ANALYZING A CLASS OF INVESTMENT DECISION IN NEW VENTURES : A CBR APPROACH

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ABSTRACT

An application of case-based reasoning is proposed to build an influence diagram for identifying successful new ventures. The decision to invest in new ventures is characterized by incomplete information and uncertainty, where some measures of firm performance are quantitative, while some others are substituted by qualitative indicators. Influence diagrams are used as a model for representing investment decision problems based on incomplete and uncertain information from a variety of sources. The building of influence diagrams needs much time and efforts and the resulting model such as a decision model is applicable to only one specific problem. However, some prior knowledge from the experience to build decision model can be utilized to resolve other similar decision problems. The basic idea of case-based reasoning is that humans reuse the problem solving experience to solve a new decision.

In this paper, we suggest a case-based reasoning approach to build an influence diagram for the class of investment decision problems. This is composed of a retrieval procedure and an adaptation procedure. The retrieval procedure is carried out two phase, business item selection and case selection. An adaptation procedure is based on a decision-analytic knowledge and decision participants' knowledge. Each step of procedure is explained step by step, and it is applied to the investment decision problem in new ventures.

KEYWORDS

Case-based reasoning, Decision analysis, Influence diagram, Investment decision, Venture

1. Introduction

Venture investment decision has tended to rely on venture capitalist's intuition and experience (MacMillan, Zerman, and Subba Narasimha 1987; Khan 1987). New venture survival is tenuous at best, but those backed by venture capitalists (VCs) tend to achieve a higher survival rate than non-VC-backed business (Kunkel and Hofer 1990; Sandberg 1986; Timmons 1994). Thus, many researchers have investigated how VCs make their decisions (Wells 1974; Poindexter 1976; Tyebjee and Bruno 1984; MacMillan, Seigel, and Subba Narasimha 1985; MacMillan, Zerman, and Subba Narasimha 1987; Robinson 1987; Timmons et al. 1987; Sandberg, Schweiger, and Hofer 1988; Hall and Hofer 1993; Zacharakis and Meyer 1995). To make their venture investment decisions, the VCs have been used multiple criteria (Jain, Bharat, and Brain 1996; Hall, John, and Hofer 1993; Hall and Hofer 1993). The investment decisions in new ventures are the problems having followed characteristics such as incomplete information and uncertainty, where some measures of firm performance are quantitative, while some others are substituted by qualitative indicators. VCs assess the probability of success or failure by evaluating information surrounding a venture. Influence diagrams (IDs) can be used as a tool for representing and analyzing the investment decision problems based on incomplete and uncertain information from a variety of sources. Also, IDs are used to structure the economic and practical considerations in a value hierarchy and to calculate the preferred alternative. The traditional formulation of investment decision problems is done by lengthy interviews between decision maker (DM), domain expert(s), and decision analyst(s). Such a process needs much time, effort, and cost, but the main difficulty is that a constructed decision model such as influence diagrams are usually applicable to only one specific problem (Olmsted, 1984). Decision makers and domain experts found that some prior knowledge from the experience to model IDs can be utilized to resolve other similar decision problems (Kim, 1991).

In this research, we propose a case based reasoning (CBR) approach, a methodology to build IDs for investment decision in new venture. The basic idea of case-based reasoning is that humans reuse the problem solving experience to solve a new problem (Kolodner, 1991). The CBR approach regards an ID of one decision problem as a case, so it stores IDs of the venture investment decision problems at a case base. CBR can acquire knowledge with ease using inductive methodology, so it is useful especially when knowledge is incomplete, or evidence is sparse (Kolodner, 1993). The main task of using CBR is generally the representation of a class, a retrieval procedure, and an adaptation procedure (Kolodner, 1993). In this research, we represent a case as a frame -typed data structure corresponding to a decision situation and an ID. A retrieval procedure is suggested to retrieve a case to model a new investment decision. We suggested also an adaptation procedure of the retrieved IDs to get an ID for the given a new situation. Our procedure is applied to a decision for the ventures having the business items such as software and hardware development and Internet business.

