Modeling Decisional Situations Using Morphological Analysis

Răzvan PETRUŞEL, Cluj-Napoca, Romania
Loredana MOCEAN, Cluj-Napoca, Romania

This paper focuses on models of financial decisions in small and medium enterprises. The presented models are a part of a decision support system presented in the ph.d. dissertation. One of the modeling techniques used for model creation and development is morphological analysis. This technique is used for model scale reduction not by reducing the number of variables involved but by reducing the number of possible combinations between variables. In this paper we prove how this approach can be used in modeling financial decision problems.
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Brief introduction in morphological analysis

Morphological analysis was first developed by Fritz Zwicky (1966, 1969) and it was aimed to explore all possible solutions for multi-dimensional and non-quantifiable problems. By using cross consistency assessment, Ritchey [Ritchey98], [Ritchey04], used this technique in order to reduce the complexity of a model not by diminishing the number of variables but by eliminating the solutions generated by an illogical combination of variables. An introduction in morphological analysis is presented in [Ritchey02]. One of the promoters of morphological analysis is the Swedish Morphological Society [SMS]. This society aims to encourage and spread the morphological analysis both in practice and in theoretical research. Morphological analysis represent also a course at the Utrecht University.

The process of morphological analysis has several steps. In the first stage of the process the studied problem is described and all relevant aspects of the decisional situations are explored. There is also some attention paid to the causes that require a decision to be made and effects generated by the selection of one decisional alternative. The main artifact of this first stage is a general documentation of the problem studied. During this phase there are several idea generation methods that can be used like: brainstorming, voting, interview, questionnaires, etc. In the second phase, starting from the artifacts of the previous phase, the main problem is decomposed into sub-problems. Each sub-problem can consist of one or several variables. The variables are decomposed further in some less abstract concepts named parameters. Again, in this stage, some of the idea generation methods presented before are used. The third stage is finalized by the construction of a morphological table that allows a better communication between team members and improves the idea structuring process. This table is a bi-dimensional matrix. The columns of the matrix are composed of values determined earlier. Under each value are listed all parameters of that value. In the fourth stage, all possible solutions are generated and analyzed. All parameters are thoroughly analyzed and the parameters that rule out each other are determined. The constraints are also determined. The results of this stage are cross-checked with the morphological table determined earlier. All those activities lead to the creation of a space of possible solution. Based on this space, the decision maker chooses one alternative or decides if some of the previous steps need to be retraced.

Some of the concepts used by the morphological analysis are [Ritchey 03]:

- problem (a problem is any situation that arises in the company);
- issue (a relevant aspect that causes a problem to occur);
- sub-problem (represents any part of a problem that can be solved independently);
- problem documentation;
- morphological table;
- variable (a variable represents a possible instance of a point of view and every value

represents a column of the morphological table);
- parameter (represents a concrete value of a variable and in the morphological table is written in the column represented by the variable);
- constraint (is a parameter that must be included in the problem space and, usually, represents the starting point in problem solving);
- solution space (is the result obtained after cross consistency analysis. This analyze is aimed to reduce the set of all possible combination of solutions);
- real action (represents a set of actions derived from the solution space. The action represents, in fact, all the necessary steps in order to actually implement a decision).

2. Employing morphological analyze in problem modeling

The main reason for building a morphological table is the decomposition of the decisional problem in sub-problems. The decomposition also aims to identify all relevant aspects of the problem. In this section of the paper we show how morphological analyze can be employed in modeling a financial decision problem. The general statement for the decision we model is "a decision is required when a new invoice is issued regarding the cashing method". There are four ways of cashing an invoice. Those are: cash payment, bank order (OP), promissory note (BO) and CEC. As a consequence, the decision maker has to choose between four possible decision alternatives. We identified several variables that influence this decision. Some of those variables are: value of the invoice, the total amount owed by the client, the general situation of the client, past payment record of the client, etc. Each variable can have a different weight in the decision process.

