

Computer Go as a Model of Research Evaluation

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Abstract

In this paper, we employ the position evaluation of computer Go as a model of research evaluation and discuss the applicability of the concepts and the methods developed by computer Go to research evaluation. We show good analogies between the two in the hierarchical structure of objects, the strength of objects, the relations between objects, and the application of search and knowledge, etc..

Keywords: computer Go, research evaluation, position evaluation

1 Introduction

Researches on computer games, especially computer chess, has produced a lot of results mainly in the field of search method. It is expected that the research of computer Go will produce useful results in the field of not only search method but also other general AI methods which can be applied to various research fields.

Nowadays research evaluation itself becomes a subject of research. Objective evaluation is necessary. It is, however, very difficult because of various reasons, e.g. there are a lot of factors to evaluate, each individual factor is difficult for ones except few experts to evaluate, and some factors are overlooked by experts but can be evaluated by only intelligent persons. There are always the pitfalls of arbitrary evaluation or subjective evaluation. Totally automatic evaluation is desirable in order to secure the objectiveness. Although totally automatic evaluation is impossible, algorithms of evaluation as accurate and clear as possible can claim objectiveness of evaluation. And more accurate evaluation can be realized by concentrating resources of evaluation to what cannot be automated.

For example, Fiddaman [1] proposed an interesting system to simulate rational allocation of research budget. It deals with the subject by utilizing a kind of game theory. Program Assessment Rating Tool [2] is a tool adopted by US government for research program evaluation. It is an example of a practical system to totally evaluate programs of research and development. It makes observations and total evaluation of all factors that affect the performance of a program. The factors include program purpose and design, performance measurement, evaluations, strategic planning, program management, and program results. It is a typical system practically used today.

The evaluation of research is similar to the position evaluation of Go in the sense that it aims at the maximum effect using limited resources, e.g. budget and researchers, since the game of Go aims at the maximum territory using limited amount of moves and thinking time. Since the game of Go is just a game, its complexity is much less than that of research, but it seems appropriate as a simplified model. Methods developed in researches of computer Go could be applied to research evaluation with some adaptation.

We will show some characteristics of position evaluation of Go in Section 2, present current research evaluation especially in National Institute of Advanced Industrial Science and Technology (AIST) in Section 3. In Section 4, we will show analogies between position evaluation and research evaluation. We will have some discussions of the defects of current research evaluation in Section 5, and we will conclude this paper in Section 6.

2 Position Evaluation of Go

It is well known that the position evaluation of the game of Go is very difficult when it is compared with those of other games. In the case of chess or shogi, elementary evaluation is not so difficult, since it has some kinds of pieces and each piece can be assigned a value according to its kind. On the contrary in the case of the game of Go, it has only a single kind of pieces (stones). However, its evaluation, even elementary one, is very difficult in spite of the simplicity. Go has a complicated evaluation property that a configuration of stones constructs some higher level objects and the hierarchical structure determines the value of the position.

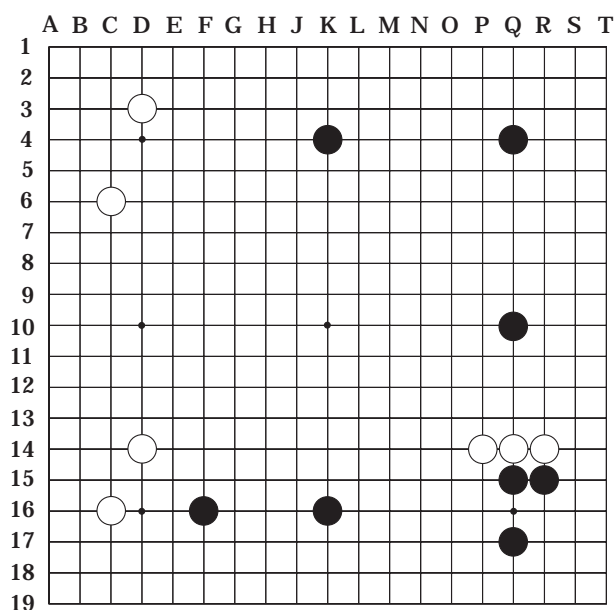


Figure 1: An example of position

Fig.2 shows the hierarchical structure of the objects in the position shown in Fig.1. The basic relations in the structure is:

stone - string - group - family.

