IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Bone Fracture Detection System Using Image Processing

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Abstract: The bone is a major component of the human body. Bone provides the ability to move the body. The bone fractures are common in the human body. The doctors use the X-ray image to diagnose the fractured bone. The manual fracture detection technique is time consuming and also error probability chance is high. Therefore, an automated system needs to develop to diagnose the fractured bone. The Deep Neural Network (DNN) is widely used for the modeling of the power electronic devices. In the present study, a deep neural network model has been developed to classify the fracture and healthy bone. The deep learning model gets over fitted on the small data set. Therefore, data augmentation techniques have been used to increase the size of the data set. The three experiments have been performed to evaluate the performance of the model using softmax and Adam optimizer. The classification accuracy of the proposed model is 92.44% for the healthy and the fractured bone using 5 fold cross validation. The accuracy on 10% and 20% of the test data is more than 95% and 93% respectively. The proposed model performs much better than [1] of the 84.7% and 86% of the

Keywords- Bone fracture, Deep Learning, Fracture detection, Fracture classification

I. Introduction

The human body consists of many types of bone. Bone fractures are mostly caused by the automobile accident or bad fall. The bone fractured risk is high in aged people due tothe weaker bone [3]. The fracture bone heals by givingproper treatment to the patient. The doctor uses x-ray or MRI(Magnetic Resonance Imaging) image to diagnose the fractured bone [4]. The small fracture in the bone becomes difficult to analyze by the doctor. The manual process for thediagnosis of the fractured bone is time consuming and the error probability is also high. Therefore, it is a necessity to develop a computer based system to reduce the time and the error probability for the fracture bone diagnosis [4]. The

II. Type Style and Fonts

Of five years. The time series monthly data is collected on stock prices for sample firmsand relative macroeconomic variables for the period of 5 years. The data collection period is ranging from January 2010 to Dec 2014. Monthly prices of KSE -100 Index is taken from yahoo finance.

III. Ease of Use

Bone fracture detection and classification has been developed in the past. Dimililer and Kamil [7] have used ANN (Artificial Neural Network) to classify fracture bone and edges in the image. After that features are extracted from the bone image. Finally, system is trained with the features and classificationis performed by the ML (machine learning) algorithms but authors have not classified the bone into the healthy and the fracture. Yang et al. [8] have used a contour feature of the x-ray image to detect the fractured bone. The accuracy ofthe system is 85%, which need to improve. In the paper of the Chai et al. [9] Gray-Level Co-occurrence Matrix (GLCM)was used to extract the texture feature to classify the bone into the fracture and the non-fracture. The features are extracted from the image of the size 410×500 resolution. Theclassification accuracy of their system is 86.67%.

In the present work, we have developed a deep neural network for the identification and the classification of the healthy and the fractured bone. The data set consists of 100 images of different types of human bone. The deep neural network gets over fitted due to a small data set. Therefore, an image augmentation technique was has applied on the data set.The classification accuracy of the proposed model is92.44% for the healthy and the fractured bone using 5 fold cross validation. The classification accuracy on 10% and 20% test data is more than 95% and 93% respectively. The proposed model performs much better than [1] of the 84.7% and 86% of the [2].

The proposed paper consists of five sections as follows: Section 2 contains the proposed work with details of data set.Section 3 describes the results and section 4 represents the conclusion and future scope of the proposed scheme.

PROPOSED WORK:

This section includes data collection, augmentation of data using transformations of the image and finally classification of healthy and cancerous bone using deep CNN.

The experiment has been performed on the bone X-ray image data sets, collected from different sources publicly available for research such as the Cancer Imaging Archive(TCIA) and Indian Institute of Engineering Science and Technology, Shibpur (IIEST) [13].The fracture and the healthy bone is shown in figure1.

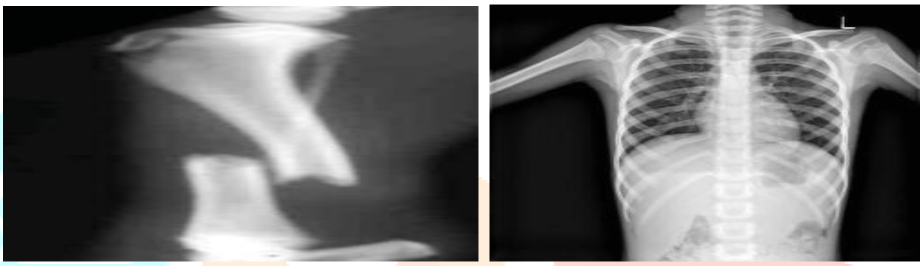

Fig 1.The facture and healthy bones

Data Augmentation: In a deep learning approach, the sizeof the data set is an important component. If the data set sizeis small, then the possibilities of over fitting may arise [10]. To overcome this problem, data augmentation technique is used to increase the size of the data set. Keras module provides ImageDataGenerator method to augment image11]. We have applied an image transformation technique flipping and shifting to generate a new image from the available data set. The more generalize capability of a machine learning model can be achieved by training with theoriginal image and with the augmented image. In the past several researchers have used data augmentation technique toreduce the error rate of the machine learning model [12].In the present study data set is a collection of the different typesof the human bone. The data set size is small due to this memorization of the algorithm may arise. Therefore, we haveapplied an image augmentation technique to increase the sizeof the data set [13].