2. Decision Class Analysis and Case Based Reasoning

The practical decision analysis process is viewed as a three-stage closed-loop process whose three stages are formulation (i.e., development of a decision model, like influence diagram), evaluation (i.e., computation of a recommendation from the model) and appraisal (i.e., interpretation of the formal recommendation) (Howard 1984). The closed-loop decision process can be viewed as a conversation involving two key participants: the decision maker (and his/her team of domain expert(s)) and a decision analyst. Most of the insight developed in the closed-loop decision process results from the interchange of information and new knowledge between the DM and the decision analyst. The conversation between analyst and DM of the closed-loop decision is lengthy, costly and very complicated like developing an art (Kolodner 1991). Therefore, it grows a necessity to replace the role of decision analyst and furthermore, domain expert(s). The decision analysts have observed that a constructed decision model such as an ID is usually applicable to only one specific problem, even if the formulation of a real decision problem needs much time, efforts, and cost. They often investigate that some prior knowledge from the experience of modeling IDs can be utilized to resolve other similar decision problems (Chung, Kim, and Kim 1992; Holtzman 1989; Howard 1988). Decision class analysis (DCA) treats a set of individual decisions at a higher level of abstraction and refinement. Given the DM's situation-specific information, the DCA should abstract and refine the corresponding specific decision variables for solving the individual problem. VCs usually consider the economical benefits and the consequences for denying the permit. They encounter this decision above five or six times a month. So these problem are to be modeled using DCA.

CBR is a general paradigm for reasoning from experience. A case based reasoner solves new problem by adapting the solution that was used to solve similar old problems (Risebeck and Schank, 1989). It assumes a memory model of representing, indexing, and organizing previous cases and a process model for retrieving and can mean adapting old solutions to meet new demand, using old cases to explain new situations, using old cases to critique new solutions, or reasoning from precedents to interpret a new situation or create an equitable solution to a new problem (Kolodner, 1993). In this research, the CBR is used as a methodology to implement a DCA, i.e., to build an ID.

3. Case Based Reasoning Approach for Venture Investment Decision

In this paper, a case based reasoning approach is presented to effectively apply the past experiences and expertise of decision analysts for modeling an ID for investment decision in new venture. Within our approach, the case based decision modeling process consists of the following components: formal case representation, case indexing, similarity-based case retrieval, and case adaptation. The formal case definition helps classify past cases by their attributes, and focus on a specific group relevant to the current situation, For an efficient case indexing, a hierarchical case structure is constructed by the business item of the ventures. The closeness between a past case and a new venture case is assessed based on the business item and the situations. The difference between the most similar case retrieved and new venture case problem, the adaptation process is interactively carried out by domain experts. The overall procedure is illustrated in Figure 1.

When a new order requiring investment arrives from a venture, the procedure for building an ID deciding investment is as follows.

1. *Classifying the kind of the business item of the new venture*. The case bases are classified by the business item of the venture such as hardware, software, and Internet. As a relevant case bases is selected based on the business item, next step is to find past case having similar situations with the new venture.
2. *Identifying the situation of the new venture*. Past cases that consist of the old situations and corresponding ID are compared with the new ventures' situations and are scored based on a similarity metric between the old situation and new situation. If the past case that exactly matches the current situation is found, its corresponding ID can be used without any modification. However, in many cases, the most similar case is chosen to adapt for the current situation. A formal definition of the case and similarity is explained in detail in section 4.
3. *Modifying the retrieved ID for the new venture*. The ID of the retrieved case is adjusted to remove the gap between the past ID and new situation of a current venture problem. The ID adaptation is carried out by the two steps, modification of an ID and aggregation, while satisfying the model constraints and given situations of the venture. The adaptation process is detailed in section 5.

