February 21st, 2020
Professor Craig Scratchley
School of Engineering Science
Simon Fraser University
Burnaby, BC V5A 1S6

**RE: ENSC 405W/440 Requirements Specification for IntelliChess**

Dear Professor Scratchley,

The following document contains the requirements specifications for our product IntelliChess by Antebellum, as part of the course ENSC 405W. At Antebellum, our goal is to make learning chess a more fun and interactive experience, while maintaining the originality and simplicity of normal chessboards. IntelliChess is a smart chessboard that aims to bring the computer opponent from your screen to a physical chessboard.

Whether you are a chess Grandmaster or just starting out, IntelliChess has something for everyone. The board offers an invisible opponent that moves its own pieces while also providing hints during the match and feedback after the match through the included mobile app.

This document will outline the different requirements our product must meet through the various phases of this project which include the proof of concept, engineering prototype and the final product. The document will cover the scope of the project, main system requirements, safety and sustainability, engineering standards and an acceptance test plan that covers what to expect from our proof of concept in April. Also, an appendix that covers the most important chess rules is included at the end of the document for your reference.

Our company consists of 5 passionate engineers coming from diverse backgrounds, united under the goal to demonstrate and apply the knowledge acquired from SFU throughout the years. We would like to thank the TAs Shervin, Mike and Chris for their ongoing help and guidance throughout the project. And thank you for taking the time and effort to review our requirement specification document. If you have any questions, please contact me at cwliang@sfu.ca

Sincerely,

Marco Liang
CEO, Antebellum Inc.

# Antebellum

# IntelliChess Requirements Specification

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| 1.0 | Initial Creation of Document | 2/13/2021 |

# Abstract

This document aims to provide a comprehensive list of requirements pertaining to the self-moving smart chess board, IntelliChess. These requirements provide an overview of the system and its various components, and will give the reader a general idea of the product and its desired functionality. If the reader is not familiar with the game of Chess, an appendix containing the rules of the game can be found at the end of this document under Appendix A: The rules of chess.

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# Glossary

| Term | Definition |
|------|------------|
| Rank | A term used for the 8 rows on the chess board, running from 1-8. |
| File | A term used for the 8 columns on the chess board, running from a-h |

**Table 1: Glossary**

# Table of Contents

# 1.0 Introduction

Easy to learn, yet almost impossible to master; the game of Chess is a timeless masterpiece. Even with the tremendous technological progress, we have yet to find a recreational activity that engages and stimulates the brain as deeply as a fulfilling and competitive game of chess. With the relatively recent ability to play the game online, the popularity of the game has seen explosive growth [1].

Amateurs and professionals alike are increasingly shifting to virtual chess; move assistance, match summary and real time feedback are just some of the tools available for a player to improve and learn the game. The convenience and functionality of virtual chess is just too useful to be ignored. The only reminder of physical chess now, is the frustratingly outdated 'hardware' that is highlighted during chess tournaments and the awkward camera angles which make it very difficult to follow the sophisticated game without getting distracted.

However, this shift to virtualization has left a void in the heart of many enthusiasts. The 'feel' of the game seems to be slowly fading away. The satisfaction of plucking your opponent's piece after a capture or the flicking of the clock with only a few seconds to spare is slowly getting replaced with the opponent's 2D piece magically disappearing and a timer that waits for the release of your left click. As a result, new players often do not feel the connection or complete thrill of the game that many professionals speak of. That is where our company, Antebellum steps in. We are on a mission to bring functionality to the classical.

With our smart chess board, IntelliChess, the user will be able to enjoy chess the way it is meant to be enjoyed with no compromise on functionality or capability. Our automated chess movement system has the incredible ability to move its own pieces which makes the user feel like he is playing against a real opponent. We also have a real time assistant that trains you to make the best move possible and identifies illegal actions. The difficulty of the computer player is also adjustable allowing new players to grow and learn at their own pace. Our companion app will display relevant information and provide a convenient portal for the user to tweak settings based on their preference. The implicit ability to recognize the chess pieces and their movement also allows us to display a duplicated virtual board for streaming worthy occasions (such as tournaments), providing an overall better experience for the fans of the game as well.

