Estimation and Management of Post-Miscarriage Depression in Women Using Fuzzy Logic and Genetic Algorithm

(Expert System For Estimation and Management of Depression By Using ANFIS)

Fahmida Naveed
Department of Computer Science
Kinnaird College for Women
Lahore, Pakistan
fahmidanaveed@hotmail.com

Mehreen Khawar
Department of Computer Science
Kinnaird College for Women
Lahore, Pakistan
mehreenkhawar1993@gmail.com

Dr. Fahad Ahmad
Department of Computer Science
Kinnaird College for Women

Lahore, Pakistan
fahad.ahmad@kinnaird.edu.pk

Dr. Muhammad Rizwan
Department of Computer Science
Kinnaird College for Women
Lahore, Pakistan
muhammad.rizwan@kinnaird.edu.pk

Dr. Kashaf Junaid
Department of Clinical Laboratory Sciences
Jouf University
Kingdom of Saudi Arabia.
kashaf_junaid@hotmail.com

Abstract
At present, a vast amount of people are suffering from mental health disorders. Mental health problems are not taken as seriously as the physical health problems. With the growing rate of miscarriages occurring, the different styles and mechanisms miscarrying-women adopt in order to overcome their grief are explored and used by an expert system based on Fuzzy Logic. The proposed method would estimate the severity of post-miscarriage depression in women using fuzzy systems and genetic algorithms. A dataset would be generated by interviewing the women suffering from post-miscarriage depression. The severity of the depression would be predicted using the variables such as the condition of the women interviewed. Fuzzy logic uses interpretability whereas genetic algorithms along with its five phases makes the production of fuzzy systems automatic and certain coping mechanisms would also be discussed which will help lower the rate of severity of depression in women. The genetic-fuzzy approach gives us optimized results.
Keywords
fuzzy logic, genetic algorithm, coping mechanisms, membership functions, post-miscarriage depression

1. INTRODUCTION

In the developing countries, mental health is still not considered as significant as the physical health, till date. People are not that aware of the mental health specialists. In a country like Pakistan, people often hesitate to seek help from a professional psychiatrist; there are multiple reasons behind it. Awareness needs to be created. Our purpose to develop an expert system for predicting the severity of the depression in the miscarrying-women is to provide them with a system that would help them cope with it(8). The proposed expert system would be helpful for women who cannot seek professional help as they do not have access and are also looked down upon by their families if they go to a psychiatrist.

Depression is a serious illness that affects the person severely. It affects how a person acts, reacts or feels towards certain things when depressed. The person behaves differently than how he usually acts, it is a feeling of sadness and a depressed person cannot perform his/her duties to the fullest. Like other countries of the world Pakistan also has a population of women who undergo suffering from the loss of an unborn child or a miscarriage (7). Although the rate of miscarriages is unknown as quantifying the rate is difficult, however a rough estimate tells that almost one in every four pregnancy ends in a miscarriage. The trauma and grief that the miscarrying-mother has to face is a time of intense instability in a society like Pakistan.

The woman feels depression and guiltiness like any other woman who loses a baby, however women in Pakistan have to face a lot more than just the grief of losing a baby(4). The woman may feel physically all right, but the emotional damage that follows a miscarriage is what she has to go through alone. There seems to be extreme pressure from the family and friends, especially the in-laws.

In 1965, the theory of Fuzzy Logic was introduced by LoftiZadeh. This theory works on the basis of 'degrees of truth' unlike the Boolean logic which only considers two output values (1 or 0). It is a logical system containing fuzzy sets. It can take any value from 0-1. It takes a crisp input then fuzzifies it. The values are checked against the knowledge base and the value is inferred. Then the output is defuzzified to obtain a crisp value. The Fuzzy Logic makes use of the Membership functions and other if-then rules or simply fuzzy rules. The importance of fuzzy logic is about the precision it gives in answers but sometimes finding a good fuzzy system can be a tedious task and that is where genetic algorithm plays its role. (1)The genetic-fuzzy algorithms can be considered as a model for good optimization results. We have used fuzzy logic because it resembles human decision-making abilities and hence would come up with a solution that is close to the recommendation provided by the psychiatrist.

