Research Paper Engineering

A Diagnostic Evaluation For Microgravity and Radiation Against Immunity and Tumor in Space: A Fuzzy Logic Approach

Saurabh Kumar Bajpai	Shobhit University, Babu Vijendra Margh, Gangoh-247341 Saharanpur, Uttar Pradesh
Gaurav Kumar	IIT BHU, Banaras
Prof. (Dr.) D.V.Rai	Shobhit University, Babu Vijendra Margh, Gangoh-247341 Saharanpur, Uttar Pradesh

ABSTRACT

Microgravity and radiations are the most critical health risk factors affecting the performance of astronauts during their long duration space exploration missions. Microgravity gradually damages the immune system which slows down the body's ability to protect itself and increased radiation level causes severe mutations resulting in tumors. In this study we have developed a Mamdani model for diagnostic system by using Fuzzy Logic Toolbox in MATLAB. Two types of membership functions i.e. Triangular and Gaussian were used for as inputs to the system "gravity and radiations" risk factors were taken and the outputs were "Immunity and Tumor".

KEYWORDS space missions, gravity, health risk, fuzzy logic, membership function

INTRODUCTION

Fuzzy logic (FL) is a multi-valued logic that has the ability to mimic the human intelligence capabilities. Fuzzy systems has been extensively used in industrial control system, medicine, transportation and household appliances such as self-focusing cameras, washing machines and anti-lock breaking systems and it allows the treatment of indefinite, unpredictable, inaccurate and distracted concepts and knowledge in an exact arithmetical form [1]. When the complexity of a system rises, the capability of making correct decisions about ones behavior reduces and the degree of the result is highly compatible with the fuzzy restriction according to the compatibility principle of Zedeh i.e. "The closer one looks at a 'real' world problem, the fuzzier becomes its solution" [2]. FL has been widely used in medical diagnostic control systems such as diabetes, dysplasia prediction and tumor [3-4].

Lot of work based on FL models has been reported predicting structure and composition of proteins and amino acids [5-6]. Recently, a fuzzy logic based system had been designed to diagnose the hemorrhage and brain tumor diseases in which RBCs, proteins, neutrophils, lymphocytes and eosinophils were taken as input variables [7]. Fuzzy logic principles and neural network techniques were applied to adjust intravenous insulin administration rates during the infusion of glucose [8]. Sadegh-Zadeh proposed that health and disease are two fuzzy states of health [9]. Ohayon developed a fuzzy logic based expert system to assess the sleep disorders by using fuzzy sets to meet the diagnostic criteria in terms of frequency, intensity, quantity and graduated yes–no variables [10]. A fuzzy logic based cerebrospinal fluid expert system was designed to identify the possibility of the disease which consists of cytology, glucose concentration and protein level data. Fuzzy modeling techniques were adapted in the neuro medical field which evaluates the fuzzy logic on the basis of facial expression and human behavior [11]. The prediction capability of Fuzzy Cognitive Map (FCM) was used to design immune system for the protection of human body [12]. The medical applications of FL range from diagnostic control systems to imaging technology such as magnetic resonance imaging, dynamic single-photon emission tomography(SPECT) imaging, echocardiograms, electrocardiograms, and coronary and renal arteriogram [13-15]. A. Sproule et al. [16] reviewed the applications of fuzzy logic in the emerging field of pharmacology.

The Effect of space conditions on various physiological functions needs to be investigated to stay for a longer period of time in space for research purpose. One of the most significant effect observes during the space flight is on the immune system [17]. Deregulation in the immunity affected the ability of the host to resist infection and tumors. The reports made on the effects of space flight on the immune system have been interesting but not commemorative [18]. Some constraints originated in the space during the research which is small sample size, the relatively small number of flights available for immunological studies, and by experimental conditions [19-20]. On the other hand, it is obvious that some alterations of immunological parameters transpire during space flight. Several factors could contribute to those effects, including microgravity, stress, and radiation [21-22]. It has been difficult to conclude the absolute contribution of each of those factors to alterations in immunological parameters induced by space flight. Most important of which is how the immune responses change, the possible effects of space flight on substantial resistance to infection have not been developed/identified.

