Leiden University

Computer Science

Compact Decision Trees for

Dou Shou Qi Tablebases

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BACHELOR THESIS

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Abstract

Dou Shou Qi is a two-person game with full information that combines rules from Chess and Stratego. To win the game one needs to capture all of the opponent's pieces or reach a specific square on the game board. An important part of solving the game is the study of endgames and construction of tablebases.

We focus on visualising the endgame tablebases for this game by using data mining and making decision trees. To do this we need to split the endgame tablebases with a set of attributes that explain the logic of the game. By using well-known data mining algorithms, such as C4.5 we can generate decision trees. We look into the many different situations of the game and analyse all of the generated decision trees, starting with two-piece endgames followed by three-piece endgames. After analysis of the decision trees of the game Dou Shou Qi we created compact decision trees that hopefully provide more insight into the endgame situations.

Contents

1 Introduction

The game we study in this thesis is called Dou Shou Qi [2]. It is a two-player strategy game and a variant of Chess combined with some elements of Stratego where one needs to occupy the opponent's den or capture all of the opponent's pieces. More about the game can be found in Section 2.

In 2012 Van Rijn [8] began studying the complexity of the game Dou Shou Qi. Later Van Rijn and Vis continued studying and calculating the endgames of Dou Shou Qi [9]. The main goal was trying to solve Dou Shou Qi, in the style of the solution of Checkers [5]. They calculated the endgame tablebase using retrograde analysis [6] and used more methods similar to the ones used when solving Checkers [4, 5]. Van Rijn and Vis completed the tablebases up to the four-piece endgames and discovered that calculating the whole endgame tablebase would take too long and would be too big to calculate on current systems.

In 2014 Van Boven did some research [7] about endgame tablebases and a simplified version of Dou Shou Qi, called Jungle Checkers. Here he reached completion of the five-piece endgame tablebase.

In 2015 Vos did a research project [11] where he generated the six-piece endgame tablebase of Jungle Checkers. His focus is trying to solve Jungle Checkers in less then two days on a state of the art desktop PC.

Most of the research done on Dou Shou Qi was for solving the game completely but not looking at the already obtained endgame tablebases. In 2014 Van Rijn and Vis started looking into the different endgame tablebases [10]. They used decision trees to visualize the endgames and find interesting patterns [1, 3].

In this thesis we continue on the research by Van Rijn and Vis [10]. The goal is to obtain more insight in the two-piece and three-piece endgames. This will be done by visualizing all of the different configurations for two-piece and three-piece endgames and creating decision trees.

First we are going to explain more about the game Dou Shou Qi in Section 2, where we address the game board, pieces and rules of Dou Shou Qi. Then we talk about the two-piece endgames in general in Section 3. In Section 4 we present all of the decision trees and split criteria for the two-piece endgames and we are going to generate more decision trees starting from the two-piece endgame tablebase and process all of the different two-piece endgame configurations. After that we simplify them and mention some observations in section 5. In Section 6 we proceed to the three-piece endgames. In Section 7 we discuss different situations in three-piece endgames and the difference according to two-piece endgames. Section 8 covers decision trees in three-piece configurations, where we have data about all of the different decision trees and give some interesting findings. The conclusions and plans regarding future work can be found in Section 9.

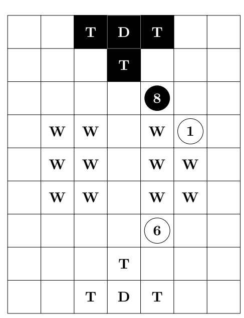


Figure 1: Dou Shou Qi three-piece endgame situation
white Rat, Tiger vs. black Elephant.

2 The game

The game we are talking about in this thesis is called *Dou Shou Qi* [2], which is Chinese for: "Game of Fighting Animals". This game is also known as Jungle Chess or Animal Chess. It is a strategy game between two players in which every player controls eight pieces of their own colour representing animals.

2.1 Board

The game board of *Dou Shou Qi* consists of 9×7 squares. This rectangle exists of nine rows, or also called *ranks* and seven columns, or also called *files*. The board is viewed from the white players perspective. The ranks on the board are labelled 1–9 from bottom to top, due to the white players position. The files are labelled a–g from left to right.

The board has four types of squares. The first type is the *den*. The dens are denoted by D on the board can be found in the middle of the first and last rank of the board (at $d1$ and $d9$). One square adjacent to each den there are *traps* denoted by T on the board. Then there are two 3×2 rectangles of *water*, denoted by W, next to each other. The first rectangle of water begins at $b4$ and the second rectangle of water begins at $e4$. The rest of the squares on the board is what we call *land*. Most of the time the pieces will be on this type of square. An image of an empty board can be found in Figure 2.

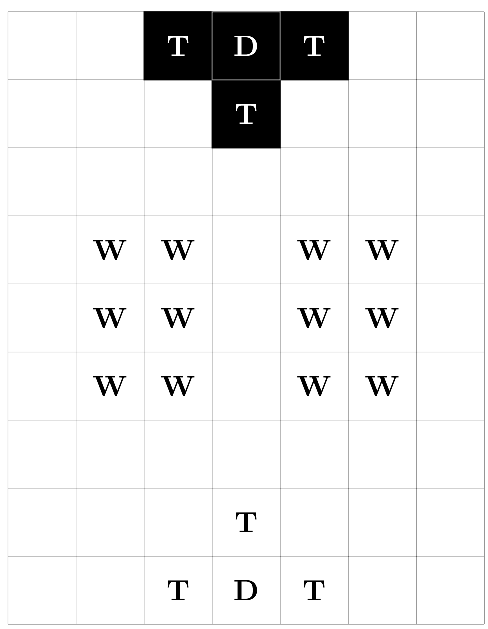


Figure 2: Dou Shou Qi empty board.

2.2 Pieces

Dou Shou Qi has eight white and black circles serving as pieces. Every piece represents an animal each with its own strength. Table 1 contains the different animals and their strengths.

Table 1: Pieces in Dou Shou Qi.

Piece	Strength
Rat	1
Cat	2
Wolf	3
Dog	4
Panther	5
Tiger	6
Lion	7
Elephant	8

At the beginning of the game each piece has a fixed position on the board and this situation is default for starting the game, and cannot be changed. The initial game situation is shown in Figure 3. The white circles are the white pieces, the same goes for black. Each piece is represented as the number of strength on the board in all the game examples.

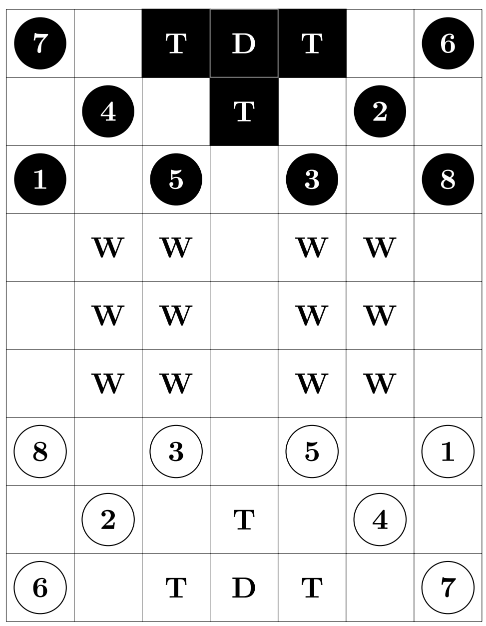


Figure 3: Dou Shou Qi game board, initial position.

2.3 Rule set

Like every other game *Dou Shou Qi* has its own set of rules. The rules are as follows:

- The player wins when he reaches the opponent's *den* with one of his pieces.
- The player wins when he captures all the pieces of the opponent.
- If the player is in one of the opponent's *trap* squares with one of his pieces, the strength of the piece that is in this square becomes zero.
- In a turn every piece can only move one square horizontally or vertically.
- The *Rat* is the only piece that can swim in the *water* squares and capture pieces while being in the water.
- The *Tiger* and *Lion* can jump over the water, if a *Rat* isn't blocking you in the water. When such piece is adjacent to a water square, it needs only one move.
- Only pieces with the same or lower strength can be captured. The exception to this rule is the *Rat*. This piece is the only piece that can capture the *Elephant*.
- A capture is done by moving a piece on an adjacent square with an opposing piece on it.

3 The two-piece endgames

To gain better understanding of the game Dou Shou Qi, we reduce our endgames to a situation where we only have two pieces in the game. An endgame is a position with at most a given number of pieces on the board. This way we can observe the weaknesses and strengths of each situation. The main goal is to make decision trees to see if we can win from any given situation.

3.1 Two-piece endgame tablebases

We already have the endgame tablebase for two-piece endgames. We can count for number of the wins, draws and losses. In this table every configuration of two pieces is present in the table. Note that we only consider positions in which white starts, therefore we can't simply mirror the results. The white pieces are denoted with a upper-case letter and the black pieces are denoted with a lower-case letter. In Table 2 we see the amount of games played for each configuration and the amount of wins, draws and loses. For example the cell $R - c$ in Table 2 means an endgame where the white Rat is up against the black Cat. In Table 3 we see the same values as in Table 2, but converted to percentages of wins, draws and losses.

Table 2: two-piece endgame values.

	r	c	w	d	p	t	l	e
R	2055 - 0 - 1605	915 - 698 - 1327	915 - 698 - 1327	915 - 698 - 1327	915 - 698 - 1327	849 - 203 - 1888	849 - 203 - 1888	1565 - 407 - 968
C	1700 - 640 - 600	1317 - 0 - 1035	779 - 97 - 1476	779 - 97 - 1476	779 - 97 - 1476	749 - 71 - 1532	749 - 71 - 1532	779 - 97 - 1476
W	1700 - 640 - 600	1716 - 98 - 538	1317 - 0 - 1035	779 - 97 - 1476	779 - 97 - 1476	749 - 71 - 1532	749 - 71 - 1532	779 - 97 - 1476
D	1700 - 640 - 600	1716 - 98 - 538	1716 - 98 - 538	1317 - 0 - 1035	779 - 97 - 1476	749 - 71 - 1532	749 - 71 - 1532	779 - 97 - 1476
P	1700 - 640 - 600	1716 - 98 - 538	1716 - 98 - 538	1716 - 98 - 538	1317 - 0 - 1035	749 - 71 - 1532	749 - 71 - 1532	779 - 97 - 1476
T	2229 - 177 - 534	1774 - 74 - 504	1774 - 74 - 504	1774 - 74 - 504	1774 - 74 - 504	1403 - 0 - 949	905 - 155 - 1292	993 - 584 - 775
L	2229 - 177 - 534	1774 - 74 - 504	1774 - 74 - 504	1774 - 74 - 504	1774 - 74 - 504	1676 - 134 - 542	1403 - 0 - 949	993 - 584 - 775
E	1352 - 365 - 1223	1716 - 98 - 538	1716 - 98 - 538	1716 - 98 - 538	1716 - 98 - 538	1086 - 632 - 634	1086 - 632 - 634	1316 - 0 - 1035

If we look at both tables we can see a pattern in some of the results. We can begin by separating the non-special and the special pieces. The non-special pieces are the ones that can only move one square, i.e. the Cat, Wolf, Dog, Panther and Elephant. The special pieces can be divided into the only piece that can move into the water, i.e., the Rat, and the ones that can jump over the water, i.e., the Tiger and Lion. We now have three groups of situations that are different. For the non-special pieces it does not matter if the strength of the opponent's piece is one or two higher, the results are the same. It can just be seen as an opponent with higher strength.

Table 3: two-piece endgame percentages.

	r	c	w	d	p	t	l	e
R	56% - 0% - 43%	31% - 23% - 45%	31% - 23% - 45%	31% - 23% - 45%	31% - 23% - 45%	28% - 6% - 64%	28% - 6% - 64%	53% - 13% - 32%
C	57% - 21% - 20%	55% - 0% - 44%	33% - 4% - 62%	33% - 4% - 62%	33% - 4% - 62%	31% - 3% - 65%	31% - 3% - 65%	33% - 4% - 62%
W	57% - 21% - 20%	72% - 4% - 22%	55% - 0% - 44%	33% - 4% - 62%	33% - 4% - 62%	31% - 3% - 65%	31% - 3% - 65%	33% - 4% - 62%
D	57% - 21% - 20%	72% - 4% - 22%	72% - 4% - 22%	55% - 0% - 44%	33% - 4% - 62%	31% - 3% - 65%	31% - 3% - 65%	33% - 4% - 62%
P	57% - 21% - 20%	72% - 4% - 22%	72% - 4% - 22%	72% - 4% - 22%	55% - 0% - 44%	31% - 3% - 65%	31% - 3% - 65%	33% - 4% - 62%
T	75% - 6% - 18%	75% - 3% - 21%	75% - 3% - 21%	75% - 3% - 21%	75% - 3% - 21%	59% - 0% - 40%	38% - 6% - 54%	42% - 24% - 32%
L	75% - 6% - 18%	75% - 3% - 21%	75% - 3% - 21%	75% - 3% - 21%	75% - 3% - 21%	71% - 5% - 23%	59% - 0% - 40%	42% - 24% - 32%
E	45% - 12% - 41%	72% - 4% - 22%	72% - 4% - 22%	72% - 4% - 22%	72% - 4% - 22%	46% - 26% - 26%	46% - 26% - 26%	55% - 0% - 44%

For pieces of equal strength it really matters if the piece can do the first move, in order to win. Pieces that are stronger lose in a situation where the opponents piece is closer to the *den*. What is remarkable is that the white jumping-pieces with a lower strength win in more cases from the Elephant.

4 Decision trees in two-piece endgames

Now we know what the probability is for winning, given the pieces that are on the board. What we really want to know is, given a configuration on the board, does this result into a win or a loss for the player and can we find a pattern by using decision trees. Dividing the endgame database and placing attributes for each endgame we can derive decision trees with data mining. Early work showed some attributes that can be used for making decisions in the game. Some cases are already done by van Rijn and Vis [10]. For example:

- equal material ;
- black stronger (no rats, lions or tigers);
- white lion vs black Elephant.

First we explain what kind of attributes we used for making a decision. An overview and explanation for the attributes used in the decision trees are presented in Table 4.

Table 4: Game features extracted from the endgame tablebase used as split criteria[10].

Attribute	Value	Description
closest	{white, black}	The player who is closest to the opposing den
fastest	{white, black}	The player who is fastest to the opposing den
adjacent	boolean	Distance between black and white piece = 1
distance	boolean	Distance between black and white piece
{w,b}Unopposed	boolean	piece can move to opponent his den without being blocked
{w,b}UnopposedQD	boolean	piece can move to opponent his den with a detour, without being blocked
{w,b}BankUnopp	boolean	piece can move to the water bank without being blocked
{w,b}Parity	boolean	Manhattan distance view from given piece
{w,b}CanCross	boolean	Piece can cross rank 7 unopposed to opponent his den
{w,b}InWater	boolean	Piece is in a water square
{w,b}InTrap	boolean	Piece is in a trap square
{w,b}{w,b}DisToDen	numerical	Piece distance to given den
{w,b}{w,b}DenMoves	numerical	amount of moves that can be made towards the given den
{w,b}Advanced	{DEF, MID, ATT}	Checks in which sector the piece takes place
diagonal	boolean	Pieces are standing diagonal to each other
closestDiff	numerical	Difference between the distance who is closer to the den

The attributes used in Table 4 are relevant for the game rules and logic and derived by playing the game and looking for which attributes are important. By using the attributes described in Table 4, we can derive decision trees for the different game situations. Note that all of the two-piece endgame decision trees are 100% correctly classified. As described before and be looking at Table 3 we can categorize the different endgames. The following categorization can be made:

- equal Pieces;
- white stronger, excluding Rat, Tiger and Lion;
- black stronger, excluding Rat, Tiger and Lion;
- animal x vs. black/white Rat;
- animal x vs. Tiger or Lion;
- Tiger/Lion x vs. Rat;
- Tiger vs. Lion;
- Rat vs. Elephant.

