Fuzzy Database and Fuzzy Logic for Fetal Growth Condition

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ABSTRACT---- ***Humans have a remarkable capability to reason and make decisions in an environment of uncertainty, imprecision, incompleteness of information, and partiality of knowledge, Fuzzy logic technology has achieved impressive success in diverse engineering applications ranging from mass market consumer products to complicated decision and control problems. Database is collection of data which is related by some aspect. Database is a well known method for collect information. Data aids in producing information which is based on facts. A database system stores data, in such a way which is easier to retrieve, manipulate and helps to produce information. In this work, a medical fuzzy database is introduced to help users in providing correct information when there is uncertainty in database. In this paper, a fuzzy database management system is introduced to Fetus Growth and predicts Fetus condition to diagnose the seriousness of the disease of Fetus by using available data in the common database systems.***

Keywords--- fuzzy Logic, fuzzy database, membership function, linguistic variable, Matlab, C

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1. INTRODUCTION

Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. The data collection component of research is common to all fields of study including physical and social sciences, humanities, business, etc. While methods vary by discipline, the emphasis on ensuring accurate and honest collection remains the same.

There are huge data management tools available within health care systems, but analysis tools are not sufficient to discover hidden relationships amongst the data. Most of the medical information is vague, imprecise and uncertain. Extracting correct information from this data is considered an art. Washington, Jan 26 (ANI): Feeling stressed during pregnancy is not good for fetal development, says a new study. To test whether high stress levels in pregnant mice had an impact on their offspring, pregnant mice received the natural glucocorticoid corticosterone at different times during pregnancy, either from day 11 to 16 (20 females), from day 14-19 (31 females), or not at all (74 control females).Researchers found that increased levels of glucocorticoid stress hormones caused to a decrease in foetal weight.

Having fuzzy data management capability in a database is important to be able to store vague data. Ignoring vague data management means the risk of losing important information, which may be useful for some applications. A database that supports vague, imprecise and uncertain information is called a fuzzy database. It is based on fuzzy logic and fuzzy set theory which is introduced by Zadeh [1].

This paper is organized as follows: first describes related work then about Expert's Opinion regarding the risk factors of featal growth and fuzzy sets after that deals with the methodology and proposed system which includes Algorithm of the system, Membership functions, Input and Output of the system, C program, System testing, lastly will conclude and discuss future outcomes.

2. RELATED WORKS

There are many papers published related to the diagnosis of various diseases.

Shrandhanjali [2] developed a Fuzzy Petri net application for Heart Disease Diagnosis. The rule based is associated with transition for certainty factors. The fuzzy Petri net is drowning for the rule base and get decision of the disease, truth value proposition is used.

Lavanya et al. [3] designed a Fuzzy rule based inference system for detection and diagnosis of lung cancer. The dataset is used from domain expert with symptoms, stages and treatment facilities to provide an efficient and easy method to diagnose lung cancer.

Adeli et al. [4] proposed a Fuzzy expert system for the Heart Disease Diagnosis. The developed system uses fuzzy logic. In their system the crisp value is fuzzified to get fuzzy values. The expert system uses those fuzzy values and the output is also fuzzy. The fuzzy output is defuzzified to get a crisp output.

Sony et al. [5] designed an Intelligent and Effective Heart Disease Prediction System using weighted associative classifiers. They used Java as front end and Ms Access as backend tool. They only consider two cases for prediction (Heart disease and No Heart Disease).

Neshat et al. [6] developed a Fuzzy Expert System for diagnosis of Liver Disorder. They considered two cases, people with healthy liver, and people with unhealthy liver along with calibration of disease risk intensity measure. The fuzzy inference system is developed in MATLAB software.

Kadhim et al. [7] implemented a fuzzy expert system which was to diagnosis the back pain. The rules were developed by experts and decision sequence is illustrated by a decision tree.

Rehana Parvin and Dr. Abdolreza Abhari developed Fuzzy Database for Heart Disease Diagnosis using SQL.

All the works explained above are the developed systems that use Fuzzy Logic to diagnose disease. Most of them is based on developing a fuzzy inference engine by using MATLAB and SQL.