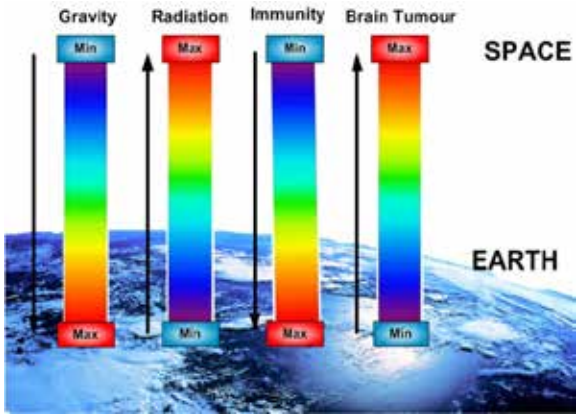

Fig.1. **General Criteria of the Proposed Work**

General Criteria of the Proposed Work clearly showing the gradual change in gravity and radiation in space and decrease in immunity and increase in chances of occurring of tumor

Gravity and radiations have an impact on the tumor and

immune system. The general criteria of the proposed work are shown in the Fig. 1. On earth, gravity and radiation exposure is normal which make our immune system to work at maximum and as a result tumor induction chances are less. But in space where there is no gravity and high intensity of radiation exposures both factors affect the human immune system hence there is maximum chances of tumor. This proposed work addresses the diagnostic system using fuzzy control logic to find the chances of occurrence of tumor and behavior of immunity due to radiations and gravity effects. This proposed fuzzy logic based diagnostic system consists of two input variables: gravity and radiation, and two output variables: immunity and tumor induction.

Basic Structure of the Proposed Diagnostic Model

The basic structure of the proposed model is shown in Fig. 2. Fuzzifier consists of four linguistic values: two for each input variable, and two for each output variable. Further these linguistic values are then processed through human decision based Rule-Base. Finally, after the process of Defuzzification, two output crisp values are given to show the probability of the disease i.e. immunity and tumor.

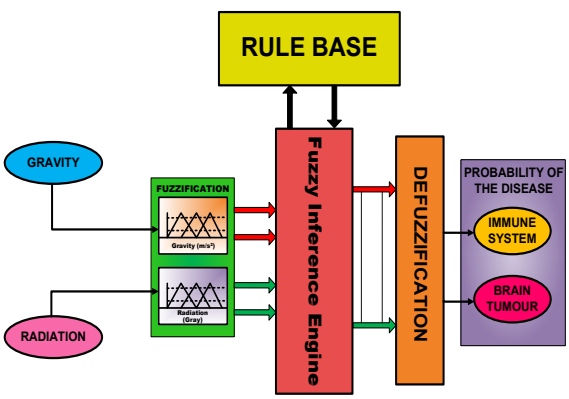

Fig.2 **Block Diagram of Fuzzy Logic Based model showing the input and output values**

Fuzzy Membership

In classical set theory1, a subset U of asset S can be defined as a mapping from the elements of S to the elements the subset {0, 1},

U: S → {0.1}

The mapping may be represented as a set of ordered pairs, with exactly one ordered pair present for each element of S. The first element of the ordered pair is an element of the set S, and second element is an element of the set (0, l). The value zero is used to represent non-membership, and the value one is used to represent complete membership. The truth or falsity of the statement 'X is in U' is determined by finding the ordered pair whose first element is X. The statement is true if the second element of the ordered pair is 1, and the statement is false if it is 0. The fuzzy set can be defined mathematically by assigning to each possible individual in the universe of discourse, a value representing its grade of membership in fuzzy set. This grade corresponds to the degree to which that individual is similar or compatible with the concept represented by the fuzzy set. In a fuzzy set many degree of membership (between 0 and 1) are allowed. Thus, a membership function μ (a) is associated with a fuzzy set A such that the function maps every element of the universe of discourse X to the interval [0, 1]. The fuzzy membership not only provides for a meaningful and powerful representation of measurement of uncertainties, but also provides the meaningful representation of vague concepts expressed in natural language [21].The algorithm designed for diagnostic control system comprises of two fuzzy input variables.

