OPERATIONAL RISK MANAGEMENT SYSTEM VIA SOFT-COMPUTING PARADIGM

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ABSTRACT: Operational Risk is a side effect of ambiguous organizational services and operations and has become a serious problem that threatens most organization. Although different systems and methods for combating operational risk exist, most of these systems focus on detecting and not managing risk. The proposed system specified in this research not only detects but also manage risk based on incremental operational risk factors. The system utilizes the synergy of fuzzy logic and genetic algorithm in other to adapt optimization and handle impreciseness associated with operational risk factors while formal specification were utilized for the formal design. Based on the occurrence of the operational risk factors, the system determines when it is necessary to Ignore Risk, Avoid Risk, Mitigate Risk, Transfer Risk and Accept Risk. The system reduces management operational risk to the minima in an organization.

INTRODUCTION

Business risk is the likelihood that an organization in the course of its daily operations will encounter unforeseen occurrences which will adversely hamper its organizational productivity, thereby incurring reasonable loss to the organization. It differs from audit risk, which is the probability that an auditor will issue an unqualified opinion on materially misstated financial statements. For example, an auditor may be sued (business risk) whether or not the audit and the financial statements comply with professional standards (audit risk). Audit risk can influence business risk because an inappropriate opinion can be a significant factor in the events that lead to loss or injury to an auditor's professional practice. Conversely, business risk may, within limits, influence the auditor's assessment of the acceptable level of audit risk (Craig *et al*., 1983).

Business risk is an inherent factor of very well meaning organization from the very inception of the organization through its life span; it is a critical factor for organization policy formulation, amendment and auditing. Any organizational assets are critical risk factors. Business risk can result from internal conditions or some external factors (environmental risk) which can be marked in the wider area of business society. On the other hand, when a company does not have adequate cash flow to meet its operating expenses it is called business risks. Environment risk arises when there are external forces that could affect the viability of the enterprise's business model, including the fundamentals that drive the overall objectives. They include; competitor riskcustomer wants risk, technological innovation risk, sensitivity risk, shareholder relations risk, capital availability risk, sovereign/political risk, legal risk, regulatory risk, Industry risk, financial markets risk and catastrophic loss risk (PWC, 2011).

Operational risk is the threats arising from loss of key personnel, settlement failure, systems failure, compliance failure and theft. While risk management is the process of identifying vulnerabilities and threats to information resources used by an organization in achieving business objectives and deciding what countermeasures (safeguards or control), if any, to take in reducing risk to an acceptable level (i.e. residual), based on the value of the information resources to the organization (ISACA, 2011).

Effective risk management begins with a clear understanding of the organization's appetite for risk. This drives all risk management efforts, and in an IT context it impacts future investments in technology, the extent to which IT assets are protected and the level of assurance required. Depending on the type of risk and its significance to the business management and a board may choose any of the under listed strategies to risk management (ISACA, 2011)

a. Avoid Risk: where feasible, choose not to implement certain activities or processes that would incur risk (Eliminate risk by eliminating the cause)
b. Ignore Risk: An organization may choose to reject risk by ignoring it, which can be dangerous.
c. Mitigate: Lessens the impact of the risk by defining, implementing and monitoring appropriate controls mechanism.
d. Transfer and share risk with partners, transfer via insurance coverage, contractual agreement or other means
e. Accept: Formally acknowledge other existence of the risk and monitor it.

Operational risk interfaces with other forms of risks directly or indirectly. Since operational risk is vague, it is inevitable but manageable. This is the bedrock of most successful organization. This paper focuses on utilizing soft computing approach (basically fuzzy logic and genetic algorithm) for assessing the level of operation risk in an organization. An appropriate model for risk management is developed utilizing formal specification (Z notation).

