free Challenge", in which no penalty whatsoever is applied to a player who unsuccessfully challenges. This is the default rule in Ireland and the United Kingdom, as well as for many tournaments in Australia, although these countries do sanction occasional tournaments using other challenge rules.
  + Modified "Single Challenge", in which an unsuccessful challenge does not result in the loss of the challenging player's turn, but is penalized by the loss of a specified number of points. The most common penalty is five points. The rule has been adopted in Singapore (since 2000), Malaysia (since 2002), South Africa (since 2003), New Zealand (since 2004), and Kenya, as well as in contemporary [World Scrabble Championships](https://en.wikipedia.org/wiki/World_Scrabble_Championship) (since 2001) and North American (NASPA-sanctioned) Collins tournaments, and particularly prestigious Australian tournaments. Some countries and tournaments (including Sweden) use a 10-point penalty instead. In most game situations, this penalty is much lower than that of the "double challenge" rule. Consequently, such tournaments encourage greater willingness to challenge and discourage playing dubious words.
* Under NASPA tournament rules, a player may request to "hold" the opponent's play in order to consider whether to challenge it, provided that the opponent has not yet drawn replacement tiles. If player A holds, player A's clock still runs, and player B may not draw provisional replacement tiles until 15 seconds after the hold was announced (which tiles must then be kept separate). There is no limit on how long player A may hold the play. If player A successfully challenges after player B drew provisional replacement tiles, player B must show the drawn tiles before returning them to the bag.

Section 2: Market Survey

2. Market Survey



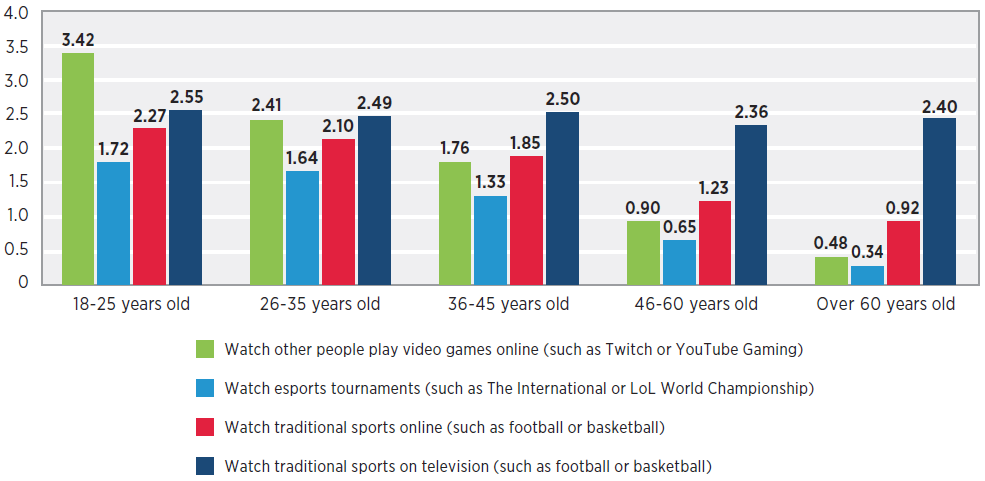
## Intended Customers

Our main targeted customers are:

* Gamers who love challenging games
* Lovers of Scrabble
* Gaming Software Developers

## Online Gaming Marketing Analysis

Online gaming market is expected to witness substantial growth over the forecast period. This may be attributed to increasing number of users taking up online gaming as an entertainment tool, the following figure represents how much people have consumed in online Gaming during the past few years.

And according to a lot of Statistics:

* The average age of gamers: 35
* The average age of game purchasers: 38
* Households that own a device used for playing video games: 65%
* Households that own a device exclusively for playing video games: 48%
* The average number of years gamers have been playing: 13

## Popularity of Scrabble

Scrabble is very popular among both men and women…

## Scrabble games in the Market

### Quackle

### Maven

Section 3: Research

3. Research



## Board Representation

## A bitboard is a [data structure](https://wikivisually.com/wiki/Data_structure) commonly used in [computer systems that play](https://wikivisually.com/wiki/Game_AI) [board games](https://wikivisually.com/wiki/Board_game). A bitboard, often used for board games such as chess, checkers, Othello and word games, is a specialization of the bit array data structure, where each bit represents a game position or state, designed for optimization of speed and/or memory or disk use in mass calculations. Bits in the same bitboard relate to each other in the rules of the game, often forming a game position when taken together. Other bitboards are commonly used as masks to transform or answer queries about positions.

