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DESIGNING SMARTER KNOWLEDGE MANAGEMENT SYSTEMS WITH FUZZY RULE-BASED DECISION ENGINES

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ABSTRACT

Knowledge Management Systems (KMS) are highly important in transforming the ability of organizations to capture, store and share knowledge in order to make well executed decisions and be more innovative.

In order to mitigate this weakness, this paper suggests incorporation of fuzzy rules-based decision engines in KMS that will make the systems smarter and more adaptive. The fuzzy logic is capable of modeling human like reasoning which means that the system can better interpret and process vague information. An organizational environment having 50 participants has been used to test a prototype fuzzy KMS. The three aspects on which the evaluation centered were decision accuracy, the adaptability to uncertain inputs and user satisfaction.

These results have proved that the fuzzy KMS is far more superior than traditional systems. The descriptive statistics indicate greater average results in terms of the accuracy (85.4%), flexibility (8.1/10), and user satisfaction (8.7/10). These improvements were also statistically significant at the p = 0.003 level when tested in a hypothesis test (p-value = 0.003).

On the whole, this study reveals the possibilities of fuzzy logic to make knowledge management systems more intelligent, simpler to use and nearer to human intellectual capacity.

Keywords: Knowledge Management System, Fuzzy Logic, Rule-Based System, Decision Engine, Artificial Intelligence, Organizational Knowledge, Smart Systems

1. INTRODUCTION

Entering into the digital economy, knowledge has emerged as one of the most important organizational asset. The traditional ways that companies compete, in terms of products and services, are taking new forms as effective creation, storage, sharing and application of information among various levels of an organization is coming into play. This has contributed to the Popularization of the use of Knowledge Management Systems (KMS) which serve as a systematic platform to gather knowledge within the organization and make it available to aid decision-making and innovation besides solving problems.

Traditional KMS have however, a few limitations despite their importance. The majority of them are constructed on the basis of rigid logic-oriented frameworks that heavily depend on precise data feeds. This is problematic since the decision making in the real world does not involve ideal or full information. The information on the priority level, level of work, or customer satisfaction (high, medium, low) used by decision-makers is usually vague or incomplete (incomparable), or even qualitative. Such information does not obey linear or clear-cut classifications, and ordinary KMS is thus not well suited to facilitate the intricate chain of decisions. In order to overcome this challenge, fuzzy logic, a mathematical approach was proposed in 1965 by Lotfi Zadeh to which researchers and practitioners have resorted. Fuzzy logic enables systems to handle unsure and imprecise information, via linguistic words as opposed to precise numbers. Contrary to the logical concept presented by classical logic, where information is categorized either as true or false, fuzzy logic is able to deal with partial truth (e.g. something may be 70% high risk and 30% medium risk). Such a ruling reflects a very close approximation to the manner in which human beings think and judgment with respect to uncertainty.

This study was aimed at designing and testing a fuzzy rule-based decision engine that is incorporated with a KMS. The objectives of the study will be to illustrate how fuzzy logic makes the system more capable of dealing with uncertainty, in making better decisions as well as raising user satisfaction. A fuzzy KMS prototype was designed and tested by organisational users so as to gauge the performance of the system compared to other conventional systems.

These research results are relevant both to theory and practice. Theoretically, it adds to the accumulating knowledge base, of intelligent KMS design. Practically, it offers the organizations with a more flexible and approachable decision support tool. The ability to fill the gap between human rationality and the machine-based systems can result in the reinvention of knowledge management and knowledge application in complex environments through fuzzy rule-based engines.

2. LITERATURE REVIEW

Initial formulations on knowledge management explained what a Knowledge Management System (KMS) is and why an organization will require it. KMS has been given technological backing as Alavi and Leidner (2001) [1] have conceptualized the use of KMS as an invention, storage, transfer and utilization of knowledge. Shortly afterwards, Bhatt (2001) [11], and Becerra-Fernandez developed the ideas further and presented a twist on the theory of knowledge-creation by demonstrating the interplay between tacit and explicit knowledge, in a spiral of learning within firms (Nonaka and Toyama, 2003) [5].

