Module Interface Specification for Chess Connect

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April 4, 2023

1 Revision History

Table of Revisions

Table 1: Revision History

Date	Developer(s)	Change
2023-01-16	Jonathan Cels, Rupinder Nagra	Web Application Modules
2023-01-17	Alexander Van Kralingen	Detailed Modules used by Arduino Mega 2560
2023-01-18	Jonathan Cels, Rupinder Nagra	Finalized Web Application Modules

2 Symbols, Abbreviations and Acronyms

symbol	description
M	Module
MIS	Module Interface Specification
R	Requirement
FEN	Forsyth-Edwards Notation

Contents

3 Introduction

The following document details the Module Interface Specifications for Chess Connect. The Chess Connect project aims to bridge the gap between physical and online chess play by enabling two players to play a game on a physical board while simultaneously transmitting the moves to a web application via Bluetooth. This central platform will eliminate the need for players to switch between different mediums and will provide a more flexible and accessible way for new players to learn the game.

Complementary documents include the System Requirement Specifications and Module Guide. The full documentation and implementation can be found at https://github.com/ChessConnect/chess-connect.

4 Notation

The structure of the MIS for modules comes from Hoffman and Strooper (1995), with the addition that template modules have been adapted from Ghezzi et al. (2003). The mathematical notation comes from Chapter 3 of Hoffman and Strooper (1995). For instance, the symbol := is used for a multiple assignment statement and conditional rules follow the form $(c_1 \Rightarrow r_1|c_2 \Rightarrow r_2|...|c_n \Rightarrow r_n)$. String concatenation uses the + symbol between strings surrounded by ‘’, such as ‘this’ + ‘that’.

The following table summarizes the primitive data types used by Chess Connect.

Data Type	Notation	Description
character	char	a single symbol or digit
integer	int	a number without a fractional component in (-∞, ∞)
boolean	boolean	true (value of 1) or false (value of 0)
enumeration	enum	keywords assigned an integer value in order of declaration beginning at 0
structure	Piece	C++ struct data-type containing PieceType enumeration and int colour (0 for white, 1 for black)

The specification of Chess Connect uses some derived data types: sequences, strings, and tuples. Sequences are lists filled with elements of the same data type. Strings are sequences of characters. Tuples contain a list of values, potentially of different types. In addition, Chess Connect uses functions, which are defined by the data types of their inputs and outputs. Local functions are described by giving their type signature followed by their specification.

5 Module Decomposition

The following table is taken directly from the Module Guide document for this project.

Level 1	**Level 2**
Hardware Hiding Module	Arduino Controller Module
	Arduino Module
	Software Serial Module
Behaviour-Hiding Module	Web Application Input Module
	Display Module
	Web Application Output Module
	Piece Identification Module
	Communication Module
	Teensy Input from Mega Module
	Teensy Input Bluetooth from Web App Module
	Teensy Output Bluetooth from Web App Module
Software Decision Module	User Mode Module
	Board Module
	Web Application Game State Module
	Engine Module
	Chess Board Module

Table 2: Module Hierarchy

6 MIS of Arduino Controller Module

6.1 Arduino Controller

6.2 Uses

Arduino
Software Serial
Chess Board
Piece Identification
Communication

6.3 Syntax

6.3.1 Exported Constants

None

6.3.2 Exported Access Programs

None

6.4 Semantics

Name	In	Out	Exceptions
setup	-	-	TeensyConnectionFailed
loop	-	-	TeensyConnectionFailed
changeGameState	gameState	gameState	InvalidAction
changeGameMode	gameMode	string	InvalidAction
competeUserAction	string	userAction	InvalidAction, UnknownAction
lightLED	int, int	int	-

6.4.1 State Variables

gameMode := enum { beginner, normal, engine }
gameState := enum { init, play, end, reset }
userAction := enum { wait_white, wait_black, piece_lifted, remove_piece, promoting, valid_move, invalid_move, draw, resign, reset }

boardState := FEN string playerWarning := enum { check, checkmate, stalemate }

6.4.2 Environment Variables

HALL_PINS: input pin addresses for receiving signal from Hall-effect sensors
LED_PINS: output pin addresses for lighting up the LEDs on the board
rx_from_Teensy: input pin for communication with Teensy controller
tx_from_Teensy: output pin for communication with Teensy controller

