Analysis of lower back pain disorder using deep learning

To cite this article: K Ritwik Kulkarni *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **263** 042086

Analysis of lower back pain disorder using deep learning

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Abstract. Lower back pain (LBP) is caused because of assorted reasons involving body parts such as the interconnected network of spinal cord, nerves, bones, discs or tendons in the lumbar spine. LBP is pain, muscle pressure, or stiffness localized underneath the costal edge or more the substandard gluteal folds, with or without leg torment for the most part sciatica, and is characterized as endless when it holds on for 12 weeks or more then again, non-particular LBP is torment not credited to an unmistakable pathology such as infection, tumour, osteoporosis, rheumatoid arthritis, fracture, or inflammation. Over 70% of people usually suffer from such backpain disorder at some time. But recovery is not always favorable, 82% of non-recent-onset patients still experience pain 1 year later. Even though not having any history of lower back pain, many patients suffering from this disorder spend months or years healing from it. Hence aiming to look for preventive measure rather than curative, this study suggests a classification methodology for Chronic LBP disorder using Deep Learning techniques.

1. Introduction

Lower back pain (LBP) might be a very regular issue and influences all scopes of the population, be that as it may, its burden is normally considered irrelevant.

Lower back pain happens in comparable extents in all age groups and influences with personal satisfaction and work execution, and is the essential purpose behind medical consultations.

Some of the cases of this disorder are due to causes while most cases are non-specific. In the Global Burden of Disease Study (GBD) 2010, it was shown that this issue is one among the top ten high weight diseases and wounds, usually with higher figures in DALYs (disability-adjusted life years) higher than HIV, street injuries, tuberculosis, lung cancer, incessant obstructive aspiratory disease and preterm birth entanglements [1].

Lower Back Pain is one of the prominent factors behind health problems. It's stated that the yearly occurrence of spine pain from, 5% to 65% as the lifetime occurrence can range around 84%. The monthly occurrence stated is between 35% and 37%. Many individuals have their first experiences of spine pains in late teens or early twenties and these experiences frequently reoccur throughout adult life ultimately causing severe chronic disorders. Typical reasons of lower back pain include: (i) The large nerve roots in the lower back that visit the legs might be irritated, (ii) The Small nerves that supply the lower back might be irritated, (iii) The large paired spine muscles (erector spine) might be strained, (iv) The bones, ligaments or joints might be damaged.

According to a survey conducted by 'National Centre of Health Statistics', low back pain was the most common pain reported (27%) with neck pain suffered by 15% of people, the same percentage who experience severe headaches or migraine which is shown in Figure 1.

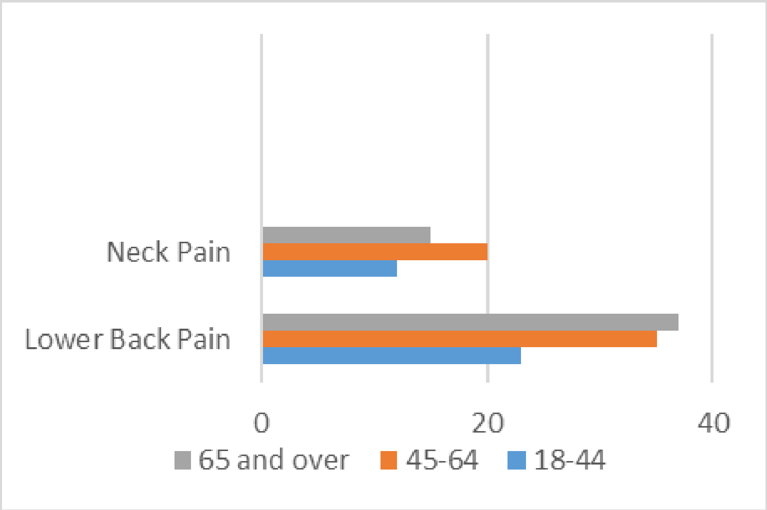

Figure 1. Occurrence of Lower Back Pain in Different age groups

Precise analysis of the spine and spinal structures from medical pictures is a basic tool in numerous clinical uses of spinal imaging. Learning of the detailed state of individual vertebrae can extensively help early finding, surgical arranging and follow-up evaluation of various spinal pathologies, for example, degenerative disorders, spinal distortions, trauma and tumors, as well as for the assessment of vertebral fractures. Segmentation and classification of broken vertebrae by computer helped strategies may consequently give extra support to finding and treatment of vertebral fractures. The objective of computing on Segmentation and Classification of Cracked Vertebrae is to approve the performance of the existing or recently created algorithms on a similar standard database of pictures with vertebral cracks, and give an institutionalized assessment structure for segmentation and characterization comes about examination and positioning.

