Application of Fuzzy Cognitive Maps to Business Planning Models

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Abstract. Soft computing modeling of business planning is considered. Our ultimate aim is to provide new proactive and innovative resolutions for designing a soft computing simulation tool for learning business planning. In our Learning Business Plan Project we have established a theory on business planning which assumes that we should replace the traditional business planning with a more creative approach and thus we should focus more on invention and development of business ideas. We have designed a model of five stages according to our theory, and we apply soft computing and cognitive maps for our model simulations. In simulation we particularly apply linguistic cognitive maps which seem more versatile than the corresponding numerical maps. Two modeling examples are also provided.

Keywords: business planning, entrepreneurship, soft computing, cognitive maps.

1 Introduction

This paper considers a novel approach to business planning from the soft computing modeling standpoint, in particular, we focus on the processes in which invention and innovation are involved when new business ideas are created. Our ultimate aim is to provide new proactive and innovative resolutions for designing a soft computing simulation tool for learning business planning. Our economical and behavioral-scientific theories stem from the ideas suggested by [2-4], and according to them, instead of conducting the traditional business planning, we should be more creative and flexible as well as we should focus more on invention and development of business ideas.

Our approach, which is studied in our *Learning Business Plan Project* (LBP Project), models the invention of business ideas by combining theories on creativity in order to provide a new proactive and innovative resolution for learning business planning. Our approach also attempts to combine certain relevant philosophical aspects and results of the behavioral sciences (more details are provided e.g. in [5]).

We thus assume that human intelligence is creative and capable of interacting with reality, and these assumptions lead us to certain methodological and theoretical choices in our model construction. Our models, in turn, are simulated in a computer environment by using soft computing methods. In practice we make both concept map and cognitive map configurations on the business planning problems of the real world, and then we construct the corresponding soft computing models in order to simulate our phenomena [1,6,8] (Fig. 1).

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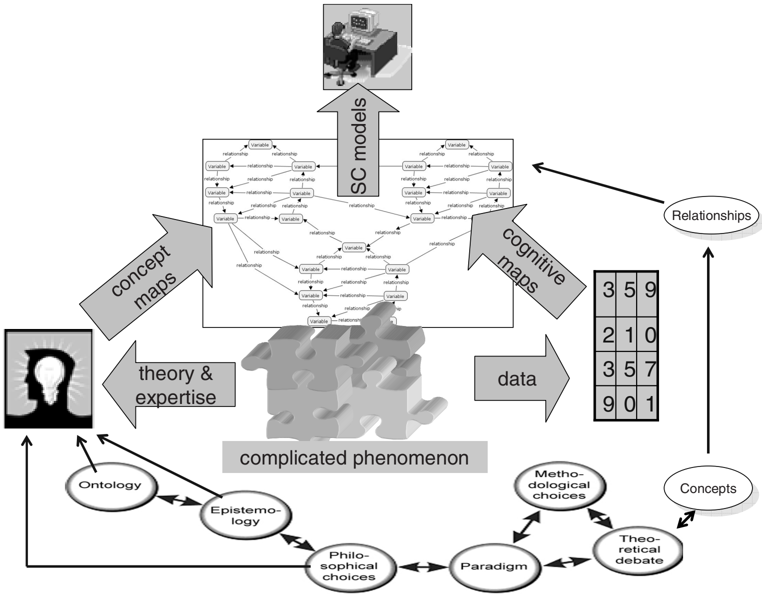

Fig. 1. The Framework for Our LBP Modeling

Below we introduce our approach which combines our theories and computer simulations. We also provide simplified examples which hopefully illuminate how we will proceed in practice. Since more concrete results will be published in the forthcoming papers, we at present mainly expect comments and feedback on our approach from the scientific community.

Section 2 briefly introduces the theoretical basis of our project. In Section 3 we consider our linguistic approach to cognitive map modeling. Section 4 provides two examples, and Section 5 concludes our paper.