Genetic algorithms are almost used in everyday commercial use. They are search procedures designed to work with large spaces that can be represented as strings, which can then be used to produce a new set of samples. One of the types of this system is classifiers which are parallel production systems which makes use of the implicit parallelism of genetic algorithms. Genetic algorithms are also being used in the study of machine learning known as genetic based machine learning. Genetic algorithms begin with a population of candidate problem solutions which are evaluated according to their ability of solving different problem instances. This algorithm was inspired by theory of revolution and reflects upon the process of natural selection. The five phases of this algorithm are: initial population, fitness function, selection, mutation and cross over. Initial population is the nature of the problem. Selection shows the number of individuals chosen for further research. Mutation and crossover-also known as recombination- work side by side.

In this paper, we have used a hybrid approach which uses genetic algorithms and fuzzy logic to predict the severity of post-miscarriage depression in women. Genetic algorithms will help in selecting women who are a victim of depression and membership functions of fuzzy logic will be applied to calculate the severity along with the coping mechanisms that miscarrying women should follow to overcome their grief. The rest of the paper is structured as follows. Section II gives the literature review; Section III shows the methodology that we have proposed in the paper. Finally, Section IV summarizes the conclusion and scope for future research.

2. LITERATURE REVIEW

Fuzzy systems have gained a lot of importance in the past few years. The main idea behind fuzzy systems is to include uncertainty in the process. Fuzzy systems use fuzzy logic which is a logical system closer to human thinking. This system uses a fuzzy logic controller which plays an important role in industrial systems. This controller provides a basis for converting a linguistic control strategy into an automatic control strategy. It plays a vital role in determining the performance level of a fuzzy control system. This type of system is needed when higher accuracy and reliability are required. The author of (2)has used a fuzzy technique and has identified grief as common feature following miscarriages as women feel depressed after losing a baby because there is no routine follow-up care for miscarrying women. Anxiety, depression, intrusion and avoidance levels were assessed at one week and four months post-miscarriage and results showed that after one week of miscarriage, women show significant signs of depression and that it was necessary for them to follow a certain routine to come out of that depression.

Fuzzy logic deals with vagueness and has many applications associated with it. It works on a range of possible input and gives a definite output. Nowadays it is widely used in medical diagnosis systems. Neuro-fuzzy inference systems are used which helps in the estimation of survival prediction. Fuzzy inference is a system of mapping from a given set of inputs to the outputs using the assumption of fuzzy sets. In this paper, by adapting the method known as partial linguistic artificial neural network model, the author proposed to use adaptive neuro fuzzy inference system in predicting the severity of post miscarriage depression in women(9). A specific preprocessing was performed on raw data set in order to obtain the probability of severity and its curve. Both these models have demonstrated their predictive power in producing proportional severity of depression.

John Holland proposed the theory of genetic algorithm. This theory is better than other evolutionary theories in the sense that it provides better optimization techniques that helps individuals by only needing fitness function and avoiding difficult mathematical problems.(10) The main disadvantage of genetic algorithm is the time consuming process of search and the number of combinations required that depends on crossover rate, mutation rate and other factors. In this paper, the author has used a hybrid approach i.e., genetic algorithm and fuzzy logic to calculate the rate of severity of depression in miscarriage women. The author's solution consists of a fuzzy system and a threshold value. The fuzzy system calculates a continuous value of the severity of the case, based on the input values of the data set. The threshold unit

outputs a diagnosis to be applied based on the fuzzy system's output.

In (3), the author states that all sorts of questions are thrown towards the miscarrying-mother, ones that may easily pass off as inappropriate given to the situation that she is in. These questions may include inquiries like: what had the mother eaten that led her to lose her baby; whether she lifted something heavy that caused her to miscarry her baby; or the fact that she works tirelessly at her job led the baby to not survive through the hectic routine. The reassuring remarks that come from family and friends fail to console and hide the fact that those supposed comforting remarks are no less than demeaning taunts. The author has proposed a cross-sectional study where the author has examined both the exposure to miscarriage to the outcome of depression at the same time. This study was conducted at the Aga Khan University Hospital, Nairobi. The factors that seemed to have an impact on the depression were younger age, lower educational level and older gestational age.