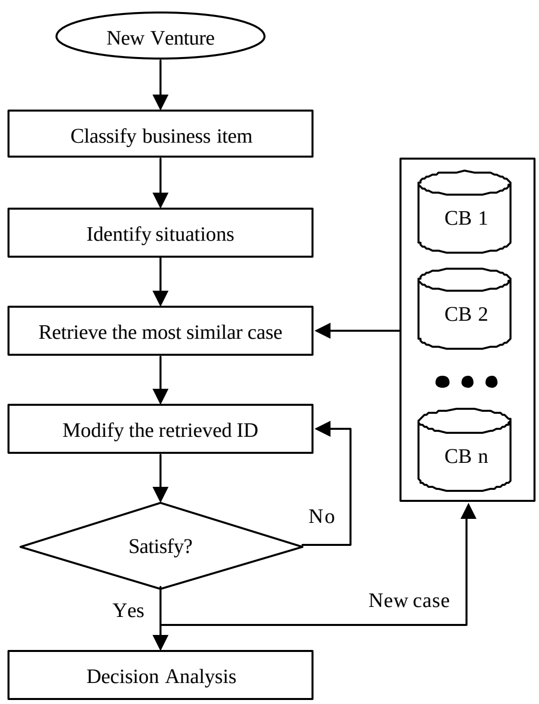


Figure 1. The overall procedure of the case based reasoning approach for venture investment decision

4. Case Representation and Retrieval

Case Structure and Representation

In this paper, a case is composed of an ID and its corresponding specific situation of one venture. A venture case is characterized by the attributes about business categories where the new venture is classified, and the attributes about the business environment such as domestic economic state. ID is composed of decision node, chance node, value nodes, and influence between nodes. In the terminology of DCA, a case is related with decision analysis, whereas a case base is related with decision class analysis. A case of case base contains all the ID related information such as the situations of one specific decision problem, nodes, and influences. IDs of similar decision problems of a same class is stored in the same case base.

In this research, we focused on the venture related with information communication or Internet. We classified the venture cases into three categories, hardware, software, and Internet-based business which are shown Figure 2. Case bases are constructed according to the classified categories of ventures. When a case is retrieved for a new venture case, its corresponding case base is first selected.

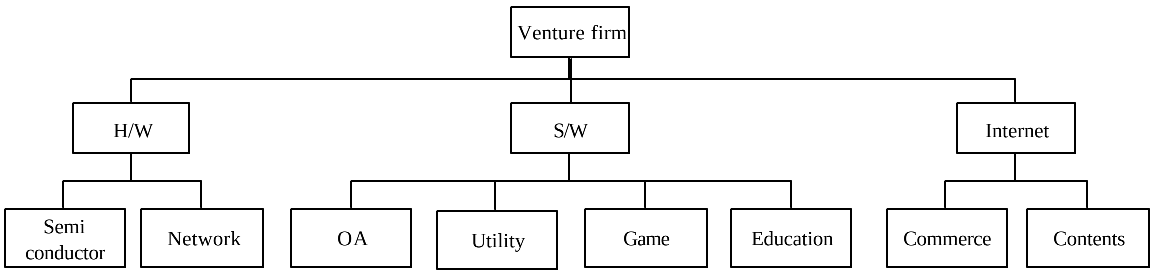


Figure 2. The hierarchical structure of the case base

The situation-specific knowledge about decision problem does a very significant role in our approach. When retrieving a case from case base, one of important criteria is the degree of similarity between a given decision problem and the case of case base. The attributes about the business environment are summarized like following Table 1. Each attribute has only one value of the possible values. Based on the diverse attribute values, diverse ID may be retrieved.

Table 1. Situations of the venture

Situation attribute	Vale
Major competitor (MC)	(yes/no)
Strength of competition (SC)	(high/low)
Technology Characteristics (TC)	(revolutionary/modification)
Target market (TM)	(domestic/global)
Maturity of the target market (MM)	(early/developing/matured)
Stage of venture (SV)	(idea/prototyping/business)
Location of the venture (LV)	(Seoul/Local)
Investment scale (IS)	(100M/300M/5M/10M)

To represent the structure of an ID, it is used a frame typed knowledge representation method. The frame-typed representation of an example case is shown like Figure 3. The 'VENTURE' frame refers a specific decision problem of a class and it contains the information about decision nodes and situations of the case. The information of nodes contains node name, corresponding case name, node type, predecessor node(s), and successor node(s). Figure 3 shows a part of venture investment decision case of Figure 1. The frame named 'Case 1' has two decision nodes and eight situations. Each situation has a name and its value. We designed each case of a same class to consist of a same set of situations. However the situation values are usually different from each other. A case base of one decision class consists of several 'VENTURE' frames like 'Case1' and their corresponding node frames like 'Business-success'. Whereas the number of 'VENTURE' frames represents the number of decision problems of one class, the number of node frames represents the sum of nodes of the IDs in the same class. The arc of an ID is represented by 'EVENT', 'PREDECESSORS' and 'SUCCESSORS' of node frame.

