Verbose Matrix/Vector Notation

By: Kyle L.

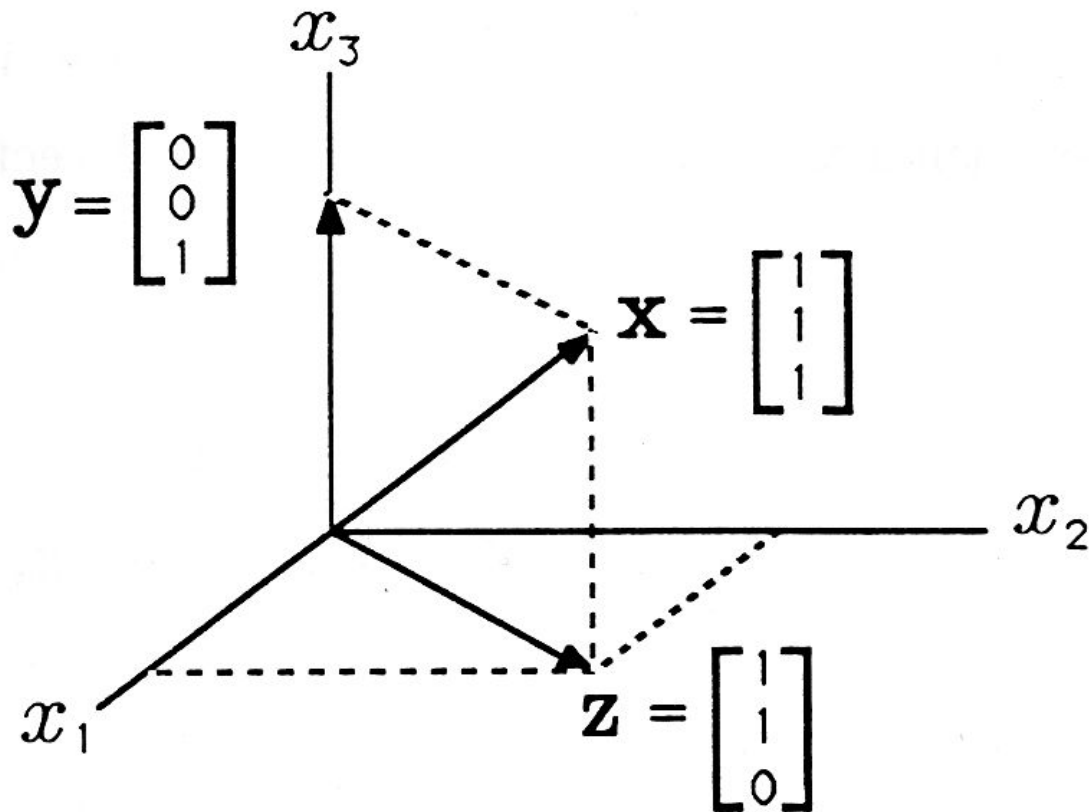My attempt to make an easy to understand but all encompassing guide. Read the simple version first.

Verbose Matrix Notation is a 5d chess notation system which concisely describes all the actions that players take on a 5d chess board. Using vectors and matrices, the actions taken on the chess board can be neatly organized so that useful information is grouped into sections. I hope that with this system, entire games in 5d chess can be easily read and understood. I assume those who read this already understand how normal chess algebraic notation works (https://en.wikipedia.org/wiki/Algebraic_notation_(chess)), have some idea on how the FEN notation works, and already know all the rules and mechanics of 5d chess. FEN notation isn't necessarily important, but can be useful for describing puzzles.

A matrix is a mathematical tool that is used to describe vectors and linear transformations. Although deep knowledge of matrices is not required to use this notation, the basics will be described in the next sections to give a very simple overview.

Note: It would be helpful to have some math and programming background as that is where I take most of my inspiration from. This system can be quite bulky(which is why it is called verbose) and is more of an experiment than something that I expect people to use.

A. Vector

In its most basic definition, a vector is a list of elements. In mathematics, they are often used to describe an arrow pointing in some direction.

$$y = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \qquad x = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \qquad z = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}$$

In the above picture you can see the three vectors x, y and z.

