IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Fracture detection: A quick survey of deep learning models

Prof. Nilesh Mahajan[1], Irfan Khatik[2]

[1](Research Guide and Scholar, IMED Bharati Vidyapeeth University, Pune)

[2](Research Scholar Bharati Vidyapeeth University, Pune)

Abstract: Bone fracture is a common problem now days due to road accidents, unhealthy lifestyle and many other causes. Bone is an integral part of the human body to move and shape it. A small fracture in the bone affects normal functioning of the bone and in result affects the free movement of the person. Fracture is common in human bones. There are a lot of techniques to find out fractures. Normal technique is time consuming and expert dependent. It also has a high error rate. In case of suspected fractures, the patient visits emergency units and X-ray is the primary tool to assess the patient for fracture. X-ray detection is economical mean for fracture. Missing a fracture has severe consequences on patients. Automated detection of bone fracture is a hot research topic today. There are a lot of papers on automated fracture detection. This paper focuses on deep learning methods for bone fracture detection. Deep learning is a Neural Network based method where more hidden layers are used with the artificial neural network. Objective is to provide an overview of deep learning methods on bone fracture to help researchers to further explore the idea. This paper also discuss about the popular python APIs in deep learning

Keywords - deep learning, bone fracture, neural network, X-ray, python

1. INTRODUCTION

Bone fracture is one of the major injuries these days. Due to heavy traffic, fast lifestyle, dealing with heavy objects and other causes, a lot of road accidents happen, causing traumatic fractures. It is common for peoples of all ages. A large number of people suffer from bone fractures and proper diagnosis is very important to make right treatment decisions. X-Rays are still common for bone fracture detection as they are not much expensive. In normal human based diagnosis of X-rays of affected bone, there is a high probability of improper diagnosis. This leads to permanent damage of a bone. Many researchers worked and wrote papers on automatic detection of fractures using X-ray images.

Fracture is a typical bone damage that occurs when bone is unable to handle an external force such as fall, direct hit, and other injuries. Discontinuity in bone alignment is termed as fracture. Latest techniques use CAD and machine learning techniques to detect fractures. Machine learning uses techniques like regression, SVM, and Neural network for classification.

Deep learning is machine learning with extra hidden layers. It is an Artificial Intelligence function that simulates working of the human brain in processing data and making decisions with the help of patterns. It is also termed a deep neural network. There is an explosion of data in various forms. Deep learning has the capability to process huge unstructured data called big data and extract the useful information from this data that could normally take human decades to process. In this era deep learning is used by many companies for a number of different tasks. Deep learning is taking ground in medical diagnosis and digital pathology.

The most popular types of deep networks used in supervised learning are multi-layered perceptrons or MLP, also known as deep feed forward networks, convolution networks or CNNs, and recurrent networks or RNNs, and there are many others such as auto encoders, generative adversarial networks, de-convolution networks, etc.

There are six steps required to train a deep network. First, the weights of the network are initialized by drawing samples from some distribution. Second, a small batch of data is fetched. Third, the data in the batch is passed through the network. This is known as forward propagation. Fourth, the cost C is computed. The cost is a metric of difference between the actual output Y hat and the expected output Y. Fifth, gradients of the cost with respect to the weights and activations are back propagated in order to know how to adjust the weights to reduce the cost. Six, the weights are updated. This is repeated starting with step two until the cost remains the same.

2. LITERATURE SURVEY

Deep-learning systems can accurately identify fractures throughout the adult musculoskeletal system. These methods are a mechanism by which senior medical specialists can deliver their expertise to generalists on the front lines of medicine, thereby providing substantial improvements to patient care.[6]

Digital pathology has created opportunities to support the triaging of difficult cases it also enables immediate and remote access across the world [2] .It also offers computer-aided diagnostic procedures (CAD) through which systems and experts can focus on high affected regions of image [3]. Computerized analysis based on deep learning has shown potential benefits as a diagnostic strategy and has recently become feasible [5]. In emergency departments, missed fractures are the most common diagnostic error and can lead to treatment delays and long-term disability.

In 2016, Geoffrey Hinton, a notable computer scientist often referred to as the "Godfather of Deep Learning,", predicted that radiologists — specialists who diagnose diseases from medical imaging like X-rays, computed tomography (CT) scans, and magnetic resonance imaging (MRI) — would soon lose their jobs. "People should stop training radiologists right now," he announced, "It's obvious that within five years deep learning is going to do better than humans."[7].