String, *group*, and *family* are the set of adjacent stones of the same colour, the set of strings of the same colour connected by a virtually connecting line that the opponent cannot cut, and the set of groups which constitute a region, respectively [3][4]. For example, stones Q15 and R15 form string s_{11} ; and this string and string s_{10} that is formed by a single stone Q17 form group g_8 ; and this group forms family f_2 together with groups g_3 , g_4 , g_5 , g_6 , g_7 .

In the case of Go, strength of object, size of dominated area, and relations (connectivity and disconnectivity) between objects are important evaluation factors. For example, black group g_6 can compete the opponent group g_2 , since it is supported by a neighbouring group g_7 ; and white group g_9 is unstable, since it is enclosed by two opponent groups g_8 and g_5 .

In the researches of computer chess like games, methods which reduce the evaluation of a position to evaluations of its factors have not been successful. Instead the method which has

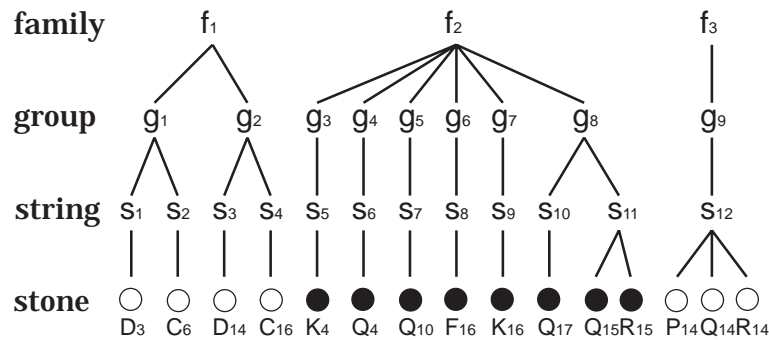


Figure 2: Hierarchy of objects

simple position evaluation and compensates huge global search for the simplicity has made a great success. In the game of Go, however, simple position evaluation is difficult, and moreover, the brute force search is impractical because of its enormous number of branch factors. As a matter of fact the effect of global search is limited in current playing programs. Therefore, it is important to estimate each evaluation factor as accurately as possible.

One more difficulty we have to mention is that the final position is so distant from the opening positions that it is very difficult to derive the evaluation method of the opening positions from that of the final position. The purpose of the game is of course to obtain territory as large as possible. Since the purpose is pretty different from that in the opening or the middle game, evaluation factors and the evaluation function to totalize the factors are difficult to find.

3 Research Evaluation

What and how do we evaluate? How can we assure objectiveness? These two questions are important in research evaluation.

Conventionally, main evaluation factors of research evaluation are straight output from the research, typically the number of papers etc.. In general, however, they are not directly related to the true value of research, though they might have some correlation. Truly innovative results are very few, but such a result might be thousands times valuable. In order to compensate such imperfect evaluation, practical evaluators utilize their intuition, which has no rationale but may be rather accurate. Since such evaluation, however, does not have objectiveness, explanation of the evaluation is difficult.

And it should be considered that most of today's research activities are performed not by individuals but by groups of many researchers. In addition to the abilities of individuals, the organizing ability of groups should be evaluated. Moreover a research community which a number of groups informally constitute is also an important evaluation factor. However, the ability of a group and the ability of collaboration are difficult to evaluate objectively.

AIST took such characteristics of researches into account and decided to evaluate itself from the viewpoint of *outcome* during the second period, from 2005 to 2009 [5]. AIST defines the following terms including 'output' and 'outcome'.¹

output direct result from research & development, e.g. application of patents, publication of papers, submission of drafts of standards, etc.