6.4.3 Assumptions

- setup() will run before any other function.
- Connection exists between both controllers and remains constant

6.4.4 Access Routine Semantics

loop():

- transition:
  - Main control loop.
  - Polling sensors to update boardState FEN string.
  - Checking for check/checkmate/stalemate signal from Web App to update playerWarning.
  - Wait for userAction based on Hall-effect sensor inputs.
- exception: TeensyConnectionFailed

changeGameState():

- transition: Change gameState based on user input button presses (game start, draw, reset).
- exception: InvalidAction

changeGameMode():

- transition: Change gameMode based on user input button presses (beginner, normal, engine).
- exception: InvalidAction

completeUserAction():

- transition: Update boardState based on completed userAction
- exception: InvalidAction, UnknownAction

lightLED():

- output: LED_pin := HIGH ($\mathbb{Z} := 1$) or LOW ($\mathbb{Z} := 0$).
- exception: TeensyConnectionFailed

6.4.5 Local Functions

setup():

- transition: initialize serial connection; read board state; game state set to "init"
- exception: TeensyConnectionFailed

7 MIS of Piece Identification Module

7.1 Piece Identification

7.2 Uses

None

7.3 Syntax

7.3.1 Exported Constants

None

7.3.2 Exported Access Programs

Name	In	Out	Exceptions
readSensors	int	Piece	SensorOffline
waitForPiece	int, int, Piece	bool	PieceMissingTimeout

7.4 Semantics

7.4.1 State Variables

None

7.4.2 Environment Variables

sensorInput: readings from various hall-effect sensors

7.4.3 Assumptions

Hall-effect sensors will give accurate readings.

7.4.4 Access Routine Semantics

readSensors():

- output: Piece
- exception: SensorOffline

waitForPiece():

- transition: Waiting to send signal based on a sensor transition from $HALL\_PIN[\mathbb{Z}][\mathbb{Z}] := \mathbb{R} \Rightarrow 0$

- output: bool value of ($PieceNotPlaced \Rightarrow false | PiecePlaced \Rightarrow true$)
- exception: PieceMissingTimeout

7.4.5 Local Functions

None

8 MIS of Chess Board Module

8.1 Chess Board

8.2 Uses

Arduino
Piece Identification

8.2.1 Exported Constants

int numRows : Chess board rows
int numCols : Chess board columns
int LED_PINS[numRows][numCols] : 2-D array controlling the LED output pins
int HALL_PINS[numRows][numCols] : 2-D array controlling the Hall-effect sensor input pins

8.2.2 Exported Access Programs

None

8.3 Semantics

Name	In	Out	Exceptions
movePiece	int, int, int, int, Piece-Type	boolean	InvalidMove
removePiece	int, int	Piece	InvalidMove
isCheckmateCheckOrStalemate	int, int	bool	-
boardToFEN	-	string	-
recieveMoves	-	Colour	InvalidMove
lightSquare	int, int, Colour	-	DigitalWriteFailed
pieceToChar	Piece	char	-

8.3.1 State Variables

gameMode := enumeration
check := boolean
checkmate := boolean

draw := boolean

8.3.2 Environment Variables

HALL_PINS: input pins receiving signal from Hall-effect sensors
LED_PINS: output pins lighting up the LEDs on the board
serialToTeensy: serial communication to and from the Teensy controller

8.3.3 Assumptions

- Serial connection between both microcontrollers will remain constant
- All LED pins will remain connected
- Hall-effect sensors will function as intended

movePiece():

- transition: Update Piece type and colour on the "to" square, while removing the piece from the "from" square.
- exception: InvalidMove

removePiece():

- transition: Update Piece type and colour on the "to" square, while removing the piece from the "from" square. Remove the piece taken by the opponent.
- output: returns the Piece that was removed.
- exception: InvalidMove

isCheckmateCheckOrStalemate():