2 Theoretical Basis of the LBP Project

In [5] a model including five stages for business planning is constructed (Fig. 2). First, the business idea is created; second, we develop our idea; third, we evaluate the idea by performing certain transformations, financial calculations and feasibility analysis; fourth, we have the implementation stage for our idea, and finally, we apply various re-evaluation and follow-up procedures. At present we focus on stages one to three.

Hence, we have designed a model which adds action and creativity as essential constituents to business planning whereas the previous models have focused on stage three. These five stages constitute a complicated network the nodes and interrelationships of which we consider in a computer environment.

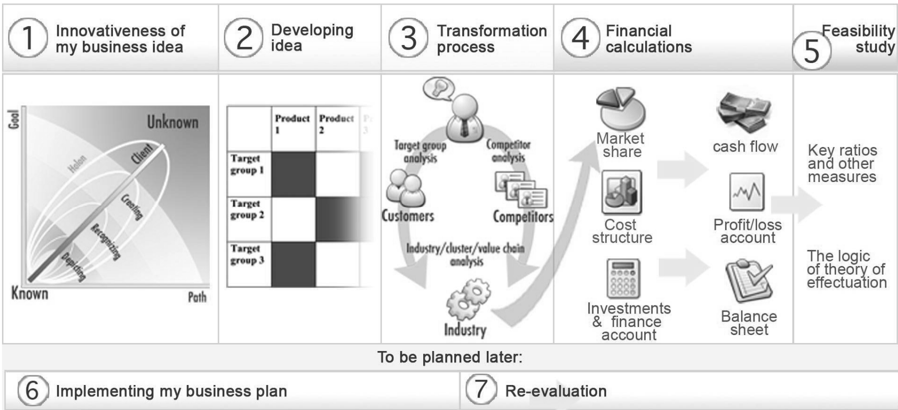

Fig. 2. Five Principal Stages in Business Planning ((3)-(5) comprise Stage three)

However, we still lack sufficient knowledge on the dynamics of the five stages above, and the available knowledge seems contradictory and confusing. At present we focus on the interrelationships between the stages one to three, and hence this problem area is only studied in this paper.

Another problem is that all business ideas are not novel, but rather they can be imitations of the existing ideas. One reason for this is that the concepts of invention, creativity and imitation are quite confusing in entrepreneurship research and their analyses has lead to various debates. However, there seems to be a general acceptance for the assumption that creativity and ability to innovations are connected to opportunity recognition in entrepreneurship research. For example, one definition is that entrepreneurial creativity means the entrepreneur's recognition of opportunities for development and the exploitation of resources. Hence the concepts of creativity and recognition of opportunity seem to have almost similar meanings.

To overcome this confusion we have applied Eijnatten's ideas on novelty [3]. He draws a distinction between individual and collective entrepreneurial novelty with improvement. Eijnatten suggests that, first, if we know both the goal and path we can only make improvements, second, if either of them is unknown, we renew our practices, and finally, if both of these aspects are unknown, we can reach the real novelty.

Eijnatten's approach enables us to understand how to recognize, create and mimic or depict opportunities. We can thus assume that if we know both the path and the goal, we can depict our business idea. If we recognize something, it is either the goal or path. If we create something, it refers to entities which are still non-existent to us, and we encounter unknown goals and paths. We thus have three basic alternatives and their different variations, viz. depicting, recognizing and creating opportunities to be exploited, as well as various degrees of known or unknown (Fig. 3).

By connecting the foregoing assumption to our model of learning business planning means that the more creative is our business idea, the more unknown it is to us.

