



Chess XIV

Software Specification

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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

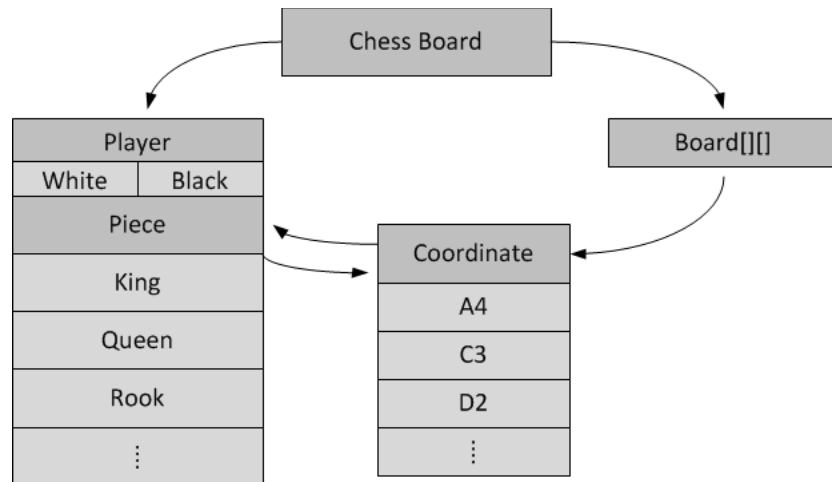
Control: The set of modules responsible for program flow