The miscarrying woman has nothing but to isolate and mourn on her own (6). She deems it best to not face anyone because she feels tired of giving answers and explaining to every other person that comes asking how the miscarriage happened. She lives in her depression by herself and this is the time when she needs support and compassion the most. Becoming part of support groups and hearing others narrate their respective stories of miscarriage eases the process of mourning. Knowing that she is not the only one to miscarry restores her faith about the fact that she can conceive again. In (5), the author has proposed a scheme which makes use of biomarkers to detect post miscarriage depression. Biomarkers are a gene or a molecule with the help of which a pathological process or a disease can be identified. In this process, a method to identify the likelihood of post miscarriage depression comprises of three steps. 1) Providing a sample from patient. 2) Measuring white blood cells count, 3) identifying the patient as likely to develop depression on the relative DNA methylation levels.

3. METHODOLOGY

In this section, we discuss our proposed method of predicting the severity of post-miscarriage depression. It consists of three steps. In the first step, we have used genetic algorithms along with its five phases to distinguish women who are a victim of post-miscarriage depression. Research is carried out whether a woman has already suffered from this depression and if yes, then what are the possible steps that should be taken to avoid further depression. In the second step, all the parameters are passed through our model and membership functions are applied to calculate the

severity and in the last step, coping methods are provided for miscarrying women to follow to come out of their grief. The membership functions are as follows:

A) Membership function for Age:
- 15-30 Young
- 29-45 Middle
- 40-65 Old

$$\mu\,young(x) = \begin{cases} 0, & x < 15 \\ \dfrac{x-15}{15}, & 15 \le x \le 30 \\ 0, & x > 30 \end{cases}$$

$$\mu\,middle(x) = \begin{cases} 0, & x < 29 \\ \dfrac{x-29}{16}, & 29 \le x \le 45 \\ 0, & x > 45 \end{cases}$$

$$\mu\,old(x) = \begin{cases} 0, & x < 40 \\ \dfrac{x-40}{25}, & 40 \le x \le 65 \\ 0, & x > 65 \end{cases}$$

B) Membership function for miscarriage duration
- 1st month (0-30 days)
- 2nd month (29-60 days)
- 3rd month or more (59-100 days or more)

$$\mu\,1st\,month(x) = \begin{cases} 0, & x < 14 \\ \dfrac{x-15}{15}, & 0 \le x \le 15 \\ \dfrac{30-x}{15}, & 15 \le x \le 30 \\ 0, & x > 30 \end{cases}$$

$$\mu\,2nd\,month(x) = \begin{cases} 0, & x < 29 \\ \dfrac{x-29}{15}, & 29 \le x \le 45 \\ \dfrac{60-x}{15}, & 45 \le x \le 60 \\ 0, & x > 60 \end{cases}$$

$$\mu\,3rd\,month(x) = \begin{cases} 0, & x < 59 \\ \dfrac{x-59}{15}, & 59 \le x \le 75 \\ \dfrac{100-x}{15}, & 75 \le x \le 100 \\ \dfrac{x-100}{15}, & x > 100 \end{cases}$$

C) Membership function for physical capacity Iron:
- Weak: 10- 30 mg
- Normal: 25-60 mg
- High: 55mg- 100mg

D) Membership function of support from family
- Low: 0-30 %

- Mild: 25-70%
- High: 65-100%

E)   Membership function for social blaming
- Low: 0-30 %
- Mild: 25-70%
- High: 65-100%

F)   Membership function for number of miscarriages
- 1^{st}low: 0-30%
- 2nd mild: 25-70%
- More than 2 High: 65-100%

Based on the parameters given in   Figure 1, we have designed certain rules for predicting the severity of post-miscarriage depression in women. The rules are summed up as:

1.   If age = young, number of miscarriages=low, duration = 1st month, physical capacity= weak, family support = low, social blaming= low, then severity =low.
2.   If age = middle, number of miscarriages=mild, duration = 2nd month or more, physical capacity= normal, family support = mild, social blaming= mild, then severity =mild.
3.   If age = old, number of miscarriages=high, duration = 3rd month or more, physical capacity= high, family support = high, social blaming= high, then severity =high.
4.   If age = old, number of miscarriages=high, duration =3rd month or more, physical capacity= normal, family support= low, social blaming= high, then severity =high.
5.   If age = young, number of miscarriages= high, duration= 3rd month or more, physical capacity= normal, family support = low, social blaming= high, then severity =high.
6.   If age = middle, number of miscarriages= low, duration= 1st month, physical capacity= normal, family support = high, social blaming= low, then severity =mild.
7.   If age = old, number of miscarriages= mild, duration= 3rd month, physical capacity= weak, family support = high, social blaming= low, then severity =mild.
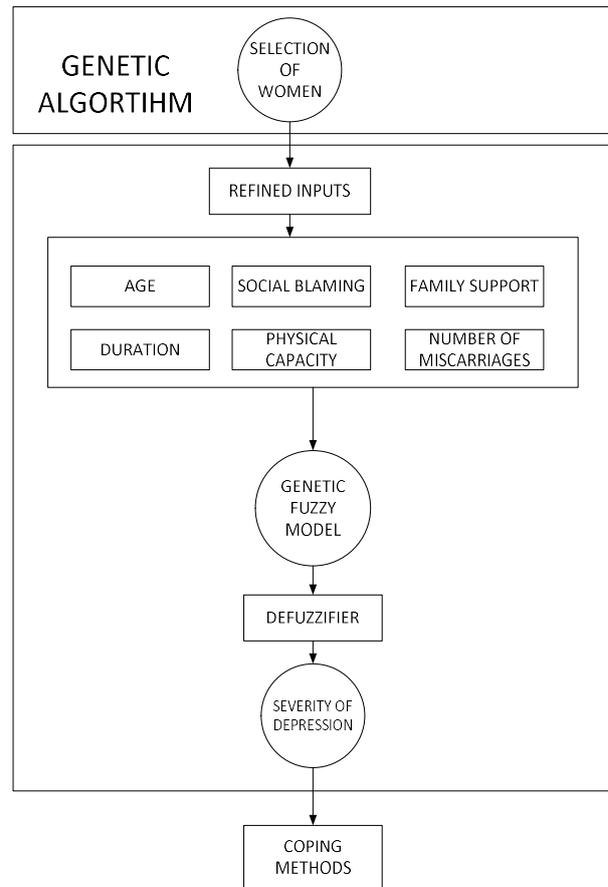

Figure 1 Genetic Algorithm

8.   If age = young, number of miscarriages= low, duration= 2nd month, physical capacity= normal, family support = mild, social blaming= mild, then severity =mild.
9.   If age = young, number of miscarriages= mild, duration= 3rd month, physical capacity= weak, family support = low, social blaming= mild then severity =high.
10.   If age = young, number of miscarriages= mild, duration= 2nd month, physical capacity= weak, family support= low, social blaming= high, then severity =high.
11.   If age = old, number of miscarriages= mild, duration= 3rd month, physical capacity= weak, family support = mild, social blaming= high, then severity =high.
12.   If age = old, number of miscarriages= mild, duration= 1^{st}month, physical capacity= weak, family support = low, social blaming= low, then severity =mild.
13.   If age = young, number of miscarriages= high, duration= 3rd month, physical capacity= weak, family support = low, social blaming= low, then severity =high.

