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Long Bone Fracture Detection Using Machine Learning

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الملخص

تقدم الباحثة في هذا العمل نظاماً آلياً للكشف عن كسور العظام الطويلة باستخدام الصور السريرية المأخوذة من الأشعة السينية لأغراض التشخيص. يعتبر إجراء تشخيص كسور العظام خطوة حاسمة للغاية بناءً على عوامل لتحديد هذه الصورة على أنها طبيعية أو غير طبيعية لتوفير الجهد والوقت الذي يقضيه للكشف عن كسور العظام. غالبًا ما يحدد أخصائي الأشعة المدربون الأمراض النادرة بدقة عالية مثل الكسور. ومع ذلك، فقد أظهرت الاختبارات التي فحصت دقة شخص ما أنه عند قراءة الأشعة السينية مع وجود العديد من الأخطاء، قد يرتفع معدل الخطأ في بعض الحالات. التشخيص الدقيق لكسر العظام مهم. يتم استخدام خوارزمية التدرجات الموجهة للمخططات البيانية (HOG) وخوارزمية النمط الثنائي المحلي (LBP) لاستخراج الميزات. استخدمت هذه الدراسة مصنفين مختلفين، المصنف الأول هو مصنف المتجهات الداعمة للألة (SVM) (Support Vector Machine)، والذي يوفر دقة تصل إلى 97.85٪ من خلال دالة نواة الأساس الشعاعي (RBF) والمصنف الثاني هو مصنف الإدراك متعدد الطبقات (MLP) (Multilayer Perceptron)، والذي يعطي دقة تصل إلى 99.15٪، ثم تتم مقارنة دقة المصنفات مع بعضها البعض. وبالتالي، فإن خوارزمية الإدراك متعدد الطبقات لديها أعلى دقة بنسبة 99.15 بالمائة. لقد حصلنا على أفضل النتائج من خلال مصنف MLP باستخدام LBP الذي حقق أفضل النتائج مثل الحساسية والنوعية والدقة بنسبة 100 و98.35 و99.15 بالمائة. نتيجة لذلك، تعد معالجة كسور العظام على المدى الطويل مشكلة رئيسية في العظام والأشعة، ويقترح أن برنامج اكتشاف الكسور الجديد بمساعدة الكمبيوتر يمكن أن يساعد في تقليل مخاطر فقدان العظام على المدى الطويل.

تقدم الأطروحة مناقشة واكتشاف نظام قائم على الكمبيوتر للكشف عن كسور العظام الطويلة بواسطة برنامج MATLAB، والذي تم استخدامه كأداة برمجة لتحميل الملفات ومعالجة الصور.

الغرض من هذا العمل هو توفير نظرة ثاقبة للأنشطة ذات الصلة بالبحوث التي أجريت. بالإضافة إلى ذلك، اقترحت الباحثة نظام الكشف عن كسور العظام الطويلة باستخدام برنامج مدعوم بالحاسوب. علاوة على ذلك، ذكرت الباحثة لمحة موجزة عن المصنفات المستخدمة في الكشف عن كسور العظام الطويلة.

الكلمات المفتاحية: كشف عن كسور العظام الطويلة، طبيعي، غير طبيعي، مصنفات، آلة.

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 for diagnostic purposes. 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. However, tests examining the accuracy of someone have shown that when reading X-Rays with several errors, the error rate may rise in some cases. 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. As a result, long-term bone marrow transplantation is a major problem in bone and radiology, and it is suggested that a new computer-assisted discovery program could help reduce the risk of long-term bone detection loss.

The study presents a discussion and discovery of a computer-based long bone fracture detection system by MATLAB, that had been used as the programming tool for loading files, image processing.

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. Furthermore, the researcher has mentioned a brief overview of classifiers used in the detection of long bone fractures.

Key words: long bone fraction detection, normal, abnormal, classifiers, machine learning.

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 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 a**l [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 mentioned a brief overview of classifiers used in detection of long bone fractures.

Problem Background:

Diagnosis supported by computers is a warm field of research. It is highly desirable to have devices with the potential to provide a highly accurate diagnosis using little resources. One type of such systems relies on clinical images to provide instant diagnosis based on certain discriminative features extracted from the images after they have been processed for noise reduction and improvement. We are proposing a system in this paper Which consisting of improvement. (either individually using bagging and boosting techniques or as a team using stacking and voting techniques). Mena et al [3].

consider the issue of imbalanced data sets in medical diagnosis and

propose a rule-induction algorithm. This research addresses the issue of identifying X-Ray fractures in the long bone. Two 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].

Problem Statement:

Through the study and diagnosis ways for bone fractures using traditional methods, it has shown the there are four difficulties faced by doctors during the diagnosis of bone fractures are as follow:

1- There are some wrong diagnoses.
2- A little experience with doctors and radiologists in the Current situations.
3- Needed for large time in bone fractures analysis by doctors.
4- The manual identification is not fast, accurate and efficient.

Research Aim:

This study aims to detect whether there is a broken bone by developing a system with computer-assisted automated detection of long bone fractures using image processing algorithms. The study was carried out on much group of long bone CT images including the arm, shoulder, leg and hand. The study value is to take methodological steps to identify or analyze the existence of a broken bone, It also use Artificial Neural Network (ANN) technology to improve the accuracy of images taken to diagnose and detect bone fractures and to save the effort, time and cost to detect bone fractures. The program capable to overcome the difficulties faced by physicians during diagnosis, and to provide a clear sight for clinical bone fractures, which usually improves diagnostic performance and reliability and increases accuracy.