The purpose of the morphological table is the decomposition of the decision so that all important aspects are considered. The decisional problem stated above can have three dimensions: clients, invoices and the accounts receivable. The clients dimension will have the following variables: the general situation of the client and the past payment record of the client. The invoice dimension will have the following variables: the value of the issued invoice, the values of previously issued invoices, the products or services invoiced and the payment period for the invoiced products or services to the providers. The accounts receivable dimension will have the following variables: the cashing method and the casing confidence. According to this decomposition the following table containing the variables and the parameters for each variable:

Cashing method	Invoice value	Client situation	Previous invoices	Cashing record	Invoiced goods	Supplier payment time	Cashing confidence
Cash	*Small*	Unknown	*First*	*New*	*Services*	0	Low
Bank order	*Medium*	*Bad*	*Small values*	Recent	Rare goods	1-14	Medium
Promissory note	High	Good	High values	Old	Usual goods	15-29	High
CEC	Very high	Very good				30-44	*Very high*
						45-60	*Absolute*
						Over 60	

Table 1. Example for Morphological table

After the morphological table is built the cross analyze of the parameters is done. This analyze aims to determine all possible solution spaces by comparing parameter values and by eliminating the solutions that contain opposing parameters. For example the CEC parameter and the cash parameter are not opposed to the absolute parameter of the cashing confidence variable. They are opposed however to the parameter little of the cashing confidence variable. The parameter high values of the previous invoice value variable is

considered to be opposed to the parameter new of the cashing record variable. The parameter cross analyze method allows the user to build several solution spaces containing parameters that do not contradict each other. If the values of a parameter are instanced (for example a new invoice is issued and as a result the invoice value, client situation, previous invoices, client record, invoiced services or goods and supplier payment time variables are instantiated) the search for possible decisional alternatives will be realized only in the solution space determined according to the existing values. For example, the following solution space, that contains no opposing parameters, is determined: invoice value (small, medium), client situation (doubtful, bad), previous invoices (first, small values), client record (new), invoiced goods (services), cashing method (cash, CEC), and cashing confidence (very high, absolute). This solution space is extracted from the previous table:

Cashing method	Invoice value	Client situation	Previous invoices	Cashing record	Invoiced goods	Supplier payment time	Cashing confidence
Cash	*Small*	Unknown	*First*	*New*	*Services*		
	Medium	*Bad*	*Small values*				
CEC							*Very high*
							Absolute

Table 2. Instance of Morphological table

It can easily be observed that since the service of the company is invoiced all the parameters of the supplier payment time variable are excluded. It can also be observed that the parameter first of the previous invoices variable rules out the recent and old parameters of the cashing record variable. This solution space actually reduces the possible solutions previously determined as a simple combination of all parameters.

If we go further with the instantiation process we can consider that the company invoices to a new client a 5500 lei sum representing a fee. The company also has no indication regarding the client's situation. This situation is places in the solution space determined above because the invoice value is medium (the limits of the medium range was previously set between 1000 and 7500 lei), the client situation is unknown, it is the first invoice issued and there is no previous client record. The law imposes that invoices over 5000 lei can not be paid in cash (this is a constraint of the environment). The cashing method has to be CEC and this leads to the conclusion that the cashing certainty is very high.

In the big picture of our project we used this technique as a knowledge acquisition method. It allows the decision maker to better visualize the variables and the parameters while not being forced to run scenarios in order to determine all possible outcomes or influences. It allows a better communication between the knowledge engineer and the user. We also used the morphologic tables to determine the degree of confidence in invoice cashing. This contributes to the construction of the cash-flow forecast. This forecast is designed to have three different forms, based on the cashing confidence of invoices. The invoices with very high and absolute cashing confidence are considered in the pessimistic scenario. The invoices with medium, high and absolute cashing confidence are considered in the normal scenario. The invoices with low, medium, high, very high and absolute cashing confidence are considered in the optimistic scenario. The construction of the three cash-flow forecasts contributes to enterprise cash-flow planning.

3. Conclusions

In this paper we tried to shortly introduce the

reader in morphological analyze and to present one example of modeling with this methodology.

We consider morphological analyze helped the reduction of the model scale by reducing the number of possible solutions to a decision. This was done by creating various solution spaces. In case some variables are instanced the search space is reduced to the viable solution spaces. We also view this approach as a better representation technique than the decision trees because it can contain several decision trees at one time. A decision tree can cover only one scenario at a time while the morphological table can represent several scenarios that contain no opposed parameters. It also helps the decision maker to have a better overview of the problem. We also argue that morphological analyze can be used in conjunction with otjer modeling methodologies and with knowledge presentation techniques in order to improve the models of multi-dimensional and multi-criterial problems.

References

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