For the chess notation, we only need to recognize that the vector can be a list of horizontal elements or vertical elements. $- \begin{bmatrix} 1 & 2 & 3 & 4 \end{bmatrix}$ $\begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{bmatrix}$ The orientation of the elements does not matter, they Are both the same type of vector.

B. Matrix

A matrix is simply a collection of vectors

$$\begin{bmatrix} 1 & 1 & 1 \\ 2 & 2 & 2 \\ 3 & 3 & 3 \\ 4 & 4 & 4 \end{bmatrix}$$

Fig. Basic 3 by 4 matrix

For now, just imagine a matrix as an organised series of elements. Matrixes won't come up until

I start talking about how to simplify the entire 5d chess game into a single list.

C. Premise

Technically, traditional chess algebraic notation can be thought of as a vector of moves. For example -

$$\begin{bmatrix} 1.E4, \ E5 \\ 2.Nf3, \ NC6 \\ 3.BC4, \ BC5 \\ 4.C3, \ NF6 \end{bmatrix}$$

The main goal behind Verbose Matrix Notation is to create a visually appealing notation that easily explains itself. When the game is all said and done the final matrix will look similar to the actual game board. However, because the playing space expands every time a player decides to create an alternate timeline, we need two ways to write out all the moves: 1. a way to write each move turn by turn, 2. A way to compile all the information together into a single source. We need different ways to write out the notation because the number of alternate timelines of the final board is unknown.

This is why I break up my notation into turns (which can technically be written in any notation), and the final game tree. The turn by turn notation will be referred to as Verbose Vector Notation (VVN). VVN will be a little tricky to get a grasp of, but will be helpful in the long run, so I will begin by explaining the Basic Notation.

D. Basic Notation

The Basic Notation encloses the information for an action the pieces take. There are three parts of important information to the describe a single action of a piece which are:

      1. if the piece is traveling through time (Time Displacement)

      2. The name of the piece

      3. The time and location the piece ends up

Here is one simple example where I move the queen back in time, and the opponent moves a pawn -

<p align="center">2(-Q.T1.e4, c6)</p>

This is the basic structure for moves. Actual player turns have more complexity to them, but I will describe what is happening here first before I move on.

1. Time Displacement

To describe that a piece is going back or through time, I use the ' - ' symbol. It makes intuitive sense to use this symbol because that piece is being removed from that board. Additionally, I use the ' + ' symbol to denote that a piece is being added to a board using similar logic. If a piece does not move through time, it does not need to have a preceding symbol.
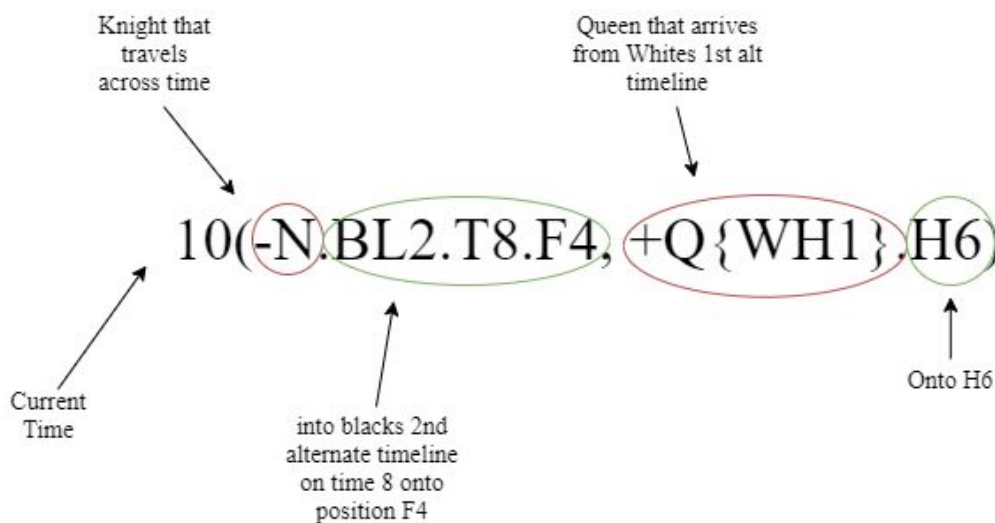
2. Piece Names

The names of the pieces are what they normally are in algebraic notation of chess, with the addition of the dragon (D) and unicorn (U) pieces. To help differentiate if two different pieces can access the same location, use curly braces ('{}') to describe what square/time the

piece was originally on. For example if a knight travels to e2 from c3 you could write the move as N{c3}e2.