The fuzzy logic controller (FLC) design consists of the following steps:

1) Identification of input and output variables.
2) Construction of control rules.
3) Establishing the approach for describing system state in terms of fuzzy sets, i.e. establishing fuzzification method and fuzzy membership functions.
4) Selection of the compositional rule of inference.
5) Defuzzification method, i.e., transformation of the fuzzy control statement into specific control actions.

Inference Engine

If x presents the maximum no. of membership functions and y denotes the total no. of inputs, then Total Number of Rules = x^y. In this case, there are six membership functions for two input variables, so the total numbers of rules are 6^2=6×6=36 [23]

Membership Function

The variables chosen for this is Gravity, Radiation, Immunity System, Brain tumor. In this Gravity and Radiation are input variable while Immunity system and Brain Tumor are output variable. Six fuzzy membership functions (MF) for gravity are: G1 0-20, G2 0-40, G3 20-60, G4 40-80, G5 60-100, G6 80-100 and for radiation input are given as: lowest 0-100, low 0-200, below medium 100-300, medium 200-400, high 300-500 and very high 400-500. Two outputs of this proposed diagnostic system are: Immunity and Tumor. Six membership functions are for Immunity: lowest 0-5, lower 0-20, low 10-50, medium 40-60, higher 50-90 and highest 80-100 whereas the six membership functions for Tumor are: impossible 0-20, rare 0-40, moderate 20-60, uncertain 40-80, probable 60-100 and severe 80-100.In the proposed work two types of membership function are used i.e. Triangular Membership function and Gaussian Membership function for same range.

Triangular membership function is mostly used membership function for their simple working while Gaussian membership function is a smooth membership function.