4.1 Equal pieces

First let us take a look at pieces with equal strength, excluding the Tiger and Lion. As done before by van Rijn and Vis [10], we can derive a 100% correctly classified tree. This tree can be found in Figure 4. All the trees must be read from top to bottom, an elliptical node is an attribute and a rectangular node is an outcome. What we can conclude from this tree is that if a piece is closest to the den and unopposed it is likely a win. Nothing can cross your path to the den. The parity is also important, remember that the parity means which piece can capture the other piece first. If, i.e., white has parity, it can capture black, therefore white wins. This is one of the most compact trees, also seen in [10].

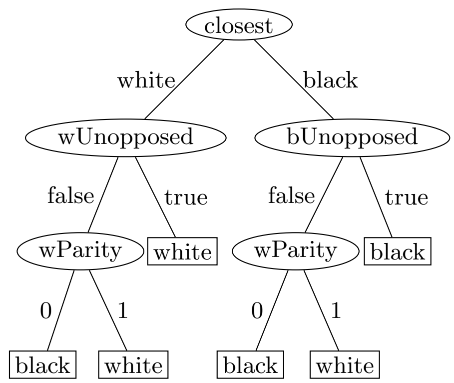


Figure 4: Tree for pieces with equal strength (excluding Tiger and Lion).

4.2 White stronger, excluding Rat, Tiger and Lion

When the white piece is the stronger one, excluding the Rat, Tiger and Lion, we can see in Figure 5 that it is very easy to win. In this situation if you are closest to the den as a white piece, you will always win, because even if you are opposed by a black piece it does not matter. You simply capture the piece that is opposing, because white is stronger .

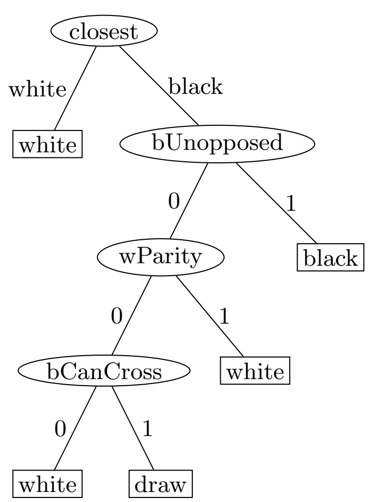


Figure 5: Tree for white stronger (excluding Rat, Tiger and Lion).

4.3 Black stronger, excluding Rat, Tiger and Lion

Now we are looking at configurations where the black player has the stronger piece, excluding Rats, Tigers and Lions. We expect that black will have the upper hand, because even if it is opposed it can capture the white piece easily. The white player makes the first move, therefore has a bit of advantage, it can run away or around black in order to get to the den. The decision tree can be seen in Figure 6. Most of the configurations are covered in the top of the tree. If we traverse the tree and come to the node wCrossShort only 9.2% of the instances are being covered in this sub tree, which makes the tree a lot larger, therefore it is a choice to prune this tree, but that does not give a 100% correctly classified tree.

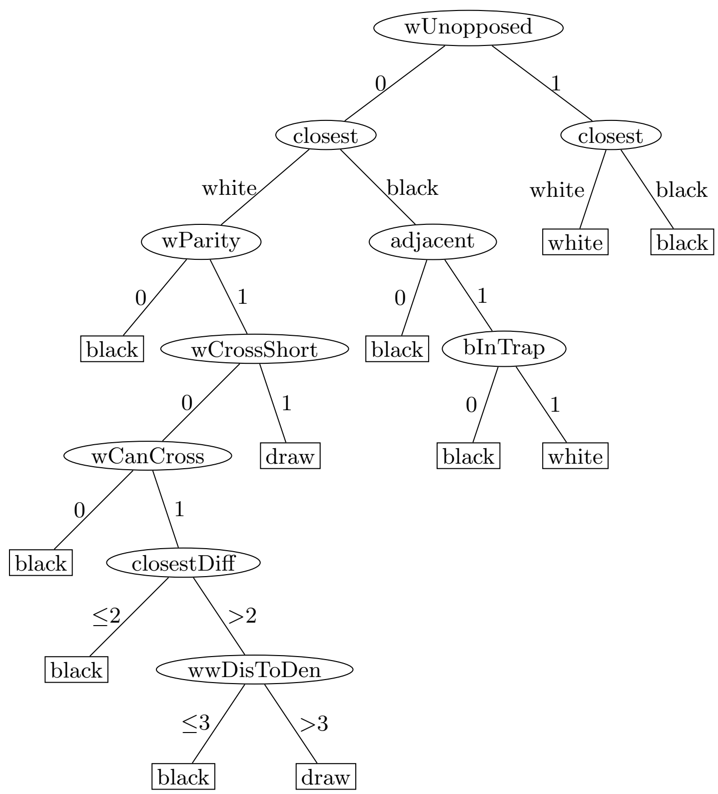


Figure 6: Tree for black stronger (excluding Rat, Tiger and Lion).

4.4 Rat vs. stronger, excluding Lion, Tiger and Elephant

The expectation is that the Rat in most cases can get faster to the den, because it does not have to go around the water. It can cross the water and can be faster in some cases. Remember that the opponent can not capture the Rat, if the Rat is in the water. The only difference in configuration when playing as the white Rat is that the Rat may begin and the black Rat does not. The tree can be found in Figure 7, the white Rat is used for this tree. Most of the time the Rat will be captured, because it is the weakest piece in the game, if you are not closest to the den and opposed, it is most likely to lose. Playing as the Rat it really matters crossing the river bank, as for the weakest piece it is an advantage that one can directly cross the water banks. Also when looking at the tree in Figure 7 we see many numerical nodes, maybe one wants to exclude some nodes to prune this tree at the cost of misclassification. Pruning this subtree gives a 5% misclassification.

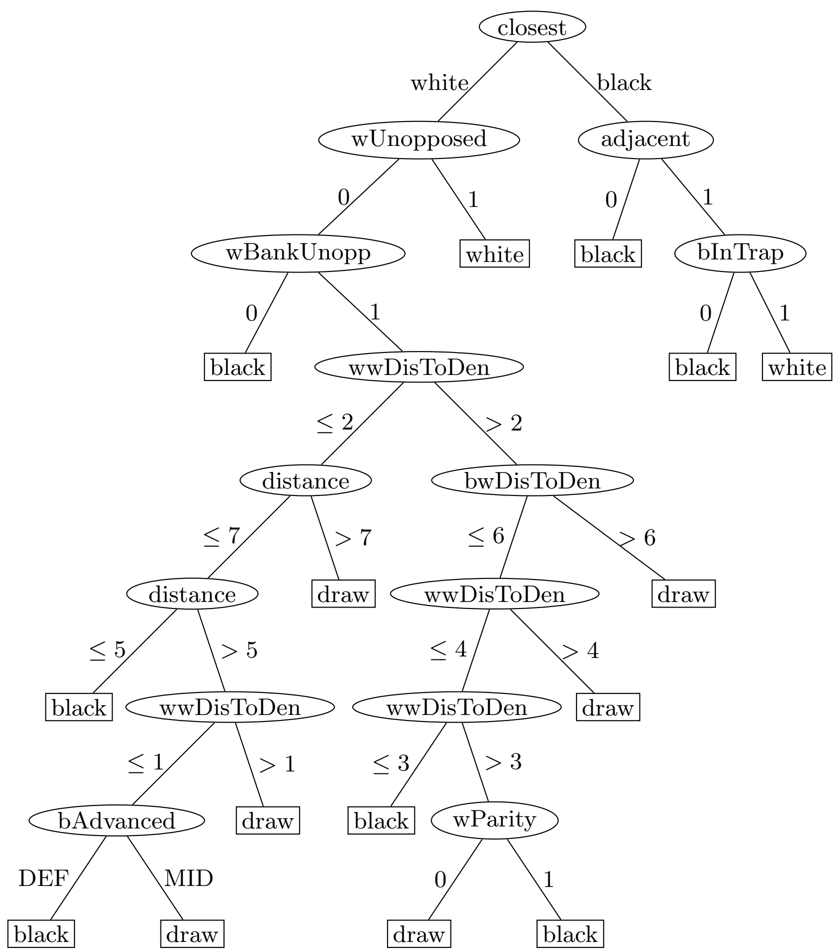


Figure 7: Tree for white Rat vs. black Stronger (excluding Tiger and Lion).

The decision tree for playing with the black Rat vs. white stronger can be found in Figure 8.The tree uses some of the same attributes, mostly in the top of the tree. Going from the top of the tree into a large subtree, where at matters if the black Rat is standing on square D7 or not. The reason why square D7 is important, is because this square is between two water banks, increasing the mobility of the Rat by going up or down on a normal square, or by going left or right on a water square. As for the tree in Figure 8 pruning the subtree at the node bAtD7 gives a misclassification of 21.8% covering 642 instances.

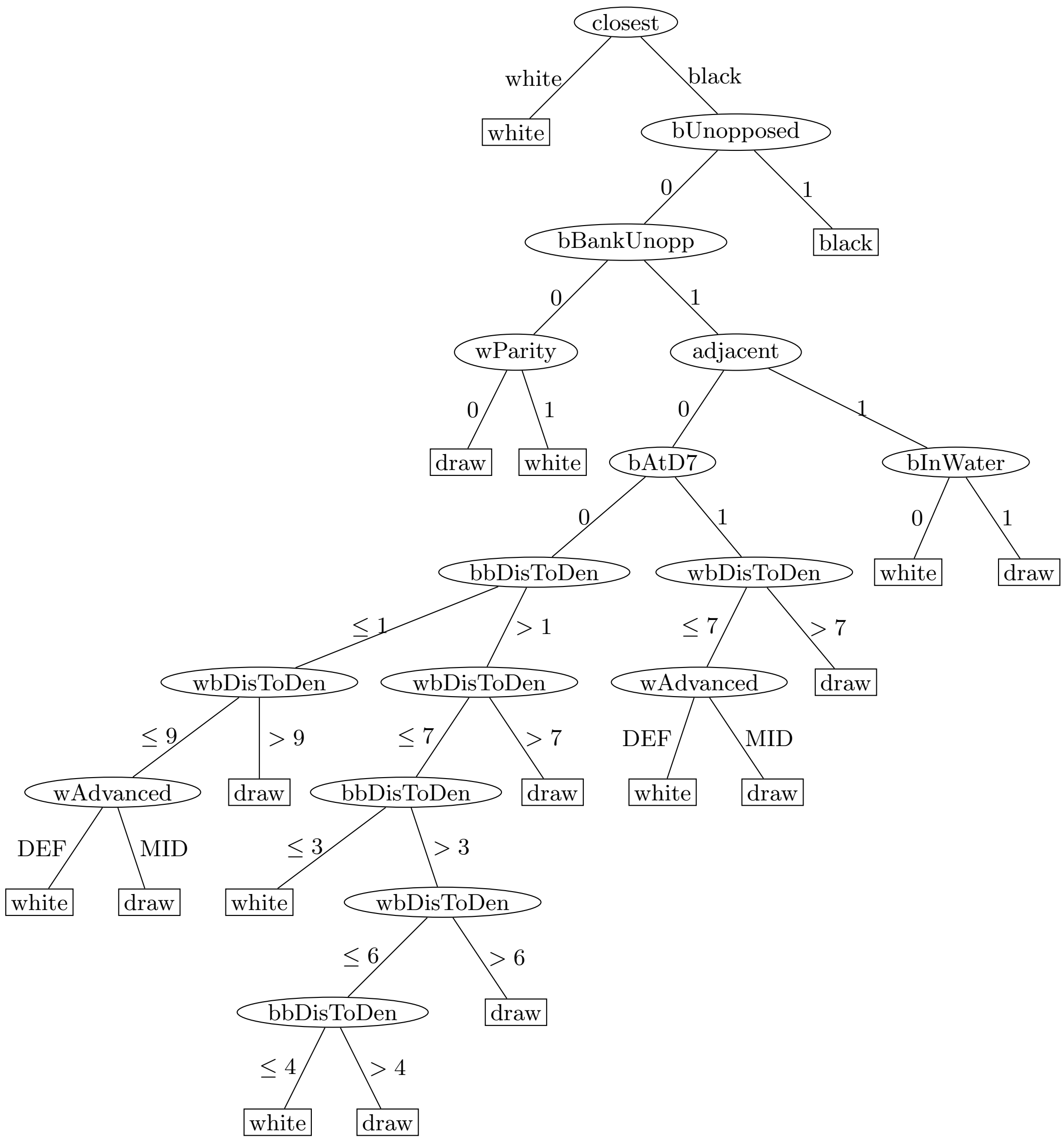


Figure 8: Tree for black Rat vs. white Higher (excluding Tiger and Lion).

4.5 Rat vs. Elephant

Although the Rat and the Elephant have a different strength the pieces can be seen as equal. If we remember the rule set the Rat is the only lower piece that can capture the Elephant, like the Spy and Marshal from the game Stratego. The decision tree that goes with the configuration white Rat vs. black Elephant can be found in Figure 9. If we compare the Figures 4 and Figure 9 we can see that they are similar to one point, but a change occurs when the Rat is in a water square. The Elephant can not go in to the water, therefore it can not capture the Rat, but the Rat can capture the Elephant from within the water. The Rat is a strong piece against the Elephant. When playing with a Rat against an Elephant the Rat is adjacent to the Elephant in more positions than the Elephant is to the Rat. The tree in Figure 9 can be divided in three parts. The first part is the top of the tree, which similar to the tree for equal pieces, the other part is the left subtree pruning in the first bwDisToDen gives a misclassification of 2.7%. Pruning the right subtree from wInWater gives a misclassification of 1.2%, so pruning the left and right subtree gives a total misclassification of 3.9%, but makes the decision tree more compact.

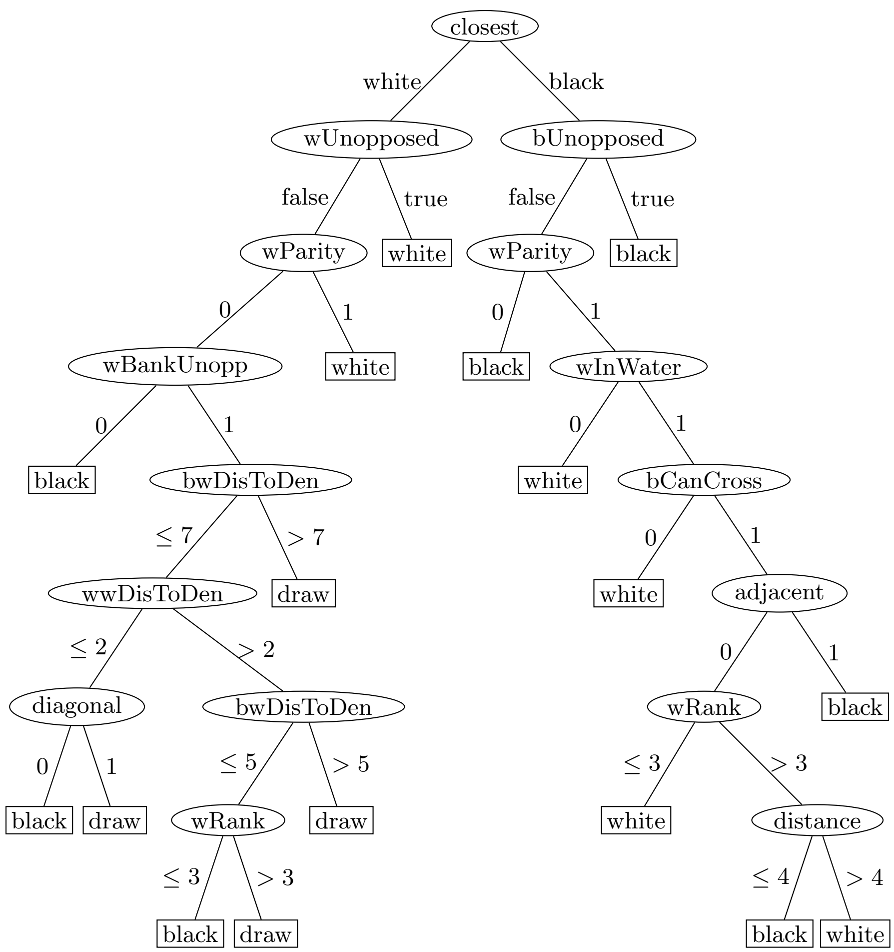


Figure 9: Tree for white Rat vs. black Elephant.