METHODOLOGY

Genetic Algorithms (GA) mimic the biological evolution process for solving problems in a wide domain. A GA operates through the following stages (Zhang and Nguyen 1993):

a. Creation of a "population" of strings,
b. Evaluation of each string,
c. Selection of best strings and
d. Genetic manipulation to create new population of strings

GA is made-up of five main components namely fitness function, selection, mutation, reproduction and crossover (Amit, 1999). These are defined thus:

Fitness or evaluation Function: is the genetic algorithm component that rates a potential by calculating how good they are relative to the current problem domain.
Selection: is a way for the genetic algorithm to move toward promising regions in the search space. The individual with the highest fitness are selected and they will have a higher probability of survival to the next generation
Mutation: is a genetic operator that changes one or more gene values in a chromosome. The mutation process helps to overcome trapping at local maxima. The offspring's produced by the genetic manipulation process are the next population to be evaluated.
Crossover: involves exchanging Chromosomes portions of genetic materials.
Reproduction: Birth of a new generation

Fuzzy logic, a multivalued (as opposed to binary) logic was developed to deal with imprecise or vague data. Classical logic holds that everything can be expressed in binary terms: 0 or 1, black or white, yes or no. In terms of Boolean algebra, everything is in one set or another but not in both. Fuzzy logic allows for partial membership in a set, values between 0 and 1, shades of gray, and maybe-it introduces the concept of the "fuzzy set." When the approximate reasoning of fuzzy logic is used with an expert system, logical inferences can be drawn from imprecise relationships.

Fuzzy logic which is a superset of conventional (Boolean) logic is extended to handle the concept of partial truth - truth values between "completely true" and "completely false"(Kasabov, 1998; Robert, 2000). This theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. A fuzzy set A is called trapezoidal fuzzy number (Figure 1) with tolerance interval [a, b], left width α and right width β if its membership function has the following form:

$$A(t) = \begin{cases} 1 - (a-t)/\alpha & if\ a - \alpha \leq t \leq a \\ 1 & if\ a \leq t \leq b \\ 1 - (t-b)/\beta & if\ a \leq t \leq b + \beta \\ 0 & otherwise \end{cases}$$

and we use the notation A = (a, b, α, β). It can easily be shown that

$$[A]^{\gamma} = [a - (1 - \gamma)\,\alpha,\ b + (1 - \gamma)\,\beta],\ \forall\, \gamma\ \varepsilon\ [0, 1].$$

The support of A is (a − α, b + β).

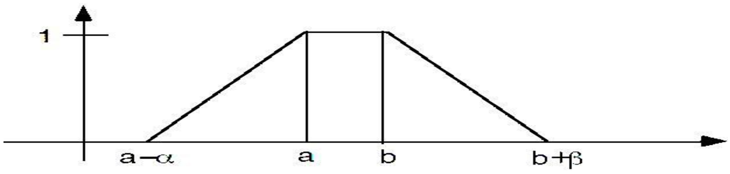

Figure 1: Trapezoidal fuzzy number

Fuzzy systems often learn their rules from experts. When no expert gives the rules, adaptive fuzzy systems learns by observing how people regulate real systems (Leondes, 2010).

Fuzzy Set (Linguistic Variable): Derived as an extension of the classical notion of a set. According to classical set theory, an element either belongs or does not belong to the set. In contrast, fuzzy set theory permits the gradual assessment of the membership of elements in a set.

Membership Function: This is described as a graph that defines how each point in the input space is mapped to the membership value between 0 and 1.

Fuzzy Inference Systems: Fuzzy Inference Systems (Figure 2) involves formulating the mapping from a given input to an output. It is defined as the process in which a Fuzzy Logic System or a Fuzzy Inference System maps the crisp inputs into crisp outputs. It contains five components: Rule-base, Data-base, Fuzzifier (transformation of crisp values into fuzzy set), Inference and Defuzzifier (transformation of fuzzy set into crisp value).

In other to design a risk detector and management system, we develop a model which consists of the following set of eleven parameters needed for detecting operational risk:

a. Economic instability: this is the environmental state of a country at a particular time.
b. Inadequate customer satisfaction: a particular good and service deployed by an organization should satisfy a customer, but due to certain factors such as late delivery of goods and services such needs are not met, giving rise to operational risk.
c. Lack of human resources: this is critical in any well-meaning organization.
d. Poor development product: a product not developed according to specification or market demand will never succeed.
e. Inefficiency: efficiency is the proper use of organizational resource to yield maximum results. Inefficiency is the reverse.
f. Low productivity: minima organizational result.
g. Regular business interruption: environmental disaster due to natural phenomena or man-made disaster which can result in business interruption.

h. Product/Service failure: product that do not satisfy customer or market requirements.
i. Lack of organizational compliance: when organizational policy and standards are not complied with either the employee or outsourcer, then operational risk is bound to occur.
j. Inappropriate organizational channel: poor organizational channel of communication will not only hamper productivity, but increase operational risk greatly.
k. Inapt sitting of organization: when organizations are poor sited, it greatly hamper productivity, profit and customer satisfaction. This invariably increases operational risk.