Another variation of back pain usually known as vertebral fracture, is regularly seen as a fall of the vertebra that happens because of conditions, for example, osteoporosis, unreasonable pressure, or injury. Radiography of the thoracolumbar spine is the standard imaging approach for assessing vertebral cracks in clinical practice, be that as it may, visual elucidation of vertebral body distortions from two-dimensional (2D) radiographic pictures is a testing assignment because of the projective way of pictures and fluctuation in the state of both typical and pathologically disfigured vertebral bodies.

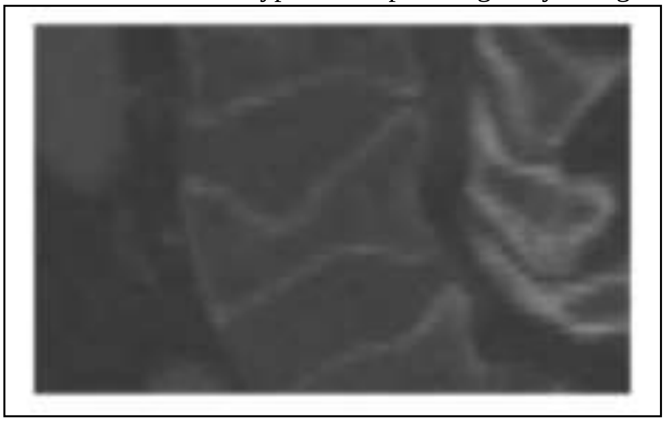

Figure 2. X-Ray Image of Vertebral Fracture

As shown in Figure 2, the vertebral fractures are hence frequently undetected by clinicians or under-analyzed by radiologists. As both over-analysis and under-analysis may have clinically genuine outcomes for individual subjects, radiologists must be all around prepared and with long-term clinical experience to give an effective visual understanding and right determination of vertebral body misshapen. To diminish the subjectivity in elucidation and enhance the understanding among eyewitnesses, quantitative morphometric (QM) and semi quantitative (SQ) strategies were proposed and stretched out to electronic assessment of vertebral breaks, regularly upheld by picture preparing and investigation systems. Then again, by producing point by point 3D pictures of the life systems, registered tomography (CT) gives intends to exact estimation of vertebral deformations in three measurements (3D).Segmentation of cracked vertebrae in 3D may give extra support to surgical treatment of vertebral breaks, for instance, to gauge the volume of the vertebral body on account of vertebroplasty, while the discovery and arrangement of vertebral cracks may offer help to clinical practice, and to research and comprehension of vertebral cracks. In spite of the fact that the application in 3D may not make up for extra expenses and patient presentation to ionizing radiation on account of CT imaging, the advantages of an exact conclusion exceed the related dangers, and CT imaging of the spine is every now and again performed to precisely gauge bone thickness in the spine and anticipate whether vertebral cracks are probably going to happen in patients who are at danger of osteoporosis.

In the study, we use deep learning framework known as Tensor Flow to progress with the segmentation and classification of the LBP x-ray data. Tensor Flow is an open source programming library for machine learning over a range of errands, and created by Google to address their issues for frameworks fit for building and preparing neural systems to recognize and interpret examples and relationships, practically equivalent to the learning and thinking which people use. It is as of now utilized for both research and generation at Google products.

2. Related Work

In 2002, Hazel Jenkins [1], proposed an algorithm which provided a screening tool to classify lower back pain acquiescent to chiropractic treatment and pains due to pathological cause. The categorization method allows the practitioners to avoid making assumptions depending upon the heuristics and pattern recognition until it has been established that the patient is a candidate for chiropractic care. The proposed methodology considers underlying distinction of four clinical patterns which are simple mechanical lower back pain, lower back pain with radiculopathy, serious pathological lower back pain and lower back pain with psychological overlay. In the study further, an algorithmic diagnosis between these categories is considered to facilitate the evaluation of lower back pain.

Later a study by Nicholas Henschke etal.[2], suggests that there exists numerous resemblances between the research questions that practitioners need answered and those promoted in clinical practice guide lines, but there are also vital contrasts. Essential care professionals recognized a scope of subjects needing additional data including conclusion, diminishing the weight on essential care, and viability of medicines. Their review gives vital data to specialists, and highlights the significance of incorporating essential care professionals in the advancement of an exploration plan.