In Figure 10 we can find the configuration black Rat vs. white Elephant.

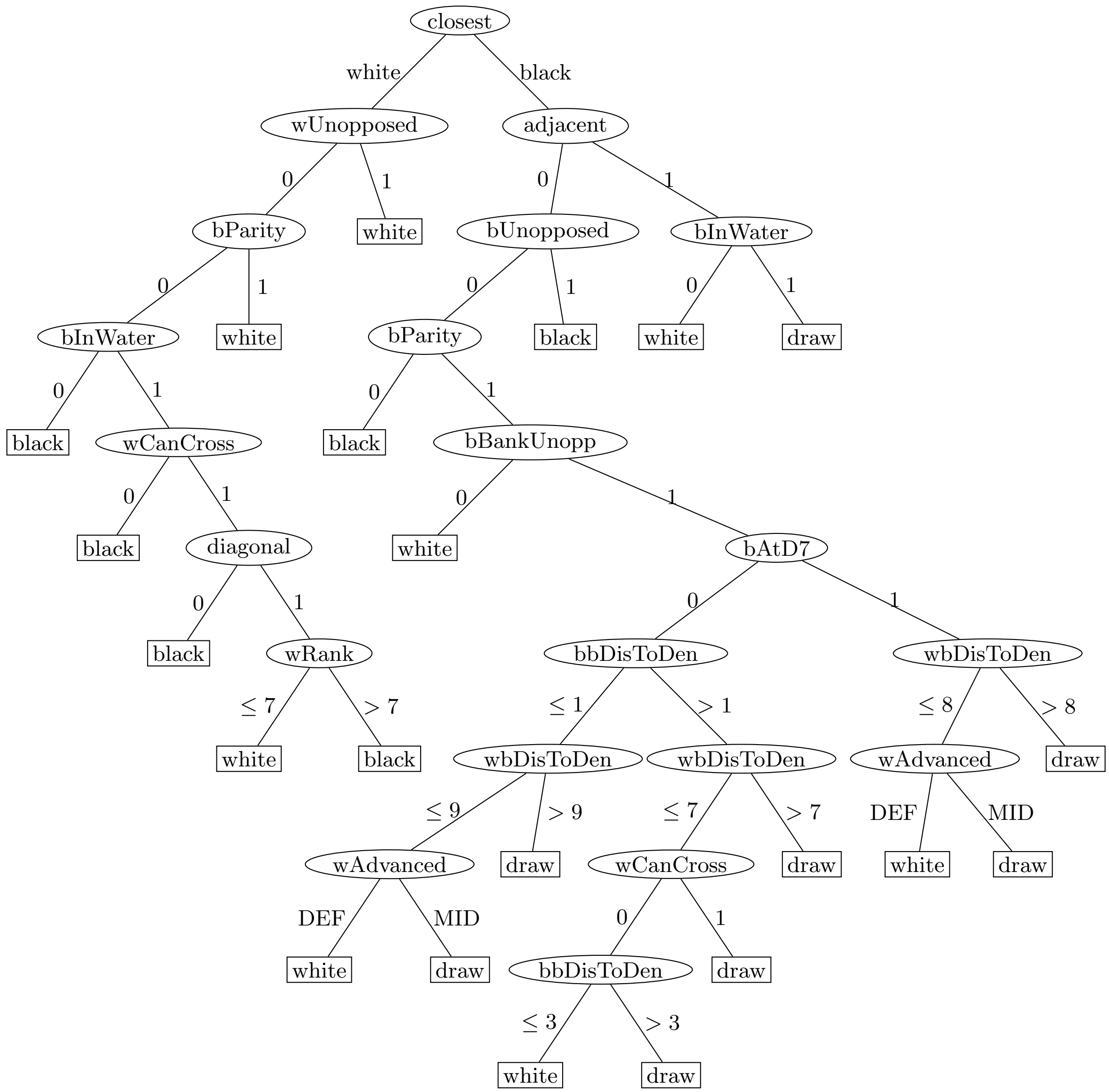


Figure 10: Tree for black Rat vs. white Elephant.

4.6 Tiger or Lion vs. Rat

The Tiger or Lion vs. Rat will give an interesting configuration. The Rat can capture a piece from within the water and the Tiger or Lion can not jump across the water when the Rat is in the water. Most of the situations the Lion or Tiger will win, because they can cover many squares in one jump and it is the piece with the highest strength. Jumping over the water moves two or three squares in one turn, where the other pieces only move one square in a turn. The decision tree in Figure 11 holds for the configuration white Lion or Tiger vs. black Rat. When we look at the tree in Figure 11 we can see that it matters more who is faster to the den and not who is closer, because the Tiger or Lion can move faster near the river banks. This does not hold when the Rat is in the water. The difference between faster and closer is the amount of turns it takes to reach the den, the Lion or Tiger can cover more squares in one turn, by standing adjacent to a water square.

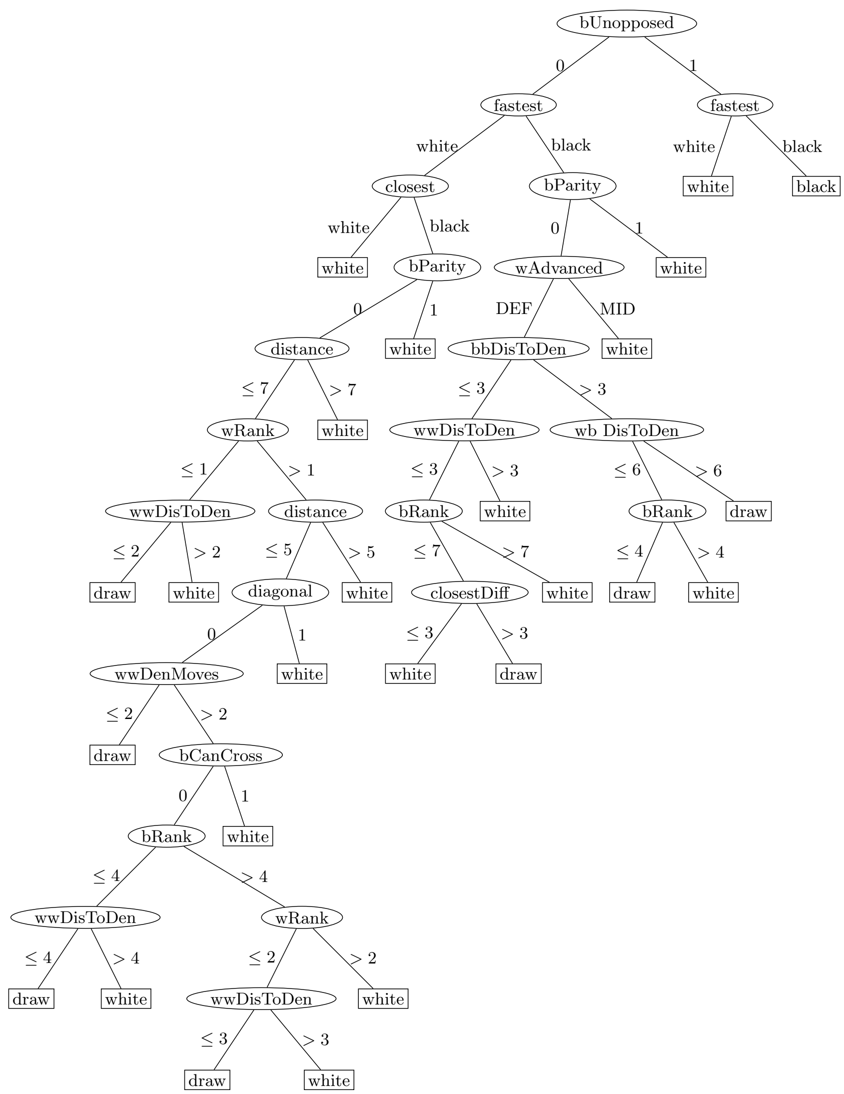


Figure 11: Tree for black Rat vs. white Tiger or Lion.

See Figure 12 for the decision tree that holds for the configuration white Rat vs. black Tiger or Lion. Looking at the decision tree we see a large subtree in the first bRank node, this subtree covers 86 instances which is only 2.9%.

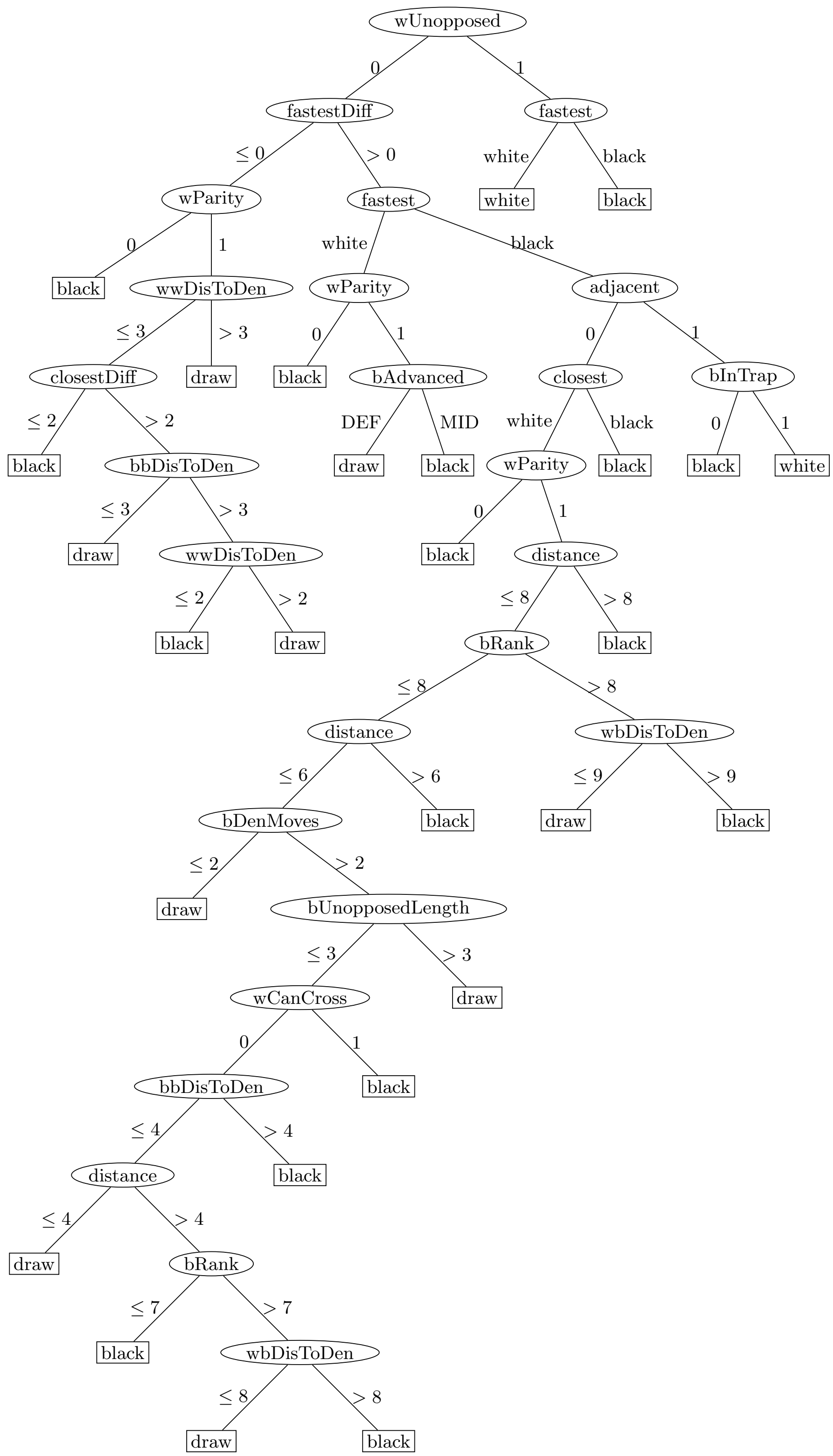


Figure 12: Tree for white Rat vs. black Tiger or Lion.

4.7 Tiger or Lion vs. lower pieces, excluding Rat

The expectation of the decision tree for the situation of Tiger or Lion vs. Lower pieces, excluding Rat is that it will be partially the same as playing with a stronger piece vs. a weaker piece. We have situations, because black or white can play with the jumping piece. Figure 13 shows the tree for playing with the white Lion or Tiger; Figure 14 shows the decision tree for player with the black Lion or Tiger against lower pieces. If we compare Figure 5 and 13 the main difference is that it is more important to be faster to the den, then closer to the den. This is also mentioned in the section about Lion or Tiger vs. Rat due to the special ability of jumping over the water, therefore reaching the den faster.

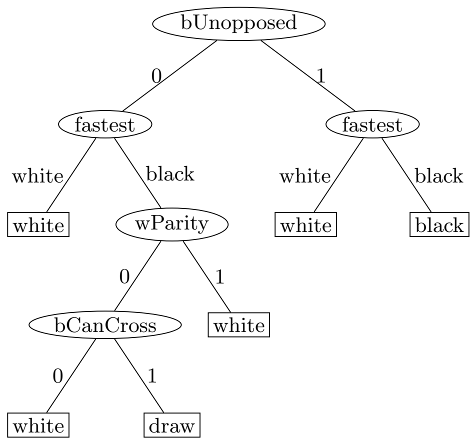


Figure 13: Tree for white Lion or Tiger vs. lower pieces, excluding Rat.

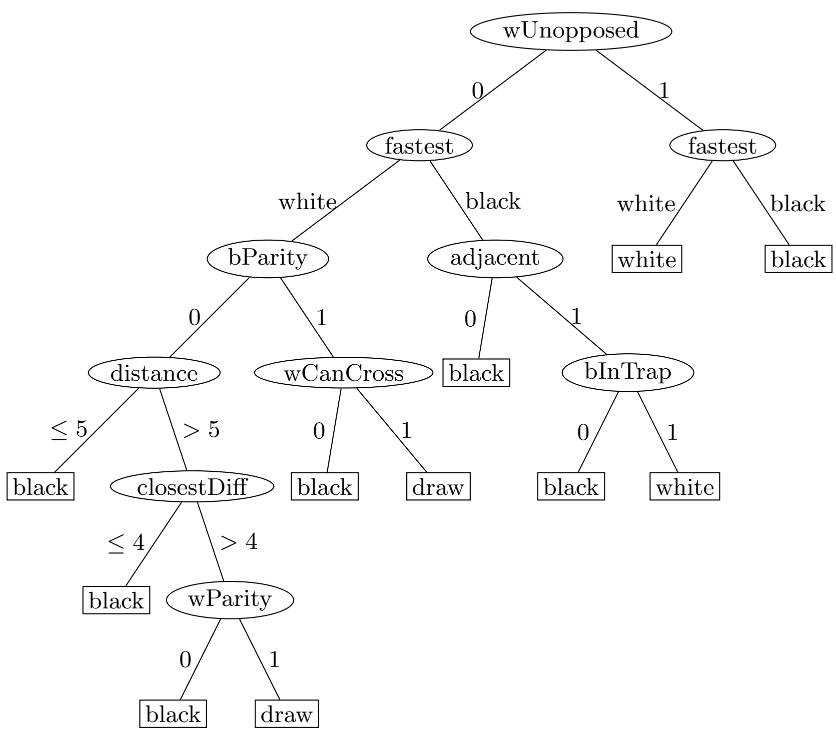


Figure 14: Tree for black Lion or Tiger vs. lower pieces, excluding Rat.

