Machine learning for aiding the diagnostic of pathology on the vertebral column

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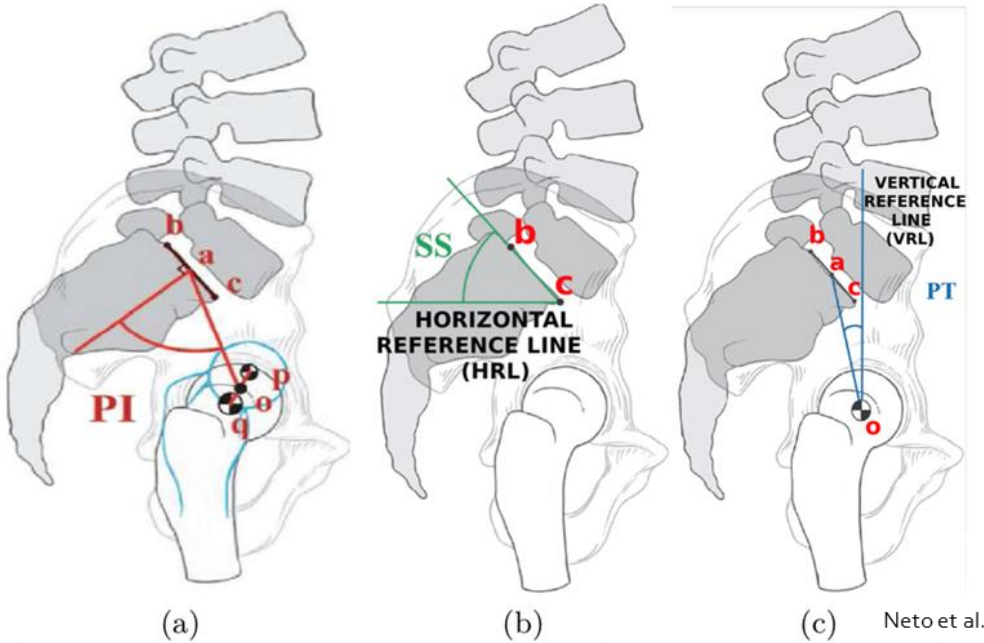
Objective

The purpose of study is applying machine learning to characterize pathologies of the vertebral column by using SIX biomechanical attributes derived from the shape and orientation of the pelvis and lumbar spine: Pelvic Incidence (PI), Pelvic Tilt (PT), Lumbar Lordosis Angle (LLA), Sacral Slope (SS), Pelvic Radius (PR) and Grade of Spondylolisthesis (GOS).

Understanding the relationships of these biomechanical characteristics are significantly importance for the discernment of vertebral column disorder in normal and pathologic (abnormal) conditions of the spine and pelvis.