# 2.0 Requirements

The requirements below are categorized into sections based on the high level features of the IntelliChess product. These sections include chess piece detection and movement, chess board design, chess piece design, and lastly safety and sustainability. Each requirement has an associated stage of development, indicated in the **Phase** column of the requirements tables.

The three phases:

- **Alpha (A)**, requirements aimed to be completed as soon as possible for our proof-of-concept prototype, which will be demonstrated at the end of **ENSC 405W**
- **Beta (B)**, requirements that will be satisfied in the engineering prototype for demonstration at the end of **ENSC 440**
- **Final Product (FP)**, requirements that will be satisfied upon delivery of the final product.

Many of the requirements were decided upon after our team conducted a market research survey. The survey gained over 170 unique responses from family, friends, the SFU chess club and r/Chess on reddit. Through this survey, we gained valuable insight on what features people preferred, what material they like for their chessboard and how much they are willing to pay for this type of product. For example, an overwhelming 82.5% of people said they preferred wooden chess pieces as seen below in the pie chart.
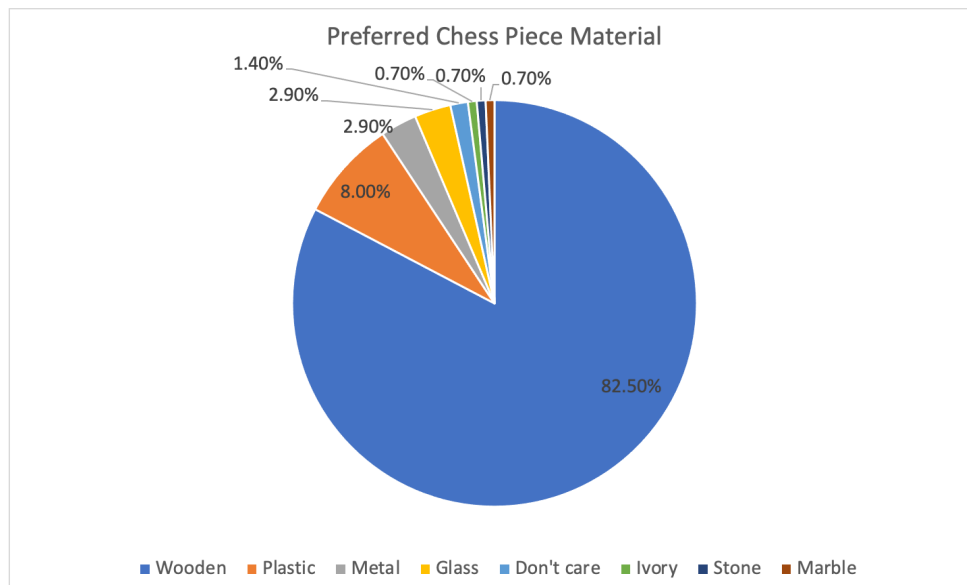


**Figure 1: Preferred Chess Piece Material by Customers**

## 2.1 Gameplay Requirements

| RS - Req ID - Phase | Requirement Description |
|---|---|
| RS-2.1.01-B | The game must abide by the official chess rule handbook governed by The International Chess Federation (FIDE)  [2] |
| RS-2.1.02-B | The user shall be able to select the difficulty level of the CPU opponent. |
| RS-2.1.03-B | The user shall be able to select the side they would like to play as (black or white). |
| RS-2.1.04-B | The user shall be able to specify a time limit/format for the game (bullet, blitz, rapid, classical, etc). |
| RS-2.1.05-B | When playing as white, the user must move first to start the game. |
| RS-2.1.06-B | When playing as black, the user must wait for the CPU opponent to play a move to start the game. |
| RS-2.1.07-B | The moves played by the CPU must not violate any of the official chess piece movement rules [2] (see appendix A for the rules of chess). |
| RS-2.1.08-B | The user must be informed if they play an illegal move |
| RS-2.1.09-B | If the user plays an illegal move, the user should be informed why it was illegal |
| RS-2.1.10-B | The user must be prompted to undo their last move if it was illegal. |
| RS-2.1.11-B | The CPU opponent must not respond to an illegal move played by the user. |
| RS-2.1.12-B | The user shall be able to request a hint on their turn which will show their best possible move. |
| RS-2.1.13-B | The user shall be able to make a request which highlights their pieces that are currently under attack. |
| RS-2.1.14-B | The user must be responsible for removing pieces that they have captured. |
| RS-2.1.15-B | The user should be responsible for replacing their pawn with another piece upon pawn promotion. |
| RS-2.1.16-B | Pieces captured by the CPU opponent must be removed automatically. |
| RS-2.1.17-B | Pawn promotion should occur automatically if a CPU opponent's pawn promotes. |
| RS-2.1.18-B | The user should be able to resign. |
| RS-2.1.19-B | The user must be able to stop/start a timing clock. |

