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Long Bone Fracture Detection Using Machine Learning

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Abstract : In this work, the researcher presents an automatic system to detect the presence of long bone fractures by using clinical images obtained from X-Ray. The procedure for the diagnosis of the bone fractures is considered to be a very critical step based on factors to identify this image as normal or abnormal to save the effort and time spent to detect bone fractures. Trained radiologists often identify rare diseases with high accuracy such as fractures. Accurate diagnosis of the bone fraction is important. The Histogram Oriented Gradients (HOG) and Local Binary Pattern Algorithm (LBP) are used for features extraction. This study used two different classifiers. The first classification is Support Vector Machine (SVM), which provides accuracy of 97.85 percent by Radial basis kernel function (RBF) and the second classifier is Multilayer Perceptron (MLP), which gives accuracy of 99.15 percent, then the accuracy of the classifiers are compared with each other. Consequently, Multilayer Perceptron algorithm has the highest accuracy of 99.15 percent. We obtained the best results by MLP using LBP which has the best results as Sensitivity, Specificity and Accuracy are 100, 98.35 and 99.15 percent. The study presents a discussion and discovery of a computer-based long bone fracture detection system by MATLAB. The purpose of this work is to provide insight into the related activities of research conducted. In addition, the researcher proposed long bone fraction detection system by using a computer-supported program.

Keywords: Long Bone Fraction Detection, Normal, Abnormal, Classifiers, Machine Learning.

1. Introduction

The discovery of X-Ray images in emerging health care systems is an important task. The automatic detection of fractures from an X-Ray image of the bone allows a straight line of the affected skeletal structure to be removed by a broken line of long bones occurring in a fractured area with an irregular (uneven) or spaced line. Fracture of the bone marrow is a common health problem, requiring immediate care. Large number of men and women suffer daily from osteoporotic or long fracture bone. Automatic detection of cracks can help doctors and radiologists by monitoring cases and sending suspects cases of experts from nearby tests, since fractures can occur in two ways, one method may not

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be enough to accurately analyze the different types of fractures. In bones such as the hummers, radius and ulna, femur, tibia and fibula, fractures of the long bones often refer to injuries. Donnelley et al [1] proposed a CAD system for the detection of long bones using a scale--based measurement method, parameter measurements using Hough transform, diathesis classification followed fracture detection using gradient analysis. Separation, a frequently used data mining method, has also been widely used to detect the presence of fragments of the past few systems. Such systems include various features (such as form, texture, and color) based on X-ray images and moving machine learning algorithms to differentiate fractures [1]. Bone formation (bone analysis) to measure texture and statistical analysis of high order of fracture detection. In this study we have proposed a long bone fracture detection system by using computer supported program .The purpose of this study is to provide insight into the related activities of the research conduct . In addition ,the researcher proposed long bone fraction detection system by using computer support program and mentione a brief overview of classifiers used in detection of long bone fractures . Techniques are being developed for the step of image pre-processing and classification by using the Neural Network classifiers, an accuracy rate approaching 96 percent is achieved. These findings are extremely encouraging as a first attempt at this issue. There is still field for improvement in the future [2].

2. Materials and Methods

The proposed methodology presented in bone fractures detection that returns the proper an accurate result as shown in the following:

- X-Ray image: the images that are taken from X-Ray machine for bone.
- Pre-processing: plays very important role in this system. It uses some method to remove noise.
- Feature Extraction: is the Extracting the most important features from X-RAY images for the bones
- Classification: classification the bone fractures X-RAY images as the non-fracture bone or the fractures bones.

2.1. Research method:

As a result of the nature of the current research aimed to identify the application of long bone fraction processing technology in Yemen and the development of Electronic Medical Diagnostics in Ministry of Health in Yemen. The Researcher uses qualitative and descriptive analytical methods through surveying, test, interview (telephone interview) and observation by return the related literature.

