A Security System and Employees Performance Evaluation Using RFID Sensors and Fuzzy Logic

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***Abstract*—This paper introduces an efficient security system that, not only prevents intruders from being in unauthorized places, but also evaluates the performance of the employees by monitoring their movements in the facility and analyzing their behavior using the fuzzy logic theory. Rules were constructed using Mamdani fuzzy modeling and the design is made using the MATLAB fuzzy logic tool. The security system is extended to include employee performance evaluation. This paper was made for a machining workshop and the approach was setup using the data submitted from that workshop to determine the effective working hours that a worker actually makes. The salary is paid for the time the employee spends in his department working under the supervision of his supervisor. The employee is paid also to work in other departments for some time according to his work credibility and the relation of this department with his original department. The access of the employee to any department is monitored by IR and RFID sensors for security reasons and for the fuzzy evaluation of his performance. The base station is provided by a microcontroller to analyze the data obtained from the related stations. Fuzzy logic is used to determine for each employee the allowed time he can spend outside his original department.**

Keywords- ***Performance evaluation,Identification,Security system, Fuzzy logic, RFID sensors.***

I. INTRODUCTION

This paper introduces an automated security system which is designed to prevent intruders from breaking into the facility. The system is extended to trace the employees' movement, so an evaluation of their performance is given instantly and continuously. Any movement will be recorded at the main-gate or at any sub-gates, which will be considered as checking points, and referred to as stations. A station is responsible for the detection, identification and sending data to a base station which will be responsible for tracking and analyzing the events.

Decisions regarding the time allowed of the employee outside their departments are made by combining the data from the stations and the base station. Figure (1) represents the whole system which consists of several stations controlled by a base station.

Radio Frequency Identification (RFID) sensors are used to perform the detection, identification processing while the tracking, analysis and decision making are made by using micro controllers or a micro-computer. The channel is simple wires for short distances but for longer distances Ethernet modules can be used.

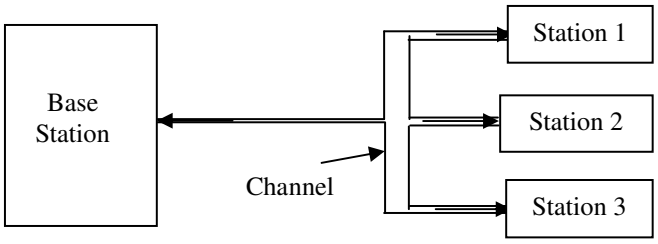

Figure (1) A block diagram of the system showing 3-stations with a base station

A station consists of IR sensors, RFID reader and a micro controller. The base station includes of a microcontroller with high capabilities. Each employee is given a unique identity number. Anyone crossing a station will be recognized by two successive IR detectors as well as a RFID reader. The security system recognizes each movement (entering \ exiting) and records it, if the employee is authorized to enter this department. Modeling is made using fuzzy logic. There are many reasons to use fuzzy control but the most important is that this system is dealing with people who are not machines. They do not only differ from machines but from the other hand, their behavior is characterized by being undetermined and rather fuzzy. That would lead to highly non-linear relations which make fuzzy logic the most appropriate to be used. So, as human actions and behaviors are not specific on the contrary they may vary from one person to another, the fuzzy modeling was the apt to deal and characterize the problem. The term monitoring the employees is used, not watching them, because employees' actions are not restricted. Employees have to work in a comfort environment to make them give their best efforts, but at the same time a complete idea how employees are spending their working time is needed.

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Modeling was made using 4-inputs to the system and these inputs are formed as function sets of the fuzzy logic.

1) Working times: it is found that employees tend to go from their department to other departments in some specific times, when employees are permitted to exchange work.

2) Rank of the employee: not all employees are permitted to spend more time or even be in other departments but some employees are permitted to be more than others according to their rank.

3) Relation between different departments: not any employee of any department can enter any other department but departments may be categorized as related departments so employee of department 'A' can enter department 'B' for some specific time while he can enter department 'C' for another specific time.

4) Credibility of the employee: each employee has some credibility according to the last 3-annual reports made by his direct manager.