View: The set of modules responsible for program display

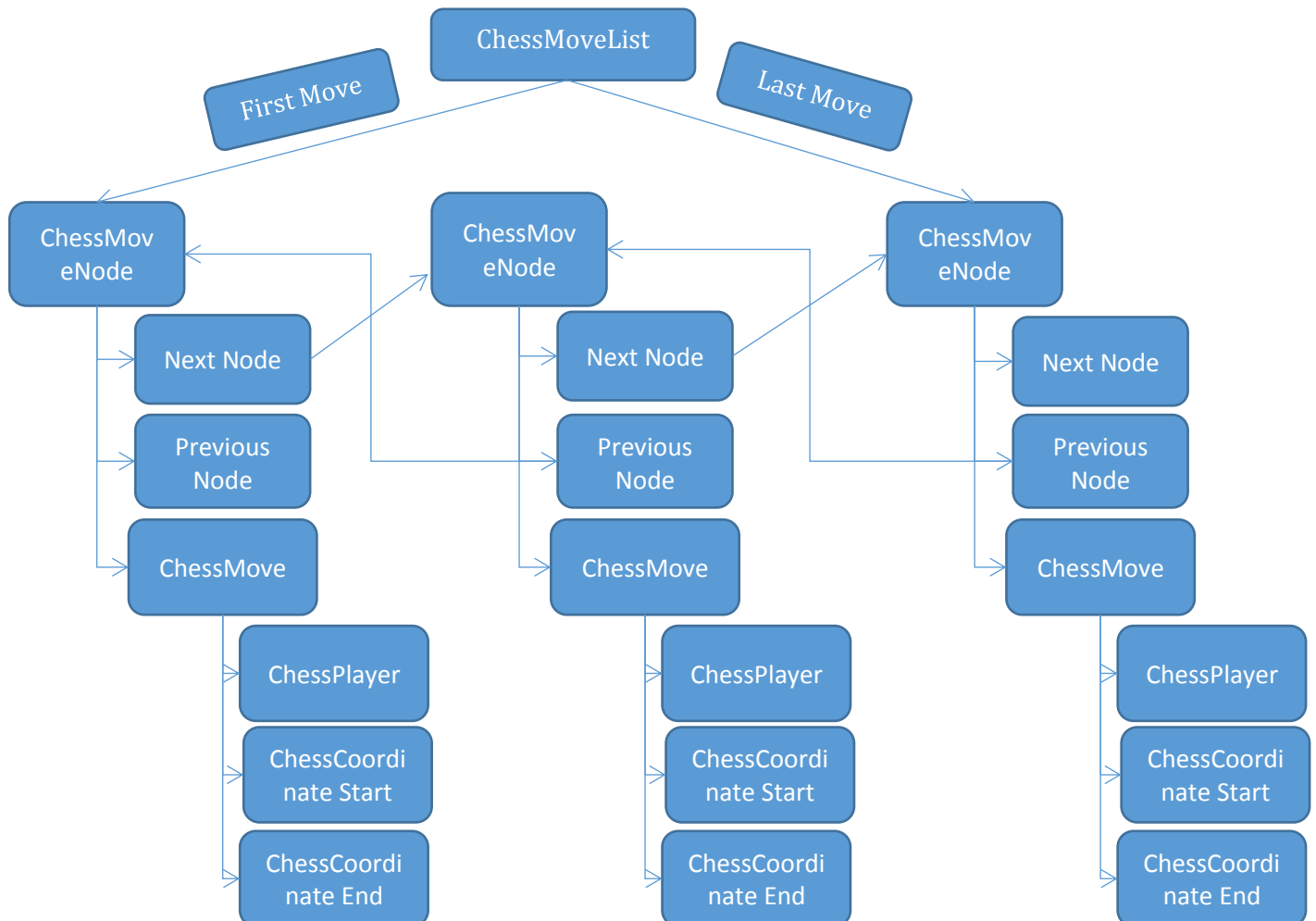
1: Software architecture overview

1.1 Main data types and structures

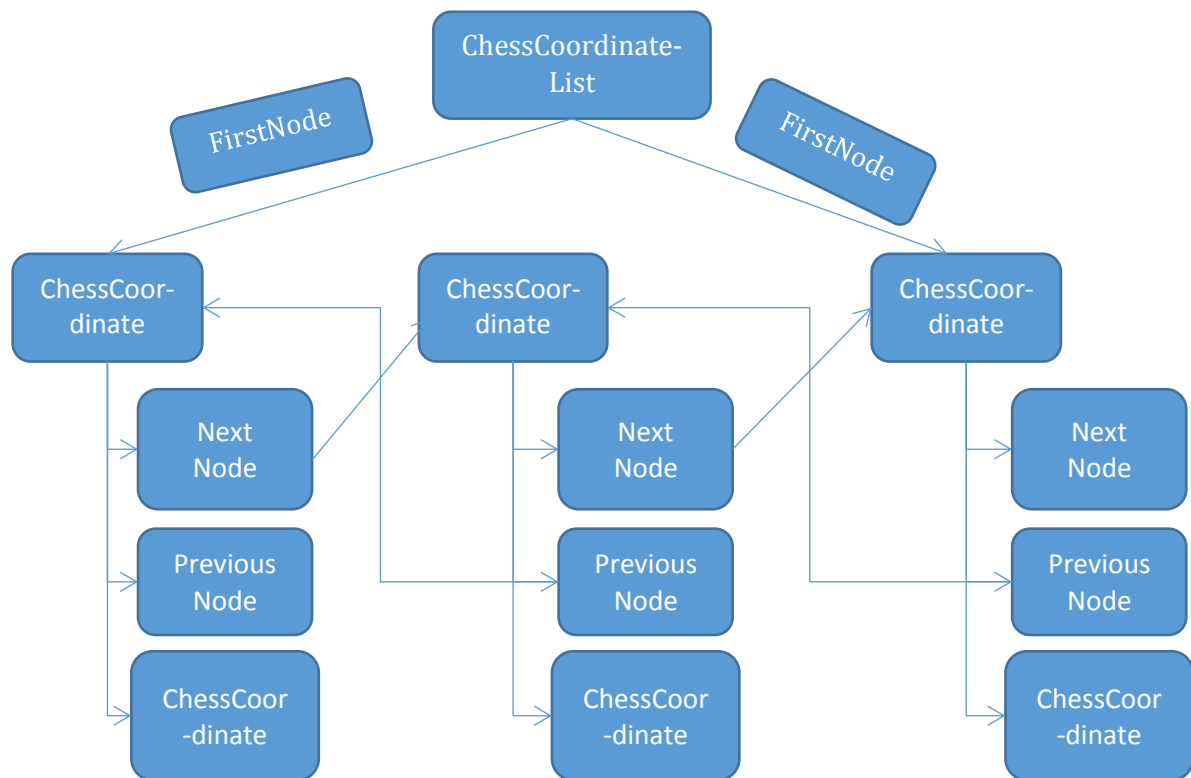
ChessBoard



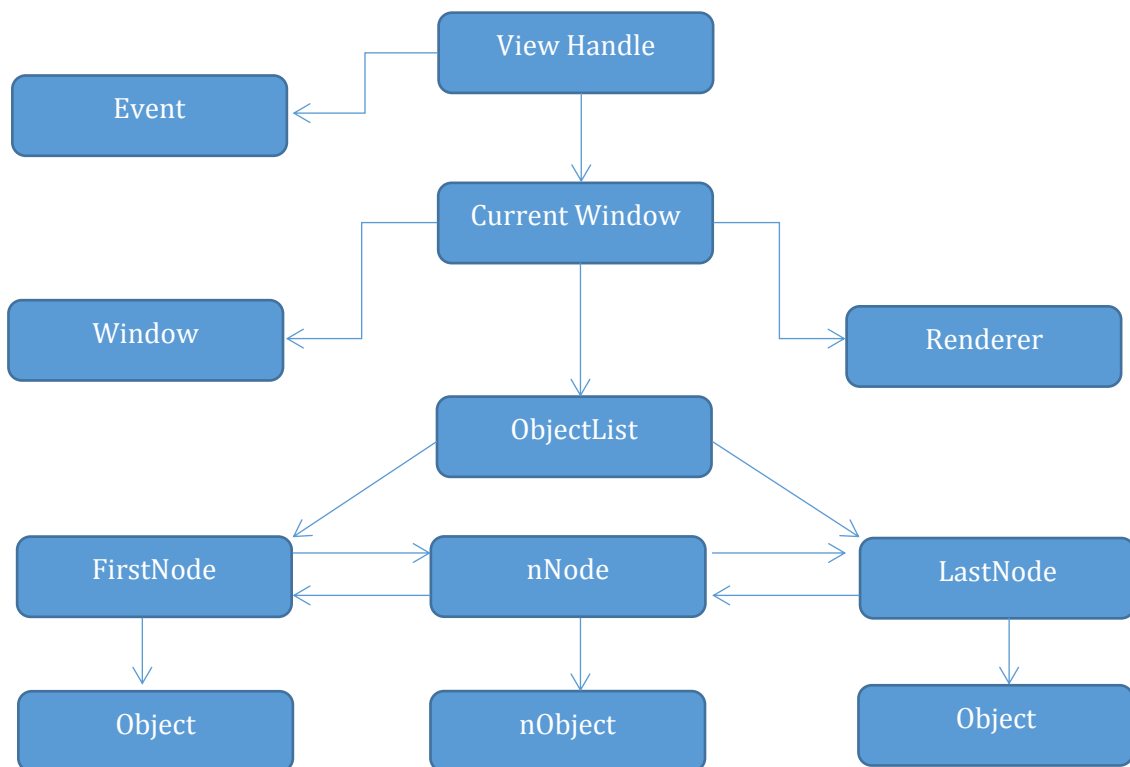
ChessMoveList



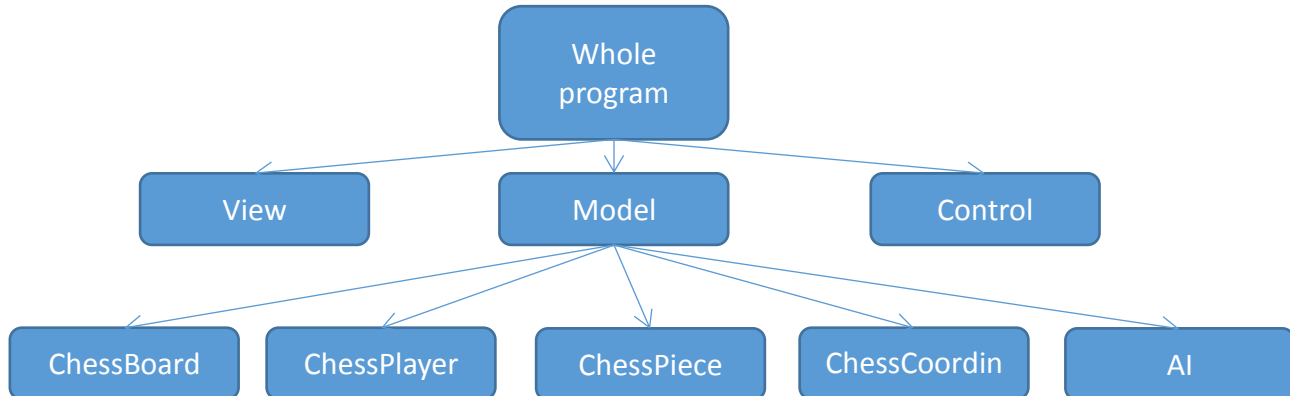
ChessCoordinateList



View



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*);

int writeToLogFile(char fname[100], ChessMoveList *);ChessMoveTypeEnum
