System Engineering and Data Analytical Techniques for Web Centered Decision Support System Integrated with Machine Learning

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Abstract: In real world applications most of the success rates depend on the right decision making at right time. There are certain pre-triage decision support improvement strategies to provide an optimized workflow structure. System integrated decision making becomes increasingly important while dealing with complex problems. Decision making is the ability to know the context without applying analytical reasoning. Web-centered decision support functions provide a strong platform to achieve a better decision support system. Third order analytics demand the collaboration of Business Intelligence and Predictive Analytics Tools. Tools such as Decision Matrix provide an opportunity to analyze Subjective quantization versus Objective quantization. Pugh Matrix is one of the qualitative techniques which provide the advantage of multi-dimensional choices for an option set. It facilitates Sensitivity Analysis also. Efficient Decision making mechanisms always focused on implementing cognitive intelligence to analyze deeply and to attain Optimized Decision Support System.

Keywords: Decision Support System, Predictive Analytics Tools, Machine Learning, Deep Learning, Algorithmic Data Analysis, Priority Vector, Decision Matrix.

I Introduction
Decision Making is one of the most focused domains today. In case of Organizations, the optimal decision making results in a better productivity. In Society, the right decision taken in the place of voting suitable political leader gives better service to humanity. Decision-support systems are capable of handling the increasing complexity of the problems in their domains of application. In educational system, right decision making leads to best career and future. There are various situations of decision making and the solutions in day-today life. A confusion matrix is a summary of prediction results on a classification problem. The number of correct and
incorrect predictions are summarized with count values and broken down by each class. This is the key to the confusion matrix. A decision matrix is a list of values in rows and columns that allow an analyst to systematically identify, analyze, and rate the performance of relationships between sets of values and information. Elements of a decision matrix show decisions based on certain decision criteria. The matrix is useful for looking at large masses of decision factors and assessing each factor's relative significance. A belief decision matrix is used to describe a multiple criteria decision analysis problem in the Evidential Reasoning Approach. Instead of being a single numerical value or a single grade as in a decision matrix, each element in a belief decision matrix is a belief distribution [1]. Different Processes that enforce suitable decision making system are mentioned as follows: Practicability of probability-computation. Design of methodologies and techniques are created for constructing and analyzing probabilistic networks and evolutionary algorithms. Application of probabilistic networks and evolutionary algorithms are done in decision support systems.

II Algorithmic Data Analysis

There is a wide range of Decision Support tools available such as simulation models, proprietary and open source tools. The tools are capable to extract the information Transaction is carried out and Execution of Decision making. Information is gathered via different methods such as conducting interviews, Survey, Strategic Options Development and Analysis. Modern technologies available at present for Decision Support Systems are web-based, knowledge-based, neural network-based and fuzzy systems. DSS may be initialized by top management, user groups or system specialists.

III Literature Survey

A belief structure is a distributed assessment with beliefs. It is used in the evidential reasoning (ER) approach for multi-criteria decision analysis to represent the performance of an alternative option on a criterion. For example, the quality of a car engine may be assessed to be “excellent” with a high degree of belief (e.g. 0.6) due to its low fuel consumption, low vibration and high responsiveness. At the same time, the quality may be assessed to be only “good” with a lower degree of belief (e.g. 0.4 or less) because its quietness and starting can still be improved. Such an assessment can be modeled by a belief structure: $S_i(\text{engine})=\{(\text{excellent}, 0.6), (\text{good}, 0.4)\}$, where $S_i$ stands for the assessment of engine on the $i$th criterion (quality). In the belief structure, “excellent” and “good” are assessment standards, whilst “0.6” and “0.4” are degrees of belief [2]. In the Evidential Reasoning approach, Multiple Criteria Decision Analysis problem is modeled by a belief decision matrix instead of a conventional decision matrix. The difference between the two is that in the former, each element is a belief structure while in the latter, each element is a
single value (numerical or Character) [3] Decision Support System are specific class of computerized information system that support any domain, business and Organizational decision making activities. The Pugh Matrix provides a simple approach to taking these multiple factors into account when reaching a decision. By exploiting the innate ability of people to make a pair-wise comparison allows for subjective opinions about one alternative versus another to be made more objective. The Pugh Matrix also allows for simple sensitivity analysis to be performed, thereby providing some information as to the robustness of a particular decision [4]