Since the role of a client is also crucial to business, we can add this dimension to our model. Thus the degree of knowing leads to three zones of innovativeness, viz. depiction, recognition and creation in a three-dimensional space which constitutes the goal, path and client. In each zone these three dimensions have to be in balance, and

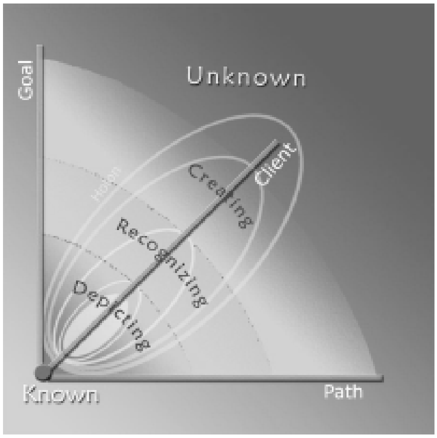

Fig. 3. Dynamics of Innovativeness in Business Planning

thus the creativity of the business idea is dependent upon person's ability to integrate these dimensions. If we provide answers to this process in business planning, we can model the dynamics between the five foregoing stages. In Section 4 we provide a simulation model of this idea.

3 Modeling with Soft Computing

The foregoing theoretical frameworks also presuppose simulation models which are good in practice. To date it has been problematic to model these phenomena in a computer environment because the conventional quantitative models have been fairly complicated whereas qualitative computer modeling as such arouses difficulties. By virtue of soft computing, on the other hand, we can construct both usable quantitative and qualitative models which also correspond well with human reasoning [6-7,10-11].

At general level, we apply the modeling depicted in Figure 1. Hence, we first design configurations by using concept and cognitive maps and these maps include our variables and their interrelationships [1,8]. Then we construct computer models which base on the idea of cognitive map modeling.

If (empirical) data on the behavior of a cognitive map is unavailable, we only operate with *a priori* cognitive maps, and thus our constructions are only based on our theories and expertise, otherwise we can also construct *a posteriori* maps, and then we can apply such methods as statistics (e.g., regression and path analysis), fuzzy systems, neural networks, Bayesian networks or evolutionary computing [9]. According to [9], most cognitive maps are still a priori maps and thus manual work seems to play an essential role in this context. However, more automatic or semi-automatic procedures are expected in this area.

To date numeric cognitive maps have been usual and they provide us a fairly good modeling basis as well as they are quite simple systems from the mathematical standpoint. They also allow us to use feedback or loops in our models, and this feature is problematic at least in the Bayesian networks.

However, the numeric cognitive maps also arouse some well-known problems. First, most of them have been a priori maps. Second, they can only establish monotonic causal interrelationships between the variables. Third, only numerical values and interrelationships can be used, and thus they are less user-friendly than the linguistic maps. Fourth, time delays are problematic because some phenomena can take place in a short term whereas others can occur in a long term [6].

The author has suggested that we use appropriate linguistic cognitive maps instead in order to resolve most of the foregoing problems [6]. In linguistic maps we use fuzzy linguistic variables and we establish the interrelationships between these variables by using fuzzy linguistic rule sets [6-7,10-11]. Hence, this approach, allows us to employ both quantitative and qualitative variables, use more versatile variable values and interrelationships, apply non-linear and non-monotonic modeling and construct more user-friendly systems. In addition, we can construct a posteriori linguistic cognitive maps in an automatic or a semi-automatic manner if we apply statistics and neuro-fuzzy systems [6].

4 Simple Modeling Examples

Consider first Eijnatten's model above (Fig. 3). In this context our modeling can base on Figure 4 and we thus use three input variables, Path, Goal and Client. These variables represent the degrees of knowing, and we can assign such values to them as *known*, *fairly known*, *medium*, *fairly unknown* and *unknown*. The output variable represents the degree of creativity, and we assign to it the values *depicting*, *recognizing* and *creating*. The relationships, which are established with fuzzy rules, are analogous with positive correlation (either linear or non-linear), i.e., the more unknown the input situation, the more creative is our business idea and vice versa (if we use the scales known - unknown and depicting - recognizing - creative).

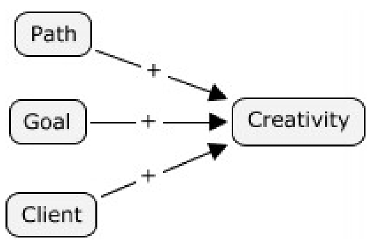

Fig. 4. The Modified Eijnatten's Fuzzy Model

Hence, we operate with such fuzzy rule sets as

1. If path is unknown and goal is unknown and client is unknown, then our business idea is creative.
2. If path is medium and goal is medium and client is medium, then our business idea is recognizing.
3. If path is known and goal is known and client is known, then our business idea is depicting.