4.8 Tiger or Lion vs. Elephant

When looking at Table 3 we can already see that most of the time the Tiger or Lion does not always lose the game. This is remarkable because the Elephant is the highest piece in the game. In Figure 15 the white Elephant and the black Lion are being used. Many nodes in this tree result in a draw. When looking at Figure 15 it makes sense why the Lion has some advantage it can run away from the Elephant when being chased. It can jump over the water, therefore the chance of being captured as the Lion or Tiger decreases.

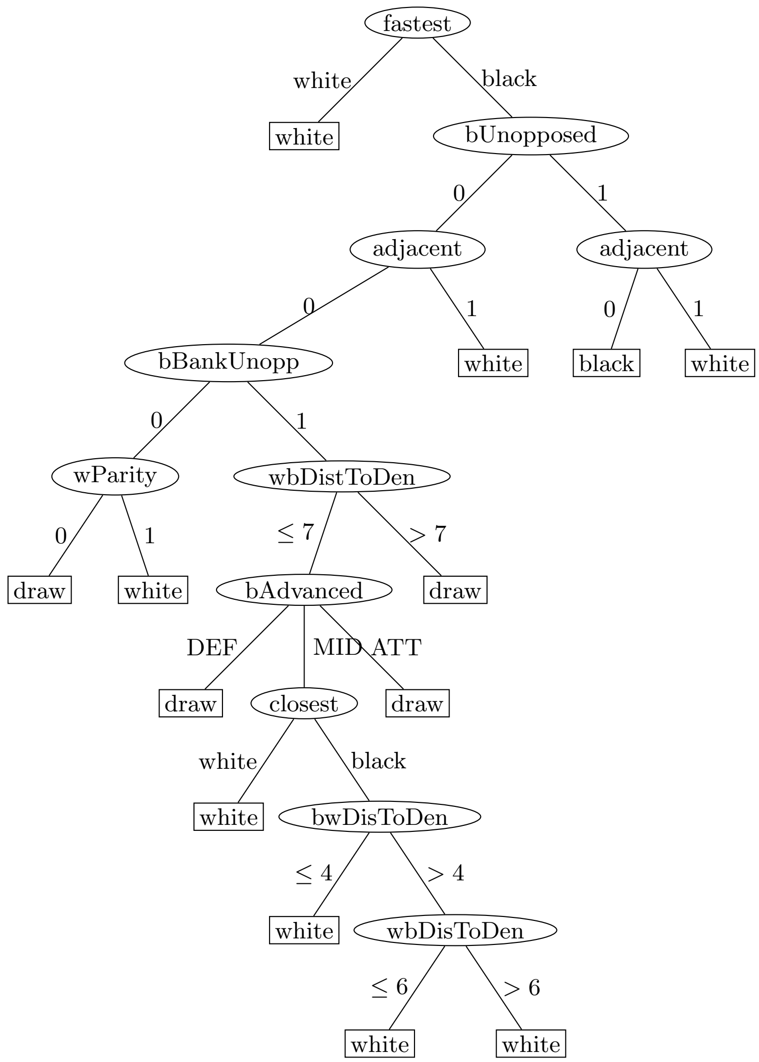


Figure 15: Tree for black Lion or Tiger vs. white Elephant.

The inverse configuration can be found in Figure 16. Here the decision tree for white Lion vs. black Elephant can be found. Look at the large subtree in the node bwDisToDen. This subtree covers only 42 instances which is 1.8%. Cutting this subtree gets rid of all the numerical nodes.

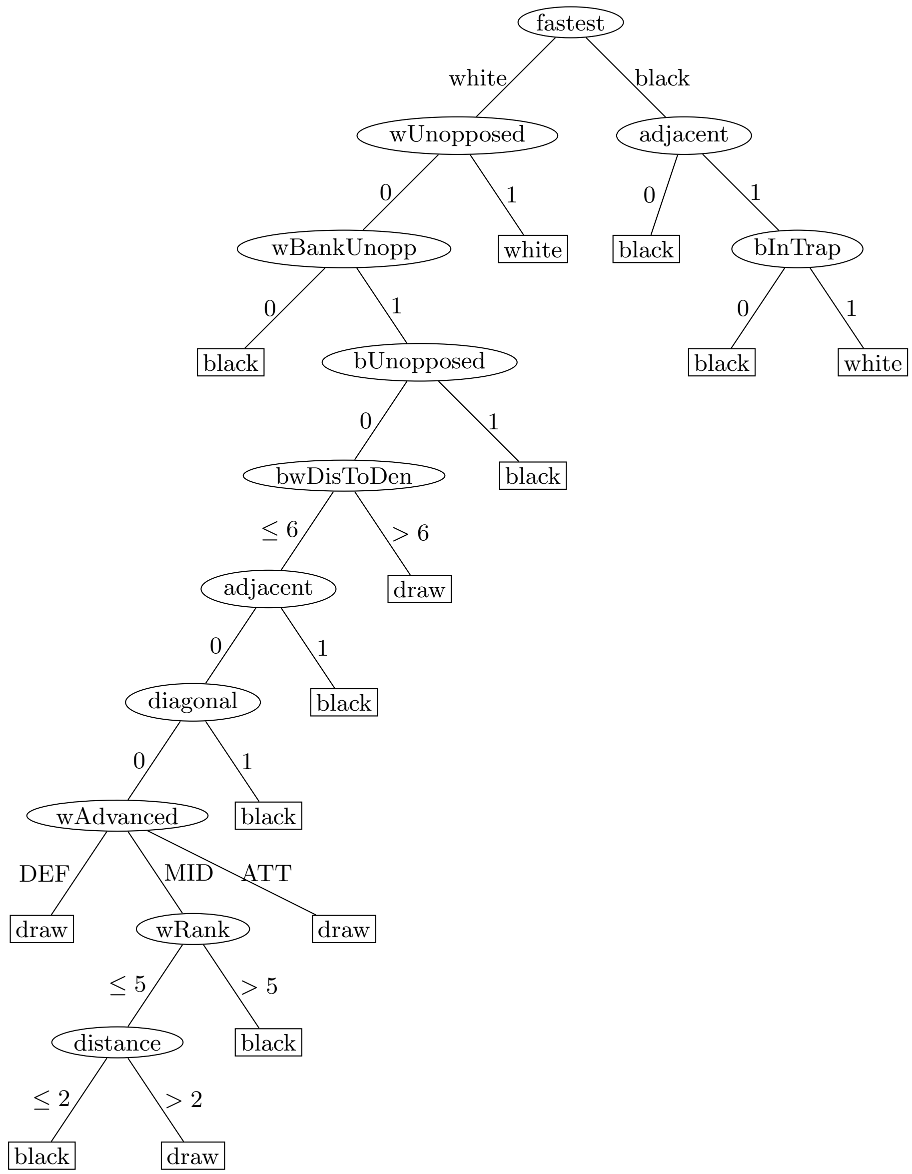


Figure 16: Tree for white Lion or Tiger vs. black Elephant.

4.9 Tiger vs. Lion

The Tiger vs. Lion configuration is complicate to answer, because both pieces can jump. The advanced attribute plays a great role in this tree. Because the Lion or Tiger can Jump from the DEF section to the ATT section of the board in one move. See Figure 17 for the decision tree of the configuration for white Lion vs.black Tiger we can see that it is a very large decision tree and uses a lot of numerical attributes for determining a win for white or a draw. This can be explained by the great mobility of both pieces.

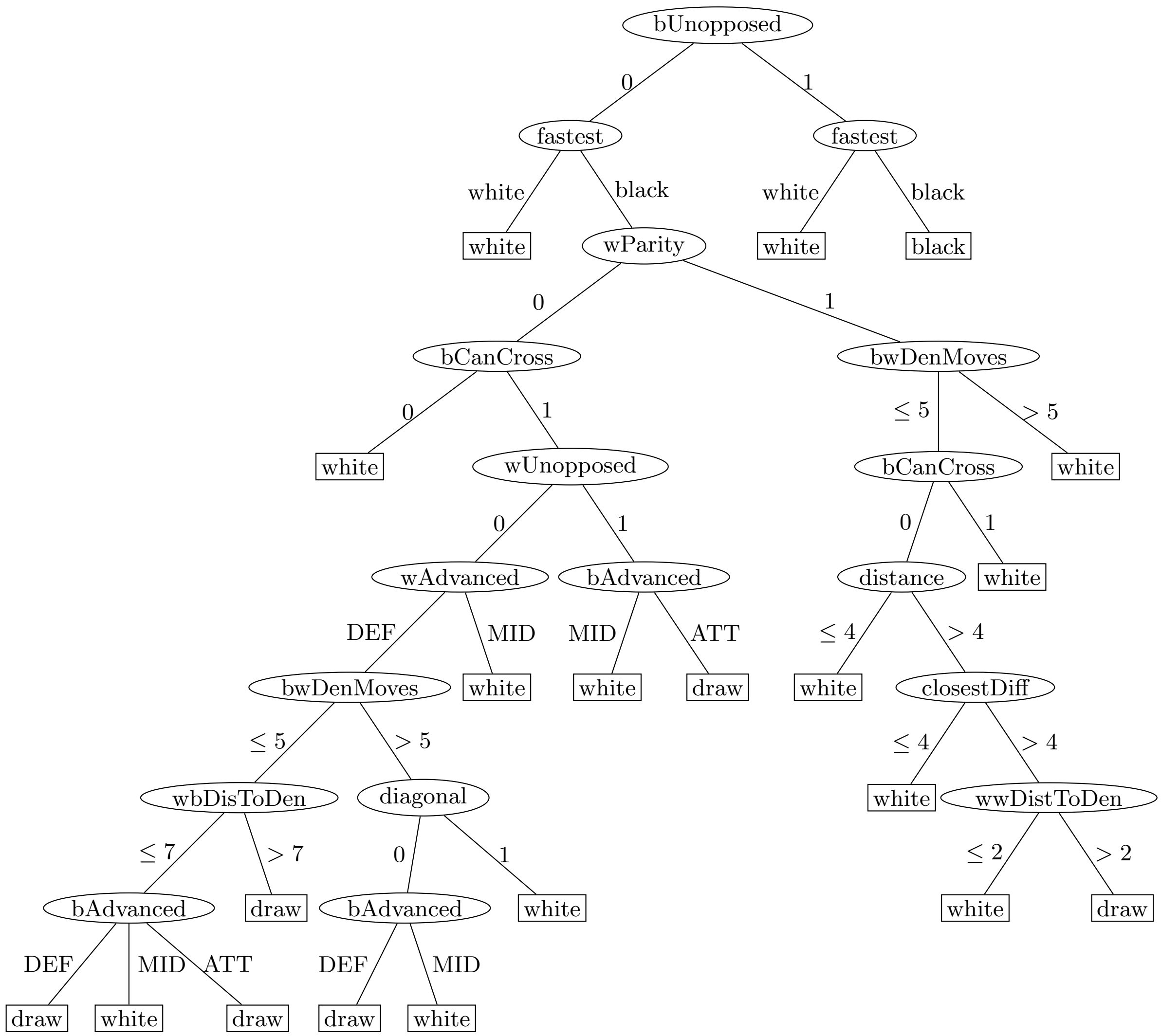


Figure 17: Tree for white Lion vs. black Tiger.

Now we can look at Figure 18 for the decision tree of the black Lion vs. white Tiger. To make this tree more compact the subtree at node closest can be pruned. This subtree covers 132 instances, which is 5.6%.

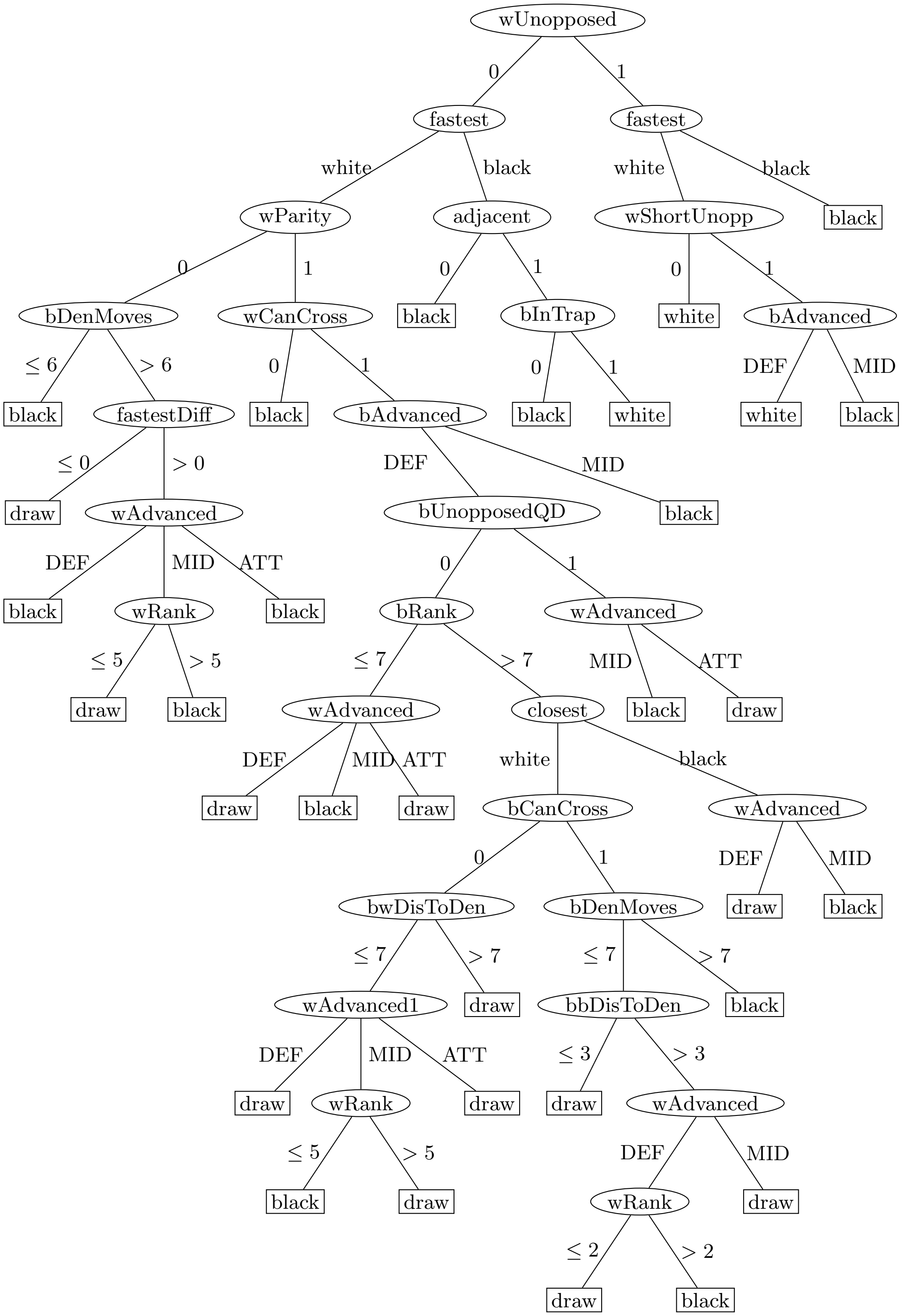


Figure 18: Tree for black Lion vs. white Tiger.

4.10 Complete two-piece endgame decision tree

In the previous subsections we showed different decision trees for parts of the two-piece endgames. Now when we do not divide the total amount of two-piece endgames, but put the entire two-piece endgame database into a decision tree. Now we get a figure that is too complex to show. Even after pruning large subtrees the decision tree is way to big and chaotic. This three covers 160.067 instances and the decision tree has a size of 487 nodes, by dividing the two-piece endgames the largest decision tree we git is Figure 18, with a size of 52 nodes. Therefore dividing all of the two-piece endgames into smaller configurations was a good choice.