3. Time And Location

The specific time and location that a piece ends up in can be split into 3 parts, but the location is the only piece that is needed if the piece does not move through time. Location is obviously done in traditional algebraic notation. Time is described by a T followed by a number to denote the number of moves away from the first original move. Finally specific alternate timelines are split between White and Black (WH, BL) followed by when it was branched. Thus, if White were to branch for his first time, that branch would be denoted as WH1. If no branch is specified, then it is assumed that it is traveling to the original timeline, which can also be denoted with an O. If there are multiple original timelines, then the original timelines can be numbered. I recommend to use a most to least general approach, starting with the time branch followed by the time and finally the location and separating each element with a period for readability.

The comma separates the white and black individual moves. The entire move is encapsulated by parenthesis and is prefixed by a number of where the timeline is for that specific move.

Knight that travels across time

Queen that arrives from Whites 1st alt timeline

10(-N.BL2.T8.F4, +Q{WH1}.H6)

Current Time

into blacks 2nd alternate timeline on time 8 onto position F4

Onto H6

Practice writing down some of these singular moves before going onto the next section, as this is the central tool for writing down all the moves. Just write down the piece which travels across time along with its new location as previously described.
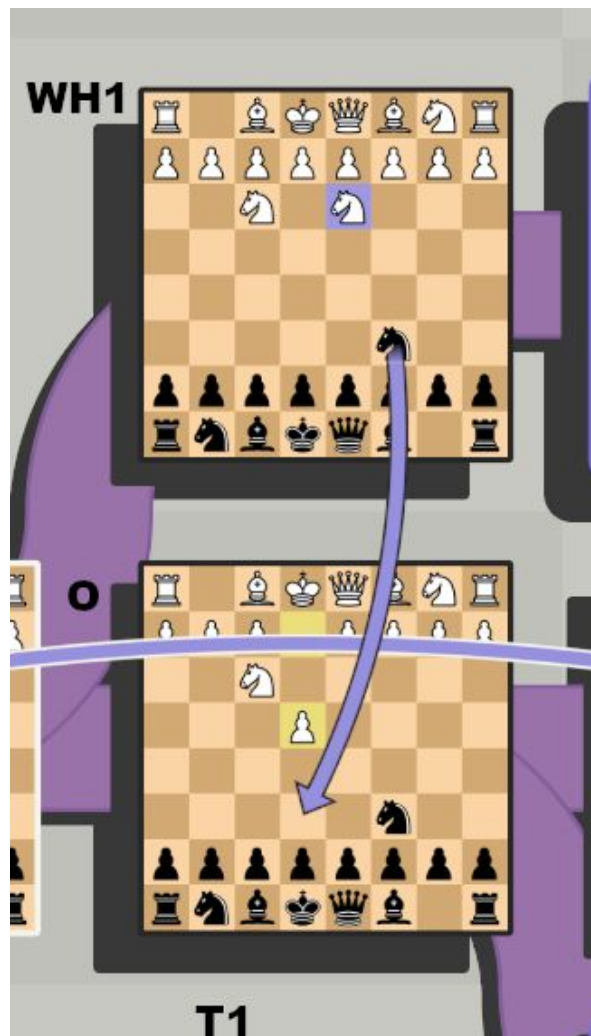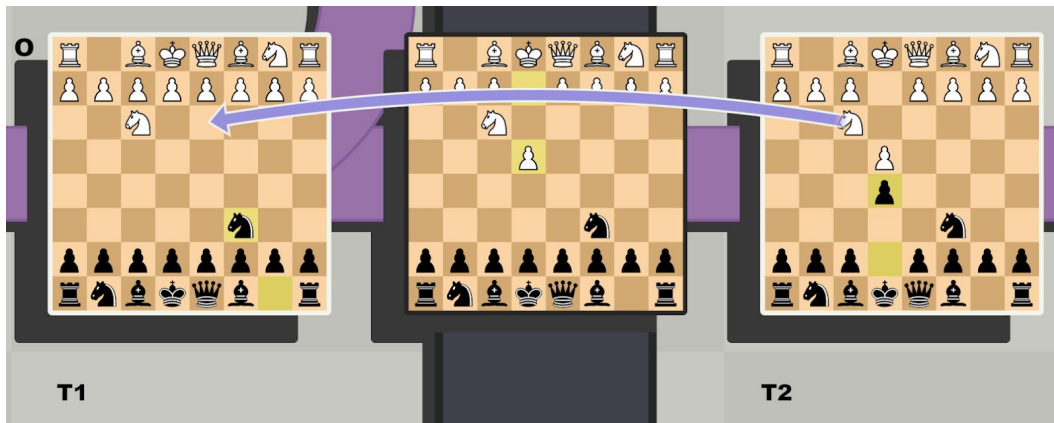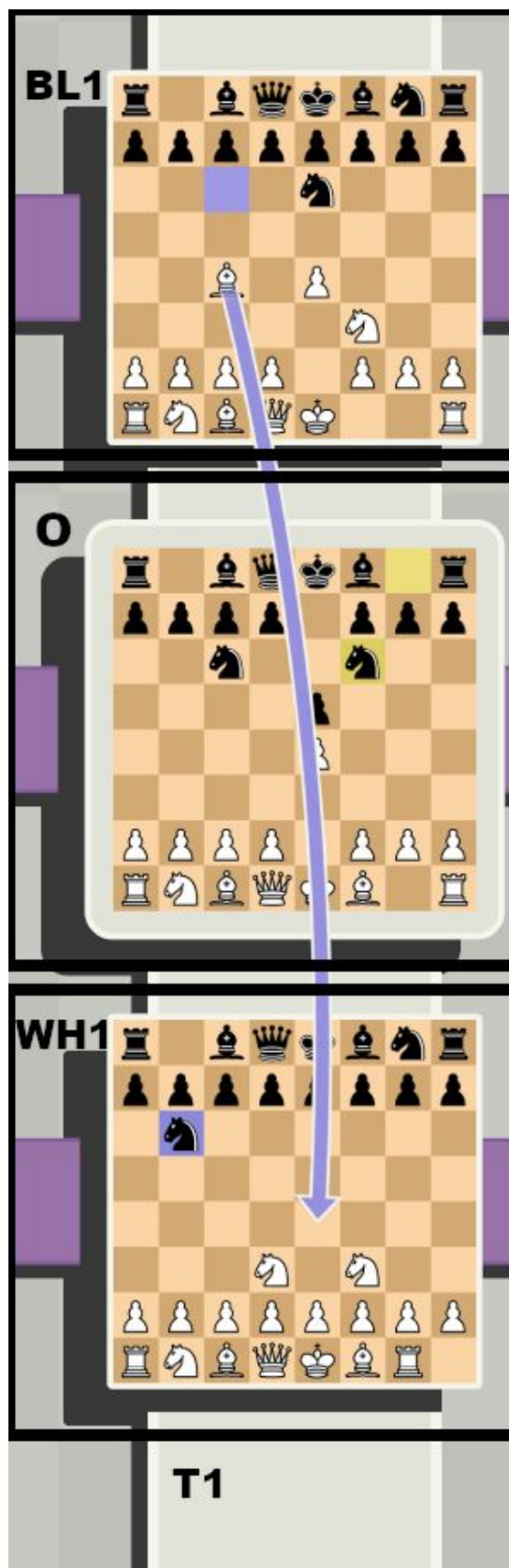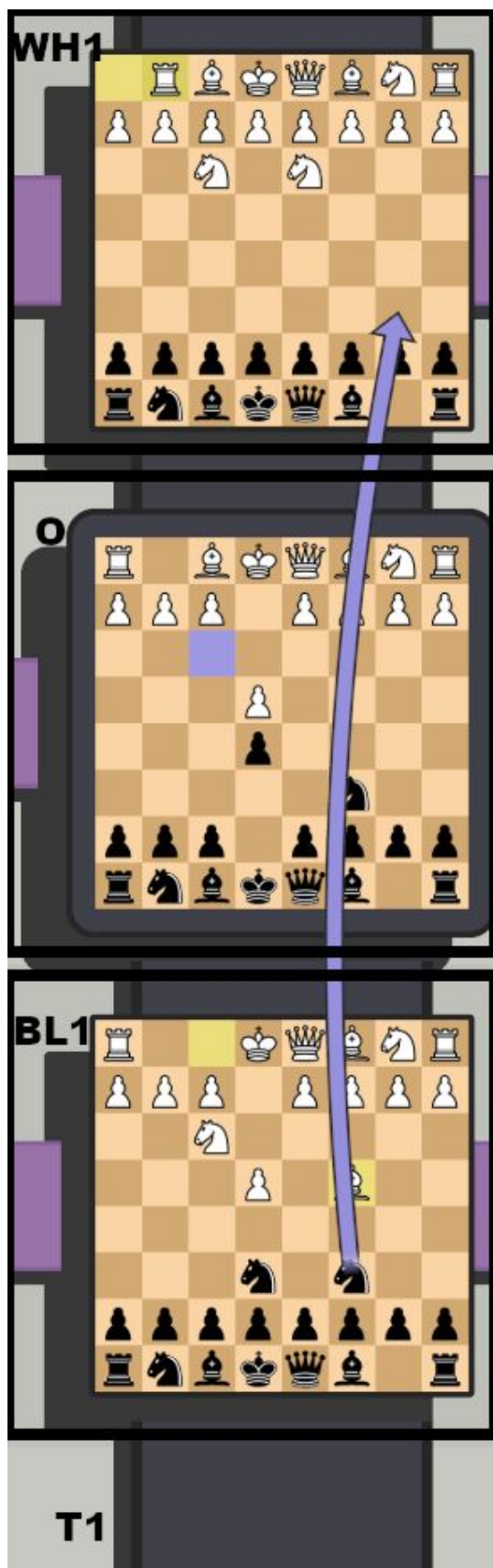
Answers:

1. 2(-N{c3}.T2.d3)   1(+N{T2.c3}.d3)

2. 1(-N{WH1.c6}.O.T1.e6)   1(+N{WH1}.e6)

3. 1(-N{c6}.WH1.b6)   1(+N{BL1}.b6)

4. 1(-B{BL1.c4}.WH1.e4)   1(+B{BL1}.e4)

Note: it is not always necessary to write out all information, just enough to let people reading the notation to understand which pieces moved where.

E. Verbose Vector Notation (VVN)

In the following paragraphs I will define several terms that encompass VVN. Knowledge of the mechanics of 5d chess is required to understand the following.

In VVN, A Vector Cycle occurs when both players pass the ownership of the present once. In the most general case, white moves the present to blacks turn and then black moves the present to white's.
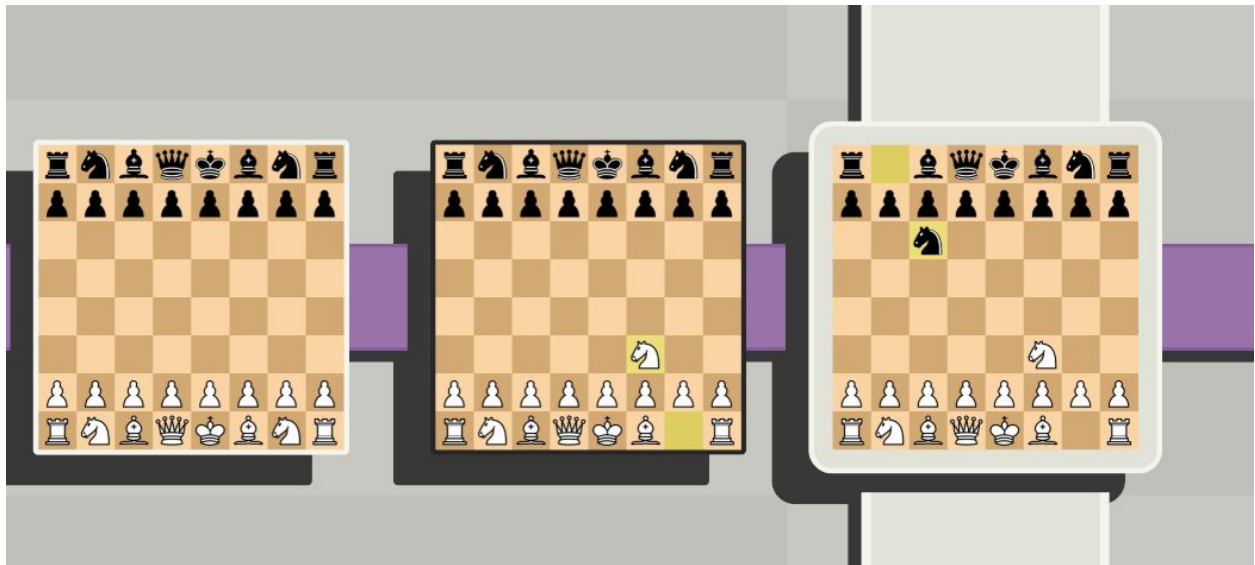