Model_GetMoveType(ChessBoard * board, ChessMove *move);
```

View module:

```
ViewHandle * View_Initialize(void);

ViewHandle * View_CleanUp(ViewHandle *);
```

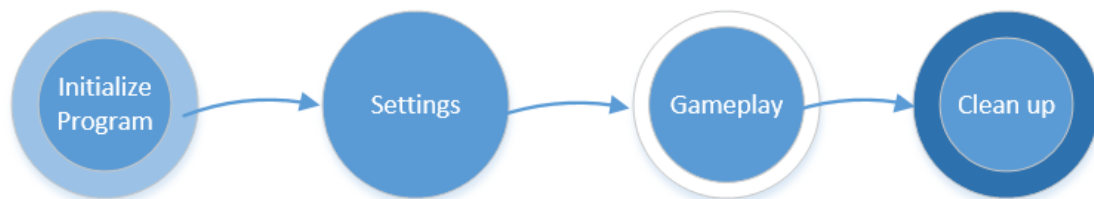
```
Event * SetOptions(ViewHandle *, ChessBoard *);  
  
void DisplayChessBoard(ViewHandle * MainViewHandle, ChessBoard * MainBoard);  
  
void HighlightCoordinates(ViewHandle * MainViewHandle, ChessBoard * MainBoard,  
ChessCoordinateList * CoordList);  
  