5 Simplified two-piece endgame decision trees

By looking at the figures in the previous sections we can see that some trees have a very large subtree containing the same nodes. In these subtrees we can see that most of the child nodes are only resulting in a win for black and a draw i.e. the subtree starting at wUnopposed in Figure 7, or resulting in a win for white and a draw e.g. the subtree starting closest in Figure 11. When playing as white we can accept a subtree that is winning or resulting in a draw. The information we can derive from such a subtree is that we can not lose and in the worst case we get a draw. In a subtree combining the black and draw nodes we have the information that in the best case we can result in a draw. Given this information we can make new decision trees that are simplified a lot.

5.1 White stronger, excluding Rat, Tiger and Lion

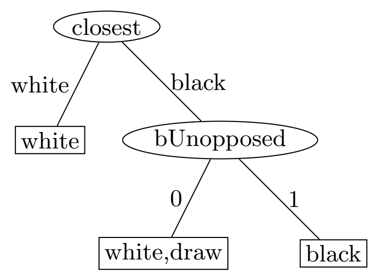


Figure 19: Tree for white stronger simplified (excluding Rat, Tiger and Lion).

Figure 19 is the simplified version of Figure 5. Remember we pruned the decision tree in the subtree that always results in a win or draw for white.

5.2 Black stronger, excluding Rat, Tiger and Lion

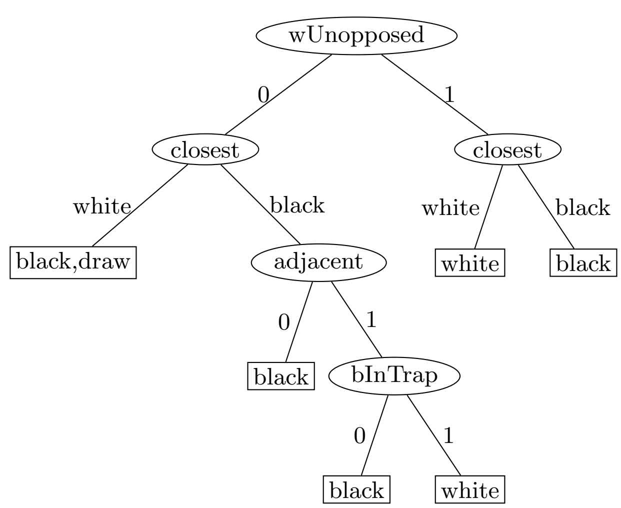


Figure 20: Tree for black stronger simplified (excluding Rat, Tiger and Lion).

Figure 20 is the simplified version of Figure 6. We now use a more compact set of attributes in the tree, where before we had some numerical values.

5.3 Rat vs. higher, excluding Lion, Tiger and Elephant

In Figure 21 we can find the simplified version of Figure 7. Here the depth went down from eight to three and all of the numerical values are gone.

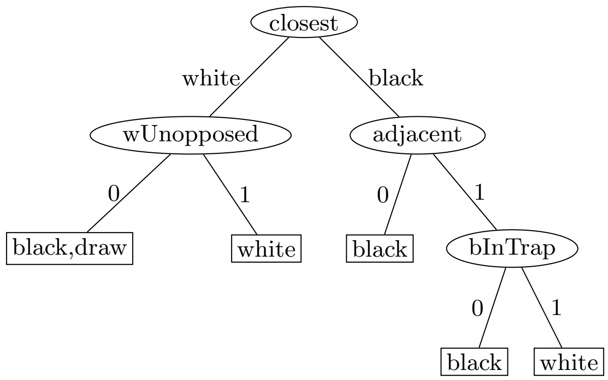


Figure 21: Tree for white Rat vs. black higher simplified (excluding Lion, Tiger and Elephant).

We also have Figure 22 the simplified version of Figure 8, here the depth went down from ten to two and all of the numerical values are gone.

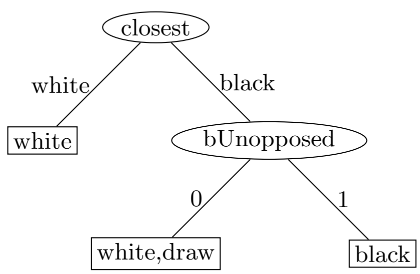


Figure 22: Tree for black Rat vs. white higher simplified (excluding Lion, Tiger and Elephant).

5.4 Rat vs. Elephant

Figure 23 is the simplified version of Figure 9. This is still a very large tree, but at least we could prune the whole left subtree. In the right subtree only in the last node we know if it is a win for white or a win for black, therefore it can not be simplified more. It is possible to prune the right subtree, the right subtree contains 36 instances, which is 1.2%.

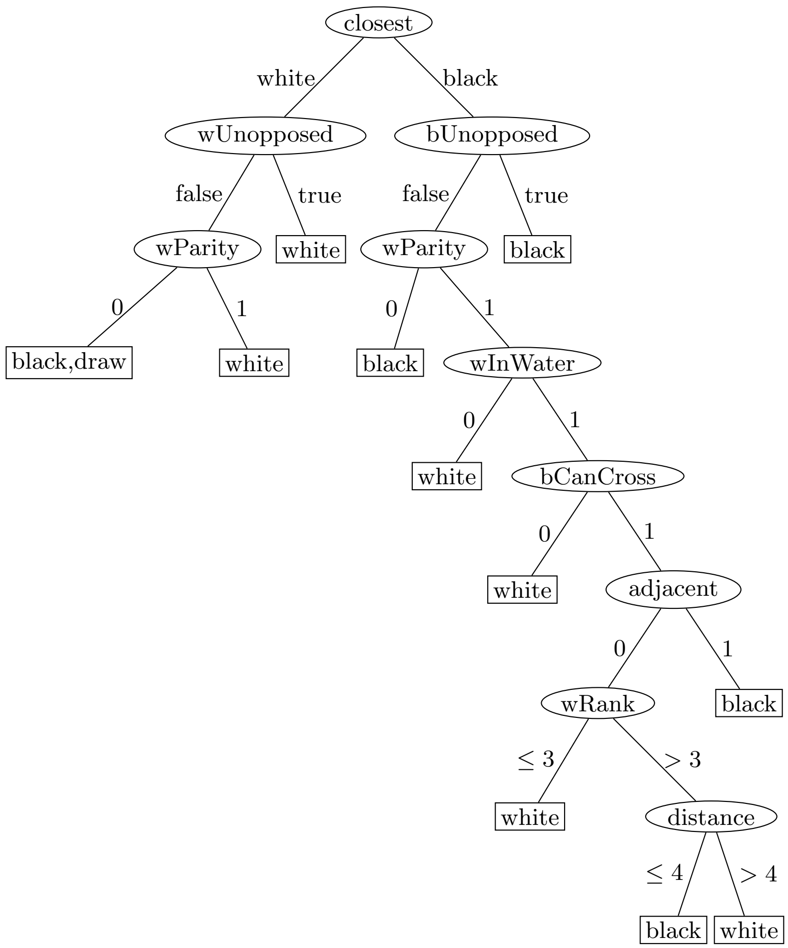


Figure 23: Tree for white Rat vs. black Elephant simplified.

Figure 24 is the simplified version of Figure 10. The same conditions apply to this simplified tree as to the other simplified tree in Figure 9 with the configuration Rat vs. Elephant.

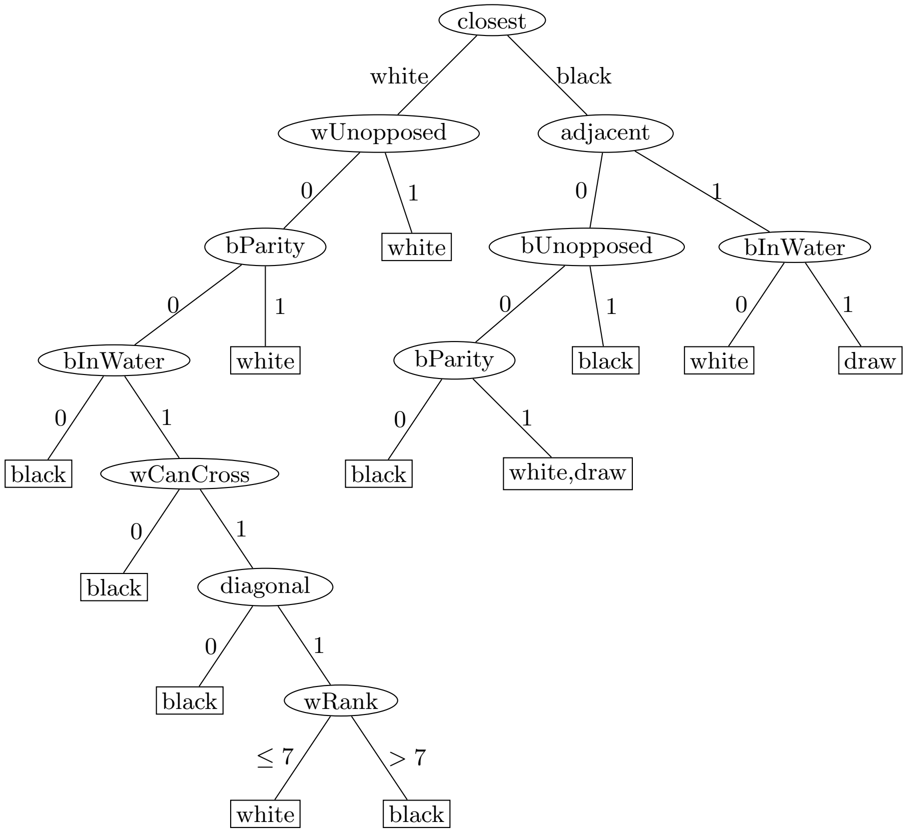


Figure 24: Tree for black Rat vs. white Elephant simplified.

5.5 Tiger or Lion vs. Rat

It is remarkable that Figure 25 has multiple figures that result in the same simplified tree, these are the Figure 11, Figure 13 and Figure 17. What they have in common is the configuration Lion or Tiger vs. lower and in Figure 17 even Lion vs. lower pieces holds. It is interesting that the simplified version has a depth of two, where the normal version looking to the configuration Rat vs. Tiger has a height of thirteen.

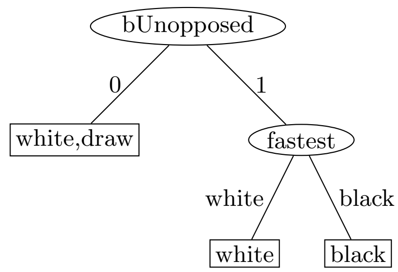


Figure 25: Tree for white Tiger or Lion vs. black Rat simplified.

This also holds for playing with the black Tiger or Lion vs. Lower. Figure 26 resembles the simplified version of Figure 12, Figure 14 and Figure 18.

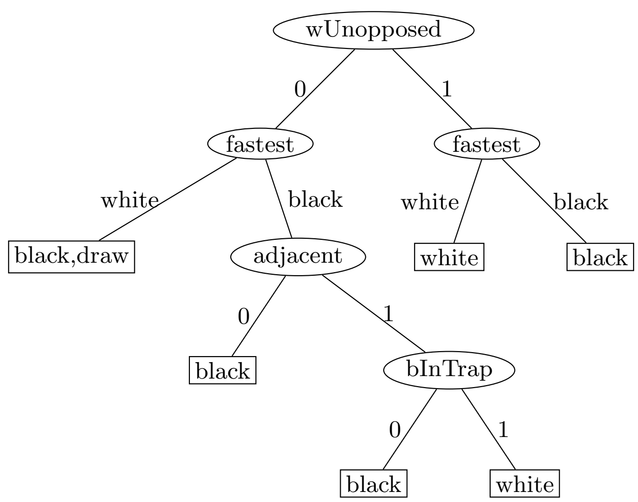


Figure 26: Tree for black Tiger or Lion vs. white Rat simplified.

5.6 Tiger or Lion vs. Elephant

In Figure 27 we see the simplified version of Figure 15, where it went down from depth nine to three.

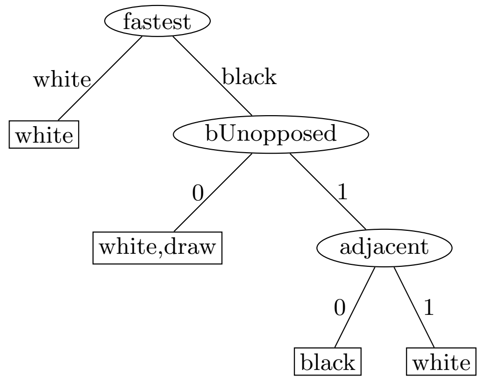


Figure 27: Tree for black Tiger or Lion vs. white Elephant simplified.

In Figure 28 we see the simplified version of Figure 16, where it went down from depth nine to three.

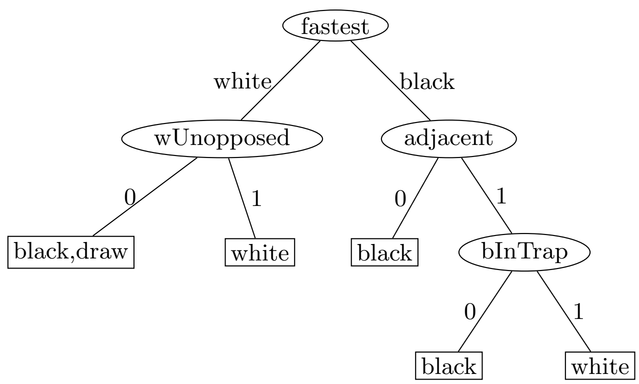


Figure 28: Tree for white Tiger or Lion vs. black Elephant simplified.

5.7 Conclusions on two-piece endgames

We now have visualized all of the decision trees for the two-piece endgames simplified and non-simplified. From these decision trees we can conclude the following: there are a some attributes that are more important than others. The most important attributes are:

- fastest or closest to den;
- black or white unopposed to den;
- adjacent.

These attributes are always in the root of the tree or its children.
Comparing the simplified and non-simplified trees we derive Table 5 where we see the difference between these two, showing the difference in depth and the amount of nodes for a certain configuration and its simplified version. In the heading H org means the original depth or the tree, where H simp means the depth of the simplified tree. N org is the number of nodes in the original tree and N simp means the number of nodes in the simplified tree. Now that we know this difference we can calculate the percentage of how simplified this tree is. How bigger the difference, the more simplified the tree is according to the original. Here we can also conclude that some trees have very large subtrees.
We see it takes less space to store all of the decision trees for the two-piece endgames than storing the two-piece endgame tablebase. When looking to the size of the two-piece endgame tablebase we need 6 MB to store this, where for the decision trees, including all of the attributes it takes around 300 KB.

Table 5: Two-piece decision trees normal vs. simplified.

Situation	**H org**	**N org**	**H simp**	**N simp**	**H diff**	**N diff**
Equal	3	11	3	11	0%	0%
wStronger(ex. Rat, Tiger, Lion)	4	9	2	5	50%	44.4%
bStronger(ex. Rat, Tiger, Lion)	7	21	4	11	42.9%	47.6%
wRat vs. stronger	8	29	3	9	62.5%	68.9%
bRat vs. stronger	10	33	2	5	80%	84.8%
wRat vs. bElephant	8	33	8	21	0%	36.4%
bRat vs. wElephant	10	43	7	23	30%	46.5%
wTiger vs. bRat	13	50	2	5	84.6%	90%
bTiger vs. wRat	16	52	4	11	75%	78.8%
wTiger vs. Lower(ex. Rat)	4	11	2	5	50%	54.5%
bTiger vs. Lower(ex. Rat)	6	21	4	11	33.3%	47.6%
wTiger vs. bElephant	10	26	3	9	70%	65.4%
bTiger vs. wElephant	9	24	3	7	66.7%	70.8%
wTiger vs. bLion	14	60	4	11	71.4%	81.7%
bTiger vs. wLion	9	38	2	5	77.8%	86.8%

6 The three-piece endgames

After seeing the two-piece endgames we proceed to the three-piece endgames. In the given situation when playing with three pieces on the game board there is always a player who has more pieces.

