Equivalent Size of Moyo

TAJIMA Morihiko, SANECHIKA Noriaki

National Institute of Advanced Industrial Science and Technology
Tsukuba Central 2, 1-1-1, Umezono, Tsukuba-shi, 305-8568 JAPAN
tajima.m@aist.go.jp, sanetika@sepia.ocn.ne.jp

Abstract

It has been recognized that the position evaluation of the game of Go is an important theme, though it is very difficult. The authors have proposed a method that evaluates opening positions by utilizing the possible omission number (PON) and has shown its effectiveness. However, they have also shown that there exists problems the method cannot solve. One of the reasons is that the method considers only the neighboring points of groups. In order to solve the problem, a large framework of territory (*moyo*) should be dealt with. This paper presents a concept named "enclosed equivalent size", which is the equivalent size reflecting moyo, and a means of estimation of the value.

Keywords: computer Go, fuseki, *moyo*, equivalent size

1 Introduction

In nowadays, the interest in computer games is being transfered from chess to shogi and go. Contrary to the case of chess, where brute force search is amazingly effective, it has been recognised that more intelligent methods are necessary for the games of shogi and go. Especially the game of go is regarded as the most challenging theme after chess because of the enormous size of the search space of the game tree and the difficulty in the evaluation of positions which have a lot of complexity and varieties in spite of the fact that the game uses only a single kind of piece, the stone.

Methods to make position evaluation has not been utilized effectively in playing programs yet. It is getting recognised, however, that position evaluation in the game of go is an important theme, though it is difficult (e.g. [1][2]). We have proposed a method that evaluates opening positions by utilizing the possible omission number (PON)[3] and has shown its effectiveness. However, we have also shown that there are some problems the method cannot solve[4]. One of the reasons is that the method is based on the assumption that the closer a point is to a stone the stronger the influence of the stone. On the assumption, the method counts only the neighbouring points (as far as distance 4) of the stone. Therefore, the method is comparatively suitable for measuring the "strength of stones", but it is not sufficient as a means to measure the other element of evaluation, "size of area." Especially in the measurement of *moyo*, which is an area incomplete as a territory, there are a lot of problems.

We have been challenging the problems by using the concepts of "family" and "region"[5]. In this paper, we present a means to estimate "equivalent size" of a vacant point in a region considering the whole go board as a refined means of the approach. We review the *atsumi* (or thickness), which is a fundamental element of position evaluation, in Section 2, and the "board partition by equidistance line" in Section 3. Then we present *cutoff number* and *enclosed equivalent size*, which is calculated from the cutoff number, in Section 4. We discuss the properties of enclosed equivalent size in 5 and conclude this paper in 6.

2 Atsumi by group

In this paper, we utilize the position shown in Fig.1 as an example. This is the 34th position of the second game of Challenger Decision Match of Kiseisen in 1989 (Black: Chou Chikun 9 Dan, White: Takemiya Masaki 9 Dan, Result: White won by regignation after 168 moves.)[6]. It is an example where Black's strategy and White's strategy contrasts strikingly, i.e. while Black established territories on corners and an edge, White made a large moyo in the center of the board.

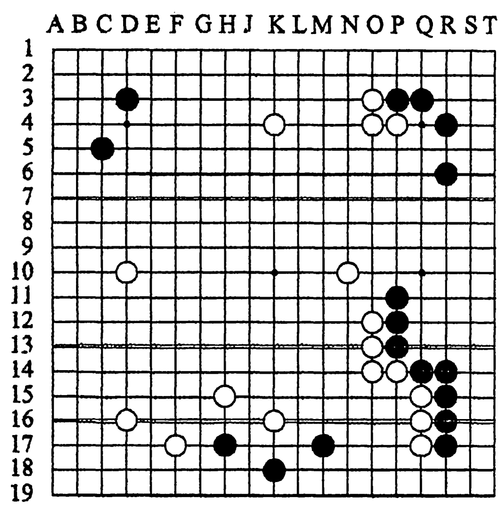

Figure 1: Example of a position

Fig.2 shows the *atsumi* which our playing system named Shikou Sakugo gives[1]. The values mean the equivalent size, which are obtained by normilising the potential values [7] that show the influence of the stones to their surrounding vacant points. As a matter of convenience, the values are shown as

[1]Though *atsumi* is usually the term which expresses advantageous state or form (e.g. influence, wall, etc.) in a battle for existence of stones, we let the term mean the degree of control of a group to its surrounding vacant points in this paper. The degree is 1.0 point if a point is completely controlled.