{{**Case 1**
IS-A: VENTURE
DECISION: Investment Preview
BUSINESS: hardware network
SITUATION: (MC yes) (SC high) (TC revolutionary) (TM global)
(MM early) (SV early) (LV 200M) (IS prototyping)
}}

{{**Business-success**
IS-A : CHANCE-NODE
PART-OF : Case1
EVENTS: Success Failure
PREDECESSORS : Ability-of-entrepreneur
SUCCESSORS : Preview-result Costs-of-venture Revenue-of-venture
}}

Figure 3. A part of a case represented by frame

Case Retrieval

Responding to the request for the case based decision modeling for a new venture, the case retrieval process selects the case base that fits the new venture through hierarchical structure of the business categories. Within the selected case base, all the past cases consist of the corresponding business category, situations, and the ID. The most similar case is retrieved from case base based on the predefined criteria. For the retrieval of a case, we developed a similarity measure.

Let's define some terminology as follows.

N: the number of cases.
$X_1, X_2, \ldots, X_N$: cases
$T=\{S_1, S_2, \ldots, S_N\}$: the set of the situation frames, where S_k is the situation frame of case X_k, $k=1,\ldots, N$.
m: the number of situation frames.
F_k: the fitting ratio.
$S_k=(e_{k1}\ e_{k2}\ \ldots\ e_{km})$: the situation frame of case X_k, $k=1,\ldots, N$.
$S_0=(e_{01}\ e_{02}\ \ldots\ e_{0m})$: the situation frame of the new decision problem,
$A \otimes B=(c_1\ c_2\ \ldots\ c_m)$ is defined as follows; if $a_j=b_j$ then $c_j=1$, else if $a_j \neq b_j$ then $c_j=0$, where $A=(a_1\ a_2 \ldots\ a_m)$, $B=(b_1\ b_2 \ldots\ b_m)$ are situation frames and a_j, b_j are the value of jth situation frame of A and B.

Based on the above terminology, we defined *fitting ratio*, F_k as a similarity measure between a new case and a case of case base.

$$F_k = \frac{n(S_0 \otimes S_k)}{m}$$, where $n(A)$ is the number of elements of A, which have "1" value.

Based on the fitting ratio for similarity, past case is scored and ranked. The most similar case with highest score is selected for the adaptation process that attempts to reconcile.

Table 2 shows the description of the situation frames of a given decision problem. It is a semi conductor venture, and its situations are shown at Table 2. The VC has to permit or deny the proposal. Using the value of situation attributes, fitting ratio is calculated between the example case and each case of a corresponding case base. Based on the values of fitting ratio, Figure 4 is retrieved, which has the biggest values of F_k .

Table 2. Situations of the venture

Situation attribute	Vale
Major competitor (MC)	(yes)
Strength of competition (SC)	(high)
Technology Characteristics (TC)	(modification)
Target market (TM)	(global)
Maturity of the target market (MM)	(matured)
Stage of venture (SV)	(prototyping)
Location of the venture (LV)	(Seoul)
Investment scale (IS)	300,000,000

5. Case Adaptation

If an exact same case is found from the case retrieval process, the ID can be used for the new venture without any modification. Otherwise, an adaptation process is invoked to detect the discrepancies between the most similar case and new venture, to reconcile the discrepancies by adapting the past ID for the new situation.