14.   If age = middle, number of miscarriages= mild, duration= 3rd month, physical capacity= weak, family support = low, social blaming= high, then severity =high.
15.   If age = young, number of miscarriages= mild, duration= 1st month, physical capacity= high, family support = high, social blaming= low, then severity =low.
16.   If age = middle, number of miscarriages= low, duration= 1st month, physical capacity= normal, family support = mild, social blaming= mild, then severity =low.
17.   If age = old, number of miscarriages= mild, duration=3rd month, physical capacity= high, family support = mild, social blaming= high, then severity =high.
18.   If age = old, number of miscarriages= high, duration= 1st month, physical capacity= weak, family support = mild, social blaming= low, then severity =mild.
19.   If age = middle, number of miscarriages= low, duration= 1st month, physical capacity= weak, family support = mild, social blaming= high, then severity =mild.
20.   If age = young, number of miscarriages= low, duration= 1st month, physical capacity= normal, family support = high, social blaming= low, then severity =low.
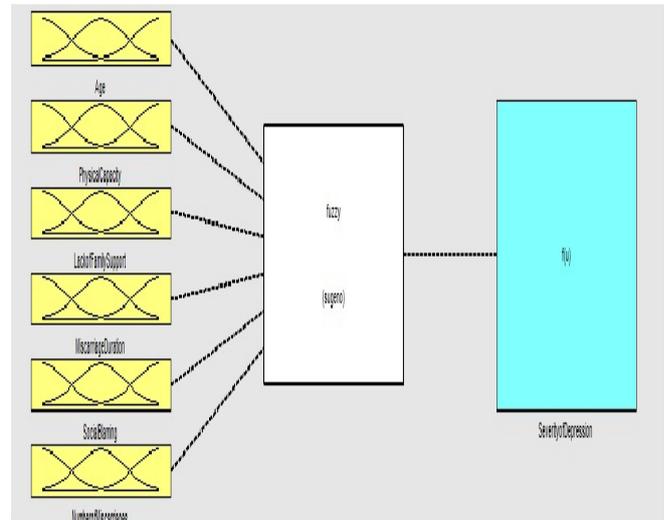
4. SIMULATION BASED RESULTS:

4.1 Implementation of Sugeno Model in Fuzzy Genetic System :

In our proposed system, we have used sugeno model in which we have defined inputs as age, number of miscarriages, physical capacity, family support and social blaming, and output as severity of depression as shown in Figure 2. We have used sugeno model because it is computationally effective and works well with optimization techniques and adaptation skills which makes it perform better in different control problems.
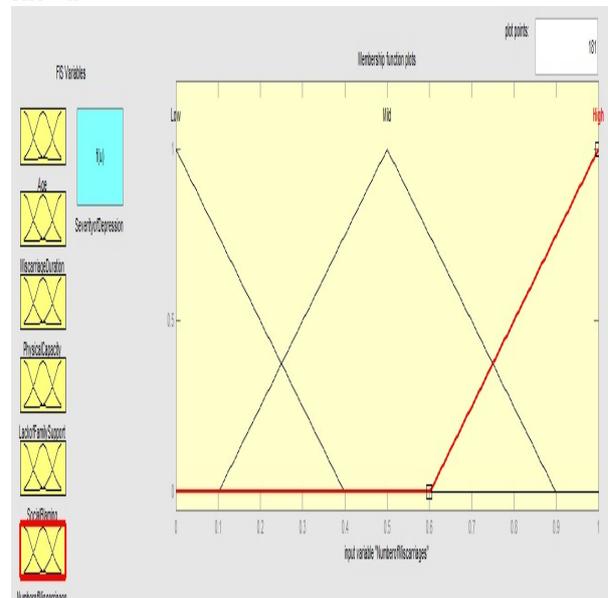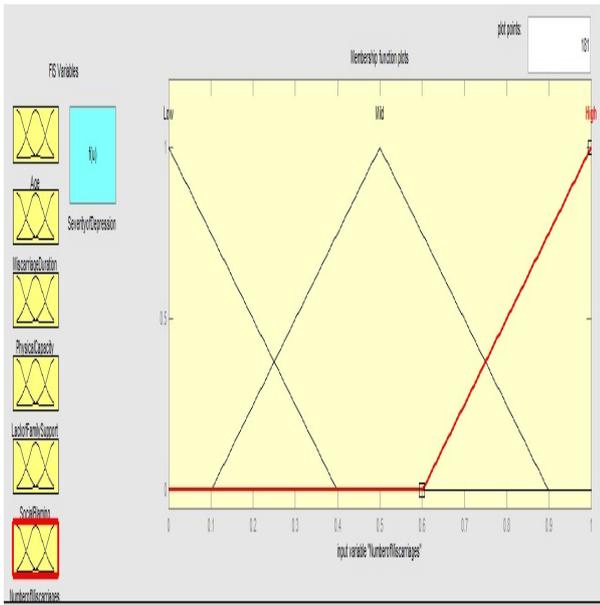

Figure 2 family support and social blaming, and output

4.2 Membership Function Plot:

In this step, we have defined membership functions for all inputs along with their suitable ranges, thus defining the level of severity as low, mild and high of depression as shown in

Figure 3.