¹The term *outcome* can be defined in a different manner that an outcome is an output produced by a customer after receiving some output from a researcher and is what cannot be controlled by the researcher directly. In this definition, a result can be an output and an outcome at the same time, but it can be clearly defined from the viewpoint of manipulatability.

outcome effect of output to society and economy, e.g. creation of products, establishment of world standards, development of new research fields, etc.

road map sketch of research plan which shows expected outcomes, milestones to realize the outcomes, technical factors, and benchmarks along the axis of time

milestone subgoal or target set up along a road to an outcome on a road map

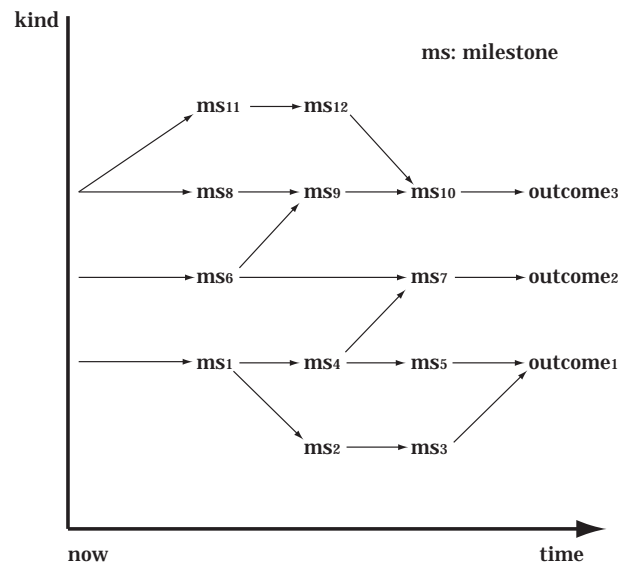


Figure 3: Roadmap

It should be emphasized that the result of research is not evaluated only from its outcomes but evaluated *from the viewpoint of outcome*, i.e. AIST evaluates the output of its research having sense of the final goal. Researches forwarded to the right direction are highly evaluated even if no outcome has been realized. What are evaluated are the following:

1. outcomes realized so far
2. road map
3. output
4. management

There are three kinds of evaluation each of which corresponds to each phase of research, i.e. beginning, middle stage, and the final stage. In the final stage, what are evaluated are outcomes (if any) and outputs of research (which are evaluated from the viewpoint of the outcomes). In the beginning, the road map and its milestones are evaluated from that viewpoint, and whether the management for the road map is appropriate or not is also evaluated. In the middle stage, all of the factors described above are evaluated. Fig.3 shows an example of a road map, which has some outcomes, some milestones, and some relations between them. In general it has more than one kind of outcome.

The following shows the procedure of each kind of evaluation in AIST.

1. Road map evaluation

Evaluators make much of the viewpoint of the quality of research target and evaluate the validness of the research plan totally. What are evaluated are the road map of the whole

research and the road maps for the individual tasks of the research. They understand the outcomes, the milestones, and necessary technical elements, etc. and evaluate whether it is a good research plan based on an appropriate strategy or not.

2. Output evaluation

Target research unit presents outputs produced so far referring to the corresponding road map of each task. Evaluators evaluate whether its research has well proceeded according to the road maps and whether outputs which contribute to the outcomes have been produced referring world standards and the targets shown by the milestones as criteria.

3. Management evaluation

Evaluators evaluate the idea of the research and the concrete management system to drive the research from the viewpoint of realizing the outcomes.

4 Position Evaluation vs Research Evaluation

In this section, we will examine the analogies between the position evaluation of computer Go and research evaluation and examine the applicability of the method of position evaluation to research evaluation.