The output is given as the permitted allowable time for that employee to spend in that department. It is the time which will be counted for that employee as working time outside his department.

A section is devoted to review the related work regarding the employee evaluation system as well as fuzzy sets. Then the method for calculating the working time permitted for each employee outside his department is given. Results and appropriate conclusions are then driven.

II. RELATED WORK

The described application uses fuzzy sets to extend an automatic access system based on RFID sensors to include employees' performance evaluation. Thus, it seems in order to discuss the fuzzy sets as well as the employees' evaluation systems. The previous contributions are accounted for in the section dedicated to the employee evaluation system.

A. Employee Evaluation System

The evaluation system is vital in any organization and affects prosperity. An extreme attention and care must be paid as it works as a fair system inside that organization which will affect strongly upon the employee's allegiance and loyalty toward his work [1]. Many approaches were made to create successful and fair systems. One of the approaches uses experimental and statistical techniques. In the experimental approach the selection is made depending on how much the decision-maker can figure out the specification of a job, while the statistical approach tests scores candidates made to quantify their achievements [2].

Advanced approaches depend on the Analytical Hierarchy Process AHP which is very complex but would give good results. AHP is a powerful and flexible decision-making process to assist people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. By reducing complex decisions to a series of comparison pairs, then synthesizing the results. AHP, not only helps decision makers arrive at the best decision, but also provides a clear rationale for the decision. Designed to reflect the way people actually think, AHP continues to be the most highly regarded and widely used decision-making theory [3]. An analytical way to reach the best decision is more preferable in many business platforms when variables are quantitative and, the number of criteria is not high. However, beside the measurable variables, there exist qualitative variables; thus, an analytical way to make a successful decision is needed. Fuzzy AHP is a synthetic extension of the classical AHP method when the fuzziness of the decisions is considered. The other contemporary methods in the employee evaluation and selection are artificial intelligence techniques that are the fuzzy sets and neural networks. Lazarevic [4] presented a two-level employee selection fuzzy model to minimize subjective judgment in the process of distinguishing between an appropriate and inappropriate employee for a job position. [5][6].

B. Fuzzy Sets

Fuzzy sets were particularly designed to mathematically represent fuzziness and vagueness, and to provide the fundamental concept for handling the imprecision intrinsic to the problems of subjective evaluation and measurement [7]. Fuzzy set is based on possibility instead of probability [8] – [12]. A Fuzzy logic differs from classical logical systems in that it aims at modeling the imprecise modes of reasoning that play an essential role in the remarkable human ability to make rational decisions in uncertainty and imprecision. This ability depends, in turn, on our ability to infer an approximate answer to a question based on a store of knowledge that is inexact, incomplete, or not totally reliable [12][13].

The whole approach is based on measurements taken from an experimental set up with certain typical commercial sensors. The outputs of sensors are monitored by a microcontroller, and then a proper intelligent processing using fuzzy logic has been used as it gives better results and enhances discrimination techniques. Fuzzy logic comprises fuzzy sets which are methods of representing non statistical uncertainty and approximate reasoning, including the operations used to make inferences. It is a tool for mapping the input features to the output, based on data in the form of "IF – Then" rules. An implementation of a fuzzy expert system depends on a Mamdani type fuzzy controller. The objective of the controller is to discriminate between employees and intruders (security system) and to determine how long it is permissible for a specific employee to be in specific department (evaluation system) according to the fuzzy input variables [14].

III. METHOD FOR CALCULATING THE PERMITTED TIME (ALLOWANCE)

There are five steps to construct a Mamdani type fuzzy controller [9] -[14]:
Step 1: Identify and name the input linguistic variables and their numerical ranges.
Step 2: Identify and name the output linguistic variables and their numerical ranges.
Step 3: Define a fuzzy membership function for each of the input and output variables.
Step 4: Construct the rule base that governs the controller' operation
Step 5: Determine how the control action will be combined to form the executed action.

