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Comparison Supervised Learning Algorithms for Spinal-Column Disease

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Abstract: ***In this study the classification were performed on Vertebral Column study. The dataset that were used in this study was performed and studied on 310 orthopedic patients and their vertebral column parameters were evaluated as 6 features for each patient (pelvic_incidence, pelvic_tilt numeric, lumbar_lordosis_angle, sacral_slope, pelvic_radius, degree_spondylolisthesis). These parameters were obtained from a panoramic image of the spine. The 100 subjects had no spinal vertebral pathology issues (normal). and other 210 subjects were assigned as abnormal (60) patient were suffering from disc dislocation (disc hernia) and 150 subjects were suffering fromspondylolisthesis . So the results for these attributes were assigned two classes normal or abnormal (disc dislocation or spondylolisthesis). In this study classification were compared according to their performance by using different (7) classification algorithms are: (RF, RF, DT, SVM, Naïve Bayes (NB), KNNc, MLP). And each of the classifier were evaluated their performance (Accuracy, sensitivity, specificity, Errors). The highest accuracy and specificity and lowest Errors were recorded about (83.4% and 100%, 16% respectively) in naïve bayes classifier. where for the highest sensitivity in Random forest were recorded (81.4%). In this study were showed that naïve bayes classifier were recorded the best classifier performance.***

Keywords: Vertebral column dataset, ML classification algorithms Logistic Regression, Random Forest, decision Tree, Support Vector Machine, Naïve Bayes, k-nearest neighbor's classifier, neural network classifier

1. Introduction

The use of automated learning in various medical fields has been demonstrated in the classification and prediction of disease. The use of automated learning is widely disseminated with the growth of medical data in the medical field to improve medical services and diagnosis of diseases since each medical study includes these techniques, Various medical fields have implemented different learning algorithms for many purposes, disease implementation, classification and therapeutic recommendations for the patient through their biological characteristics, In this article to help doctors Predict and explore bone disease easily.

In This paper **python language version (2.7)** were used as program language of using ML classifiers algorithms that applied on biomechanical dataset for classify the dataset into two classes (normal and abnormal) of orthopedic subjects that were investigated and got their information about their spinal-column posture and angle parameters that were determined by using method of X-Ray lateral standing Analyze the articular balance of the spine and pelvis and identify the shape and orientation parameters of spino-pelvic parameters: (pelvic_incidence, pelvic_tilt numeric, lumbar_lordosis_angle, sacral_slope, pelvic_radius, degree_spondylolisthesis) **[1] .**

2. Background

Biomechanics is the study of the movement of living beings using the science of mechanics and anatomical structure of the body. According to the science of mechanics, the motion is created by force, Living beings create motion using forces, Biomechanics gives the mathematical and theoretical analysis information, for example, body movements or weight bearing, forces which applied and deforming the anatomical structural.

Vertebral column in general: The vertebral column is also known as spinal column, A system consisting of a group of (vertebrae, vertebral discs, nerves, muscles, marrow and joints). The main functions of the vertebral column are as follows:

1) Supporting the human body in a vertical axis
2) Consider the skeletal protector of the spinal cord and nerve roots
3) Movement of the body in three cases: front, arrow, transverse

The spine is usually composed of 33 vertebrae as follows: 24 presacral vertebrae, 7 cervical and 12 thoracic, 5 of which are lumbar and followed by 5 fused sacral vertebrae, and 4 frequently fused coccygeal vertebrae **[2].**

Curvatures: The adult spine consists of four Rear front arches: the thoracic and the sacral, the posterior concave, the lumbar neck and the lower back, Both concave back disorders associated With spine curvature includes: **kyphosis** (Excessive back bend of the chest area), **lordosis** (Excessive frontal curvature of the lumbar region), and **scoliosis** (Abnormal curvature, accompanied by spinal sprain)**[3].**