4.1 Game to fight for limited pie

The game of Go is a zero sum game where two players fight for limited area. On the contrary research is not a zero sum game or two persons game. From the viewpoint of pure science it is quite inappropriate to regard research as zero sum game. Such scientific research can be regarded as a kind of game to attain some given purpose or to maximize some index to show the purpose. From the position to pursue interests, however, some situations can be regarded as zero sum games, e.g. economic scene in a commercial market, race for acquiring a prize, etc..

4.2 Huge amount of selections in a position

It is well known that the number of legal moves at a position of Go is very large when compared with other games. Of course, the number of selections in a research strategy is also enormous. There are great number of selections about what resource, human or capital, and to what field to invest. In general since the number of the latter is much greater than the former, research evaluation is more difficult.

Unlike the case of computer chess, forward pruning is essential in computer Go, and the technique to implement the knowledge of forward pruning is needed. There always exists, however, the risk to prune critical branches. In choosing candidates, resources to invest, expected results, and the amount of risk and return should be evaluated.

It is very difficult to evaluate research by search or looking ahead. Moves in research correspond to possible ways of investment of human or monetary resources. Strategy to decide a move of a game corresponds to management to decide a hopeful way.

One of the applications of the method of position evaluation of Go to research evaluation is to store heuristics about useful or useless moves and to make a database from them. The possibility of innovative methods should not be overlooked and pruned even if they are heresies. Such knowledge that can evaluate potential abilities of researchers and originality of their ideas is important. In Go, book moves or moves commonly known as good moves are usually optimum in advantageous situations, but some speculative or abnormal moves are sometimes effective in disadvantageous situations. There are also cases where pursuing heretical methodology is effective in the field of scientific research.

4.3 Very difficult position evaluation

The game of Go and the society of researcher share hierarchical concepts, i.e. **stone - string - group - family** in Go and **individual researcher - research group - research organization - research community** in the society. In Go, the collaboration between friendly groups is important, e.g. a group is strengthened if a friendly group is located nearby. And there are also competitive relations, e.g. capturing race with an opponent group in Go and research race with a rival research group in the field of research. There are many similarities. Accurate evaluation is impossible unless all of such factors are counted.

Even in computer Go, position evaluation as a subject of research is rather new [6]. The method based on the possible omission number (PON)[7][8] is a method to evaluate quantitatively board patterns which are very fuzzy and vague. We can evaluate a board pattern by applying an evaluation function to the sizes of its groups and the groups' strength which is based on PON^2 . The optimum evaluation function was designed by using a collection of position - optimum move; pairs.

In the case of research evaluation, it may be possible to design a quantitative evaluation function by collecting past successful pairs of position (state of research) and the best move taken (way selected) at that time. The size of groups in Go corresponds to the size of research group and the strength corresponds to the ability of researchers and the quality of papers etc.. The present state of research could be evaluated from the viewpoint of future outcome with rather good accuracy in this manner.

In the following, we show the correspondent concepts of research to those of the game of Go.

1. Strength

The abilities, monetary resources, and the results in the past, etc. of individual researchers or research groups are the strength.

2. Friendly group and opponent group

Cooperative research group in an organization and groups in a research community are friendly groups. For example, competitive or rival groups in a commercial market are opponent groups.

3. Critical stone

If a researcher or a research group plays critical role, he (she) or the group is a key person or a key group. Such an individual or a group should be evaluated appropriately.

4. Risk and return

Risks with research is inevitable. Or rather, research without risks does not deserve the name of research. The amount of risk, however, ranges from little to very large. It is necessary to consider the trade-offs between the expected return and its risk in the case of research. In general large risks can be allowed for basic researches, but they cannot be allowed for researches on commercial production.

5. String capturing and life & death of groups

In researches which are directly connected to commercial production, winning the race against competitors is important. Local win in the research is directly related to the share in a market.

6. Connection of groups

Cooperation and liaison with other research groups are important. Such groups that make cooperative activities are highly evaluated.