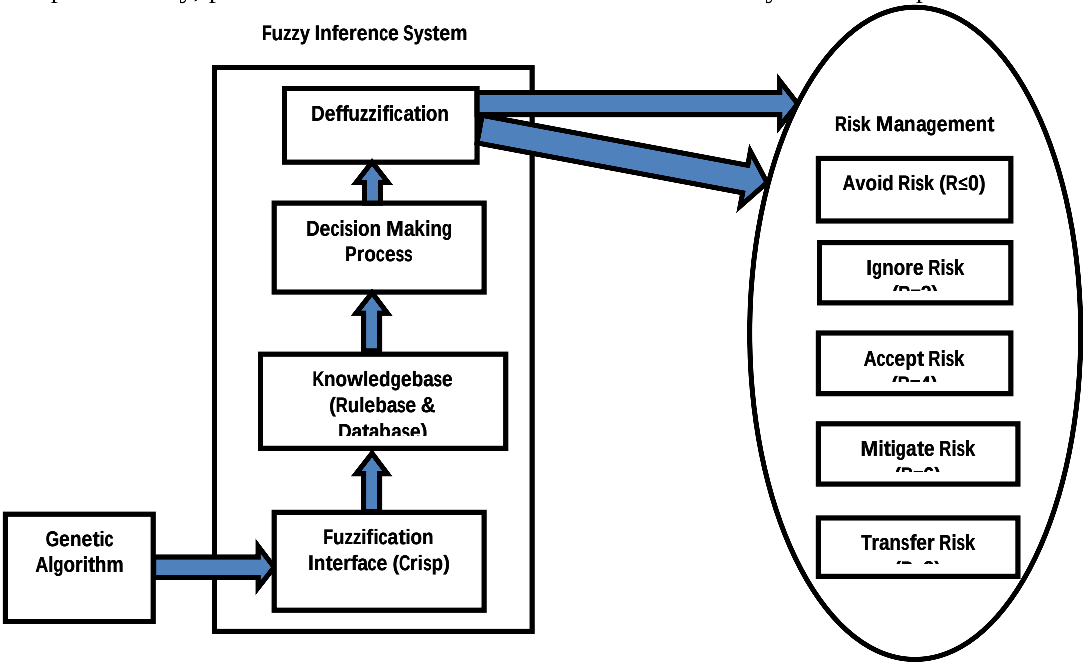

Figure 2: Operational Risk detector and Management System

EXPERIMENTATION

The experimentation was done using z notations, a formal method based on mathematical representation and analysis of software. It includes software analysis and proof, transformation development and program verification. Using the Z notation, the system specification was subdivided into schemas which described both the static and dynamic aspects of the system.

The static aspects include:

a. The states the system can occupy.
b. The invariant relationships that are maintained as the system move from state to state.

The dynamic aspect includes:

a. The operations that is possible, b. The relationship between their inputs and output,
c. The changes of state that occur.

Every user is authenticated using his user name and ID (Fig.3).

User
User_name: seq CHAR
User_ID: seq CHAR
User: ℙ USER
Access! : Boolean
(user∈user.access! = accepted) V (user ∉user.access! = denied)

Figure 3: User Schema

There is no limit to the number of registered users. Logging on, each agent must register its name (Fig. 4).

Operational Risk Management

Ξ OperationalRiskDirectory
OpeartionalRiskCriteria?: OPERATIONALRISKCRITERIA
Risklist? ℙ RISK

(risklist! = {risk : risks / directory (risk) = criteria? }∨ (risk∉ risks ∧ report! = not_known)

Figure 4: Risk Management Schema.

The Operational Risk Management receives a set of risk criteria and returns the particular risk option. This is represented as (Fig. 5):

RiskCatalogue

Risks: ℙ RISK
criterias: ℙ CRITERIAS
Catalogue: RISK → CRITERIAS

Risks = dom catalogue

Figure 5: RiskCatalogue Schema

The Operational Risk Catalogue shows the set of risk management schema available on the system. The directory is initialized at the beginning with no agents and no services (Figure 6).