Research questions:

The study tries to answer the following questions:

1- What is the difference between a current fracture system and a computer-assisted computer?
2- What is the current type of orthopedic program used by the Yemeni Ministry of Health?
3- What are the requirements to use the computer-assisted computer program in Yemen?
4- What is the suggestion for improving the use of computer support program in Yemen?

5- What electronic services can be provided by computer-assisted computer programs in Yemen?
6- How can you use a computer program to locate a bone marrow transplant?

Research Objectives:

Some objectives used by the system are as follows:

1- Identify bones and separates.
2- Reduce the time required to diagnose fractures to overcome some problems.
3- Search for the best way to detect fractures with machine learning technology by using algorithm for training and testing.

Research Justification (Significance):

The importance lies in human ability to recognize the long bone fracture detection systems are one of the main topics to study the fields of computer vision and Machine Learning.

1- The importance lies in the needed of application the long bone fracture detection systems, human-computer interaction.
2- This study evaluates the performance of algorithms and creates a flexible and easy to use system by user.
3- System provides a very good accuracy and save time and effort.

Research Scopes:

This Research focuses on the develop a system that implements computer-assisted automatic bone fractures detection in Yemen for applying Information Technologies (ITS).

The Research is one of the of Information Technology field (IT) as follows:

1- The used X-Ray images are collected from some hospitals especially Al Safwa Hospital.
2- Use the Matlab for bone fracture system analysis
3- Use the Matlab for MLP and SVM classifiers development, training and testing.

Research Terminology:

1- **Histograms of Oriented Gradients (HOG) algorithm:**

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]. The final product of the

HOG is a feature vector which consists of the all of the feature descriptors in the image. The larger the amount of bins, the more detail the histogram will contain. A balance must be made between the amount of desired detail and the size of the feature vectors [5].

2- **Local Binary Pattern (LBP) algorithm:**

LBP is a global texture-based features descriptor introduced by **Ojala in 2002 [6]** and LBP features labels the pixel value by threshold the neighborhood of each pixel and analyze the outcome as binary numbers. The feature descriptor algorithm allows better handling the scale changes and occlusion. Also it a simple algorithm that are used for feature extraction from hyper spectral image. Also it was powerful descriptor for feature extraction and improved the classification accuracy by classifiers using **[7].**

3- **Support Vector Machine (SVM) classifier:**

Support vector machine (SVM) is a type of supervised learning method, capable of performing both classification as well as regression. The idea is based on the non-linear mapping of vectorized input data to very high dimensional feature space. Following that a linear decision hyperplane is generated in the features space, nearest to the extreme samples in the dataset. The decision hyperplane is also called the decision boundary **[8].**

Related Work (Review of Related Literature):

Artificial Intelligence (AI) is used in various applications. Automatic medical diagnosis was introduced in the early 1970s in the form of a tree analysis solution **[9]**, in which details were organized into a tree-like structure for easy search purposes. The simplest implementation of automatic diagnostics using some.

Neural network complexity have drawn by the number of input parameters and the communication factors between the layers of the neural network.

The related activities described in this work, focus on fracture detection methods using X-ray images by Machine Learning. Other related computer-focused activities (feature extraction Techniques) The computer-assisted viewing techniques include image-and-element separation and feature-removal in image sources. The classifiers used in my study are Support Vector Machine (SVM) and Multilayer perceptron (MLP), but researchers were used the different of classifiers in the past as show in the related literature.

Previous Similar studies:

The researcher summarized some Previous Similar studies as follows:

- Fracture Detection by Machine Learning:

Brahim A. et al (2019) [10] introduced the CAD program for early knee detection of Osteo Arthritis (OA). The system uses knee X-ray imaging and learning algorithms to detect. X-ray images are like that processed using Fourier _filter on the Fourier domain. The selection of the extracted elements was done using Independent Component Analysis (ICA), which is a method of reducing the size. These selected features are provided to the Na five Bayes and classifiers random forest OA forest acquisition authors The authors obtained 82.98% accuracy using 1024 X-Ray images **[10, 11]**.

The authors in [33] (2018) introduced a computer-assisted diagnostic system that combines two methods. The First Hough transform fracture detection (HTBFD) method, which uses an unsupervised learning method using abnormal c-mean blocking and detection of bone marrow transplantation. The second method involves the acquisition of a Gradient based fracture detection (GFBFD) feature that uses a supervised learning method. Gradients are extracted using a window search. The authors found a better performance of the GFBFD method with 88% accuracy compared to the HTBFD method **[12]**.

Donnelley, M et al (2016) [31] recommended a Computer Aided Diagnosis (CAD) system for detecting permanent fractures during X-ray examination by medical professionals. The system consists of long bone detection, parameter measurement, diaphysis separation and fracture detection using gradient analysis.

In the discovery of a long bone marrow, the features are extracted using a morphological scale space. The parameter measurement does not include areas of long bone formation using Hough Toggle to get a straight line. Straight line boundaries are used to mark formation areas. In the dividing phase of the diaphysis, the line between the bones is cut. Gradients are drawn on a straight line obtained. Fractures are obtained based on the direction of a specific line in the normal lines. If a certain line corresponds to a normal line, then it is considered non-breaking. However, lines with large gradients that do not match the edges of the bones indicate something unusual, that's why the line is broken. The authors obtained an accuracy of 83% acquisition of the proposed CAD program **[13, 1]**.