Literature Review

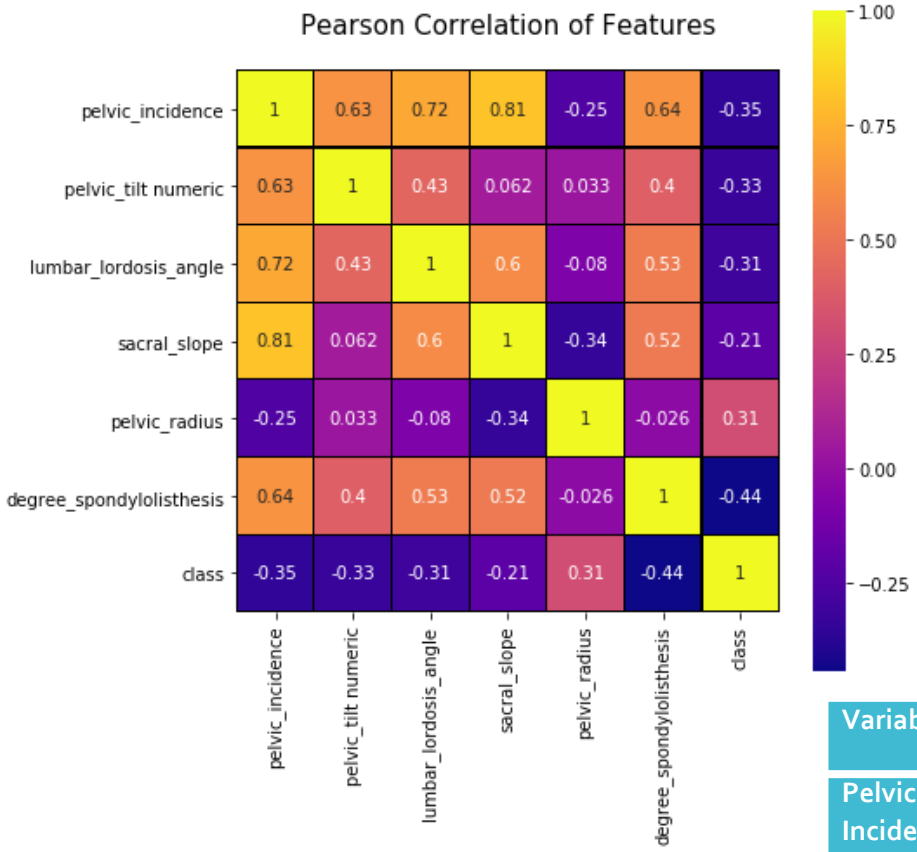
1. Patients with high (PI) and sacral slope (SS) show an increase in the shear forces incident at the lumbosacral junction (Tabet, 2014).
2. The value of PI is higher in spondylolisthesis, increasing linearly, according to the severity of slippage (Tabet, 2014).
3. The pelvic tilt (PT) and the sacral slope (SS) measure the sacro-pelvic orientation in the sagittal plane (Tabet, 2014).
4. PI is the sum of SS and PT, as PI is a strong determinant of the spatial orientation of the pelvis in the osthostatism, i.e.the higher the PI, the greater will be the PT or SS, or both (Tabet 2014).

Dataset: The database applied in this study was provided by Dr. Henrique da Mota, who collected it during a medical residence in spine surgery at the Centre M´edico-Chirurgical de R´eadaptation des Massues, placed in Lyon, France. This database contains data about 310 patients obtained from sagittal panoramic radiographies of the spine.

-It is composed of 210 abnormal patients who have pathology in their spines & 100 normal.

Results #1- Pearson Correlation of Features

It is used as a measure for quantifying linear dependence between two continuous variables X and Y. Its value varies from -1 to +1.



The highest correlation of Pelvic Incidence are sacral_slope (0.81), followed by lumbar_lordosis_angle (0.72), degree_spondylolisthesis (0.64) and pelvic_tilt_numeric (0.63)

Variables		Hypothesis	Correlation correlations
Pelvic Incidence (PI)	Sacral Slope (SS)	H1: Patients with high PI is higher impact on SS.	0.81
	Lumbar Lordosis Angle (LLA)	H2: Patients with high PI has higher Lumbar Lordosis Angle (LLA).	0.72
	Degree of spondylolisthesis	H3: Patients with high PI has higher risk of presenting a spondylolisthesis.	0.64
	Pelvic tilt numeric	H4: Patients with high PI has higher pelvic tilt numeric.	0.63

Results #2- Confusion matrix with random forest

N=93 (30% for test)	Predicted Abnormal	Predicted Normal	
Actual Abnormal	TP=58	FP=8	66
Actual Normal	FN=7	TN=20	27
	65	28	

TP: True Positive
TN: True Negative

(When it predicts Abnormal, how often is it correct)