6.1 Three-piece endgame tablebase

In most of the games the player with the most pieces can do more moves, e.g., when having two pieces one piece can move to the den and the other piece can corner the other piece, by making him escape to a corner square, when one is playing with an higher piece, making an unopposed path to the den. Playing with two weaker pieces, i.e., one piece can move around the left water bank and the other piece can move around the right water bank, the opponent can focus on one piece only. Therefore the assumption is that most of the three-piece endgames result in a win for playing with more pieces or going from the three-piece endgames to the two-piece endgames, which is fine, because we already solved the two-piece endgames. Given this information we can divide the three-piece endgames in the following cases:

- white has two pieces and is stronger than black
- white has two pieces and is weaker than black
- white has one piece and one piece is stronger than black
- white has one piece and is stronger than black
- white has one piece and is weaker than black
- white has two piece and black has one piece stronger
- white has two pieces and one is stronger and one is equal to black
- white has two pieces and one is weaker and one is equal to black
- white has one piece and is equal to the strongest black piece
- white has one piece and is equal to the weakest black piece

In these cases we do not consider special cases for the special pieces, i.e., Rat, Tiger and Lion. In Table 6 we can find the wins, losses and draws for the three-piece endgame cases and represents the number of pieces used by the white player. When looking at Table 6 we see the player who has two pieces wins most of the time and that only a small amount of plays result in a draw.

Table 6: Wins - Draws - Losses in three-piece endgame cases.

White	One Piece	Two Pieces
Stronger	34.27% - 2.46% - 63.27%	86.7% - 0 - 23.3%
Weaker	24.3% - 0 - 75.7%	66.7% - 6.7% - 26.6%
One stronger	27.1% - 0.15% - 72.75%	83% - 0.001% - 17%
Equal strongest	31.35% - 0.25% - 68.4%	83.4% - 0% - 36.6%
Equal weakest	24.9% - 0.1% - 75%	86.3% - 0% - 33.4%

7 Situations in three-piece endgames

Now we look deeper into the different situations in three-piece endgames and make simple decision trees. These decision trees are not 100% correctly classified, because we only look at the top of the decision trees. Looking at the top of the tree we can determine the most import attributes for three-piece endgames in the different situations. Here we take the situations where white plays with two pieces and black with one piece, i.e., white can be stronger than both black pieces, white can be weaker than both black pieces and white can be one piece stronger.

7.1 White has two pieces and is stronger than black

Playing with two stronger pieces gives you an advantage in most cases, because you can win by capturing the opponent's piece or by rushing to the den with two pieces. It does not matter if a piece of the opponent is in your way, you simply capture this piece. Here we use the example white Dog, Lion vs. black Cat. Looking at Figure 29 confirms our assumption.

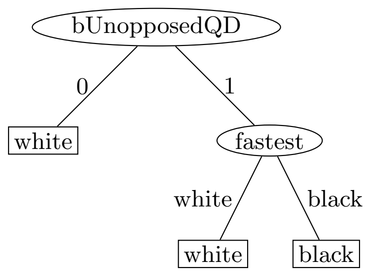


Figure 29: Decision tree top white Dog, Lion vs. black Cat.

This decision tree has 56 misclassified instances in the left branch of the three, which is only 0.05%.

7.2 White has two pieces and is stronger than black

Playing with two weaker pieces means that the opponent can capture you at any time. The only possible way to win is to reach the den. In figure 30 we find the top of the decision tree belonging to the configuration white Cat, Tiger vs. black Elephant. Here we have 1888 misclassified instances, which is 1.7%. The most misclassified instances can be found in last leaf. Here there are 1586 instances, which is 84% of all the misclassified instances.

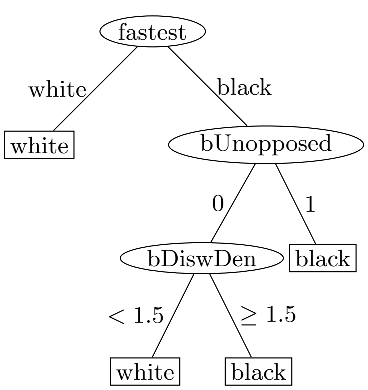


Figure 30: Decision tree top white Cat, Tiger vs. black Elephant.

7.3 White has two pieces and one is stronger than black

Having one stronger and one weaker piece than black gives you the opportunity to capture the opponent's piece, but also makes you vulnerable for the opponent. Here one tactic could be letting your lower piece guard the den near a trap square and try to reach the den with the stronger piece. For this situation we use the configuration white Rat, Elephant vs. black Lion. What will be an interesting one, because you can also prevent the Lion from jumping over the water squares by using your Rat. The top of this decision tree can be found in Figure 31, here we have 4182 misclassified instances, which is 3.0%. There is a misclassification in every node. The most wrongly classified instances are in the node left from the distance between the white Lion and the white den. In this node there are 2313 wrongly classified instances, which is 55.3% of all of the misclassifications.

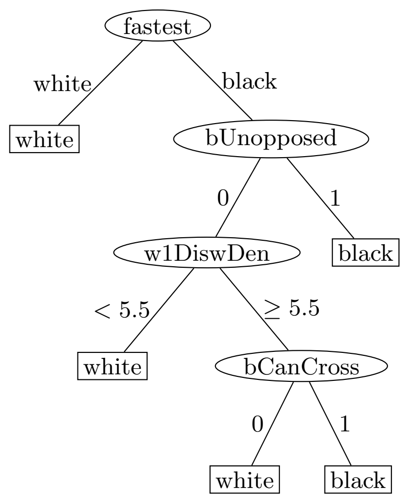


Figure 31: Decision tree top white Rat, Elephant vs. Lion.

7.4 Conclusions on Situations in three-piece endgames

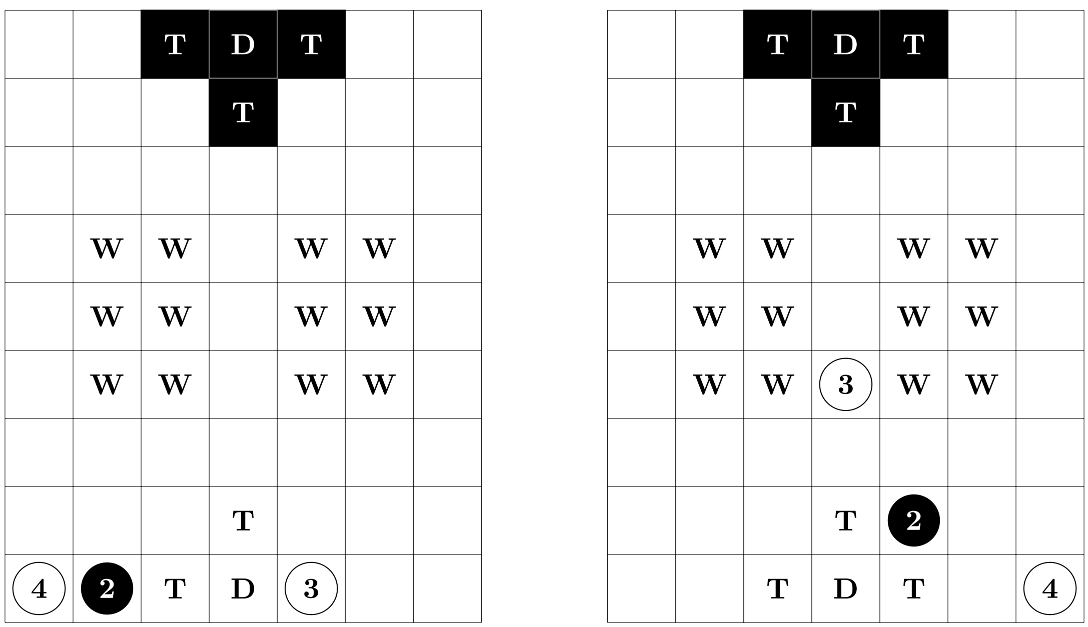
Having seen the different decision trees we have seen that most of the instances, mostly half of all the instances, are being covered for in the first node. From this we conclude that is important the be unopposed to the den or to be the fastest to reach the den. Shown in Figure 29, Figure 30 and Figure 31 we see a direct edge from the root node to a win for the white player, who has the most pieces and is the first to move a piece.

8 Three-piece configuration decision trees

After grouping the different three-piece endgame configurations, let us take a look into a thee-piece decision tree as a whole.

8.1 Findings in three-piece configuration decision trees

In comparison to two-piece endgames we expect that tree-piece decision trees are a lot more complex, due to having many more game situations in the case of two-piece endgames. The decision tree, which can be found in Appendix A, has the configuration white Dog, Wolf vs. black Cat, which would be a very simple configuration, where no special pieces are being used and white has two stronger pieces. In the decision tree the nodes with a rectangle represent the amount of endgames resulting in this node. By traversing the decision tree we see that only a small percentage of the endgames reaches the bottom of the tree. Remember that the total amount of situations in this configuration is 110,544.
This tree can be made a lot smaller, when taking a small error for granted, we can prune the tree and reach the tree in Figure 33. Here we take an error of 48 situations for granted, which is 0.043%. Two of those situations can be found in Figure 32a and Figure 32b.



(a) Misclassification example 1 (b) Misclassification example 2

Figure 32: Misclassification in white Wolf, Dog vs. black Cat.

Shown in the first example of Figure 32a black is unopposed and closest to the den, according to Figure 33 this would result in a win for black, but you can see that the first move that white will do is capture black, that means white will win. Shown in the second example of Figure 32b black is unopposed and closest to the den, according to Figure 33 it would win, but the white dog will capture the black cat if it moves to the right. If the black cat moves down, the white wolf will capture the black cat, that means that white will win and not black.

This situation where white has two stronger pieces is as expected, because you have more pieces and these pieces are stronger, therefore winning the game being white is obvious.

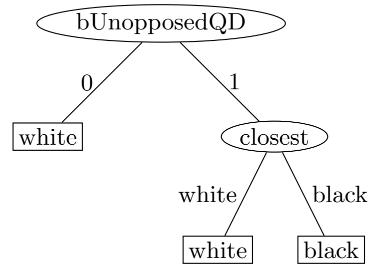


Figure 33: Decision tree white Dog, Wolf vs. black Cat pruned.

Now the situation where black has two pieces and those pieces are stronger is almost the same as the situation where white has two stronger pieces. The only difference is that white always begins, which is a great advantage.
What will be interesting is looking at the decision tree where white has one piece and is stronger then both black pieces. Here we take non special pieces as an example, e.g., white Elephant vs. black Wolf, Dog. It is not doable to show this tree, because it is too large with its tree size of 2705 nodes. If we compare this tree to the configuration of the tree in Appendix A we see that there was zero error in the original tree, where in our current configuration white Elephant vs. black Wolf, Dog there already is an error in 380 instances, which is only 0.34% of the total amount of instances. This error can be linked to some attributes we do not have at the moment for splitting the endgame tablebase. By pruning the decision tree for the configuration white Elephant vs. black Wolf and Dog we reach a tree size of 494 nodes and an error of 2993 instances. This is an error of 2.71% but we reduced the size of the tree by 81.73%, which makes the tree a lot more comprehensive.
So looking at three-piece endgame decision trees we see great differences in each configuration, where in some trees there are errors and in other trees there are none. To see what kind of configuration makes a tree big or small we have to look into the tree size, leaves and errors for all of the different configurations in the tree-piece endgames.
By looking in the table in Appendix B we can derive some interesting results and look, e.g., to the smallest and largest three-piece decision tree or the configuration that has the most errors. We can even find which configuration can be pruned best by looking at the difference of the size of the tree before and after it is pruned. This information can be found in Table 7.

Table 7: Three-piece decision trees results.

Conf	**Leaves**	**Size**	**InC**	**InC%**	**LeavesP**	**SizeP**	**InCP**	**InCP%**	**LeafDiff**	**SizeDiff**
Cde	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
Dpe	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
rtL	1865	3647	284	0.20%	318	609	3963	2.86%	82.95%	83.30%
RTl	1819	3540	252	0.18%	196	377	4369	3.15%	89.22%	89.35%
Tte	234	443	2	0.00%	56	106	431	0.39%	76.07%	76.07%
CEe	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
rcD	1078	2109	462	0.33%	187	365	2978	2.15%	82.65%	82.69%
cdP	1394	2705	380	0.34%	257	494	2993	2.71%	81.56%	81.74%
Rrc	212	410	6	0.00%	50	97	434	0.25%	76.42%	76.34%

When looking at Table 7 we see that the configurations where white has one weaker piece than both black pieces and there are non special pieces involved that this results in the smallest decisions trees. It is also remarkable that after pruning we get 0.06% errors, but a difference in tree size of 90.20%.
The largest decision trees are the configurations where special pieces are involved, especially the configurations where we have all three of them, i.e., Rat, Tiger and Lion on the same board.
As for error rates, remember that we saw configurations where we have errors and there are trees that have none, so what is causing those errors? It certainly has something to do with an unknown attribute that we did not implement yet. The question is, for what configurations this holds. We look at the configurations that have a small error rate in the original decision tree. The breakpoint for having errors in the original tree is the configuration white Tiger vs. black Tiger and Elephant. It is no surprise that it is with special pieces, but more important when looking at the rest of the data it mostly happens when there is a piece of equal strength involved like the configuration white Cat and Elephant vs. black Cat and white Tiger vs. black Tiger and Elephant.
The configurations that have the most errors in the original decision trees are the configurations where white has one stronger piece and black has two weaker pieces, e.g., the configuration white Panther vs. black Cat and Dog. It is not known what causes this sort of error.
If we look at the errors in the pruned decision trees we see that pruning the already small decision trees results in small errors but results in making the decision trees smaller for at least 85%. The larger decision trees, mostly including special pieces, have a larger error on pruning, but also results in an at least 85% smaller tree.
We have seen that we have a lot of different decision trees for the three-piece endgames, i.e., small, big, zero errors and a lot of errors. Now we introduce a measurement for the quality of the tree. The quality depends on the amount of leaves the tree has and the amount of errors. It is more important if the tree is smaller. According to this we can propose the following formula:

$$Quality = \frac{\%Correctclassified}{\#Leaves}$$

So by looking at the quality, the smaller the number is the worse the quality. Now we can calculate the quality for all of the configurations on the three-piece endgames, both unpruned and pruned. Here we obtained the best quality of 33.3 and the worst quality of 0.0535.
The quality of the configurations used in Table 7 can be found in Table 8.

Table 8: Quality results from configurations used in Table 7.

Configuration	Quality Unpruned	Quality Pruned	Quality Diff
Cde	3.700	33.31	88.88%
Dpe	3.700	33.31	88.88%
rtL	0.054	0.31	82.48%
RTl	0.055	0.49	88.89%
Tte	0.430	1.78	75.97%
CEe	0.320	1.63	80.55%
RcD	0.360	2.26	84.28%
cdP	0.071	0.39	81.11%
Rrc	0.470	1.99	76.36%

More useful information about the quality regarding the configurations of the three-piece endgames is that when calculating the difference of the quality in the original and pruned decision tree we find a pattern of configurations that score low or high in this difference.

For a low difference, where low is defined as the lowest difference on the current dataset based on the decision trees, we get around 67%. We find that most of these configurations involve a black Lion or Tiger and the white piece is at least equal or weaker than the black piece.
When looking at the highest differences in quality we find configurations of the kind white Lion and Tiger vs. lower. Here the difference is around 93.5%.
There is one configuration that stands out the most with a difference of 96.15% in quality, which is the configuration white Rat and Elephant vs. black Elephant. The pruned decision tree belonging to this configuration can be found in Figure 34. It is similar to the one in Figure 33, where we also have white with two higher.

