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A Rule based Fuzzy controlled Decision Support System for Management of Breast Cancer

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Abstract - Breast cancer is one of the most common cancers all around the world and an early diagnosis of breast cancer plays a very vital role in the survival of the patient. Though there are plenty of experienced doctors, top range imaginary devices and advanced radiological techniques etc. but still computer assisted decision support system for the diagnosis of breast cancer can help a lot to medical staff for the said decease. This paper introduces a fuzzy logic (FL) based decision support system (DSS) for identifying the risk of breast cancer a person can have. The primary focus of the paper is on the algorithm used to identify the risk of breast cancer that a patient may have based on seven input parameters. The proposed system uses seven input parameters; namely age, genetic factor, menopause age, HER2, age of first pregnancy, alcohol intake & body mass index (BMI) which is based on diagnosis risk degree and one output which identify risk status of breast cancer recurrence or mortality in early diagnosed patients. Different medical practitioners dealing with the said decease were consulted before setting up the rule base. Through decision support system, the meaning of transferred data is translated into linguistic variables that can be understood by non-experts. Mamdani inference engine is used to deduce from the input parameters to stage the risk level of breast cancer.

Keywords - Fuzzy Logic, Fuzzy Inference Systems (FIS), Decision support system, Breast Cancer, risk analysis

I. INTRODUCTION

Breast cancer, the most common type of cancer in women with the exception of skin cancer, is a disease which is characterized by cells in the breast that become abnormal and multiply uncontrollably, finally forming a tumor. If timely not treated then malignant cells may eventually spread beyond the original tumor to other parts of the body. Hormones also play a role in the development of certain types of breast cancer. Skin changes, pain, nipple discharge, a lump are among the major signs of breast cancer. Breast cancer's causes are not exactly clear.

According to the National Cancer Institute, the incidence of breast cancer is highest in white women for most age groups, followed by African-American/black, Hispanic/Latina, Asian/Pacific Islander, American Indian/Alaska Native women [19]. African-American women have higher breast cancer incidence rates before 40 years of age, and higher rates of dying from breast cancer than women of any other racial/ethnic group [21][23]. Breast Cancer Symptoms includes a breast lump, breast pain, a noticeable change in the size or shape of a breast, dimpling of skin on part of the breast (like an orange peel), redness or a rash-like appearance to the skin on the breast, flaky or crusty looking skin around the nipple, inward turning nipple and nipple discharge (perhaps with blood). While it is in an early stage, finding and treating breast cancer, before it spreads beyond the breast and through the lymphatic system, offers the best possible prognosis. In the field of breast cancer, decision support system (DSS) is very important. Many DSSs have been developed in cancer management as ONCOCIN [24], Lisa [25]. The diagnosis of disease involves several levels of uncertainty and imprecision [26]. Many medical applications use fuzzy logic for a better solution of the above like MILORD [27], DOCTORMOON [28], and MDSS [29].

In this paper, a fuzzy based algorithm is proposed to identify the risk of breast cancer that a patient may have based on seven input parameters; namely age, genetic factor, menopause age, HER2, age of first pregnancy, alcohol intake & body mass index (BMI) which is based on diagnosis risk degree and one output which identify risk status of breast cancer recurrence or mortality in early diagnosed patients. Different medical practitioners dealing with the said decease were consulted before setting up the rule base.
Rest of the paper is organized as follows. Section 2 gives the related work done by earlier researchers in the said field of

decision support system for breast cancer using fuzzy logic. Section 3 gives the general Structure of Fuzzy Logic based Decision Support System. Design of the proposed system is given in section 4. Finally work is concluded in section 5.

