

Qualitative Model for Identifying Leadership Using Fuzzy Logic

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Abstract

When humans are born, there are some things that they do by instinct, and there are some other things that they have to learn to do. Management and leadership have become over the years the critical ingredient in organizational theory and practice. In the present, globally competitive environment, effective leadership style is necessary to reduce the attrition rate. From the effective leadership style it is possible to achieve organizational goals effecting the employee performance and productivity. This study explores the nature of leadership styles using Fuzzy Logic, which prioritizes the effective leader by considering various selection criteria for managing risk. Fuzzy logic is a practical and useful tool for Multi-Criteria Decision Making (MCDM), which provides the foundation for making such evaluations.

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1. Introduction

Leadership development is vital because leadership training and development can maximize productivity, shape a positive culture and promote harmony. Leadership is never easy. No matter how effortlessly some leaders appear to manage, the path of a leader is one fraught with constant challenge and surprise. However, the leader does not face the challenge alone. By definition, a leader has a group or organization working to meet each challenge and achieve each goal. The leader's job is not to solve every problem alone, but to inspire those he or she leads to

solving the problems. Good leaders recognize that they do not have all the answers and are constantly reeducating themselves on their businesses and sharpening their leadership skills. Beyond personal qualities such as vision and positive thought, a leader must also take careful steps to communicate with his or her staff in the best way possible. With effective leadership, all participants within the organization are confident someone they know is working towards the greater good, both on their behalf personally and that of the company, as well as the larger impact created by the specific product or service. And within this system, one of the most critical elements to success is a leader in whom they can place their trust. That's because true leadership is about taking people to the places they would not or could not go on their own. And achieving that level of loyalty and dedication is next to impossible without the genuine allegiance inspired by true leadership skills.

As leadership is a human quality it is not easy to select the best leader. If a man is hard working honest and good decision maker it is not necessary that he will be a good leader.

In this research, authors have studied some human quality and developed rules in fuzzy logic toolbox using MATLAB. The selected criteria can be changed with purpose.

2. Literature Review

Leadership is a social influence process in which the leader seeks the voluntary participation of subordinates in an effort to reach organization goals [1]. A leader can be defined as a person who delegates or influencing others to act so as to carry out specified objectives [2]. Leadership is a process by which one person influences the thoughts, attitudes, and behaviors of others. In most organizations, one associates high levels of leadership with high levels of authority. The chief executive of a company usually plays more of a leadership role than people at lower levels of the hierarchy in the firm. It is the same in not for-profits and government agencies. The higher on the job ladder a person is, the more is expected to exhibit leadership [1]. Running an organization effectively requires administration, management, and leadership. Leadership is ordinarily in shorter supply than administrative or managerial competence. Leadership is more important and more demanding for most people. Fewer people are able or willing

to be leaders, so it tends to be a higher calling than administration or management. There is a large literature discussing the differences between leaders and managers. There is also an important distinction to make between leaders and administrators. In general, a leader takes a broader view and points an organization toward necessary, even critical change [3].

Early analyses of leadership, from the 1900s to the 1950s, differentiated between leader and follower characteristics. Finding that no single trait or combination of traits fully explained leaders' abilities, researchers then began to examine the influence of the situation on leaders' skills and behaviors. Subsequent leadership studies attempted to distinguish effective from non-effective leaders. These studies attempted to determine which leadership behaviors were exemplified by effective leaders. To understand what contributed to making leaders effective, researchers used the contingency model in examining the connection between personal traits, situational variables, and leader effectiveness. Leadership studies of the 1970s and 1980s once again focused on the individual characteristics of leaders which influence their effectiveness and the success of their organizations. The investigations led to the conclusion that leaders and leadership are crucial but complex components of organizations [2]. In order to understand the development of authentic leadership as a construct it is helpful to understand how the study of leadership in general has developed over the last several decades. Leadership is a challenging topic of study due to the complex nature of the concept and near impossibility of studying it in a clinical setting. Prior to the late 1970s leadership research had produced little useful output despite numerous research efforts. The legitimacy of the topic of leadership as a scholarly study was even questioned by scholars [4]. Until that time, leadership in the workplace was largely focused on a transactional model. Since the Industrial Revolution, the workforce was largely composed of individuals performing repetitive tasks. Such work lends itself to transactional leadership since that style utilizes exchanges of tangible rewards for work and loyalty. As will be discussed later in this review of literature, tangible rewards are uses of extrinsic motivation which has been shown to work well in motivating people to perform routine tasks such as assembly line work. This lack of viable leadership research shifted in the mid 1980's as a new leadership model arrived on the research scene. Lloyd-Walker and Walker propose that leadership can be divided into one of three categories: non-leadership (hands-off approach),

transactional leadership (give and take between leaders and followers), and transformational (leader attains organization's goals by inspiring followers) [5].