The classifiers used in my study are Support Vector Machine (SVM) and MLP:

The researcher discussed similar studies that are used the same classifiers in her study as follows:

Memon et al (2020) [8] presented a study of the problem of detecting abnormality in forearm X-rays, Main preprocessing techniques are applied in this system, canny edge method is used to identify the ROI and intensity based detection is used to determine the abnormality. In addition, different group of features are extracted, then SVM Classifier is used, afterthat, invisible 40 images have been tested and achomplished 85.7% accuracy, 90 images have been trained and the 93.5% accuracy has been achomplished in this system [**8].**

He, JC et al (2019) [14] introduced the process of finding the divisions that divided the problem into smaller problems. Minor problems lie in the SVM kernel space. The training process trains two SVMs, such as each small problem can be solved by a special SVM, so a SVM management team is created. The test results obtained show that the SVM management category works better than a single SVM. In addition, performance has been shown to improve the accuracy and reliability of SVMs **[14, 15].**

The authors of [16] (2018) presented a study of a model designed to predict the type of fracture in X-ray images. There are two types of elements considered by the authors, namely the removal of the feature and the composition. The layout elements connect to the Hough Transform feature release, while the text elements are extracted using HOG. Exposed structural features mean higher Hough Transform values and standard deviations of higher Hough Transform values. text features include image brightness, strength, homogeneity and blending **[16]**.

Sharmila S. .et al [17] (2015), were presented a machine learning based system for automatic detection and classification of fracture types in long bones using x-ray images. Several image processing tools like corner and edge detection were used to extract useful and distinguishing features. In the classification and testing phase, SVM classifier was found to be the most accurate with more than 78% accuracy under the 10-fold cross validation technique. This paper deals with the automatic detection and classification of fractures in long bones using various image processing techniques and machine learning algorithms. The paper primarily focuses on diagnosis of x-ray images **[17].**

The authors of [18] (2013) described the mechanism for the detection of bone fractures in the femur in the femur and radius. The system consists of a combinational approach. The First step of the system is

to pre-process the input by extracting features, namely Gabor texture, Markov Random Field texture and intensity gradient. The classifiers implemented for testing are Bayesian classifier and Support Vector Machine (SVM). From experimental results, the combined approach improved the detection rate of bone fractures as well as the classification accuracy compared to a single classification approach **[18, 19].**

Umadevi, N. et al (2012) [9] introduced a multi-segmentation system that finds fractures in the long bones (especially the tibia). Features used by the system texture and shape. The program uses two different classifiers, namely Back-Propagation Neural Network (BPNN), K-Nearest Neighbor and Support Vector Machine (SVM). Each classifier is trained with different data sets. Fusion Election was adopted as a voting system for the decision-making process. The decision made by the system is binary. It indicates whether the fracture is present or not **[9]**.

Alzohairy, T. A. et al [20] (2012) present a new date fruits sorting system using artificial neural networks (ANN). The aims of this study are to define a set of external quality features from the shape and color for different types of date fruits and to examine the effectiveness of the neural network models for image classification. In the experiments for performance evaluation the neural networks achieved a recognition rate equal to 87.5% and 91.1% respectively for MLP with backpropagation and RBF **[20]**.

Mahendran. S and et al (2011) [21] described a study conducted to test the effectiveness of single classifiers. The classifiers used in the study are Back-Propagation Neural Network (BPNN), Support Vector Machine (SVM) and NB (NB classifiers. Brightness, Similarity, Power, Entropy, Mean, Variance, Standard Intersection deviations, Gabor orientation (GO), Markov Random Field (MRF) and gradient direction (IGD) are factors considered in the evaluation of each classifier.

Metrics are used to assess the performance of each classifier sensitivity, specificity, fair amount of guessing, poor guessing value, accuracy and duration. The authors found that fusion classifiers improve discovery capacity. In addition, the results showed that the combination of SVM and BPNN received excellent performance **[21]**.

The authors of [22] (2011), proposed a four-step system that uses fusion separation techniques to facilitate the detection of fractures specifically for the skeletal bones (tibia). The four steps include processing, dissection, defect removal and bone detection. The two classifiers during the fusion Classifiers are Support Vector Machine

(SVM) and NB Classifiers (MLP). In an effort, the authors claim that the proposed four-step plan reflects significant development in terms of detection rate and severity rate **[22].**

The authors in [23], (2011) proposed a system based on Artificial Neural Network (ANN) for bone marrow detection. The system is designed to accept X-ray images as its objects. Images are enhanced using pre-processing techniques. The ANN module is trained using advanced X-ray images. "True Detection Rate" and "False Detection Rate" are used to test system performance. The results obtained by the authors of the proposed program showed that the program was 89% successful **[23].**

- Related Studies in Feature Extraction Techniques:

The authors of [24] (2018) proposed a process to remove the edges feature of X-ray images using the Simplified Gabor Wavelet Transform. Gabor Wavelet Transform is a project built on the basis of Fourier Transform. It is often used to extract time and quantity information from a given signal [44]. In the proposed model, the Simplified Gabor Wavelet Transform is used to extract features from the edges. The use of the Simplified Gabor Wavelet Transform has been selected for comparison with the standard Gabor wave, which is more complex and does not appear to be useful for real-time applications **[24, 25].**