IV Stages in Decision Making Process

❖ Define the process or requirement: Understand and state the specifications of Decision Support System Development tasks: Innovate a framework for Decision Support System development
❖ Develop alternative courses of action: Analyze various models of decision support system
❖ Evolve the individual and organizational model: Select the Best one among the different models.
❖ Review it: Evaluate the performance of different models and optimize.
❖ Act on it: Implement the appropriate model.

Major Components of Decision Support System

▪ Databases
▪ Users with user interface.
▪ Classification and Prediction Techniques.
▪ Systematic Models of Decision Making.
▪ Communication Components.
▪ Specific Software that links users, data and model
Figure 1: Basic Structure of Decision Support System

Decision Support System is classified as follows:
- User level
- Conceptual level
- System level

Multiple Attribute Value Theory

- Satisfaction of preferential independence among any groups of Attributes
- Satisfaction of the corresponding Trade-Off or Thompson Condition
- Internal scale property for constructing Marginal value.
- Weights of attributes need to be assessed as scaling constantly.

Cost Benefits Analysis: A cost-benefit analysis is a process businesses use to analyze decisions. The business or analyst sums the benefits of a situation or action and then subtracts the costs associated with taking that action.

Value Analysis: Value analysis is one of the newer scientific aids to managerial decision-making. It comprises a group of techniques aimed at the systematic identification of unnecessary costs in a product or service and efficiently eliminating them without impairing its quality and efficiency. It can also be defined as a systematic analysis and evaluation of techniques and functions in the various areas of a concern with a view to exploring channels of performance improvement so that the value attached to a particular product or service may be improved.
Sensitivity Analysis is processed by changing weights using different normalization methods or changing value functions.

**Table 1 Desirable Features of Decision Support Systems Evaluation Methods**

<table>
<thead>
<tr>
<th>Desirable Feature</th>
<th>Effectiveness Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for DSS Evolution</td>
<td>Integrated Support for DSS planning and Design</td>
</tr>
<tr>
<td>Organizational Objectives</td>
<td>Goal Orientation</td>
</tr>
<tr>
<td>Support for Multiple Evaluative Users</td>
<td>Prioritization / Synthesis of view points</td>
</tr>
<tr>
<td>Assessment of Qualitative Benefits</td>
<td>▪ Qualitative benefits</td>
</tr>
<tr>
<td></td>
<td>▪ Incorporation of uncertainties</td>
</tr>
<tr>
<td></td>
<td>▪ Consistent/Comparable Measurement</td>
</tr>
<tr>
<td>Support DSS flexibility</td>
<td>▪ Modeling Capability</td>
</tr>
<tr>
<td></td>
<td>▪ Adaptability of the approach</td>
</tr>
</tbody>
</table>

.V Multi-Attribute Utility Value Algorithm
This algorithm has the following steps:

Step-1: Use Utility functions to convert numerical attribute scales into a utility unit scale.

Step-2: Assign weights to the attributes and then calculate the weighted average of each end result set as an overall utility score.

Step-3: Compare utilities using the overall utility score. The Utility quantifies the degree of fulfillment of an outcome and for n possible outcomes \(X_1, X_2, X_3, \ldots, X_n\), the expected utility is

\[
EU = \sum p(X_i) \times U_i(X_i) \quad \text{--------------------------- (1)}
\]

The same formula for the Expected Utility theory (EU) is then modified to form

\[
U(X) = \sum_{i=1}^{n} w_i \times u_i(x_i) \quad \text{with} \quad \sum w_i = 1 \quad \text{------------------------ (2)}
\]