Since that time numerous transformational leadership theories have been proposed and studied including the closely related concepts of servant leadership [6] which prioritizes the needs of followers and results in leaders deemphasizing their own glory and demonstrating high moral standards, and authentic leadership [7]. Transformational leaders engage followers and energize employees by appealing to higher ordeals and morals. Transformational leaders offer purpose by communicating the significance of the work at hand. Such leaders also offer encouragement to place the good of the team as paramount. One of the main functions of a transformational leader is to offer hope and optimism to their followers. As Ralph Waldo Emerson says "Nothing great was ever achieved without enthusiasm," and transformational leaders realize these all transformational leadership styles are considered to be positive forms of leadership which use rewards, education, incentives and encouragement to lead as compared to negative leadership styles which utilize penalties with greater frequency. Transactional leadership may still be appropriate for highly operational environments but is not suitable for knowledge-workers [8].

Transformational leadership became the preferred theory for knowledge workers toward the end of the 20th century as the workforce shifted toward knowledge workers who needed to come up with creative solutions to complex problems. Authentic leadership grew out of attempts to add an ethical component to transformational leadership at the start of the 21st century. Although the majority of transformational leadership theories were antecedent to the development of authentic leadership, authentic leadership is considered by some to be the root construct of these other theories of leadership [9]. As George et al. explains, there is an inherent difficulty in defining any leadership style because a specific trait-like definition is not flexible enough to encompass all situations [10]. George goes on to say that if there was one specific "cookie cutter leadership style, individuals...would make themselves into personae, not people, and others would see through them immediately". In other words, if there was a formula that people could follow to lead others, it would remove the authenticity of their leadership which many authors believe is so crucial to leading effectively [10]. Findings from both the literature and the major incident analysis suggest that leaders should

pay attention to the importance of open and trusting safety communications with the workforce. Leader behaviors as well as the quality of relationships that they develop with employees are crucial for developing trust and promoting open safety communications. Leaders can influence the extent to which employees will communicate safety issues and concerns by developing good working relationships characterized by openness, support and mutual respect [11]. Many discussions of leadership involve all the above—personality, important objectives, formal position, specific behaviors—with leadership [12]. But leadership is more than any of the above characteristics. It's a process by which one influences the thoughts and behaviors of others in a substantial way. It may involve charisma, important objectives, a formal position, and a particular set of behaviors, but it is not limited to any of them. Effective leaders are often very complex people. Karwowski and Evans identify the potential applications of fuzzy set theory to the following areas of Industrial Engineering: new product development, facilities location and layout, production scheduling and control, inventory management, quality and cost benefit analysis [13]. In their book, Evans et al. combined contributions from world renowned experts on the various topics covered such as: traditional IE techniques; ergonomics; safety engineering; human performance measurement; man, machine systems and fuzzy methodologies [14]. Klir and Yuan and Zimmermann reviewed the applications of fuzzy set theory and fuzzy logic [15]. A rational approach toward decision-making should take into account human subjectivity, rather than employing only objective probability measures. This attitude towards the uncertainty of human behavior led to the study of a relatively new decision analysis field: Fuzzy decision-making. Fuzzy systems are suitable for uncertain or approximate reasoning, especially for the system with a mathematical model that is difficult to derive. Fuzzy logic allows decision-making with estimated values under incomplete or uncertain information. A major contribution of fuzzy set theory is its capability of representing vague data. Fuzzy set theory has been used to model systems that are hard to define precisely. As a methodology, fuzzy set theory incorporates imprecision and subjectivity into the model formulation and solution process. Fuzzy set theory represents an attractive tool to aid research in industrial engineering (IE) when the dynamics of the decision environment limit the specification of model objectives, constraints and the precise measurement of model parameters.

