ON MANAGEMENT STRATEGY SEARCH SIMULATION

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ABSTRACT

We formulate the management strategy search problem as a composition of two sub-problems: strategy planning and assessment. We develop the framework for the application of certain advanced methods previously developed in Artificial Intelligence to the management strategy assessment

INTRODUCTION

1. *The management strategy search problem*, in general, asks the following questions:

- Where are we now?
- Where do we want to go?
- How can we get there?

The first two are questions of *strategy planning* and the last question is related to *strategy assessment*.

The usual management methodology recommends going through the following steps in a strategy search [*Porter1980*]:

1. Identification of the market situation
2. Selection of the initial plan
3. Identification of the competitors
4. Specification of basic alternative strategy plans
5. Assessment of strategies

The management strategy search is an *expert knowledge based* process that is not well formalized and is difficult to simulate [*Mintzberg1994*]. Most methodologies focus more on the first four stages, i.e. on constructing strategy plans. Advanced man-machine interactive tools already exist to help managers in planning [*Rouse1999*]. However, the transition from having a strategy plan to the construction of actual strategies and their ***dynamic testing*** in competitive environments is studied minimally.

2. A promising strategy analysis tool, Value War (VW), was developed by David Reibstein and Mark Chussil *[Chussil ,Reibstein 94]*. VW employs strategy search simulation for predicting the outcomes of oligopoly competitions. In VW there is a selection of typical strategies in the price and quality competition and an option to modify them manually. The identification of different situations and the prescription of strategies to the competitors is processed by the user. The prescribed strategies and the alternative strategies of the user's company compete against each other in a series of simulated competitions. The final strategy has to be selected by analyzing the so-called matrix of grades which records the performance of each strategy in each of the different (simulated) market situations.

All stages of the management strategy planning are represented in VW. But there is need for further development of the competition analysis. There is room for improvement in the feedback from the competitive environment to the strategy making and in the assessment of the results of the competitions.
Strategies like “follow the leader”, “tit for best tat”, etc. have feedback only from the integrated behavior of the competitors. There is no dynamic feedback reflecting a change in the current market situation and that makes the analysis of possible competitions incomplete. There are also no means for the analysis of the matrix of grades even though VW does provide the matrix.

3. We are going to discuss ways to improve the management strategy search simulation. These include improving the completeness of necessary competitions and developing methods for assessment of the results of competitions. We formulate certain constructive concepts of management strategy planning and assessment and identify the applicable methods of strategy search from Artificial Intelligence. We find that Botvinnik’s expert knowledge based strategy search method in chess [*Botvinnik* 1979] is one of the most promising. Then we discuss how some of the advanced methods of the analysis of alternatives can be applied to the assessment of management strategies and outline perspective directions for research.

THE MANAGEMENT STRATEGY SEARCH PROBLEM

1.1. A company C with certain properties is going to trade in the market. The properties include in particular the system of company’s values, the set of possible actions and all kinds of available resources and means such as its world perception, research, information, human resources, production, etc.,
The company C *perceives* its environment as a *market situations* S, which can be *initial* or *current*, and recognizes *all trade related elements* available to its perception such as the market and market place description, industries, their objectives and possible actions, general economic characteristics, etc. It also recognizes competitive companies C1,C2,…, Cm competing according to a set of criteria K1, K2,…, Km**.** Among criteria could be, for example, the maximal value of the cumulative profit.
Let us emphasize the fact that any competition and its results are considered from the perspective of a certain company, let’s say the company C.

1.2. We assume that each competitor is identified by a corresponding deterministic program and the competition in a market may be described by sets of situations, actions and strategies in discrete time periods.
Competitors make allowed actions, or *moves*, from corresponding sets **A1,…, Am** simultaneously, step by step and in T periods. We name a vector of such actions as a *bundle of actions*. Bundles of actions transform the initial situation S into sequences of new situations.
We call a tree of all possible sequential bundles of actions of competitors from an initial situation S in T periods a *S-game tree,* or *S-tree.*
In fact, S-tree is the sum of performances of all possible competitors' programs started from S. The whole performance of the programs may be described by the forest of such trees from different initial situations**.** To avoid technical complications we assume to have only one initial situation and all competitors have the same sets of allowed market moves.
We name the performance of the competitor C (i.e. the performance of corresponding program) in S-tree as a (*complete) S-strategy of C.*
A competition, or a game, of competitors C1,C2,...,Cm is determined by the sample of corresponding programs and by the initial situation.

