

## Predicting and Propagation of Diabetic Foot Infection by Deep Learning Model

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### Abstract

**INTRODUCTION:** A deep learning model may be used to predict the occurrence of diabetic foot infections and to understand how these infections spread over time by using sophisticated machine learning methods. Untreated diabetic foot infections, a common diabetic complication, may have devastating effects.

**METHODOLOGY:** One area where deep learning models—a kind of machine learning—shine is in healthcare, where they are well-suited to deal with data that contains intricate patterns and correlations. The metabolic illness of diabetes affects more individuals than any other. Neuropathic and Ischemic ulcers are two types of foot ulcers that these issues may cause. Damage to the nerves and blood vessels is the primary cause of this ulcer. Numerous amputations and fatalities have resulted from these sores. There are millions of victims of this illness throughout the globe. The amputation of a human leg occurs once every 30 seconds. The precise anticipation of diabetic foot ulcers has the potential to significantly alleviate the substantial impact of amputation. Therefore, it is crucial to correctly categorize foot ulcers and discover them as soon as possible for more effective treatment.

**RESULTS:** An extensive literature review of classification methods, including decision trees, random forests, the M5 tree method, Random trees, neural network models, ZeroR, Naive Bayes, the Back Propagation Neural Network, Linear Regression model, and Deep Learning Algorithms is presented in this research with a primary emphasis on foot ulcer classification. Using the Kaggle dataset, these algorithms are ranked. In the end, it presents a comparison of different classifiers.

**Keywords:** Metabolic illness, Neuropathic Ulcer, Blood vessels, Neural Network Models, Foot Ulcer Classification, Deep Learning Algorithms

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### 1. Introduction

Most of the world's population now has diabetes. High blood glucose levels are the primary contributor to diabetes [1]. According to the World Health Organization (WHO), the occurrence of type 2 diabetes has been rising in all regions of the globe and among individuals of all economic levels [2]. Worldwide, about 424 million people have diabetes, and every year, 1.7 million individuals lose their lives due to the disease [3]. Over the last several decades, the prevalence of diabetic foot ulcer diabetes has risen dramatically [4]. An artificial intelligence-based

neural network and decision tree algorithms for the prediction of diabetic foot ulcers were designed [5]. The researchers used a structured interview questionnaire as their designed instrument, which consisted of three distinct sections [6]. Part I of the questionnaire focused on gathering demographic information of the participants [7, 8]. Part II aimed to collect medical data, while Part III focused on in vivo measurements [9, 10]. Artificial intelligence methods were used to achieve the aim of this study [11]. The researchers used a set of 19 relevant features derived from medical history and foot photographs that have been shown to have an impact on the occurrence of diabetic foot ulcers [12]. Subsequently,

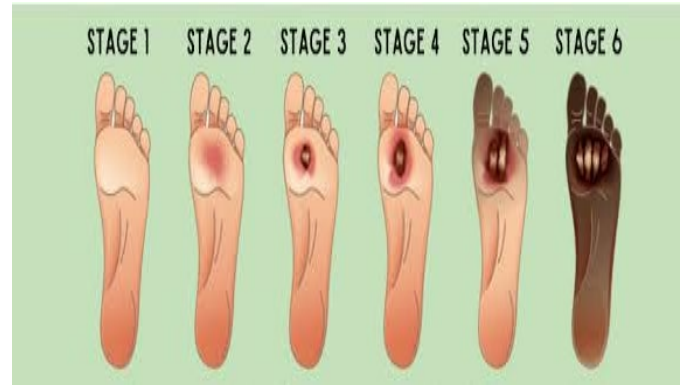
they put forward two distinct classifiers, namely a feed forward neural network and a decision tree, to predict the likelihood of foot ulcers in diabetes patients [13]. In conclusion, the researchers conducted a comparative analysis of the outcomes obtained from the two classifiers [14]. The experimental findings demonstrated that the suggested artificial neural network exhibited superior performance in contrast to the decision tree [15]. Specifically, the proposed model achieved a notable maximum accuracy in the automated prediction of diabetic foot ulcer Table 1 A1C, Fasting Glucose in blood, and Oral Glucose Tolerance test.