Initialize_Directory

Operational RiskDirectory
Criteria: ℙ CRITERIA
Risks ℙ RISK

Risk = ∅
Criteria = ∅

Figure 6: Initialize_Directory Schema

The fuzzy partition for each input feature consists of criteria for recognizing Operational risk, Economic instability, Inadequate customer satisfaction, Lack of human resources, Poor development product, Inefficiency, Low productivity, Regular business interruption, Product/Service failure, Lack of organizational compliance, Inappropriate organizational channel and Inapt sitting of organization. However, it can occur that if the fuzzy partition for operational risk is not set up correctly, or if the number of linguistic terms for the input features is not large enough, then some patterns will be misclassified. The rules that are generated from the initial fuzzy partitions of the classification of operational risk are thus:

a. Avoid Risk (C1)
b. Ignore Risk (C2)
c. Accept Risk (C3)
d. Mitigate Risk (C4)
e. Transfer Risk (C5)

where an organization not experiencing one or noneoperational risk criteria is denoted as C1, if the organization experiences two or three criteria (C2), experiencing four or five criteria (C3), experiencing six criteria (C4), and experiencing seven and above criteria (C5).

The Fuzzy IF-THEN Rules for Operational Risk is thus:

R1: IF the organization is experiencing none THEN is in C1.
R2: IF the organization is experiencing economic instability and inadequate customer satisfaction THEN is in C2.
R3: IF the organization is experiencing economic instability, inadequate customer satisfaction and lack of human resources THEN is in C2.
R4: IF the organization is experiencing economic instability, inadequate customer satisfaction, lack of human resources and poor product development THEN is in C3.

R5: IF the organization is experiencing economic instability, inadequate customer satisfaction, lack of human resources, poor product development and inefficiency THEN is in C3.

R6: IF the organization is experiencing economic instability, inadequate customer satisfaction, lack of human resources, poor product development, inefficiency and low productivity THEN is in C4.

R7: IF the organization is experiencing economic instability, inadequate customer satisfaction, lack of human resources, poor product development, inefficiency and low productivity and regular business interruption THEN is in C5.

R8: IF the organization is experiencing economic instability, inadequate customer satisfaction, lack of human resources, poor product development, inefficiency and low productivity, regular business interruption and product/ service failure THEN is in C5.

R9: IF the organization is experiencing economic instability, inadequate customer satisfaction, lack of human resources, poor product development, inefficiency and low productivity, regular business interruption, product/ service failure and lack of organizational compliance THEN is in C5.

R10: IF the organization is experiencing economic instability, inadequate customer satisfaction, lack of human resources, inefficiency and low productivity, regular business interruption, product/ service failure, lack of organizational compliance and inappropriate organizational channel THEN is in C5.

R11: IF the organization is experiencing economic instability, inadequate customer satisfaction, lack of human resources, poor product development, inefficiency and low productivity, regular business interruption, product/ service failure, lack of organizational compliance, inappropriate organizational channel and inapt siting of organization THEN is in C5.

RESULTS AND DISCUSSION

Table 1 shows the Degree of Membership of operational risk using a scale of 0.00 -1.00. The algorithm terminates when the stop criterion is met. The following Genetic algorithm utilizes the following conditions to determine when to stop (Generations or Fitness limit). In this case, we used the number of generation (3rd generation) to determine the stopping criterion.

Table 1: Degree of Membership of Operational Risk (Scale: 0.00 -1.00)

Parameters of Operational Risk	Codes	Degree of Membership Function				
		Cluster (C1)	Cluster (C2)	Cluster (C3)	Cluster (C4)	Cluster (C5)
Economic Instability	R01	0.10	0.10	0.10	0.10	0.60
Inadequate customer Satisfaction	R02	0.00	0.50	0.50	0.00	0.00
Lack of human Resource	R03	0.00	0.50	0.50	0.00	0.00
Poor Product Development	R04	0.15	0.10	0.60	0.05	0.10
Inefficiency	R05	0.05	0.15	0.60	0.10	0.10
Low Productivity	R06	0.00	0.00	0.00	0.50	0.50
Regular Business Interruption	R07	0.00	0.00	0.00	0.50	0.50
Product/ Service Failure	R08	0.00	0.00	0.00	0.50	0.50
Lack of Organizational Compliance	R09	0.00	0.00	0.00	0.50	0.50
Inappropriate Organizational Channel	R10	0.00	0.00	0.00	0.50	0.50
Inapt sitting of organization	R11	0.00	0.00	0.00	0.50	0.50
RESULTS		Avoid Risk	Ignore Risk	Accept Risk	Mitigate Risk	Transfer Risk