We evaluate the quality of a program by the forest of strategies generated by the program from all possible initial situations. Thus, to evaluate a program we have to consider all its possible games against all possible samples of other competitors in all possible initial situations. The number of competitors in samples depends upon the assessment objectives. For oligopoly competitions, for example, we have to consider all possible combinations of competitors which are in the oligopoly.
Since each competitor is represented by a program and the performance of the program in the S-tree is a S-strategy, in order to evaluate the quality of the program the assessment criterion K must be applied to that S-strategy. We suppose that the value of the criterion is determined by terminal nodes of the S-strategy. For example, we can use the profit gained by S-strategy as a criterion and calculate by averaging the values of the profit for all of its terminal nodes.

1.3. Given criteria F we say that a *strategy G achieves the goal F* if criteria F satisfied for the set of terminal nodes of G. The strategy *G* will be called *F-projected* if we are interested in whether the terminal nodes of G satisfy criteria F or not. Any description of an F-projected strategy G aimed to make a search of G more efficient is named *a Strategy Plan* for *F* .
A description of the problem under consideration and of the solving strategy itself are extreme example of strategy plans. A useful strategy plan would systematically identify the directions that are not promising and eliminate them there for reducing the search space. Such a strategy plan would have to be described in a high level language.
Strategy planning is a process of narrowing the search space for the target strategy which also reflects the specifics of the planner such as knowledge of language, the system of values and methods of search.

2. Contemporary marketing theory assumes that each competitor at all times during the competition acts according to some strategy plan [*Porter1980, Cravens1994]*. Given a criterion F the competitor constructs a series of strategy plans and by using constrains of the plans is narrowing the search space, thus efficiently selecting the strategy that will solve the problem.
In general, the ***Management Strategy Planning*** of a company C is the identification of the set of objectives K and the set of initial market situations S for C_and finding the set of the best K-projected strategy plans in S.
These plans specify a class B of possibilities for further search of strategies and become a guideline for the actual strategy selection by executive managers in the competitive environments.
There are several levels in the strategy planning: corporate, department, division and unit. These levels are hierarchic and consistent. Each subordinate organization refines the plan of its predecessor, that is makes it more specific.
For example, a *corporate plan* describes the company's mission, policy, goals, allocations, organization, methods of management and etc. It also selects alternative scenarios for its activity (such as growth or survival, intensive, integrative or diversified, etc.). It identifies the competitors and the investment portfolio [*Cravens1994*]. The corporate plan constrains the next levels of strategy planning and reduces their space for strategy search. Actually, all components of the corporate plan determine, explicitly or not, the space of desired strategies and a set of recommended actions to find them. Resolution of the strategy search problem requires the complete analysis of all the above stages of planning.

3. We think of the ***Management Strategy Search*** problem as a composition of two sub-problems: the *Management Strategy Planning* and the *Management Strategy Assessment*.
Management Strategy Assessment problem*: Given a set of initial situations S, competition criteria K, the integrated performance of strategies, an evaluation method M and a class B of alternative strategies for one of the competitors it is required to find an optimal strategy in the B.*

Here we consider the Strategy Assessment problem at the marketing department level. We consider a market situation/scenario and a variety of possible oligopoly competitors competing for certain criteria such as profit, Return of Investment, 01success, etc. The process starts with the input of the set of initial market situations and the corporate plan description, i.e. we are given S, K and. B.
Thus, we do not consider the strategy planning process, which is not well formalized yet. That includes, for example, the identification of situations and selection of objectives in a high level language. Rather, we concentrate efforts on a more realistic step in a strategy search simulation – strategy assessment, or *strategy programming* fairly distinguished in [*Mintzberg1994*].
The quality of the Management Strategy Search solution depends on the adequacy of the criteria K, the method M and the class B in the Strategy Planning solution as well as on the effectiveness and the efficiency of the solution to the Strategy Assessment problem.
In the frame of these concepts the VW strategy analysis tool needs a better adequacy in the selection of the class B and a better description of the method M for strategy assessment.
We are going to analyze some promising approaches to solving the Strategy Assessment problem. Since we identify the recommended management strategy search methodology as based on expert knowledge, we start with an advanced representative of that class – Botvinnik's method .