The difference between our work and theses works is we build our system based on the available data existing and developed a system that uses C program.

3. EXPERT'S OPINION REGARDING THE RISK FACTORS OF FETAL GROWTH AND FUZZY SETS OF THE SYSTEM

Here a very brief explanation of Fuzzy theory in medical application is presented. A crisp property P can be defined $\mu: x \rightarrow \{0, 1\}$ whereas a fuzzy property can be described by $\mu: x \rightarrow [0, 1]$. $\mu(x)$ indicates the degree to which x has the property.

For example: in case of fever, the linguistic variable is high fever. If the body temperature(x) is greater than 39 degree Centigrade then in medical concept $\mu(x)$ for high fever is 1 it means x has surely 'High Fever'. If x is less than 38.5 degree centigrade then $\mu(x)$ of medical concept ' High Fever' is 0, which means x surely does not have 'High Fever'. If x is in the interval [38.5 degree Centigrade, 39 degree Centigrade] then x has a property of high fever with some degree (i.e., membership function) between [0, 1].

In our proposed system, the inputs have fuzzy sets according to the range that they fall in. Then, to achieve more accurate result the inputs are connected with the membership function multiplied by output membership function to generate the rules strength.

According to the medical Science the major risk factors of Fetal Growth are Age, blood pressure, blood sugar, haemoglobin, Thyroid-stimulating Hormone (TSH), Biparietal diameter (BPD), Head Circumference., Abdominal Circumference and Femur Length, Fetal Weight**.**

Therefore, in our system input variables are: Age, blood pressure, blood sugar, haemoglobin, Thyroid-stimulating Hormone (TSH),Biparietal diameter (BPD), Head Circumference., Abdominal Circumference and Femur Length, Ultrasound Fetal Weight Estimation. The Output is the fetal growth Condition shown as the linguistic terms.

4. METHODOLOGY AND PROPOSED SYSTEM

In this section, first the algorithm and methodology are explained and then the system functions and testing are illustrated.

Algorithm

Step I: Inputs are Age, blood pressure, blood sugar, haemoglobin, Thyroid-stimulating Hormone (TSH), Biparietal diameter (BPD), Head Circumference., Abdominal Circumference, Femur Length,Fetus Weight.
Step II: The Output is the fetal growth Condition shown as the linguistic terms.
Step III: Each input variable has fuzzy variables.
Step IV: Each Fuzzy variable associated with membership function
Step V: The rules strength is calculated based on the membership function of the fuzzy variable.
Step VI: Fetal Growth condition is calculated by taking the maximum of the selected output set as final result.

Membership Function, Input and Output

i) Age: As a woman ages, it takes longer to conceive and the risk of not being able to get pregnant increases. Also, the risk of miscarriage, and complications in pregnancy and childbirth, increase.

Table 1: Age

Input Field	Range	Linguistic Representation
Age	<30 30-35 35-40 40>	Young Mid Old Very Old

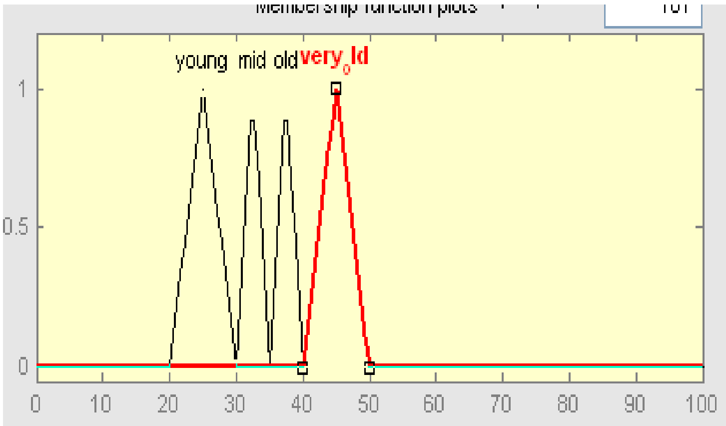

Figure 1: Membership function for Age

ii) Blood Pressure: Another important risk factor is Blood Pressure. It can be Systolic, Diastolic and Mean types. In our system, we consider Systolic Blood Pressure. It is possible to choose any type of Blood Pressure. This field has four fuzzy sets. The ranges for the Linguistic variable representation are given in Table 2. The membership function is calculated based on the range.