1 .Rotation (40º): The image is rotated in the random direction in the left or right through 40º in the range of 0- 180.

2. Zoom (10%): The new pixel value was added to the original pixel of the image and the closest value was chosen

3. Horizontal Flip: The pixel values are moved in the random direction and pixel values are moved horizontally from one half of the image to the other half.

4. Vertical Flip: The image was vertically flipped by drawing horizontal from the center of the image.

5. Shearing (40%): The image was shift at a specific angle in the counter-clockwise direction. The value was set to 40º in the present study.

The images are transformed with the open source programming language python and keras library. The transformed images are shown in figure2. After augmentation the data set size is 4000, out of which 2000 areof the cancerous bone and 2000 are of the healthy bone.

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Proposed CNN Model Architecture: In the proposed work a deep convolution neural network model has been

Designed. It contains convolution, pooling, flatten and dense layer [14]. The feature of the input image is automatically extracted by CNN and a fully connected layer is used to classify them into the cancerous and the healthy bone. The pooling layer and convolution layer (CL) extract features from the image [15]. At each of the convolution and poolinglayer, a suitable size of 3x3 is applied to remove noise. Afterthat classification is performed by the dense layer. The architecture of deep CNN is shown in figure3. Thedescription of each phase is as:

CL*:* In the present study we, have apply 4 convolution layers CL of 16 feature map with filter size of 3x3;CL of 32 feature map with filter size of 3x3;CL of 64 feature map withfilter size of 3x3; CLof 128 feature map with filter size of 3x3. The convolution layer extract feature from the input image by applying filters. The convolution layer extract feature from the input image by applying filters.

Max-Pooling Layer*:* It was used to reduce the dimensionof the filtered image at each convolution layer. Therefore thislayer focused on the concerned object in the image and best feature of the image. In the proposed study at each convolution layer, a max-pooling layer of size 2x2 has been applied.

Flatten Layer*:* This layer reduced the 2- dimensional feature vector into an array that is feed to a fully connected layer.

Fully Connected Layer*:* This layer is also known as fullydense layer. We have added one dense layer, because of binary class problem. The proposed model predictsthe bone into the healthyand the fracture. The activation function relu has been implemented in each layer. In the dense layer two activation functions softmax and adamax have been used to one at a time. We added two output nodes for the cancerous and the healthy bone.

Fig2.Augmented image of the1, 2, 3, 4 and 5 process respectively

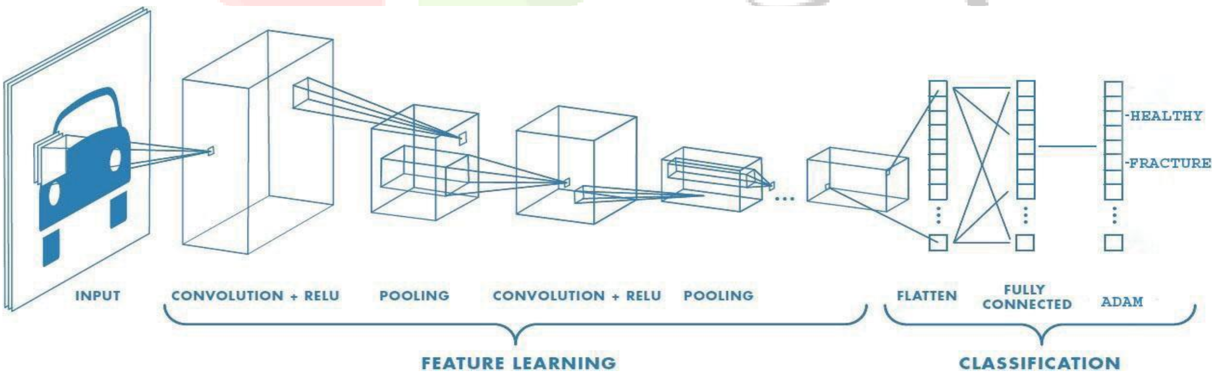

Fig3.CNN model for the bone classification

RESULT AND ANALYSIS:

The experiment was performed using python 3.8,anaconda 3 with Jupiter notebook in the window 10 operating system with 8 GB RAM and i7 processor. The three experiments are conducted as follow.

Experiment 1*:*

First the deep CNN are trained with the 90% of the sample and testing has performed with 10% of the samples. The activation function softmax was used for 100 epochs with batch size of 40. After that the activation function Adam was used for 100 epochs with a batch size of40.The batch normalization was applied to minimize thefluctuation of the performance.