II. RELATED WORK

One of the leading causes of death among women worldwide is breast cancer and about one third of the costs of cancer treatment can be reduced if cases are detected and treated early, as per World Health Organization [1]-[2], [18]-[21]. Healthcare processes are increasingly becoming computerized to provide better security, reliability and robustness to services and procedures. Computational Intelligence (CI) is applied to the processing of information necessary for the medical diagnosis [3]-[7]. A carcinogen breast tumor is a breast mass that is growing abnormally and uncontrolled. There are three popular methods for breast cancer diagnosis: mammography; FNA with visual interpretation; and surgical biopsy [17]. The ability of these methods to diagnose cancer correctly when the disease is present is: mammogram - from 68% to 79%; FNA with visual-interpretation - from 65% to 98%; and surgical biopsy - 100%. [18]. It is noted that: mammography lacks sensitivity; the sensitivity of FNA with visual interpretation varies greatly (as a result of the visual interpretation); and although surgical biopsy is accurate it is also a very intrusive, time-consuming and expensive method [19].
Computational Intelligence (CI) enables, through intelligent techniques CI enables the development of intelligent systems that imitate different aspects of human behavior like learning, perception, reasoning etc. [8]. Artificial Neural Networks, biological neuron-inspired technique [9]-[10]; Evolutionary Computation, inspired by biological evolution [11]; Expert Systems, inspired by inference process [11]; and Fuzzy Logic, inspired by language processing [22] are few examples of CI. Fuzzy set theory provides is a tool to model the imprecision and ambiguity that arises in complex systems [12]-[13]. Fuzzy systems defines the degrees of relevance were created from the combination of the concepts of classical logic and groupings of Łukasiewicz [14]. A comparative study of IRT and other imaging techniques for breast screening and have concluded that IRT provides additional functional information on the thermal and vascular condition of the tissues [15],[23]. Authors in [16]-[17] found that an aggregation of the knowledge, observation and experience of medical experts serves as the backbone of a fuzzy models based medical diagnostic system.

III. GENERAL STRUCTURE OF FUZZY LOGIC BASED DECISION SUPPORT SYSTEM

The general structure of fuzzy logic based decision support system is shown in figure 1. During fuzzificationn sub-process all seven crisp inputs are changed to fuzzy inputs with the use of membership functions. For properly adapting the output fuzzy inference sub-procedure uses if-then rules during fuzzy inference. There are a total of 1458 rules (3*2*3*3*3*3*3= 1458) in each fuzzy set. These rules determine the output. During aggregation sub-procedure minimum of membership function of all inputs is determined for each rule. Results of aggregation sub-procedure are used for composition. A membership function for each region of the output parameter is calculated using the rule base and the values determined in the aggregation step. Min-max procedure is used for composition. During defuzzification subprocedure, the fuzzy output values are converted into real numbers. The defuzzification method used in this work is Weight-of-Average-Formula.

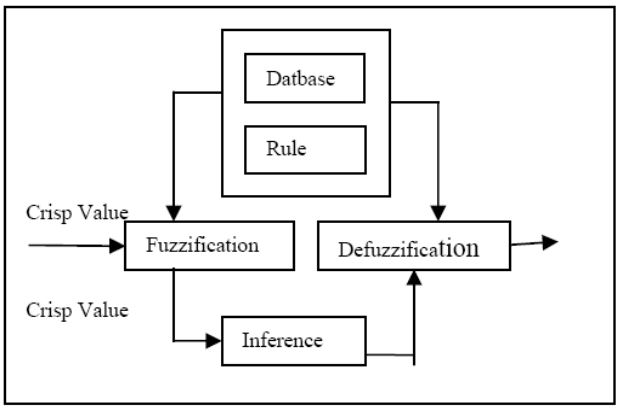

Figure 1: General Structure of Fuzzy Logic based Decision Support System

IV. DESIGN OF THE SYSTEM

Fuzzy decision support system designing, membership functions, fuzzy rule base, fuzzification and defuzzification are shown in this section. In the proposed system a total of seven inputs are chosen which determines the output.

A. Input Variables

1. Age

Age plays a vital role in case of breast cancer. In our case, we have taken three ranges of age, young, middle and old. Fuzzy sets for input variable Age are shown in Table 1. Figure 2 shows the membership function of the input age.

Table 1: Fuzzy sets for Input variable Age

Linguistic variable	Range	Fuzzy sets
Age	0-25	Young
	20-60	Middle
	50-80	Old

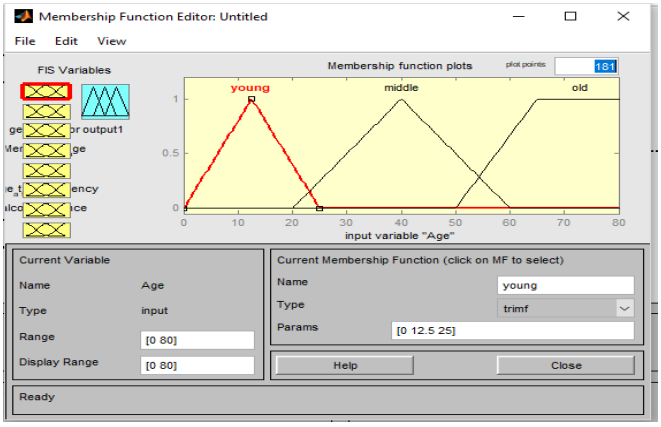

Figure 2: Membership function of the input age

2. Genetic Factor

Genetics of the decease also plays a vital role in case of breast cancer. In our case we have taken three ranges of none, fair and 1st degree. Fuzzy sets for input variable genetic factor are shown in Table 2. Figure 3 shows the membership function of the input genetic factor.

