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ANALYSIS IN ABNORMAL ALIGNMENT VERTEBRAE BY NEURAL NETWORK ALGORITHM

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Abstract - This research is an application of the neural network (NN algorithm) to medical work. The NN algorithm was used to classify and analyze the alignment of human vertebrae from computerized tomography(CT). The data used in this research, CT images and patient information, was obtained by the support from Suranaree university of technology hospital, Nakhon Ratchasima, Thailand. This study focused on the alignment of vertebrae, especially on cervical vertebrae (C1-C7). The methodology consisted of 2 main steps. The first step was the image processing used to extract the essential characteristic of an image. The 3D CT images were processed by RadiAnt Program and 4 positions were extracted to 2D images, which were anterior, posterior, right, and left side. Ridge detection with various parameters was applied to the 2D images. In the final step, we trained the images processed with Ridge detection by the RapidMiner program using NN algorithm to make the prediction model. The model obtained with the highest evaluation had parameters, training cycles=450, learning rate=0.03 and, momentum=0.9. The accuracy, precision, recall and AUC of the model were 62.22% +/- 18.35%, 62.22% +/- 18.35%, 100.00% +/- 0.00% and 0.528 +/- 0.197, respectively.

Keywords - CT Scan Image, Cervical Vertebrae Alignment, Ridge Detection, Neural Network.

I. INTRODUCTION

Artificial intelligence (AI) has increasingly been used in healthcare systems, for example, the application in the diagnosis viamedical imaging [1].Generally, a doctor uses an X-ray, CT Scan and, magnetic resonance imaging (MRI) to identify abnormalities. These imaging techniques are also used to identify the abnormalities in vertebrae of human skeletons, which are important parts concerning the central nerve human system [2]. If these parts are abnormal, the body control can be damage. Therefore, the quick detection helps in the fast recovery of a body and reduces the critical risk of the patient. Accordingly, AI has come to support the diagnosis of the medical image for all abnormal identification in patients [3].

Many medical applications of AI are still researched which are in the early trial stage. They are not high in performance and successful in healthcare systems. By the virtue of the fact that each disease has a special attribute of clinical characteristics, such as the analysis of medical images and the scans for early signs of disease or the monitoring of patients' vital signs, the performances of applications are not reliable yet (accuracy, precision, and recall) [4]. For some cases, the insight of process uses originally medical image in an AI application, the irrelevant parts of the medical images lead to an inefficient detection.

In the study, the researcher team approaches to improve the performance of the AI application for abnormal vertebrae classification. Machine learning (ML) was an AI technique equipped in this work. For a preprocessing process of the abnormal recognition, we used "ridge detection". The ridge detection is an image processing that was used for the extraction of some specific features in the medical images [5].The processed imagesprovide the main alignment and ridges of the vertebrae, which reduces non-relating information before the learning part of AI. Thispre-processingpart was expected tohelp in increasing the performance of ML. In the ML process,it was doneby neural network algorithm (NN algorithm). The ML modelswere set in different conditions to learn, classify and analyze abnormal cervical vertebrae detection (Alignment section) of the medical images processed by ridge detection. The performance of the models obtained was evaluated by accuracy, precision, recall and, **a**rea **u**nder the **c**urve (AUC).

II. BASIC STRUCTURE OF MEDICAL IMAGE

Computed tomography (CT) is the medical imaging test for creating detailed images of internal human organs, bones and soft tissues. The resource of CT scan bases on x-ray radiation. CT scans estimate the cross-sectional images and combine multiple planes of the cross-sectional image to generate three-dimensional images (3D images) that can operate on a computer monitor. The advantage of CT scan is fast, painless, non-invasive and, accurate. For example, in emergency cases, it can indicate internal injuries and bleeding quickly. This is a non-invasive and non-destructive technique that is very convenient to use for the fast diagnosis. An example of CT scan model is showed in Figure 1. [6]

III. BASIC STRUCTURE OFRADIANT PROGRAM

RadiAnt is a **p**icture **a**rchiving and **c**ommunication **s**ystem (PACS) which is used for view a**d**igital

imaging and **co**mmunications in **m**edicine image (DICOM). It is a medical image viewer software which is capable for Digital Radiography (DR),Mammography (MG), CT, MRI, and etc. The advantage of RadiAnt program is extremely fast, also available to run from CD/DVD media without installation on programming requirements such as Microsoft Windows and MacOS. This viewer program is particularly important in preparing files or practicing for the radiology exams. The program provides many tools for manipulation and measurement of images, for example, fluid zooming, tilting and, panning for 3D images, brightness and contrast adjustments, negative mode, segment measurement, etc. We appliedthis program to view our resources.

Figure 1: CT scan image in DICOM format opened by RadiAnt Viewer Program.