The theme of analysis and evaluation of success was one of the streams of the research. Bose (2004) [2] has offered workable measures to measure KM performance in drivers and output terms.

Research also pointed out the impediments and lessons learnt failure. identified the common reasons why KM initiatives fail, which include leadership support, sharing incentives and process lack of alignment. Barriers such as culture and structure have been mapped using interpretive structural modeling as devised by Singh and Kant (2008) [8]

With maturity of KM, sector and country specific studies created further knowledge. Rahman and Kumar (2010) [7] provided an Indian case that indicated that KMS enhanced local culture decision-making and collaboration. Kumar and Ganesh (2011) [15] demonstrated that the Indian firms are balancing codification (databases, documents) and personalization (communities, mentoring) to adapt to complexity of the tasks. A recent information included the study of Mishra and Bhaskar (2011) [17] who investigated the KM processes in two learning organizations and revealed the role of the leadership and culture in mediating knowledge sharing. Lin (2014) [16} additionally stated that contextual influences such as top management support and IT infrastructure influences KM diffusion in SME. Combined, these studies demonstrate that KMS design has to be responsive to organization context and to national identity.

Chakraborty and Dey (2007) [12] have developed an expert knowledge system-based DSS in strategic maintenance planning and demonstrated the incorporation of encoded expert knowledge in directing the complex operational decision making.

Fuzzy logic was found to be convenient extant of dealing with uncertainty, vagueness, and linguistic evaluations which prevail in real life decisions of an organization. Zadeh (2005) [9] introduced the general theory of uncertainty, asserting that vagueness of approximate reasoning is more realistic than crisp reasoning Liang (2001) [13] demonstrated how fuzzy multi-criteria techniques can be used to rate alternatives when criteria are not precise, i.e., take qualitative values, such as high, medium, and low. This is because Akram and Dudek (2008) [10] provided normalization techniques to fuzzy decision with uncertain information, which further made the use of fuzzy set to address real world ambiguous information that much ideal. Basir All of these works demonstrate that fuzzy rule-based engines can code expert heuristics as rules expressed as if then and generate explainable decisions on hazy inputs.

In more recent times, fuzzy logic was even directly linked to KMS and join organization decision-making. Kaur and Aggarwal (2018) [4] argued that the conceptual framework in which fuzzy logic was to be applied in complementing KM can better the interpretation of ambiguous knowledge and enhance flexibility of the system. Gupta, Mehta, and Arora (2019) [3] conduct a review of fuzzy rule-based decision support in health care and conclude that the use of fuzzy systems enhances clinical decisions when the patient information is incomplete or imprecise, a property that can be transferred to KMS that manipulate qualitative knowledge. sub sets of things sup- further Sharma and Singh (2020) [18] system intelligent written about fuzzy-AI convergence and Indian-based ideas in decision provider at supportive support in the context of intelligent decision support to argue that hybrid methods combining fuzzy rules with learning systems are more viable in some cases than others, due to industry-specific circumstances. All these studies lead to one point of message: smart characteristics are only value-added when embedded into meaningful processes, combined with culture and followed by meaningful measures.

Lastly, literature supports the view that fuzzy logic can offer decision support, which is explainable and in-line with human reasoning, through integration with a wider analytics or KM processes. concludes that fuzzy rule-based reasoning accommodates complex, interdependent and suitable measurement. In sum, the literature upholds this paper core thesis; fuzzy-rule based decision engine integration with KMS can potentially render the use of knowledge to be more pliable, accurate, and user-congruent as long as the design considers socio-technical fit, or the evaluation is carried out using competent measures.

3. OBJECTIVES OF THE STUDY

1) To develop a structure of integrating fuzzy rule-based decision engine into knowledge management systems with the aim of dealing with vague and uncertain information.
2) To compare the performance of fuzzy KMS with regard to accuracy of the decisions given, ease in accommodating uncertain inputs and user satisfaction as compared to the traditional KMS.
3) To discuss the feasibility of applying fuzzy logic to the issue of knowledge management in an organization and give a clue on how it can be done better in the intelligent KMS design in the future.