2.2. Research tools:

Scientific Research tools or instruments are Multiple, which used to collect the information and data that are necessary to answer the questions of members of the study community. The study tools include observation, interview, test, survey, brain storming, consultation, review, experiment, design, document and scale. But the researcher used the observation ,interview, test and survey, because which are the most suitable scientific research tools, that suitable to the study data and achieve the objectives of the research to obtain information , images and documents related to a specific situation by return the related literature. The research will invent tools by return the related literature, then the reliability and reliability of the tool will be checked by getting reliability from experts.

2.3. Research procedures:

After the researcher obtained a letter from the research supervisor, she collected the long bones images, then data analyzed and extracted for results.

2.4. Proposed Model of long bone fracture detection system (Methodology Overview):

The proposed approach is divided into five steps with the aim of constructing a predictive model. Proposed Model of long bone fracture detection system (General Alogrithm **Figure 1**):

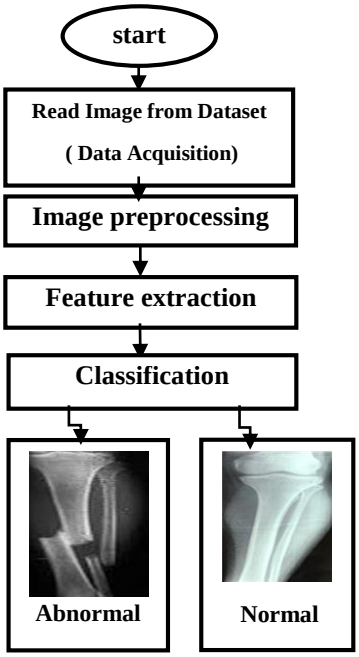

Figure.1: Proposed Model of long bone fracture detection system

The predictive model is for the system of long bone fracture detection based on radiology as follows :

2.4.1 Read Image from Dataset (Data Description):

Collecting image data, that is reading from the X-Ray machine. This study was conducted with dataset collected from Al-Safwa General Hospital, dr. Ghazi Alariqi (orthopedic specialist) classified the X-Ray images into broken images and non-broken images. The database consists of 1170 images, 565 images of broken bones (Abnormal). The remaining 605 images belong to normal bones. The collected dataset is divided into 936 images for training phase and 234 for testing phase.

2.4.2 Image preprocessing:

Pre-processing plays a very important role in this process. It uses a certain method to erase the noise. The colored picture was are processed by system. If the image is already in the gray scale, then there is no need to convert it to a gray scale. The system can also accept color images. If the input image is color or RGB format, then it will convert to a gray scale .Simply processing is nothing but the removal of unwanted data or objects from images only.

2.4.3 Feature extraction:

Histograms of Oriented Gradients (HOG) is one of the more popular methods used today in human detection applications [3]. A detection window slides across an image frame wherein a grid of cells is created. The gradients of the pixels in each cell are then used to create a histogram of edge orientations [4].Extraction of the image features by using Histogram Oriented Gradients (HOG) and Local Binary Pattern (LBP) algorithm generally. The 36 attributes are extracted for each image by HOG algorithm. In addition 59 attributes are extracted for each image by LBP algorithm.

2.4.4 Classification:

Classification and predictive model building using Machine Learning, especially using classifiers such as Support Vector Machine (SVM) and Multilayer Perceptron (MLP). The important step of CAD system is classification [5]. The purpose of this step is to group and classify bone images as normal

and abnormal (broken bone) based on the selected features by using two classifiers such as SVM and MLP. Support Vector Machine (SVM) is utilized which is powerful supervised machine learning techniques for classification and regression. SVM has a lot of kernel functions such as linear, radial basis kernel function ,Quadratic kernel function and others types of kernel functions .In this work, radial basis kernel function gives the best performance (accuracy), among other SVM kernel functions in the bone fracture Classification. The basic phases of supervised classification contains feature execration, classification, training, performance and testing [6]. The two classifiers are SVM and MLP which are both non-linear feedforward neural network with training, The purpose of this classification is to group and classify bone images as normal and abnormal bone (broken bone).

where,

CLASS A :- Normal (Non Fracture Bone) ⟶ 0

CLASS B :- Abnormal (Fracture Bone) ⟶ 1

The two classifiers are Support Vector Machine (SVM) and Multilayer Perceptron (MLP), which are used in the training and testing phase for classification [7]. The purpose of this classification is to group and classify bone images as normal and abnormal (broken bone).

