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AI Driven Diabetic Foot Ulcers Prediction Using Deep Learning

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***Abstract*— Diabetes is a type of illness or problem which can't be treated surgically or operated on. Lack of consciousness regarding lifestyle can easily cause diabetes. Diabetes is generally caused because of a gain of weight, laziness, not taking a proper diet, etc. A person who is having diabetes should be very proactive about his health as it can also lead to death or more severe complications. One of such complications is Diabetic Foot Ulcers(DFU). One of the leading reasons of death in the world, diabetes can also result in complications like diabetic foot ulcers. (DFU). A patient's foot may be removed if their diabetic foot ulcer is handled improperly and late. With the use of a computer-assisted classifier, thermal imaging may be utilized to detect DFU signs early on. With the aid of deep learning neural networks, we plan to develop a model that may be utilised to aid patients by providing an early warning of diabetic foot ulcers. Big Data Analytics plays a noteworthy role in healthcare industries. With the help of big data, we can store a wide variety of data on different patients and have a wide range according to age groups. So, this will be helpful in getting hidden features from stored data. As we see the classification of data nowadays this is not that reliable. The use of the same dataset and different models are not giving that much accuracy. So our main focus is on increasing accuracy and getting better results for classification. We have referred few types of research which were done before so came to conclude we will use EfficientNet for better understanding the features of the images and it helps in increasing the accuracy of classification.**

Index Terms*— *Deep Learning, Convolutional Neural Network, EfficientNet, Artificial Intelligence, Classification, Diabetes Diagnosis, Diabetic Foot Ulcers, Healthcare Domain, Supervised Learning.

I. INTRODUCTION

Diabetes is an illness in which insulin level in blood get depleted below the normal level which is needed to stay healthy. This will cause malfunction of organs of body like patient will gets frequent urination, etc. If it is not treated on time, it can cause central numerous complications. This difficulty leads to demise. There are some specific diseases, which includes diabetes, kill around 19% of world's population. In 2000, deaths caused by diabetes increased by 72%, and in 2023, these deaths are expected to rise by 85%. Diabetes can be caused by many lifestyles' routine such as laziness, taking pills, heavy weight, etc.

Foot ulcers are among the most devastating effects of diabetes. Diabetes-related foot wounds known as diabetic foot ulcers (DFUs) are significant diabetes cases. According to reports, there were only 151 million diabetics globally in 2000; by 2014, that number had risen to over 422 million, and by 2021, it was projected to reach over 537 million.

The incidence of diabetes illness increased by 10.5% among persons over the age of 18 between 2000 and 2021. The major goal of our study is to develop a model that can be utilised for early diabetic foot ulcer prediction so that it may be treated appropriately and the patient doesn't have to lose a limb.

In this situation different Deep learning algorithms can be used to create a model which can predict whether ulcer is abnormal or normal. Diabetes can be cured at early stages if proper care is taken and proper medication is given to the patient. Artificial Intelligence approaches can assist in the earlydetection of this disease. The analytical model can identify and understand the incoming data, allowing it to make more specific decisions.

TABLE 1: PREVALENCE FACTS AND COUNTERMEASURES FOR DIABETES AND DIABETIC FOOT ULCERS

At the glint	Year			
	2000	2021	2030	2045
World adult (19–79 years) population (in billion)	3.2	7.9	8.6	9.5
Number of people with diabetes (in million)	151	537	643	783
Prevalence of diabetes (in percentage)	4.6%	10.5%	11.3%	12.2%
Diabetic foot ulcer with 15% prevalence (in million)	22.65	80.55	96.45	117.45
Number of people with diabetes in India (in millions)	32.7	74.2	101	124.9

Since the dataset consists of images we are using the concept of Convolutional Neural Networks (CNN). There are different CNN architectures that can be used for classification whether the ulcer is normal or not such as VGG, AlexNet, EfficientNet, etc.

We can use different architectures for better understanding the features of the images or dataset and this helps in for forecasting the disease. Deep Learning methods can help in detecting diabetic foot ulcers at its preliminary stages. This can help patient in detecting disease priory and taking necessary precautions in order to stay healthy**.**

II. LITERATURE SURVEY

It is known that patients' understanding of the effects of diabetes is low or non-existent, which contributes to complications. Analysts' assessment of DFU's findings included the use of different sensors and CNN models, although one or two widths, depths, or definitions of images were being considered. Thus, three highlights are taken into account when broadcasting the prediction of diabetic foot ulcer conclusion in this broadcast of a deep learning experiment, EfficientNet. By accurately distinguishing a diabetic foot from a normal foot, he can detect the severity of the foot ulcer and take timely action.