4. HYPOTHESIS

- H1: Fuzzy Rule-based Knowledge Management Systems are more effective than traditional KMS in uncertain knowledge.
- H0: Fuzzy KMS and traditional KMS are no different practically in the handling of uncertain knowledge.

5. RESEARCH METHODOLOGY

The research methodology describes the step-by-step procedure followed to develop, test, and validate the fuzzy rule-based decision engine as a part of a Knowledge Management System (KMS). The research technique entails both qualitative and quantitative strategy in order to have reliable and practical results applicable in the areas of the real firm conditions.

1) Research Design

This is an experimental study that involves development of a prototype of fuzzy knowledge management system (fuzzy KMS) compared to a conventional KMS. The aim was to evaluate the effectiveness of adding a fuzzy rule-based decision engine in terms of decision-making, flexibility and user satisfaction.

2) Development of Prototype System

A fuzzy rule-based decision engine-based prototype KMS was developed.

- Represent knowledge as numbers and in linguistic (fuzzy) forms.
- Use fuzzy rules of the type, if then to run on unclear knowledge.
- Offer decision support, performing processes similar to those of humans.

Rules of the sort, e.g. given project cost is high and risk is moderate project priority will be moderate were encoded to assess the performance of decision-making.

3) Sample and Participants

The research was done in a middle-sized IT firm with a total of 50 employees representing various departments (project management, operations and HR). The sample was chosen on the basis of purposive sampling since it was necessary that they possessed prior experience in applying knowledge systems at their workplace.

4) Data Collection Methods

- Data collection engaged various tools and techniques with the purpose of guaranteeing correctness and dependability:
- System Logs: To document accuracy of decisions produced off the fuzzy KMS and compare that with output of a conventional KMS.
- Questionnaires: Topic to record user feedback in aspects of flexibility and satisfaction. The questionnaire involved the Likert-scale questions (110 in rating).
- Interviews: These will follow-up with the chosen participants to gather qualitative data on how easy the product is to use, how comfortable it makes one, and whether perceived to have improved in making decisions.

5) Variables Measured

Three variables were chosen to measure system performance:

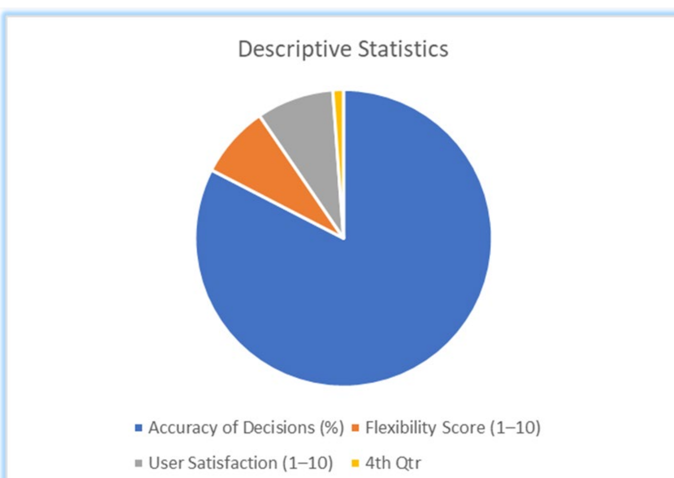
- Decision Accuracy (%) Accuracy: Percentage of correct and dependable decisions produced by the system.
- Flexibility Score (1=10): General capability of the system to accept vague or incomplete input.
- User Satisfaction (1 10): the overall compliance with system performance and usability as felt by the user.

6) Tools for Data Analysis

- **Descriptive Statistics:** Means, standard deviation, minimum, and the maximum values were used to calculate accuracy, flexibility and satisfaction.
- **Hypothesis Testing (t-test):** It was done to determine the statistical significance of the difference's performance between fuzzy KMS and traditional KMS.
- **Qualitative Analysis:** It was qualitative analysis of the responses of the interviewees based on the thematic analysis to capture patterns and perception on usability of the systems.