3. Results and Discussion

3.1 Training phase:

The dataset which totally contains 1170 X-Ray bone images are partitioned into 936 X-Ray for the system training phase and 234. X-Ray images for the system testing phase. For Training phases 245 images of broken bones and 691 as normal bones were used.

3.2 Testing phase:

For testing phases 234 images were used (154 images of broken bones and 80 as normal bones).

3.3 Results:

The researcher discussed four distinct variables, namely true positive, false positive, true negative and false negative. Additionally, it is defined as follows:

- True Positive, TP - A correct detection which indicates the presence of a particular condition.
- False Positive, FP - An incorrect detection which indicates the presence of a particular condition while the condition is absent.
- True Negative, TN - A correct detection which indicates the absence of a particular condition.
- False Negative, FN - The detection of an absence of the particular condition, while the condition is present. All that is showing in the next **Table 1** [8].

Table 1: The truth table (confusion matrix) with two classes (Normal, Abnormal):

Actualgroup	Predicated Group	
	Norma L (Nofracture)	Abnormal(Fracture)
Normal (No Fracture)	Tp	Fp
Abnormal(Fracture)	Fn	Tn

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}} \times 100\%$$

$$\text{Specificity} = \frac{\text{TN}}{\text{FP} + \text{TN}} \times 100\%$$

$$\text{Sensitivity} = \frac{\text{TP}}{\text{TP} + \text{FN}} \times 100\%$$

In general, sensitivity points out, how well model characterizes positive cases and specificity computes how well it identifies the negative cases .While accuracy is predicted to measure how well it characterizes both categories. Therefore, if both sensitivity and specificity are high (low), accuracy will be high (low). But, if any one of the measures, sensitivity or specificity is high and other is low, then accuracy will be prejudiced towards one of them. For this reason, accuracy single cannot be a good performance measure [8].

3.4 3.4.Classification Result :

The researcher will explain the results of each classifier separately as follows:

-Support Vector Machine (SVM) Classifier:

In this work, the Histogram Oriented Gradients (HOG) algorithm are used for features extraction by SVM classifier[9] ,and the Local Binary Pattern (LBP) algorithm is used for features extraction by SVM classifier as follows .

- SVM Classifier using HOG:

Dataset are trained by using HOG process. HOG is used for features execration as 36 features. Test has been carried out after training process only with test dataset. HOG algorithm is used for features extraction by SVM classifier.

Table 2: The result of SVM using HOG by different kernel function with test dataset

Characteri	Linear	Quadratic	Polynomial	RBF
Specificity	85	86.44067797	86.66666667	85
Sensitivity	85.97	87.71929825	87.71929825	87.71929825
Accuracy	85.47008547	87.06896552	87.17948718	86.32478632

With this algorithm (SVM using HOG) the accuracy that we got is 87.18% by the polynomial kernel function using in testing phase. This accuracy is the best result with SVM by the polynomial kernel function (see figure 2).