**Table 2: General Gameplay Requirements**

## 2.2 Chess Board

| RS - Req ID - Phase | Requirement Description |
|---|---|
| RS-2.2.01-A | The board must be able to distinguish between empty and occupied spaces. |
| RS-2.2.02-A | The board must keep track of the location of the pieces |
| RS-2.2.03-A | The board must be able to move chess pieces in all directions (forwards, backwards, diagonal) |
| RS-2.2.04-B | The board should have markings for each of the 8 ranks. |
| RS-2.2.05-B | The board should have markings for each of the 8 files. |
| RS-2.2.06-B | The board must include enough parking space for fifteen captured pieces on both sides. |
| RS-2.2.07-B | The board must include, for both sides, an extra of each piece that can replace a pawn after it promotes (refer to appendix A for information on pawn promotion) |
| RS-2.2.08-B | The board must include space on both sides for the four extra pieces which may be used upon pawn promotion. |
| RS-2.2.09-B | The board should indicate when illegal moves are played. |
| RS-2.2.10-B | The board should be able to highlight squares in different colors depending on action (user asks for hint, or illegal move) |
| RS-2.2.11-B | When an illegal action is performed, the board should indicate the correct action to perform and wait until it is performed |
| RS-2.2.12-B | The board should not be prone to scratches or scuffs |
| RS-2.2.13-B | The board must be cased |
| RS-2.2.14-B | The board can have an easily removable base for easy access to the internals |
| RS-2.2.15-B | The board must be easily liftable by an adult |
| RS-2.2.16-B | The board size must accommodate pieces moving in between each other |
| RS-2.2.17-FP | The board must be priced below the competitions' price of $449 ($571 CAD) |

**Table 3: Chessboard Specific Requirements**

## 2.3 Chess pieces

| RS - Req ID - Phase | Requirement Description |
|---|---|
| **RS-2.3.1-A** | The chess pieces must be movable by the CPU opponent with no physical intervention by the user |
| **RS-2.3.2-A** | The pieces must not collide at any point when being moved by the board mechanisms. |
| **RS-2.3.3-A** | The King piece should have the largest base diameter |
| **RS-2.3.4-A** | The chess pieces must be detectable on the board |
| **RS-2.3.5-B** | Extra chess pieces must be provided for pawn promotion (refer to appendix A) |
| **RS-2.3.6-B** | The diameter of the base of the King chess piece must be less than or equal to half the length of a chessboard square |
| **RS-2.3.7-B** | The chess pieces can be wooden |

**Table 4: Chess Pieces Specific Requirements**

# 3.0 Engineering Standards

Since we are targeting Canada as our first market, our product will be designed to adhere to Canadian laws and standards. The following standards were identified as requirements for our product. They will be met in the final product, and met to the best of our abilities for the prototypes.

| Standard | Description |
|---|---|
| **CSA C22.2 NO. 62115** | Safety standards for electric toys, which are defined as any electric product intended for users aged 14 and under (exclusively or not) [3] |
| **CSA C22.1:21** | Canadian Electrical Code, Part I - Safety Standard for Electrical Installations [4] |
| **IEEE 802.15.4-2020** | IEEE Standard for Low-Rate Wireless Networks (Includes RFID) [5] |
| **IEEE/ISO/IEC 12207-2017 - ISO/IEC/IEEE** | International Standard - Systems and software engineering -- Software life cycle processes [6] |

