Chess XIV

Software Specification

Team 1

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Glossary

AI: Artificial Intelligence

GUI: Graphical User Interface

Model: The set of modules responsible for the rules and logic of program

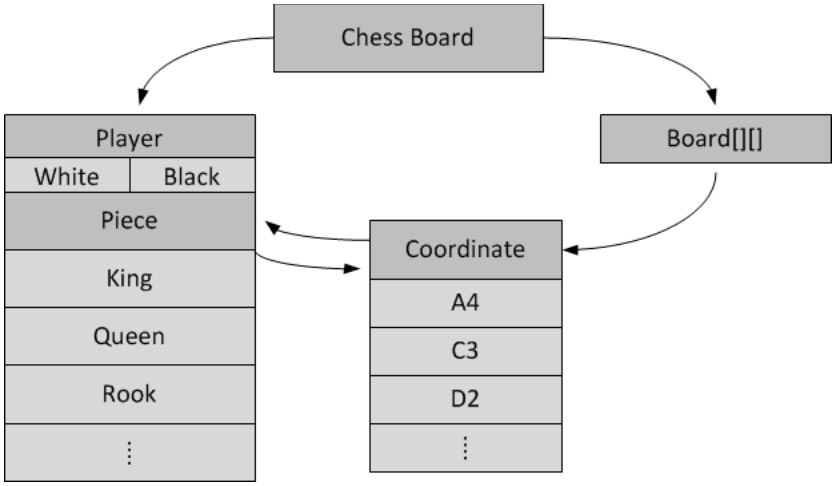
Control: The set of modules responsible for program flow