A novel research by S. Rahimi etal.[3] is conducted using fuzzy approach for the diagnosis of Degenerative Disc Diseases. The primary focus of their study was to show the interval type-2 fuzzy hybrid rule-based system, which was the combination of forward and backward chaining approach in its inference engine. According to the research, combining forward and backward chaining leads to detect the exact location of degenerated disc that shows some spinal instability. The results showed that Type-2 Fuzzy Expert System could diagnose more successfully than Type-1 Fuzzy Expert System and Crisp Expert System. Using Fuzzy Expert System can decrease unnecessary cost and unnecessary people aggregation in Magnetic Resonance Imaging centres.

In 2005, Peter O'Sullivan [4], proposed a research study which used maladaptive movement and engine control impairments as basic system for the finding and classification of constant low back pain disorders. Classification of CLBP pain issue into sub-gatherings, based on the mechanism underlying the disorder, is viewed as basic to guarantee suitable administration. The study suggests that three gatherings of CLBP issue exist. The main gathering of clutters present where underlying pathological processes drive the pain, and the patients' motor responses in the disorder are adaptive. A second group of scatters present where mental as well as social elements speak to the primary mechanism

IOP Conf. Series: Materials Science and Engineering **263** (2017) 042086 doi:10.1088/1757-899X/263/4/042086

underlying the disorder that centrally drives pain, and where the patient's adapting and engine control systems are maladaptive in nature. At long last it is suggested that there is an expansive gathering of CLBP issue where patients give either development hindrances (described by pain avoidance behaviour) or control debilitation's (portrayed by pain provocation behaviour). In the study further, it is also proposed that there is a large sub-group of CLBP disorders where mal-adaptive movement and control impairments dominate the disorder, resulting in either excessive or impaired dynamic spinal stability and stacking. This turns into an instrument for progressing pain. Physiotherapy intercessions that are classification based and particularly coordinated to the basic driving component, can possibly change these disorders and effect on both the essential physical and secondary cognitive drivers of pain. This approach is not limited only to the lumbo-pelvic region but can be applied to all regions of the musculoskeletal system.

3. Methodology Used

The procured informational collection contains figured tomography lumbar spine pictures including non-cracked vertebrae and vertebrae with breaks of various morphological evaluations and cases. The pictures are available in the Meta Picture (MHD) arrange, a solution picture organize utilized as a part of the Understanding Division and Enlistment Toolbox (ITK) and other therapeutic representation programming, as per which each picture is spoken to by a header file(*.mhd) and an information document (*.raw) shaping a couple.

Vertebra division is given as volume veils that allot each picture pixel to a predefined vertebral level or to the foundation, and was characterized through the accord of two eyewitnesses. For one subset of pictures, each lumbar vertebral level from L1 to L5 is doled out a remarkable cover esteem mm:

$$L1: \quad m = 200$$
$$L2: \quad m = 210$$
$$L3: \quad m = 220$$
$$L4: \quad m = 230$$
$$L5: \quad m = 240$$

While for the other subset of picture, each lumbar vertebral level from L1 to L5 is doled out the accompanying cover values m:

$$L1: \quad 195 \leq m \leq 205$$
$$L2: \quad 205 \leq m \leq 215$$
$$L3: \quad 215 \leq m \leq 225$$
$$L4: \quad 225 \leq m \leq 235$$
$$L5: \quad 235 \leq m \leq 245$$

with the esteem m=0 speaking to the foundation. Covering veil qualities will be considered to have a place with the relating two vertebrae. For instance, if a pixel is appointed a cover estimation of m=215, it will be expected that that pixel has a place both with L2 vertebra and to L3 vertebra. The grades and cases of vertebrate fracture is shown in Figure 3.

To assess vertebral cracks, quantitative morphometric (QM) strategies were composed that [1-4] apply the standard six-indicate vertebral morphometric sagittal radiographic pictures, which comprises of manual arrangement of six focuses on the sides of vertebral bodies and at the focuses of vertebral endplates. From these focuses, the front, focal and back vertebral body statures are measured and used to ascertain the foremost to-back, key to-back and back to-back neighbouring tallness proportions (the

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last is computed if the back stature of the predominant or second rate adjoining vertebral body is accessible). To recognize vertebral cracks from different distortions that regularly happen in solid subjects, the acquired statures and tallness proportions are then contrasted with their standardizing values. Regardless of the generally target nature of QM techniques, manual estimation of vertebral body statures is tedious, and even a moderately little estimation imprecision may considerably affect the characterization of vertebral body disfigurements. In clinical practice, radiologists lean toward visual estimation of the misfortune in vertebral body statures over manual estimation of vertebral body statures. Therefore, the semi quantitative (SQ) technique for Genant et al. which presented particular morphological cases and grades of vertebral body breaks, is acknowledged as the "ground truth" for the assessment of vertebral cracks. By assessing the front, focal and back tallness of the vertebral body in sagittal radiographic pictures, the SQ strategy characterizes the accompanying morphological instances of vertebral cracks:

The wedge (foremost) morphological instance of vertebral cracks is portrayed by a particular distinction between the front and back vertebral stature. The biconcavity (centre) morphological instance of vertebral breaks is portrayed by comparable front and back yet a littler focal vertebral tallness. The pulverize (back) morphological instance of vertebral breaks is portrayed by the mean vertebral tallness lower than the factual incentive for that vertebra or for neighbouring vertebral bodies. Also, the SQ technique characterizes the accompanying morphological evaluations of vertebral breaks: The gentle (1) morphological review of vertebral cracks is portrayed by a 20–25% diminishment in the vertebral tallness. The direct (2) morphological review of vertebral breaks is portrayed by a 25–40% lessening in the vertebral tallness. The extreme (3) morphological review of vertebral breaks is described by a more than 40% diminishment in the vertebral tallness.

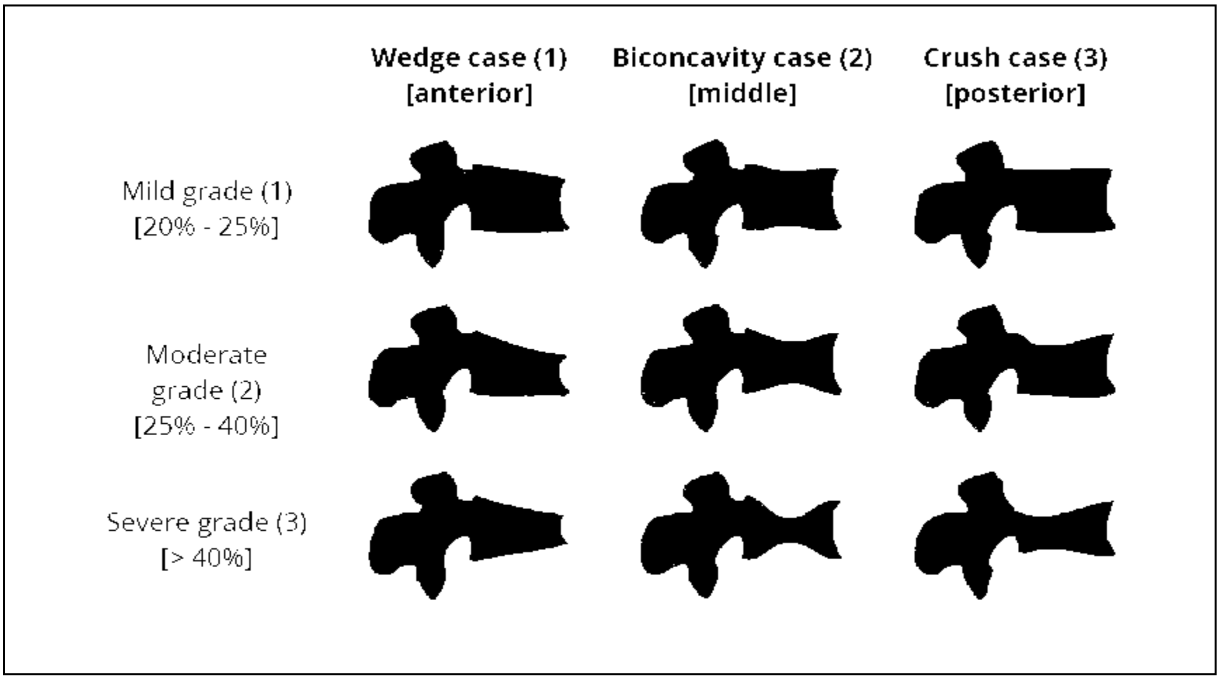

Figure 3. Grades and cases of Vertebrate Fracture

4. Results

Initially, different segments in the images of vertebral spine were highlighted using MATLAB support of feature selection. The segmentation of vertebral spine is shown in Figure 4.