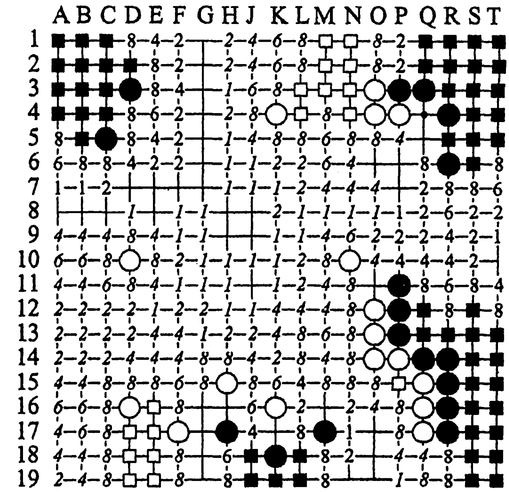

Figure 2: Atsumi by groups

are multiplied by 10 and are written in Roman font and Italic font for Black and White, respectively. We let the points with atsumi of 1.0 territory and show those of Black and those of White by "■" and "□", respectively. On a vacant point without a value, Black and White share the control equally. A point with atsumi over or equal to 0.8 (shown as 8) can be regarded as a point which can prevent the opponent from invading. We call such a point *cutoff point*.

The atsumi shown here is based on the distance from groups, and the equivalent size is assigned to only the *dame* (or liberty) points as far as the 4th dame points (also to some exceptional 5th dame points). This is based on the heuristics that the degree of dame points which a group is likely to make its territory is substantially up to 4. There is, however, the problem that the possibility that a large *moyo* will form a territory is neglected, since the atsumi based on the closeness cannot express the fact that it is not until stones of the same colour encloses necessary vacant points that a territory is completed. In other words, since the element of enclosing is more important than that of distance for making territory, it is necessary to express the degree of enclosing by some number which can be calculated easily.

3 Board partition by equidistance line

In order to solve the problem of expressing the degree of enclosing, we have defined and utilized *region* formed by the board partition by equidistance line where the distance from Black is equal to that from White[5]. Fig.3 shows an example where the board is partitioned into three black regions and one white region. Black regions and white regions are shown by small "■" and "□", respectively, and a point on a equidistance line is shown by "*".

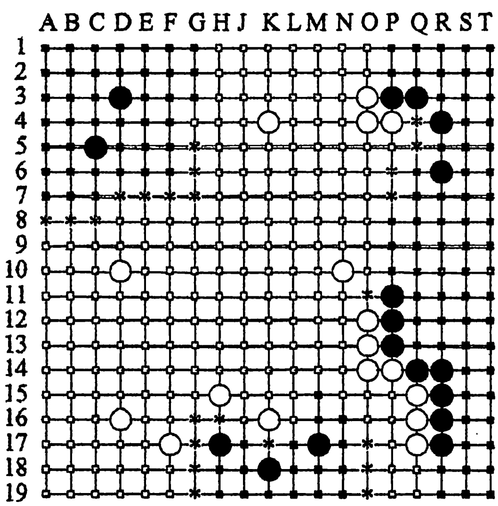

Figure 3: Regions formed by board partition by equidistance line

The following can be observed from this example. The regions roughly show the areas each colour controls, i.e. we can see that Black controls the upper left corner, the lower middle edge, and the whole of the right edge and White controls the lower left corner and the central part of the board. Especially, the points H8, H9, J8, J9, and J11, which seem to belong to neither colour in Fig.2, can be clearly identified in the region of White.

From the method, however, we cannot know how likely each vacant point of a region will be territory. In order to utilize region effectively, more quantitative means should be developed.

4 Cutoff number and equivalent size

We wish to estimate in terms of equivalent size which colour and how a vacant point in a region belongs to. We call the equivalent size *enclosed equivalent size.* We estimate the size, which is not based on the distance from groups, by obtaining the enclosed equivalent size as the "the degree of enclosing".