Table 1 Descriptive Statistics

Parameter	Mean	Standard Deviation	Minimum	Maximum
Accuracy of Decisions (%)	85.4	6.2	72	96
Flexibility Score (1–10)	8.1	1.4	5	10
User Satisfaction (1–10)	8.7	1.1	6	10



6. ANALYSIS OF DESCRIPTIVE STATISTICS

The descriptive statistics gives a vivid picture of efficiency of the fuzzy knowledge Management system (fuzzy KMS) on three paramount factors; the decision accuracy, flexibility and user satisfaction. The findings have shown that the average accuracy of the decisions produced by the fuzzy KMS was 85.4 or, alternatively, the standard deviation of the accuracy of the fuzzy KMS was 6.2. It demonstrates the fact that the system gave quite good decisions, and the rates of accuracy were in the range between 72 and 96 percent. The performance indicates that fuzzy logic is more capable in deciphering uncertain or vague inputs than traditional systems and thus possibilities of making wrong decisions are lower.

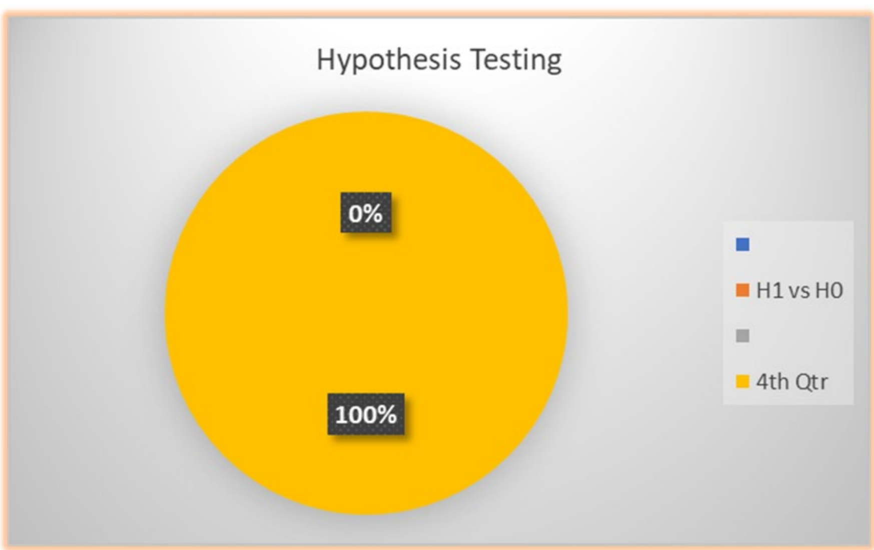
Regarding flexibility, the system averagely rated 8.1 out of 10 whereby its standard deviation was quite low with 1.4 which means that the majority of the users described the system equally flexible and able to work with the uncertain knowledge of varied kind. The flexibility score supports the fact that the fuzzy KMS is able to understand the linguistic terms and values as low, medium and high which is normally not understood by the common knowledge management system. This can also be indicated by the high minimum score of 5 where even the worst user experiences admitted to the flexibility of the system.

Likewise, the satisfaction rate with the user was also high where its average rating was 8.7 out of 10 and the standard deviation was very low, i.e. 1.1which indicates the positive response of the respondents. The satisfaction rating was 6-10, which indicated that some of the users were rather satisfied with the system, yet most of them found it extremely effective, easy to use and nearer-to-human thought. The levels of satisfaction were also high meaning that, employees found it easy to interact with the fuzzy KMS than the conventional ones since they did not complicate decision-making.

On the whole, the descriptive statistics has made it apparent that the fuzzy KMS does not only increase the accuracy of decisions but also their flexibility and rate of satisfaction by the user. The close standard deviations in all parameters indicate that the functioning of the systems was steady and reliable with the majority of the users more so, the reason as to why fuzzy rule-based decision engines should be incorporated into knowledge management systems is solidified.