Selecting the best Leader highly affects the stability and economy of industrial firms. Evaluating leader's suitability for a job is an important tool for Human Resources Managers (HRMs) to select the better candidates under various evaluation criteria. This paper introduces a fuzzy model in decision competition making for selecting the best technician in any firm or organization. Selected leader must fulfill the machining as well as the human requirement skills. Many of these attributes are of high level of vagueness and imprecision especially in concern with the human psychology. Due to the lack of complete information, uncertainty, and a high level of vagueness and imprecision for technician ranking in any opportunity, a technique to perform selection calculations on imprecise representations of parameters is presented. In this paper, linguistic terms and triangular fuzzy numbers describe decision makers' opinions. A new algorithm is developed based on fuzzy measures to deal with such types of ranking problems. Determining and quantifying the skills required to be an effective leader is a complex task. Many human attributes are correlated to each other in order to find a crisp output. Human assumptions and traditional methods to find leadership quality might not be accurate. Thus, it is very important to find a logical approach to select a leader. This research has accommodated the Fuzzy Reasoning Approach (FRA) to quantify the leadership qualities.

3. Leadership Quality Assessment and Selection

Leadership depends on many human attributes and qualities. Business leaders serve a range of important functions in their organizations. Leaders are responsible for training employees to perform their tasks effectively, as well as supervising the actual completion of those tasks on a regular basis. Appropriate standards should be set in order to quantify a good leadership quality. However, there are some qualities which hinder overall leadership ability. Poor leadership can have several negative effects on the company and staff. Considering the negative leadership quality will result in more accurate and practical outputs. Though leadership qualities have evaluated in numerous ways over the years, six major qualities are set for this work based on elaborate research. The leadership qualities taken under consideration are:

1. Decision Making Capability
2. Intercommunication Skill

3. Motivational Power
4. Teamwork Capability
5. Arrogance
6. Dishonesty

4. Concept of Fuzzy Set

Fuzzy sets serve as a means of representing and manipulating data that was not precise, but rather fuzzy. There is a strong relationship between *Boolean* logic and the concept of a subset, there is a similar strong relationship also between fuzzy logic and fuzzy subset theory. In classical set theory, a subset A of a set X can be defined by its characteristic function $\chi(A)$ as a mapping from the elements of X to the elements of the set $\{0, 1\}$

$$\chi(A): X \rightarrow \{0, 1\}$$

This mapping may be represented as a set of ordered pairs, with exactly one ordered pair present for each element of X. The first element of the ordered pair is an element of the set X, and the second element is an element of the set $\{0, 1\}$. The value zero is used to represent non-membership, and the value one is used to represent membership.

In an analogous way a fuzzy subset A of X can be represented as the set of ordered pairs $\{(x, \mu(x)): x \in X\}$, where $\mu: X \rightarrow [0, 1]$ is its membership function that may take infinite values in the interval $[0, 1]$.

A fuzzy number is a special form of a fuzzy subset of the set of the real numbers. In particular, a Triangular Fuzzy Number (TFN) (a, b, c) , where a, b and c are real numbers such that $a < b < c$ is a fuzzy subset of the real numbers with membership function

$$\mu(x) = \begin{cases} 0 & \text{if } x < a \\ (x-a)/(b-a) & \text{if } a \leq x \leq b \\ (c-x)/(c-b) & \text{if } b \leq x \leq c \\ 0 & \text{if } x > c \end{cases}$$

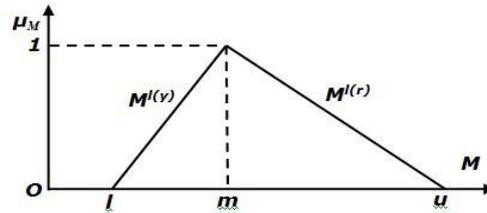


Figure 1: Graph of the TFN (1, m, u)