Table 2: Blood Pressure

Input field	Range	Linguistic Representation
Blood Pressure	< 134 127- 153 142-172 154>	Low Medium High Very High

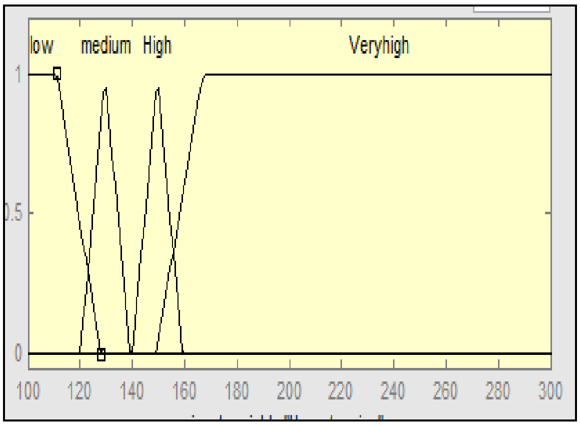

Figure 2: Membership function for Blood Pressure

iii) Blood Sugar: This field plays an important role in changing the results. It has two linguistic representations. Each fuzz variable is associated with membership function based on the range. The ranges of fuzzy sets are given in Table 3.

Table 3 Blood Sugar

Input Field	Range	Linguistic Representation
Blood Sugar	>=120 <120	Yes(1) No(0)

iv) Haemoglobin: plasma volume expansion in normal pregnancy causes a drop in maternal hemoglobin to concentrations commonly regarded as indicating anemia; in fact, concentrations of 95–115 g/L with a normal mean corpuscular volume (84–99 fL) should be regarded as optimal for fetal growth and well-being and are associated with the lowest risk of preterm labor. Routine hematinic administration to women with values in these ranges is probably unnecessary.

Table 4: Haemoglobin:

Input field	Range	Linguistic Representation
Haemoglobin	< 8 8-11 11-14 14>	Low Medium High Very High

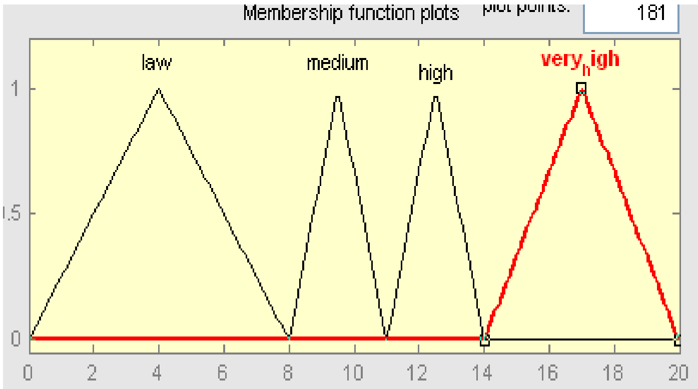

Figure 3: Membership function for Haemoglobin.

v) Thyroid-stimulating Hormone (TSH) - The thyroid gland is a small gland in the neck that secretes thyroid hormone. Thyroid hormone plays an important role in the metabolism of the body and is involved in nearly every body function. The thyroid hormone is present in two forms, T3 and T4. A part of the hormones is attached to protein, whereas some part is present as free hormone.

The hormone that controls the secretion of thyroid hormone is Thyroid-stimulating Hormone (TSH), which is secreted by a small gland in the brain called the pituitary. Thus, if the level of thyroid hormone is low, the pituitary secretes more TSH to stimulate the thyroid. The reverse is the case if the thyroid hormone levels are high.

The condition where thyroid hormone levels are low is referred to as hypothyroidism while the condition where thyroid hormone levels are high is referred to as hyperthyroidism. Hypothyroidism is more common in pregnancy as compared to hyperthyroidism.

Hypothyroidism during Pregnancy: Hypothyroidism is more common during pregnancy as compared to hyperthyroidism. If untreated, it can result in goiter in the fetus and even malformations. However, if it is detected at the right time, the condition can be easily treated with thyroid hormone tablets, thus preventing any adverse consequences.