View: The set of modules responsible for program display

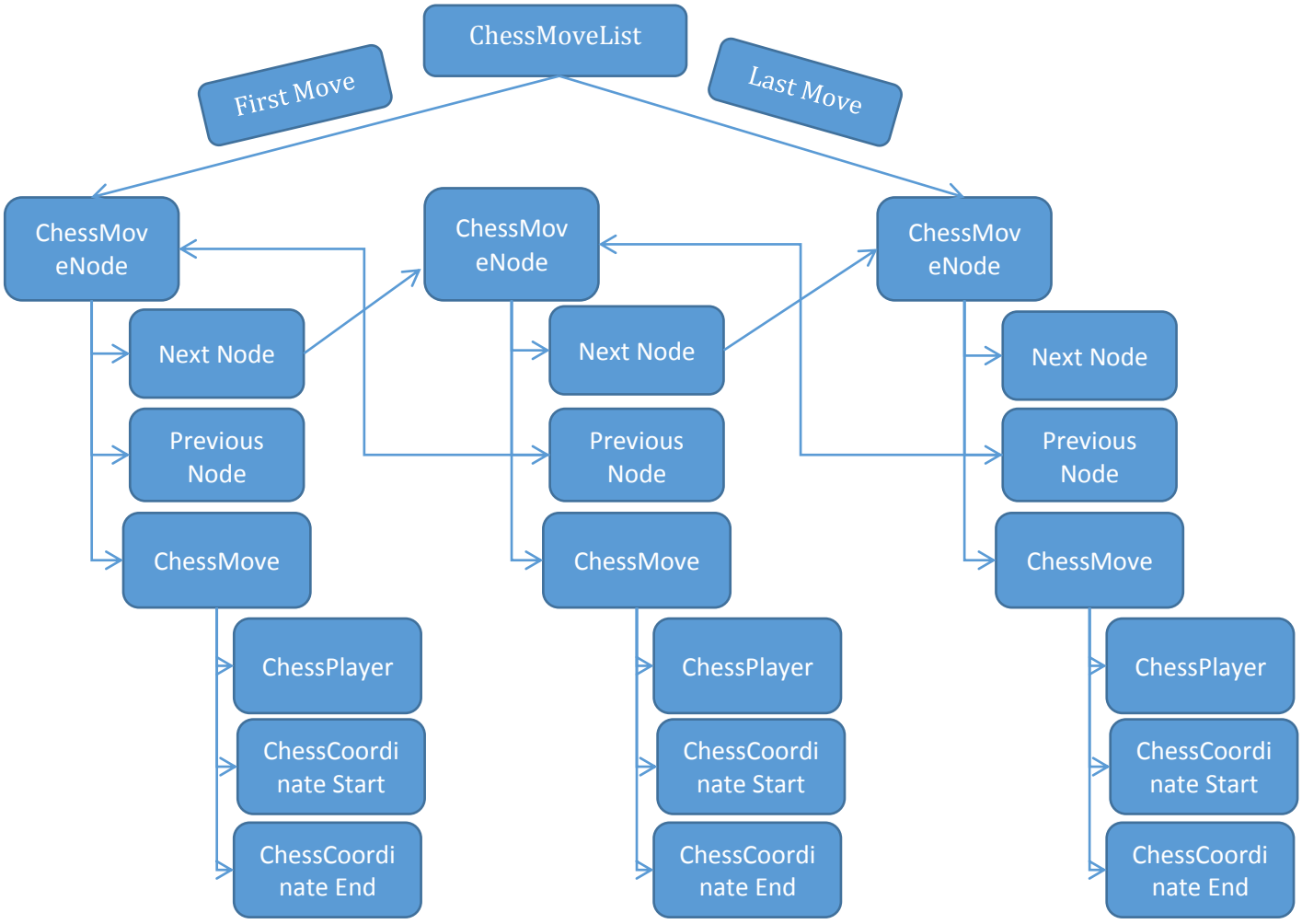
1: Software architecture overview

1.1 Main data types and structures

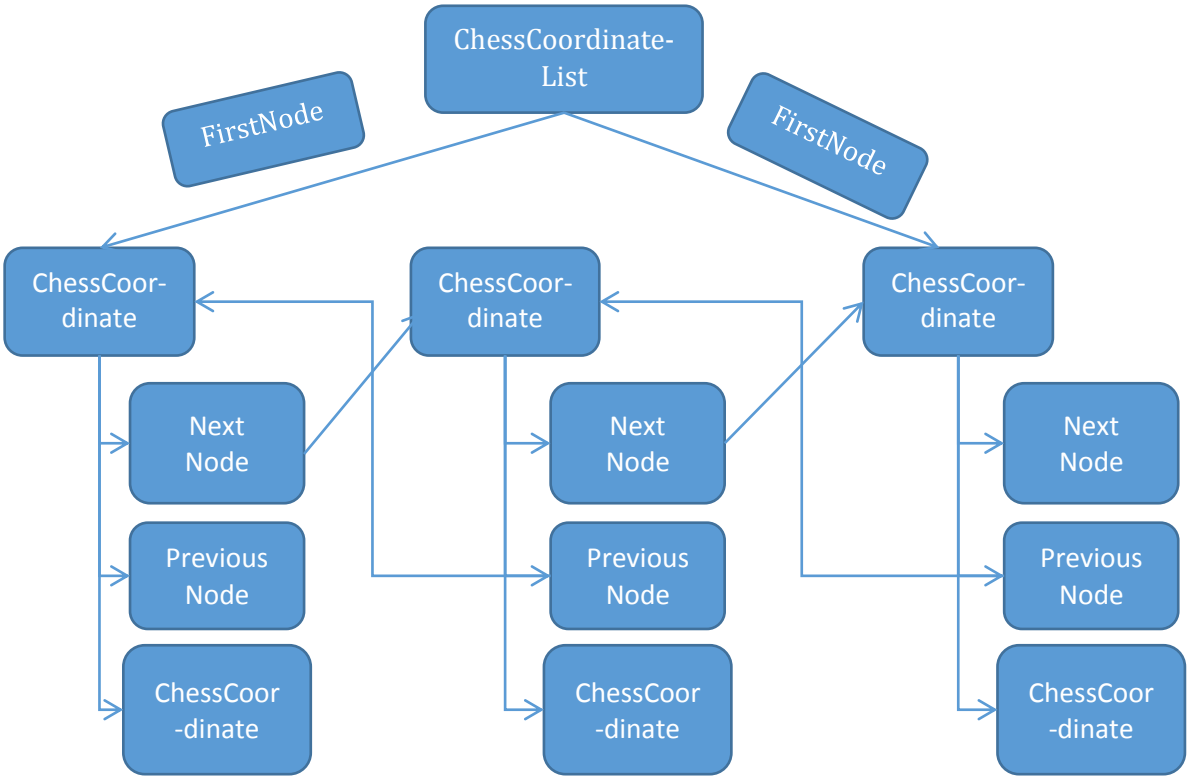
ChessBoard



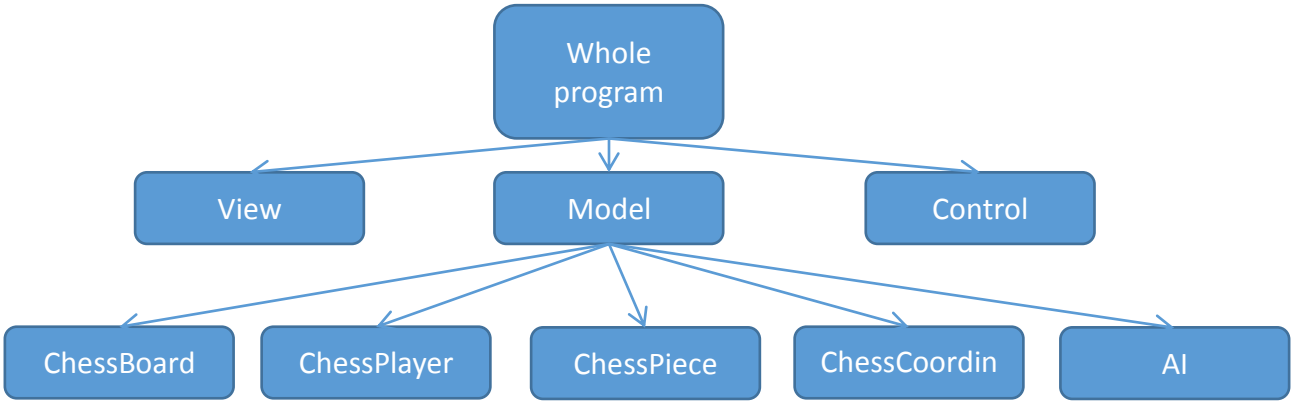
ChessMoveList



ChessCoordinateList



1.2 Major software components



1.3 Module interfaces

Model module:

ChessBoard* Model_Initialize(void);

ChessBoard* Model_PerformMove(ChessBoard*, ChessMoveList*, ChessMove*);

ChessBoard* Model_UndoLastMove(ChessBoard*, ChessMoveList*);

int Model_CheckLegalMove(ChessBoard*, ChessMove*);

ChessCoordinateList * Model_GetLegalCoordinates(ChessBoard*, ChessPiece*, ChessPlayer*, ChessMoveList*);

ChessCoordinateList * Model_GetAllLegalCoordinate(ChessBoard*, ChessPlayer *, ChessPlayer *, ChessMoveList*);

ChessBoard* Model_duplicateChessBoard(ChessBoard*, ChessBoard*);

ChessMove* Model_GetBestMove(ChessBoard*, ChessPlayer*);

int Model_CheckStalemate(ChessBoard*, ChessPlayer*, ChessMoveList*);

int Model_CheckCheckmate(ChessBoard*, ChessPlayer*, ChessMoveList*);

int Model_CheckCheckedPosition(ChessBoard*, ChessPlayer*, ChessMoveList*);

