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Development of Intelligent Application for Diagnosis of Gestational Diabetes Mellitus Disease in Pregnant Women

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ABSTRACT

Glucose intolerance during pregnancy or in women with reduced glucose tolerance after pregnancy termination is known as gestational diabetes mellitus. One of the main reasons pregnant women die is gestational diabetes mellitus (DMG). One of two factors can lead to diabetes: either insulin resistance (the body does not fully respond to insulin) or an autoimmune reaction (the body's defense system assaults the cells that make insulin). If there is an increase in both the 2-hour postprandial and fasting blood glucose levels between weeks 24 and 28 of pregnancy, DMG illness is manually diagnosed. Blood pressure and body mass index calculations are part of the physical examination in the early stages of pregnancy. Analyzing risk variables such age, hypertension, hyperlipidemia, prior history of gestational diabetes, family history of diabetes mellitus, and history of giving birth to infants weighing more than 4,000 grams (macrosomia) is essential during the anamnesis. Doctors also evaluate the results of the examination. Developing a machine learning model to identify early gestational diabetes mellitus (DMG) in expectant mothers is the aim of this study. Artificial Neural Network (ANN) Backpropagation is the technique employed. Prior to being incorporated into the JST model, the dataset is cleaned and normalized. The optimal model for diagnosis is obtained by processing and testing the JST model. 94% accuracy is the resultant accuracy.

KEYWORDS: gestational diabetes mellitus disease; pregnant women; diagnosis

ARTICLE DETAILS

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I. INTRODUCTION

One of the biggest health issues in the globe is diabetes. It is a disorder caused by insufficient insulin production or utilization by the body, which is responsible for transporting glucose into the body's cells and enabling it to enter and fuel them. Diabetes mellitus, sometimes known as "diabetes," is a chronic illness marked by elevated blood glucose (sugar) levels (Nilashi, Abumalloh, Alyami, Alghamdi, & Alrizq, 2023).

In 2019, the International Diabetes Federation published its research on the number of people with diabetes worldwide. Indonesia ranks 2nd after China in the West Pacific region with 10.7 million people out of a total adult population of 172.2 million. That means there are about 6.2% of adults in Indonesia suffering from diabetes. Of these patients, 115.6 thousand people died. That means about 1.1% of the total people with diabetes died. There are 73.7% of people who have not been diagnosed with diabetes in Indonesia, meaning that these people have the opportunity to suffer from diabetes (Webber, 2013).

Meanwhile, the prevalence of gestational diabetes has increased over the past few decades (Parikh, Bhargava, & Shukla, 2024). Diabetes mellitus is a collection of symptoms that arise in a person due to increased blood sugar levels and insufficient insulin hormones. Pregnant women with diabetes mellitus may experience a number of problems. One of the factors contributing to maternal and newborn mortality is DMG. The World Health Organization defines maternal mortality as death that occurs during pregnancy or within 42 days following the end of pregnancy and is caused by any cause connected to or made worse by pregnancy or its care, but is not brought on by an accident or injury (Who, 2008). One of the leading causes of death for expectant mothers is gestational diabetes mellitus (GDM). It ranks as the ninth most common cause of death for women worldwide. 10–25% of cases of DMG disease go undiagnosed (Silmina, Hardiani, & Robi'in, 2020). One of the causes of death in pregnant women is the lack of information or knowledge about the risk factors of DMG inherent in mothers during pregnancy, resulting in low efforts to prevent death.

Early detection is one of the preventive measures that can be taken by people with diabetes. In many cases, early information related to diabetics helps in disease avoidance, cure and relevant disease treatment. Many computer systems are built by embedding human intelligence that is useful to the sufferers in disease management. Research conducted by Devi (Devi, Bai, & Nagarajan, 2019) tried to diagnose diabetes using data mining methods. Sequential Minimal Optimisation Support Vector Machine (SMO-SVM) and Farthest First (FF) are the techniques employed.

The data is grouped into many clusters using the Farthest First algorithm, and the clustering output is then fed into the SVM classifier. Patients will be categorized as either diabetes or non-diabetic. 768 samples of diabetic individuals from the Pima Indians Dataset are included in the dataset used to diagnose the disease. According to experimental findings, the suggested unified method predicts diabetes mellitus with a classification accuracy of 99.4%.

Sisodia has did research on diabetes with the goal of creating a model that can most accurately forecast a patient's risk of developing the disease (Sisodia & Sisodia, 2018). Naive Bayes, Decision Trees, and Support Vector Machines are the techniques employed as classifiers. The Pima Indians Diabetes Database (PIDD), which was obtained from the UCI machine learning repository, was used for the experiments. According to the results, each algorithm's accuracy is 76.30% for Naïve Bayes, 65.10% for Support Vector Machines, and 73.82% for Decision Trees.