- transition: Update game state based on a command sent from the Web Application.
- exception: None

boardToFEN():

- output: FEN string representation of the current board state.
- exception: None

recieveMoves():

- transition: Process best moves recieved from the web application and light appropriate LED's.
- exception: InvalidMove

lightSquare():

- transition: Light appropriate LED's based on various conditions such as game mode, game state, check/mate/stalemate warning, etc.
- exception: DigitalWriteFailed

8.3.4 Local Functions

pieceToChar():

- output: Converting the Piece type into the FEN-string character representation.
- exception: None

9 MIS of Communication Module

9.1 Communication

9.2 Uses

Arduino.h SoftwareSerial.h

9.3 Syntax

9.3.1 Exported Constants

None

9.3.2 Exported Access Programs

Name	In	Out	Exceptions
encodeMessage	string	-	UnknownAction
decodeMessage	-	string	UnknownCommand
processCommand	string	string	InvalidCommand

9.4 Semantics

9.4.1 State Variables

command: The decoded message to update values (game state, game mode, light specific LED, etc.).

9.4.2 Environment Variables

messageEncoder: The string formatting to send a message to the Teensy Controller via Serial Communication.
messageDecoder: The string formatting to read a message from the Teensy Controller via Serial Communication.

9.4.3 Assumptions

- Communication string format remains consistent
- Connection exists between both controllers and remains constant

9.4.4 Access Routine Semantics

encodeMessage():

- output: Translate game state or action into encoded string to be read by Teensy or the Web Application
- exception: UnknownAction

decodeMessage():

- output: Translate encoded message from Teensy or the Web Application and convert into state change command
- exception: UnknownCommand

processCommand():

- transition: Command received from Web Application or Teensy controller will be used to change the chess board accordingly.
- –¿ This could be to change the game state, game mode, player warning (check, checkmate, stalemate) or to light appropriate LED's
- exception: InvalidCommand

9.4.5 Local Functions

None

10 MIS of Web Application Input Module

10.1 Module

Web Application Input

10.2 Uses

Board Module
User Mode Module

10.3 Syntax

10.3.1 Exported Constants

10.3.2 Exported Access Programs

Name	In	Out	Exceptions
parseInput	string	seq of string	invalidInput

10.4 Semantics

10.4.1 State Variables

inputString: string #String containing FEN string, user mode, game termination state, and delimiting characters

10.4.2 Environment Variables

N/A

10.4.3 Assumptions

N/A

10.4.4 Access Routine Semantics

parseInput():

- output: sequence of strings. The first is the FEN string, the second is the user mode, the third is the game termination state.
- exception: invalidInput if any of validFen, validUserMode, or validGameTermination return false.

10.4.5 Local Functions

Name	In	Out	Exceptions
validFen	string	boolean	
validUserMode	string	boolean	
validGameTermination	string	boolean	

11 MIS of Display Module

11.1 Module

Display

11.2 Uses

Board Module

11.3 Syntax

11.3.1 Exported Constants

11.3.2 Exported Access Programs

Name	In	Out	Exceptions
drawSquare	string		
drawBoard	seq of (seq of int)		
displayGameTermination	int		
setBackground	string		

11.4 Semantics

11.4.1 State Variables

N/A

11.4.2 Environment Variables

N/A

11.4.3 Assumptions

N/A

11.4.4 Access Routine Semantics

drawSquare():

- output: Draw board square
- exception: none

drawBoard():

- transition: Uses drawSquare to display the game board
- exception: none

displayGameTermination():

- transition: Displays game termination state (checkmate, stalemate, etc.)
- exception: none

setBackground():

- transition: Sets the background colors of the display.
- exception: none

11.4.5 Local Functions

N/A

12 MIS of Web Application Output Module

12.1 Module

Web Application Output

12.2 Uses

Engine Module
Game State Module

12.3 Syntax

12.3.1 Exported Constants

12.3.2 Exported Access Programs

Name	In	Out	Exceptions
sendData	string	string	

12.4 Semantics

12.4.1 State Variables

N/A

12.4.2 Environment Variables

N/A

12.4.3 Assumptions

N/A

12.4.4 Access Routine Semantics

sendData(string):