Event * View_GetEvent(ViewHandle * MainViewHandle, ChessBoard * CurrBoard, Event *);  
  
void View_DisplayEvent(ViewHandle * MainViewHandle, ChessBoard * CurrBoard, Event *);  
  
void View_ConcludeGame(ViewHandle * MainViewHandle, ChessPlayer *);  
  
Event * View_AskMoveTransform(ViewHandle * MainViewHandle, ChessPlayer *  
ChessPlayerAsking);
```

Control module:

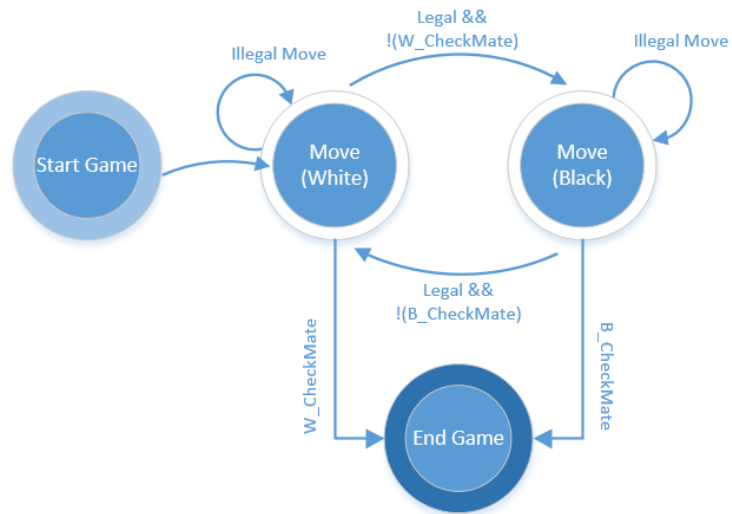
```
void Control_Initialize(void);  
  