Some researchers reviewed the bone fracture detection techniques to find out similarities , state of art giving direction for further research and focusing on the gap. Different bone fracture detection techniques were reviewed by Khatik [11] Bone fracture using deep learning was studied by Robert Lindsey et al [12].

3. METHODOLOGY

During the analysis of papers under study it realises no specific method exist to identify all fractures there types and classify them. We have studied and summarised some papers on fracture detection by deep learning. One paper uses image processing and rest of the papers based on deep learning. For each paper we have summarized the data set used, a short description of methods used and result of the study. The summary of study also represented in tabular form. At last popular python APIs are included with the advantages and disadvantages for the purpose of fracture detection

3.1 Bone Fracture Detection System using Image Processing and Matlab.[16]

This section focuses on work of B Harinath, Sitrarasu, T.J. Nagalakshmi.

Authors enhanced and segmented the input image and developed a complete GUI in MATLAB show and compare the results.

3.2 Thigh fracture detection using deep learning method based on new dilated convolutional feature pyramid network[10]

In this section we have summarised and presented the work of Bin Guan, Jinkun Yao, Guoshan Zhang, Xinbo Wang.

They have collected X-ray images by the newest Digital Radiography (DR) technology from the Department of Radiology of a People's Hospital and designed a separate dataset for thigh fracture detection. The dataset is composed of 3842 thigh fracture images with 24-bit jpg format divided as 3484 and 358 images as training and testing data respectively.

As per the finding and conclusion, the DCFPN has strong potential applicability in practical clinical environments as Average Precision (AP) of DCFPN reaches 82.1% in the testing thigh fracture images, which is 3.9% higher than that of state-of-the-art FPN.

3.3 Arm fracture detection in X-rays based on improved deep convolution neural network [9]

In this section we have summarised and presented work of Bin Guan, Guoshan Zhang , Jinkun Yao , Xinbo Wang and Mengxuan Wang. Here the new method of fracture is developed and applied on Arms.

They have used MURA dataset and performed preprocessing. For noise removal opening with 21x 21 kernel is used and for brightness cumulative distribution function of normal distribution was used, maximum pixel value of main area is used as the mean of the normal distribution, the network is trained with 3392 annotated images, and the model is tested by 612 images.

Three important steps are used. First, a new backbone network is pro- posed based on feature pyramid architecture. Second, an image preprocessing procedure including opening operation and pixel value transformation is developed to enhance the contrast of original images. Third, the receptive field adjustment containing anchor scale reduction and tiny ROIs expansion is exploited.

3.4 Deep learning and SURF for automated classification and detection of calcaneus fractures in CT images [13]

This section focuses on the work of Yoga Dwi Pranata, Kuan-Chung Wang, Jia-Ching Wang, Irwansyah Idram, Jiing-Yih Lai, Jia-Wei Liu, I-Hui Hsieh

Author used two data sets of real-patient calcaneus bone CT images in three different views (sagittal, coronal and transverse) from a hospital in Taiwan. Total 1931 images are classified,used in 80:20 proportion in training and testing images.

Images are resized to 224 X 224 pixels and transformed to vector matrix to be used on pre trained DCNN (Deep Convolutional Neural Network), VGG and ResNet networks pre-trained on ImageNet images. SURF is used to identify bone fracture location, a fast-Hessian matrix is applied in the SURF feature detection process. Fast library for approximate nearest

neighbors (FLANN) is applied to match extracted features from test1 and reference images. RANSAC is used for feature mismatch reduction. Canny edge detection is applied and OpenCV library is used for Contour detection.

Study shows that 98% accuracy can be achieved in the computer assisted classification of calcaneus bone fractures in CT images.

3.5 Bone fracture detection through the two-stage system of Crack-Sensitive Convolutional Neural Network[15]

In this section we present the work of Yangling Ma, Yixin Luo.

Author collected the dataset of 3053 X-ray images from website Radiopaedia and hospital DICOM files, 2001 images were used for training and testing of the object detection network and recognition network, and the remaining images are used for comparison of the two-stage system proposed by them with other methods.1800 images from dataset1 were used as training dataset and 201 images from dataset1 were used as testing dataset.

They have proposed a novel system to fast and systematically detect fractures in X-ray images. Faster RCNN method is used, features extracted using Convolution layer, Relu.

3.6 Artificial intelligence for the classification of fractures around the knee in adults according to the 2018 AO/OTA classification system

In this section we summarise the work Lind A, Akbarian E etc.