ChessBoard* Model_CleanUp(ChessBoard*, ChessPlayer*);

void SaveLog(ChessMoveList *, char *);

View module:

PlayerControlEnum AskPlayerControl(ChessPlayer *);

AIDifficultyLevel AskAIDifficultyLevel(void);

void DisplayChessBoard(ChessBoard *);

void HighlightCoordinates(ChessBoard *, ChessCoordinateList *);

Event * View_GetEvent(void);

Boolean AskSaveLog(char *);

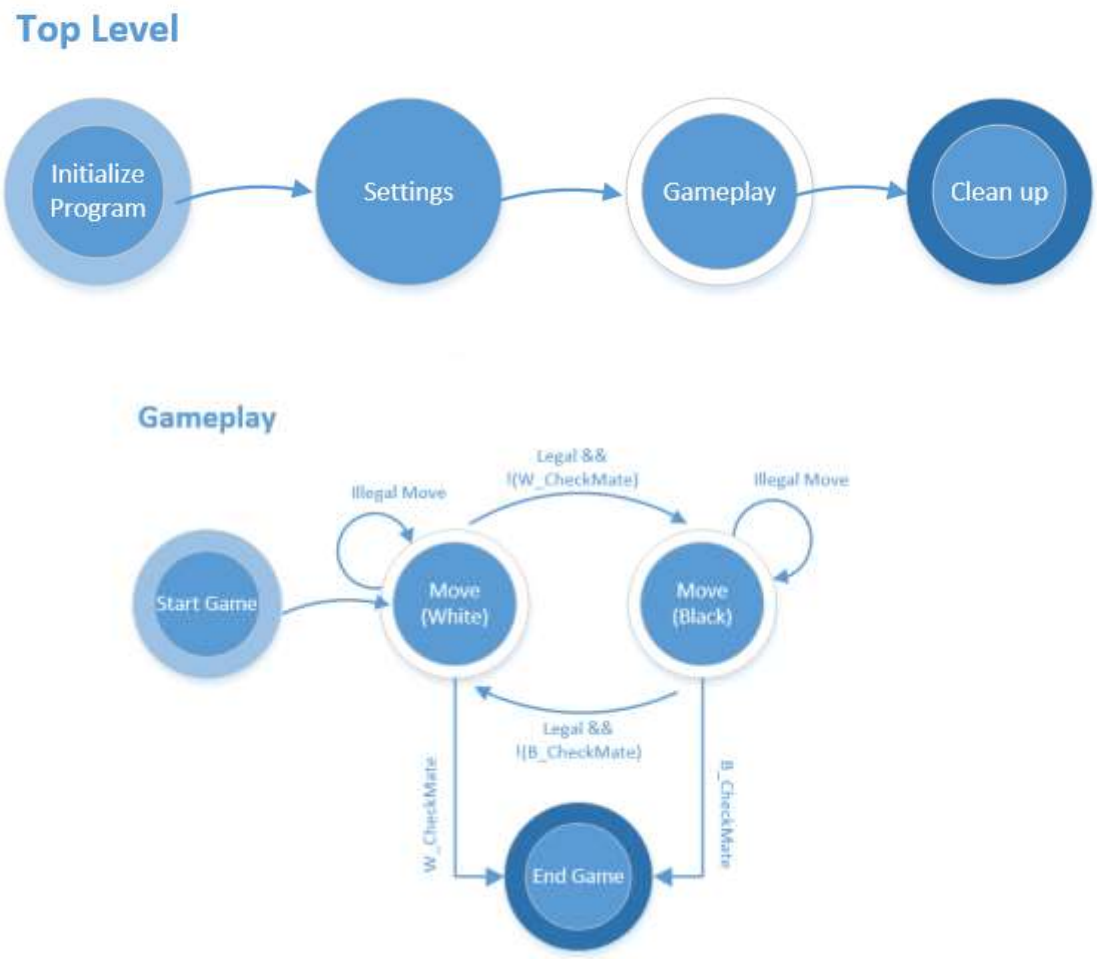
Control module:

void Control_Initialize(void);