Diseases of the Vertebral Column: The spine system can suffer from dysfunction that can cause back pain with very different densities. **Disc herniation** and **vertebral incontinence** are examples of spinal diseases that cause severe pain. **The disc herniation** appears when the heart of the spinal disc is removed from its place (from the center to the periphery of the disc). Once they go to their places where the roots of the nerves lie, this leads to the inevitability of their pressure. As shown in **fig (1) Spondylolisthesis** Occurs when one of the 33 vertebrae slides in relation to each other. This slide generally occurs towards the base of the spine in the lower back area, causing pain or nerve irritation symptoms **[2]. Spondylolisthesis** has different types of which can be including **Congenital spondylolisthesis which**

associated during, birth **Isthmic spondylolisthesis** when there is the defect in a bone of vertebrae caused by fracture, and **Degenerative spondylolisthesis** more popular type among three types and caused by the disc malfunction and disc diseases **[4]**. Patients with spondylolisthesis are often advised not to participate in a heavy activity such as sports in order to avoid neurological spinal damage or paralysis to body movement as shown in **fig (2**).

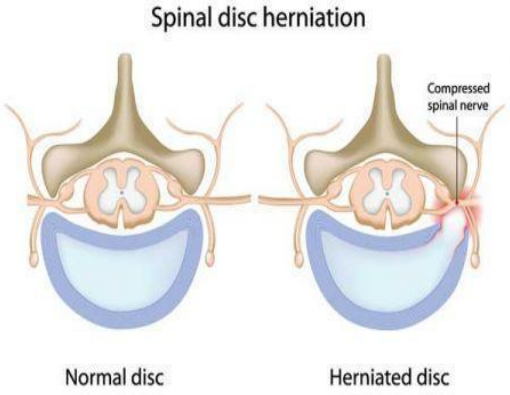

Figure 1: Disc hernia **[5]**

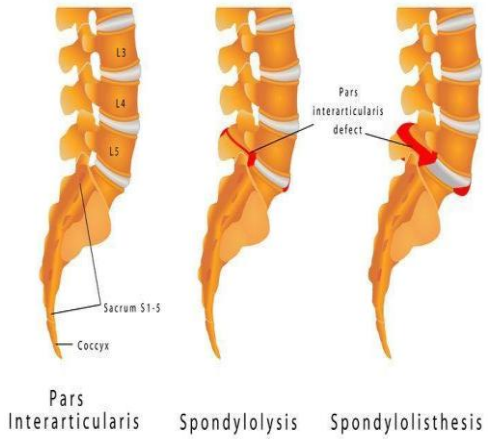

Figure 2: Spondylolisthesis development **[4]**

3. Literature Reviews

1) Recent studies have been conducted by evaluating the utility of methodologies for rejection options embedded in the diagnosis of pathology on the spine. By using **SVM (KMOD kernel) and SVM (linear) with** neural Network classifiers **MLP** with each different training sets **40%** (SVM linear accuracy % 85.0, SVM (KMOD) Accuracy 83.9) and training sets **80%** (SVM (linear) Accuracy % 84.3, SVM (KMOD) accuracy 85.9%) for each algorithm **[2].**
2) In another study the same dataset were classified by using support vector machine **SVM,** neural networks classifiers **MLP** in which used the classification module of the SIMPATICO platform To obtained results clearly were indicated that the classifiers are better at performance than stand-alone classifiers **[6].**

4. Methodology

The classification was performed by using the Python version (2.7) in this study.