Hyperthyroidism during Pregnancy: Hyperthyroidism can also have serious consequences on the mother as well as the baby if it is untreated. In pregnancy, a drug calle propylthiouracil is preferred for its treatment.

Thyroid disease in pregnancy can affect the health of the mother as well as the child before and after delivery. Thyroid disorders are prevalent in women of child-bearing age and for this reason commonly present as an intercurrent disease in pregnancy and the puerperium.[1] Uncorrected thyroid dysfunction in pregnancy has adverse effects on fetaland maternal well-being. The deleterious effects of thyroid dysfunction can also extend beyond pregnancy and delivery to affect neurointellectual development in the early life of the child. Demand for thyroid hormones is increased during pregnancy which may cause a previously unnoticed thyroid disorder to worsen. Still, the overall lack of evidence precludes a recommendation for universal screening for thyroid disorder in all pregnant women.

Table 5: Thyroid-stimulating Hormone (TSH)

Weeks Gestation after 15 weeks	Range	Linguistic Representation
Thyroid-stimulating Hormone (TSH)	0.3 – 4 .5 <0.3 >4.5	Normal (1) Hyperthyroidism(0) Hypothyroids(0)

vi). Biparietal diameter (BPD) - The biparietal diameter (BPD) is among the most accurate 2nd trimester measures of gestational age. Measured from the beginning of the fetal skull to the inside aspect of the distal fetal skull ("outer to inner") at the level of the cavum septum pelucidum, this is one of the basic fetal measurements. Using this same image, the frontal occipital diameter (FOD) is obtained and the fetal head circumference (HC) is either obtained directly, or by formula from the BPD.BPD can be used to determine gestational age with a 95% confidence of 10 to 14 days. If the gestational age is already known with precision (1st trimester ultrasound scan), then the BPD can be used to evaluate fetal growth. In cases of symmetrical growth retardation, the fetal BPD will fall below the 10th percentile.

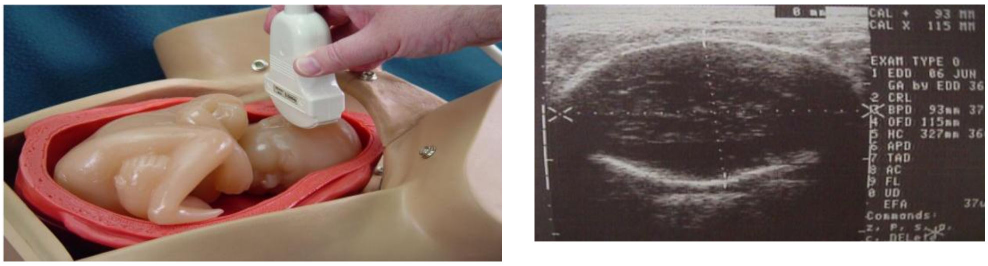

Figure 4: Scanning for the BPD and Biparietal Diameter

Table 6:.BPD

Weeks Gestation after 15 weeks	Range	Linguistic Representation
Biparietal diameter (BPD)	< 28 28-30 30-32	Very Critical Critical Normal

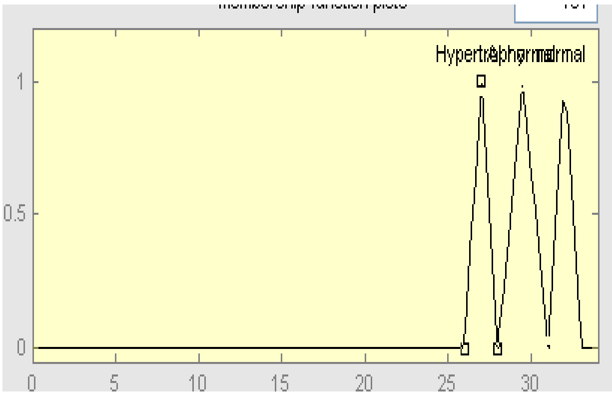

Figure 5: Membership function for BPD

vii) Head Circumference.