We utilize a concept named *cutoff number* to calculate enclosed equivalent size. In the following, we will expand the concept of "cutoff point" explained in 2, define cutoff number under the concept, and propose a calculation method of enclosed equivalent size based on cutoff number.

4.1 Cutoff object

Firstly, we expand the concept of cutoff point, which is a point that can prevent the opponent from invading. We name the expanded concept *cutoff object.* It include stones, cutoff points of connecting lines, territories, and two kinds of new objects, *n-perpendicular* ($n \leq 4$), and *same colour span* with less than or equal to 5-space. "n-perpendicular" is perpendicular from a stone on the n-th line to the edge. "Same colour span" is the span between two n-perpendiculars ($n \leq 4$) of the same colour. As described in 2, cut off points of connecting lines and territories can be recognised as vacant points whose atsumi is greater than or equal to 0.8.

We call n-perpendicular *n-leg* hereafter. Legs under 5th line can be included among cutoff objects from the viewpoint of enclosing, since it has the effect of cutoff. And when two n-legs ($n \leq 4$) of the same colour face each other on the same edge, we regard the same colour span as to be a cutoff object if the interval is less than or equal to 5-space (i.e. The distance is not more than 6.).

Fig.4 shows the new cutoff objects, n-legs ($n \leq 4$) and same colour spans of less than or equal to 5-space. The legs of Black and White are denoted by "#" and "@", respectively, and the same colour spans of Black and

White are denoted by "&" and "!!", respectively. Cutoff objects of same colour span are shown on the points on the 1st line.

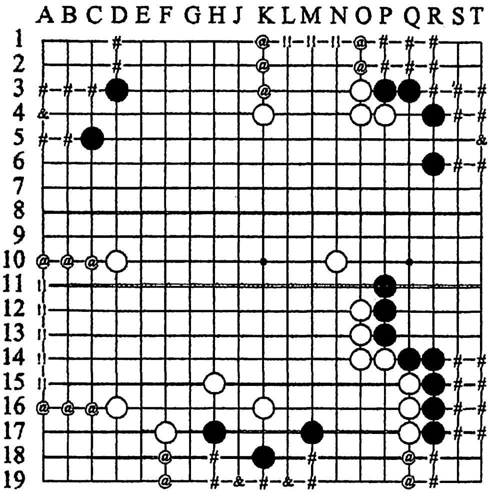

Figure 4: Other cutoff objects

4.2 Cutoff number

We introduce a new concept named *cutoff number* in order to estimate the degree of enclosing vacant points.

【Definition】 *cutoff number*

Black's cutoff number on a target vacant point is defined as follows. Let a cursor start from the target point and move along vacant points on each straight line in the four directions (up, down, right, left), and count the number of directions to which the cursor can reach black cutoff object. When the cursor reaches white cutoff object on the way, it fails.

White's cutoff number is defined in the same manner.

We obtain the cutoff numbers for vacant points which are not cutoff objects. Since the number of the directions is four, both (Black's and White's) cutoff numbers cannot have values other than 0, 1, 2, 3, and 4, and the sum of both cutoff numbers does not exceed 4 either. The cutoff number of a colour C means how tightly the point is enclosed by C in the macroscopic view on the whole board. We can obtain useful information as to how a vacant point is likely to be territory when we observe the pair of cutoff numbers, the number of Black and that of White.

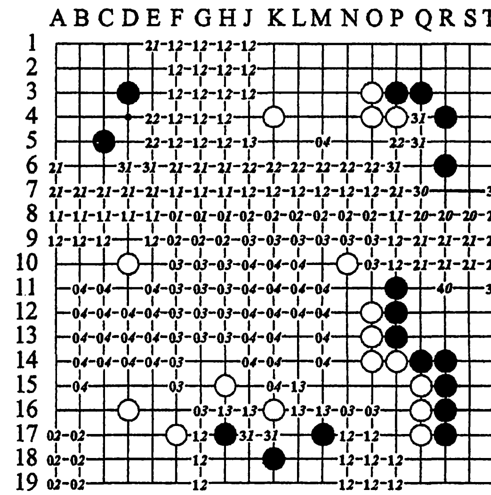

Figure 5: Pairs of cutoff numbers on vacant points

Fig.5 shows the pairs of cutoff numbers. The left side (in Roman font) and the right side (in Italic font) show the cutoff numbers of Black and White, respectively. For instance, we do not obtain cutoff numbers of the points A1, C6, B10, and A11, since they are Black's territory, a Black's cutoff point, White's leg, and White's same-colour span, respectively. And, for instance, the pair of cutoff numbers of the point M6 is 2*2*, since the cursor reaches the white cutoff point M4, white cutoff point M10, black cutoff point C6, and black cutoff point Q6 in the directions up, down, left, and right, respectively.