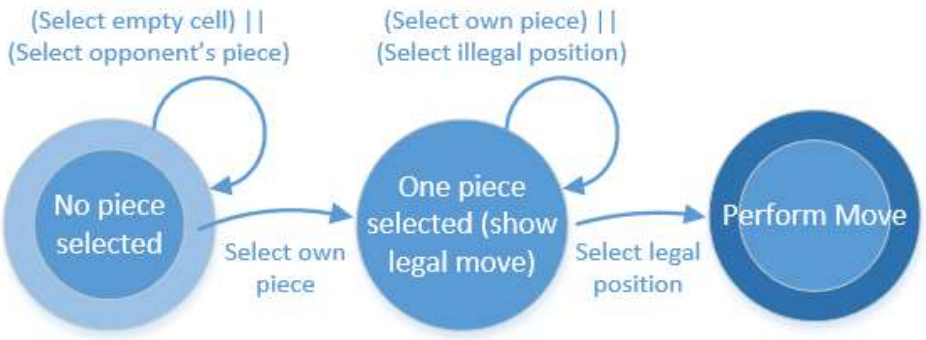
void Control_MainLoop(void);

void Control_CleanUp(void);

1.4 Overall program control flow



Move


(Select empty cell) ||
(Select opponent's piece)
(Select own piece) ||
(Select illegal position)
No piece selected
Select own piece
One piece selected (show legal move)
Select legal position
Perform Move

2: Installation

2.1 System Requirement

- Hardware: PC Hardware (x86_64 server)
- Operating system: Linux OS (RHEL-6-x86_64)
- Dependent third party software:
  i. gcc
  ii. GNU make
- Dependent libraries:
  i. SDL for graphical user interface: SDL2, SDL2_img, SDL2_gfx, SDL2_ttf, SDL2_mixer
  ii. Math library

2.2 Setup and Configuration

- SDL library installation: details are shown at http://libsdl.org

2.3 Building, compilation, installation

- The software comes in a tar.gz package. After downloading, extract the package by running:
  tar –zxvf ChessXIV.tar.gz
- Change into the directory by running:
  cd ChessXIV
- Compile the code by running:
  make
- Run the program by running:
  ./ChessXIV

3: Documentation of packages, modules, interfaces

3.1 Detailed description of data structures

Structures related to Chess game play:

```
typedef enum {Pawn, Rook, Knight, Bishop, Queen, King, None}  ChessPieceTypeEnum;

typedef enum {Human, AI}        PlayerControlEnum;
typedef enum {White, Black}        PlayerColorEnum;
typedef enum {Normal, EnPassant, Castling, Transformation}  ChessMoveTypeEnum;

typedef enum {False, True}       Boolean;

typedef struct {
  ChessCoordinate * Board[CHESS_BOARD_MAX_ROW][CHESS_BOARD_MAX_COL];
  ChessPlayer * WhitePlayer, * BlackPlayer;
} ChessBoard;
```

Description: ChessBoard hold all player, piece and coordinates

```
struct ChessCoordinateStruct {
  unsigned char Rank, File;
  ChessPiece * Piece;
  ChessBoard * MainBoard;
};
```

Description: ChessCoordinate hold the rank, file and the piece occupying that coordinate

```
struct ChessCoordinateListStruct {
  ChessCoordinateNode * FirstNode, * LastNode;
};
```

Description: Holds a linked list of ChessCoordinateNodes to generate possible move list

```
struct ChessCoordinateNodeStruct {
  ChessCoordinateNode * NextNode, * PrevNode;
  ChessCoordinate * Coordinate;
  ChessCoordinateList * List;
};
```

