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Kidney stone classification using deep learning neural network

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Abstract

Kidney stones are the common problem in the healthcare system. It is rapidly increasing day by day and becomes a global health crisis in worldwide. Various deep learning algorithms are used for classificationof stone in kidney area. The computer aided design approach can be used for assist doctor for finding out the stone in kidney area. For kidney transplantation and dialysis, a proper treatment is required. It is important to have reliable techniques for predicting kidney stone size atits early stages. Different machine learning (ML) algorithmsare given excellent results in predicting stone. In this paper, clinicaldata is used for predicting of stone in kidney. If data have some missing values, data unbalancing problem then machine learning algorithms assist to solve this problem in which includes data preprocessing, a technique for managing missing values, data aggregation,

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feature extraction and prediction of result by evaluating values. In this study, deep learning algorithm for classification of kidney stone sizes automatically on the patient's dataset is used. A total of 1000 patient's dataset are used for finding out kidney stone size i.e., large or small. The binary classification algorithm is used for classification of stone size. We observed that our model gives best result for classification of kidney stone image size.

Subject Classification: *Primary 68T07, Secondary 03C45.*

Keywords: *Deep learning, Kidney stone, Classification.*

Introduction

Kidneys are an important component of our body. The important functioning of the kidney is to cleanblood by filtering process. Kidney also removes waste, toxins, and excess water from our body. Because of these functioning of kidney, ourbones keep healthy and regulate blood pressure properly. But due to bad lifestyle, hypertension, diabetes and polycystic some problems arise in kidney. These kidney problems [1] damage the kidneys, and damaged kidneys are unable to clean blood. In the first stage, there are usually no symptoms. In the second stage, problems such as swollen legs and fatigue appear. Sometimes serious problems, such as heart disease, can occur. Symptoms include weight loss, short births, itching, muscle pain, cramp, severe headache, and insomnia. Hemoglobin is an important factor in kidney damage. High hemoglobin in the body is dangerous for the kidneys [2]. Damaged kidneys cannot protect albumin, so it is excreted in the urine. Test strips can measure albumin in urine. In the final stages, kidney patients cannot live without dialysis. To prevent kidney disease, doctors give the following advice: For example, quit smoking, eat healthy, and exercise regularly. According to statistics, about 400 people are injured every day due to kidney stone problem.

Kidney stone is major disease [3] in the global economynow days. Every country spent 2-3% of their annual income for diagnosis of this disease. In 2015, United States spent her $64 billion on treating the disease. Middle-class families are depressed when someone gets this disease of kidney failure [4]. So, people would benefit if we Figured out what factors these diseases affect. In the past, many researchers worked on kidney stone classification manually and automatically with deep learning algorithms. Classification of stone manually is not efficient these days as they are costly and time consuming. Automated systems, on the other hand, are efficient but can be unreliable. Moreover, the existing algorithms are not reliable enough that are adopted by the layperson as an alternative to physicians.

We particularly focused on the integration of deep learning algorithms and proposed [17] a model to help both patients and professionals to take specific actions to classify kidney stone size at the early stages. In our work, we use deep learning concepts to develop efficient models for society. Physicians can benefit from this model. Our society can also take benefit from this model because it can help in prediction whether they have stone or not.

Several previous works have been done on classification of stone size in kidney areaby using machine learning and deep learning techniques. For composition of kidney stone of different sizes, a deep learning detection model is proposed by Black et al [10] and A Convolutional neural networks (CNNs) deep learning model is proposed by Lankvist et. al. for detection of stones in kidney CT images automatically [11]. Parakh et. al. developed a method for detection of stone in CT images and evaluated the performance parameter of two pre-trained CNN models [12]. Xiang et. al. developed a CNN model for detection of crystals of calcium oxalate in urine [13]. Anotherapproach for detection of stones in kidney area automatically with use of ensemble learning is proposed by Kazemi et. al. [14]. The different algorithms like artificial neural networks and a gravitational search algorithm were proposed by author chronic kidney disease detection [15]. For encoding and decoding of text data using machine learning algorithms is proposed by Kumar A et. al. [16]. Previously different machine learning and deep learning techniques were used for the detection of kidney stones alone for good results.

Hence, the objective of this paper is to develop an approachfor kidney stones classification of different size from dataset via deep learning techniques automatically.

1. Material and methods

Data Preparation:

Kidney stone dataset downloaded from Kaggle; this dataset contains 1000 rows with three columns. In the dataset, there are three columns contains information of patient treatment, stone_size and success. There are two classes in our dataset 0 and 1 i.e., 0 means stone not present and 1 means stone is present. The first column of dataset describes the treatment that having the value A or B, second column of dataset describes stone_ size having values large or small and the third column of dataset describe success having 0 or 1 value. The description of dataset table is shown in Figure 1.

```
<bound method NDFrame.tail of     treatment stone_size  success
0           B      large        1
1           A      large        1
2           A      large        0
3           A      large        1
4           A      large        1
..        ...        ...      ...
994         A      large        1
995         B      small        1
996         A      large        0
997         A      small        1
998         A      large        1

[999 rows x 3 columns]>
```

Figure 1

Description of Dataset

Among all dataset of kidney stone having success 0 and 1 i.e., stone present or not present is shown in Figure 2

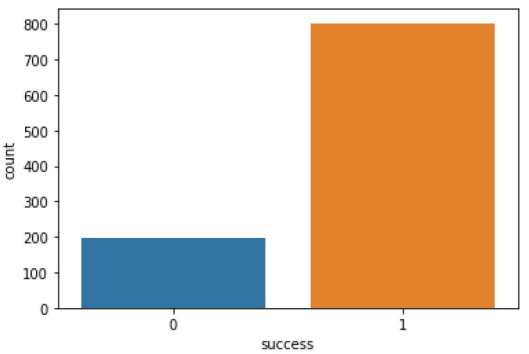

Figure 2

Total amount of class success

Methods:

In this study, deep learning neural network model is applied for classification of dataset that detect stone is present or not with respect to 0 and 1 value. Deep learning neural network is a part of artificial intelligence where the greater number of intermediate layers are used for learning.The Deep learning networkcan do classification of large amounts of data with higher accuracy. Deep learning algorithms are mainly used in segmentation of images, prediction of disease, and recommendation systems.