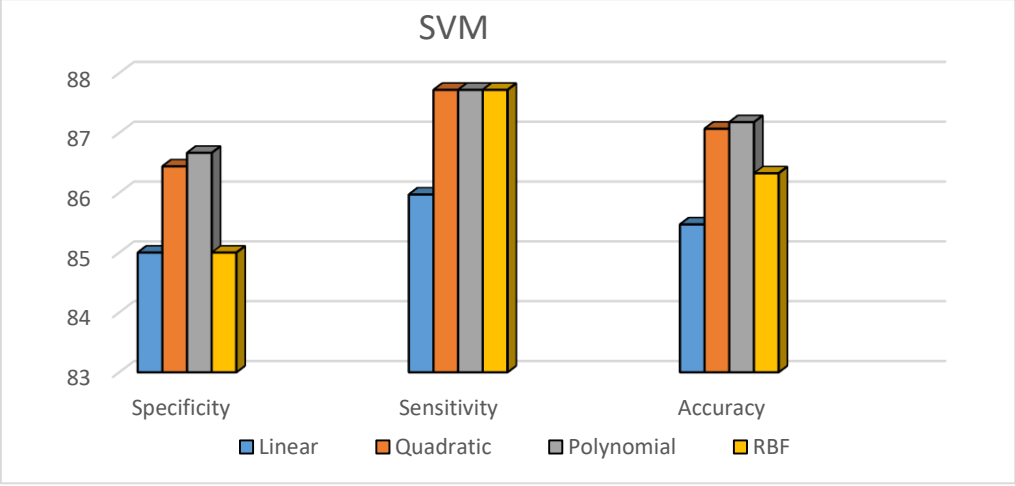

Figure 2: The result of SVM using HOG by different kernel function with test dataset

- SVM Classifier Using LBP:

In this work, the Local Binary Pattern (LBP) is used for features extraction by SVM classifier. Dataset are trained using LBP process for features execration as 59 features.

Table 3: The result of SVM using LBP by different kernel function with test dataset

Characteristic	Linear	Quadratic	Polynomial	RBF
Specificity	97.91666667	85	97.6744186	97.91666667
Sensitivity	88.88888889	87.71929825	86.95652174	97.77777778
Accuracy	93.5483871	86.32478632	92.13483146	97.84946237

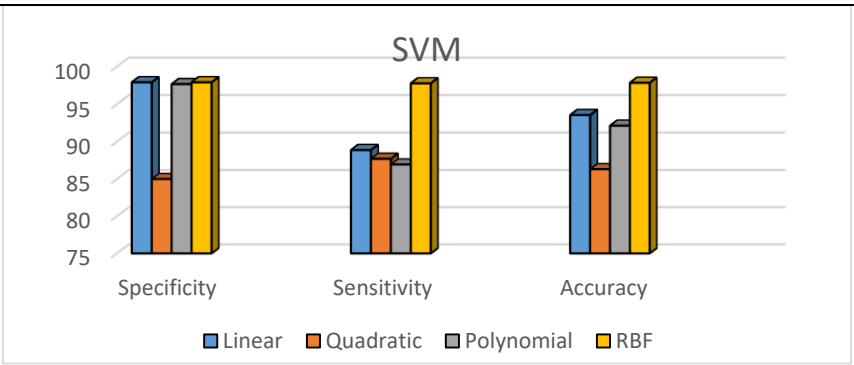

Figure 3: Graph is illustrating that SVM using LBP by different kernel function with test dataset.

The above **Table 3** shows the best accuracy in SVM using LBP by RBF kernel function. Accuracy is 97.85 % by RBF kernel function using as the best results.

Referring to the previous results of SVM classifier and comparing them with all Kernel Function types, it is illustrated that SVM using LBP by RBF kernel function has the best results as shows in the following **Table 4** which shows the best accuracy in SVM using LBP by RBF kernel function. It is find out that the probability of detecting true positive (Sensitivity) is 97.78%, whereas the detecting rate of true negative (Specificity)is 97.92% and the detecting rate of all correct cases(Accuracy) is 97.85 % by RBF kernel function using as the best results.