Description: Nodes for ChessCoordinateListStruct that point to coordinates to generate possible move list

```
struct ChessPlayerStruct{
    PlayerColorEnum      PlayerColor;
    AIDifficultyLevel    AIDifficulty;
    PlayerControlEnum    PlayerControl;
    time_t StartTime;
    double ElapsedTime;
    ChessPlayer * OtherPlayer;

    /*list all the pieces that could belong to a player*/
    ChessPiece * Pieces[16];
};
```

Description: ChessPlayer holds player color, player control (AI or human), start time of last move, total elapsed time so far, an array of all its pieces, and a pointer to the opponent

```
struct ChessPieceStruct{
    ChessPieceTypeEnum      Type;
    unsigned char           Index;
    ChessPlayer *           Player;
    ChessCoordinate *       Coordinate;
    Boolean                 AliveFlag;
    int                     MoveFirstFlag;
```

};

Description: ChessPiece holds the coordinate it stays, the index to distinguished with other pieces of same type, the player it belongs to, a counter to keep track of how many times it has moved (mostly used to check if opening move of piece) and alive flag to let people know it's alive

```
struct ChessMoveStruct{
    ChessPiece *          MovePiece;
    ChessCoordinate * StartPosition;
    ChessCoordinate * NextPosition;
    ChessPiece *          CapturePiece;
    Boolean CaptureFlag;
    Boolean check;
    ChessMoveTypeEnum       MoveType;
    ChessPieceTypeEnum Transform_IntoType;
};
```

Description: ChessMove holds the piece that moves, the start and end coordinates, if a piece is being captured, and what type of move it is (normal move versus special move such as en passant)

```
struct ChessMoveNodeStruct{
    ChessMoveList * PrevMove;
    ChessMoveList * NextMove;
    ChessMove * Move;
    ChessMoveList * List;
};
```

Desciption: Nodes for ChessMoveListStruct

```
Struct ChessMoveListStruct {
    ChessMoveNode * FirstNode, * LastNode;
};
```

Desciption: ChessMoveListStruct is the double linked list of Chess Move, used to display move history or undo last move

Data structures to communicate between View and Control:

typedef enum {SelectCoordinate, UndoMove} EventTypeEnum;

typedef struct {

    EventTypeEnum EventType;

    ChessCoordinate * Coordinate;

    ChessPlayer * Player;

} Event;

Description: This structures allows information passing between View and Control

3.2 Detailed description of functions and parameters

Model Module:

ChessBoard* Model_Initialize(void);

Description: Initializes the model by creating a ChessBoard.

ChessBoard* Model_PerformMove(ChessBoard*, ChessMoveList*, ChessMove*);

Description: Takes in the current board and a move and returns the board after the move is performed. This function increments the move counter by piece, appends to the ChessMoveList, and takes care of captures by updating the necessary fields of pieces involved.

ChessBoard* Model_UndoLastMove(ChessBoard*, ChessMoveList*);

Description: Gives the user the option to undo the previous move. Is able to restore all values to previous state (such as the alive flag of captured pieces and previous state if a transformation occurs).

int Model_CheckLegalMove(ChessBoard*, ChessMove*);

Description: Boolean function to check if the move entered is valid based on the current board and the piece at the position given.

ChessCoordinateList * Model_GetLegalCoordinates(ChessBoard*, ChessPiece*, ChessPlayer*, ChessMoveList*);

Description: Returns a list of possible coordinates for a particular piece specified by the function parameters. Also inputs the player in turn to properly return the possible spaces of the king (to avoid suicides for the player in turn).

ChessCoordinateList * Model_GetAllLegalCoordinate(ChessBoard*, ChessPlayer *, ChessPlayer *, ChessMoveList*);

Description: Calls Model_GetLegalCoordinates to form a list of all possible spaces in any particular turn.

ChessBoard* Model_duplicateChessBoard(ChessBoard*, ChessBoard*);

Description: Duplicates the chess board to simulate a move.