Head circumference is a measurement of a child's head around its largest area. It measures the distance from above the eyebrows and ears and around the back of the head.

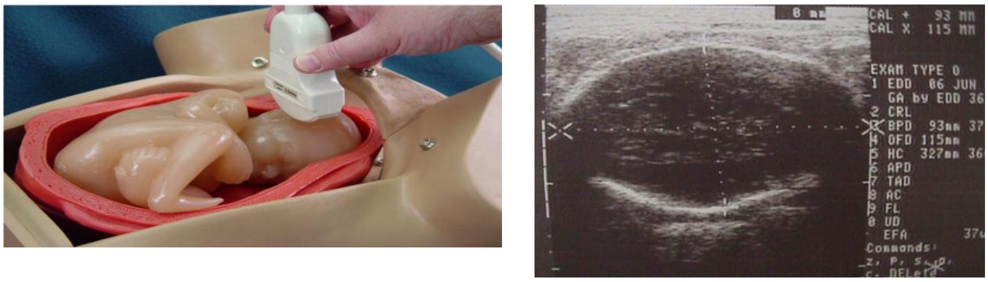

Figure 6: Scanning for the HC and Head circumference.

Table 7: HC

Weeks Gestation after 15 weeks	Range	Linguistic Representation
HC	< 100 100-106 106-112	Very Critical Critical Normal

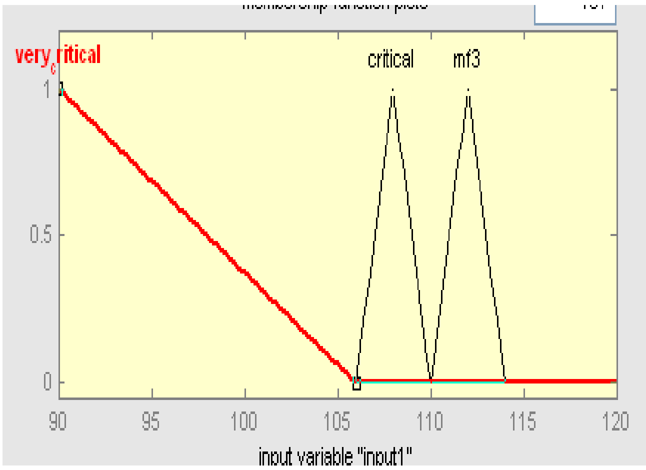

Figure 7: Membership function for HC

viii) Abdominal Circumference:

The abdominal circumference (AC) is a transverse section (coronal) through the fetal abdomen at the level where the umbilical vein enters the liver. The AC may be measured directly, or calculated from the AP and transverse abdominal measurements. Both techniques give good results. Although the AC can be used to calculate gestational age, it is more useful in determining fetal weight. Combined with the BPD, with or without the fetal femur length, reliable formulas can be used to predict fetal weight.

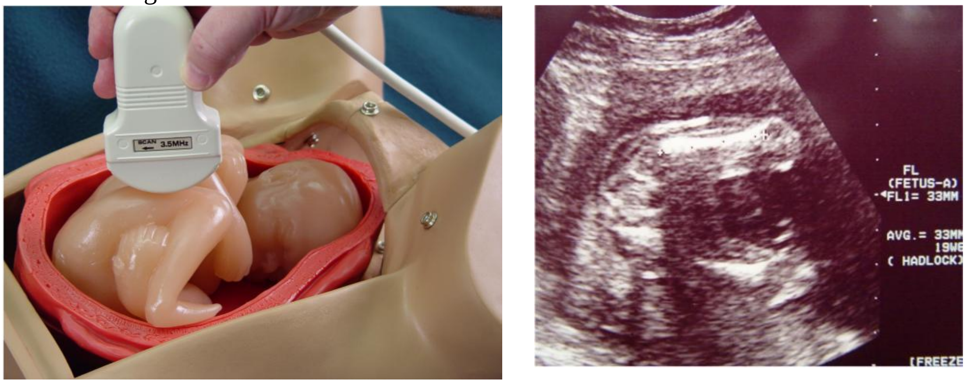

Figure 8: Scanning for the AC and AC Circumference

Table 8: AC

Weeks Gestation after 15 weeks	Range	Linguistic Representation
AC	< 90 90-92 92-94	Very Critical Critical Normal