**Table 5: Product Engineering Standards**

# 4.0 Safety & Sustainability

| RS - Req ID - Phase | Requirement Description |
|---|---|
| **RS-4.0.1-B** | The board should not slip when placed on table |
| **RS-4.0.2-B** | The electronics must be fully hidden inside the chessboard away from the user |
| **RS-4.0.3-B** | The materials used must not be toxic or harmful |
| **RS-4.0.4-B** | The electronics must not overheat to the point of discomfort to the user |
| **RS-4.0.4-FP** | The packaging of the chess pieces must contain a choking hazard warning |
| **RS-4.0.5-FP** | The packaging should be recyclable/biodegradable |

**Table 6: Safety & Sustainability Requirements**

# 5.0 Acceptance Test Plan

## Alpha (POC Prototype)

A basic prototype of the Intellichess board will be developed as a proof of concept for ENSC 405W. For this proof of concept, we will aim to have a small scale 3x3 chess board (size may change depending on time and resources) that will showcase the aforementioned Alpha (POC) requirements. This will be demonstrated by the steps seen below in table 7. Note that the steps have been oversimplified to be easily understandable by the user. Although the steps seem simple, each one covers a number of substeps like communication between the board and the bluetooth module and successfully reading data from the matrix of RFID antennas.

| Step | Associated Requirement ID | Test Description | Pass/Fail |
|------|---------------------------|------------------|-----------|
| 1 | **RS-2.2.01-A** | 3x3 board initially empty, chess GUI shows empty board | ☐ P ☐ F |
| 2 | **RS-2.2.02-A** **RS-2.3.4-A** | Place chess pieces on the board and indicate that they have been detected through the chess GUI | ☐ P ☐ F |
| 3 | **RS-2.2.02-A** **RS-2.3.4-A** | Replace one of the pieces with another, and show that chess GUI has updated | ☐ P ☐ F |
| 4 | **RS-2.2.03-A** **RS-2.3.1-A** | Remove all pieces except one, showcase piece movement in all directions (forwards, backwards and diagonal) | ☐ P ☐ F |
| 5 | **RS-2.2.03-A** **RS-2.3.2-A** | Repopulate board and showcase a piece moving in between other pieces to the desired square | ☐ P ☐ F |

**Table 7: POC Test Plan Checklist**

# 6.0 Conclusion

Modernizing chess is a mammoth of a task. The variety of possible movements and subtle intricacies of the game add an incredible amount of complexity to the process. To approach the problem, we broke it down into three different phases, each one allowing us to thoroughly test the most important components of the product while also allowing us to work through potential problems in a focused manner.

In this document, we highlighted all the requirements for our IntelliChess product. We also discussed safety concerns by specifically defining safety requirements and talked about the important sustainability aspect of the product by laying out concrete sustainability requirements that addressed the main problematic issues. For our report and project, we have only considered the Canadian laws and standards as they are the most immediately applicable to our product.

Our goal is to have the Alpha phase completed by the end of March, while the Beta phase will be ready by the end of July. The one month period before the required final submissions of each phase will give us just enough time to critically review and test our designs, enabling us to straighten out possible bugs and roadblocks. Lastly, after the completion of the beta phase, we will also develop a comprehensive report, listing all the features and functionality for what is expected to be delivered as the final product.

# Appendix A: The Rules of Chess

## The Setup

Each piece has its own unique way of moving, however all pieces share some common traits. There can never be more than one piece on a square at any given time. Pieces cannot move through other pieces, except for the knight which will be explained below. One side's pieces may capture the opposing side's pieces, in which case the piece being captured is removed from the board and replaced by the capturing piece. Pieces may not capture pieces of the same colour. White always plays the first move to start the game. Figure 2 below shows the pieces in their initial positions, with one of each type of piece numbered 1 through 6, corresponding with the number in the heading in the subsections below.



**Figure 2: The Chess Board and its Pieces [7]**

## Board Setup

The board setup is shown above. There are a couple key things to notice here. Firstly, the bottom right square for both players will always be a light coloured square. Secondly, each player's queen is on its own colour, white's queen is on a light square, and black's queen is on a dark square.