Ye, W. and all [26] (2018) presented a study for a face recognition method based on the dense grid histograms of oriented gradients (HOG). In addition, The HOG features are extracted EXACTLY based on non-overlapped grid face images FOR EACH PERSON, the performances of face recognition according to different parameters in this method. Moreover, The performances are compared with the two populist local feature description methods of the Gabor and LBP **[26].**

In [27] (2017), the authors analyzed a series of image processing algorithms for the classification of osteoporosis. The classification utilises K-Nearest Neighbors (KNN), whilst feature extraction uses the HOG technique. There are eight distinct features extracted from the X-ray images using the GLCM technique, namely mean co-occurrence matrix, standard deviation, entropy, angular second moment (ASM), energy, contrast, homogeneity, and dissimilarity. The authors obtained a 97.83% accuracy for the assessment osteoporosis from the complete implementation of the KNN and GLCM extracted features **[27].**

The authors of [28] (2016) used the discovery of the canal of Canny for photography. The proposed program includes image enhancement, image classification and feature removal. Feature releases are based on line detection by the Hough Transform process. Canny's edge detection is used for image separation to ensure focus on ROI. The straight lines obtained by the Hough Transform are used as elements of the break detection. Both distance and angle are used to represent the line. This is used to detect fractures, where distance and angle are analyzed. A line is found to be cracked if the line angle is less than 85, and unbroken lines have a range between 85 and 90 Authors tested the system using 21 X-ray images, where the detection of the system is 90%, but the system has a low detection rate where it can only find 3 broken images in 5 broken images **[28]**.

Sahin, F et. al [5] (2016) presented a new method to determine partially obscured humans by collecting features detected in RGB, depth, and thermal images. Moreover, the HOG features extracted from the three image types, which provided a very useful group of data to detect obscured humans usefully. In addition, The multi-layer classifier that was created achieved a high level of accuracy when tested against untrained data. The multi-layer classifier had a much tighter standard deviation and fell within the band of the SVM thermal classifier **[5].**

Alessandro S Martinse et. al [29] (2016**)** were presented a new method based on the association among curvelet transform, LBP, feature selection by statistical analysis and distinct classification techniques, in order to support the development of CAD systems for cancer breast tissues **[29]**.

In [30] (2015), the authors presented a model for the analysis of the texture and identification of lower extremity bones in X-ray images. The model is made up of two main components. Elements use HOG and K-Means merging techniques for texture analysis. The features extracted using the HOG process are: brightness, blending, strength and homogeneity. The K-Means compilation process is used to classify X-ray images as broken or unbroken based on extruded images. It does this by analyzing each point given in the excerpt. The authors reported 80% accuracy of system partition, of which 10 images were used for testing **[30].**

Vijayakumar, R et al (2013) [31] proposed an autoimmune algorithm for detecting bone fractures in X-ray images. The algorithm uses HOG to extract a feature to find the slope. The outputs are: comparison, local homogeneity, duration of contrast, entropy, adjustment,

variability, and scale. Fragmentation and non-fragmentation is performed based on HOG parameters. The authors reported 87% accuracy of detection **[31]**.

The authors Yang, F et al (2013) [18] suggested a procedure to exclude a feature based on greyscale histograms for the diagnosis of advanced esophageal cancer. The proposed process consists of two main steps, the first of which is image processing followed by the removal of a feature from the greyscale histogram and the finally Bayes discriminant used for verification of differentiation capabilities in extracted features.

Image processing converts RGB images into greyscale, as well as removing audio objects introduced by external interference. The results of the precision classification obtained using extracts were 66.7% of preventable esophagus cancer and 86.7% of ulcerative colitis **[18].**

In [32] (2012), the authors studied texture feature extraction in X-ray chest images. The study is conducted by first processing the X-ray images using histogram equalisation and morphological filtering, which improves both the contrast and SNR of the image. The texture features are extracted from the processed image. The authors indicated that the precision and recall accuracy of utilizing texture feature extraction is 85.32% and 85.56% retrieval accuracy, respectively **[32].**

The authors in [33] (2011) proposed a novel CAD system for the detection of long bone fragments using X-ray images. The system uses GLCM to locate and extract the element from X-ray images. The extracted features include the strength and contrast of the X-ray image. These factors are considered to be the parameters for the detection of the presence of a fracture. A set value of 0.95 of the GLCM generated parameters is used for the separation of cracked and non-broken X-ray image. The accuracy of the authors is 86.67% [**33]**.

Research Methodology:

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

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

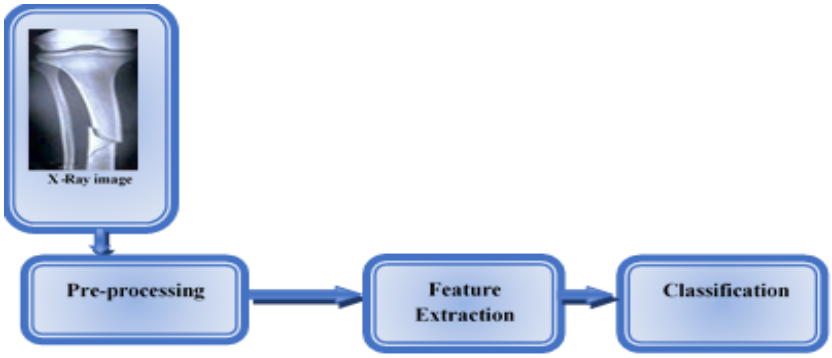

Figure 1: Block diagram of the proposed method

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.

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.