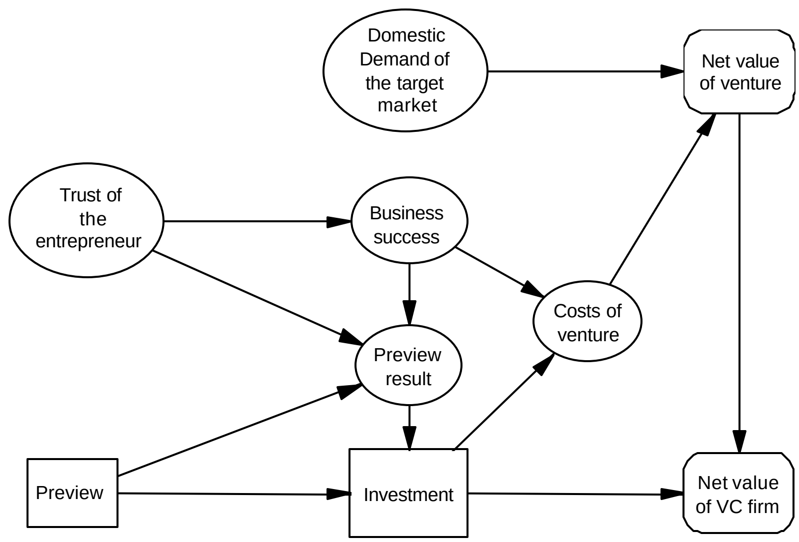


Figure 4. The retrieved ID

Modification of the initial ID

We call the ID retrieved from case base an *initial ID*, ID_{INI}.
It is represented as a set of $DCV_{INI} = \{d_k \in D \mid k = 1, ..., p\} \cup \{c_k \in C \mid k = 1, ..., q\} \cup \{v_k \in V \mid k = 1, ..., r\}$ and a set of $ARC_{INI} = \{ a(i,j) \in A \mid i < j; \quad i = 1, ..., p+q+r-1; \quad j = 2, ..., p+q+r\}$, where p, q, r are respectively the number of decision, chance, and value nodes.

To build an ID, ID_{INI} is modified by each domain expert who is intimately familiar with the problem domain. The domain experts usually have different domain knowledge, information, and preference. So each expert may give a slightly different modified ID. We call the modified ID by the kth domain expert as ID_k. ID_k is composed of DCV_k and ARC_k, defined similarly as DCV_{INI} and ARC_{INI}. The next subsection explains the interactive procedure to aggregate IDs of u experts.

Aggregation of IDs

A core ID, ID_{CORE}, is calculated by finding the intersection of all domain experts' IDs. It means the overlapped or intersected part of IDs which they can take, and each expert agrees on the core ID. The super ID, ID_{SUPER}, calculated by finding the union of each group expert's ID of given decision problem, represents a possible extent of group expert's information or knowledge of the given problem. The difference between super ID and core ID, ID_{DIS} implies a degree of preference or knowledge conflict between group domain experts. Our interactive procedure suggests for each expert to reconcile the initial ID to make a consensus for the given decision problem. The IDs modified by group domain experts may have two kind of disagreement. One is *naming disagreement* and the other one is *structural disagreement*. There are two sources of name disagreements, synonyms and homonyms. Synonyms occur when the same nodes of the application domain are represented with different names in the two IDs. Homonyms occur when different application nodes of the domain are represented with the same name in the two IDs. Renaming is performed by a decision maker or his/her appointed supervisor (one of the domain experts), whenever a synonym or a homonym is detected in the IDs.

After performing a resolution of naming disagreements, we achieve an interactive *reconciling process* for structural disagreement resolution. In this paper, backward reconciling process(BRP) is suggested. The basic idea of BRP is that BRP starts from ID_{SUPER}, which contains all the possible information about IDs that each domain expert can take. From ID_{SUPER}, BRP reduces the differences of each expert's incomplete ID into a complete ID.

Backward Reconciling Process:

Step(0) Set t=0.

Let $ID_{INI(t)} = ID_{INI}$ and $ID_{k(t)} = ID_k$, where ID_k is *k*th expert's modified ID.

Step(1) Obtain $ID_{SUPER(t)}$ and $ID_{DIS(t)}$ from $ID_{k(t)}$.