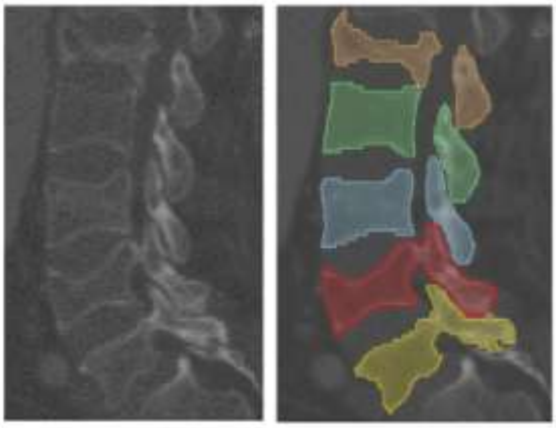

Figure 4. Segmentation of Vertebral Spine

These selected features were used to train deep learning model using keras package in python and Tensor Flow framework at backend The deep learning framework ‘Tensor Flow’ was operated on following configuration of the system:

Table 1. System Configuration

Parameter	Specification
Platform Used	64-bit Linux.
Framework compitability	Python 2.7.
GPU Configuration	NVIDIA CUDA® 7.5 (CUDA 8.0 required for Pascal GPUs)
GPU Framework	NVIDIA cuDNN v4.0 (minimum) or v5.1 (recommended)

The system configuration to perform testing is shown Table 1. Interestingly, in spite of balanced distribution of weights on the GPU, the processing resources required to carry out the epochs were seemingly insufficient. The keras package consists of various activation functions, namely ‘softmax’, ‘softplus’, ‘tanh’, ‘relu’, ‘elu’, ‘sigmoid’, ‘hard_sigmoid’ etc. In this case, to compare accuracy ratio, the model was trained using 4 activation functions namely ‘relu’, sigmoid, tanh, and elu. When executed upto 100 epochs, ‘relu’ function managed to yield highest accuracy ratio compared to other layers with considerable accuracy of around 65%. The comparison of accuracy rates of activation function is shown in Figure 5.

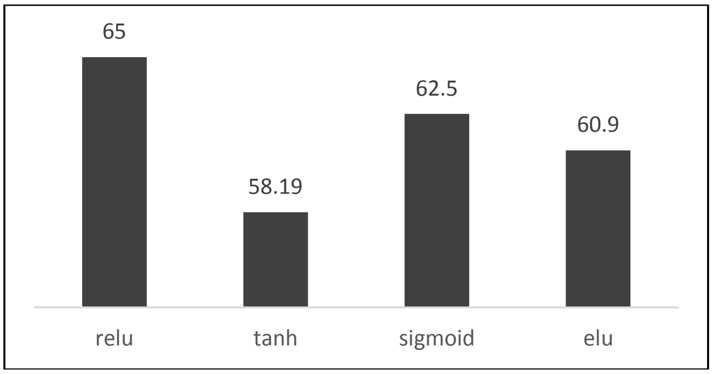

Figure 5. Comparison of Accuracy Rates of Activation Functions

The following table demonstrates the segmentation and classification results obtained,

ID	Spine image	L1		L2		L3		L4		L5	
	Name	Grade	Case	Grade	Case	Grade	Case	Grade	Case	Grade	Case
1	image001	1 mild	3 crush	0 normal	0 normal	1 mild	1 wedge	1 mild	1 wedge	1 mild	3 crush
2	image002	0 normal	0 normal	0 normal	0 normal	0 normal	0 normal	1 mild	1 wedge	0 normal	0 normal
3	image003	1 mild	2 biconcavity	1 mild	2 biconcavity	1 mild	2 biconcavity	1 mild	2 biconcavity	1 mild	3 crush
4	image004	0 normal	0 normal	0 normal	0 normal	1 mild	3 crush	1 mild	3 crush	1 mild	1 wedge
5	image005	1 mild	2 biconcavity	1 mild	2 biconcavity	0 normal	0 normal	1 mild	1 wedge	0 normal	0 normal
6	image006	0 normal	0 normal	2 moderate	2 biconcavity	1 mild	2 biconcavity	1 mild	3 crush	0 normal	0 normal
7	image007	3 severe	2 biconcavity	1 mild	2 biconcavity	1 mild	2 biconcavity	2 moderate	2 biconcavity	1 mild	1 wedge
8	image008	1 mild	1 wedge	1 mild	1 wedge	0 normal	0 normal	0 normal	0 normal	0 normal	0 normal

Figure 6. The overall comparison

As mentioned earlier, a subset of dataset was selected to process, in the first subset of images, on each segment among L1 to L5, classification of the fracture in terms of normal, mild, crush, wedge, severe and biconcavity was obtained. The overall comparison is shown in Figure 6.

5. Conclusion

Back pain is not a disease but a constellation of symptoms which origins remain in most cases unknown even though risks factors have been identified. Low back pain is disabling and causes enormous socioeconomic impacts on societies. Treatments for now are focused on reducing the pain. Back pain is both a major cause of temporary disability and a challenge to medical and surgical treatment decisions. It imposes high socio-economic burden in modern western countries, since it not only affects the elderly population but also the working population from 25–60 years. In this study, an approach using deep learning technique is demonstrated which segments and classifies lower back pain image with respect to severity levels.

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