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.

Proposed Modle of long bone fracture detection system (General Alogrithm):

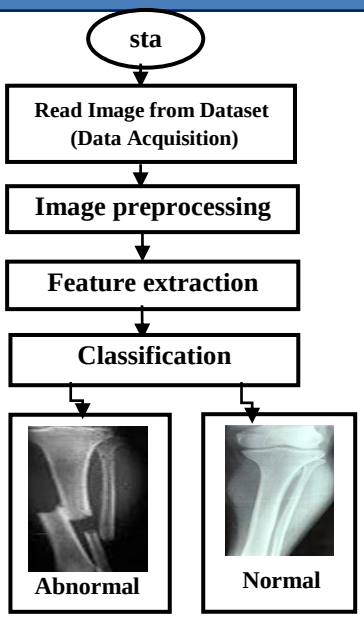

Figure.2: Proposed Model of long bone fracture detection system

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. Which is for the system of long bone fracture detection based on radiology as follows:

- 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.

- 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.

- Feature extraction:

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.

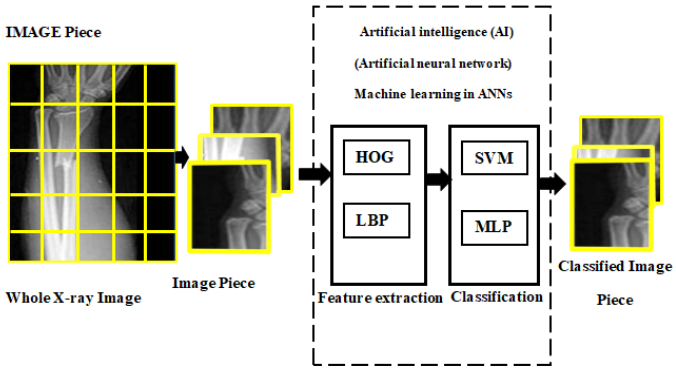

Figure 3: The long bone fracture detection System Overview

The features are extracted for the long bone fracture detection system by using HOG:

The 36 features that are extracted by using HOG algorithms. HOG Features apply classification on HOG features as general features.

The features are extracted by using HOG algorithm, this algorithm are applied on 1170 instances as follows:

1- HOG features that extracted 36 features (attributes).
2- The more effective set of features (attributes) are selected by using chart as Attribute Evaluator.
3- Two different classifier methods SVM and MLP are used for classification.

We take some of the bone images as examples of extracting the features using the HOG algorithm. Consequently, the 36 features are extracted for each image as follows:

First: take one of the normal bone image as example of extracting the features using the HOG algorithm. Consequently, the 36 features are extracted for image in the following chart (see figure 3.6), it shows the value of each the original feature for the selected image.

The non-broken bone image

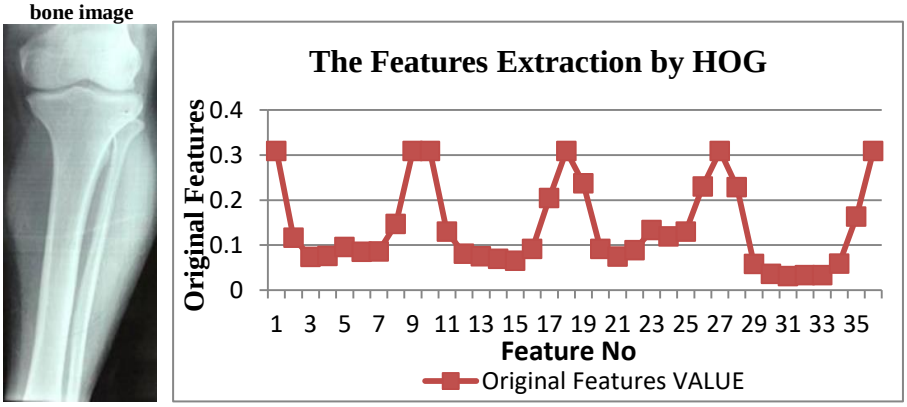

Figure 4: Graph is illustrating the original features which are extracted by using HOG for the normal bone image (the non-broken bone image).

From above figure, the curve is constructed using the original features for one image in the long bone fracture detection system. Consequently, 36 features are extracted by using HOG algorithm for the normal bone image.

Second: Take one of the Abnormal bone image as example of extracting the features using the HOG algorithm, consequently the 36 features are extracted for image in the following chart (see figure 4), it shows the value of each the original feature for the selected image.

The broken bone image

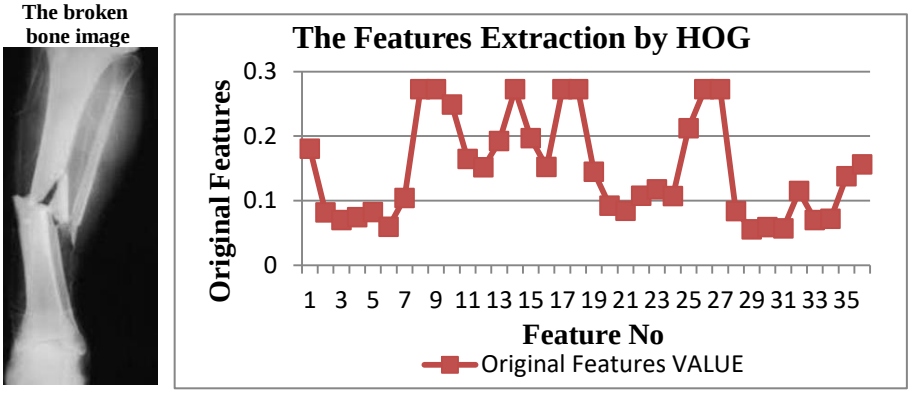

Figure 5: Graph is illustrating the original features which are extracted by using HOG for the Abnormal bone image (the broken bone image).