Step(2) Modify $ID_{SUPER(t)}$ by applying model reduction procedure repeatedly until $ID_{DIS(t)}$ becomes a null set.

Step(3) If the resulting $ID_{SUPER(t)}$ of Step(2) satisfies the termination condition, then stop.

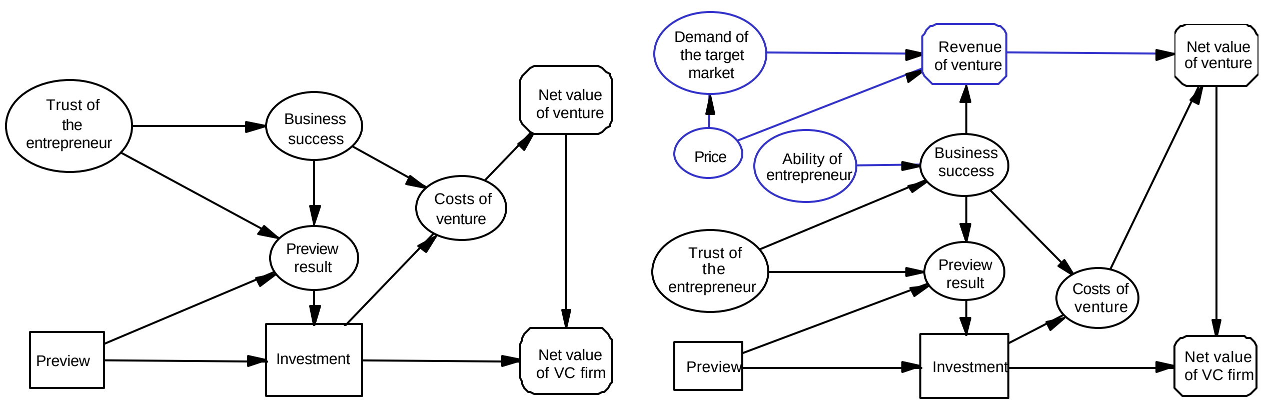
Otherwise go to step (4).

Step(4) Set t=t+1.

Each expert modifies the resulting $ID_{SUPER(t)}$. Let the modified ID by *k*th expert be $ID_{k(t)}$

Go to Step(2).

The above the process iterate until all the domain experts are satisfied. In some cases, group experts may not be satisfied after a relatively long iteration. In such a non-terminating cases, a decision maker or his/her appointed supervisor of the modeling process terminates the process. The number of iteration may depend on the urgency of the problem, the characteristics of decision problem, and cost of the decision analysis. The *'t'* in the process represents the iteration stage, so, for example, $ID_{INI(4)}$ represents an initial ID at the 4^{th} stage. The predefined number of *t* may be used as a termination condition to bind the iteration. We tested the case example of Figure 4 with three decision makers. Each DM modified the initial ID, ID_{INI}. Based on three modified IDs, the core ID and super ID is depicted like Figure 5.



(a) core ID (b) super ID

Figure 5. The core ID and super ID

Three DMs tried to resolve the nodes in disagreed subdiagram, ID_{DIS} according to the BRP. Our example is very simple, so they reach a final ID, without difficulty. The final ID is a super ID except "price" node, because price may be treated as a deterministic value in our example.

6. Conclusions

The investment decisions in new ventures like Internet business are the problems with incomplete information and uncertainty. The venture capitalists has tended to make a decision their intuition and experience. In this paper, we suggested a DCA-based CBR approach as a new methodology for investment decisions in new ventures. CBR does not needs many similar decision problems, and works well in domains that are poorly understood. The suggested CBR approach consists of the following functions: the retrieval of candidate case using suggested fitting ratio measure, adaptation to the specific situation of a given problem, and storing the result as a new case. We tested our methodology with a simple illustrative case example and three decision makers, but it will be extended to several case problems with many DMs.

We explained each step of the CBR approach in detail and applied it to a real investment decision problem. The evaluation of the CBR approach will be a promising research area. Developing a group decision support system will be helpful for applying our suggested methodology to real world problems.

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