Section 2.1 – Go Background

Go is a two player board game that originated in China more than 2,500 years ago and is still mostly played in its original form. Players have ranks from 30-1 Kyu, and 1-9Dan where Dan ranks are for grand masters. It is a territorial game. Simply put the aim of Go is to surround more territory than your opponent. The board, usually marked with a grid of 19 lines by 19 lines, may be thought of as a piece of land to be shared between the two players. One player has black stones and the other white stones. Each player takes a turn to place a stone; stones are placed on the intersections of lines and not in the squares themselves. The game continues until either both players pass or there are no more legal moves for each player. Some of the basic rules are detailed bellow:

· The board is empty at the beginning of the game unless the players agree to a handicap (If one player has a handicap of 3 then that player will start with 3 stones on the board at the start of the game).

· Once placed on the board, stones may not be moved, but stones may be captured. This is done by surrounding an opposing stone or group of stones.

· A player may pass his turn at any time.

· A stone or solidly connected group of stones of one colour is captured and removed from the board when all the intersections directly adjacent to it are occupied by the enemy(The group has no liberties).

· A player's territory consists of all the points the player has either occupied or surrounded.

· The game is won by gaining the most points, which are determined by:

1. The number of pieces captured.

2. The amount of territory held at the end.

List of Go terms relevant for life and death problems

A **liberty** is an empty intersection that is adjacent to a stone or to a connected chain of stones.

Figure 2.1.3 eyes

**Eyes** can be described as internal liberties of a group of stones that, like external liberties, prevent the group’s capture but are much harder for an opponent to fill in. Eyes are very significant for life and death problems as the existence or non-existence of eyes in a group determine whether that group is alive or dead. A group with no eyes or one eye will die unless its holder can develop them into two eyes. A group with two or more eyes will live because it is impossible to remove all liberties of the group in one move by the attacker. In figure 2.1.3 all internal liberties with a red circle can be described as eyes.

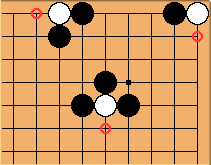
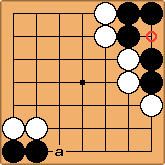
 

Figure 2.1.1 – single stones in Atari Figure 2.1.2 – groups of stones in

**Atari** is a term used in Go for a situation where a stone or group of stones only has one liberty and can be captured on the next move unless the defending player places a stone on the liberty thus giving the group more liberties and at least temporarily taking the group out of Atari. In figure 2.1.1 above if black places a stone at any of the liberties with a red circle then black will capture the white stone. In figure 2.1.2 if white places a stone at either the liberty at “a” or the liberty with a red circle then the black stones will be captured.

Figure 2.1.4 a hane

A **Hane** is a move that wraps around the opposing players stone or group of stones and doesn’t touch any of the player’s stones or a diagonal move played in contact with an enemy stone. There are many positions where a hane is considered a good move [\*find a position where a hane would be a good move\*]. In figure 2.1.4 the stone labelled with a one is a hane as it wraps around the black stone and isn’t adjacent to another white stone.

Figure 2.1.5 – The Ko rule

**Ko** describes a situation where two alternating single stone captures would repeat the original board position. These alternating captures could repeat indefinitely creating an infinite loop in the game. The Ko rule stops this infinite loop from occurring: *If one player captures the Ko, the opponent is prohibited from recapturing the Ko immediately*. In figure 2.1.5 above black can capture the white stone with the red circle by a play at “”*a*. The resulting position is shown on the right. Without a Ko rule, in this position White could recapture the black stone with the red circle by playing at “b, which would return the board to the position on the left and then Black could also recapture creating an infinite loop. So, if in left position of the diagram above Black captures at “a”, White may not play at “b” for his first move after the black capture. Instead White has to play elsewhere. After that Black can choose either to win the Ko by playing at” b” in the right position in the diagram, or to play elsewhere as well. Playing elsewhere however would allow White to take the Ko back, since the recapture restriction is only valid for the next turn.

Figure 2.1.6 miai

**Miai** can be defined as a pair of empty points that have the same value. For example if black plays at A, white can play at B and suffer no disadvantage from the exchange. Equivalence is an important aspect of miai, in the sense that the two options allow the same objective to be achieved more or less. For example, miai in a life and death context might mean the existence of two different moves resulting in the same outcome of a group living or being killed. In figure 2.1.6 above both point “a” and point “b” have the same value in terms of the life and death of the group if black plays at “a” then white plays at “b” and vice versa. If white places a stone at either “a” or “b” he creates a second eye for the group and thus keeps it alive.

Figure 2.1.7 - seki

The term **Seki** translated into English means mutual life, this situation occurs when two live groups share liberties which neither of them can fill without dying so neither player will.

In figure 2.1.7 above the white group of stones and black group of stones with red circles share two liberties “a” and “b”. If either player plays into one of these points the opposing player with play into the other and capture the opposing player’s stone so neither player will. [\*maybe include another seki example where the group has eyes\*] .

Section 2.2 – Go problems

Why only life and death?

The search space for Go's game tree is both wider and deeper than that of chess. It has been estimated to be as big as ~10^170 compared to ~10^50 for chess. It is possible for the search space for a life and death problem to be larger than all of chess. The universe just has 10^82 atoms in it at most. With the timescale and number of people on this project it would not be feasible for us to create an AI to play a full sized game of Go. Therefore it has been decided to concentrate our efforts into solving some life and death problems which is a more realistic yet still challenging goal. Furthermore, the project initially focused on a small subset of life and death problems before moving on to more computationally challenging problems once the initial problems were being solved with a reasonable success rate.

Common life and death problems/patterns

Most life and death problems be grouped into a shape or a technique used to solve the problem given the limited time scale of the project, the number of different type of patterns the program can solve is constrained to a small subset of the common problems. However with that said one small positional change of a stone can a big difference to the complexity of the problem.

Unsettled Three Pattern

Figure 2.2.1 – The unsettled 3 pattern showing 2 different groups

This shape is concerned with when a group’s interior eye shape consists of three spaces in either the form of a bent three space or a straight three. Here the key number is 3 if the space is any less than three then the group is dead, four spaces and the group is alive. In figure 2.2.1 above if white plays at either of the red circles the group lives because it creates two eyes for that group if black plays at either of the red circles it kills white.

Six Die, Eight Live Pattern

The groups of stones in this section consist of rows of stones on the second line in from the edge of the board. Therefore the groups eye space lies on the edge of the board. When the group is away from the corner the rule is six die, eight live