Figure 3 the level of severity

Figure 4 Rule Viewer of Proposed System
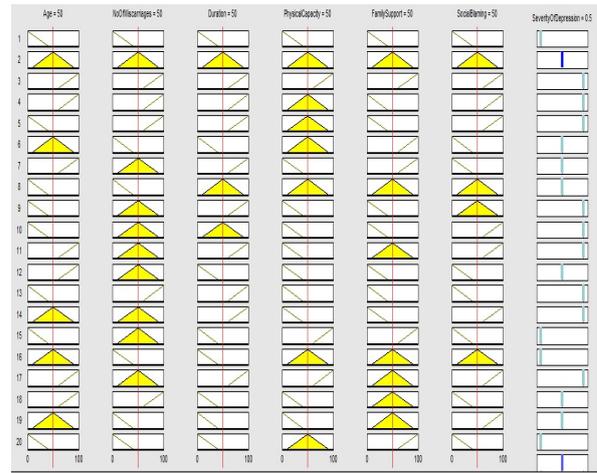
4.3 Rule Viewer of Proposed System:

The   rule   viewer   in
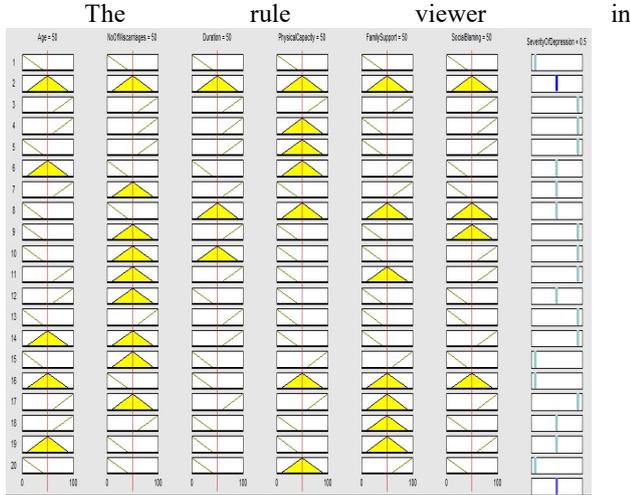

Figure **4** shows the on sight view of our proposed system in which we have defined different rules of the membership functions. The rules show how the shape of membership functions has an impact on the final result.

4.4 Training and Testing Performance:

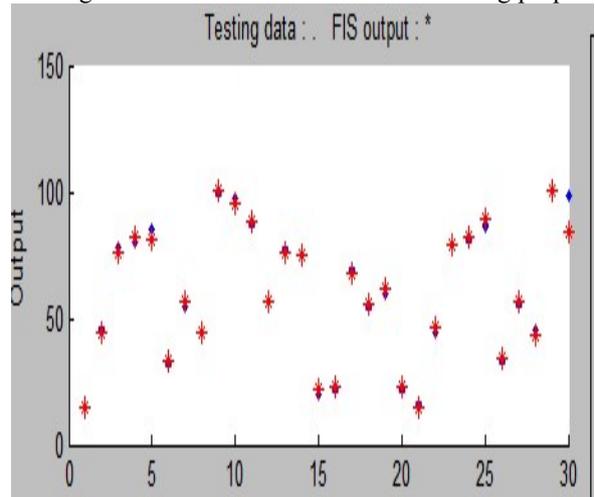In our sample data, we have used 70% of data for training whereas 30% of data is used for testing purpose. In

Figure 5, blue dots represent training data and red stars represent testing data.
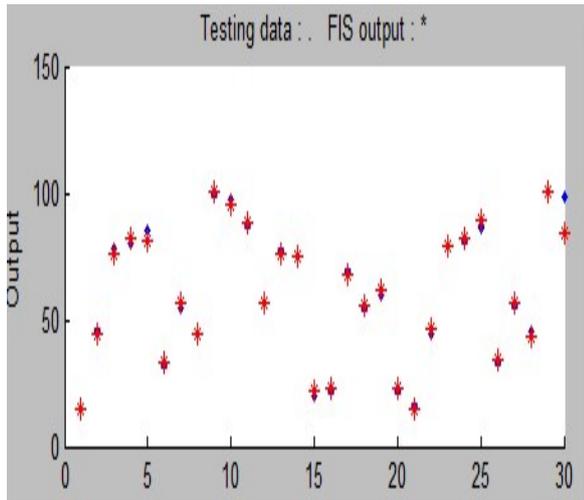
Figure 5 Training and Testing Performance**:**