Table 4: The best accuracy for SVM Classifier Using LBP by RBF kernel function with test dataset

SVM using RBF kernel	
Specificity d / (c+d)	97.91666667
Sensitivity a / (a+b)	97.77777778
Accuracy (a+d) / (P+N)	97.84946237

- Multilayer perceptron (MLP) Classifier:

Multilayer perceptron (MLP) classifier is used to train the image that extracted its features by using two methods as HOG and LBP, also this classifier is used in the testing phase to test the image that extracted its features by using two methods as HOG and LBP, then the researcher summarized each method separately as follows

- Multilayer Perceptron (MLP) Using HOG:

The HOG features are extracted exactly based on non-overlapped grid bone images for each person,the performances of bone recognition according to different parameters in this method [9]. The researcher got results such as specificity, sensitivity and accuracy for each neuron number by HOG using . Number of neuron in the hidden layer =24 which considered the best results (specificity, sensitivity and accuracy) in MLP as follows in **Table 5.**

Table 5: The Number of neuron in hidden layer =24 which considered the best results (specificity, sensitivity and accuracy) in MLP.

Number of Neuron In	Specificity	Sensitivity	Accuracy
18	95.8677686	96.46017699	96.15384615
19	95.8677686	98.2300885	97.00854701
20	97.52066116	95.57522124	96.58119658
21	95.04132231	99.11504425	97.00854701
22	95.8677686	99.11504425	97.43589744
23	96.69421488	97.34513274	97.00854701
24	97.52066116	99.11504425	98.29059829
25	97.52066116	98.2300885	97.86324786
26	97.52066116	98.2300885	97.00854701
27	95.8677686	99.11504425	97.43589744
28	95.8677686	98.2300885	96.15384615
29	94.21487603	99.11504425	97.43589744
30	95.8677686	98.2300885	96.58119658
31	95.04132231	96.46017699	95.72649573
32	95.04132231	97.34513274	96.58119658
33	95.8677686	84.61538462	93.28358209
34	94.21487603	100	97.86324786
35	95.8677686	96.46017699	95.2991453
36	94.21487603	98.2300885	97.86324786

In **Figure 4**, the curve is constructed using the specificity, sensitivity and accuracy. From the binary classification system for the long bone fracture detection, there four variables that are considered for specificity, sensitivity and accuracy, this variables are true positive, false negative, false positive and true negative. Consequently, that the number of neuron in hidden layer =24 which considered the best results (specificity=97.52, sensitivity=99.12 and accuracy =98.29) in MLP by using HOG.

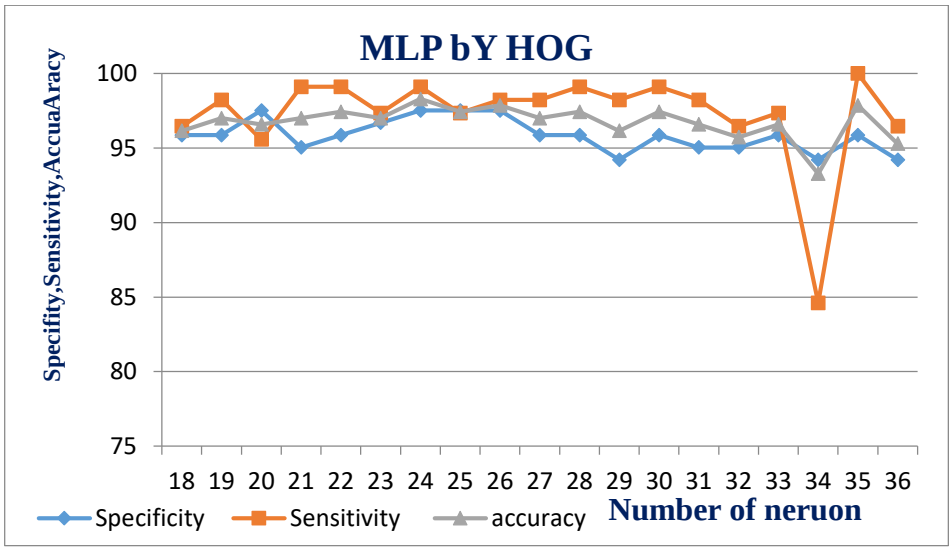

Figure 4: Graph is illustrating that the Number of neuron in hidden layer =24 which considered the best results (specificity=97.52, sensitivity=99.12 and accuracy =98.29) in MLP by using HOG