The open-source dataset used in this study consists of 1000 dataset of 0 and kidney 1. Class 0 represents the stone is not present and Class 1 represents the stone is present. The dataset is split so that 80% of the data on both the classes are used for training of deep learning model and the remaining 20% are used as testing data for prediction of model.

Training algorithm:

Training has been done with 80% of the dataset using deep learning neural network algorithm. In this model, input layer followed by number of dense layers. After the process, evaluations are done on the test data set to verify the performance. The description training steps of model is shown in Figure 3.

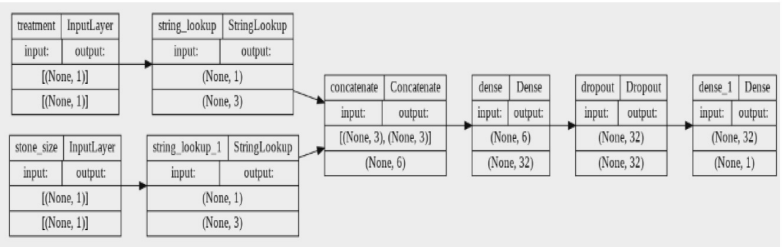

Figure 3

Description of model

After training, the model accuracy and loss value are evaluated. The evaluation results of model are illustrated in Figure 4.

```
25/25 [==============================] - 0s 2ms/step - loss: 0.4718 - accuracy: 0.8010
[0.4718475937843323, 0.801001250743866]
```

Figure 4

Evaluated model

Deep learning model:

In this study, we apply the neural network for training of deep learning model. The architecture is shown in Figure 5. This deep neural network model consists of input layers, dense layers, dropout layer and output layer. The Rectified linear unit (Relu) activation function is used at the intermediate layers. The sigmoid activation function is used at the output layer for finding out binary classification results.

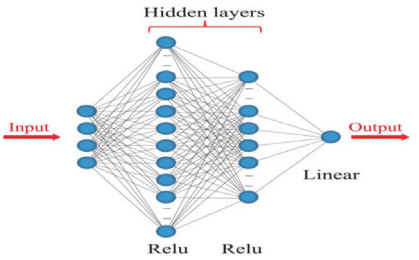

Figure 5

Deep learning neural network model

2. Results and discussion:

The deep learning model is applied on the dataset of kidney stone with different columns i.e., treatment, stone size, and success. After the augmentation process, 80% of the dataset has been trained using deep learning model. The accuracy of deep neural network model is 80% with respect to epoch value as shown in Figure 6 and the loss is 47% with respect to epoch value as shown in Figure 7. The confusion matrix of the modal is shown in Figure 8. The final prediction results accuracy is 95% as shown in Figure 9.

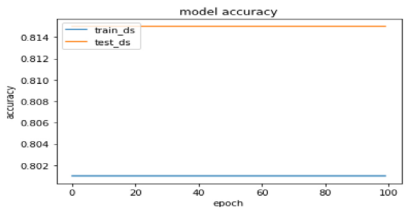

Figure 6

Model accuracy

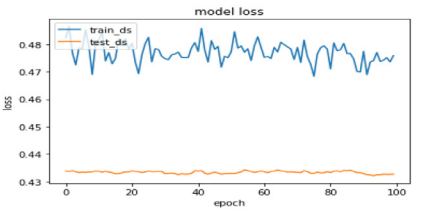

Figure 7

Model Loss

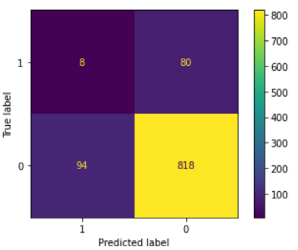

Figure 8

Confusion matrix

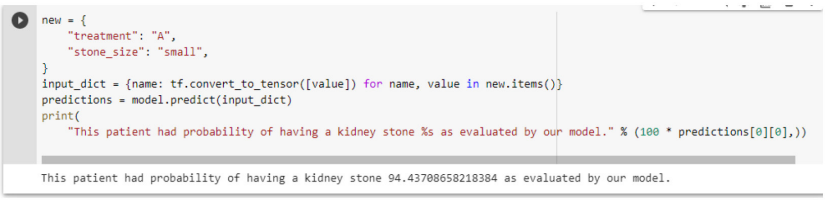

Figure 9

Final result

3. Conclusion

In this work, deep neural network model is used for classification of stones sizes in dataset. This model helps to find the stone is present or absent in kidney. The advantages of deep neural method, it can read all data deeply that is suitable for classify the kidney stone form given dataset fastly and at early stage. The prediction accuracy of our model on given dataset is approx. 95%. In future, increase the accuracy of modelby applying other deep learning model on used dataset.

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