- output: string #Encodes game state (none, check, checkmate, stalemate), and 3 engine-generated moves
- exception: none

12.4.5 Local Functions

N/A

13 MIS of User Mode Module

13.1 Module

User Mode

13.2 Uses

Engine Module

13.3 Syntax

13.3.1 Exported Constants

13.3.2 Exported Access Programs

Name	In	Out	Exceptions
getUserMode		string	
setUserMode	string		

13.4 Semantics

13.4.1 State Variables

userMode: string #Represents the current user mode (Normal, Beginner, Engine)

13.4.2 Environment Variables

N/A

13.4.3 Assumptions

N/A

13.4.4 Access Routine Semantics

getMode():

- output: string

$$output := userMode$$

- exception: none

setMode(string):

- transition: Sets userMode to the input user mode

$$userMode := input$$

- exception: none

13.4.5 Local Functions

N/A

14 MIS of Board Module

14.1 Module

Board

14.2 Uses

Engine Module
Game State Module

14.3 Syntax

14.3.1 Exported Constants

#define letters [‘a’, ‘b’, ‘c’, ‘d’, ‘e’, ‘f’, ‘g’, ‘h’]
#define startFEN = ‘rnbqkbnr/pppppppp/8/8/8/8/PPPPPPPP/RNBQKBNR w KQkq - 0 1’
#define boardDimension = 8

14.3.2 Exported Access Programs

Name	In	Out	Exceptions
initialize			
getXYPosition	int	tuple of int	invalidIndex
getPosition	int	tuple of int	
getFenString		string	
setFenString	string		

14.4 Semantics

14.4.1 State Variables

fenString: string #Stores FEN string of current game position

14.4.2 Environment Variables

N/A

14.4.3 Assumptions

initialize is called before any other access routine.

14.4.4 Access Routine Semantics

initialize():

- transition: #Initializes fenString to the starting chess board position

$$fenString := startFEN$$

- exception: none

getXYPosition(int: squareInd):

- output: #X and Y number coordinate for an input square number. Eg. getXYPosition(14) returns (0, 6).

$$out := (squareInd \;//\; boardDimension,\; squareInd \;\%\; boardDimension)$$

- exception: none

getPosition(int: squareInd):

- output: #letter and number coordinate for an input square number. Eg. getPosition(14) returns 'g7'.

$$out := `letters[squareInd \;\%\; boardDimension]' + `boardDimension - (squareInd \;//\; boardDimension)'$$

- exception: none

getFenString():

- output:

$$out := fenString$$

- exception: none

setFenString(string: fen):

- transition:

$$fenString := fen$$

- exception: none

14.4.5 Local Functions

N/A

15 MIS of Web Application Game State Module

15.1 Module

Web Application Game State

15.2 Uses

N/A

15.3 Syntax

15.3.1 Exported Constants

15.3.2 Exported Access Programs

Name	In	Out	Exceptions
isCheck	string	boolean	
isCheckmate	string	boolean	
isStalemate	string	boolean	

15.4 Semantics

15.4.1 State Variables

N/A

15.4.2 Environment Variables

N/A

15.4.3 Assumptions

N/A

15.4.4 Access Routine Semantics

isCheck():

- output: True if the position is 'check', false otherwise
- exception: none

isCheckmate():

- output: True if the position is 'checkmate', false otherwise

- exception: none

isStalemate():

- output: True if the position is 'stalemate', false otherwise
- exception: none

15.4.5 Local Functions

N/A

16 MIS of Engine Module

16.1 Module

Engine

16.2 Uses

N/A

16.3 Syntax

16.3.1 Exported Constants

#define depth #How many layers of depth the chess engine should use to evaluate the position #define maxSearchTime #The maximum time the chess engine should take to evaluate the position

16.3.2 Exported Access Programs

Name	In	Out	Exceptions
evaluatePosition	string	string	

16.4 Semantics

16.4.1 State Variables

N/A

16.4.2 Environment Variables

N/A

16.4.3 Assumptions

The depth and maxSearchTime values will determined experimentally after the system is built. There is a trade-off between move quality and speed/depth of the search.