## The Pawn (1)

Each side begins with eight pawns each. Pawns may only move forward, one square at a time except for the first time they are moved, where they may be moved two squares forward as well as one. Pawns may capture pieces which are diagonally in front of them by one square. Pawns become blocked when there is another piece directly in front of them as they can no longer move forward, or capture the piece.

## The Rook (2)

Each side begins with two rooks each. Rooks move horizontally and vertically, but cannot move diagonally under any circumstance. The rooks can move as many squares at a time as they desire in one direction, they cannot change direction at any point during movement.

## The Bishop (3)

Each side begins with two bishops each. Bishops move on diagonals, both forward and back, and can move multiple squares at a time.

## The Knight (4)

Each side begins with two knights each. Knights are unique in Chess as they are the only piece that is able to jump over other pieces. They move in an "L" shape, two squares forward/back/left/right, followed by one square in a direction perpendicular to that of the direction of the first two squares.

## The Queen (5)

Each side begins with one queen each. Queens are the most powerful piece in chess as they can move in any direction (forward, back, left, right, diagonally), for as many squares as they like.

## The King (6)

The king is similar to the queen in the sense that it can move in any direction, however it can only move one square at a time. The most important thing about the king, is that the king cannot remain under attack. If the king is attacked the king must either move or another piece must stop the attack by blocking, or capturing the attacking piece.

# The Objective

The objective of the game is fairly simple: prevent your opponent from capturing your king, and try to capture the opponent's king. When the king is placed under attack, the king is in check. The king cannot remain in check, it must either move out of the way of the attacking piece, have the attack blocked by a piece of its own, or capture the attacking piece. The king also cannot

place itself in check. When it is not possible for the king to escape an attack, the king is in checkmate and the game is over. Whichever side checkmates the opposing side's king first wins. It is possible for a game to end in a draw however. If the game reaches a point where one side cannot make a move without putting its king in check, the game ends in a draw. This is called a stalemate. It is also common at higher levels for players to agree to a draw, as certain positions near the end of the game are unwinnable for both sides.
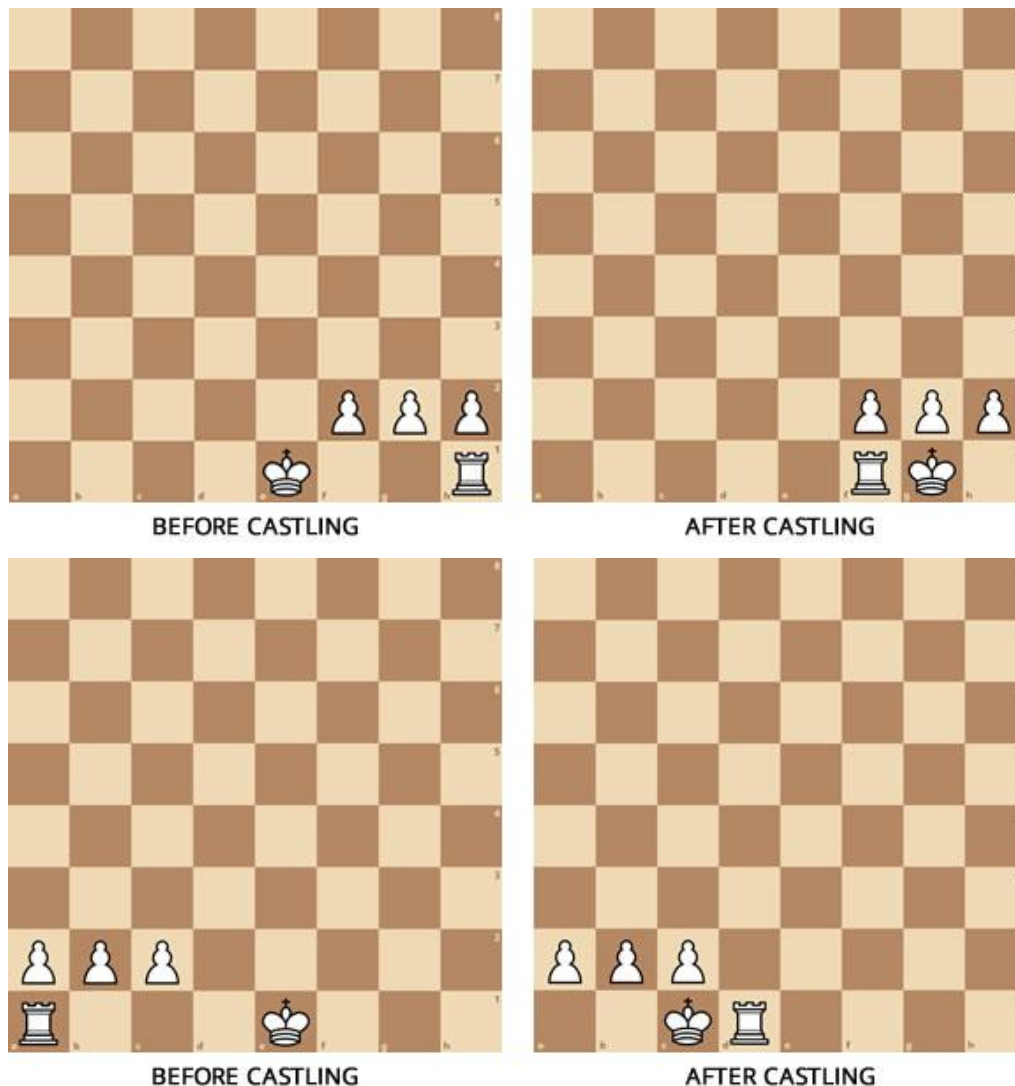
## Special Moves