**Table 1** A1C, Fasting Glucose in blood, and Oral Glucose Tolerance test

Increasing range of glucose	Nature	A1C (%)	plasma glucose fasting		Oral tolerance test for glucose.	
			Mg/dl	mmol/l	Mg/dl	mmol/l
↑	Diabetes	6.6 & above	127 & above	8 & above	200 & above	12.1 & above
	Pre-diabetes	5.8 to 6.5	101 to 127	5.5 to 8	141 to 200	7.78 to 12
	Healthy	Below 5.7	100 & below	3.90 & 5.6	140 & below	7.73 & below

## 2. Types of Foot Ulcers

The body may have several issues when glucose levels rise. This study focuses on blood vascular and nerve issues. This issue may cause foot ulcers. Foot ulcers are caused by poorly treated diabetes. The foot's bones are steadily affected by this issue. Red foot ulcers are skin craters. Poor blood circulation affects nerves and vessels. A foot ulcer often exhibits these characteristics. A wound like this either never fully heals or keeps coming back. Stages of Foot Ulcers are shown in Fig. 1, with the ulcer's intensity increasing from mild to severe. Severity increases from stage 1 to stage 6, with stage 6 being the worst. More severe consequences may occur if Stages three and four are misdiagnosed. Removal of the patient occurs when these phases are complete.



**Fig. 1.** Stages of Foot Ulcers

Nearly 30 % of diabetic individuals get foot ulcers, possibly leading to disability and amputation. One patient has the issue of leg elimination about once every 30 seconds. Many lives may be saved if foot ulcers are diagnosed and classified at the earliest possible stage so that practitioners can develop more effective treatment plans and follow-up strategies. The foot ulcer is divided into three categories based on location, appearance, and medical history in a study from the Cleveland Clinic: venous stasis ulcer, neurotrophic (diabetes), and arterial (ischemic). ulcers caused by venous stasis are often red and manifest on the inner thigh or lower leg. People at risk may have neither varicose veins nor leg oedema nor either of these conditions. Neurotrophic ulcers are diabetic in origin. The circulation determines whether it's pink or red and the position of the base. However, the bottoms of the feet are the most prevalent site for this kind of ulcer. Numbness, tingling, and burning are the most prominent signs of neuropathy. There is an arterial ulcer between the toes and the bottom of the foot. It comes in shades of black, brown, and yellow. This ulcer is more likely to develop in those with impaired circulation. Neuroischemic ulcers, diabetic foot ulcers, and neuropathic ulcers are all included in this category. Neuropathic ulcers have been linked to diabetes in 92% of cases. High blood sugar levels are harmful to the nervous system. As a result, there will be issues with the autonomic, sensory, and motor nerves. Muscles become weak, the feeling is dulled, and reflexes are lost. The main contributor to ischemic ulcers is the peripheral artery. Hand and foot veins may be affected by peripheral artery disease (PAD), generally known as poor circulation. A neural ischemic ulcer is a kind of ulcer that results from the interaction of neuropathy and ischemia. The classification of ulcers in diabetic feet is the primary focus of this research as it relates to effective patient care. Machine learning algorithms will be used to make this sorting determination.

### 3. Techniques for Classification

Supervised learning, unsupervised learning, and learning with reinforcement and deep learning methods. Algorithm training and testing are the primary bases of this learning. Label training is carried out in supervised learning when the computer is given the class labels of the data being studied. However, with unsupervised learning, the computer cannot access this class label. In this case, the machine will be taught by humans who already know much about the subject matter. In Deep learning Artificial intelligence (AI) refers to the embodiment of human intellect in machines. Currently, this field is categorized as a subfield of computer science that specializes in the analysis of intricate medical data and its use in improving patient outcomes. Which is reliant on its surroundings is called reinforcement learning. The environmental component serves as the basis for the machine's training. The structural design of the categorization method is shown in Fig 2. The following are the stages of the classification: categorization, following the steps of feature extraction and feature selection.