4.3 Enclosed equivalent size

We try to calculate the equivalent size of a vacant point from the pair of cutoff numbers by some appropriate formulae.

Let the cutoff numbers of Black and White be b and w, respectively. The difference

$$d = b - w$$

is a useful value. Fig.6 shows d of each point. We omit the number when $d = 0$, and show

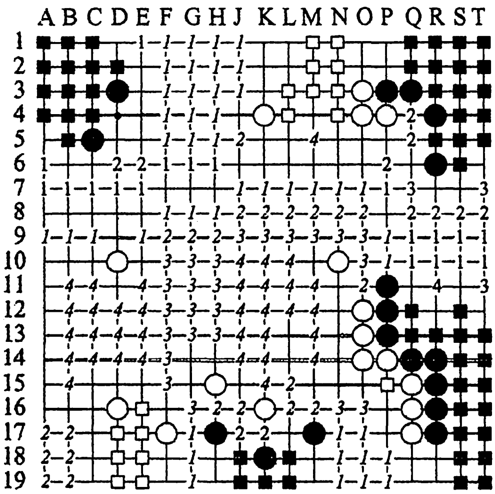

Figure 6: Difference of cutoff numbers

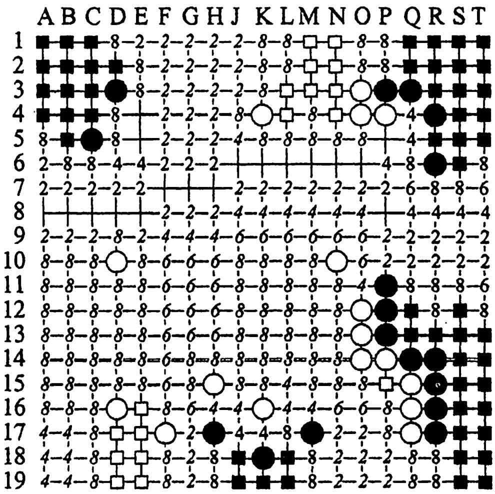

Figure 7: Enclosed equivalent size

the absolute value in Italic font when $d < 0$, i.e. a number in Roman font shows that the control of Black is greater than that of White, and vice versa. Let the equivalent size of Black and that of White be B and W, respectively. When we estimate them as follows, their values range naturally (between 0.1 and 0.9).

$$B = (d+5)/10$$

$$W = 1 - (d+5)/10$$

Contrary to the case of atsumi which is based on distance, the fact that the equivalent size is $a(0.5 \leq a \leq 1)$ means that the colour with stronger control to the point gets the territory of the size of a and the other colour has the remaining size. Therefore, the value of D defined below can be regarded as the relative equivalent size from Black's viewpoint.

$$D = B - W = 2d/10$$

Hereafter, we use this value D as Black's ***enclosed equivalent size*** and use $-D$ as White's ***enclosed equivalent size.***

Since $-4 \leq d \leq 4$, D is $-0.8 \leq D \leq 0.8$. Fig.7 shows D on each point (shown as is multiplied by 10). The usage of the fonts is the same as in Fig.6. In Fig.7, values which are consistent with the size are also assigned to the points where equivalent size is not calculated. We let the equivalent size of cutoff objects other than territory be 0.8 (shown as is multiplied by 10). The equivalent size of each point in territory is 1, of course.