Castling



**Figure 3: How to castle in chess [8]**

Castling is a technique used in the early stages of the game to get the king out of the centre of the board, and to a safer square. Castling is only possible if the king and the rook have not yet been

moved. Castling also requires all of the squares between the king and the rook to be empty, which implies that the bishop and knight, or bishop knight and queen have been moved out of the way. This allows the king to castle either "kingside", the side of the board that the king is closer to, or "queenside" the side of the board that the queen is closer to. The movement is demonstrated in the images above.
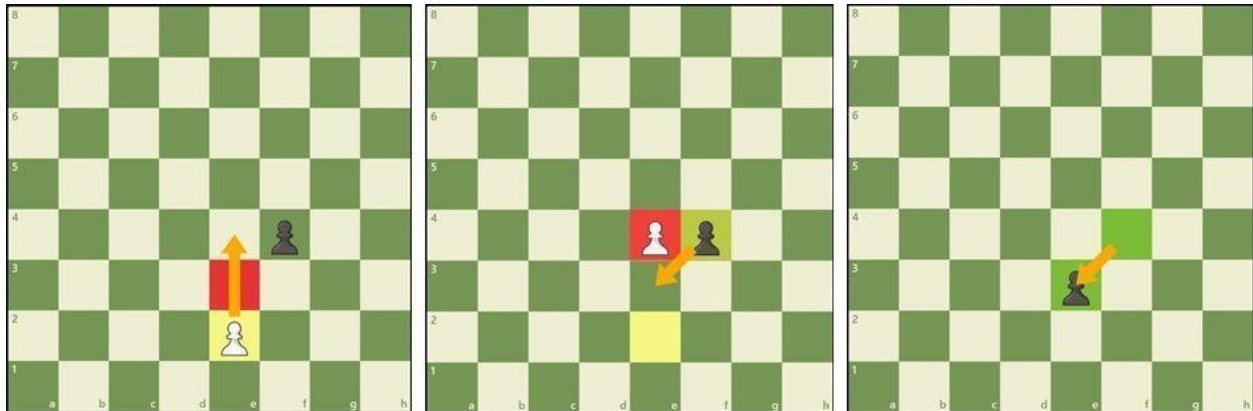
## En Passant



**Figure 4: How to play En Passant in chess [9]**

En passant is a special move which allows a pawn to capture an opponent's pawn which is one square to the left or right of it. This special capture is only possible if the opponent's pawn was moved for the first time, and was moved two squares forward. After capturing, the pawn moves one square forward, and also moves onto the same file as the captured pawn as demonstrated in the image above.

## Pawn Promotion

When a pawn reaches the last rank on the opposite side of the board from where it started, it can be replaced by a stronger piece. A pawn can promote to a queen, knight, rook, or bishop.

# References

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