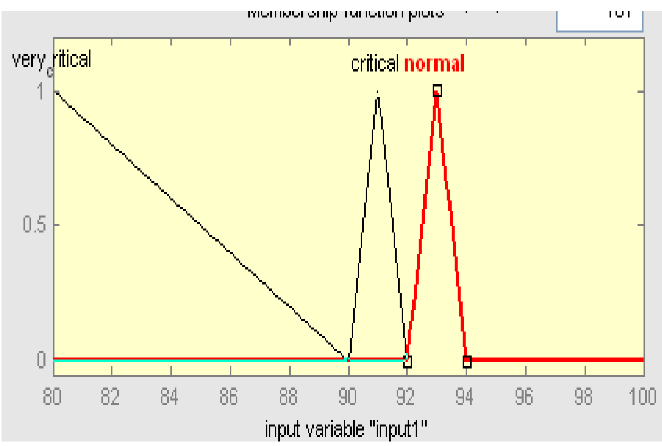

Figure 9: Membership function for AC

ix) Femur Length: -

The femur length can be used to determine gestational age, but it is more useful in helping evaluate fetal weight. It is also useful as a marker for fetal malformation and genetic abnormality. Many, though not all, trisomy 21 fetuses will have shortened femurs.Identify the fetal pelvis. Keeping one end of the transducer over the fetal pelvis, slowly sweep the other end of the transducer in a clockwise fashion toward the fetal small parts. The fetal femur will be found at about a 45 degree angle away from the fetal spine.Slowly move the transducer back and forth until the longest bright echo within the femur is identified. This is the fetal femur length.

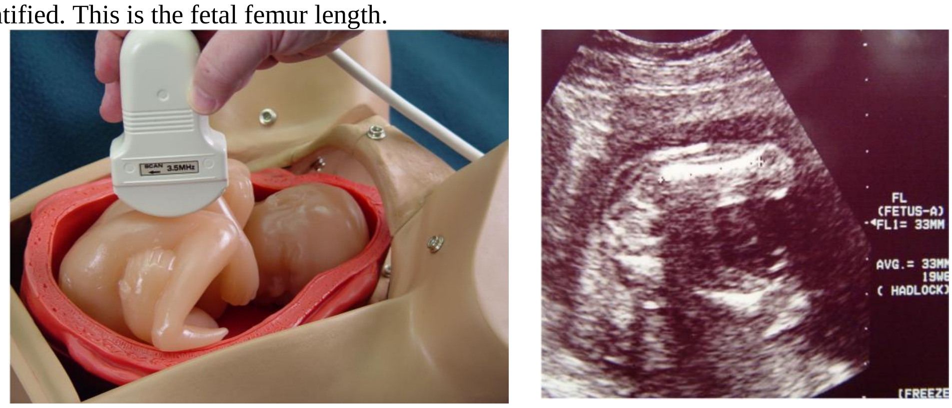

Figure 10: Scanning for the FL and Femur Length

Table 9: FL

Weeks Gestation after 15 weeks	Range	Linguistic Representation
FL	< 15 15-17 17-19	Very Critical Critical Normal

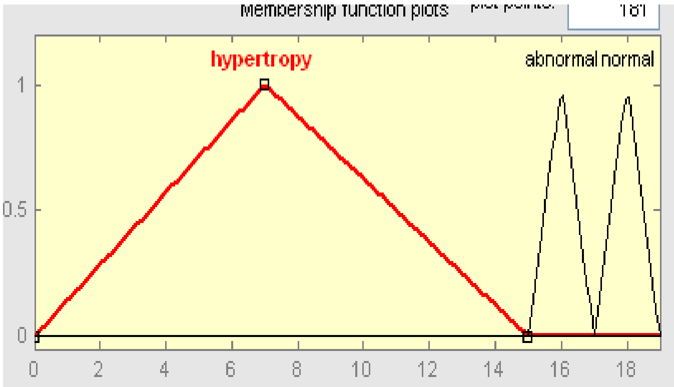

Figure 11: Membership function for FL

x) Ultrasound Fetal Weight Estimation

One of the most important reasons for prenatal visits and for doing an ultrasound examination is to estimate fetal size. If the fetus is too small, for example, there may be a problem with the placenta, or with the fetus, and if it's too big, the mother could have gestational diabetes.