Our inference engine operates with the foregoing rules and appropriate reasoning algorithms, for example, with the Mamdani or Takagi-Sugeno algorithms.

A more concrete example is the zero-order rule set in Figure 5 which was generated by using grid partition method in Matlab's Fuzzy Logic Toolbox. In this case the input values of 1 mean fully unknown situation and correspondingly the output value of 1 means fully creative business idea. In the real world, however, our variables constitute networks of variables, and this standpoint is taken into account in our LBP modeling.

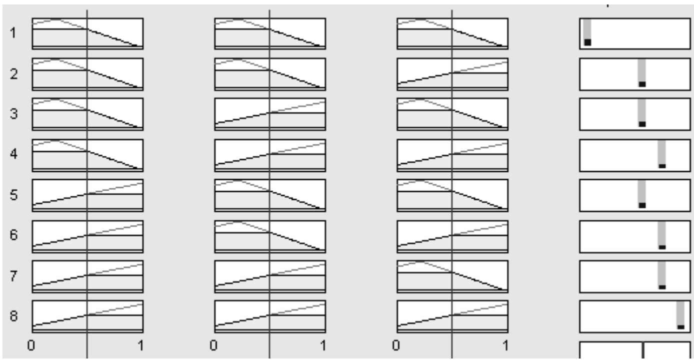

Fig. 5. Eight Fuzzy Rules for Eijnatten's Model. Inputs (which can be in any order): 0 = known, 1 = unknown. Output: 0 = depicting, 1 = creative.

Our second example considers our application of Eijnatten's chaotic growth of an high-tech enteprise [3]. He maintains that the founding of a high-tech start-up may be seen as an entrepreneurial process of successfully escaping the known valley ("business as usual"), climbing the mountain ("exploring the radical innovation"), and gliding into a new unknown valley ("the new business process"). For example, the product of service prototype may change or the business focus may change. Hence, coming from a relative stable state the enterprise is entering a relative unstable one. It will experience all kinds of dilemmas and contradictions, and literally "feels" the turbulence.

One version of Eijnatten's idea is a cognitive map which models the variation in sales of a given enterprise when the need for innovations varies more or less randomly or in a "chaotic" manner in a given period of time. We can thus assume that whenever our sales is increasing sufficiently, our enterprise meets new challenges (e.g. more competition in the markets) and we have to contribute more to innovations, otherwise our sales can decrease.

If we apply the simplified cognitive map in Fig. 6, our sales is dependent upon the variation in the needs for innovations (which is determined by various factors in practice) and our contributions to meet and fill these needs. If we focus on sales, we can generate such rules as

1. If the previous sales was fairly small and our contribution to innovations is slightly less than the true needs for innovations, then our sales is small.
2. If the previous sales was fairly large and our contribution to innovations is slightly more than the true needs for innovations, then our sales is large.

Fig. 7 depicts a corresponding tentative zero-order fuzzy rule set for the output variable Sales which was generated by using the grid technique.

If we construct fuzzy reasoning systems with linguistic rule bases for each variable as well as a meta-level system which applies these systems in simulation, we obtain a cognitive map system analogous to the prevailing numerical cognitive maps but in our case we can use more versatile interrelationships between the variables. The historical curves in Fig. 8 are based on this modeling approach and they show a simulation in which our sales is at first fairly small and our contribution to innovations is slightly less than the true need for innovations. In addition, our contribution is kept at a constant level. We notice that in this case our policy leads us to a zero-level sales.

The foregoing simplified examples hopefully illustrate our simulation approach with our novel linguistic modeling method. At present, we are constructing cognitive maps for the stages one to three, and these results will be presented in the further papers.