STRATEGY SEARCH BY BOTVINNIK

1.1. Botvinnik's method is based on strategy planning and assessment with extensive use of the standard chess master level knowledge and on the individual chess knowledge. It describes high skilled chess player's approach to the strategy search in middle-game positions that are either studied before or are completely new and where the previous experience may be used to eliminate some branches in order to reduce the search.
The idea of the Botvinnik's method is in the following.
Along with the ultimate chess goal, the mate, one needs to identify the sub-goals such as winning of the material (eating the pieces of the opponent) and positional advantages. One distinguishes between the sub-goals that have a current or a future purpose.
The system of goals may be imagined as a hierarchy where the achievement of subordinated goals provides conditions for achieving the superior goals. The complete system of goals, especially for positional advantage, in fact, includes the whole range of chess concepts.
The system of those goals is the initial description of the strategy plan. The plan is consecutively developed so far by extracting supportive and deteriorate sequences of moves considered for achieving the goals on the "clean" board - trajectories, their interrelated systems - zones, and system of zones, named "mathematical mapping".
The system of zones is in a fact strategy plan for a given position. It describes the most promising sequences of moves that must be tested primarily in the search tree to achieve the target goal. Testing for that restricted search tree is arranged by a standard minmax procedure During the search the initial strategy plan is continuously modified and adapted to the current position to guide the search for an optimal move.
Let's note that the strategy plan initially is described in the language of primary actions of one of the competitors without taking into account the distortion caused by the opponent's moves. Such plans are later corrected with the moves of the opponent by an executive part of the program to get a realistic plan.

1.2. The above chess master's planning for a middle game position is based on the standard knowledge that a skilled player uses when searching for the best move. But the chess master's skill includes both: the standard knowledge and the stored memory of the successful experience. In Botvinnik's method it is realized by the process of zone construction, i.e. strategy planning. A comparison is performed among the descriptions of positions in the tree with the positions already stored in the memory to utilize the previous experience. That classification of positions is realized at all stages of the game, i.e. in the debut, middle and end games.

2. Botvinnik's model of the chess master strategy planning is very close to the model of management planning that was described in the previous section. Both are expert knowledge based and the degree of the success in resolving strategy search problems is dependent on the completeness of that knowledge.

The strategy planning steps of Botvinnik's method include:

- The situation identification. Particularly, its classification as the beginning, middle game, endgame, sharp, etc.
- Generation of a variety of strategy plans. These are the trajectories that lead to possible gain of material.

At the assessment stage, the trajectories are developing into realistic strategies by the analysis of the competition and selection of the most beneficial among all realistic options. The technique of zones in the game tree is used to analyze the competition and to choose the most prospective zone. The result of the analysis is the best move in the current position.

The execution of the recommended move results in a new situation where the entire above analysis should, generally speaking, be applied again. However, its essential reduction is possible.

The completeness of the analyzed strategies is determined by use of the game tree where all strategies are presented. The efficiency of that search is based on the expert hypothesis about the class of relevant plans, which essentially is reducing the search space.

To apply Botvinnik's method to similar management strategy search problems there is need for the following:

to represent the strategy search space of the problem by a game tree where is possible to interpret the trajectories of actions in the context of their positive or negative influence on the intermediate goals of the solution.

3.Note, that Botvinnik's idea was tested only for a few difficult chess etudes and combinations. The program was realized by B.Stilman who is developing it now effectively for other applications [*Stilman 2000*].

Ideas similar to Botvinnik's method have been successfully developed by J.Pitrat [*Pitrat 72*]. and D.Wilkins [*Wilkins 82*] to resolve a series of complex tactically sharp chess combinations. Wilkins's program is a unique experiment in using a great amount of strategy planning expert knowledge. The two major advantages of Wilkins' program over Pitrat's program are in using conditionals which allow specification of different plans for different replies of the opponent and using easily modifiable language for plans which gives a natural way for chess program learning. This approach was successfully developed for robotics' application.

PERSPECTIVE METHODS FOR MANAGEMENT STRATEGY ASSESSMENT

1.*The alternative strategies are listed in a table.*

Given a pair of assessment 01success criterion K for a competition and method M for a strategy performance integrative evaluation, we can play a series of real market simulation games for each competitor against all possible bundles of strategies in oligopoly competitions from any initial situation and then order competitors in accordance with their performances.

The results of such tournaments can be presented by a (m, n) matrix – *Matrix of Grades* where m and n are the numbers of analyzed competitors and all competitive market situations, correspondingly.

As it was shown in *[Pogossian 98*] an ordering of competitors based on their game performances, or tournaments, is a computationally hard problem and the question of the appropriate constraints becomes essential in reducing that complexity.