ChessMove* Model_GetBestMove(ChessBoard*, ChessPlayer*);

Description: Gives the 'best move' as determined by the program. Can be used to generate the next move for the computer and also as a hint for the human player.

int Model_CheckStalemate(ChessBoard*, ChessPlayer*, ChessMoveList*);

Description: Boolean function to check if the board is in stalemate based on the player in turn.

int Model_CheckCheckmate(ChessBoard*, ChessPlayer*, ChessMoveList*);

Description: Boolean function to check if the board is in checkmate for the player in turn.

int Model_CheckCheckedPosition(ChessBoard*, ChessPlayer*, ChessMoveList*);

Description: Boolean function to check if the current player in turn is in check.

ChessBoard* Model_CleanUp(ChessBoard*, ChessPlayer*);

Description: Cleans the board

void SaveLog(ChessMoveList *, char *);

Description: Save the MoveList to a log file

View Module:

View(View.c, View.h):

PlayerControlEnum AskPlayerControl(ChessPlayer *);

Description: Ask the user for the control of White player and Black player. Return Human or AI

AIDifficultyLevel AskAIDifficultyLevel(void);

Description: If user selected AI, ask for AI difficulty level. Return one of three options: Easy, Medium or Difficult

void DisplayChessBoard(ChessBoard *);

Description: Take a chessboard structure and display it on the screen

void HighlightCoordinates(ChessBoard *, ChessCoordinateList *);

Description: Highlight Coordinate in Coordinate List on the board

Event * View_GetEvent(void);

Description: Wait for user to make an event and return the event handler

Boolean AskSaveLog(char *);

Description: Ask the user if he/she wants to save a log file. If yes then ask for file name

Render (render.c, render.h)

SDL_Texture *loadTexture(const char *fileName, SDL_Renderer *renderer);

Description: loads an image from the filename parameter into the renderer. Upon success, a texture is returned; returns NULL if the load fails.

void renderTexture(SDL_Texture *texture, SDL_Renderer *renderer, int x, int y, int w, int h);

Description: appends a texture to a destination rect at the coordinates x and y. This function is used when a specific width and height (scaling) for the texture is desired, which is indicated by the w and h parameters.

void renderTexture2(SDL_Texture *texture, SDL_Renderer *renderer, int x, int y);

Description: appends a texture to a destination rect at the coordinates x and y. This function is used when preservation of the size of the texture is desired; no scaling of the image in the texture.

SDL_Texture *renderText(const char *message, const char fontFile, SDL_Color color, int fontSize, SDL_Renderer *renderer);

Description: loads a .ttf font file, renders it in the specified color and size, and renders a message to a surface. Returns a texture on success, and returns NULL otherwise.

Display (display.c, display.h)

void drawMainMenu(SDL_Renderer *renderer);

Description: renders the main menu graphics assets; this includes background image and all menu text.

void drawOnePlayerMenu(SDL_Renderer *renderer);

Description: renders the graphics assets for the one-player options menu; this includes background image and all text.

void drawTwoPlayerMenu(SDL_Renderer *renderer);

Description: renders the graphics assets for the two-player options menu; this includes background image and all text.

void drawAdvancedMenu(SDL_Renderer *renderer);

Description: renders the graphics assets for the advanced options menu; this includes background image and all text.

void drawGameplayScreen(SDL_Renderer *renderer, int mode, int time);

Description: renders the graphics assets for the gameplay screen; this includes sub-menus, counters, and all text.

void drawChessboard(SDL_Renderer *renderer);

Description: uses SDL primitive rendering to draw and color the chessboard.

void drawPieces(SDL_Renderer *renderer);

Description: renders the chess piece images to a texture, and then renders them to the chessboard at starting position.

void drawError_p1_Options(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the user selects play in a one-player option menu without selecting all relevant options.

void drawError_p2_Options(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the user selects play in a two-player option menu without selecting all relevant options.

void drawError_kbd_Input(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the user attempts non-standard notation or incomplete keyboard inputs.