Experiment2:

In this experiment deep CNN model was trained with 80% of the sample and testing was performed with 20% of the sample. The activation function softmax wasused for 100 epochs with batch size of 40. After that the activation function Adam was used for 100 epochs withbatch size of 40.

Experiment3. We have applied 5 fold cross validation to our data set to further investigate the performance of the system.

EXPERIMENT EVALUATION:

The performance of the system was measured using twomatrices one for the training data and other for the test data. The training accuracy (TR-Ac) measure the performance of the model on the training data set and the validation accuracy(VL-Ac) measure the accuracy of the system on the unseen data. The training loss (TR-Loss) and the validation loss (VL-Loss) were also calculated to measure the error in the training and the validation data.

The experiment results of the experiment1 are shown in table1. The healthy and the fracture bone image data set wereloaded to the system. The binary class classification problemloss was calculated using binary_crossentropy. Theperformance of the Adam optimizer is much better than the softmax in term of the accuracy metrics and the loss metrics

TABLE I. EXPERIMENT RESULTS OF DATA SET USING SOFTMAX AND ADAM OPTIMIZER ON 90% TRAINING AND 10% TEST DATA SET

	Healthy Bone Using Adam	98.03%	95.23%	0.046	0.9807
Exp-1	Fracture Bone Using Adam	98.45%	95.67%	0.035	0.5608

The experiment2 results are shown in the table2. In the experiment2, the data set was divided into the 80% and 20%ratio for the training and the testing. The performance of the Adam optimizer is much better than the softmax in term of theaccuracy metrics and the loss metrics.

TABLE II.EXPERIMENT RESULTS OF DATA SET USING SOFTMAX AND ADAM OPTIMIZER ON THE 90% TRAINING AND 20% OF THE TEST DATA SET.

Exp.Id	Exp. description	Accuracy Type (Tr-acc) VL-acc)		Loss Type (Tr-Loss) (VL-Loss)	
Exp-2	Healthy Bone Using softmax	95.03%	91.42%	0.085	0.1723
	Fracture Bone Using softmax	96.42%	92.02%	0.077	0.9812
	Healthy Bone Using Adam	96.18%	92.25%	0.052	0.1107
	Fracture Bone Using Adam	97.45%	94.67%	0.045	0.6102

The experiment results of the experiment3 are shown in the table3.In the experiment 3 the 5 fold cross validation wasapplied on the data set to further evaluate the performance ofthe different ML techniques. The training and the test result of the fold4 is better compare to the other folds. Thus, we can conclude that the batch size of the training and the test data set can affect the performance of the system.

TABLE III.EXPERIMENT RESULTS OF THE5 FOLD CROSS VALIDATION.

Metrics	Fold1	Fold2	Fold3	Fold4	Fold5	Average
Tr-acc	94.12%	93.25%	93.14%	97.16%	95.23%	94.58%
VL-acc	91.20%	92.24%	89.25%	95.26%	94.23%	92.44%
Tr-Loss	0.0751	0.8503	0.5791	0.45023	0.0521	0.4013
VL-Loss	0.8413	0.7451	0.6214	0.4612	0.5404	0.6481

The training and the test accuracy of the experiment1 indicates that on the 80% of the training data and the 10% ofthe testing data set, the performance of the system is better compared to the other experiment. In deep learning the over fitting problem may occurs due to the small size of the data set. Therefore, 5 fold cross validation was applied on the dataset. The Adam optimizer performs better in all the performed experiments.

COMPARISON OF THE PROPOSED METHOD WITH OTHER METHODS:

In the present approach long bone, short bones and flat bones fracture detection has been proposed using tensor flowand deep learning approach. Yang and Cheng have used ANN to classify the long bone using contour based feature selection technique. The features are selected using PCA (Principal Component Analysis) by forming the cluster. Theaccuracy of the method is 82.98%. Chai et al. have used Gray Level Co-occurrence Matrix (GLCM) to extract texturefeature for the long bone fracture detection. The accuracy of the method is 86.67%.Tripathi et al. have used support vectormachine (SVM) to classify the human bone into the fracture and thenon-fracture bone. The accuracy of the model is84.7%. The proposed model is much better than the state-of art with 92.44 in the 5- fold cross validation.

CONCLUSION:

In this paper bone fracture detection and classification system using deep learning technique has been developed. The X-ray image of the human fracture bone and the healthybone were used to perform the experiment. The original 100 images were collected from the different source. The data setwas augmented to overcome the over fitting problem in the deep learning on the small data set. Finally, the size of the data set was set to 4000. The classification accuracy of the model is 92.44% for the healthy and the fractured bone. The proposed accuracy is much better than [7] of 82.89% and 84.7% of the [9]. The accuracy of the model can be further improved by selection of other deep learning model. The system needs validation on the larger data set to further investigate the performance.

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