### Why Bitboard is used over 2D array

## The advantage of the bitboard representation is that it takes advantage of the essential logical bitwise operations available on nearly all CPUs that complete in one cycle and are fully pipelined and cached etc. Nearly all CPUs have AND, OR, NOR, and XOR. Many CPUs have additional bit instructions, such as finding the "first" bit, that make bitboard operations even more efficient. If they do not have instructions well known algorithms can perform some "magic" transformations that do these quickly.

## In terms of memory:

## Bitboards are extremely compact. Since only a very small amount of memory is required to represent a position or a mask, more positions can find their way into registers, full speed cache, Level 2 cache, etc. In this way, compactness translates into better performance (on most machines). Also, on some machines this might mean that more positions can be stored in main memory before going to disk.

### Usage of Bitboard and tile representation

### This link explains the most important details:

http://boardword.com/static/bitboards.html

## Move Generation

### Sub

## Searching the Best State

### Search Tree

### Search Algorithms

### Depth-First Search

## State Evaluation

## Game Implementation

### Programming Language

### Libraries

### Implemented Projects

Section 4: GUI

4. GUI



## Phase 1: Preparation

One of the important (if not the most) factor of enjoying games is in its graphics and GUI. So we decided to implement a simple yet beautiful design to our Scrabble game. While doing the market research, we found out that the Unity engine is one of leading platforms in the industry while also being easy to learn so we went with it.

## Phase 2: Implementation

FILL TEXT

[Insert Final GUI Figure]

Section 5: Implementation

5. Implementation



## Game Rules Phase 1

### Algorithms Used

### Challenges Faced

### Code Implementation

## Board Representation and Move Generation

### Algorithms Used

### Challenges Faced

### Code Implementation

## Evaluation

### Algorithms Used

### Challenges Faced

### Code Implementation

## Optimized Move Generation

### Algorithms Used

### Challenges Faced

### Code Implementation

## Searching Phase

### Algorithms Used

### Challenges Faced

### Code Implementation

## Quiescence Search

### Algorithms Used

### Challenges Faced

### Code Implementation

Section 6:  Communication

6. Communication



## Send to the server

### Sub

## Receive from the server

### Sub

Section 7: Integration

7. Integration



The integration team have used Unity for the GUI implementation and C# for the game logic.

[INSERT INTEGRATION FIGURE]

Section 8:  Testing

8. Testing



## Testing Plan

### Unit Testing

### Module Testing

## Testing Phases

### Sub

## Evaluation’s Test Cases

### THIS IS THE LONGEST PART OF THE REPORT

[Insert table for each test case]

Section 9:  Tools Used

9. Tools Used



## Python

Python is a programming language. It's used for many different applications. It's used in some high schools and colleges as an introductory programming language because Python is easy to learn, but it's also used by professional software developers at organizations, such as Google, NASA, and Lucasfilm Ltd.

[Insert Python Logo]

## C++

C++ is a general-purpose programming language. It has imperative, object-oriented and generic programming features, while also providing facilities for low-level memory manipulation

[Insert C++ Logo]

## C#

C# is a multi-paradigm programming language encompassing strong typing, imperative, declarative, functional, generic, object-oriented, and component-oriented programming disciplines.

[Insert C# Logo]

## Unity

Unity is a cross-platform game engine developed by Unity Technologies, which is primarily used to develop both three-dimensional and two-dimensional video games and simulations for computers, consoles, and mobile devices.

[Insert Unity Logo]

Section 10: Conclusion and Future Scope

10. Conclusion and Future Scope

In a nutshell,

Our future scope,

Section 11: References

<https://www.limelight.com/resources/white-paper/state-of-online-gaming-2018/>

<https://www.researchgate.net/figure/Video-game-consumer-market-value-worldwide-from-2011-to-2019-by-distribution-type-in_fig1_328902434> 11. References



## Introduction References

* Reference 1
* Reference 2

## Market Survey References

* Reference 1
* Reference 2

## Research References

* <http://boardword.com/static/bitboards.html>
* <https://wikivisually.com/wiki/Bitboard>
* <https://www.youtube.com/watch?v=MzfQ8H16n0M&t=573s>
* Reference

## Implementation References

* Reference 1
* Reference 2

## Testing References

* Reference 1
* Reference 2