The fuzzy addition and fuzzy subtraction of any two TFN are also TFNs, but the multiplication of any two TFNs is a fuzzy number, but not a TFN in general. More explicitly, ff $M_1 = (a_1, b_1, c_1)$ and $M_2 = (a_2, b_2, c_2)$ are two TFNs, then their operational laws can be expressed as follows:

$$M_1 + M_2 = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$$

$$M_1 - M_2 = (a_1 - c_2, b_1 - b_2, c_1 - a_2)$$

$$M_1 * M_2 = (a_1 a_2, b_1 b_2, c_1 c_2), \text{ when } a_1, b_1, c_1, a_2, b_2, c_2 > 0 \text{ (approximate operation)}$$

$$\lambda * M_1 = (\lambda a_1, \lambda b_1, \lambda c_1), \text{ where } \lambda > 0, \lambda \in \mathbb{R}$$

4.1 Fuzzy Inference System

Fuzzy inference system is also known as fuzzy rule-based system, fuzzy models, fuzzy associative memories (FAM), or fuzzy controllers when used as controllers. Basically, a fuzzy inference system is composed of five functional blocks as shown in Figure 2.

- A rule base
- A database which defines the membership functions
- A decision-making unit which performs the inference
- A fuzzification interface which transforms the crisp inputs
- A defuzzification interface which transform the fuzzy

Usually, the rule base and the database are jointly referred to as the **knowledge base**

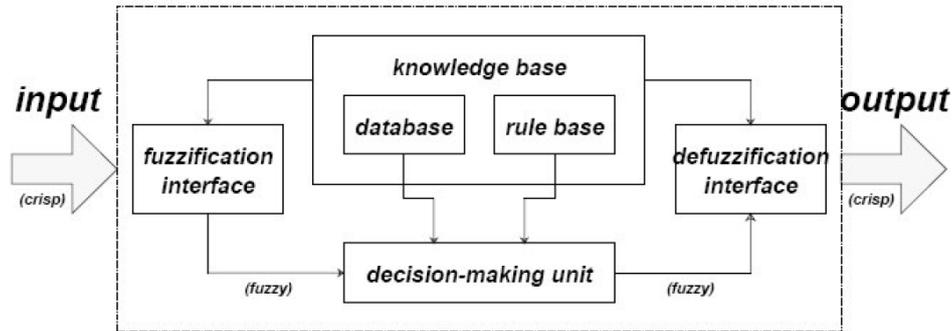


Figure 2: Fuzzy Inference System

There are three main types of fuzzy reasoning models available in literature, the Madmani fuzzy model, the Sugeno fuzzy model (TSK model) and Tsukamoto fuzzy model. The first two models are the most widely used. In ANFIS models Sugeno model is used widely because its rules are tunable based on input parameters.

5. Research Methodology

Here, the methodology involves the selection of a suitable leader or a department from a number of candidates. The selection process based on multiple criteria. Those criteria were identified from a rigorous study and based on the facts which are most critical for the selection of a leader. The approach is based on the nonlinear dependencies' identification by fuzzy knowledge bases. In the proposed study the research will be confined to basic human effecting the leadership and simple modeling of the solution.

Proposed model will be like this:

Six inputs $P_1(x)$, $P_2(x)$, $P_3(x)$, $P_4(x)$, $P_5(x)$, $P_6(x)$ and the single output is $Q(x)$

Where:

$P_1(x)$ is Decision making capability, i.e. the ability of a leader to take quick, accurate and proper steps to achieve the team goals.

$P_2(x)$ is Intercommunication skill, i.e. the behavior of the leader with his co-workers or team mates.

$P_3(x)$ is Motivational power, i.e. this indicates how much a leader is capable to positively encourage his people to perform more for the team or company.

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$P_4(x)$ is Team work capability, i.e. it is very crucial that a leader should give priority to become a team man and to set goals according to the company's need rather than his own requirements. It also includes the tolerance to other opinions.

$P_5(x)$ is Arrogance, i.e. how much a leader's rudeness and stubbornness with the team mates. It is actually a negative term the more a person is arrogant the less he is capable of a good leadership quality.

$P_6(x)$ is Dishonesty, to determine the ability of a leader to remain unbiased and truthful at any situation.

$Q(X)$ is the output of the leadership which will show the effect of all the criteria that has been set to find out the appropriate leader.

All six input variables are used to identify the leadership capability of a candidate and all of them have three divisions- High, Medium, Low.