This study was conducted out of concern that many people are negatively affected by diabetes mellitus with the incidence rate continuing to rise. Most diabetic patients are unaware of the risk of prediabetes that leads to the actual disease. In this study, the main objective of this research is to classify diabetic diseases with machine learning methods. Improving the estimating model's accuracy and making it adaptable to multiple datasets are the primary problems this study aims to address. Data collecting, data preparation, and classification model construction are the primary tasks involved in this study**.** The diabetes-related benchmark dataset in this study was obtained from the Kaggle website.

Pregnancy-related medical record data management software and software to identify gestational diabetes mellitus (DMG) in pregnant women using the Backpropagation Artificial Neural Network expert system method are the two primary focuses of this study. The developed application is expected to help pregnant women and midwives in recognising gestational diabetes mellitus (DMG) during pregnancy based on the symptoms and examination results of pregnant women.

II. RESEARCH METHOD

A. Materials

Data collection in this study was carried out through literature studies and interviews with experts, namely obstetricians. Words and deeds are the primary data sources in qualitative research; the remaining data comes from documents and other sources. This research obtained two types of data, namely: Primary data obtained through direct interviews with obstetricians (experts) then the data is stored through recording and recording.

B. Detection Of Diabetes Mellitus in Pregnant Women

There is currently little research on the use of expert systems for the automatic identification of gestational diabetes mellitus (GDM) in expectant mothers. To conduct a study, previous research results related to this study are needed in order to compare the accuracy results in the study. Previous research used as a reference for conducting this study. The first previous study conducted by Prasatya (Prasatya, Siregar, & Arianto, 2020) examined the Application of the K-Means and C4.5 Methods for Diabetes Prediction. In this study, the K-Means technique and C4.5 were combined to predict HbA1C. The Diabetes 130 US Hospitals for Years 1999-2008 Dataset served as the study's source of data. After data cleaning, the original data, which totaled 101767, was reduced to 17019. K-Fold Cross Validation will be used to validate the prediction results and assess the accuracy level. The obtained accuracy value was 72 percent.

Kumari and Chitra (Kumari & R.Chitra, 2014) investigated "Classification of Diabetes Disease Using Support Vector Machine" in their second study. This study employed the RBF kernel in conjunction with the SVM algorithm. The 460 data samples from the Pima Indian diabetes dataset were used in this investigation. The SVM approach produced classification results with an average accuracy of 78%, sensitivity of 80%, and specificity of 76.5%.

As can be seen from the preceding description, the current state of research indicates that the detection of gestational diabetes mellitus (GDM) in pregnant women is still done by hand. Few studies are now being conducted on the creation of intelligent systems to identify gestational diabetes mellitus (GDM) in expectant mothers. K-Means and C4.5, two traditional techniques, are still used by the expert system to identify Gestational Diabetes Mellitus (GDM) in expectant mothers. The modeling of the calculation process's uncertainty using the K-Means and C4.5 methods is typically still up for debate, and data processing needs to be done multiple times for more than two data sets. This is the methods' drawback. While the weakness of the Support Vector Machine method is that it can decrease the accuracy obtained. This decrease is because the data used is mostly error-value and does not vary. In addition, the data used does not go through a preprocessing process first. The goal of the research is to create an artificial intelligence-based application for detecting gestational diabetes mellitus (GDM) in expectant mothers. The Backpropagation Artificial Neural Network (ANN) is the technique employed. Momentum is added to the development of the backpropagation algorithm. A change in weight depending on the direction of the gradient of the prior pattern and the current pattern is known as momentum in a neural network. In order to speed up the learning process toward convergence, momentum parameters are added to the artificial neural network. Additionally, the experimental results demonstrate that this approach can swiftly and steadily bring the network to convergence. This backpropagation algorithm with momentum is the contribution and novelty of the proposed research. Intelligent systems will be very much needed, especially in the classification process in determining Gestational Diabetes Mellitus (GDM) in normal pregnant women and pregnant women with Gestational Diabetes Mellitus (GDM). Figure 1 illustrates the steps involved in creating an intelligent application that uses artificial intelligence to identify gestational diabetes mellitus (GDM) in expectant mothers.