4.5 Error in training and testing of data:

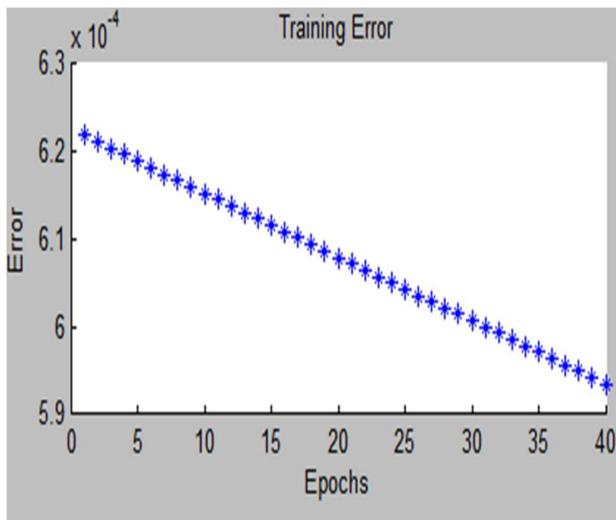The error of the training system came out to be 0.00059 and the average testing error was 1.507 as shown in Figure **6**.

Figure 6 Error in training and testing of data:

4.6 Surface Viewer

Figure 7 shows the 3-D plot obtained with any two inputs showing on horizontal axis and an output showing on vertical axis. The surface viewer provides the ability to examine the system at diverse angles for additional corrections.
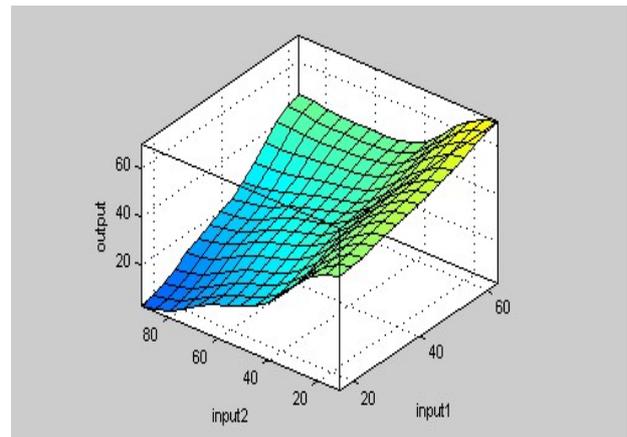

Figure 7 Surface Viewer

4.7 Neuro Fuzzy Inference Model

After the completion of training, the neuro fuzzy inference model is shown in Figure with 6 inputs and one output with their different combinations.
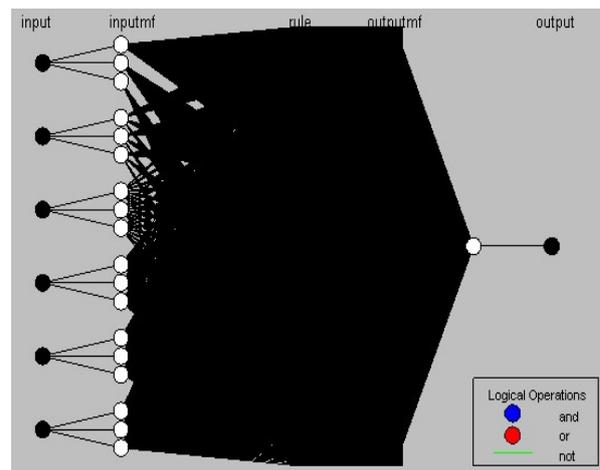