IV. IMAGE PROCESSING

Image processing is a methodology for manage, manipulate and analyze an image to digital information. It can be used for image quality enhancement, objects in image extraction, face recognition, image segmentation, etc.In the studies, we focus on digital image processing [7].

The feature extraction is designed to emphasize and extract features from the image. The features are defined by inner operators of image feature extraction equipment. In this paper, we proposed to use ridge detection for the feature extraction process.Ridge detection is one of theimage processing techniques. The ridge function represents important geometric information authentic to a function. It uses mathematics function to calculate the curves of valley-like parts of the image. The watershed technique, edge detection and, local maxima are the main algorithms used in ridge detection.The function has two variables which are in sets of curve points to be made precise below and local maxima of the function in at least one dimension. The primary motivation for the creation of ridge detection has come from image analysis and computer vision. It captures the interior of elongated objects in the image domain. Ridge-related representationsterms of watersheds which areused for image segmentation. The program attempts to capture the shapes of objected by graph-based which reflect ridges, valleys, and critical points in the image domain. The described model is shown in Figure 2.

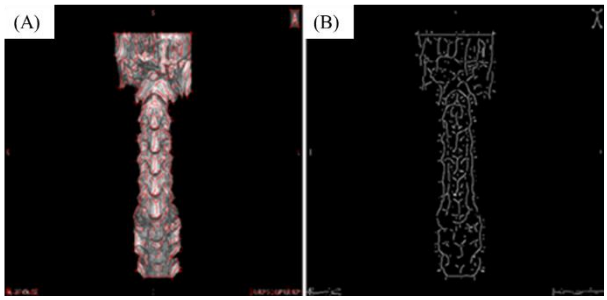

Figure 2: Image Feature Extraction by Ridge Detection (A) CT scan image (B) Ridge detection image.

V. BASIC STRUCTURE OF ARTIFICIAL INTELLIGENCE

Artificial Intelligence is a new trend of technology. It is a computer system conception that imitates human intelligence. The system uses tools and logic for representinghuman thinking. An AI system may beincluded withsymbolic transforming, data mining and,ML. The symbolictransforming is related to the conversion of images, videos, voices, etc. to the objects which can be statistically or mathematically manipulated.The system has the power of recognition and authentication. The function in the AI systemcan be createdand processed by computer software like VEGA, python and, RapidMiner. The ML consists of supervised learning (labeled data sets), unsupervised learning (unlabeled data sets), and reinforcement. The system learns to solve problems in unexpected ways, such as education, business, finance, law, manufacturing, banking, transportation, security, and, especially healthcare field [8]. The healthcare field has the biggest challenge development. The system tries to make better and faster diagnoses than doctor. The system presents confident statistic scoring. AI applications are used to be health assistants. Theyhelp patients and healthcare customers to find medical information, appointments, predict patient symptoms, understand the billing process, and complete other administrative processes in healthcare field [9].

VI. BASIC STRUCTURE OF NEURAL NETWORK (NN)

Neural Network is a technique used in machine learning that runs through neural network architecture. The concept of neural networks, which works similarly human brain. The neural networks contain several hidden layers. The input data arecollectedto the layer. The output layer is classification or analyzation. The inner process builds upthe network with the provided information. For

instance, the data comprises ofthe quantities of security techniques. The potential outputs could be "reliable" and "nonreliable." The networks in the model are constructed by a hidden layer. So, neural networks providean adoption in many filed such as forecasting, research solutions, fraud detection and, risk assessment. The neural network algorithm is better in analysisthan many classical heuristic algorithms [10]. Manyultimate achievementsof using neural networks in medical works inspired us to use this method in this research.

VII. BASIC STRUCTURE OF RAPIDMINER

RapidMiner is one of the operating data science software, which offers a distinctive analytics capability and versatility. The software is able to create a prediction model. The software system can be manipulated and programmedby thinking boxes like normally require human command.This helps people anticipating problems or dealing with issues as real situation. This software is quite easy to build the prediction model.To make a model, one starts with the preparation ofthe attribute of data. It is claimed that data must haveessential elements. After that, we input the data into RapidMiner program. The programwill try to find an appropriate algorithmfor training the model. When it is done, we are able to see the parameters that RapidMiner chooses for our obtained model [11].

VIII. METHODOLOGYOF THE AI APPLICATION

This research studied the algorithm of AI for analyzing and classifying abnormal cervical vertebrae from the medical image. The section demonstrated how to indicate features from the medical image and using an algorithm, parameter for the buildup model. The research focused on CT image which was a diagnostic imaging test. The image was used to help diagnose the abnormal alignment of vertebrae in the patient. The ML model was built up by the RapidMiner platform. The platform supported the design and documentation of an overall data mining process. It offered not only operation but also generated structure that expressed the control flow of the process.