Authors works to evaluate how well an AI can classify knee fractures according to the detailed 2018 AO-OTA fracture classification system. They have selected 6003 radiograph exams taken at Danderyd University Hospital between the years 2002–2016. Then they trained a ResNet-based neural network on this data and evaluated performance on 600 exams. They have captured more than 49 fractured classes, and achieved more than 0.8 accuracy.
They concluded that deep learning and AI can also be used for more detailed classification of fractures around the knee joint than just fracture identification.

3.7 Application of a deep learning algorithm for detection and visualization of hip fractures on plain pelvic radiographs

Authors we developed an automated fracture diagnosis algorithm trained based on the DCNN to examine PXRs. Authors collected the data and images of all trauma patients treated from August 2008 to December 2017 at CGMH. They chosen 90% of the limb dataset for training and 10% for validation. DCNN used by researchers is based on TensorFlow 1.5.1 and Keras 2.1.4 open-source library with Python 3.6.5.
They used 3605 PXRs to build the model. The achieved an accuracy of 0.94, 0.90 for training and validation respectively.

4. PYTHON APIs.

There are many technologies in which machine and deep learning can be implemented. Python is best suited for this purpose, it is stable flexible and has tools available to implement the research which is why lot of research is in python today.

Benefits that make Python the best fit for machine learning and AI-based projects include simplicity and consistency, access to great libraries and frameworks for AI and machine learning (ML), flexibility, platform independence, and a wide community. In addition python is easy to learn. It has simple, readable, understandable and concise code. One can easily build a model in python and test it for learning process. Number of python frame work and libraries are available which reduces development time. Various features that make python popular and top for machine learning, deep learning are its free and open source nature, exhaustive libraries, easy and smooth implementation support for soft computing etc.

Out of many here we are presenting two popular libraries “Tensorflow and Pytorch” in brief and there comparison. More details are available on internet.

TensorFlow and PyTorch are among the top frameworks that are preferred by Data Scientists as well as beginners in the field of Deep Learning.

Following is the comparision of the two frameworks which will help researcher to find out which one is suitable for the respective work.

TensorFlow is an open-source software library for dataflow programming across a range of tasks. It is a symbolic math library that is used for **machine learning** applications like neural networks.

PyTorch is an open source **machine learning** library for Python, based on Torch. It is used for applications such as **natural language processing** and was developed by Facebook’s AI research group.

Pytorch, provides **lower-level API** focused on direct work with array expressions. It has gained immense interest in the last year, becoming a preferred solution for academic research, and applications of deep learning requiring optimizing custom expressions. On the other hand keras provides high level APIs.

Pytorch provides better debugging options than Tensorflow.

In summary, final choice is dependent on the user on technical background , purpose and ease of use.

Tensorflow is mature and powerful deep learning library with good visualization options and easy model development.

Pytorch is comparatively young but it is gaining fast popularity. It is more suitable for research and has better debugging fascillity.

5. DISCUSSION and CONCLUSION

This study shows that no system is complete and applicable for all bones. More testing is required for each bone type for different input. Deep learning gives better results and accuracy can be increased by modifying methods and testing with different data sets. It could be comprehended that mixing two methods will give more accurate results and reduce the error rate.

Python is popular open source language for deep learning and provides various libraries. Pytorch is young but powerful python library for research with good debugging options.

Following table shows summary of the all studied papers

Table 1. Summary of studied papers

Paper	Data Set	Size	Size of Training	Accuracy	Bone types
Pranata[13]	Real patient calcaneus images	1931	1584	98	Calcaneus
Guan et al. [10]	Thigh fracture images	3842	3484	82.1	Thigh
Bin Guan, Jinkun Yao [9]	MURA database for Arm fracture	4004	3392	62.04	Arm
Yangling Ma, Yixin Luo[15]	X-ray images, from website Radiopaedia and from hospital DICOM files	3053	1800	88.39	skull, upper trunk, lower trunk, lower limb and upper limb etc
Lind A, Akbarian E etc[17]	X-ray images taken at Danderyd University Hospital	6003	600	Above 80	Knee fracture
Lind A, Akbarian E etc[17]	X-ray images taken at Danderyd University Hospital	6003	600	Above 80	Knee fracture
Cheng, CT., Ho, TY etc [18]	Images of trauma patient at CGMH trauma centre.	3605	80%	>90	Pelvic fracture

Future directions

Artificial Intelligence and Deep Learning must continue to expand for clinical applications like bone fracture. As shown in the study more work will increase the accuracy and aid the expert to correctly diagnose the hidden fracture. Study should be performed on different bones in detail for different datasets. Mixing different methods and designing new algorithm can improve the performance on fracture detection on radiograph and it can also support fracture classification and treatment.