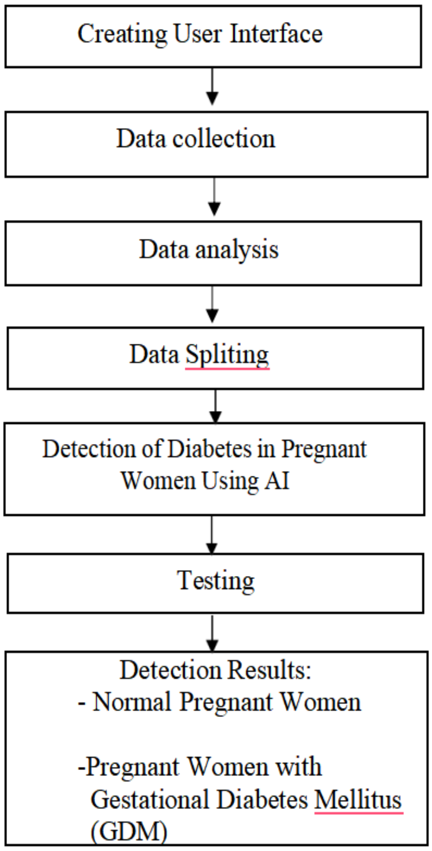

Figure 1. Research Stages

1. Data Collection

Analyzing, creating, and constructing an artificial neural network system are the phases of data collection. The Health Center or Integrated Health Post provided the secondary data used in this investigation. A hospital physician or midwife has validated the secondary data utilized in this study.

2. Analysis Stages

In order to facilitate the application design process, the analysis stage is when the data required for the training and testing phases of Backpropagation is analyzed, along with the requirements of developing applications. Input data and data transformation are included in the data analysis that is done. The input data is the symptoms of gestational diabetes mellitus (GDM) in pregnant women. Data transformation is the process of converting the symptom data into a scale of 0 to 1 so that the training and testing phases of backpropagation can be determined.

3. Data Distribution

The data is separated into training and testing data at the data division stage. At the data division stage, 30%, 20%, and 10% of the data are used for testing, and 70%, 80%, and 90% are used for training. from all of the pregnant women's data.

4. Detection of Gestational Diabetes Mellitus (GDM) in Pregnant Women Using Backpropagation

a. To enable the system to perform training in line with Backpropagation training, the first step of the system training procedure involves using pre-existing training data. The final weight will be determined upon the completion of the training phase. Testing will then be done using this final weight. The following is an explanation of the Backpropagation process: a. Choose a value from 0 to 1 to start the initial weight with that modest, random value. Establish the highest learning rate and era. A maximum epoch of 1000 and a learning rate of 0.1 will be applied in this example of manual computation.
b. Provide the target class and input variables (X1 to Xn) as training data.
c. The feedforward propagation stage, backpropagation, and weight and bias adjustments with the inclusion of momentum parameters are the three stages that make up the training stage. Complete each of the three steps in the computation process.
d. Complete the training procedure as many times as the predetermined maximum number of epochs.
e. Following the training phase, the final weights will be saved for use during the testing phase.
f. Testing. At this point, the system will undergo testing using the supplied data. The purpose of this step is to ascertain whether the output generated matches the real data.
g. Calculating Accuracy, Sensitivity and Specificity.

To test the accuracy of the proposed method using the Receiver of Characteristic (ROC) method. By comparing the classification results of the developed system with the detection results from experts (doctors or midwives). Four values, true positive, false negative, false positive, and true negative, will be obtained by comparing the classification results with the groundtruth, which consists of health center midwives, using the Receiver of Characteristic (ROC) method. A true positive (TP) denotes a normal state that has been accurately classified based on its class. A normal status that should be appropriately identified in its class but is misidentified during the classification process is known as a false positive (FP). An aberrant status that is recognized as normal is called a true negative (TN). An abnormal status that is recognized as belonging to the abnormal class is indicated by a false negative (FN). Sensitivity, or the true positive rate (TPR) value, is derived from these four numbers.

III.RESULT AND DISCUSSION

The phases of data collecting align with the phases of analysis, design, and building the architecture of an artificial neural network**.** The dataset used is the Gestational Diabetes Mellittus (GDM) dataset from Kaggle. The data used include: 2-hour blood sugar levels, Fasting blood sugar levels, Diastolic blood pressure, Body mass index, Several pregnancies and Diabetes pedigree. There are two categories of data used in this investigation. The data used for training comes first. This information will be utilized in the classification procedure. The data utilized during the testing procedure comes in second. A total of 400 patients with gestational diabetes mellitus (GDM) comprise the data.

The input variables in the system are the symptoms experienced by pregnant women while the output variable is the pregnancy status. The output variables based on the input variables are explained in Table 1.

TABLE 1. TYPES OF OUTPUT VARIABLES BASED ON INPUT VARIABLES

Output Variable (Disease)	Input Variable (Symptom)
Gestational Diabetes Mellittus (GDM)	2-hour blood sugar level
	Fasting blood sugar level
	Diastolic blood pressure
	Body mass index
	Number of pregnancies
	Diabetes pedigree

The next process is to determine all the variables used, namely input variables and output variables. Table 2 shows the Fuzzy set of each input variable for DMG. The output variable is pregnancy status.