void Control_MainLoop(void);  
  
void Control_CleanUp(void);
```

1.4 Overall program control flow

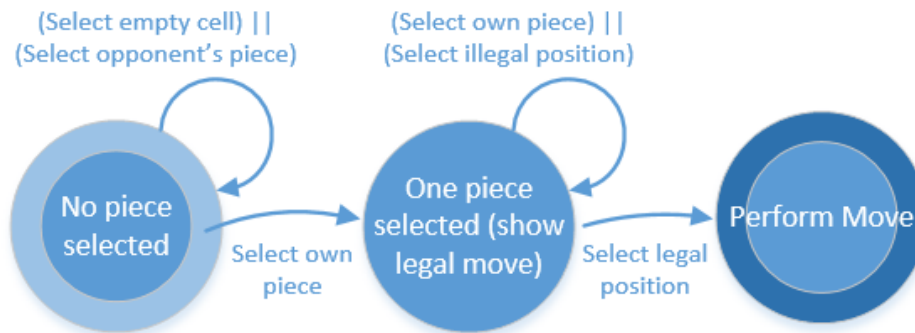
Top Level



Gameplay



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`

A) To compile the command line (ASCII) version of the program:

- Compile the code by running:
`make clean`
`make`
- Run the program by running:
`bin/ChessXIV`

B) To compile the Graphical User Interface version of the program:

- Compile the code by running

```
setenv PKG_CONFIG_PATH $PWD/SDL2_Library/lib/pkgconfig
```

```
make clean
```

```
make GUI_ENABLE=y
```

- Run the program by running

```
bin/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;
};
```

Description: Nodes for ChessMoveListStruct

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

Description: 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 {NoEvent, SelectCoordinate, UndoMove, Exit, AskTransform, Checkmate, Stalemate,\n             ButtonClicked, CoordinateClicked, PieceClicked, InCheck\n} EventTypeEnum;
```

Description: Types of event that could be passed between View and Control

```
typedef struct {\n    EventTypeEnum Type;\n    ChessCoordinate * Coordinate;\n    ChessPlayer * Player;\n    ChessPieceTypeEnum PieceType;\n    ObjectHandle * Object;\n} Event;
```

Description: Event struct contains information needed for an event to be understood by other modules

```
typedef enum {Color, Image, Text, Button, Piece, Coordinate, Outline} ObjectType;\n\ntypedef enum {\n    Option_OnePlayer, Option_TwoPlayer, Option_AlvsAI,           \\\n    Option_Black, Option_White,                                 \\\n    Option_EasyAI, Option_MediumAI, Option_DifficultAI,         \\\n    Option_PlayButton, \\\n    Title, Background, \\\n    PieceObject,  \\\n    Label_Color, Label_Difficulty,  \\\n    Option_Undo, Option_Quit, \\\n    Box, \\\n    Square, CaptureCount, Player_Label, Timer, StatusText, TransformPiece, CoordLabel\n} ObjectTagEnum;
```

Description: the Object properties that will help in identifying and updating them

```
struct ObjectHandleStruct {\n    /*id info*/
```

```

        ObjectType                Type;
        ObjectTagEnum             Tag;
        EventTypeEnum             Event;
        int                       Index;

        /*location information*/
        int X,Y, Width, Height;

        /*texture to change*/
        SDL_Texture * Texture;

        /*information only apply to certain types*/
        /*Image*/char * ImageFileName;

        /*Text and button*/int TextSize; char * FontName; char * String;

        /*color, coordinate or outline*/SDL_Color Color; int hexR; int hexG; int hexB; int hexA;

        /*coordinate*/int Rank, File;

        /*piece type*/
        ChessPieceTypeEnum PieceType;

        PlayerColorEnum           PlayerColor;
};