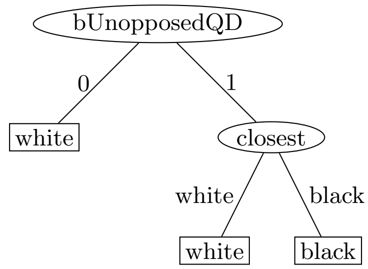


Figure 34: Decision tree white Rat, Elephant vs. black Elephant pruned.

8.2 Conclusions on three-piece endgames decision trees

For the three-piece endgame decision trees we can say that there are many differences in trees and situations. The difference between the smallest and largest tree is 3596 nodes and for pruned decision trees it is 604 nodes. Many decision trees are too large to deliver a good overview on the situation.
When comparing the size of the three-piece endgame tablebase and the size it needs to store all of the three-piece endgame decision trees we see that it takes less memory to store the decision trees. The three-piece endgame tablebase is 2 GB, where it only needs around 300 MB to store all of the three-piece decision trees including all the generated data, i.e., errors, number of leaves and the size of the three.

9 Conclusions and future work

In this thesis we have seen that there are different decision trees for the configurations in the two-piece and three-piece endgame tablebases of the game Dou Shou Qi. By visualizing the whole two-piece and three-piece endgame we gained more information on how the game Dou Shou Qi behaves and what leads to a win. We have seen that there are important attributes that contribute to the visualization of the game, especially reaching the den is better than capturing a piece. In the two-piece endgames we obtained really small decision trees after simplifying the original decision trees. In three-piece endgames we gained more insight and found patterns that explain why there are so many differences in the three-piece endgame decision trees, especially when there are special pieces involved.

In the field of game analysis one is not done until the game is fully solved. The game Dou Shou Qi is no exception to that rule. There is a lot more to discover in visualizing the game. After doing the two-piece and three-piece endgames there are more areas to cover. It is only natural to look at the four-piece endgames, five-piece endgames and so on and of course to solve the game, but what will be even more interesting to see is that we can add attributes in the three-piece endgames to give all configurations a hundred percent classification. Maybe this can be done by analysing all of the different configurations and automatically create new attributes by looking at the game and learning from all its different possibilities and finding patterns. It is also possible to combine the different decision trees into a large multi-layered tree. When having a certain game situation and capturing a piece, one reaches a small decision tree belonging to the current configuration. This can also be expanded by using decision diagrams, where for each decision tree with the same subtree one box will be made which makes it easier to find patterns.

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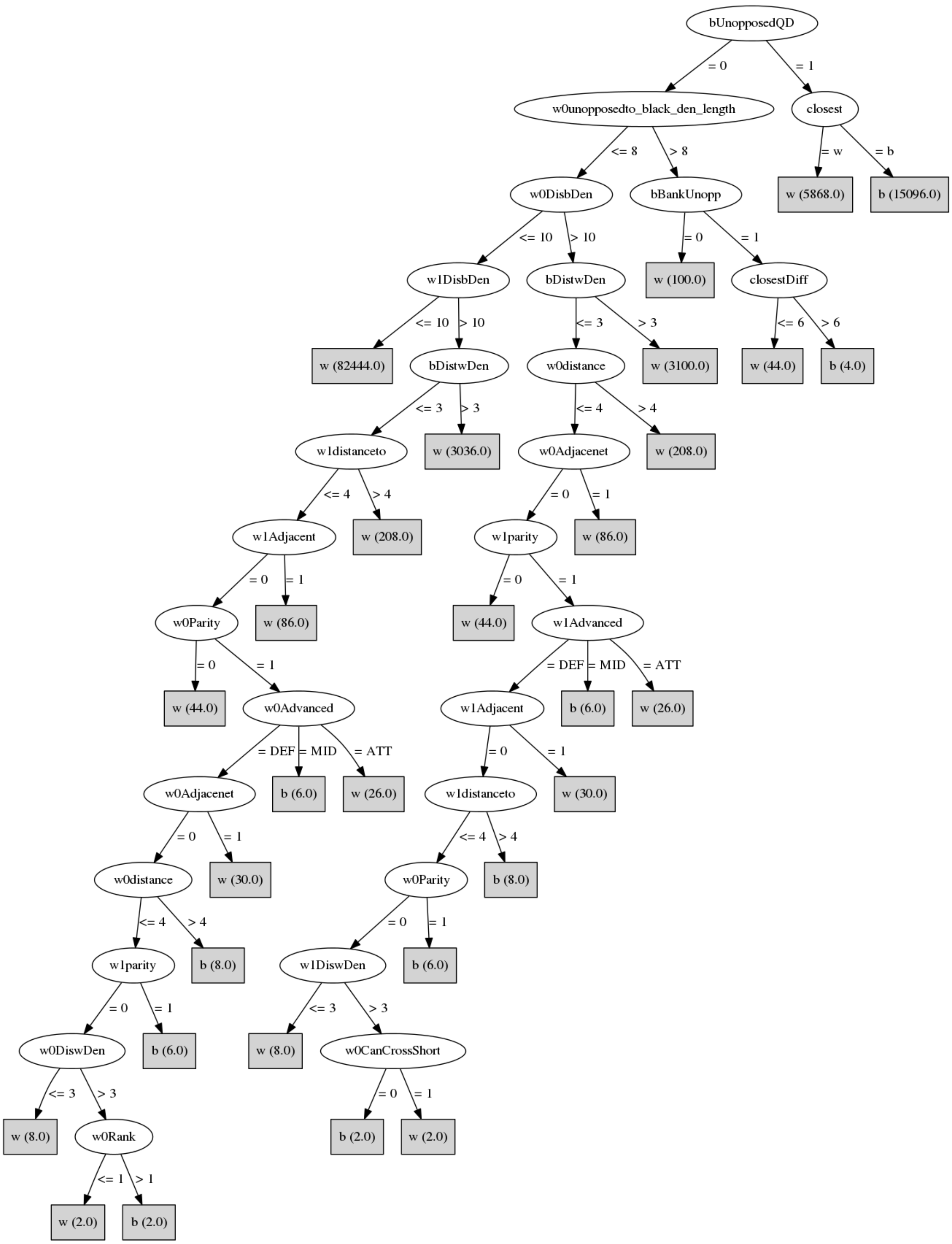
Appendices

A Three-piece white Dog, Wolf vs. black Cat



B Three-piece decision tree table

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
Ccd	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
CcD	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Cce	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
CcE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Ccl	108	207	0	0.00%	35	65	130	0.12%	67.59%	68.60%
CcL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
Ccp	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
CcP	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Cct	108	207	0	0.00%	35	65	130	0.12%	67.59%	68.60%
CcT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
Ccw	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
CcW	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
CDd	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
cDd	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
CDe	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
CDe	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
Cde	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
CdE	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%
cDE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
CdL	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
cDl	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Cdl	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
CDl	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
cDL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
cdL	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
CDp	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
cdP	1394	2705	380	0.34%	257	494	2993	2.71%	81.56%	81.74%
Cdp	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
CdP	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%
cDP	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
cDp	309	606	14	0.01%	79	153	557	0.50%	74.43%	74.75%
CdT	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
cDt	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Cdt	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
CDt	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
cDT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
cdT	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
CEe	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
cEe	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
Cle	39	75	0	0.00%	3	5	72	0.07%	92.31%	93.33%
cLE	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
CLe	501	979	116	0.10%	32	62	1158	1.05%	93.61%	93.67%
clE	679	1322	180	0.16%	69	132	1784	1.61%	89.84%	90.02%
ClE	787	1531	48	0.04%	82	160	1789	1.62%	89.58%	89.55%

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
cLe	992	1932	66	0.06%	167	321	1939	1.75%	83.17%	83.39%
CLl	459	897	18	0.02%	74	144	723	0.65%	83.88%	83.95%
cLl	773	1497	56	0.05%	110	213	1580	1.43%	85.77%	85.77%
CPe	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
cpE	1394	2705	380	0.34%	257	494	2993	2.71%	81.56%	81.74%
Cpe	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
CpE	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%
cPE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
cPe	309	606	14	0.01%	79	153	557	0.50%	74.43%	74.75%
CpL	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
cPl	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Cpl	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
CPl	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
cPL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
cpL	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
CPp	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
cPp	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
CpT	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
cPt	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Cpt	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
CPt	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
cPT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
cpT	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
Cte	39	75	0	0.00%	3	5	72	0.07%	92.31%	93.33%
cTE	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
CTe	501	979	116	0.10%	32	62	1158	1.05%	93.61%	93.67%
ctE	679	1322	180	0.16%	69	132	1784	1.61%	89.84%	90.02%
CtE	787	1531	48	0.04%	82	160	1789	1.62%	89.58%	89.55%
cTe	992	1932	66	0.06%	167	321	1939	1.75%	83.17%	83.39%
CTl	1299	2537	216	0.20%	156	294	3300	2.99%	87.99%	88.41%
ctL	1350	2634	232	0.21%	218	420	3016	2.73%	83.85%	84.05%
Ctl	28	53	0	0.00%	3	5	80	0.07%	89.29%	90.57%
CtL	401	787	20	0.02%	76	148	604	0.55%	81.05%	81.19%
cTL	48	91	0	0.00%	3	5	64	0.06%	93.75%	94.51%
cTl	607	1178	50	0.05%	72	141	1649	1.49%	88.14%	88.03%
CTt	459	897	18	0.02%	74	144	723	0.65%	83.88%	83.95%
cTt	773	1497	56	0.05%	110	213	1580	1.43%	85.77%	85.77%
CWd	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
cwD	1394	2705	380	0.34%	257	494	2993	2.71%	81.56%	81.74%
Cwd	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
CwD	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%
cWD	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
cWd	309	606	14	0.01%	79	153	557	0.50%	74.43%	74.75%
CWe	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
cwE	1394	2705	380	0.34%	257	494	2993	2.71%	81.56%	81.74%
Cwe	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
CwE	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
cWE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
cWe	309	606	14	0.01%	79	153	557	0.50%	74.43%	74.75%
CwL	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
cWl	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Cwl	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
CWl	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
cWL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
cwL	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
CWp	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
cwP	1394	2705	380	0.34%	257	494	2993	2.71%	81.56%	81.74%
Cwp	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
CwP	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%
cWP	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
cWp	309	606	14	0.01%	79	153	557	0.50%	74.43%	74.75%
CwT	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
cWt	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Cwt	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
CWt	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
cWT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
cwT	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
CWw	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
cWw	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
Dde	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
DdE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Ddl	108	207	0	0.00%	35	65	130	0.12%	67.59%	68.60%
DdL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
Ddp	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
DdP	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Ddt	108	207	0	0.00%	35	65	130	0.12%	67.59%	68.60%
DdT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
DEe	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
dEe	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
Dle	39	75	0	0.00%	3	5	72	0.07%	92.31%	93.33%
dLE	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
DLe	501	979	116	0.10%	32	62	1158	1.05%	93.61%	93.67%
dlE	679	1322	180	0.16%	69	132	1784	1.61%	89.84%	90.02%
DlE	787	1531	48	0.04%	82	160	1789	1.62%	89.58%	89.55%
dLe	992	1932	66	0.06%	167	321	1939	1.75%	83.17%	83.39%
DLl	459	897	18	0.02%	74	144	723	0.65%	83.88%	83.95%
dLl	773	1497	56	0.05%	110	213	1580	1.43%	85.77%	85.77%
DPe	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
dpE	1394	2705	380	0.34%	257	494	2993	2.71%	81.56%	81.74%
Dpe	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
DpE	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%
dPE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
dPe	309	606	14	0.01%	79	153	557	0.50%	74.43%	74.75%
DpL	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
dPl	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Dpl	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
DPl	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
dPL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
dpL	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
DPp	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
dPp	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
DpT	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
dPt	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Dpt	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
DPt	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
dPT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
dpT	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
Dte	39	75	0	0.00%	3	5	72	0.07%	92.31%	93.33%
dTE	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
DTe	501	979	116	0.10%	32	62	1158	1.05%	93.61%	93.67%
dtE	679	1322	180	0.16%	69	132	1784	1.61%	89.84%	90.02%
DtE	787	1531	48	0.04%	82	160	1789	1.62%	89.58%	89.55%
dTe	992	1932	66	0.06%	167	321	1939	1.75%	83.17%	83.39%
DTl	1299	2537	216	0.20%	156	294	3300	2.99%	87.99%	88.41%
dtL	1350	2634	232	0.21%	218	420	3016	2.73%	83.85%	84.05%
Dtl	28	53	0	0.00%	3	5	80	0.07%	89.29%	90.57%
DtL	401	787	20	0.02%	76	148	604	0.55%	81.05%	81.19%
dTL	48	91	0	0.00%	3	5	64	0.06%	93.75%	94.51%
dTl	607	1178	50	0.05%	72	141	1649	1.49%	88.14%	88.03%
DTt	459	897	18	0.02%	74	144	723	0.65%	83.88%	83.95%
dTt	773	1497	56	0.05%	110	213	1580	1.43%	85.77%	85.77%
LEe	262	508	18	0.02%	71	135	348	0.31%	72.90%	73.43%
lEe	422	822	42	0.04%	84	161	915	0.83%	80.09%	80.41%
Lle	234	443	2	0.00%	56	106	431	0.39%	76.07%	76.07%
LlE	39	76	0	0.00%	4	7	66	0.06%	89.74%	90.79%
PEe	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
pEe	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
Ple	39	75	0	0.00%	3	5	72	0.07%	92.31%	93.33%
pLE	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
PLe	501	979	116	0.10%	32	62	1158	1.05%	93.61%	93.67%
plE	679	1322	180	0.16%	69	132	1784	1.61%	89.84%	90.02%
PlE	787	1531	48	0.04%	82	160	1789	1.62%	89.58%	89.55%
pLe	992	1932	66	0.06%	167	321	1939	1.75%	83.17%	83.39%
PLl	459	897	18	0.02%	74	144	723	0.65%	83.88%	83.95%
pLl	773	1497	56	0.05%	110	213	1580	1.43%	85.77%	85.77%
Ppe	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
PpE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Ppl	108	207	0	0.00%	35	65	130	0.12%	67.59%	68.60%
PpL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
Ppt	108	207	0	0.00%	35	65	130	0.12%	67.59%	68.60%
PpT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
Pte	39	75	0	0.00%	3	5	72	0.07%	92.31%	93.33%
pTE	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
PTe	501	979	116	0.10%	32	62	1158	1.05%	93.61%	93.67%
ptE	679	1322	180	0.16%	69	132	1784	1.61%	89.84%	90.02%
PtE	787	1531	48	0.04%	82	160	1789	1.62%	89.58%	89.55%
pTe	992	1932	66	0.06%	167	321	1939	1.75%	83.17%	83.39%
PTl	1299	2537	216	0.20%	156	294	3300	2.99%	87.99%	88.41%
ptL	1350	2634	232	0.21%	218	420	3016	2.73%	83.85%	84.05%
Ptl	28	53	0	0.00%	3	5	80	0.07%	89.29%	90.57%
PtL	401	787	20	0.02%	76	148	604	0.55%	81.05%	81.19%
pTL	48	91	0	0.00%	3	5	64	0.06%	93.75%	94.51%
pTl	607	1178	50	0.05%	72	141	1649	1.49%	88.14%	88.03%
PTt	459	897	18	0.02%	74	144	723	0.65%	83.88%	83.95%
pTt	773	1497	56	0.05%	110	213	1580	1.43%	85.77%	85.77%
RCc	297	583	18	0.01%	57	110	539	0.39%	80.81%	81.13%
rCc	419	825	46	0.03%	104	204	743	0.54%	75.18%	75.27%
rcD	1078	2109	462	0.33%	187	365	2978	2.15%	82.65%	82.69%
RcD	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rCD	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rCd	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%
Rcd	52	99	0	0.00%	7	13	92	0.07%	86.54%	86.87%
RCd	869	1698	310	0.22%	159	305	2167	1.56%	81.70%	82.04%
RcE	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
RCe	391	770	14	0.01%	55	108	789	0.57%	85.93%	85.97%
rcL	1554	3043	246	0.18%	211	407	3419	2.46%	86.42%	86.63%
RcL	302	590	26	0.02%	52	98	572	0.41%	82.78%	83.39%
rCl	306	596	22	0.02%	49	95	542	0.39%	83.99%	84.06%
rCL	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
Rcl	53	103	0	0.00%	5	9	102	0.07%	90.57%	91.26%
rcP	1078	2109	462	0.33%	187	365	2978	2.15%	82.65%	82.69%
RcP	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rCP	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rCp	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%
Rcp	52	99	0	0.00%	7	13	92	0.07%	86.54%	86.87%
RCp	869	1698	310	0.22%	159	305	2167	1.56%	81.70%	82.04%
rcT	1554	3043	246	0.18%	211	407	3419	2.46%	86.42%	86.63%
RCt	1740	3406	194	0.14%	189	369	4086	2.94%	89.14%	89.17%
RcT	302	590	26	0.02%	52	98	572	0.41%	82.78%	83.39%
rCt	306	596	22	0.02%	49	95	542	0.39%	83.99%	84.06%
rCT	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
Rct	53	103	0	0.00%	5	9	102	0.07%	90.57%	91.26%
rcW	1078	2109	462	0.33%	187	365	2978	2.15%	82.65%	82.69%
RcW	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rCW	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rCw	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%
Rcw	52	99	0	0.00%	7	13	92	0.07%	86.54%	86.87%
RCw	869	1698	310	0.22%	159	305	2167	1.56%	81.70%	82.04%