The Genetic Algorithm Inference are:

R1: IF R01 THEN C1 = 0.10
R2: IF R01 AND R02 THEN C2 = 0.30
R3: IF R01, R02 AND R03 THEN C2 = 0.36
R4: IF R01, R02, R03 AND R04 THEN C3 = 0.43
R5: IF R01, R02, R03, R04 AND R05 THEN C3 = 0.46
R6: IF R01, R02, R03, R04, R05 AND R06 THEN C4 = 0.13
R7: IF R01, R02, R03, R04, R05, R06 AND RO7 THEN C5 = 0.26
R8: IF R01, R02, R03, R04, R05, R06, RO7 AND R08 THEN C5 = 0.29
R9: IF R01, R02, R03, R04, R05, R06, RO7, R08 AND R09 THEN C5 = 0.31
R10: IF R01, R02, R03, R04, R05, R06, RO7, R08, R09 AND R10 THEN C5 = 0.33
R11: IF R01, R02, R03, R04, R05, R06, RO7, R08, R09, R10 AND R11 THEN C5 = 0.35

We then convert these resolved values into whole numbers and imply them to be the fitness function (*f*) of the initial generation (Parents)

R1: 10, R2: 30, R3:36, R4: 43, R5: 46, R6: 13, R7: 26, R8: 29, R09: 31, R10:33, R11:35

Table 2: 1st and 2nd Generation Table

S/N	Selection	Chromosomes (Binary; 0 or 1)			Fitness function
		Parent (1st Gen)	Crossover	Parent (2nd Gen)	
1	46	101110	1 & 6	101111	47
2	43	101011	2 & 7	101110	46
3	36	100100	3 & 8	100101	37
4	35	100011	4 & 9	100010	34
5	33	100001	5 &10	100101	37
6	31	011111	1 & 6	011110	30
7	30	011110	2 & 7	011011	27
8	29	011101	3 & 8	011100	28
9	26	011010	4 & 9	011011	27
10	13	001101	5 &10	001001	9
11	10	001010	Mutation	001110	14

Table 3: 2nd and 3rd Generation Table

S/N	Selection	Chromosomes (Binary; 0 or 1)			Fitness function
		Parent (2nd Gen)	Crossover	Parent (3rd Gen)	
1	47	101111	1 & 11	101001	41
2	46	101110	2 & 10	101110	46
3	37	100101	3 & 9	100011	35
4	37	100101	4 & 8	100011	35
5	34	100010	5 & 7	100100	36
6	30	011110	Mutation	011100	28
7	28	011100	5 & 7	011010	26
8	27	011011	4 & 8	011101	29
9	27	011011	3 & 9	011101	29
10	14	001110	2 & 10	001110	14
11	9	001001	1 & 11	001111	15

To create our 2nd and 3rd generation from the parents (1st generation) we chose the third bit from the left to be our crossover point. In the 3rd generation each bold bit signifies the cross-over bits, a single bold bit signifies mutation of that bit and an italicized chromosomes signifies elitism. The best third generation (stopping criterion) is that with the best fitness function, 46. This implies that the clusters of the various parameters has been searched and optimized to 0.46. For convenient, we assume the roof value which is 0.50. Therefore combination of parameters which produce a membership function < 0.50 indicate low membership degree while 5.0 and above indicate high membership degree (Table 1).

CONCLUSION

The need to design a system that would assist organizations in general to detect organizational risk and backup with necessary risk management process cannot be over emphasized because organizational success is largely depended on mitigating risk to the minima point within which it can be tolerated within an organization. The practicality of genetic algorithm and fuzzy logic (Genetic-fuzzy system) for operational risk detection and management has been demonstrated by our proposed model, for the recognition of operational risks utilizing a set of fuzzy sets that has been highlighted. This model which uses a set of fuzzified data set incorporated into genetic algorithm system is more precise than the traditional system for recognizing risk. The system designed is an interactive system that tells an organization the current nature of it risk assessment. A system of this nature should be introduced in the Business Sector to ease the job of top-level management in recognizing and managing operational risk.

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