From above figure, the curve is constructed using the original features for one image in the long bone fracture detection system.

2- Local Binary Pattern (LBP) algorithm:

- The features are extracted by using LBP:

The 59 features that are extracted by using LBP algorithms for each image. LBP features apply classification on LBP features as general features.

The features are extracted by using LBP algorithm. This algorithm are applied on 1170 instances as follows:

1- LBP features that extracted 59 features (attributes) for each image.

2- The more effective set of features (attributes) are selected by using chart as Attribute Evaluator.

take one of the normal bone image as example of extracting the features using the LBP algorithm. Consequently, the 59 features are extracted for image in the following chart, it shows the value of each the original feature for the selected image.

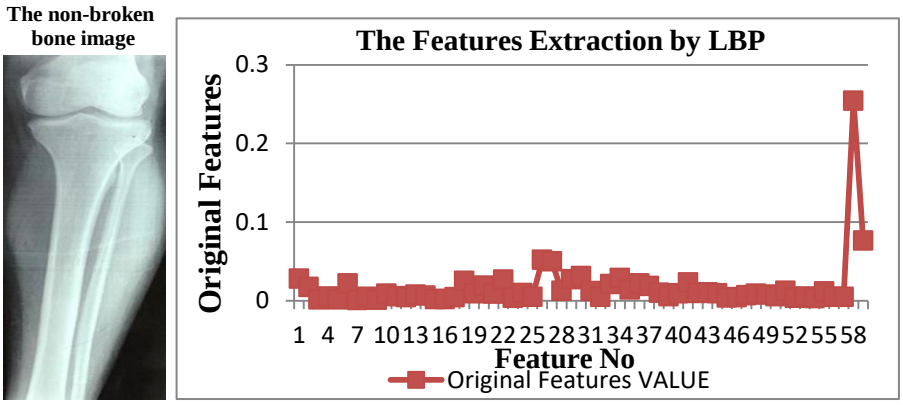

Figure 6: Graph is illustrating the original features which are extracted by using LBP for the normal bone image (the non-broken bone image).

From above figure, the curve is constructed using the original features for one image in the long bone fracture detection system. Consequently 59 features are extracted by using LBP algorithm for the normal bone image.

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. 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. 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. The purpose of this classification is to group and classify bone images as normal and abnormal (broken bone).

I as researcher, summarizes each classifiers separately as follows:

1- Support Vector Machine (SVM) classifier:

The SVM classifier is used to train the image that extracted its features by two algorithms, Which are the Histogram Oriented Gradients (HOG) and local binary pattern (LBP) algorithms, classifying the broken bone images, which are two classes as normal or abnormal bone image class (class A, class B), also this classifier is used in the testing phase to test the image that extracted its features by LBP algorithm, then the researcher summarizes each method separately as follows:

- Support Vector Machine (SVM by HOG):

The Support Vector Machine (SVM) classifier is used to train the image that extracted its features by Histogram Oriented Gradients (HOG) algorithm, which extracted 36 features. The SVM classifier is used with all its types for the kernel functions, which are linear, quadratic, radial basic and polynomial kernel function, classifying the bone images, which are two classes as normal or abnormal bone image class, the performance results are different values of accuracy, sensitivity and specificity for each type. Consequently, the best result is in the SVM classifier that used the polynomial kernel function.

- Support Vector Machine (SVM by LBP):

The SVM classifier is used to train the image that extracted its features by the local binary pattern (LBP) algorithm and produced 59 features. The performance results are different values of accuracy,

sensitivity and specificity for each type, and the best result is with the SVM classifier by the radial basic kernel function.

2- Multilayer Perceptron Classifier (MLP):

Multilayer Perceptron (MLP) classifier is used to train the image that extracted its features by two algorithms, which are the Histogram Oriented Gradients (HOG) and local binary pattern (LBP) algorithms. In the addition, this MLP classifier is used in the testing phase to test the image that extracted its features by two algorithms as HOG and LBP.

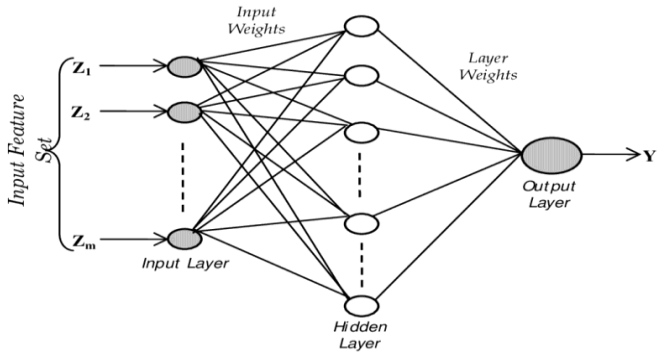

Figure :7 Multilayer Perceptron (MLP) classifiers

The researcher summarizes each method (MLP by HOG. MLP by LBP) of MLP separately as follows:

- Multilayer Perceptron (MLP by HOG):

The Multilayer Perceptron (MLP) classifier is used to train the image whose features were extracted by the HOG algorithm. 36 features are extracted by HOG algorithm as inputs in the input layer, where the number of neurons in the input layer = 36 features, the number of neurons in the hidden layer from 18 to 36 (from half the number of features using HOG to the total number of features), (but it was stopped at the number of Neuron = 36) and the number of neurons in the output layer = 1 (normal bones = 0 and broken bones=1). The results are the different values for accuracy, sensitivity and specificity. According to the detailed results for each number of neuron, the best result is by MLP whit the number of neutrons in the hidden layer = 24.