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Through an in-depth survey of the misconceptions (IA) articles that have supported DFU verification strategies, it is conceivable to consider the priorities of these strategies as well as the challenges facing them difficult to coordinate them in a realistic and solid system to achieve unattainable satisfaction understand governance.

To recognize diabetic foot ulcers, they examined the associated optical sensing and imaging strategies. The reflection takes into account the strength of the sensors as well as the physiology of the patient. The news source allows for a wide range of verification strategies and they have established restrictions on the adoption of AI innovation.

The use of a non-invasive photonic device has been recommended for the treatment of diabetic foot ulcers in diabetics. Using the concepts of hot and hyperspectral imaging, this utility studied the condition of the ulcer. The oxyhemoglobin and deoxyhemoglobin biomarkers were evaluated using these photon imaging methods. By combining flag management strategies that use deep learning to improve pixel accuracy and reduce stutter with super-resolution strategies, this utility has evolved.

Programmed DFU image classification has been proposed using a deep CNN called DFU QUTNet. When there are more layers, a normal CNN becomes very deep, but the implementation makes no progress. To extend the width of the network while maintaining the depth compared to current systems, the QUTNet DFU arrangement was implemented.

The ubiquity of corners seems to benefit mainly from sloppiness transmitted through the DFU QUTNet system on a number of different channels.

III. Problem Statement

Diabetes is becoming increasingly prevalent in today's environment. The major source of this significant condition is the individual's lifestyle. Diabetes can induce a variety of problems, some of which are life-threatening. One of these serious effects is diabetic foot ulcer. If adequate treatment is not received in time, a limb may be amputated.

When the person suffering from an ulcer is unable to walk properly, travelling to a nearby hospital or clinic is a challenging chore for such a person. With this project, a doctor or any family member may determine whether the ulcer is normal or pathological.

In addition, not all doctors are knowledgeable about all dis- eases, making it difficult to locate a doctor you can trust with such understanding.

Yet, in everyday life, the diabetic patient must determine whether he or she is indeed diabetic. A computerised system that can anticipate the right response without making any of these mistakes is required in order to prevent these blunders, and this may be accomplished with the use of DL.

TABLE 2: CNN Architectures and their number of layers

Model	No. of layers	Salient feature
AlexNet	8	Depth
VGG16	16	Very Deep CNN
VGG19	19	Very Deep CNN
GoogleNet	22	The depth and width-based CNN
DFUNET	14	The depth and parallel Conv. with homogeneous kernels.
DFU_QUTNet	30	Width-based network compared to the depth of the model.
DFU_SPNet	22	The depth and parallel Conv. with heterogeneous kernels.
EfficientNet	237	Depth, width, and high resolution

IV. Scope

Diabetic Foot Ulcers Prediction System is a project which will help both diabetic and non-diabetic people. Our project will be helpful for everyone but more helpful to non-diabetic people. We are thinking of adding the following features to our project

A. *Diabetic Foot Ulcer Test:*Using this feature any person can check whether the ulcer he/she having is abnormal or normal in nature.

*B.Doctor Consultation:*Using this feature anyone can consult to doctors and experts who will suggest you different activities which will help in improving your health as well as lifestyle.

C. *Expert System:*A person who doesn't have knowledge about this domain can use this project and get knowledge.

V. Methodologies Used

Artificial Intelligence

The Artificial Intelligence seminar provides an overview of AI that will enable you to understand the guiding principles of AI. These days, technology is ubiquitous, meaning that it is everywhere and that it is developing at a rapid rate. Artificial intelligence is one of the many booming computer science technologies that is being employed increasingly in a variety of fields. The world is being ruled by artificial intelligence, which is also providing us with fresh ideas daily to help us think critically and do something new.

Deep Learning & Convolutional Neural Networks

Deep Learning is a concept which is quite popular these days. It is basically the subset of machine learning and it uses neural networks for its working. Artificial neural networks make an effort to mimic how the human brain functions, however they fall far short of being able to match it, enabling it to "learn" from vast volumes of data.

Deep learning networks works by finding hidden and complex patterns in the data they process. The networks may develop several degrees of abstraction to describe the

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data by constructing computational models that are made up of many processing layers.