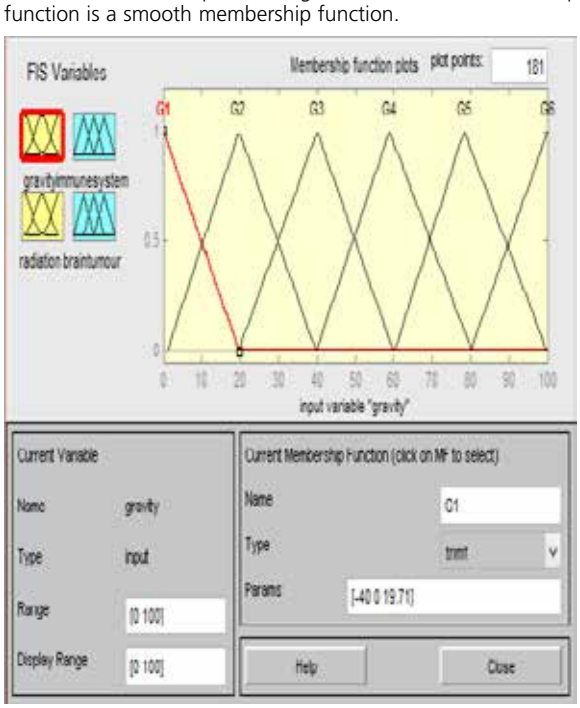

Fig.3.Membership function for Input Gravity

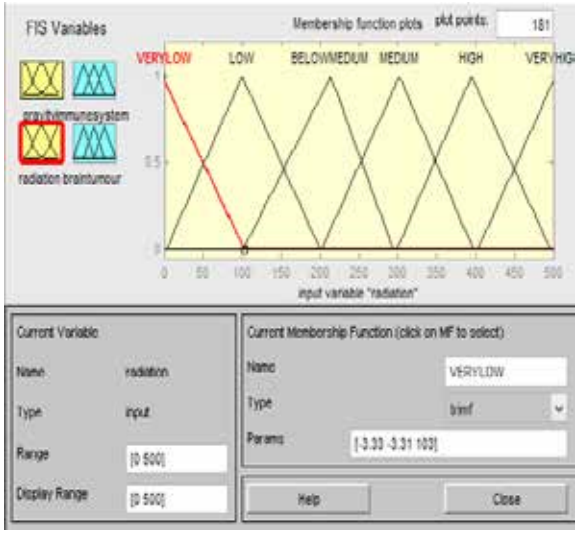

Fig.4.Membership function for Input Radiation

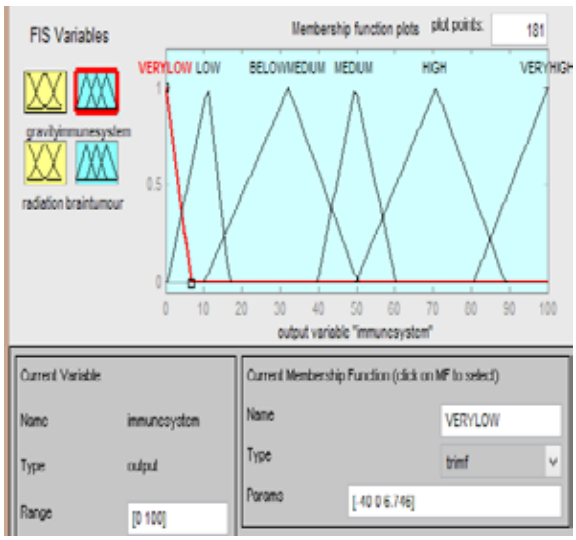

Fig.5.Membership function for output Immunity system

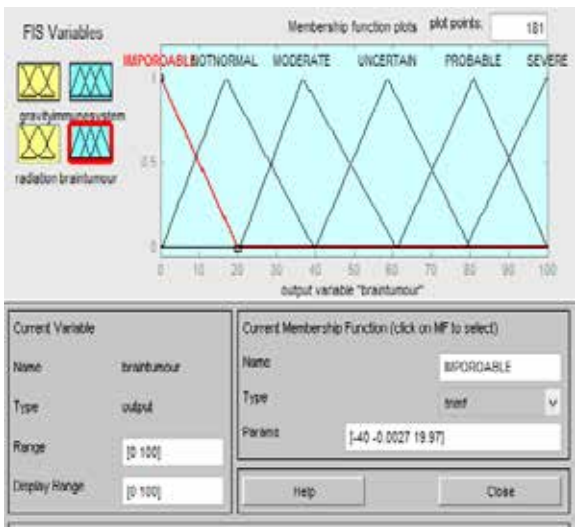

Fig.6.Membership function for output Brain Tumor

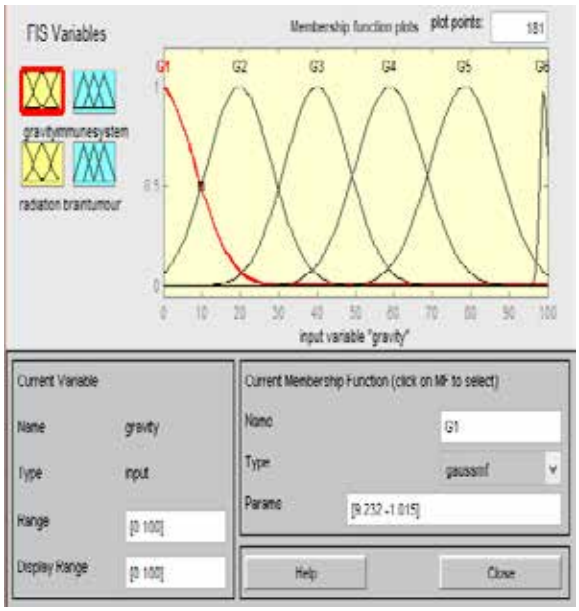

Fig.7.Membership function for Input Gravity

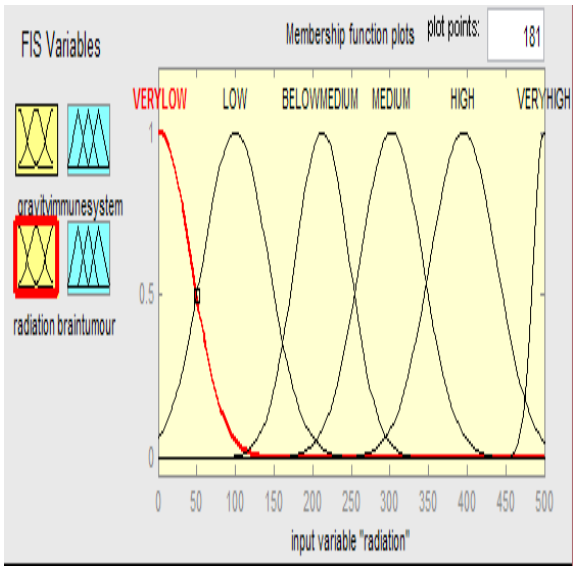

Fig.7.Membership function for Input Radiation

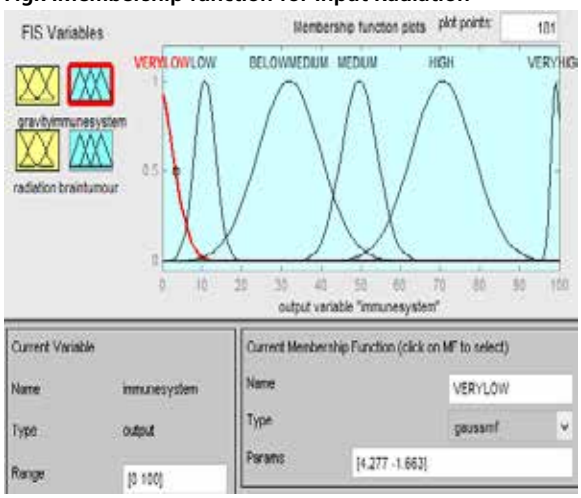

Fig.8.Membership function for output Immunity system

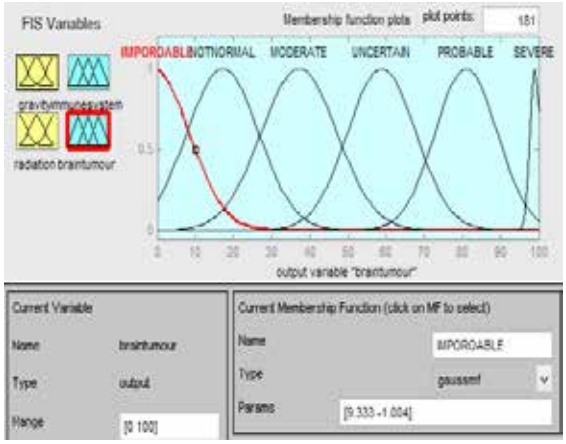