Now output $Q(x)$ categories will be like this:

Table 1: Leadership categories

Categories	Symbol
Low	S_1
Medium	S_2
High	S_3

Decision making capability vs Intercommunication skill:

While identifying the output by only considering Decision making capability (D.M.C) and Intercommunication skill (I.S.) the other inputs are considered as follows:

Motivational power – High

Team work capability- High

Arrogance – Low

Dishonesty –Low

Table 2: Output table for Decision making capability vs Intercommunication

Decision making capability	Low Intercommunication skill	Medium Intercommunication skill	High Intercommunication skill
Low	S ₁	S ₁	S ₂
Medium	S ₂	S ₂	S ₃
High	S ₂	S ₃	S ₃

Motivational Power vs Teamwork Capability:

Decision making capability- High

Intercommunication skill –Medium

Arrogance –Low

Dishonesty –Low

Table 3: Output table for Motivational power vs Team work

Motivational power	Low Team work	Medium Team work	High Team work
Low	S ₁	S ₁	S ₂
Medium	S ₁	S ₂	S ₃
High	S ₂	S ₃	S ₃

Team work vs Arrogance:

Decision making capability-High

Inter communication Skill –High

Motivational power –High

Dishonesty –Low

Table 4: Output table for Teamwork vs Arrogance

Team Work	Low Arrogance	Medium Arrogance	High Arrogance
Low	S ₂	S ₁	S ₁
Medium	S ₃	S ₂	S ₁
High	S ₃	S ₂	S ₂

Motivation power vs Dishonesty:

Decision making capability –Medium

Intercommunication skill – High

Team work capability-High
Arrogance- medium

Table 5: Output table for Motivational power vs Dishonesty

Motivation power	Low Dishonesty	Medium Dishonesty	High Dishonesty
Low	S ₂	S ₁	S ₁
Medium	S ₂	S ₂	S ₁
High	S ₃	S ₂	S ₂

6. Application of the model

6.1 Company Profile

As this model is applicable for any company with organizing structures; authors went for hypothetical data to establish the model. Any H.R. department is capable to provide information that has been used this section. So, a general approach has been taken rather than any specific company or project. Some adjustment might be needed to apply it for any particular sector, but the basic approach will remain same.

6.2 Data Collection

To promote a candidate in the head's position, the system requires some past data about the candidate. The data collection is needed to be elaborate in order to get an accurate result. Data that has been collected from R&D department or H.R. department has been placed in the range of 0-100 i.e. in Likert Scale. This range of scale has been applied for all the inputs i.e. decision-making capability, intercommunication skill, motivation power, teamwork capability, arrogance and dishonesty. Available theoretical data converted into numerical values using Likert scale for identifying leadership are shown in below table 6-10.

Table 6: Data for Candidate -1

Decision making capability	Intercommunication skill	Motivational power	Team work capabilities	Arrogance	Dishonesty
60	70	30	50	20	20

Table 7: Data for Candidate-2:

Decision making capability	Intercommunication skill	Motivational power	Team work capabilities	Arrogance	Dishonesty
80	90	70	80	50	55

Table 8: Data for Candidate-3

Decision making capability	Intercommunication skill	Motivational power	Team work capabilities	Arrogance	Dishonesty
50	50	60	40	30	30

Table 9: Data for Candidate-4

Decision making capability	Intercommunication skill	Motivational power	Team work capabilities	Arrogance	Dishonesty
20	40	10	50	20	40

Table 10: Data for Candidate-5

Decision making capability	Intercommunication skill	Motivational power	Team work capabilities	Arrogance	Dishonesty
50	90	60	30	10	05

7. Proposed Model for Leader Selection

7.1 Range

- i. Literally, Range defines the space within which all the membership functions lie. In our model, authors have used different inputs and at the same time they have classified each and every input in different sub criteria. Each criterion has been represented by one membership function. To materialize this, most general conditions are used.
- ii. It can be a company policy that, the company divides its inputs in more categories than those displayed in our model based on economic value. In that

case numbers of categories and also number of subcategories can also be increased.