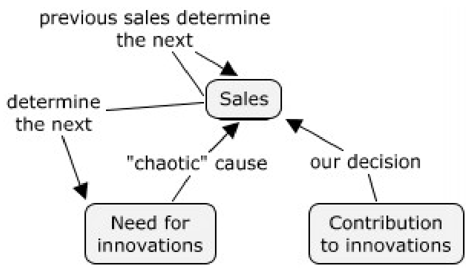

Fig. 6. An Example of Eijnatten's Chaotic Model

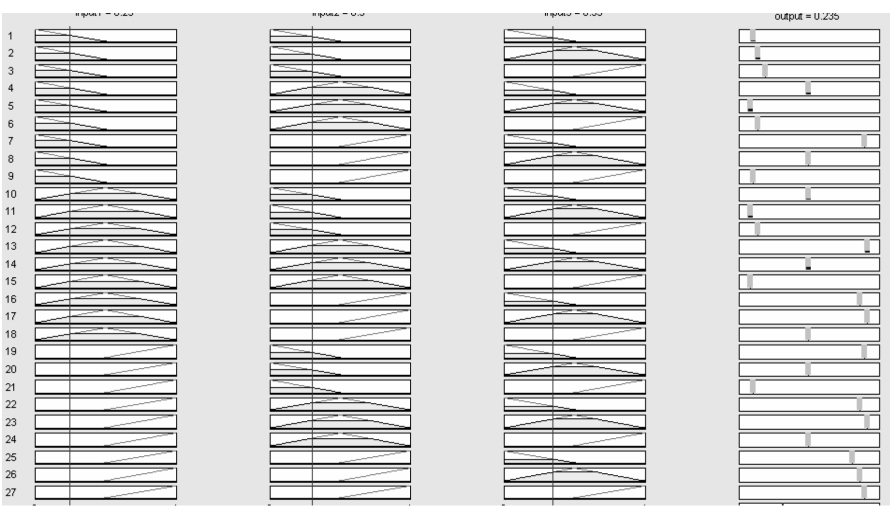

Fig. 7. Tentative Fuzzy Rules for Sales (Inputs: previous sales, contribution to innovations, need for innovations. Output: sales)

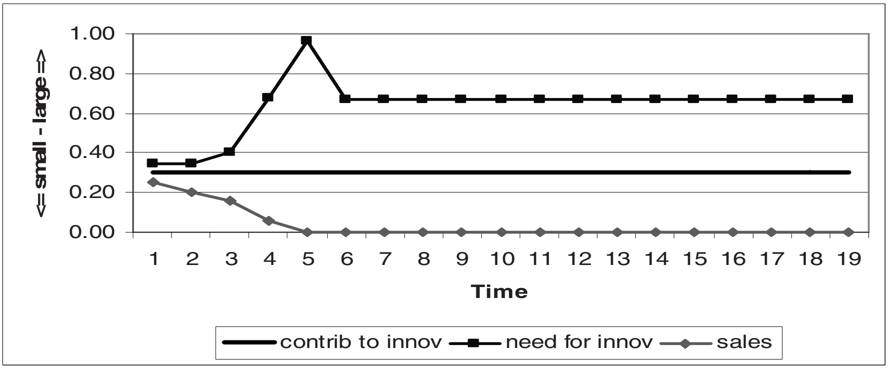

Fig. 8. Historical Curves in the Chaotic Model

5 Conclusions

Soft computing aspects of business plan modeling was considered. Our aim is to provide new proactive and innovative resolutions for designing a soft computing simulation tool for learning business planning. We have suggested two main ideas for this problem area. First, in our LBP project we have combined creativity to business planning and thus succeeded in establishing more usable logical and theoretical grounds for further modeling.

Second, in a computer environment we have applied soft computing and concept and cognitive maps to our simulations and tool construction. In this context we are applying novel linguistic maps and thus we can construct better models and tools. Two modeling examples was also sketched.

We still have unresolved problems concerning the nature of human behavior in business planning as well as in the corresponging simulation designs, and these issues will be considered in the future studies of the Project.

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