3.1.1 Employee working time

Linguistic Range	Minimum	Maximum
Empty	10 %	30 %
Medium	10 %	50 %
Busy	30 %	70 %
Very Busy	50 %	70 %

3. 1 .2 Employee rank
Its range: 1-7 according o which position the employee is occupying

Linguistic Range	Minimum	Maximum
Worker	1	3
Specialist	1	5
Supervisor	3	7
Manager	5	7

3.1.3 The employee credibility
Its range: 13-91 according to its annual report

Linguistic Range	Minimum	Maximum
Weak	-1	39
Good	13	65
Very Good	39	91
Excellent	65	91

3. 1.4 Relation between the departments
Its range: 1-7 as a weight of the relation

Linguistic Range	Minimum	Maximum
Very Far	1	3
Far	1	5
Nearly Far	3	7
Near	5	7

3. 2 Identify and name the output linguistic variables and their numerical ranges
There is one output variable, which is the Allowance (permitted time)
Its range; 10-70 minutes
There are four ranges for that variable, which have been identified as:

Linguistic Range	Minimum	Maximum
Low	0	20
Medium	0	40
High	20	60
Very High	40	60

Step 3: Define a set of fuzzy membership function for each of the input and output variables
Figures (2-5) represent the fuzzy membership functions of the different input universes of discourse. Figure (6) represents the output membership function .A membership function triangular with equal span and 50% overlap.