16.4.4 Access Routine Semantics

evaluatePosition(string):

- output: String containing 3 possible moves, calculated by a chess engine from the FEN input string
- exception: none

16.4.5 Local Functions

N/A

17 Teensy Input from Mega Module

17.1 Module

Teensy Input from Mega Module

17.2 Uses

Receives game state information from the Arduino Mega in the form of a FEN string.

17.3 Syntax

17.3.1 Exported Constants

#define baud rate #The baud rate of the serial communication system
#define stringFormat #The format of the string remains constant to perform proper communication between the two Arduinos.

17.3.2 Exported Access Programs

Name	In	Out	Exceptions
copyFen	string	string	
collectMode	string	binary	

17.4 Semantics

17.4.1 State Variables

local game state
local game mode

17.4.2 Environment Variables

N/A

17.4.3 Assumptions

The size of the string passed from the Arduino Mega aligns with the designed format.

17.4.4 Access Routine Semantics

receiveGameState(pin):

- Input: A serial line of data from an Rx pin

- Output: A string containing the FEN of the game state
- exception: none

17.4.5 Local Functions

N/A

18 Teensy Input from Web App Module

18.1 Module

Teensy Input via bluetooth from the Web Application

18.2 Uses

Receives best moves from the game engine contained in the Web Application.

18.3 Syntax

18.3.1 Exported Constants

#define baud rate #The baud rate of the serial communication system
#define stringFormat #The format of the string remains constant to perform proper communication between the two Arduinos.

18.3.2 Exported Access Programs

Name	In	Out	Exceptions
copyBestMove	string	string	

18.4 Semantics

18.4.1 State Variables

local bestMove1
local bestMove2
local bestMove3

18.4.2 Environment Variables

N/A

18.4.3 Assumptions

The size of the string passed from the Web Application aligns with the designed format.
The Web Application will always be able to return best moves with the given data.

18.4.4 Access Routine Semantics

receiveBestMove(pin):

- output: String containing 3 possible moves, calculated by a chess engine from the FEN input string

- exception: none

18.4.5 Local Functions

N/A

19 Teensy Output to Web App Module

19.1 Module

Teensy Output via bluetooth to the Web Application

19.2 Uses

Sends current game state and game mode to the Web Application via Bluetooth

19.3 Syntax

19.3.1 Exported Constants

#define baud rate #The baud rate of the serial communication system
#define stringFormat #The format of the string remains constant to perform proper communication between the two Arduinos.

19.3.2 Exported Access Programs

Name	In	Out	Exceptions
copyFEN	string	string	
copyGameMode	string	string	

19.4 Semantics

19.4.1 State Variables

local lastGameState
local currGameState

19.4.2 Environment Variables

N/A

19.4.3 Assumptions

The size of the string passed to the Web Application aligns with the designed format that the web application is expecting

19.4.4 Access Routine Semantics

sendCurrState(pin):

- output: String containing the current game state
- exception: none

sendCurrMode(pin):

- output: String containing the current game mode
- exception: none

19.4.5 Local Functions

N/A

References

FEN. Fen (forsyth-edwards notation) - chess terms. https://www.chess.com/terms/fen-chess. Accessed: 2023-01-18.

Carlo Ghezzi, Mehdi Jazayeri, and Dino Mandrioli. *Fundamentals of Software Engineering*. Prentice Hall, Upper Saddle River, NJ, USA, 2nd edition, 2003.

Daniel M. Hoffman and Paul A. Strooper. *Software Design, Automated Testing, and Maintenance: A Practical Approach*. International Thomson Computer Press, New York, NY, USA, 1995. URL http://citeseer.ist.psu.edu/428727.html.

20 Appendix

[Extra information if required —SS]