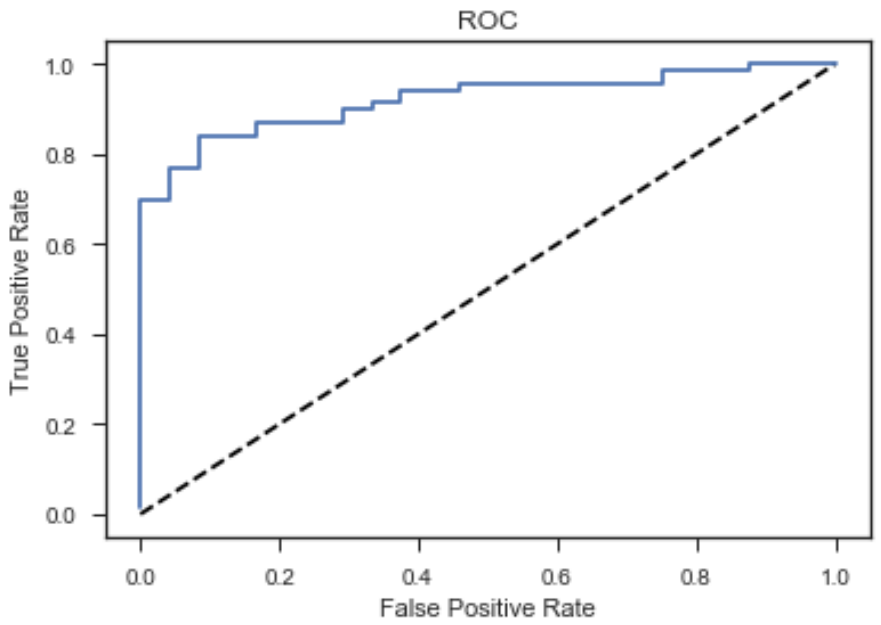
Precision of Abnormal = $\frac{TP}{predicted\ Abnormal} = \frac{58}{65} = 0.89$

Precision of Normal = $\frac{TN}{predicted\ normal} = \frac{20}{28} = 0.71$

- There are two possible predicted class: "Abnormal" and "Normal".
- The classifier made a total of 93 predictions.
- Out of those 93 cases, the classifier predicted "Abnormal"65 times and "Normal" 28 times.
- In reality, 66 patients in the sample have abnormal and 27 patients are normal

Results #3- ROC Curve with logistic regression

Logistic Regression is a classification algorithm. It is used to predict a binary outcome (1 / 0, Yes / No, True / False) given a set of independent variables.



Receiver Operating Characteristic(ROC) summarizes the model's performance by evaluating the trade offs between true positive rate (sensitivity) and false positive rate(1-specificity).

The area under curve (AUC), referred to as index of accuracy(A) or concordance index, is a perfect performance metric for ROC curve. Higher the area under curve, better the prediction power of the model.

Conclusions

- Pelvic Incidence (PI) has a positive correlation (0.63–0.81) with Sacral Slope (SS), Lumbar Lordosis Angle (LLA), degree of spondylolisthesis and Pelvic tilt numeric.
- The findings show a good agreement with literatures. As Pelvic Incidence (PI) is a constant anatomic pelvic variable given to each individual and greatly affects by the Sacral Slope (SS), Pelvic Tilt (PT), and Lumbar Lordosis, which are position-dependent variables. In this study proposes that pelvic anatomy has a direct impact on the development of a spondylolisthesis.
- Therefore, patients with an increased pelvic incidence mean to be at higher risk of occurring a spondylolisthesis, and an increased PI could be a predominant factor leading to progress in developmental spondylolisthesis.
- In this work, incorporate machine learning techniques can significantly help orthopaedist to diagnosis of pathologies on the Vertebral Column.

References: -Neto, A. R., Sousa, R., Barreto, G. D., & Cardoso, J. S. (2011). Diagnostic of Pathology on the Vertebral Column with Embedded Reject Option. Pattern Recognition and Image Analysis Lecture Notes in Computer Science, 588-595. doi:10.1007/978-3-642-21257-4_73 ; -Tebet, M. A. (2014). Current concepts on the sagittal balance and classification of spondylolysis and spondylolisthesis. Revista Brasileira De Ortopedia (English Edition), 49(1), 3-12. doi:10.1016/j.rboe.2014.02.003