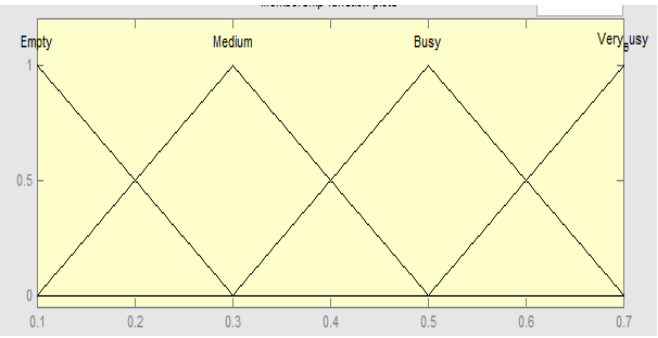

Figure (2) The membership function of the employee working time

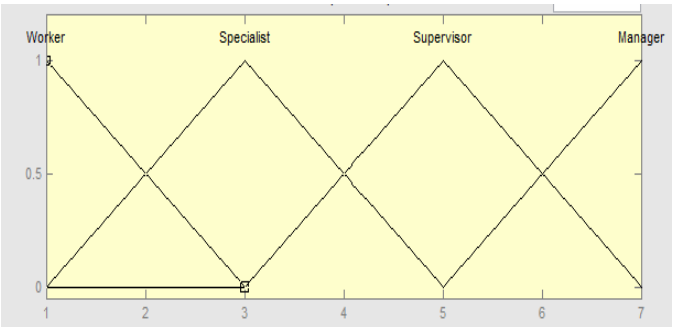

Figure (3) The membership function of the employee rank

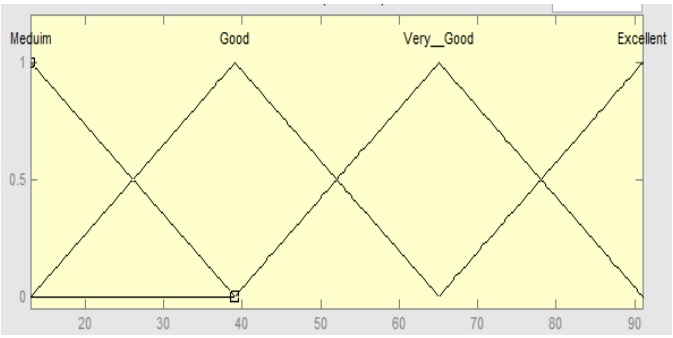

Figure (4) The membership function of the employee credibility

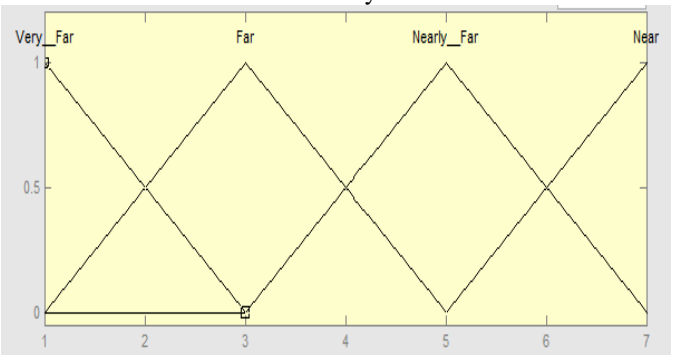

Figure (5) The membership function of department relations

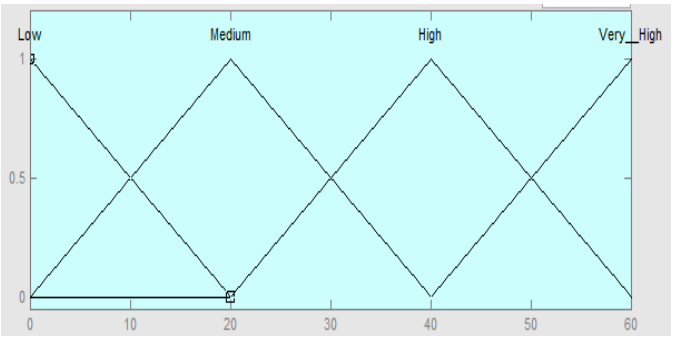

Figure (6) The membership function of time allowance

Step 4: Construct the rule base that will govern the controller operation. The rule base is represented as a matrix of input and output variables. The fuzzy rules are fired partially and parallel. They were relevant or not and the duplicate ones were removed to conserve computing time. Each rule base is defined by ANDing together with the inputs to produce each individual output response.

A fuzzy rule is a conditioned rule where all inputs must be initiated simultaneously and will affect the output as there are 4 inputs each has 4 membership functions then 256 conditions can be cited. Only 16 rules are fired simultaneously.

For example:

IF Times is Empty AND, IF Employee position is worker AND, IF Employee credibility is weak AND, IF the relation between department is very far

THEN Permitted time (to be outside own department) is low.

Step 5: Determine how the control action will be combined to form the output. The control actions will be combined to form the output. The most common rules combination method is the centroid defuzzification to get the crisp output value. This step is a repeated process, after all adjustments are made, which allows the fuzzy expert system to determine the allowable time for each worker to be out of his own department. Mamdani type fuzzy controller is used to construct the rules, which are extracted from the data driven from the RFID sensors and the microcontroller. Fuzzy logic gives on line of the employee performance evaluation. Figure (7) and Figure (8) show the relations between the different inputs and the output.

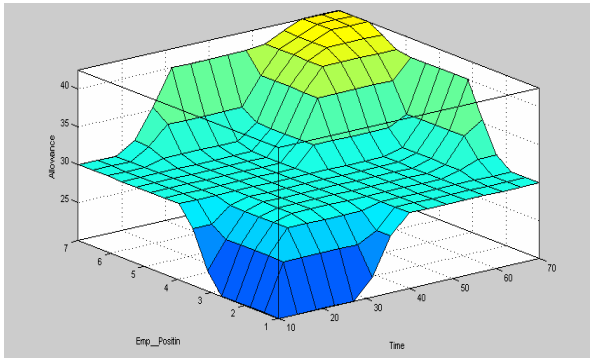

Figure (7) The relation between employee position, working time and allowed time

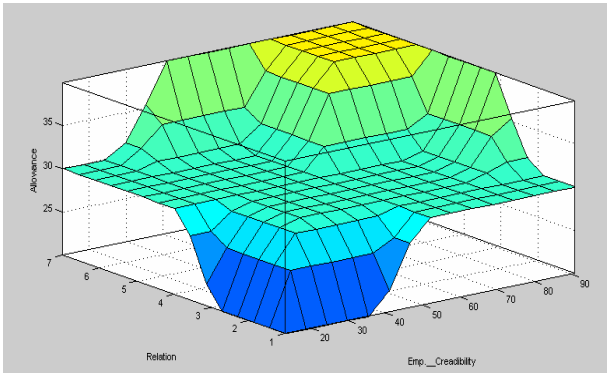

Figure (8) The relation between employee credibility, relation between departments and allowed time