REFERENCES

[1] *Amin, Shreyasee et al. "Trends in fracture incidence: a population-based study over 20 years." Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research vol. 29,3 (2014): 581-9. doi:10.1002/jbmr.2072.*

[2] *Romero Lauro, Gonzalo et al. "Digital pathology consultations-a new era in digital imaging, challenges and practical applications." Journal of digital imaging vol. 26,4 (2013): 668-77. doi:10.1007/s10278-013-9572-0.*

[3] *Petrick, Nicholas et al. "Evaluation of computer-aided detection and diagnosis systems." Medical physics vol. 40,8 (2013): 087001. doi:10.1118/1.4816310*

[4] *Permany DS, Goldbaum M, Cai Wet al (2018) Identifying medical diagnoses and treatable diseases by image-based deep learning. Cell172:1122–1131.e9.*

[5] *Yadav, D. & Rathor, Sandeep. (2020). Bone Fracture Detection and Classification using Deep Learning Approach. 282-285. 10.1109/PARC49193.2020.236611.*

[6] *England, J. R., Gross, J. S., White, E. A., Patel, D. B., England, J. T., & Cheng, P. M. (2018). Detection of traumatic pediatric elbow joint effusion using a deep convolutional neural network. American Journal of Roentgenology, 211(6), 1361-1368.*

[7] *Badgeley, M. A., Zech, J. R., Oakden-Rayner, L., Glicksberg, B. S., Liu, M., Gale, W., ... & Dudley, J. T. (2019). Deep learning predicts hip fracture using confounding patient and healthcare variables. NPJ digital medicine, 2(1), 1-10.*

[8] *Pranata, Yoga & Wang, Kuan-Chung & Wang, Jia-Ching & Idram, Irwansyah & Lai, Jiing-Yih & Liu, Jia-Wei & Hsieh, I-Hui. (2019). " Deep learning and SURF for automated classification and detection of calcaneus fractures in CT images". Computer Methods and Programs in Biomedicine. 171. 10.1016/j.cmpb.2019.02.006.*

[9] *Guan, Bin & Yaoet al Computers and Electrical Engineering 81 (2020) 106530 (2020) Arm fracture detection in X-rays based on improved deep convolutional neural network" https://doi.org/10.1016/j.compeleceng.2019.106530*

[10] *Bin Guan, Jinkun Yao, Guoshan Zhang, Xinbo Wang,"Thigh fracture detection using deep learning method based on new dilated convolutional feature pyramid network",Pattern Recognition Letters,Volume 125,2019,ISSN 0167-8655,https://doi.org/10.1016/j.patrec.2019.06.015.*

[11] *Khatik, I. (2017). "A study of various bone fracture detection techniques". International Journal of Engineering and Computer Science, 6(5), 21418-21423.*

[12] *Robert Lindsey et. al."Deep neural network improves fracture detection by clinicians",PNAS November 6, 2018 115 (45) 11591-11596; first published October 22, 2018;*

[13] *D. P. Yadav and S. Rathor, "Bone Fracture Detection and Classification using Deep Learning Approach," 2020 International Conference on Power Electronics & IoT Applications in Renewable Energy and its Control (PARC), Mathura, Uttar Pradesh, India, 2020, pp. 282-285, doi: 10.1109/PARC49193.2020.236611.*

[14] *Chung, S.W.; Han, S.S.; Lee, J.W.; Oh, K.-S.; Kim, N.R.; Yoon, J.P.; Kim, J.Y.; Moon, S.H.; Kwon, J.; Lee, H.-J.; et al. Automated detection and classification of the proximal humerus fracture by using deep learning algorithm. Acta Orthop. 2018, 89, 468–473.*

[15] *Yangling Ma, Yixin Luo,"Bone fracture detection through the two-stage system of Crack-Sensitive Convolutional Neural Network",Informatics in Medicine Unlocked,Volume 22,2021,100452,ISSN 2352-9148*

[16] *B Harinath, Sitrarasu, T.J. Nagalakshmi "Bone Fracture Detection System using Image Processing and Matlab" International Journal of Innovative Technology and Exploring Engineering (IJITEE)ISSN: 2278-3075,Volume-8Issue-12, October, 2019.*

[17] *Sharma A., Mishra A., Bansal A., Bansal A. (2021) Bone Fractured Detection Using Machine Learning and Digital Geometry. In: Marriwala N., Tripathi C.C., Kumar D., Jain S. (eds) Mobile Radio Communications and 5G Networks. Lecture Notes in Networks and Systems, vol 140. Springer, Singapore. https://doi.org/10.1007/978-981-15-7130-5_28*