Table 6: The Number of neuron in hidden layer =38 which considered the best results (specificity, sensitivity and accuracy) in MLP

Number of Neuron neuron in hidden layer	Specificity	Sensitivity	Accuracy
30	95.8677686	100	97.86324786
31	97.52066116	99.11504425	98.29059829
32	97.52066116	99.11504425	98.29059829
33	95.8677686	100	97.86324786
34	94.21487603	99.11504425	96.58119658
35	97.52066116	99.11504425	98.29059829
36	96.69421488	100	98.29059829
37	97.52066116	99.11504425	98.29059829
38	98.34710744	100	99.14529915
39	98.34710744	96.46017699	97.43589744
40	96.69421488	96.46017699	96.58119658
41	95.8677686	99.11504425	97.43589744
42	97.52066116	97.34513274	97.43589744
43	98.34710744	98.2300885	98.29059829
44	95.8677686	84.61538462	94.7761194
45	96.69421488	97.4789916	97.08333333
46	93.38842975	99.11504425	96.15384615
47	95.8677686	99.11504425	97.43589744
48	94.21487603	99.11504425	96.58119658
49	92.56198347	100	96.15384615
50	97.52066116	100	98.71794872
51	97.52066116	97.34513274	97.43589744
52	97.52066116	100	98.71794872
53	95.04132231	99.11504425	97.00854701
54	95.8677686	95.57522124	95.72649573
55	97.52066116	99.11504425	98.29059829
56	95.8677686	98.2300885	97.00854701
57	95.04132231	99.11504425	97.00854701
58	91.73553719	99.11504425	95.2991453
59	95.04132231	99.11504425	97.00854701
60	97.52066116	98.2300885	97.86324786

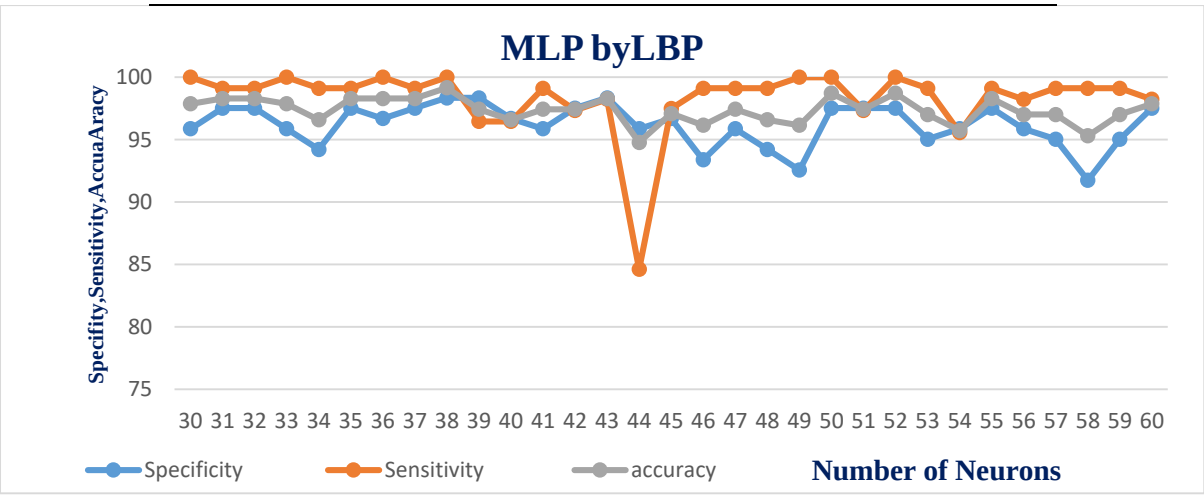

Figure 5: Graph is illustrating that the Number of neuron in hidden layer =38 which considered the best results (specificity=98.35, sensitivity=100 and accuracy =99.15) in MLP.