Sigmoid Function: This function that actives in the hidden layer in the training phase. The purpose of this function to determine the normal bones or broken bones (normal bones = 0 or broken bones = 1) then it compares results with the target output in the next layer (output layer).

Liner Function: is function that actives in the output layer in the training phase and testing phase.

The purpose of this function to determine the output as normal bones or Abnormal bones (normal bones = 0 or Abnormal bones = 1).

- Multilayer Perceptron (MLP by LBP):

The MLP classifier is used to train the image that has extracted its features using the LBP algorithm. Consequently 59 features are extracted, where the number of neurons in the input layer = 59 features, the number of neurons in the hidden layer from 30 to 60 (from half the number of features using LBP to the total number of features), (it was stopped at the number of Neuron = 60) and the number of neurons in the output layer = 1 (normal bones = 0 and broken bones = 1). The results are the different values for accuracy, sensitivity and specificity according to the detailed results for each the number of neurons, the best result is by MLP when the number of neutrons in the hidden layer = 38

RESULTS AND DISCUSSION:

- 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.

- Testing phase:

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

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.

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 **[34].**

Classification Results and Discussion:

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, 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

Characteristi	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 8).

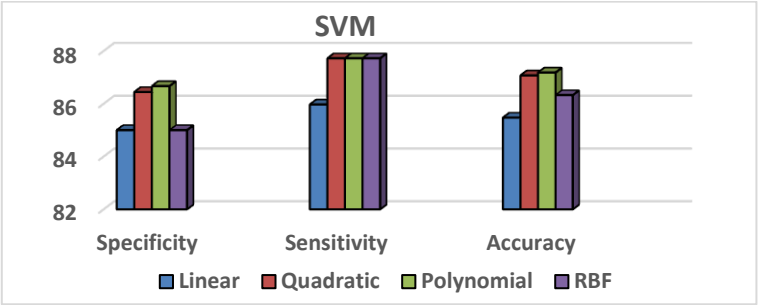

Figure 8: The result of SVM using HOG by different kernel function with test dataset

- 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**

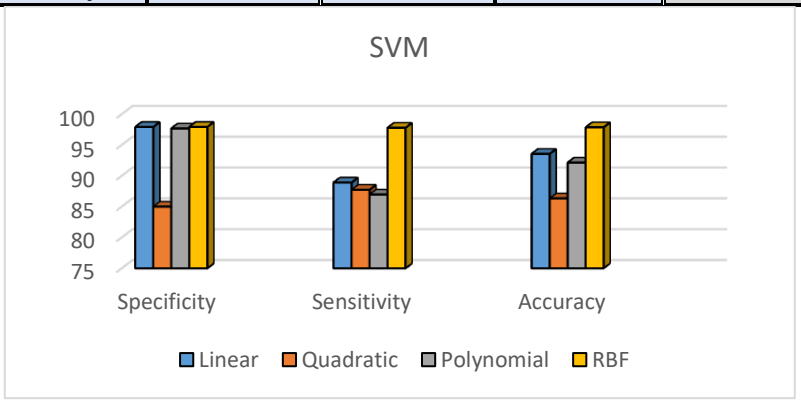

Figure 9: Graph is illustrating that SVM using LBP by different kernel function with test dataset.

The above table 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.

The following table 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 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 Table4.5.

Table5: The Number of neuron in hidden layer =24 which considered the best results (specificity, sensitivity and accuracy) in MLP.

Number Of Neuron In Hidden Layer	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

Number Of Neuron In Hidden Layer	Specificity	Sensitivity	accuracy
34	94.21487603	100	97.86324786
35	95.8677686	96.46017699	95.2991453
36	94.21487603	98.2300885	97.86324786

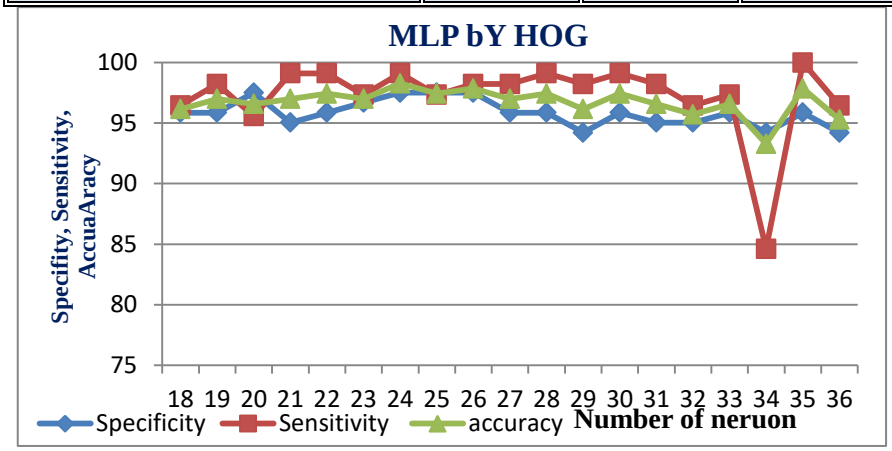

Figure 11: Graph is illustrating that the Number of neuron in hidden layer =24 which considered the best results (specificity=97.52**, sensitivity**=99.12 **and accuracy** =98.29**) in MLP by using HOG**

Discussion:

From above figure (figure 4.8), 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.