Fig. 2. The architecture of the categorization system

### 4. Methodology

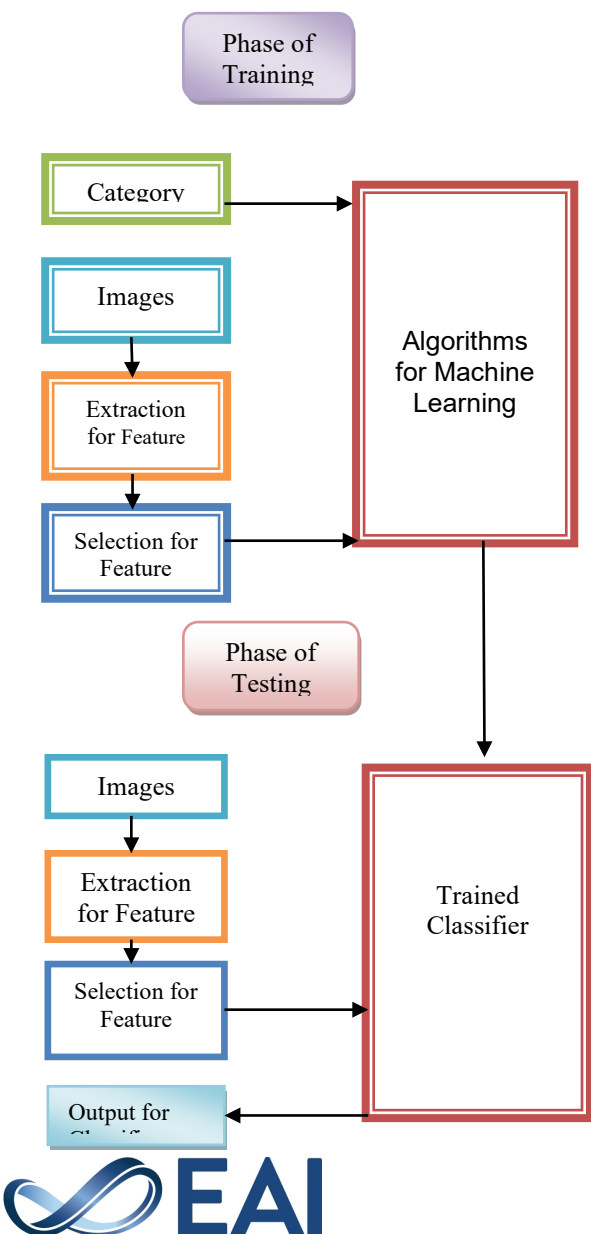
The AI method is used for the prediction of diabetic foot ulcers. The following steps are utilized. First, demographic characteristics, medical history, and in vivo measurements were obtained; second, the participants were divided into two groups: one had a foot ulcer and the other did not; third, the MATLAB program used AI applications to select the strongest predictors from all factors to determine the predictors affecting ulcer occurrence for diabetic patients. In this case, researchers use the photos themselves as the categorization input. Features are taken from photos to reveal their characteristics. Once the features have been extracted, they are sent to a feature selector, whose job is to choose the most relevant features for the classifier. Boosting the classifier's efficiency is the primary goal of this feature selection procedure. The classifier is adjusted to improve output based on mistake rate or accuracy. Popular classifier methods include:

- The Neural Network-based classifier.
- The Support Vector Machine (SVM).
- The Naive Bayes.
- The Decision hierarchy Classifier.

Machine learning classification methods are discussed in depth in the next chapter. The results of this poll will be used to choose the optimal method for use in the following classification efforts.

### 5. Algorithms for Classification Implementation

Random Forest, Decision Tree, M5 tree model, Randomized trees, Artificial Neural Networks, ZeroR, Naive Bayes, and Linear Regression model are only a few techniques used in this article. AI can accurately anticipate diabetic foot ulcers. After testing two ways to predict foot ulcers, the artificial neural network outperformed the decision tree algorithm. To avoid diabetes complications, outpatient clinics should include health education and follow-up. Weka and the R programming language are used to implement these methods. Fig. 3 displays the sugar glucose, high blood pressure, skin thickness, and insulin range, and Fig. 4 displays the attribute ranges for diabetes, peripheral neuropathy, and circulatory problems are the most critical factors. Table 2 displays the example data set for Diabetic Foot Ulcers. The Classification of Algorithms with their inaccuracy Rate is shown in Table 3.