Fig.9.Membership function for output Brain Tumor

Fuzzy Rule Base

A set of rule which define the relation between input and output of fuzzy controller can be found using the available knowledge in the area of designing Diagnostic system. The rules are defined using linguistic variables. The two inputs Gravity and Radiation, results 36 rules.

Output is obtained by applying a particular rule expressed in the form of membership function. Finally the output membership function of the rule is calculated. This procedure is carried out for all the rules and with every rule an output is obtained

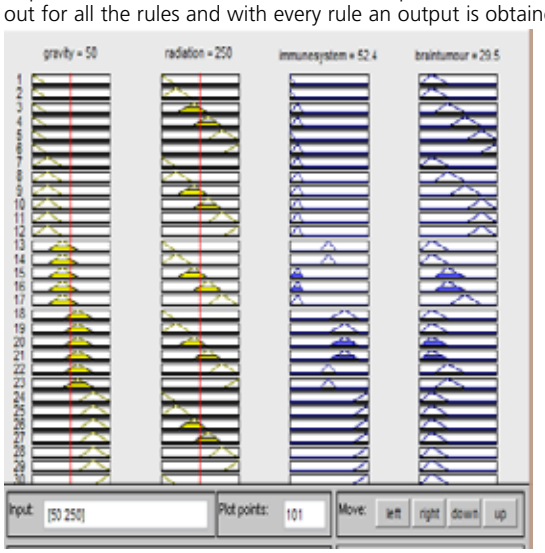

Fig.10. Rule base structure (Triangular membership function)