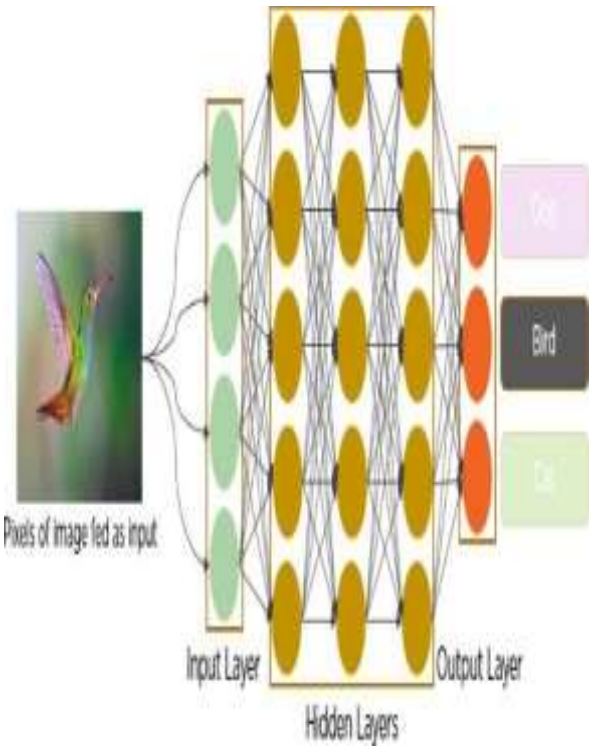

Fig. 1. Convolutional Neural Networks

Convolutional Neural Networks is one of the algorithms of deep neural networks which consist of different architectures. A neural network type known as convolutional neural net- works, or CNN or ConvNet, is focused on processing input with a grid-like architecture, such as images.

CNN basically consist of 3 types of layers which are convolutional layer, pooling layer and fully connected layer. Different of arrangement of these layers makes different architectures of CNN.

Efficient Net

Efficient Net is one of the important architectures of convolutional neural network and project about understands the features of images of foot ulcers and this architecture can help us in better understanding the features of the images and hence better accuracy in predicting. The design of the solution was influenced by the image's width, depth, and resolution. Since our project is realted to images with higher resolution and more pixels, therefore we are using EfficientNet which is the best option.

These intuitions suggest that scaling multiple dimensions re- quires coordination and balancing as opposed to the more traditional single-dimension scaling. The compound scaling method grows the network's depth, breadth, and resolution logically and uniformly using a compound coefficient.

Since DFU classification requires a more complicated network architecture to distinguish between normal and abnormal classifications, the number of layers in a CNN model does not guarantee correctness.

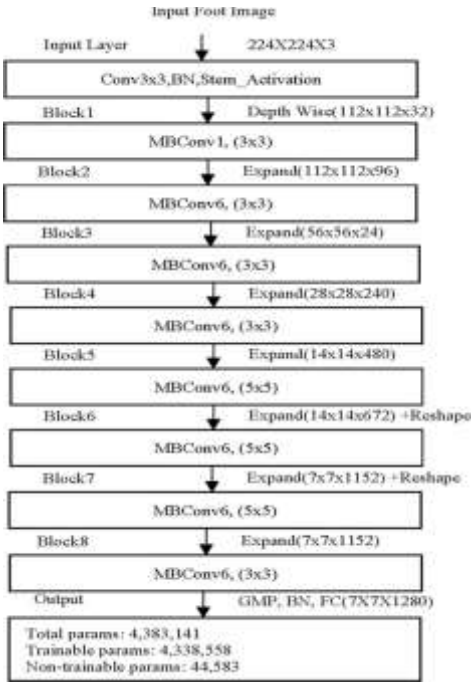

Fig. 2.EfficientNet Architecture

In some cases, network performance degrades as the number of levels increases, and a network with few layers and a simple topology is sufficient.

VI. Workflow Of Model

The model is built using a CNN architecture which is going to classify out data into whether a person is having normal or abnormal ulcer. The training of model is done using training data and train accuracy is provided. The given flow chart ex- plains the workflow of our model.