²In the example shown in Fig.1, the PONs of $g_i (i = 1, 2, \dots, 9)$ are calculated as 6, 5, 3, 3, 3, 2, 3, 3, 3, respectively.

7. *Miai*

In the case that there are two alternative moves and at least and at most one of them is successful, such a situation is called *miai*. Even if a research group cannot succeed in both of two races with its limited resources, the both races deserve to be considered if at least one of them can be won.

8. *Deiri*

The idea of *deiri* can be applied when considering whether one should be the first to start research in a new field or not. *Deiri* is the difference between the outcome when being the first and that when being the second. Of course, the greater the difference is, the more valuable being the first is.

4.4 Distant final goal

The subgoals in the opening and the middle game of Go include strengthening of specific groups and weakening of opponent groups in addition to the same purpose as what is at the goal, i.e. maximizing territory. Subgoals and the goals can be regarded as short term evaluation factors and long term evaluation factors, respectively. Especially in the game of Go, the final stage is distant from the opening stage.

In the research strategy, outcomes are the final objects, but outcomes will be attained usually in the far future even if they are realized. Therefore the matter of researchers is not necessarily outcomes but subgoals or milestones including scientific discovery, invention, champion data, development of tools. In the sense, road maps are very important and should be clear.

4.5 Knowledge and search

Computer programs to play games evaluate a position with appropriate combination of knowledge based evaluation and search based evaluation. Especially in computer Go, programs largely depend on knowledge, since combinatorial explosion occurs otherwise. Search in Go is mainly local search. Global search can be utilized in limited situations. Evaluation of local areas in a position by local search is important to evaluate strings and groups accurately and are utilized very frequently.

Circumstances are the same in research evaluation. It is impractical to predict the all outcomes (results in the future) by search at a given position. We are forced to guess it using some heuristics in most cases. However, there is a possibility of utilization of search in local evaluation. For example, the effect by an investment in an experimental equipment could be estimated by some simulation in the near future.

5 Discussion

In the light of the methods of the evaluation of computer Go, current research evaluation seems to have the following problems.

5.1 Multiple route

The move decision procedure of computer Go is that a program assumes several move continuations in the game tree and selects the principal one among them. Generally in a research plan, just the best route is presented after examining many routes. The way of the presentation is the same in the evaluation of AIST. However, it might be better to evaluate a road map which includes not only the best route or plan but also other reasonable routes. The route which is the second or the third best one might be the best one in the future according to future situations. Such a road map can cope with future changes and can be robust. If the possibility of alternative routes are recognized from the beginning, the possibility should also be evaluated.

5.2 Nonlinearity

In most cases of research evaluation (also those in AIST), the evaluation function is linear summation of given evaluation factors (or components). This is not only the case of research evaluation but also other evaluation in real world, e.g. entrance examinations, since there are not any other means with rational foundations. As seen in the case of Go, however, it is suggested that most of evaluation functions in the real world are nonlinear. In the position evaluation based on PON, the nonlinearity is essential. The function has upper limit of strength and has very sensitive behaviour when a capturing race occurs. The more real a world is, the more nonlinear its evaluation function is. Therefore more accurate and practical evaluation function should be found by accumulating knowledge of actual research activities.

6 Conclusion

Applicability of various concepts and developed methods of position evaluation of the game of Go to research evaluation was studied. Useful suggestions for research evaluation were obtained from computer Go that is the game which has well defined objects and a proper amount of complexity to be a model of research evaluation.

Research evaluation is very complicated and difficult. Although the position evaluation of the game of Go is much simpler than research evaluation, it can be expected to be a good model of research evaluation because of the similarities between them. Moreover more general evaluation method could be possible if the model of position evaluation is applied to other fields.

And reversely, research of computer games which is oriented to the applications in real world can be considered. And it is also expected that introduction of new viewpoints gives us hints of new methods of position evaluation in computer Go.

Finally we hope that this paper itself will lead to an outcome of the research of computer Go.

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