From this formula (equation-2) the probabilities are replaced by the importance weights involving the criteria. The formula for the expected utility is used, and utility functions are used to express the desirability of the attributes. The overall utility of an alternative with a number of criteria is defined by the following additive function shown in equation -(2).
VI Analytic Hierarchy Process Method
Decision situations to which the Analytic Hierarchy Process Method can be applied include:

- **Choice** – The selection of one alternative from a given set of alternatives, usually where there are multiple decision criteria involved.
- **Ranking** – Putting a set of alternatives in order from most to least desirable.
- **Prioritization** – Determining the relative merit of members of a set of alternatives, as opposed to selecting a single one or merely ranking them.
- **Resource allocation** – Apportioning resources among a set of alternatives.
- **Benchmarking** – Comparing the processes in one's own organization with those of other best-of-breed organizations.
- **Quality management** – Dealing with the multidimensional aspects of quality and quality improvement.
- **Conflict resolution** – Settling disputes between parties with apparently incompatible goals or positions.

![Figure 3 Alternative Method with different Criteria](image)

The Priority Vector is tabulated as follows:
Table 2 Priority Vector 1

<table>
<thead>
<tr>
<th>C2: Hardware Maintainability</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Priority Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1/7</td>
<td>1/5</td>
<td></td>
<td>0.233</td>
</tr>
<tr>
<td>B</td>
<td>1/7</td>
<td>1/8</td>
<td></td>
<td>0.055</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>0.713</td>
</tr>
</tbody>
</table>

$\lambda_{\text{max}} = 3.247$, CI = 0.124, and CR = 0.213.

Table 3 Priority Vector 2

<table>
<thead>
<tr>
<th>C4: User Friendly</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Priority Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>0.674</td>
</tr>
<tr>
<td>B</td>
<td>1/5</td>
<td>1</td>
<td>1/3</td>
<td>0.101</td>
</tr>
<tr>
<td>C</td>
<td>1/4</td>
<td>3</td>
<td>1</td>
<td>0.226</td>
</tr>
</tbody>
</table>

$\lambda_{\text{max}} = 3.086$, CI = 0.043, and CR = 0.074.

Decision Matrix and Solution when the Ideal Mode AHP is used:

<table>
<thead>
<tr>
<th>Criterion</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>Final Priority</th>
<th>After Normalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt.</td>
<td>(0.553)</td>
<td>(0.131)</td>
<td>(0.271)</td>
<td>(0.045)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>1.000</td>
<td>0.327</td>
<td>1.000</td>
<td>1.000</td>
<td>0.912</td>
<td>0.678</td>
</tr>
<tr>
<td>B</td>
<td>0.240</td>
<td>0.077</td>
<td>0.087</td>
<td>0.150</td>
<td>0.173</td>
<td>0.129</td>
</tr>
<tr>
<td>C</td>
<td>0.086</td>
<td>1.000</td>
<td>0.243</td>
<td>0.335</td>
<td>0.260</td>
<td>0.193</td>
</tr>
</tbody>
</table>
VII Decision Making Methods

Data Mining software employs a variety of Multiple Criteria Decision Making methods such as:

- Aggregated Indices Randomization Method (AIRM)
- Analytic Hierarchy Process (AHP)
- Analytic network process (ANP, an extension of AHP)
- DEX (Decision EXpert)
- Elimination and Choice Expressing Reality (ELECTRE)
- Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH)
- Multi-attribute global inference of quality (MAGIQ)
- Potentially All Pairwise RanKings of all possible Alternatives (PAPRIKA)
- Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE)
- Evidential reasoning approach for Multiple Criteria Decision Method under hybrid uncertainty

Intelligent Decision System:

The evidential reasoning approach has recently been developed on the basis of decision theory in particular utility theory, artificial intelligence in particular the theory of evidence, statistical analysis and computer technology. It uses a belief structure to model an assessment with uncertainty, a belief decision matrix to represent an Multiple Criteria Decision problem under uncertainty, evidential reasoning algorithms to aggregate criteria for generating distributed assessments, and the concepts of the belief and plausibility functions to generate a utility interval for measuring the degree of ignorance. A conventional decision matrix used for modeling a Multiple Criteria Decision Method is a special case of a belief decision matrix. The use of belief decision matrices for Multiple Criteria Decision Modeling in the Entity Relation approach results in the following features:

1. An assessment of an option can be more reliably and realistically represented by a belief decision matrix than by a conventional decision matrix.
2. It accepts data of different formats with various types of uncertainties as inputs, such as single numerical values, probability distributions, and subjective judgments with belief degrees.