IV. RESULTS AND DISCUSSIONS

A simulation was performed using Matlab code to show the results expected from the proposed system. Different employee with different ranks and from different departments was submitted to the system. They were moved among the different departments at different times. The results are to the corresponding allowed working hours computed by the proposed system. The difference represents the working hours wasted by the employees. Figures (9) and (10) depict the working hours wasted by 10 different employees. Figure (9) is obtained using triangular fuzzy membership functions for the inputs and the output. Figure (10) depicts the same case using Gaussian fuzzy membership functions. Figure (11) displays the difference noticed when using different shapes of membership functions. The results show a positive difference for six employees and a negative one for the remaining four. The average wasted working hours in a week were 12.9 hours when using triangular membership functions and 1.95 hours when using Gaussian distribution functions. The standard deviation was 29.28 for the first case and only 4.958 for the second case.

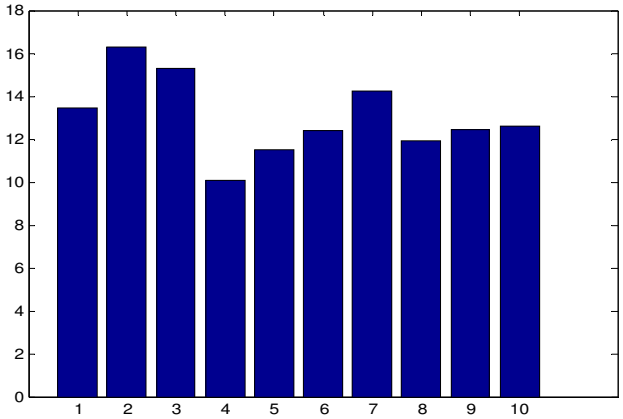

Figure (9) The hours waste by different employees during one month using triangular membership functions.

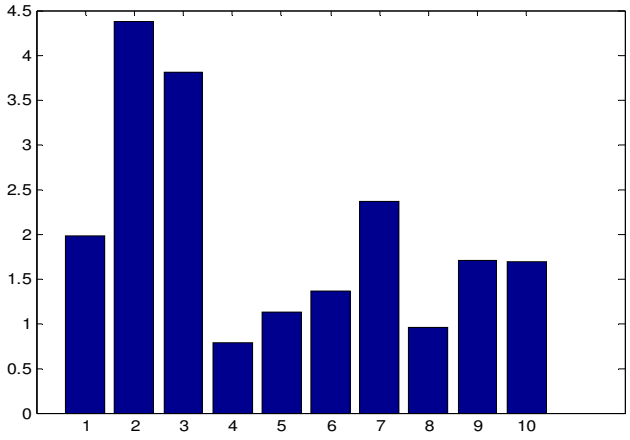

Figure (10) The hours waste by different employee during one month using Gaussian membership functions.

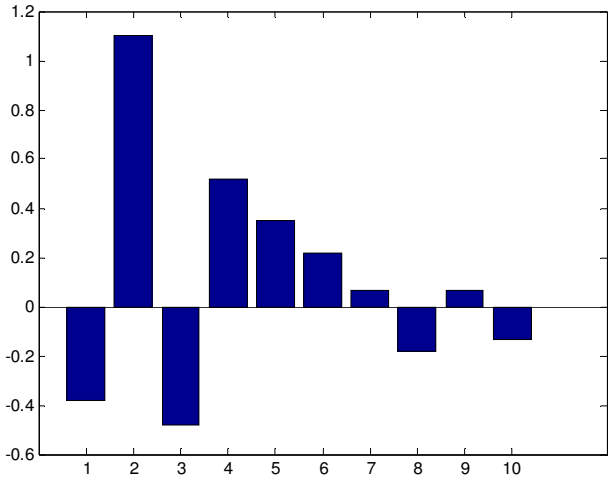

Figure (11) The difference between Figures 12, 13.

V. CONCLUSION AND FUTURE WORK

The results demonstrated the sensitivity of the adopted method to the shape of the fuzzy membershipfunctions. The results indicate clearly that adopting gaussian membership functions lead to a less descrimanatory and more fair performance evaluation system.This suggestes comparing the results of this fuzzy syste to those obtained from an analytical approach (like AHP) in the future work.

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