Let D of each vacant point $i(i = 1, 2, .., n)$ be D_i, then positins could be evaluated by the formula below.

$$S = \sum_{i}^{n} D_i$$

In our example,

$$S = -35.4$$

It shows that White has the advantage over Black by approximately 35 points. The value is too advantageous for White. It should be noted that the evaluation is based on only the enclosed equivalent size. To be fair to both colours, other algorithms of calculation is more suitable, e.g. one where the enclosed equivalent size on a point is not summed up if the point has some atsumi. If we adopt the algorithm and get the summation (Le it be S'.), a reasonable value below is obtained.

$$S' = -4$$

As in this example, we can evaluate moyo by the calculation which is based on the pair of cutoff numbers. We have confirmed from several examples that the evaluation of moyo is possible in the first approximation.

However, it is quite insufficient for practical use, since the calculation method evaluates positions only by the enclosed equivalent size. In order to show the insufficiency, it is enough to indicate one thing that it does not consider the strength of groups. Accurate judgement of situations can be expected by considering the strength of enclosing groups and by appropriately combining the element of enclosing with the element of atsumi which is based on distance.

5 Discussions

5.1 Effect of enclosed equivalent size

When Fig.7 is compared with Fig.2, the effect of enclosed equivalent size as the index of the size of moyo is apparent. It can show the advantage of White on the points in the center of the board, e.g. H9, J9, and J11. And also, the equivalent sizes are greatly improved even on the points which also have White's atsumi, e.g. G10∼K10, i.e. enclosed equivalent size conforms to reality more than atsumi.

By introducing enclosed equivalent size, the first approximation of estimation for moyo, which is necessary in the opening, becomes possible.

5.2 Property of enclosing

A region consists of a "family", which is a collection of stones of the same colour belonging to the region [5], and a set of vacant points which are controlled by the family. It is assumed that the closer a point is to the family the stronger the control is. However, the possibility of point A of becoming territory may be different from that of point B even if their distances from the family are the same. An intuitive explanation is that an area like a gulf is likely to become territory than an area like the open sea, i.e. it is not until an enclosure is completed that a territory is completed. Therefore, it is a natural idea to measure the possibility of becoming territory by the degree of completion of enclosure. The effect of enclosing is characterised by the fact that it can hardly be seen in the beginning of the enclosing process but it appears rather suddenly in the final stage.

As for enclosing, there are two problems. One is the problem of algorithm which calculates the degree of enclosing. While it is easy to recognise a complete enclosure, it is not until several preconditions are made that a method to measure the degree of an incomplete enclosure can be designed, since various ideas might be possible depending on what strategy is adopted. And the problem also involves supressing the amount of computation while keeping necessary precision.

The other one is the problem of broad or defective enclosure. An area enclosed by such an enclosure cannot be regarded as complete territory, since the opponent may be possible to live in the enclosure even if the enclosing has been finished. Complete territories need enough atsumi which can capture and kill any opponent's stones unreasonably intruding. Enclosure is just one of the principal elements to form territory.

The way this paper proposed neglects the diagonal directions. Therefore, the connected area with the same enclosed equivalent size forms a rectangle in principle. We can see such rectangles in Fig.7, e.g. one formed by F10-H10-H13-F13 etc.. The reason we limited the number of the directions is based on the heuristics that the moving speed of connecting stones in the diagonal directions is slower than that in the vertical or the horizontal directions, i.e. the opponent's stones intruding into a moyo are likely captured if they escape in a diagonal direction. However, the heuristics is not always true. The enclosed equivalent size proposed in this paper should be considered as just a standard. The merit of the method consists in its simplicity, not in the accuracy.

Fig.8 shows the pairs of cutoff numbers of the preceding position of Fig.1, and Fig.9 shows the differences.