From the above Figure, we can see that the best results by MLP using LBP with number of neuron in hidden layer =38 which considered the best results in MLP. There are the best results as Sensitivity, Specificity and Accuracy are 100, 98.35 and 99.15 percent respect by MLP. MLP using LBP has the best results. Therefore, It is must use for the long bone fracture detection system using machine learning.

3.5 3.5.The Best Result:

Referring to the previous results of SVM classifier and MLP classifier, then comparing them with all algorithms (HOG, LBP) , it is illustrated that MLP using LBP with number of neuron in the hidden layer =38 has the best results as shows in **Table 7**.

We obtained a the best results by MLP using LBP .There are the best results as Sensitivity, Specificity and Accuracy are 100, 98.35 and 99.15 percent as show in **Table 7**.

Table 7: Shows the best accuracy in MLP using LBP

Classifiers	SVM	MLP
Specificity	97.91666667	98.34710744
Sensitivity	97.77777778	100
Accuracy	97.84946237	99.14529915

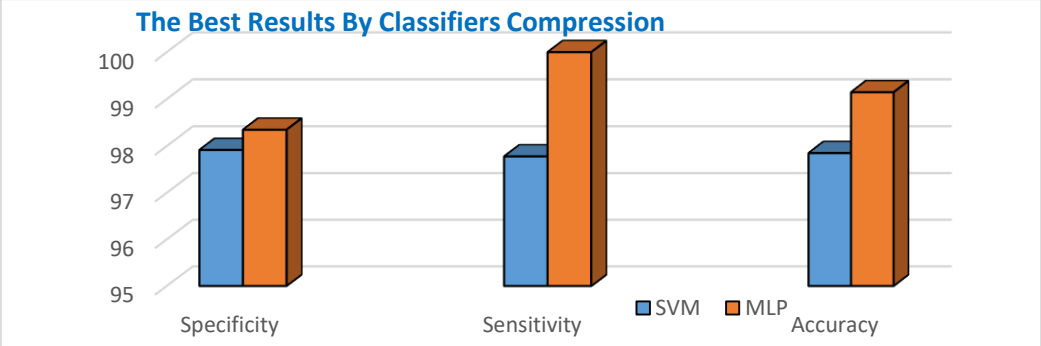

Figure 6 :The best results by classifiers compression, that MLP classifiers is considered the best results (specificity=98.35, sensitivity=100 and accuracy =99.15) by using LBP .

From the above figure, we can see that the best results of MLP , We obtained a the best results by MLP using LBP .There are the best results as Sensitivity, Specificity and Accuracy are 100, 98.35and 99.15 percent by MLP. MLP classifiers have the best results. Therefore, it is must use for the long bone fracture detection system using machine learning.

4. Conclusion

Actually the algorithm can detect correctly in fracture images for a big dataset by enhancing the dataset is required. According to the test results, the performance of the detection method affect by the quality of the image. A software algorithm capable of providing some theory after bone fracture detection has been specified, and implemented. Features are extracted using by Histogram Oriented Gradients (HOG) and Local Binary Pattern (LBP) algorithm .After that all, this system determined whether a fracture exists or not in the image.. According to the experimental results , I think that the results of the system are excellent, and this will satisfy everyone.. Multilayer Perceptron algorithm has the highest accuracy of 99.15 percent. We obtained the best results by MLP using LBP which has the best results as Sensitivity, Specificity and Accuracy are 100, 98.35 and 99.15 percent. The researcher suggested suggestions for developing his research in the future Suggestions that the system can be developed using deep learning technology in the future, and it can also be designed and connected to a network in order to examine and detect bone fracture.

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