As seen in the above illustration, white moved his knight and then black moved his knight. The present moved two ply's forward and a new cycle can be started. However, there are cases where one or both players can change the position of the present by traveling pieces back in time.
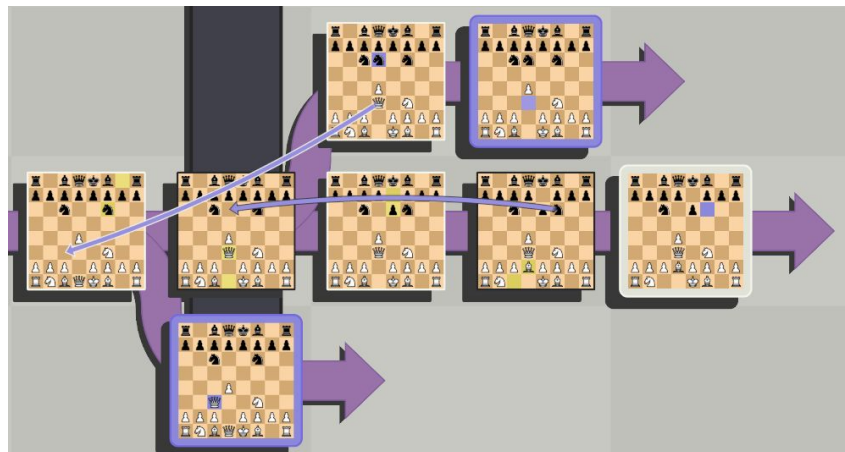
Black moved a Knight into the past, which White responded by moving his Queen into the past

Playable boards are boards which either white or black have the ability to play in. History boards are boards which can only be used via time travel.
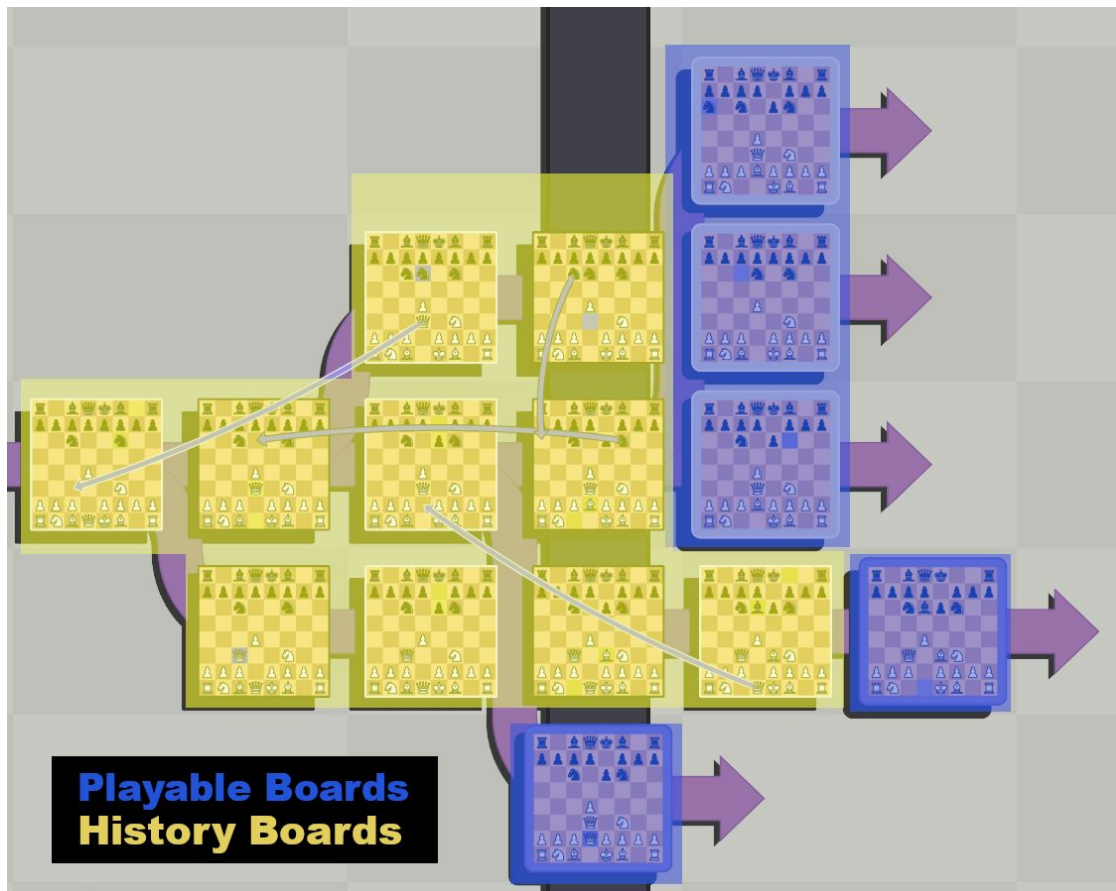
Each vector cycle contains three vectors to describe all the current playable board states.