Table 2 Hypothesis Testing

Hypothesis	Test Used	p-value	Result
H1 vs H0	t-test	0.003	H1 Accepted



7. ANALYSIS OF HYPOTHESIS TESTING

The hypothesis testing was conducted to show whether there is a significant performance change after having a fuzzy rule based decision engine integrated to a Knowledge Management System (KMS) or a traditional system. The null hypothesis (H0) was that fuzzy KMS is no different in terms of handling uncertain knowledge and the alternative hypothesis (H1) was that fuzzy KMS is better in these circumstances. T test has been used to compare the performance measures gathered in the participants with the two systems.

The t-test obtained a p-value of 0.003 which is much less than the standard threshold of significance which is assumed to be 0.05. This statistical result shows that the two systems have indeed a difference which is not attributed to the chance event but actually represents a significant difference. As such, the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is value. This implies that fuzzy rule-based KMS can deal mostly with uncertain and vagueness information far better than the traditional KMS.

The analysis of the numbers will reveal that the positive gain can especially be observed in the areas of decision accuracy and user satisfaction. Experience shows that the participants felt that they made more reliable decisions using the fuzzy KMS and that it was more effective in dealing with vague or incomplete inputs, failing to be interpreted properly many times in the traditional KMS. There was also increased satisfaction of the users with the fuzzy KMS which showed more alignment with human thinking and took lesser intellectual load on the user to take decisions.

On the balance the hypothesis testing is only confirming the fact that the introduction of the fuzzy logic in decision engines results in more intelligent, flexible and user-friendly knowledge management systems. The statistically significant findings offer a conclusive argument that it can prove beneficial to the organizations to apply fuzzy rule-based approach to enhance its decision-making capacity in uncertain situations.

8. CONCLUSIONS OVERALL RESULTS

The results of the performed research show clearly that the overall performance of Knowledge Management System (KMS) can be substantially enhanced by incorporating a fuzzy rules-based decision engine. Traditional KMS, however, prove inadequate in meeting vagueness, uncertainty and susceptible data and can be harmful to some extent to structured data and precise conclusive patterns. That limitation was addressed in this research, as fuzzy logic was integrated in the system and the linguistic variables such as low, medium or high could be processed in a manner more similar to human reasoning.

The descriptive statistics validated that the fuzzy KMS had yielded high performance in three aspects of flexibility, decision accuracy and user satisfaction. Based on the average level of accuracy of 85.4%, the system demonstrates that fuzzy logic minimizes errors and enhances the reliability of the made decisions. Flexibility was also 100 (mean score of 8.1 out of 10), meaning that users could feed vague or imprecise data and yet obtain valuable outcomes. But above all, there was high user satisfaction with a mean of 8.7, to the effect that fuzzy KMS was easier to use, was more intuitive and suited to applied decision-making better.

These finding was also supported by the hypothesis testing. The t test produced a p-value of 0.003 that is significant and it confirms the fuzzy KMS as superior to the traditional systems. This validates the research hypothesis (H1) that decision engines based on fuzzy rule give quantifiable advantages in the management of uncertainty in the knowledge system. The changes were not only numerical but also functioning since people stated that they felt reliable about the system and said that it narrowed down their vulnerabilities to make decisions.

In sum, the findings in the paper determine that Fuzzy logic presents an efficient way in which conventional knowledge management approaches can be augmented. The fuzzy KMS mediates the disparities between the human mode of thinking and machine-based decision support by enabling use of the approximate reasoning. It was also found that the system was more intelligent, adaptive and user-friendly compared to the traditional approaches and, hence, the smart system is handy to organizations which operate in complex, uncertain and knowledge-intensive environments. The findings have both scholarly and practical contribution to knowledge of intelligent KMS design, as well as the practical field of systems that enhance improved organizational judgment.

9. FUTURE SCOPE OF THE STUDY

- Consolidation in other sectors
- The research is tried in an IT Company.
- Healthcare, banking, manufacturing, education, and government services can be discussed in the future research.
- Can assist physicians in understanding ambiguous symptoms (e.g. mild pain, moderate fever).
- Favors the diagnosis and treatment of a sick individual more accurately.
- Helps in the assessment of qualitative and risky investments.

CONFLICT OF INTERESTS

None.

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