In the deterministic model we suppose that managers' activities, in its essence, can be related to the behaviors of some programs and the ordering of those programs satisfy the important quasi-transitivity constraint:

Any program in the ordering includes, to some degree, functions of its predecessors and, as a consequence, has a better performance.

A theorem is formulated that under this quasi-transitivity constraint the solution of the management skill assessment problem can be found with available computational resources.

The quasi-transitivity constraint is the analog of the criterion of "essentially improvable" strategies formulated in [*Pogossian 97*] for a symmetric problem of knowledge based systems evaluation [*Adelman 92*] and allowed to advance in the efficient evaluation strategies.

The Matrix of Grades analysis actually is dealing with a multi-criteria evaluation and assessment problem which has applications in sport [*Sadovski 1985*], matrix games and voting [*Moulin1988*] and, therefore, there is a possibility of borrowing the knowledge from these areas. More details on these issues are presented in [*Danielian,Pogossian99*] *and [Pogossian99*].

2. *The alternatives are described by a game-tree.*

A game tree is a performance tree produced by all possible competitive strategies in an initial market situation. Thus, it is determined by an initial market situation, the possible actions of the competitors in any market situation and the adequate transformations of the situations caused by the actions that were performed. Because each strategy in a competition is represented in the game tree by the corresponding performance tree we can search for the optimal strategy among possible performances in the game tree. Thus, the whole arsenal of strategy search methods in game-trees can be applied, including the minmax criterion, an evaluation function, branch and bound method, first in depth or in width search, etc. [*Nilsson1998*].

We have argued that the set of values of terminal nodes of each strategy in a game tree corresponds to some row in the Matrix of Grades . Thus, there exist a correspondence between strategy selection criteria in both presentations.

Particularly, the sequential minmax method of strategy search in a game tree corresponds to the maxmin selection method in the Matrix of Grades. The proof is by induction over the depth of the game tree.

3. *The alternatives are produced by an enumerative procedure and the list of testing markets is available for each of alternatives individually.*

The sets of alternatives may be recursively generated followed by summing up of their scores on the markets, selecting the one with max sum, adding it to the new generated set of alternatives and then returning back to the first step.

The *selection may relay on the Matrix of Grades solution methods analyzed for the assessment problem.*

4. *The alternatives are obtained using an enumerative procedure and* quasi-transitivity constraint *must be satisfied for their ideal ordering.*

M-tuples of alternatives may be recursively generated for some list of markets followed by competitions to select the winners in the situations. The method and corresponding theorems about convergence of the process to the optimal solution are described in [*Pogossian83*].

5. *The alternatives are produced evolutionary by genetic algorithms.*
Generation of the alternatives is realized by crossover and mutation procedures followed by the selection of the best alternatives according to their performances in urgent markets. In these methods we try to select a program which is absorbing the experience of successful generations by making changes in the structure of the program. An ineffective averaging can occur in this case.

6. *The alternatives are produced in a learning process.*
The basic structure of the alternatives is determined similar to the structure of managers' decision making procedure. Particularly, including their planning and knowledge storing, learning or inductive inferring, etc. The alternatives are processed in the set of urgent markets to achieve the behavior of a desired effectiveness. The solutions have to learn to act in each of the possible markets and must be ready to apply the gained knowledge to real markets.

7. *The alternatives are produced by a combination of the evolution and learning methods.*
A transparent description of evolutionary and learning methods are given in [*Nilsson1998*]. The application of evolutionary methods to economics is given in [*Tesfatsion1995*].

CONCLUSION

The problem of optimal management strategy search was studied.
We have started from the original problems of management strategy planning and assessment, constructed their formal models and made the connection to the known mathematical and computer science models.
This live chain from the original to the formal model preserves the necessary feedback that is required for the improvement of models.
We have discussed ways to improve the management strategy search simulation and the application of certain advanced assessment methods previously developed in Artificial Intelligence to the management strategy assessment
We perceive *the focus of the management strategy planning* simulation to be the construction of management expert knowledge based strategy planning methods. They can be developed on the base of actual man-machine tools by further automation of the planning process. They have to be organized as expert systems with appropriate knowledge bases for identification of market situations and competitors, competition analysis and plans generation.
We see *the focus in management strategy assessment* to be the construction of a class of strategies that are expert knowledge based as well as in further development of the assessment methods.
The strategies have to be organized as expert systems where knowledge has to be presented in form of productions. They have to be able to acquire new knowledge and relate it to the knowledge gained earlier. They have to use knowledge of different levels of abstraction consistently and to keep the appropriate feedback from changes in current situations.

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