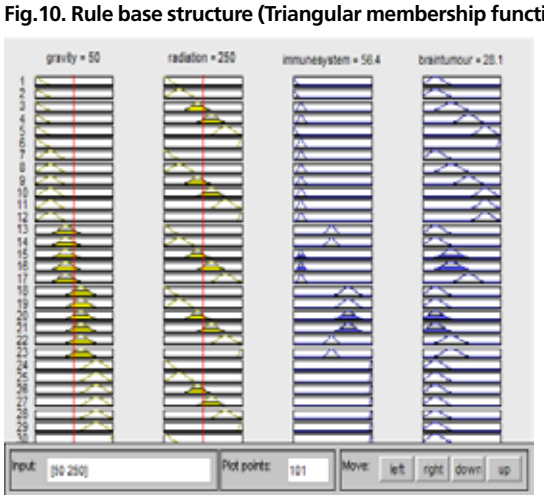

Fig.11. Rule base structure (Gaussian membership function

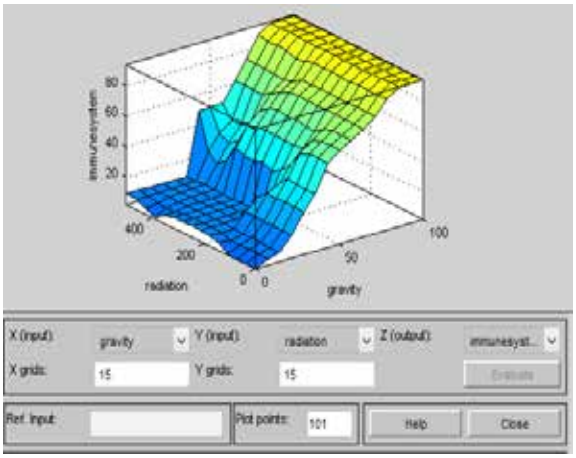

Fig.11. Surface view between gravity, radiation and immunity system (Triangular membership function)

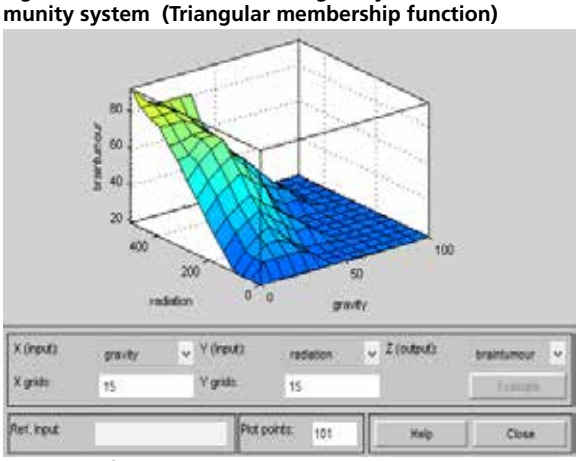

Fig.12. Surface view between gravity, radiation and brain tumor (Triangular membership function)

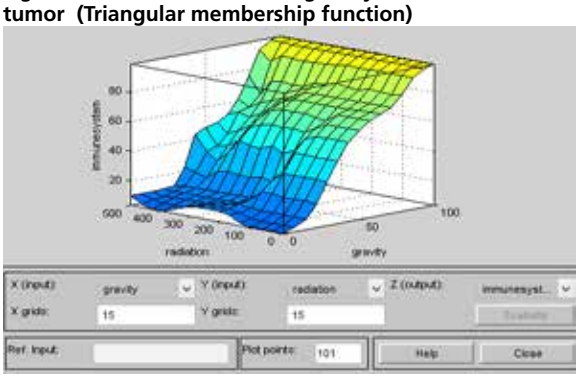

Fig.13. Surface view between gravity, radiation and immunity system (Gaussian membership function)

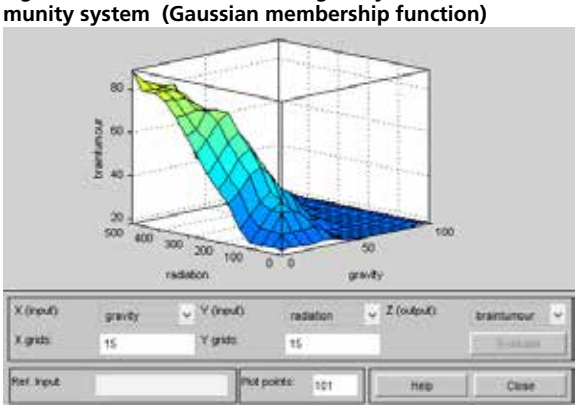

Fig.14. Surface view between gravity, radiation and brain tumor (Gaussian membership function)

Conclusion

In this paper, a two fuzzy logic based diagnostic system was designed to estimate the health risk associated with the limiting environmental conditions in space faced by the astronauts during long time space travelling. First fuzzy logic based on triangular membership function and other one is Gaussian membership function .both function design for same range and same rule base.