Traditionally, doctors or midwives estimate fetal size by measuring the height of your uterus in centimeters or by placing their hands on the outside of the uterus and feeling for the fetus.

However, measuring the uterus or estimating fetal weight manually is not foolproof because many factors can affect the examination, such as the mother's weight and height, the thickness of the uterus, the size of the placenta, and the amount of amniotic fluid. Ultrasound measurements of the fetus's head, abdomen, and upper thighbone provide a more accurate way to determine size.

But unlike weighing the baby on a scale after birth, even the best ultrasound measurements aren't 100% reliable. And no method of checking fetal size before delivery can provide more than an estimated fetal weight (EFW).

These four ultrasound measurements are the ones used most frequently to estimate fetal weight:

- HC: Head circumference
- BPD: Biparietal diameter, or the distance between the sides of the fetus's head
- AC: Abdominal circumference, the most important measurement because it most accurately reflects fetal size
- FL: Femur length, a measurement of the upper thighbone, the longest bone in the body.

These four measurements are entered into a mathematical formula that's used to calculate the estimated fetal weight. There are many different formulas for weight estimation, and even the best ones have a 15% margin of error in 85% of all fetuses. In other words, about one in seven fetuses will weigh 15% more or less than estimated.

In addition to these four measurements there are also other measurements of the fetus that can be done during an ultrasound examine.

Table 10: Fetal Weight

Weeks Gestation after 15 weeks	Range	Linguistic Representation
Fetal Weight	< 60 60-66 67-73	Very Critical Critical Normal

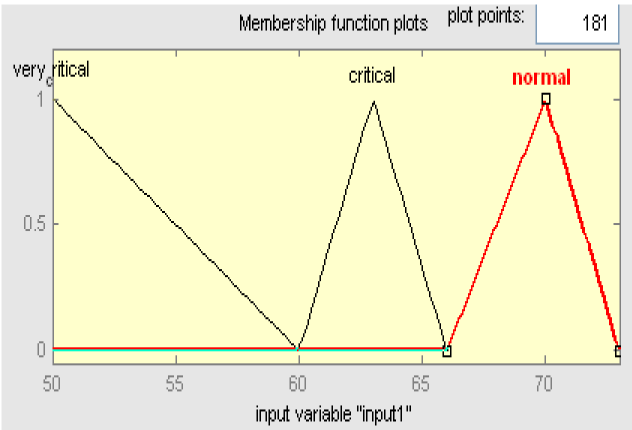

Figure 12: Membership function for fetal weight

xi) Output: The output is the presence of fetal Growth valued from 0(Healthy condition) to 8. If the integer value decrease then the Fetal disease risk increases. We divide the Output fuzzy sets {Healthy, Mild, Moderate, and Severe}.The ranges and membership function for output variable are given below:

Table 11: Output

Output Field	Range	Fuzzy sets
Result	< = 7 7- 8 8 -9 9-10	Severe Moderate Mild Healthy