1. The O vector contains the moves done on the original board

2. The WH vector contains all of white's alternative playable boards

3. The BL vector contains all of black's alternative playable boards

Here is an example of a single vector cycle -

3 [2(Rh1, -K.T1.h5)] [0] [2(+Kh5, @)]

As you can easily see from the above example The original board action on the original timeline is denoted by 2(Rh1, -K.T1.h5) where white moved his rook and black moved his king back in time. White has no alternate timelines, so a '0' is placed in that vector. Black has 1 alternate timeline, which was created because Black had just time traveled his king, which was written as 2(+Kh5, @). The 3 at the beginning of the line denotes which vector cycle occurred.

The original board vector will always stay the same size, being 1 on standard chess variants. The number of alternate timeline boards for white and black are however subject to grow as play continues. This is easily done by adding more elements onto each alternate timeline. Below is an example of a White Alternate timeline vector taken from a game.

$$
\begin{bmatrix}
5(-Q\{e1\}.BL1.T3.F3, -Q\{d8\}.BL1.T3.d6) \\
\\
4(-Q\{g4\}.WH1.F5, +Q\{WH3.d8\}.d8) \\
\\
4(+Q\{WH2\}.f5, -Q\{d8\}.WH2.d8) \\
\\
3(+Q\{WH1\}.f3 , -Q.WH3.T4.d8)
\end{bmatrix}
$$
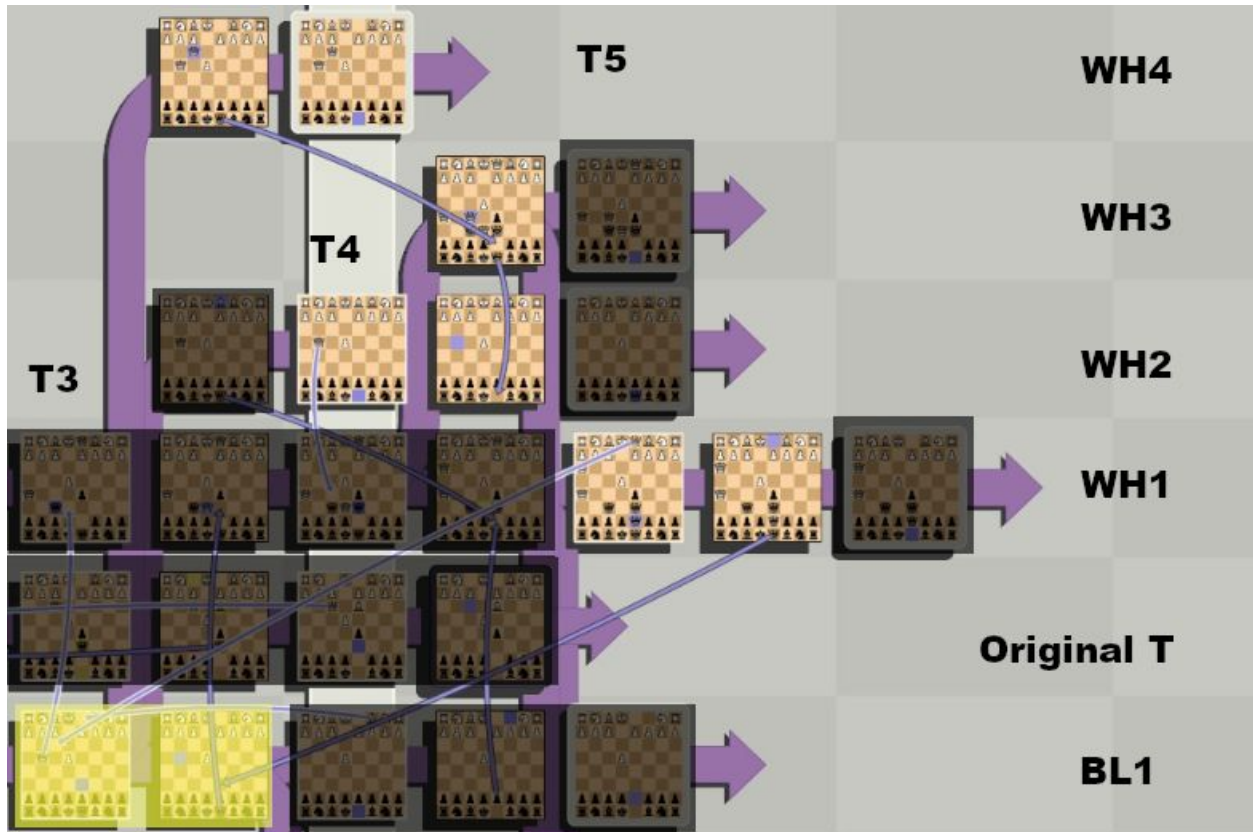
All non shaded boards are denoted in the vector, leaving out no ambiguous information. The boards highlighted yellow show history boards that were accessed by the WH1 timeline. Vectors can be written in horizontal or vertical orientations, as long as they always start with the first timeline and end with the last. In the final section, I will describe ways to put all this information into spreadsheets for convenience.

To complete the notation, I add 3 more symbols to describe a state of inaction on a playable board. An ' @ ' describes that the player color has the ability to play on the board, but has not. A ' … ' describes that the player color is not able to play on a board. Finally if a previous board contained both an '@' and '...' then the basic notation can be simplified with a * showing that nothing was done.