1-Dataset: In this paper, the dataset were obtained from the website **[7]**. The study of this dataset were performed by selected **310 subjects** by using lateral X-ray standing Method for analysis sagittal balance of the spine and pelvis and to verify the shape and orientation parameters of spino-pelvic parameters: (pelvic_incidence, pelvic_tilt numeric, lumbar_lordosis_angle, sacral_slope, pelvic_radius, degree_spondylolisthesis)**[1]. 100 of the patients** were recorded normal and **60 patients** were recorded with disc dislocation **(a disc hernia)** and other **150 patients** with **spondylolisthesis**. The dataset was created and consisted of features (6 parameters) and the output of this dataset has resulted in Two classes either (normal and abnormal). As for showing in Table (1-1) below:

Table 1-1: The Attributes parameters for a spinal-column dataset

Attributes No.	Attributes
1	The angle of pelvic incidence
2	The angle of pelvic tilt
3	Lordosis angle
4	Sacral slope
5	Pelvic radius
6	Grade of slipping
7	Two Classes (normal or abnormal)

Preparation of Dataset for Splits into Training kits and test kits

1) The datasets were loaded and read as excel file in python by using Pandas library.
2) The Datasets were shaped for knowing the number of row and columns.
3) The features were selected as into parameters (attributes) (X) For learning and Test (Y) Target (classes) for learning and test.
4) The Dataset were split into X features, Y target for (training sets and test sets) by using the split algorithm which implanted in a sklearn library. Before using classifiers' algorithms.

5. Appling the SVL Algorithms

In this step supervised classifiers algorithms were applied after splitting the datasets, For learning and predicting.

5.1 Random Forest (RF)

Is a supervised learning algorithm. Which can do both classification and regression in this study we used random. forest classifier which forming a set of decision trees which randomly selected for training sets, the summation of these sets from selected decision trees were decided to get the final class label for test set **[8].**

5.2 Logistic Regression (LR)

Is one of the supervised learning classifiers. And linear interpolation and used most commonly in statics and discrete for data analysis for determining the outcomes of one or more independent variables. The outcome can be either two possibilities for binary (1 / 0) for text labels (Yes / No, True / False, normal / abnormal) of independent variables **[9].**

5.3 Decision Trees (DT)

Is one of the supervised learning that classifies instance values by specifying and arranging them based on attribute values. Each node in the decision tree represents a feature (attributes) in an instance to classify, and each branch represents a value that the node can handle. Instances classified start from the root node and rank by their attribute values **[10, 11].**

5.4 Support Vector Machine (SVM)

These are the most recent supervised machine learning technique mainly it used for classification. SVM works on margin calculation. Basically, draw margins between layers. Margins are drawn in such a way that the distance between the margin and the maximum layers, thus, reduces the classification error **[9].**

5.5 Naïve Bayes

Mainly targeting the industry of text classification. They are mainly used for compilation and classification [11]. Naive Bayes classifier found that it led to extensive comparison with their algorithms in the induction of decision-based tree, instance-based learning rule of induction on data sets, It was also found that it can sometimes be higher than other learning algorithms **[13]** Like in this study found to perform a good classifier.

5.6 Multi-layer Perceptron (MLP)

This classifier has weights as a neural network which was found that a second-class programming problem can be solved with linear algorithms, not by solving the problem of reduction is convex and is not as limited as in the training of standard neural networks. It based on the notion of perception, Perceptron algorithm is used to learn from training situations by running the algorithm repeatedly through the training group until you find the corrected prediction vector in each training group and then use this prediction rule to predict the label categories on the test set **[14, 15].**

5.7 K-Nearest Neighbor (KNN)

This algorithm can be Used for both (classification and regression), Most of this classifier algorithms in machine learning are parametric meaning that (the classifier structure determined from the dataset) but in this classifier is nonparametric also called lazylearning algorithm All training data used in the testing phase It based on the majority of vote which it got from choosing the closest neighbors values. Choosing 'K' as the certain value of the nearest neighbors and these neighbors refers to the core of deciding the values and The value of 'K' can influence the final result **[16].**

6. Experiment Steps

In Fig (3) it will summary the Experimental steps by using the supervised algorithm.