The study population included all consenting patients admitted for cervical spinal cord injury at Suranaree University of technology Hospital between January 2017 and January 2020 (3 Years). The research complied with the International guidelines for human research protection. This research was approved by the Suranaree university of technology human research ethics committee. The medical imaging and clinical records included in this research were compiled as part of the normal and the abnormal cervical vertebrae. Inclusion criteria were the following: 1) cervical vertebrae, 2) Alignment criteria were followed by an orthopedic physician of Suranaree university of technology hospital, 3) presurgical cervical vertebrae CT imaging performed, and 4) documented motor assessment by an orthopedic physician of Suranaree university of technology hospital. Exclusion criteria were the following: 1) other vertebrae part, 2) the other alignment clinical data). We researched 93 patients, normal 53 patients (Alignment characteristics), and abnormal 40 patients (Misalignment characteristics). The detailed patient demographics and injury characteristics are summarized in Table 1.

No.	Vertebrae Characteristics	Number of patients
1	Alignment	50
2	Misalignment	43

Table 1
Alignment vertebrae of injury demography, Suranaree University of Technology Hospital

When we received the medical image for the hospital, we operated on the medical image by using RadiAnt Program. The program operated the DICOM file which was a general medical image. We gained a 3D image. Then, we set the point of a viewer for the best position analysis and classification. The position was anterior, posterior, right, and left of the CT image (PNG. File). All CT imaging of the research was performed on a multi X-ray scanner with CT application software (APPS) Version =15HW25.2_SP2-0-1.H40-P2_SS64_G_GMV (General Electric, USA). The Anterior, Posterior, Right, and Left view of C1-C7 were used for image analysis. The images were performed with the following parameters: axial C1-C7; slice thickness 2.5 mm, echo-train length 16, FOV *32, nominal in-plane pixel size 512*512mm2. Other alignment performed as CT scan images were not evaluated for this research. Next step, we used Ridge detection to extract significate features. This technique was designed to emphasize an image and extract features. The program attempted to capture the shapes of an objected image by graph-based which was reflected ridges, valleys, and critical points in the image domain. The technique management set hysteresis thresholds which were sigma, high and low thresholds. In the study, we designed 8 models as shown in Table 2 and clear indication as shown in Figure 4,5. Each model represented a special part for analyzing the alignment of abnormal vertebrae. Figure 6 shown the difference of abnormal characteristics.

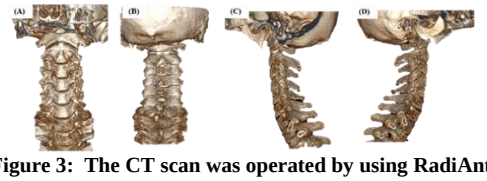

Figure 3: The CT scan was operated by using RadiAnt Program. (A) Anterior, (B) Posterior, (C) Right, and (D) Left Side of Medical Image

Models	Sigma	Low Threshold	High Threshold
1	1	10	30
2	1	20	20
3	4	10	30
4	4	20	20
5	7	10	30
6	7	20	20
7	10	10	30
8	10	20	20

Table 2
The models of Feature extraction by using Ridge Detection

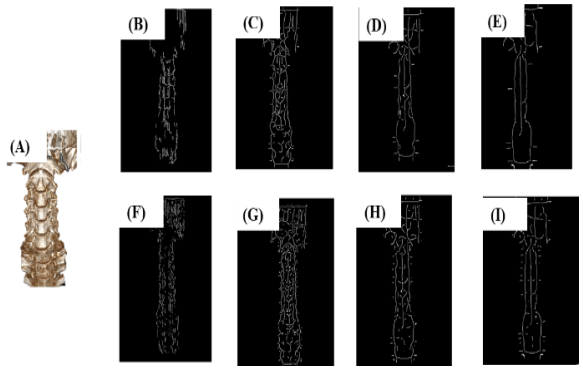

Figure 4: Image Feature Extraction by Ridge Detection including 8 models ((A) CT scan image, (B) model 1, (C) model 2, (D) model 3,(E) model 4, (F) model5, (G) model 6, (H) model 7 and (I) model 8, respectively)

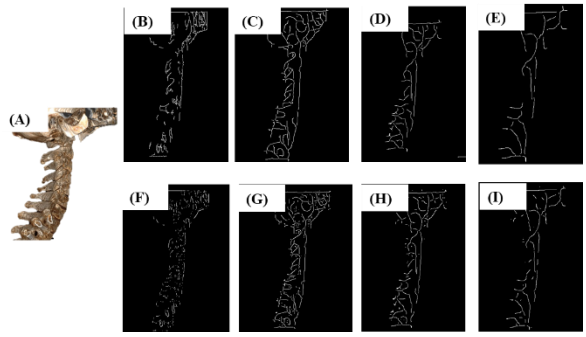

Figure 5: Image Feature Extraction by Ridge Detection including 8 models ((A) CT scan image, (B) model 1, (C) model 2, (D) model 3,(E) model 4, (F) model5, (G) model 6, (H) model 7 and (I) model 8, respectively)