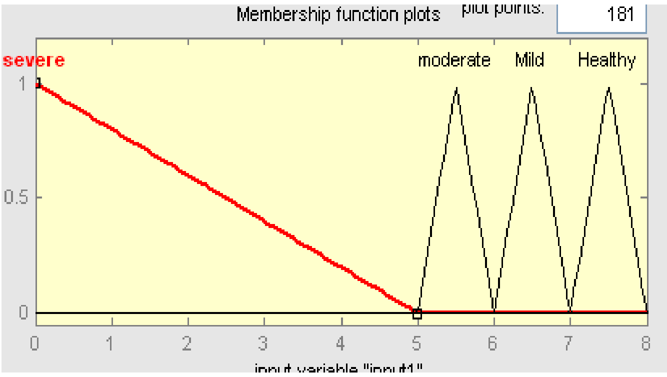

Figure 13: Membership function for Output

C Program

```
/* C-Program Of Fetal Growth Condition*/
#include <stdio.h>
#include<conio.h>
void main()
{float o,y1, y2,bp1,bp2,bs1,bs2,h1,h2,bpd1,bpd2,ac1,ac2,hc1,hc2,fl1,fl2,th1,th2,fw1,fw2;
clrscr();
printf("\nEnter your age=");
scanf ("%f",&y1);
if(y1<=26)
{
y2=((y1-20)/6);
}
else
y2=((40-y1)/14);
printf("\n%f",y2);
printf("\nEnter your blood pressure=");
scanf ("%f",&bp1);
if(bp1<=135)
{
bp2=((bp1-110)/25);
}
else
bp2=((160-bp1)/25);
printf("\n%f",bp2);
printf("\nEnter your blood sugre=");
scanf ("%f",&bs1);
if(bs1<=120)
{
bs2=1;
}
else
bs2=0;
printf("\n%f",bs2);
printf("\nEnter your Hemoglobin=");
scanf ("%f",&h1);
h2=((h1-7)/6);
printf("\n%f",h2);
printf("\nEnter your Thyroid Value=");
scanf ("%f",&th1);
if(0.3<th1<4.5)
{
th2=1;
}
else
th2=0;
```

```
printf("\n%f",th2);
printf("\nEnter your BPD=");
scanf ("%f",&bpd1);
if(bpd1<=32)
bpd2=((bpd1-26)/6);
else
bpd2=((38-bpd1)/6);
printf("\n%f",bpd2);
printf("\nEnter your HC=");
scanf ("%f",&hc1);
if(hc1<=111)
hc2=((hc1-105)/6);
else
hc2=((117-hc1)/6);
printf("\n%f",hc2);
printf("\nEnter your AC=");
scanf ("%f",&ac1);
if(ac1<=93)
ac2=((ac1-86)/7);
else
ac2=((100-ac1)/7);
printf("\n%f",ac2);
printf("\nEnter your FL=");
scanf ("%f",&fl1);
if(fl1<=18)
fl2=((fl1-14)/4);
else
fl2=((22-fl1)/4);
printf("\n%f",fl2);
printf("\nEnter your Fetal Weight=");
scanf ("%f",&fw1);
if(fw1<=70)
fw2=((fw1-65)/5);
else
fw2=((75-fw1)/5);
printf("\n%f",fw2);
o=y2+bp2+bs2+h2+bpd2+ac2+hc2+fl2+th2+fw2;
printf("\nOut of 10 = %f",o);
printf("\nFetal Growth condition is ");
if(9.0<o && o<=10)
printf("\nHealthy");
else if(8.0<o && o<=9)
printf("\nMild");
else if(7<o && o<=8)
printf("\nModerate");
else
printf("\nsevere");
getch();
}
```

Some outputs for the developed system are shown above.

```
Enter your age=25
0.833333
Enter your blood pressure=135
1.000000
Enter your blood sugre=90
1.000000
Enter your Haemoglobin=11
0.666667
Enter your Thyroid Value=0.3
1.000000
```

Enter your BPD=31
0.833333
Enter your HC=111
1.000000
Enter your AC=94
0.857143
Enter your FL=19
0.750000
Enter your Fetal Weight=70
1.000000
Out of 10 = 8.940476
Fetal Growth condition is **Mild**

5. CONCLUSION AND FUTURE WORK

Fuzzy data analysis solves many critical problem of life. In this paper a new method based on the fuzzy theory has been developed to solve the problem of fetal growth condition under the fuzzy environment. In this method, through a numerical example, calculations involved in this method have been illustrated. The method proposed in this paper has shown more effective in determining the fetus condition week by week. However, building fuzzy inference system based on current database applications is rare. In the medical diagnosis, there are huge collections of data available in the regular databases. In our proposed fuzzy database system we use the same data with the C-program to build fuzzy rules. The advantage of our developed system is that we can use the available data existing in the current database systems for decision making. In future, we want to extend our work doing more research on using fuzzy database for other diseases like cancer, diabetes and Brain diseases etc.

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