- **Multilayer Perceptron (MLP) USING LBP:**

The MLP classifier is used to train the image that has extracted its features using the LBP algorithm. 59 features are extracted, where the number of neurons in the input layer = 59 features, the number of neurons in the hidden layer from 30 to 60 (from half the number of features using LBP to the total number of features). The results are the different values for accuracy, sensitivity and specificity according to the detailed results for each the number of neurons, the best result is by MLP when the number of neutrons in the hidden layer = 38. The researcher gets results such as specificity, sensitivity and accuracy for each neuron value by using LBP as follows in Table (6).

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

Number of Neuron	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

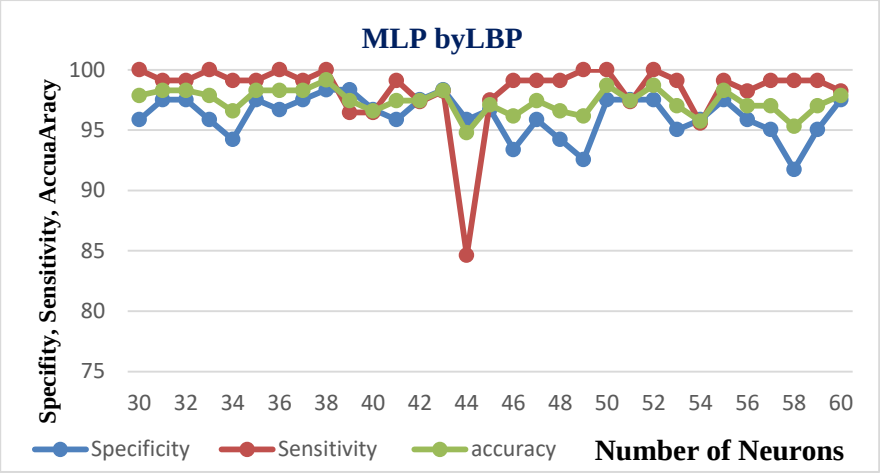

Figure 12: Graph is illustrating that the Number of neuron in hidden layer =38 which considered the best results (specificity=98.35, sensitivity=100 and accuracy =99.15) in MLP.

Discussion:

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.

Table 7: The Number of neuron in hidden layer =38 which considered the best results (specificity, sensitivity and accuracy) in MLP

Number of Neuron	Specificity	Sensitivity	Accuracy
38	98.34710744	100	99.14529915

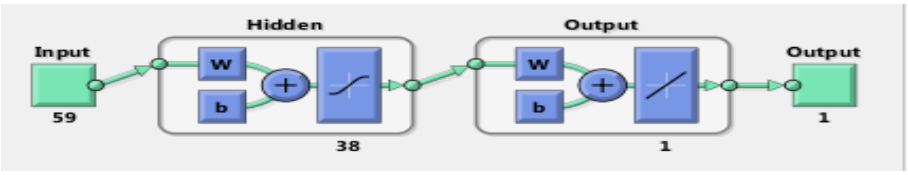

Figure 13: The neural network which Number of neuron in hidden layer =38 which considered the best result in MLP

Referring to the previous results of MLP classifier and 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 the following table.

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 the following table

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 the following table.

Table 8: 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**

Discussion:

From the above table 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, 98.35 and 99.15 percent by MLP. MLP classifiers has the best results. Therefore, It is must use for the long bone fracture detection system using machine learning.

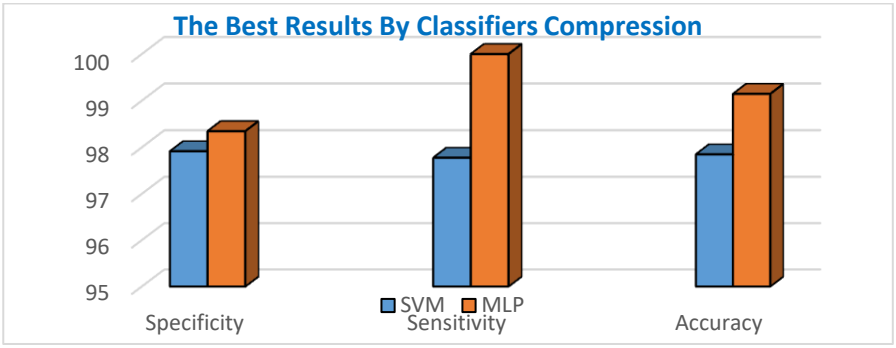

Figure 14: The best results by classifiers compression, that MLP classifiers is considered the best results (specificity=98.35, sensitivity=100 and accuracy =99.15) by using LBP.

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.

Recommendations:

Finally, this study has reached to the following recommendations:

1- Collecting a larger dataset.

2- The modern software techniques are used in designing a system for detecting bone fractures Such as Python languages
3- Extracting features for larger images
4- Using other classifiers such as CNN after dataset has grown up with machine learning upgrade
5- Using deep learning technology.

Future work as follows:

1- The system can be developed using deep learning technology
2- An online system can be designed and connected to a network, then a bone fracture is examined and detected.

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