Table 2: Fuzzy sets for Input variable Genetic Factor

Linguistic variable	Range	Fuzzy sets
Genetic Factor	0-0.7	None
	0.5-1.5	Fair
	1.1-2.0	1st Degree

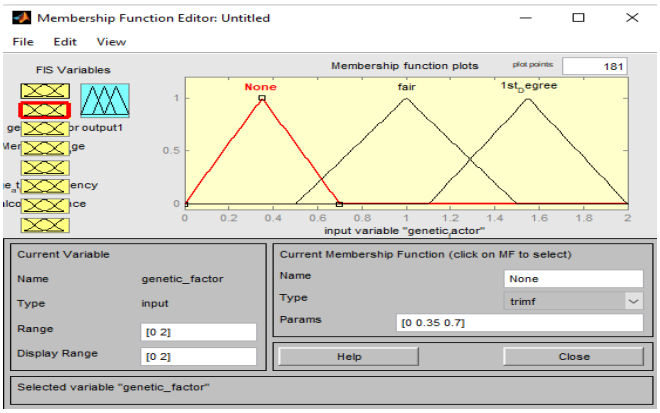

Figure 3: Membership function of the input genetic factor

3. Menopause Age

Menopause age plays a vital role in case of breast cancer. In our case we have taken two ranges, normal and late. Fuzzy sets for input variable Menopause age are shown in Table 3. Figure 4 shows the membership function of the input genetic factor.

Table 3: Fuzzy sets for Input variable Menopause age

Linguistic variable	Range	Fuzzy sets
Menopause age	40-50	Normal
	45-60	Late

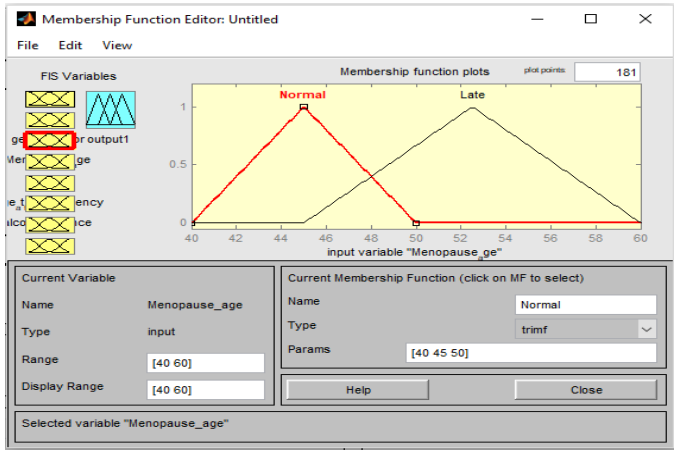

Figure 4: Membership function of the input Menopause age

4. HER2

HER2 stands for "Human Epidermal growth factor Receptor 2." It is a protein giving higher aggressiveness in breast cancers. This input variable has three fuzzy sets are negative, negative/positive and positive. Fuzzy sets for input variable HER2 are shown in Table 4. Figure 5 shows the membership function of the input HER2.

Table 4: Fuzzy sets for Input variable Genetic Factor

Linguistic variable	Range	Fuzzy sets
Genetic Factor	0 - 3.0	Negative
	1.5 - 3.0	Negative/Positive
	1.5 - 4.0	Positive

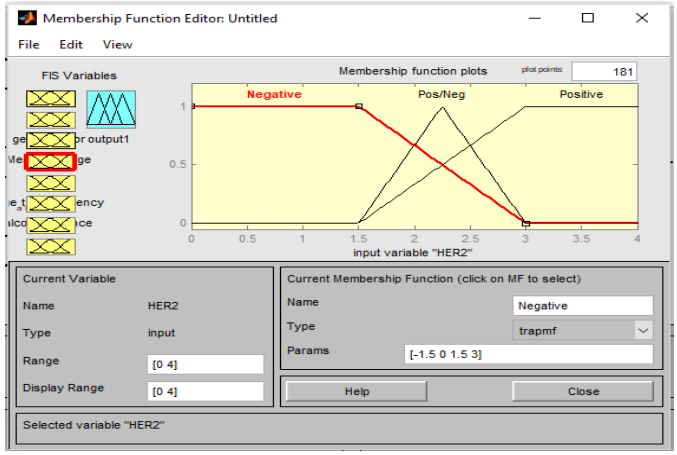

Figure 5: Membership function of the input HER2

5. Age of First Pregnancy

Age of first pregnancy also plays a vital role in breast cancers. This input variable has three fuzzy sets, early, normal and late. Fuzzy sets for input variable age of first pregnancy are shown in Table 5. Figure 6 shows the membership function of the input age of first pregnancy.

