Diagnosis of Pathology on the Vertebral Column with Backpropagation and Naive Bayes Classifier

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Abstract— **Minimizing human errors in diagnosis is one of the most important aims of Computer-Aided Diagnosis (CAD) systems. CAD software is the software helping radiologists , specialist doctor for detect abnormality on medical views by using advanced pattern diagnosis and view processing methods. In this study, a CAD system that can help detection and diagnosis of Pathology on the Vertebral Column is introduced. The vertebral database used in the application is obtained from UCI (Machine Learning Repository). Various artificial intelligence methods were applied for the classification of this database obtained. The results obtained are comparatively explained in detail in the related part.**

Keywords-component; vertebral column; artificial intelligence; machine learning; computer aided diagnosis

I. INTRODUCTION

Artificial intelligence in medicine, which is used to help practitioners in design of prosthetics, drugs, and intelligent tutoring systems by providing the interpretations of expert systems, medical images, and diagnosis, has been widely recognized for the last decade. The use of artificial intelligence in medicine includes diagnostic and educational systems and machine learning systems[1].

One of the main public health problems is lower back pain, which also causes a negative economic impact on patients suffering from it.

Ambulatory Health care data indicates that at least 20 million MRI exams, 50 % of them are about spine, are conducted in the United States per year. According to the studies conducted in recent years, there is a concern about a shortage of diagnostic radiologists.

There is a similar need for the computer-assisted image processing and assisted in order to diagnose lower back pain problems. Usually, there is a negative view about the feasibility of anatomic diagnosis. However, it may be possible to find the reason behind lower lumbar disorders using computerized tomography (CT), and magnetic resonance imaging (MRI) [2].

Information about the vertebral column pathology was provided in the first part of the study. In the background part the similar studies were reported in detail and in the method part, the methods and materials used in the study were described. In the results part, the findings of the study were evaluated and in the final part, the conclusion of the study were presented.

II. BACKGROUND

The vertebral column system comprises of invertebrate discs, nerves, muscles, medulla, and a group of vertebras. (i) human body support axle; (ii) osseous protector of the spine medulla and nervous roots; and (iii) body's movement axles, which makes movement possible in frontal, sagittal, and transversal levels, are the main functions of the vertebral column.

Dysfunctions causing backaches with very different intensities can occur in this complex system. The examples of pathologies of the vertebral column causing intensive pain includes Disc hernia and spondylolisthesis. They result of small or several traumas in the column that gradually harms the structure of the intervertebral disc [3][4].

Disc herniation is a exude of the nucleus pulposus through a tear in the wall of the annulus fibrosus. This exudes presses on the local nerve root causing the pain. Aging and/or trauma usually causes tears in the disc wall. Spinal stepnosisis, which can be caused by different conditions including disc herniation, osteoporosis, and a tumor, is the narrowing of the spinal canal. Stepnosis takes place at the same level of disc particularly if the reason is a disc herniation. Normal and herniated discs are indicated in Figure 1.

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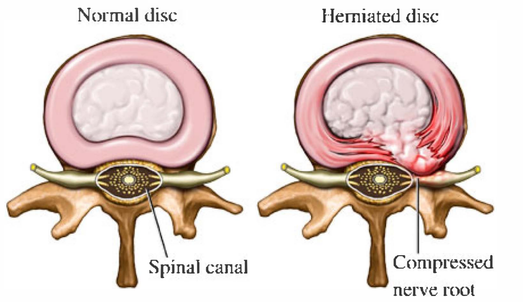

Figure 1. Structure of Normal and Herniated Disk

Degenerative spondylolisthesis is the sliding forward of a lumbar vertebra on another with an intact neural arch. It is seldom seen before the age 50 and affects disproportionately especially black woman with an approximate ratio of 1:6 for males and females, respectively. 1 slippage mostly seen at the L4-L5 level and seldom exceeds 30 % of vertebral width. In general, Degenerative spondylolisthesis is asymptomatic. However, it can be related with symptomatic spinal stenosis [5]. Structure of spondylolisthesis is indicated in Figure 2.

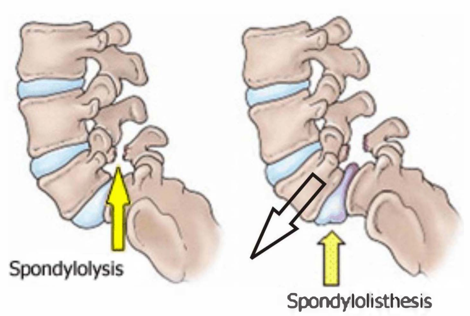

Figure 2. Structure of spondilolysthesis

III. Vertebral Column Data Set

We have used the vertebral data set (taken from the UCI machine learning repository).

Dr. Henrique da Mota built a data set during a medical residence period in the Applied Reserch group in Orthopaedics (GARO) of the Centre Médico-Chirurgical de Réadaptation des Massues, Lyon, France. The data organization is divided into two different but related classification. The first classification includes patients belonging to one of three categories, namely, Normal (100 patients), Disk Hernia (60 patients) or Spondylolisthesis (150 patients). In the second classification, the category labeled as 'abnormal'is created by merging Disk Hernia and Spondylolisthesis categories. By this way, the second classification includes patients belonging to one of two categories, namely, Normal (100 patients) or Abnormal (210 patients)[6].