3. It allows all available information embedded in different data formats, including qualitative and incomplete data, to be maximally incorporated in assessment and decision making processes.

4. It allows assessment outcomes to be represented more informatively.

Figure 4 Bias of Additive Belief function

The theory of belief functions, also referred to as evidence theory or Dempster–Shafer theory (DST), is a general framework for reasoning with uncertainty, with understood connections to other frameworks such as probability, possibility and imprecise probability theories. Epistemic uncertainty—a mathematical theory of evidence The theory allows one to combine evidence from different sources and arrive at a degree of belief (represented by a mathematical object called belief function) that takes into account all the available evidence.
Figure. 5 Classifications of Machine Learning Algorithms

Machine Learning evolved from the study of pattern recognition and computational learning theory in artificial intelligence, machine learning explores the study and construction of algorithms that can learn from and make predictions on data – such algorithms overcome following strictly static program instructions by making data-driven predictions or decisions, through building a model from sample inputs. The respective additive value is calculated as,
\[ v = \sum_{i=1}^{m} \omega_i y_i = \omega_1 y_1 + \omega_2 y_2 + \cdots + \omega_m y_m \]

However, it is more common to use the term in the wider sense of the same general approach, as adapted to specific kinds of situations. This interval contains the precise probability of a set of interest (in the classical sense), and is bounded by two non-additive continuous measures called belief (or support) and plausibility. Degree or Mass or Belief is denoted as:
\[ \text{bel}(A) \leq P(A) \leq \text{pl}(A). \]

Degree or Mass or Belief is denoted as:
\[ \text{bel}(A) = \sum_{B \subseteq A} m(B). \]

Plausibility is calculated as:
\[ \text{pl}(A) = \sum_{B \subseteq A} m(B). \]

\[ \text{pl}(A) = 1 - \text{bel}(A). \]

The inverse function is attained as:
\[ m(A) = \sum_{B \subseteq A} (-1)^{|A-B|} \text{bel}(B) \]

The level of un-certainty in predicting whether a person is alive or dead is calculated as shown in the table below:

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Mass</th>
<th>Belief</th>
<th>Plausibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null (neither alive nor dead)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Alive</td>
<td>0.2</td>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Dead</td>
<td>0.5</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Either (alive or dead)</td>
<td>0.3</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The Degree or Mass, Belief And Plausibility are Functions of Probability. Decision analysis (DA) is the discipline comprising the philosophy, methodology, and professional
practice necessary to address important decisions in a formal manner. Decision analysis includes many procedures, methods, and tools for identifying, clearly representing, and formally assessing important aspects of a decision, for prescribing a recommended course of action by applying the maximum expected utility action axiom to a well-formed representation of the decision, and for translating the formal representation of a decision and its corresponding recommendation into insight for the decision maker and other stakeholders. [19]

VIII Conclusion
A properly designed DSS is interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, and personal knowledge, or business models to identify and solve problems and make decisions. There are various techniques and methods available scientifically to achieve the best state of Decision Making. Health Care, Business Organizations, Social Service Bodies, Individuals, Educational Institutions are recently implementing the suitable methods and techniques and tools in order to achieve optimality in Decision Making.

References
[10]M.Shanmuganathan 1 , K.Kajendran 2 , A.N.Sasikumar 3 , M.Mahendran 4 1,2,3,4 Faculty, Dept of C.S.E, Panimalar Engineering College, Chennai,TamilNadu,India, International