- iii. The input categories are set as simple as can be. One of the major objectives of our study is to offer a more user-friendly system for the users. That's why concentration has been given on simplicity.
- iv. Ranges for the membership functions broadly for the inputs are determined based on the assumption and also based on our little and limited expertise.

7.2 Rule Generation

In this proposed model, six input variables have been used to find the best leader. All the six variables have 3 divisions. So, the total number of rules in this model is $3 \times 3 \times 3 \times 3 \times 3 \times 3 = 729$. Here all the rules were generated by the If-Then rules generator in MATLAB. Generation of rule is very important for the output. For instance, **If Decision** making capability is **high**, Intercommunication skill is **high**, and Motivation power is **high**. Team work capability is **high**, Arrogance is **low**, Dishonesty is **low** then Leadership is **high**. In rule generation, the weight used is 1. This means all the rules generated has equal importance and every input variable has equal impotence. All 729 rules were taken into consideration to find the appropriate leader.

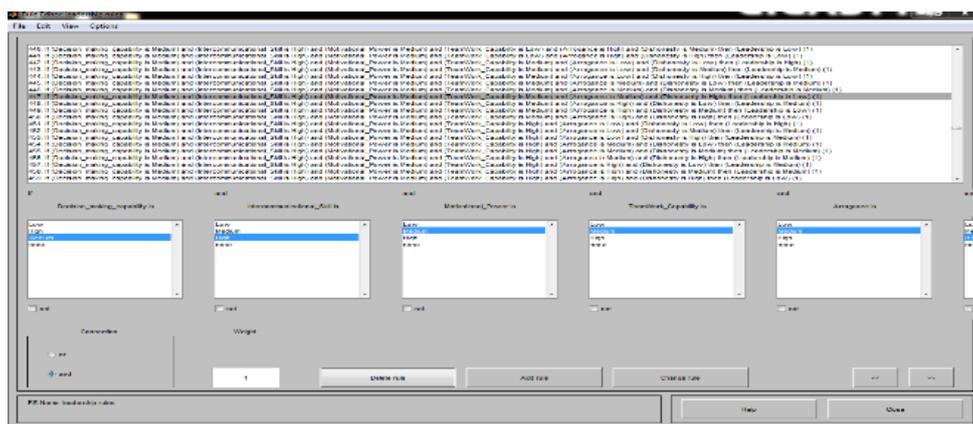


Figure 3: Rule Viewer in MATLAB

8. Result and Findings

In this section, leadership capabilities have been determined based on multi criteria decision making (MCDM) process for selected candidates. To determine the ranking, Fuzzy toolbox of MATLAB software has been used. Finally, the

most promising candidate for leadership capability has been selected based on final score.

It is clear from table 11 that the most suitable candidate for selecting leader is “Candidate 5” because he has the highest output score 64.6.

Table 11: Selection of the Best Candidate for Leadership Based on MCDM

Candidate No	Decision making capabilities	Intercommunication skill	Motivation Power	Team work capability	Arrogance	Dishonesty	Final Score
1	60	70	30	50	20	20	57.6
2	80	90	70	80	50	55	53.2
3	50	50	60	40	30	30	50
4	20	40	10	50	20	40	34.9
5	50	90	60	30	10	05	64.6