```

Description: Object Struct holds graphical information needed to render the object

```

typedef struct ObjectHandleNodeStruct ObjectHandleNode;

struct ObjectHandleNodeStruct {
    ObjectHandleNode * PrevNode, * NextNode;
    ObjectHandle * Object;
};

typedef struct {
    ObjectHandleNode * FirstNode, * LastNode;
} ObjectHandleList;

```

Description: ObjectHandleNode and ObjectHandleList helps manage many objects

```

typedef struct {

```

```

        SDL_Window * Window;

        SDL_Renderer * WindowRenderer;

        ObjectHandleList * ObjectList;
    } WindowHandle;

```

Description: Window handle keeps track of current window, the renderer and all objects under it

```

typedef struct {
    ChessPlayer    * CurrentPlayer;

    WindowHandle * CurrentWindow;

    Event * ViewHandleEvent;
} ViewHandle;

```

Description: ViewHandle keep track of events passing between View and Control and also the current window

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.

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

int writeToLogFile(char fname[100], ChessMoveList *);

Description: Save the MoveList to a log file

ChessMoveTypeEnum Model_GetMoveType(ChessBoard * board, ChessMove *move);

Description: Returns the move type.

View Module:

View(View.h):

ChessPlayer * CurrentPlayer;

ViewHandle * View_Initialize(void);

Description: Initialize ViewHandle

ViewHandle * View_CleanUp(ViewHandle *);

Description: Initialize ViewHandle

Event * SetOptions(ViewHandle *, ChessBoard *);

Description: Let users select options for player control and color

void DisplayChessBoard(ViewHandle * MainViewHandle, ChessBoard * MainBoard);


```
void HighlightCoordinates(ViewHandle * MainViewHandle, ChessBoard * MainBoard,,
    ChessCoordinateList * CoordList);;
```

```
Event * View_GetEvent(ViewHandle * MainViewHandle, ChessBoard * CurrBoard, Event *);
```

```
void View_DisplayEvent(ViewHandle * MainViewHandle, ChessBoard * CurrBoard, Event *);
```

Description: Display Event sent from Control

```
void View_ConcludeGame(ViewHandle * MainViewHandle, ChessPlayer *);
```

Description: Conclude the game

```
Event * View_AskMoveTransform(ViewHandle * MainViewHandle, ChessPlayer *
ChessPlayerAsking);
```

Description: In case of transforming, ask player which piece to transform to

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(ViewHandle * MainHandle);
```

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

```
void drawOnePlayerMenu(ViewHandle * MainHandle);
```

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

```
void drawChessBoard(ViewHandle * MainHandle);
```

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

```
void drawTransformWindow(ViewHandle * MainHandle, PlayerColorEnum color);
```

Description: draw Window to ask user which piece to transform to

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 prioritizing moves that perform a piece capture.

The advanced difficulty's aim is to test the player's ability to make smart trades. It will first attempt to perform a scholar's mate, and then it will proceed like the intermediate ai except it will prioritize capturing more valuable pieces.

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

4.4 Test plan

1.GUI test plan:

- Test drawing Main menu
- Test drawing One player menu
- Test drawing Main Game screen
 - Test updating the grave yard
 - Test updating the pieces on the board for every turn
 - Test displaying messages such as checkmate, in check
- Test drawing Transform piece menu

2.Control test plan:

Test Control Main loop with getting events in the middle of the loop to Undo and Exit

3. Model test plan:

- Test three special moves: Castling, Transforming and En Passant for GetLegalCoordinates, PerformMove and Undo Move
- Test log file writing
- Test AI vs player and AI vs AI
- Test Undo for all cases

Back Matter

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