Table 5: Fuzzy sets for Input variable Age of First Pregnancy

Linguistic variable	Range	Fuzzy sets
Age of First Pregnancy	15-20	Early
	20-30	Normal
	30 above	Late

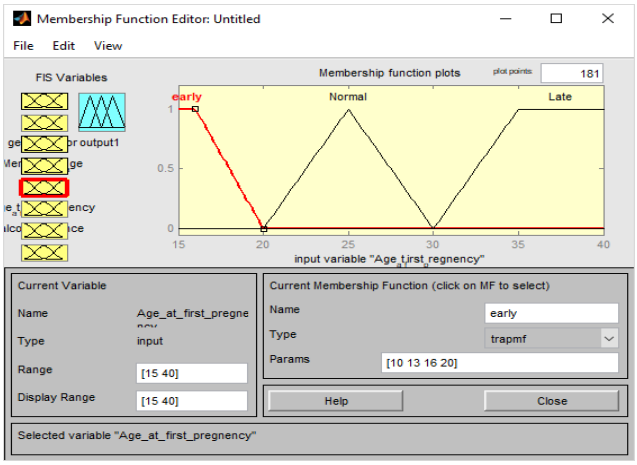

Figure 6: Membership function of the input Age of First Pregnancy

6. Alcohol intake

Alcohol intake also plays a vital role in breast cancers. This input variable has three fuzzy sets, low, medium and high. Fuzzy sets for input variable alcohol intake of first pregnancy are shown in Table 6. Figure 7 shows the membership function of the input alcohol intake.

Table 6: Fuzzy sets for Input variable Age of Alcohol intake

Linguistic variable	Range	Fuzzy sets
Alcohol intake	0-1.5	Low
	1-4	Medium
	2.5-4.0	High

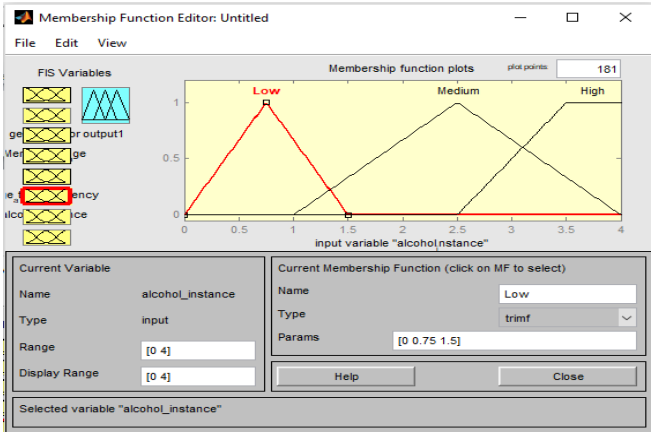

Figure 7: Membership function of the input Alcohol intake

7. Body Mass Index (BMI)

Body Mass Index (BMI) intake also plays a vital role in breast cancers. This input variable has three fuzzy sets, low, medium and high. Fuzzy sets for input variable of Body Mass Index (BMI) are shown in Table 7. Figure 8 shows the membership function of the input Body Mass Index (BMI).

Table 7: Fuzzy sets for Input variable of Body Mass Index (BMI)

Linguistic variable	Range	Fuzzy sets
Body Mass Index (BMI)	10-25	Low
	20-35	Medium
	30-45	High

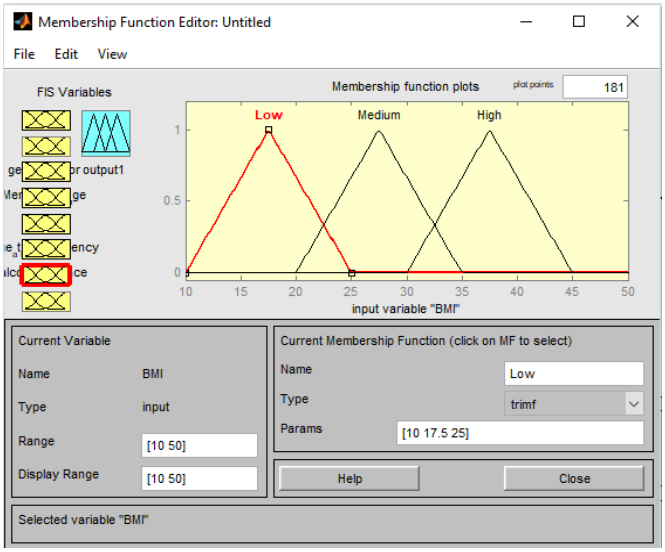

Figure 8: Membership function of the input Body Mass Index (BMI)

B. Output Variable

Aim of the present work is to identify risk status of breast cancer recurrence or mortality in early diagnosed patients. The output variable is a value from 1 to 4; representing Healthy, Low Risk status, Risky status and Extremely Risk status. This output variable has four fuzzy sets, Healthy, Low Risk status, Risky status and Extremely Risk status. Fuzzy sets for output variable are shown in Table 8. Figure 9 shows the membership function of the output.