Each patient in vertebral data set is represented as a vector with six biomechanical features, which match the following parameters of the spino-pelvic system is shown in Table I.

TABLE I. Biomechanical Attributes

No	Attribute Name
1	Angle of pelvic incidence
2	Angle of pelvic tilt
3	Lordosis angle
4	Sacral slope
5	Pelvic radius and grade of slipping
6	Grade of slipping

Each patient is characterized in the vertebral data set by six biomechanical features. These are: pelvic occurrence, pelvic tilt, lumbar lordosis position, sacral slope, pelvic radius and mark of Spondylolisthesis [7].

IV. Methods

A. Naïve bayes Classifier

Naive bayes is a classifier-based algorithm. It is commonly used in the classification of text documents. Its feasibility and performance are its main advantages. It classifies with the help of statistical methods

There are some assumptions in the implementation of Naive Bayes algorithm. The most important one of those is that its features are independent from each other. If the features affect each other, then it is difficult to calculate the probabilities. It is assumed that all features are important equally.

- Naive Bayes algorithm is based on probabilistic conclusion depending on Bayes rule
- it functions depending on the probability of hypothesis according to the data obtained.
- The hypothesis that has the maximum probability is selected according to the data obtained.

Naïve bayes algorithm expressed as

$$P(C_i \mid x) = \frac{P(x \mid C_i)P(C_i)}{P(x)}, i = r, n \qquad (1)$$

where $P(C_i)$ is the prior probability of C_i [8]

B. Multi Layer Perceptron

Multilayer Perceptron (MLP) is an artificial neural network model with advanced feed. One MLP node consists of more than one layer. Each layer is connected to the one other completely. Each node, except input node, is a neuron that owns nonlinear activation function. MLP uses back propagation learning algorithm to training network [9],[10].

The structure of a MLP with backpropagation algorithm is shown in Figure 3.

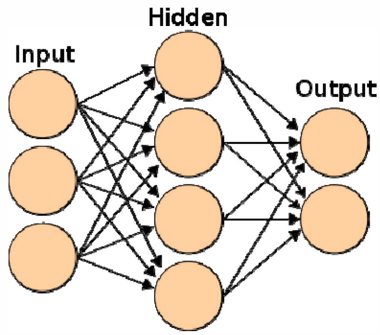

Figure 3. A simple neural network

With the organization of neurons into multiple layers, each of which includes several neurons, the architecture is implemented. The outputs obtained from one layer were used in the next layer as the input. Neurons in one layer are not link to each other but they may share the same inputs while they are connected to the ones in the next layer. The strengths of these connections are called connection weights. The layers between input nodes and output layer are known as hidden layers. Besides, biases measuring strength of the connections to neurons in a layer from nodes with constant values is included by the MLP. The biases were not indicated in the Figure 3.

Each neuron in an Multi Layer Perceptron network uses a transfer function to produce an output. Log-sigmoid and tan-sigmoid transfer functions are most commonly used in MLP [11].

The general expression of the output of Multi Layer Perceptron network Y is shown below:

$$Y = f\left(b + \sum_{j=1}^{n} z_j u_{j,k}\right) \qquad (2)$$

where b is the bias interrelated the output unit, z_j represents the hidden neuron connected to the output unit, while $u_{j,k}$ represents the connection weight between the output unit and the hidden neuron z_j.

V. RESULTS

We have taken data set having values for six biomechanical attributes used to classify orthopedic patients into three classes (normal, disk hernia or spondilolysthesis). The statistical features of six biomechanical features are given in Table II.

TABLE II. STATISTICAL ATTRIBUTES DATA SET

No	*Attribute Names*	*Min.*	*Max.*	*Mean*	*StdDev*
1	Pelvic_incidence	26.148	129.834	60.497	17.237
2	Pelvic_tilt	-6.555	49.432	17.543	10.008
3	Lumbar_lordosis_angle	14	125.742	51.931	18.554
4	Sacral_slope	13.367	121.43	42.954	13.423
5	Pelvic_radius	70.083	163.071	117.92	13.317
6	Degree_spondylosisthesis	-11.058	418.543	26.297	37.559

The classification with MLP and Naïve bayes was applied to the vertebral column data set, for which the statistical results are given above.

TABLE III. PERFORMANCE FOR VERTEBRAL DATA SET USING MLP AND NAÏVE BAYES

No	*Classification Types*	*Accurancy (%)*	*Time (Sec.)*
1	M LP	85.4839	0.41
2	Naïve Bayes	83,2258	0.01

According to Table III, 85.4839 % accuracy rate is obtained in classification with Multi-Layer Perceptron and 83,2258 % accuracy rate is obtained in the classification with Naïve Bayes. The analysis results showed that the classification with Multi-Layer perceptron is more successful.

VI. CONCLUSIONS

Today, Computer-Aided Diagnosis systems are applied successfully into many medical data. These systems applied have many advantages such as minimizing human error and decreasing costs.

In this study, the Computer-Aided Diagnosis system applying two different classification methods into vertebral column data set obtained from UCI was designed. The results obtained are presented comparatively.

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