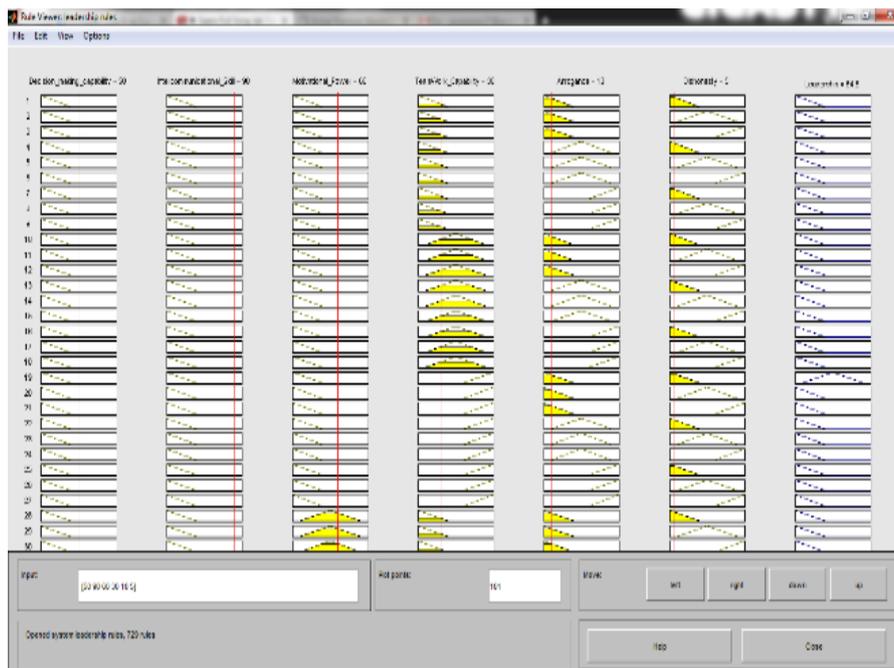


Figure 4: Best Candidate for Selection

9. Conclusion

Identification of leadership ability from the employees is a tough work for most of the companies. The company might not have sufficient information to select leaders and many companies use their past experiences to decide about such complex situation. Managers need to monitor the performance of the employees with an easy to use, dependable and applicable method. Therefore, fuzzy logic

was used to identify leadership as fuzzy logic facilitates the selection process by making it credible and accurate. In this study only six key qualities were taken into account but in real life there are many more qualities like these. So, more input variables could have been considered. Since the output mainly depends on the rules as well as on the data set collected, so the data should be collected with great care. Moreover, there are some criteria for which data have to be collected on Likert scale and for this reason proper judgment is must. Therefore, this fact should be considered while collecting the data and expertise should be given priority as much as possible.

By using the same number of outputs, the output can be evaluated with the Fuzzy Analytical Hierarchy Process (FAHP). Then, this output can be compared with that obtained in the fuzzy model.

References

- [1] B. Omolayo, "Effect of Leadership Style on Job-Related Tension and Psychological Sense of Community in Work Organizations: A Case Study of Four Organizations in Lagos," *Bangladesh e-Journal Sociol.*, vol. 4, no. 2, pp. 30–37, 2007.
- [2] B. Osayawe, E. Regina, and C. Akpan, "Roles of perceived leadership styles and rewards in the practice of total quality management," 2006.
- [3] L. A. Zadeh, "Outline of a New Approach to the Analysis of Complex Systems and Decision Processes," no. 1, pp. 28–44, 1973.
- [4] K. Klenke and S. B. Breathnach, "Authentic Leadership : A Self , Leader , and Spiritual Identity Perspective," vol. 3, no. Ldi, pp. 68–97, 1999.
- [5] J. Harding, *of Type-2 Fuzzy Sets on the Unit Interval* . .
- [6] L. Spears, "Reflections on Robert K . Greenleaf and servant-leadership," 2009.
- [7] F. O. Walumbwa, B. J. Avolio, W. L. Gardner, T. S. Wernsing, and S. J. Peterson, "Authentic Leadership : Development and Validation of a Theory-Based Measure †," vol. 34, no. 1, pp. 89–126, 2008.
- [8] B. Lloyd-walker and D. Walker, "Authentic leadership for 21st century project delivery," *JPMA*, vol. 29, no. 4, pp. 383–395, 2011.
- [9] W. L. G. T, B. J. Avolio, F. Luthans, D. R. May, and F. Walumbwa, "b Can you see the real me ? Q A self-based model of authentic leader and follower

- development,” vol. 16, pp. 343–372, 2005.
- [10] J. M. George, “Human Relations,” 2000.
- [11] N. Healey, “A review of the literature on effective leadership behaviours for safety RR952 A review of the literature on effective leadership behaviours for safety.”
- [12] J. P. Kotter, *What Leaders Really Do*, Boston: Harvard Business School Press, 1999)
- [13] F. Klawonn and D. Braunschweig, “Fuzzy Sets and Vague Environments 1 Introduction 2 Vague Environments,” pp. 1–22.
- [14] M. Hellmann, “Fuzzy Logic Introduction,” no. 1, 1965.
- [15] H. Zimmermann, “An application-oriented view of modeling uncertainty,” vol. 122, pp. 190–198, 2000.