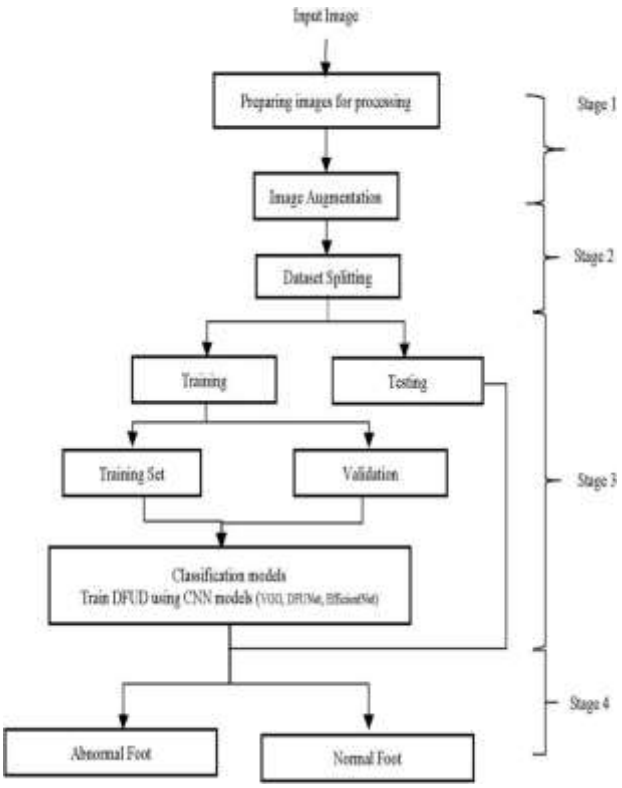

Fig.3.Workflow Diagram

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VII. Dataset Used

CNN architecture was used to build the model, which will classify the data into normal and abnormal ulcers. Model training is carried out with the aid of training data, and train accuracy is offered. Since we have used CNN as our algorithm, we have used number of images as dataset for proper training and testing of our model. Heres are some of these images:

Fig. 4. Dataset

VIII. Evaluation

Confusion Matrix

Confusion matrix is a concept in machine learning which is used for the performance evaluation of different models. This matrix is usually used for classification model evaluation. There are 4 terminologies used in this matrix which are true positive, true negative, false positive and false negative.

Using these 4 terminologies different calculations can be done and evaluation of the model can be done. These evaluations can also help in telling which feature of the model should be modified in order to improve the performance of the model.

True Positive: It is the situation in which both predicted and actual answer both is yes.

False Positive: It is the situation in which predicted answer is yes but the actual answer is no.

True Negative: It is the situation in which predicted answer is no and the actual answers is also no.

False Negative: It is the situation in which both predicted and the actual answers are no.

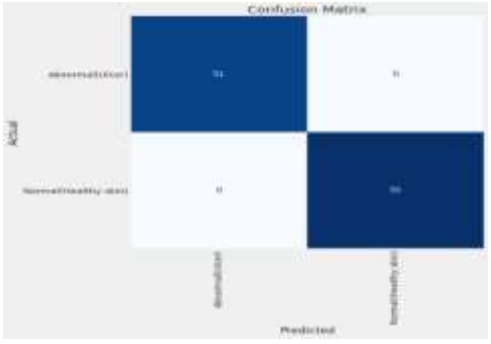

Fig. 5. Confusion Matrix

Calculations using Confusion Matrix

Above confusion matrix can be used to find some calculation which can be used for model evaluation. These calculationsare:

1. *Accuracy:*Accuracy can be defined as the measurement of prediction correctness. It is the closeness be- tween the correct and predicted value.
2. *Error Rate:* Error rate is defined as the number of incorrect predictions per all samples available. Lower the value, better the model will perform.
3. *Precision:* Precision defines the exactness of the model. It has the highest value as 1 and lowest is zero.
4. *Recall*: Recall is used find what is the ability of the model to find positive samples. If recall is high that means the model will find more positive samples.
5. *F-measure:* F measure takes recall and precision to find its value. It makes the model to use both precision and recall for finding best outputs.

IX.Conclusion

Diabetes is a very common and rising problem now a days and it is not only limited to only old people, person of any age can be affected by this disease. Sometimes this problem of diabetes leads to more severe complications. One of such complications is foot ulcers. These ulcers if not detected early whether these are normal or abnormal in nature then it can leads to losing of a limbs

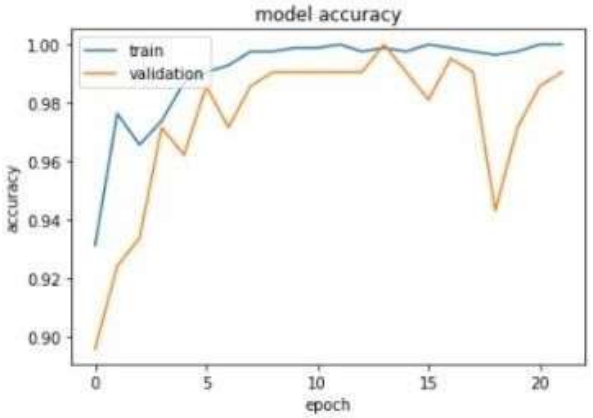

Fig. 6. Model Accuracy

Therefore for the early detection of diabetic foot ulcers we have created this project – AI driven Diabetic foot ulcers pre- diction system. For proper classification and prediction, our project uses a deep learning model known as ―Convolutional Neural Network. There are different architectures of CNN and we are using EfficientNet.

The accuracy attained by our model is about 95% but this can be improved by improving the quality of our dataset and using some other methodologies

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