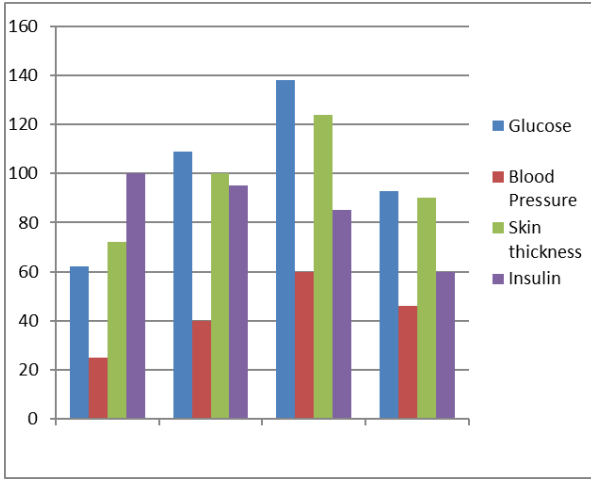


Fig. 3. Attribute Ranges Chart

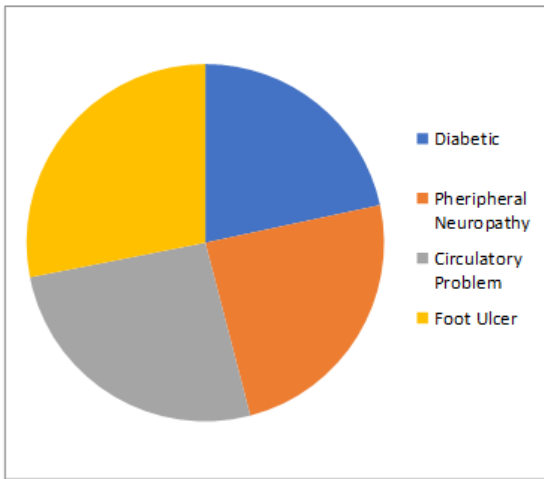


Fig. 4 Patients Average Ranges Chart.

Table 2 Sample data for Diabetic Foot Ulcers

Glucose	Blood Pressure	Skin Thickness	Insulin	Diabetic	Peripheral Neuropathy	Circulatory Problem
65	30	70	100	1	1	1
110	40	100	90	0	1	2
130	60	125	130	1	0	0
90	50	90	95	0	1	1

Algorithms	Time for execution	MAE	RMSE	RAE	RRSE
Random Forest	0.45	0.0077	0.0233	1.6878%	4.8997%
Decision Tree	0.18	0.0005	0.0040	0.0800%	0.8174%
M5 Model	0.34	0.0057	0.0142	1.2384%	2.9719%
Randomized Tree	0.02	0.0044	0.0659	0.9590%	13.8693%
Neural Networks	0.98	0.0065	0.0310	1.4285%	6.5093%
Regression Model	0.05	0.0144	0.023	3.1635%	4.6294%
ZeroR	0.2	0.4515	0.4745	100%	100%

Table 3 Classification of Algorithms with its Error Rate

Note: MAE- Mean Absolute Error, RMSE- Root Mean Square Error, RAE- Relative Absolute Error, RRSE- Relative Root Square Error

### 6. Discussions and Result

Measures of accuracy, including mean fixed error, root mean squared error, root mean absolute error, root mean absolute error ratio (RRSE) and execution time, are used to compare the relative merits of various algorithms. Here are the results of running it on the Kaggle dataset, with its duration and the various error rates it produced. Results from a Random Forest Sample: 0.45, 0.0077, 0.0233, 1.6878%, 4.8997 and 0.34, 0.0057, 0.0142, 1.2384, 2.9719 for M5 Model. Statistics for a Randomized Tree: 0.02, 0.0044, 0.0659, 0.9590, 13.8693. Using Neural Networks, the results were 0.98, 0.0065, 0.0310, 1.4285, 6.5093 In a linear regression analysis, the following values were found: 0.05, 0.0144, 0.023, 3.1635, 4.6294 ZeroR: 0.2, 0.4515, 0.4745, 100%, 100%. Decision trees have faster execution times and lower error rates than other categorization methods.

### 7. Conclusion

The worldwide prevalence of diabetes is staggering, affecting millions of lives. This illness is spreading at an alarming pace. Diabetic foot ulcers are pretty common because of diabetes. The best care for a foot ulcer may be provided if the ulcer is identified and classified quickly. The investigation and categorization of this phenomenon

hold significant intrigue within machine learning. In this study, a comprehensive evaluation of various classification algorithms is conducted. Compared with other algorithms, the Decision tree exhibits a lower error rate. The error rates associated with decision trees are as follows:

- Mean Absolute Error (MAE) is calculated to be 0.0004.
- Root Mean Square Error (RMSE) is determined to be 0.0040.
- Relative Absolute Error (RAE) is found to be 0.0800%.
- Relative Root Square Error (RRSE) is computed to be 0.8174.

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