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
RDd	297	583	18	0.01%	57	110	539	0.39%	80.81%	81.13%
rDd	419	825	46	0.03%	104	204	743	0.54%	75.18%	75.27%
Rde	160	302	2	0.00%	44	84	230	0.17%	72.50%	72.19%
RdE	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rDE	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rDe	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%
RDe	391	770	14	0.01%	55	108	789	0.57%	85.93%	85.97%
rdE	488	961	36	0.03%	110	217	866	0.62%	77.46%	77.42%
rdL	1554	3043	246	0.18%	211	407	3419	2.46%	86.42%	86.63%
RDl	1740	3406	194	0.14%	189	369	4086	2.94%	89.14%	89.17%
RdL	302	590	26	0.02%	52	98	572	0.41%	82.78%	83.39%
rDl	306	596	22	0.02%	49	95	542	0.39%	83.99%	84.06%
rDL	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
Rdl	53	103	0	0.00%	5	9	102	0.07%	90.57%	91.26%
rdP	1078	2109	462	0.33%	187	365	2978	2.15%	82.65%	82.69%
RdP	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rDP	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rDp	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%
Rdp	52	99	0	0.00%	7	13	92	0.07%	86.54%	86.87%
RDp	869	1698	310	0.22%	159	305	2167	1.56%	81.70%	82.04%
rdT	1554	3043	246	0.18%	211	407	3419	2.46%	86.42%	86.63%
RDt	1740	3406	194	0.14%	189	369	4086	2.94%	89.14%	89.17%
RdT	302	590	26	0.02%	52	98	572	0.41%	82.78%	83.39%
rDt	306	596	22	0.02%	49	95	542	0.39%	83.99%	84.06%
rDT	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
Rdt	53	103	0	0.00%	5	9	102	0.07%	90.57%	91.26%
rEe	291	561	12	0.01%	62	119	481	0.35%	78.69%	78.79%
REe	78	153	0	0.00%	3	5	214	0.15%	96.15%	96.73%
rLe	1141	2211	124	0.09%	151	290	2212	1.59%	86.77%	86.88%
Rle	144	275	2	0.00%	27	50	251	0.18%	81.25%	81.82%
RLe	323	627	28	0.02%	80	152	500	0.36%	75.23%	75.76%
rLE	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
rlE	508	987	52	0.04%	108	208	1026	0.74%	78.74%	78.93%
RlE	870	1678	70	0.05%	91	178	1629	1.17%	89.54%	89.39%
rLl	1039	2023	154	0.11%	138	269	2162	1.56%	86.72%	86.70%
RLl	495	970	64	0.05%	58	113	986	0.71%	88.28%	88.35%
Rpe	160	302	2	0.00%	44	84	230	0.17%	72.50%	72.19%
RpE	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rPE	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rPe	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%
RPe	391	770	14	0.01%	55	108	789	0.57%	85.93%	85.97%
rpE	488	961	36	0.03%	110	217	866	0.62%	77.46%	77.42%
rpL	1554	3043	246	0.18%	211	407	3419	2.46%	86.42%	86.63%
RPl	1740	3406	194	0.14%	189	369	4086	2.94%	89.14%	89.17%
RpL	302	590	26	0.02%	52	98	572	0.41%	82.78%	83.39%
rPl	306	596	22	0.02%	49	95	542	0.39%	83.99%	84.06%
rPL	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
Rpl	53	103	0	0.00%	5	9	102	0.07%	90.57%	91.26%
RPp	297	583	18	0.01%	57	110	539	0.39%	80.81%	81.13%
rPp	419	825	46	0.03%	104	204	743	0.54%	75.18%	75.27%
rpT	1554	3043	246	0.18%	211	407	3419	2.46%	86.42%	86.63%
RPt	1740	3406	194	0.14%	189	369	4086	2.94%	89.14%	89.17%
RpT	302	590	26	0.02%	52	98	572	0.41%	82.78%	83.39%
rPt	306	596	22	0.02%	49	95	542	0.39%	83.99%	84.06%
rPT	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
Rpt	53	103	0	0.00%	5	9	102	0.07%	90.57%	91.26%
Rrc	212	410	6	0.00%	50	97	434	0.25%	76.42%	76.34%
RrC	30	58	0	0.00%	3	5	52	0.03%	90.00%	91.38%
Rrd	212	410	6	0.00%	50	97	434	0.25%	76.42%	76.34%
RrD	30	58	0	0.00%	3	5	52	0.03%	90.00%	91.38%
Rre	281	551	20	0.01%	57	111	660	0.38%	79.72%	79.85%
RrE	38	74	0	0.00%	3	5	60	0.03%	92.11%	93.24%
Rrl	192	373	22	0.01%	49	94	289	0.17%	74.48%	74.80%
RrL	47	93	16	0.01%	3	5	84	0.05%	93.62%	94.62%
Rrp	212	410	6	0.00%	50	97	434	0.25%	76.42%	76.34%
RrP	30	58	0	0.00%	3	5	52	0.03%	90.00%	91.38%
Rrt	192	373	22	0.01%	49	94	289	0.17%	74.48%	74.80%
RrT	47	93	16	0.01%	3	5	84	0.05%	93.62%	94.62%
Rrw	212	410	6	0.00%	50	97	434	0.25%	76.42%	76.34%
RrW	30	58	0	0.00%	3	5	52	0.03%	90.00%	91.38%
rTe	1141	2211	124	0.09%	151	290	2212	1.59%	86.77%	86.88%
Rte	144	275	2	0.00%	27	50	251	0.18%	81.25%	81.82%
RTe	323	627	28	0.02%	80	152	500	0.36%	75.23%	75.76%
rTE	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
rtE	508	987	52	0.04%	108	208	1026	0.74%	78.74%	78.93%
RtE	870	1678	70	0.05%	91	178	1629	1.17%	89.54%	89.39%
RTl	1819	3540	252	0.18%	196	377	4369	3.15%	89.22%	89.35%
rtL	1865	3647	284	0.20%	318	609	3963	2.86%	82.95%	83.30%
rTL	32	59	0	0.00%	3	5	64	0.05%	90.62%	91.53%
Rtl	33	65	0	0.00%	3	5	104	0.07%	90.91%	92.31%
RtL	492	962	68	0.05%	72	142	948	0.68%	85.37%	85.24%
rTl	822	1586	154	0.11%	96	186	1988	1.43%	88.32%	88.27%
rTt	1039	2023	154	0.11%	138	269	2162	1.56%	86.72%	86.70%
RTt	495	970	64	0.05%	58	113	986	0.71%	88.28%	88.35%
rwD	1078	2109	462	0.33%	187	365	2978	2.15%	82.65%	82.69%
RwD	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rWD	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rWd	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%
Rwd	52	99	0	0.00%	7	13	92	0.07%	86.54%	86.87%
RWd	869	1698	310	0.22%	159	305	2167	1.56%	81.70%	82.04%
Rwe	160	302	2	0.00%	44	84	230	0.17%	72.50%	72.19%
RwE	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rWE	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rWe	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
RWe	391	770	14	0.01%	55	108	789	0.57%	85.93%	85.97%
rwE	488	961	36	0.03%	110	217	866	0.62%	77.46%	77.42%
rwL	1554	3043	246	0.18%	211	407	3419	2.46%	86.42%	86.63%
RWl	1740	3406	194	0.14%	189	369	4086	2.94%	89.14%	89.17%
RwL	302	590	26	0.02%	52	98	572	0.41%	82.78%	83.39%
rWl	306	596	22	0.02%	49	95	542	0.39%	83.99%	84.06%
rWL	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
Rwl	53	103	0	0.00%	5	9	102	0.07%	90.57%	91.26%
rwP	1078	2109	462	0.33%	187	365	2978	2.15%	82.65%	82.69%
RwP	281	551	18	0.01%	44	85	596	0.43%	84.34%	84.57%
rWP	31	59	0	0.00%	3	5	48	0.03%	90.32%	91.53%
rWp	353	684	18	0.01%	53	102	779	0.56%	84.99%	85.09%
Rwp	52	99	0	0.00%	7	13	92	0.07%	86.54%	86.87%
RWp	869	1698	310	0.22%	159	305	2167	1.56%	81.70%	82.04%
rwT	1554	3043	246	0.18%	211	407	3419	2.46%	86.42%	86.63%
RWt	1740	3406	194	0.14%	189	369	4086	2.94%	89.14%	89.17%
RwT	302	590	26	0.02%	52	98	572	0.41%	82.78%	83.39%
rWt	306	596	22	0.02%	49	95	542	0.39%	83.99%	84.06%
rWT	40	78	0	0.00%	3	5	58	0.04%	92.50%	93.59%
Rwt	53	103	0	0.00%	5	9	102	0.07%	90.57%	91.26%
RWw	297	583	18	0.01%	57	110	539	0.39%	80.81%	81.13%
rWw	419	825	46	0.03%	104	204	743	0.54%	75.18%	75.27%
TEe	262	508	18	0.02%	71	135	348	0.31%	72.90%	73.43%
tEe	422	822	42	0.04%	84	161	915	0.83%	80.09%	80.41%
tLE	34	67	0	0.00%	4	7	56	0.05%	88.24%	89.55%
TLe	371	722	60	0.05%	35	68	934	0.84%	90.57%	90.58%
tlE	580	1130	112	0.10%	60	117	1542	1.39%	89.66%	89.65%
Tle	74	139	0	0.00%	10	18	116	0.10%	86.49%	87.05%
TlE	851	1654	36	0.03%	80	153	1607	1.45%	90.60%	90.75%
tLe	972	1877	90	0.08%	135	261	2342	2.12%	86.11%	86.09%
TLl	420	821	18	0.02%	69	135	730	0.66%	83.57%	83.56%
tLl	844	1636	84	0.08%	170	328	1516	1.37%	79.86%	79.95%
Tte	234	443	2	0.00%	56	106	431	0.39%	76.07%	76.07%
TtE	39	76	0	0.00%	4	7	66	0.06%	89.74%	90.79%
Ttl	242	457	0	0.00%	47	88	487	0.44%	80.58%	80.74%
TtL	47	91	0	0.00%	3	5	64	0.06%	93.62%	94.51%
WDd	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
wDd	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
WDe	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
Wde	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
WdE	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%
wDt	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Wdt	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
wDT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
wdT	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
WEe	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
wEe	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%

Conf	Leaves	Size	InC	InC%	LeavesP	SizeP	InCP	InCP%	LeafDiff	SizeDiff
Wle	39	75	0	0.00%	3	5	72	0.07%	92.31%	93.33%
wLE	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
WLe	501	979	116	0.10%	32	62	1158	1.05%	93.61%	93.67%
wlE	679	1322	180	0.16%	69	132	1784	1.61%	89.84%	90.02%
WlE	787	1531	48	0.04%	82	160	1789	1.62%	89.58%	89.55%
wLe	992	1932	66	0.06%	167	321	1939	1.75%	83.17%	83.39%
WLl	459	897	18	0.02%	74	144	723	0.65%	83.88%	83.95%
wLl	773	1497	56	0.05%	110	213	1580	1.43%	85.77%	85.77%
WPe	1286	2497	264	0.24%	275	531	2722	2.46%	78.62%	78.73%
wpE	1394	2705	380	0.34%	257	494	2993	2.71%	81.56%	81.74%
Wpe	27	51	0	0.00%	3	5	64	0.06%	88.89%	90.20%
WpE	279	544	12	0.01%	54	104	483	0.44%	80.65%	80.88%
wPE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
wPe	309	606	14	0.01%	79	153	557	0.50%	74.43%	74.75%
WpL	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
wPl	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Wpl	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
WPl	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
wPL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
wpL	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
WPp	315	610	12	0.01%	61	117	486	0.44%	80.63%	80.82%
wPp	422	827	36	0.03%	86	169	797	0.72%	79.62%	79.56%
WpT	254	497	12	0.01%	64	124	379	0.34%	74.80%	75.05%
wPt	293	570	16	0.01%	69	132	528	0.48%	76.45%	76.84%
Wpt	37	71	0	0.00%	3	5	72	0.07%	91.89%	92.96%
WPt	406	787	32	0.03%	127	246	736	0.67%	68.72%	68.74%
wPT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
wpT	424	829	102	0.09%	109	212	1008	0.91%	74.29%	74.43%
Wte	39	75	0	0.00%	3	5	72	0.07%	92.31%	93.33%
wTE	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
WTe	501	979	116	0.10%	32	62	1158	1.05%	93.61%	93.67%
wtE	679	1322	180	0.16%	69	132	1784	1.61%	89.84%	90.02%
WtE	787	1531	48	0.04%	82	160	1789	1.62%	89.58%	89.55%
wTe	992	1932	66	0.06%	167	321	1939	1.75%	83.17%	83.39%
WTl	1299	2537	216	0.20%	156	294	3300	2.99%	87.99%	88.41%
wtL	1350	2634	232	0.21%	218	420	3016	2.73%	83.85%	84.05%
Wtl	28	53	0	0.00%	3	5	80	0.07%	89.29%	90.57%
WtL	401	787	20	0.02%	76	148	604	0.55%	81.05%	81.19%
wTL	48	91	0	0.00%	3	5	64	0.06%	93.75%	94.51%
wTl	607	1178	50	0.05%	72	141	1649	1.49%	88.14%	88.03%
WTt	459	897	18	0.02%	74	144	723	0.65%	83.88%	83.95%
wTt	773	1497	56	0.05%	110	213	1580	1.43%	85.77%	85.77%
Wwd	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
WwD	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Wwe	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
WwE	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Wwl	108	207	0	0.00%	35	65	130	0.12%	67.59%	68.60%

Conf	**Leaves**	**Size**	**InC**	**InC%**	**LeavesP**	**SizeP**	**InCP**	**InCP%**	**LeafDiff**	**SizeDiff**
WwL	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%
Wwp	125	237	0	0.00%	34	61	168	0.15%	72.80%	74.26%
WwP	30	57	0	0.00%	3	5	48	0.04%	90.00%	91.23%
Wwt	108	207	0	0.00%	35	65	130	0.12%	67.59%	68.60%
WwT	42	80	0	0.00%	3	5	56	0.05%	92.86%	93.75%