void drawError_mouse_Input(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the user attempts to move piece off the board with the mouse.

void drawError_IllegalMove(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the user commits an illegal move.

void drawWarning_BlackInCheck(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the black king is in check.

void drawWarning_WhiteInCheck(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the white king is in check.

void drawMessage_time_BlackWins(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the white timer runs out and black wins.

void drawMessage_time_WhiteWins(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when the black timer runs out and white wins.

void drawMessage_mate_BlackWins(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when white is checkmated.

void drawMessage_mate_WhiteWins(SDL_Renderer *renderer);

Description: renders a background color and an error message in a floating window. This is invoked when black is checkmated.

Control module:

void Control_Initialize(void);

Description: This function initializes Model and View and get things started.

void Control_MainLoop(void);

Description: Run the main program

Void Control_CleanUp(void);

Description: Close windows and free all used memory then quit

3.3 Detailed description of input and output formats

Syntax/format of a move input by the user:

Move input by user is recorded by the computer as mouse click on the GUI. A click on the board will be translated into a coordinate and the program will perform computational logic on it.

Syntax/format of a move recorded in the log file:

The log file will keep track of the moves in accordance to the algebraic notation. Example of what it would look like is on the wikia page:
http://en.wikipedia.org/wiki/Algebraic_notation_%28chess%29

3.4 Detailed description of artificial intelligence for computer player

The artificial intelligence machine will consist of three different difficulties: beginner, intermediate, advanced.

The beginner difficulty's aim is to familiarize the player with the basic operations of chess and nothing more. The beginner artificial intelligence setting will consist of selecting a move from LegalChessMoves[] using a random number generator. The random number generator will be using the time of day as a seed, so that the moves do not become repetitive.

The intermediate difficulty's aim is to test the player's ability to handle pressure. It will make its selection from LegalChessMoves[] by selecting the most aggressive move. The algorithm for the most aggressive move will be detailed below.

The advanced difficulty's aim is to test the player's deeper understanding of the game, and will be more similar with a human player. The advanced difficulty and the intermediate difficulty will be sharing an algorithm that will rate each move from LegalChessMoves[] based on aggressiveness and defensiveness. The algorithm for calculating the level of aggression and defense of each move will be utilizing an "InCheck" variable and "PieceValue" variable from the "ChessPiece" structure. The "PieceValues" for each piece are as follows:

Pawn: 1

Knight: 3

Bishop: 3

Rook: 5

Queen: 9

King: 1000000

The most aggressive move will be calculated based on the number of enemy pieces the move places "InCheck", which will be multiplied to the piece values for each piece that is placed "InCheck". The most defensive move will be calculated based on the number of friendly pieces the move places "!InCheck" and this will be multiplied with the piece values for the pieces that are being protected as well as factoring in the value of the piece that is protecting the pieces to avoid a queen protecting a pawn the whole game. The advanced difficulty will sum up the aggressiveness and defensiveness of each move and select the one that has the higher sum, as opposed to the intermediate difficulty which only checks for aggressiveness.

4: Development plan and timeline

4.1 Partitioning of tasks

The whole program will be divided into four main areas:

- Gameplay: All functionality of a chess program such as move, undo, checkmate, check

- AI: The intelligence behind the computer-generated moves

- GUI: The display of program for user

- Control and Integration: Program flow and integration between modules

4.2 Team member responsibilities

As discussed above, four areas will be responsible by the following team members:

- Gameplay: Hanchel Cheng, Kevin Duong and Jamie Lee
- AI: Andrew Trinh
- GUI: Ryan Morrison
- Control and Integration: Quan Chau

4.3 Timeline

By January 27:

- Finish Command line output
- Finish basic moves, excluding castling, transforming and en passant
- King can not commit suicide
- Support Undo

By February 3:

- Finish GUI output
- Finish castling, transforming and en passant
- Finish AI
- Support Move history record

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