Table 8: Fuzzy sets for Output variable

Linguistic variable	Range	Fuzzy sets
Output variable	0-30	Healthy
	25-55	Low Risk
	50-80	Risky
	75-100	Extremely Risky

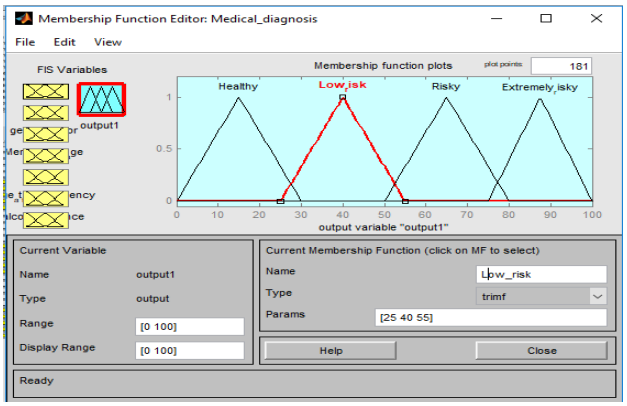

Figure 9: Membership function of the output

C. Fuzzy Rule Base

For rule base various doctors dealing with the breast cancer in women have been consulted. The rule base determine the Risk status (Healthy, Low Risk status, Risky status and Extremely Risk status) by evaluation of the input variables mentioned above. Figure 10 shows the Rule Viewer.

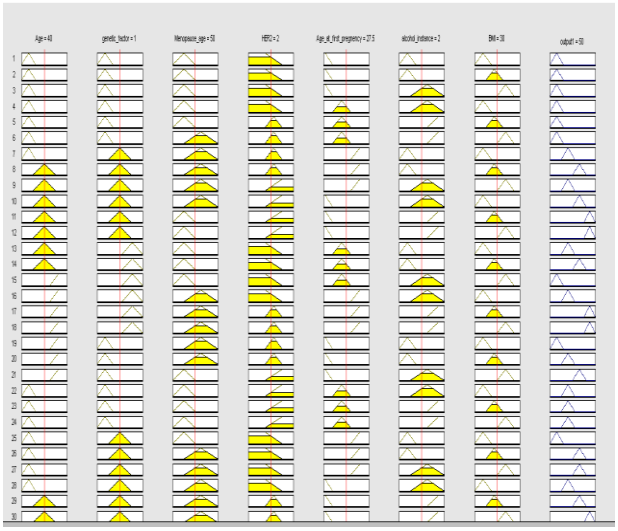

Figure 10: Rule Viewer

D. Fuzzification & Defuzzification

This system depends on Mamdani model for inference mechanism. Aggregation method between rules is maximum to combine output fuzzy set. Fuzzification method used is min-max and Defuzzification method is centroid.

V. CONCLUSION & FUTURE WORK

Breast cancer, the most common type of cancer in women with the exception of skin cancer. It is a disease which is characterized by cells in the breast that become abnormal and multiply uncontrollably, finally forming a tumor. If timely not treated then malignant cells may eventually spread beyond the original tumor to other parts of the body. An early diagnosis of breast cancer plays a very vital role in the survival of the patient. Though there are plenty of experienced doctors, top range imaginary devices and advanced radiological techniques etc. but still computer assisted decision support system for the diagnosis of breast cancer can help a lot to medical staff for the said decease. This paper introduced a fuzzy logic based decision support system for identifying the risk of breast cancer a person can have. Proposed system used seven input parameters; namely age, genetic factor, menopause age, HER2, age of first pregnancy, alcohol intake & body mass index (BMI) which is based on diagnosis risk degree and one output which identify risk status of breast cancer recurrence or mortality in early diagnosed patients. Different medical practitioners dealing with the said decease were consulted before setting up the rule base. Through decision support system, the meaning of transferred data is translated into linguistic variables that can be understood by non-experts. Mamdani inference engine is used to deduce from the input parameters to stage the risk level of breast cancer.

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