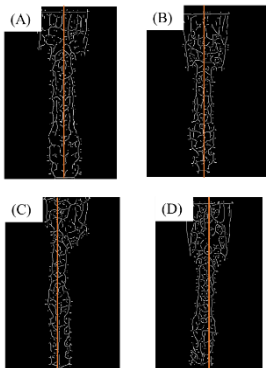

Figure 6: The comparison of alignment – misalignment characteristics ((A) Alignment Characteristics, (B) Alignment Characteristics, (C) Misalignment Characteristics, and (D) Alignment Characteristics, respectively)

The next step was model learning of medical imaging using RapidMiner. The next step used the RapidMiner platform for buildup model learning. The platform used a plugin which was a multiple color image operator (MCIO) for the imaging management. Insight of the model had algorithms which were neural network (NN). Each model was trained by the training cycle= 450, learning rate= 0.03, and momentum 0.9. The last steps were the testing model. This step used cross-validation for checking performance information. The performance indicated accuracy, precision, recall, and AUC. The performant confirmation of the model is shown in Figure 6.

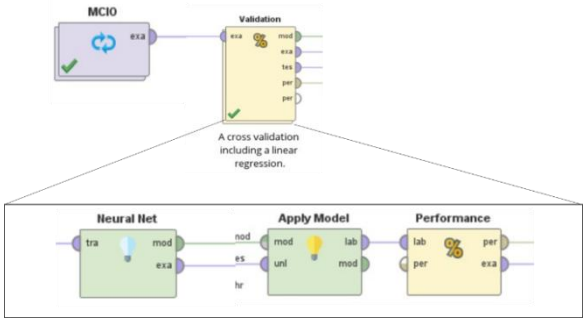

Figure 6: RapidMiner Processing of abnormal alignment cervical vertebrae image

IX. EXPERIMENTAL AND PERFORMANCE RESULTS

Classification of abnormal vertebrae (Alignment characteristics) by machine learning model using NN algorithms. This research studied 8 models. The highest result of the model was model 6. The accuracy of the model was 62.22% +/- 18.35%. The precision of the model was 62.22% +/- 18.35%. The recall of the model was 100.00% +/- 0.00%. The AUC was 0.528 +/- 0.197, respectively. All resulting statistics were calculated by computer algorithms. The resulting prediction is shown in Table 3. The results of a classification were generally assessed using the following measures: True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN). The accuracy(A), precision, recall, and AUC are derived from the following formulas:

Accuracy = ((TP+TN)/(TP + TN + FP + FN)) (1)

Precision= (TP/(TP + FP)) (2)

Recall= (TP/(TP+FN)) (3)

No.	Accuracy	Precision	Recall
1	62.11% +/- 10.59%	63.22% +/- 12.72%	92.92% +/- 12.43%
2	62.16% +/- 5.97%	62.16% +/- 5.97%	100.00% +/- 0.00%
3	62.16% +/- 5.97%	62.16% +/- 5.97%	100.00% +/- 0.00%
4	61.11% +/- 17.63%	62.28% +/- 17.73%	97.14% +/- 9.04%
5	59.00% +/- 16.27%	61.62% +/- 17.92%	93.83% +/- 10.12%
6	62.22% +/- 18.35%	62.22% +/- 18.35%	100.00% +/- 0.00%
7	58.11% +/- 13.88%	59.22% +/- 10.79%	91.67% +/- 26.35%
8	57.00% +/- 11.36%	59.94% +/- 6.71%	90.00% +/- 22.50%

Table:3
The summarized classification of abnormal alignment vertebrae by machine learning model using NN algorithms in CT scan images.

No.	AUC
1	0.458 +/- 0.229
2	0.456 +/- 0.262
3	0.527 +/- 0.128
4	0.447 +/- 0.307
5	0.304 +/- 0.210
6	0.528 +/- 0.197
7	0.480 +/- 0.244
8	0.515 +/- 0.184

Table:4
The AUC summarized classification of abnormal alignment vertebrae by machine learning model using NN algorithms.

X. CONCLUSION

These studies proposed the analysis and classification of abnormal vertebrae. The study process was generated by the NN algorithm and Ridge Detection. We evaluated the performance of the ML model (NN algorithms). We examined the feature extraction of the CT scan imaging. We investigated the performance of the ML model by the different features of Ride detection parameters. Thus, this study has shown that model 6 (Ridge detection parameter is sigma 7, low threshold 20, and high threshold 20) was the strongest model of this study. We believe that the AI trend of medical technology will support the health care system. It incorporates all healthcare platforms.

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