TABLE 2. FUZZY SET OF EACH INPUT VARIABLE FOR GESTATIONAL DIABETES MELLITUS

Input Variable (Symptom)	Fuzzy Set	Range
2-hour blood sugar level	Normal	x<130 mg/dL
	High	130<x<190 mg/dL
Fasting blood sugar level	Normal	x≤125 mg/dL
	High	125<x< 145 mg/dL
Diastolic blood pressure	Normal	x < 80 mmHg
	High	80< x < 110 mmHg
Body mass index	Normal	18<23 kg/cm
	High	23<30 kg/cm
Number of pregnancies	Normal	≤4
	High	5-9
Diabetes pedigree	Normal	<0,49
	High	0.50 <x< 0.53

This stage is made to map each input to the output to be achieved. The creation of Fuzzy rules is consulted with experts (obstetricians). Fuzzy IF-THEN rules with Fuzzy inference engines have good capabilities to describe complex systems such as nonlinear, multivariable or unpredictable. The design of these rules is a step after the formation of fuzzy sets. The rules in the system design for DMG rules totaling 64 rules are shown in Table 3.

TABLE 3.RULES FOR DIAGNOSING GESTATIONAL DIABETES MELLITUS

2-hour Blood Sugar Level	Fasting Blood Sugar Level	Diastolic Blood Pressure	Body Mass Index	Number of Pregnancies	Diabetes Pedigree	Pregnancy Status
Normal	Normal	Normal	Normal	Normal	High	Normal Pregnancy
Normal	Normal	Normal	Normal	High	Normal	Normal Pregnancy
Normal	Normal	Normal	Normal	High	High	Normal Pregnancy
Normal	Normal	Normal	High	Normal	High	Normal Pregnancy
Normal	Normal	Normal	High	Normal	High	Normal Pregnancy
----- ----	---- ----	---- ----	---- ----	---- ----	---- ----	---- ----
Normal	High	Normal	Normal	Normal	Normal	DMG
Normal	High	Normal	Normal	Normal	High	DMG
Normal	High	Normal	Normal	High	Normal	DMG
Normal	High	Normal	Normal	High	High	DMG
Normal	High	Normal	High	Normal	Normal	DMG

TABLE 4. RULES FOR GESTATIONAL DIABETES AFTER CONVERSION

2-hour Blood Sugar Level	Fasting Blood Sugar Level	Diastolic Blood Pressure	Body Mass Index	Number of Pregnancies	Diabetes Pedigree	Pregnancy Status
0	0	0	0	0	1	0
0	0	0	0	1	0	0
0	0	0	0	1	1	0
0	0	0	1	0	1	0
0	0	0	1	0	1	0
-----	----	----	----	----	----	----
----	----	----	----	----	----	----
0	1	0	0	0	0	1
0	1	0	0	0	1	1
0	1	0	0	1	0	1
0	1	0	0	1	1	1
0	1	0	1	0	0	1

The user interface of the developed system is shown in Figure 2. In Figure 2, it is explained that the user interface consists of several sections. The first section is the questionnaire section. Users can fill out a questionnaire according to the condition of pregnant women. The second part is the Gestational diabetes detection section. After filling out the questionnaire, the user can press the Detection Button, then the system will display the results of the Gestational Diabetes detection, and at the same time display the output weight value.

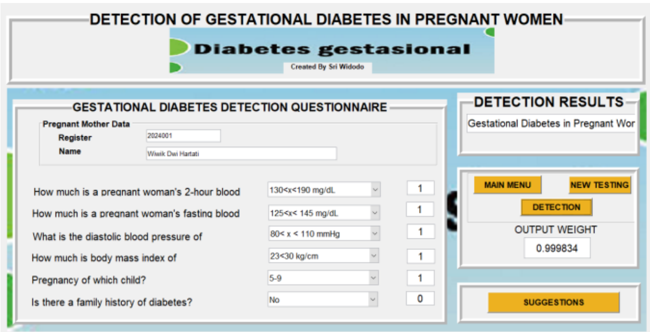

Figure 2. User Interface

This research paper presents a GDM prediction and classification model based on ML Backpropagation. Four stages of preprocessing, including format conversion, class, labeling, and missing value replacement, are first applied to the input medical data. replacement of missing values, normalization, and class labeling. The ML model is then given the processed data to identify the proper class labels. Lastly, the model is used in conjunction with voting classifiers to identify the proper class labels for the examples of applied data. The writers carried out in-depth tests on several facets to confirm the effectiveness of the model that was given. Based on the experimental analysis's findings, the Backpropagation model is said to have a 94% accuracy rate.

CONCLUSIONS

The conclusion of this study is that the Backpropagation method can detect Gestational Diabetes Mellitus. There are 6 input variables and 2 pregnancy statuses, namely normal pregnancy and gestational diabetes. The accuracy obtained is 94%.

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