As per graphical representation i.e. brain tumor vs. gravity and radiation, immune system vs. gravity and radiation for both membership function (Gaussian membership function and Triangular membership function)

Triangular membership function based fuzzy logic controller more sensitive in case of Immunity system As compare to Gaussian membership function based fuzzy logic controller, While Gaussian membership function based fuzzy logic controller is more sensitive in case of brain tumor as compare to Triangular membership function based fuzzy logic controller

As per graphical representation the area covered by system increase using Gaussian membership function based FLC but less sensitive as compare to triangular based membership function whose sensitivity is high but covered area is less in case of immunity system.

Above result shows triangular membership function based fuzzy logic controller is good as compare to Gaussian membership function based fuzzy logic controller.

REFERENCES

1. Zadeh, L. A., 1965. Fuzzy Sets, Inform, and Control, 8: 338-353. || 2. Zadeh, L. A., 1969. Fuzzy Algorithms, Inform, and Control. 11: 323-339. ||| 3. Baro, S and, Marin, R., 2002. Fuzzy Logic in Medicine. Heidelberg: physica-verlag, 2002. || 4. Moghtadaei, M., Reza M., Golpayegani, H., Malekzadeh, 2013. A variable structure fuzzy neural network model of squamous dysplasia and esophageal squamous cell carcinoma based on a global chaotic optimization algorithm. Journal of Theoretical Biology. 318: 164–172 || 5. Xiao, X., Wang, P., Chou, K.C., 2008. Predicting protein structural classes with pseudo amino acid composition: An approach using geometric moments of cellular automaton image. Journal of Theoretical Biology. 254: 691-696. || 6. Zhang, T.L., Ding, Y.S., Chou, K.C., 2008. Prediction protein structural classes with pseudo-amino acid composition: Approximate entropy and hydrophobicity pattern. Journal of Theoretical Biology. 250: 186-193. || 7. Faran, B., Khan, M.S., Noor, Y., Imran, M., 2011. Design Model of Fuzzy logic Medical diagnosis control System. International Journal on Computer Science and Engineering (IJCSE). 2093-2108. | 8. Dazzi, D., Taddei, F., Gavarini, A., Uggeri, E., Negro, R., Pezzarossa, A., 2001. The control of blood glucose in the critical diabetic patient: a neuro-fuzzy method. Journal of Diabetes and its Complications. || 9. Sadegh-Zadeh, K. 2002. Fuzzy health, illness, and disease. J. Med. Philos. 25: 605–638. || 10. Ohayon, M. 1999. Improving decision making processes with the fuzzy logic approach in the epidemiology of sleep disorders. J. Psychosom. Res.47: 297–311. || 11. Mahfouf, M., Abbod, M.F., Linkens, D.A., 2000. A survey of fuzzy logic monitoring and control utilization in medicine. Department of Automatic control and System Engineering, University of Sheffield. || 12. Yue, H., Yue, G., Yi, G., 2007. Application study in decision support with fuzzy cognitive mape International journal of computers. || 13. Hillman, G. R., 1999. A fuzzy logic approach to identifying brain structures in MRI using expert anatomic knowledge. Comput.Biomed.Res.32: 503–516. || 14. Acton, P. D., 1999. Automatic segmentation of dynamic neuroreceptor single-photon emission tomography images using fuzzyclustering.Eur. J. Nucl. Med. 26(1999)581–590. || 15. Vitez, T. S., 1996. Fuzzy logic: theory and medical applications. J. Cardiothorac. Vasc. Anesth.10: 800–808. || 16. Beth, A. S., Claudio, A. N., Türksen, I. B., 2002. Fuzzy pharmacology: theory and applications. Trends in Pharmacological Sciences. 23. || 17. Sonnenfield, G., 2001. Extreme environments and the immune system: effects of spaceflight on immune responses. J. Allergy Clin. Immunol.107: 19–20. || 18. Mandel, A. D., Balish, E., 1977. Effect of spaceflight on cell mediated immunity. Aviat. Space Environ. Med.48: 1051–1057. ||