Figure 8 Neuro Fuzzy Inference Model

5. COPING METHODS

Coping mechanisms are necessary to lessen the grief of miscarriage women and also to help them to come out of their loss. Coping can be done religiously or psychologically. For most people, religiosity carries a wide-ranging approach towards living and formulates the arrangement of denotation by way of which they come into contact with and be familiar with the world and the way it goes by, causing the world to appear nonthreatening, harmless, unbiased, intelligible, and, in the long run, manageable. The grieving ones take solace by turning towards God and building a stronger connection with The Almighty. Psychological coping entails dealing with the depression and sadness of the huge loss, support from the closest ones is sought for understanding and comfort. Often therapy and counseling is pursued in order to not deal with the loss alone. Allowing time to grieve and remember helps cope better and timely than simply pushing away the thought of having lost the unborn child. It was concluded that most women indulge in religious coping after having gone through an occurrence as severe as a miscarriage. Whether religious or not, those women turned to religion to feel comfort in the remembrance of God and find relief from Quranic verses and hadiths. All of the participants grew to have a transformed relationship with God; the transformation being inclined towards the positive side. They matured to have a different outlook on life in general in comparison to how they perceived earlier.

6. CONCLUSION

Mental health is as important as physical health but people in developing countries are still not responsive of the importance of mental health specialists which results in people going into depression. One of the major targets of this depression is women going through post miscarriage period. Therefore, we have created a fuzzy-genetic system to help women in different areas of the country to seek help from the system and also cope with the depression they face. Fuzzy systems have gained a lot of importance in the past few years and are widely used in different fields such as medical, engineering and others.

Fuzzy is vagueness by meaning but may provide accurate information due to this vagueness whereas genetic algorithm provides optimization techniques which helps in avoiding difficult mathematical functions. In this paper, with the help of genetic algorithms, firstly, we have separated and selected those women who previously have faced or may face post miscarriage depression. Secondly, with fuzzy systems, we have defined certain inputs along with their membership functions and rules to check the severity of depression in those women. We have used sugeno model in fuzzy logic design as it gives better results for adaptation problems. Training and testing of system is done in Matlab which gives the training error and average testing error of the severity of depression in miscarriage women. Thirdly, certain coping methods have also been defined for such women to help them overcome their grief. This system is especially designed for women of rural areas for helping them come out of the suffering of the depression they face due to less availability of a psychiatrist.

REFERENCES

[1] *Fuzzy Logic Controlled Genetic Algorithms.* Song, Y. H., et al. September 8, 1996, Proceedings of the Fifth IEEE International Conference, Vol. 2, pp. 972-979.

[2] *Fuzzy Logic in Control Systems: Fuzzy Logic Controller.* Lee, Chuen Chien. 2, March/April 1990, IEEE Transactions on Systems Man, and Cybernetics, Vol. 20, pp. 404-418.

[3] *Grief Following Miscarriage: A Comprehensive Review of the Literature.* Brier, Norman. 3, April 2008, Journal of Women's Health, Vol. 17, pp. 451-464.

[4] Prevalence of positive depression screen among post miscarriage women- A cross-sectional study. Mutiso, et al. 1, December 2018, BMC Psychiatry, Vol. 32.

[5] *DNA Methylation biomarkers of post-partum depression risk.* Kaminsky, et al. October 22, 2015, U.S. Patent Application No 14/439,468.

[6] *The role of religious beliefs in pregnancy loss.* Allahdadian, Maryam and Irajpour, Alireza. 99, December 30, 2015, Journal of Education and Health Promotion, Vol. 4.

[7] *Miscarriage: Emotional burden and social suffering for women in Pakistan.* Batool, Shahida, Syeda and Azam, Hareem. 10, November 25, 2016, Death Studies, Vol. 40, pp. 638-647.

[8] *Breaking the silence of African American women: healing after pregnancy loss.* Van and Paulina. 3, April 30, 2001, Health Care for Women International, Vol. 22, pp. 229-243.

[9] *Fuzzy Expert System for Miscarriage Depression.* Ohri, et al. March 23, 2016, Wireless Communications, Signals Processing and Networking, International Conference, IEEE, pp. 2487-2492.

[10] *Genetic Algorithms and Machine Learning.* Goldberg, E., David and Holland, John H. 2, October 1, 1988, Machine Learning, Vol. 3, pp. 95-99.