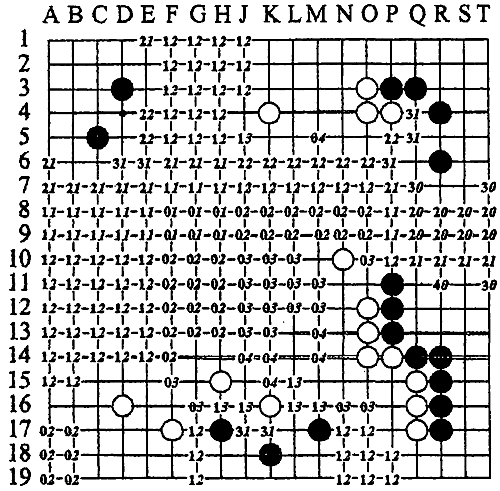

Figure 8: Pair of cutoff numbers on the preceding position

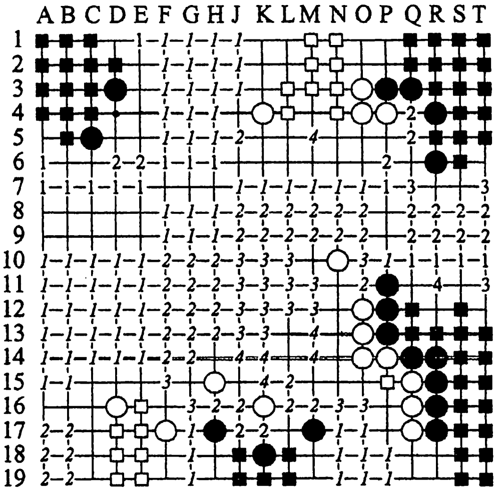

Figure 9: Difference of cutoff numbers on the preceding position

We can observe the following when we compare Fig.5 and Fig.6 with Fig.8 and Fig.9. It is natural that the left area became still more controlled by White. And the values in the central area of the board unanimously changed still more to White's advantage, i.e. each equivalent size of the area enclosed by E9-E14-M12-M9 changed to White by approximately 0.2. It can be considered that especially the great increase of the area with $d \leq -3$ well shows the completion of moyo.

5.3 Relation with region

Here we examine the relation betwen the enclosed equivalent size and the region based on the equidistant lines. The regions does not necessarily agree with the areas indicated by the enclosed equivalent size, since the cutoff number has nothing to do with the distance. For instance, while the five points, F1～F5, are in a black region (See in Fig.3.), their enclosed equivalent number for Black is -0.2 (See in Fig.7.). Therefore, it is necessary to examine how to deal with the region when inconsistent enclosed equivalent sizes are obtained.

The following two variations can be considered. Whether they are adopted or not depends on cases.

- When the controlling colour determined by region differs from that determined by enclosed equivalent size, the former is adopted.
- The distance to cutoff objects is considered when the cutoff directions are counted so as to reduce or limit the effect of distant cutoff objects.

6 Conclusion and Future Work

We proposed the concept "enclosed equivalent size" as a means to estimate the effect of moyo in the opening positions and proposed a practical method of calculation. We showed the effectiveness and some characteristics of the concept. We have not succeeded in accurate position evaluation by the concept yet.

Future works include the following.

1. "Region" and "enclosed equivalent size"

   As described in 5.3, some method to use the two different concepts appropriately is necessary.

2. Designing a unified evaluation function

   We are studying how we can combine the enclosed equivalent size with our evaluation method based on PON[4]. Some preliminary experiments showed that simple functions like simple linear summation are not useful. Since atsumi and moyo are essentialy different evaluation elements, deep examination seems to be needed in order to combine these two elements.

3. Refinement of enclosed equivalent size

   As described in 5.2, we neglected the enclosing from diagonal directions to obtain enclosed equivalent size. The introduction of cutoff objects in the diagonal directions might be needed in order to form more flexible shape of enclosure and estimate more accurate equivalent size.

   We calculated the enclosed equivalent size by the linear summation of the differences of the cutoff numbers. More sofisticated function, however, should be designed experimentally because of the nonlinearlity of the enclosing effect. It might be necessary to consider the size or the shape of the set of connecting points over a certain level of equivalent size.

4. Application as an auxiliary parameter

   Enclosed equivalent size gives the estimation of moyo at a point in time. However, it is more important to know how well the moyo will be arranged finally and how many moves are needed to complete the moyo in order to know the strategic value of moyo. The enclosed equivalent size can be utilized as the auxiliary parameter to accomplish this purpose.

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A Glossary (English - Japanese)

The new terms introduced in this paper are as follows:

equivalent size - 等価目数
enclosed equivalent size - 囲み等価目数
equidistant line - 等距離線
family - 族
region - 領域
cutoff point - 遮断点
cutoff number - 遮断数
cutoff object - 遮断対象
n-Perpendicular, n-leg - n 線足
same color span - 同色対峙（区間）