Be careful! Sometimes the vector cycle will change before a player makes a move, forcing you to use the '@' and '...' symbols for their turn. As long as you are always paying attention to where the current present lies and you write each vector cycle one by one then you should be fine. Technically, the vector cycle will always repeat once it becomes white's turn, so you should make a new vector cycle when it is white to move.

3 optional variables can also be added to each vector cycle to ensure conciseness. The present variable describes which time period the present currently lies in which can be denoted as "P = (time number)". Board Checks and History Checks can also be given as a list of pieces which attack certain king squares. For example BL.HC = [Q{WH1.e4}.T1.e8] would describe that there is a black history check given by the queen in White 1 on e4, which attacks the king on time 1 on square e8.

F. Verbose Matrix Notation (VMN)

Congratulations, you have everything you need to describe the entirety of a game. All you need to do is order each collection of moves onto a large grid. Each column of the matrix is a branching path, and each row is a timestep. I recommend writing all of whites branching paths to the left, puting the original path in the center, and blacks branching paths to the right, separating them with a bar, which would look along the lines of this-

T1[WH1 WH2 WH3 | O | BL1 BL2]

T2[WH1 WH2 WH3 | O | BL1 BL2]

T3[WH1 WH2 WH3 | O | BL1 BL2]

Place a '0' where there is a nonexistent board.

G. Writing Everything Down

There is a Google spreadsheet that I created that organizes the information needed for VVN and VMN. For VVN, additional alternate branches come after one another after the White and Black alt timelines. The VMN, should be self explanatory.