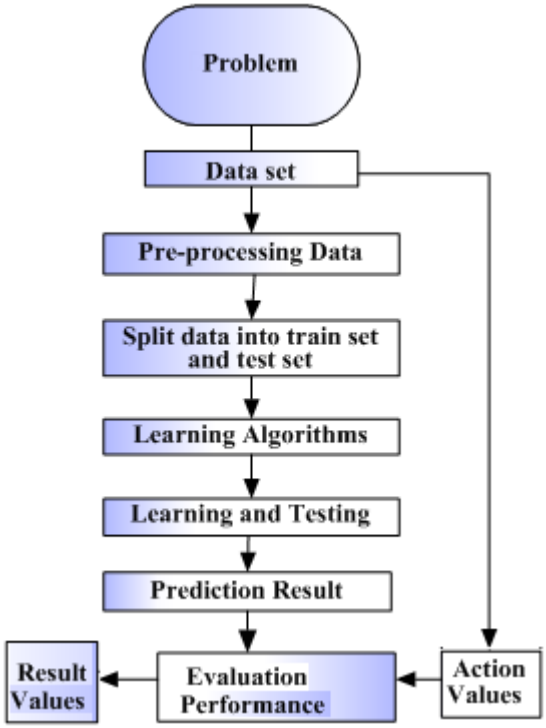

Figure 3: The Steps For classification in this study

7. Results Discussion

After classification, confusion Matrix was created by summoning the function in a sklearnlibrary which were represented as the actual and predicted values of the classification process of the datasets. So by CM, the Accuracy, sensitivity, specificity, and Errors (for each classifier performance) were obtained .as shown in the table below:

Table (1-2): The Results performance of different SVL Algorithms

Classifier	% Accuracy	% Sensitivity	% Specificity	% Errors
Random Forest	78.7 %	81.4%	72.7%	21.3%
Logistic Regression	75.7%	78%	70%	24.2%
Decision Tree	79.6%	83.5%	72.22%	20.3%
Support Vector Machine	64.07%	64%	0%	35.9%
Naïve Bayes	83.4%	79.5%	100%	16%
K-nearest neighbor	73.7%	80.9%	62.5%	26.21%
Multi-layer Perceptron	73.7%	80.9%	62.5%	26.21%

This study, spinal column datasets were applied to SVL (supervised learning algorithms). And They were compared and evaluated according to their classification performance which was recorded and determined as (Accuracy, sensitivity specificity, and Errors) For each classifier. The **%Accuracy (83.4%)**, **%Specificity (100%)** were found to be highest at **Naïve Bayes** with lowest **%Errors (16%).** Whilst in DT were recorded as the highest **sensitivity (83.5%).** SoThat Showed That the best classifier in SVL to be used in this study is the **Naïve Bayes.** Because of the highest accuracy, specificity with lowest errors which recorded when we used this classifier. For other classifiers showed that their performance was varied according to their characteristics process that performed on a dataset, for instance, the **SVM** classifier showed the lowest performance (accuracy, sensitivity, specificity)with high errors (**64.07%,**

64.0%, 0%, 35.7%) respectively. Also, the Results above showed that **K-nearest neighbor, Multi-layer Perceptron classifiers** were recorded the exact performance% &errors (**Accuracy 73.7%, sensitivity 80.9%, specificity 62, 5%, Errors 26.21%)**

8. Conclusion

In This Paper different classifiers of **SVL algorithms** were used on the spinal-column dataset and compared their performance to show which classifier were suitable for the classification process. The results were showed That**naïve bayes** classifier was the best option in this study because of their high performance and low Error recorded because this classifier was popular. To classify documents due to their computational efficiency and relatively good predictive performance.

While for **SVM** classifier found to be performed poorly with a high error in this study because of a number of samples that fall in one of the classes far outnumber those that are a member of the other class which leads to the actual negative in confused matrix did not classify. For the **KNN and MLP** algorithms performance were the same the reason is because of in case of **KNN** classifier that called the lazy algorithm meaning all training sets phase were used in test phase (**normal** class is the class were selected among Two classes in target label . the number of normal neighboring class were determined among the other **abnormal** numbers) While MLP was performed by running the algorithm repeatedly through the training set up, the vector finds the correct prediction in each training group. This prediction rule is then used to predict labels on the test set.

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