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A SURVEY ON THE ERA OF DEEP LEARNING IN MEDICAL IMAGE ANALYSIS

Koyel Roy, Krishnakant Sawant, Karamjot Singh, Aakash Sonawane

Computer Engineering
JSPM's Rajarshi Shahu College of Engineering
Pune, India

Abstract: *Deep learning is growing at an incredible pace in the world of medicine rapidly. It can help the doctors make faster and more accurate diagnoses. Predicting the risk of diseases in time to prevent them is an important application of deep learning nowadays. Deep learning, very easily enhances the doctor's ability to analyze medical images. This review focuses on introducing applications of deep learning in medical image analysis. Convolutional neural network (CNN) can be used for image related problems. The advantage of deep learning in an era of medical big data is that alike patterns within the data can be discovered algorithmically without any manual work of extracting features. We have covered the areas and applications of medical image classification and detections. We have concluded by conferring the applications, advantages, methodologies and future scope of deep learning.*

Keywords*: Deep Learning, Convolutional Neural Network (CNN), Medical Images analysis, Accurate Diagnosis*

1. INTRODUCTION

In recent years, deep learning has set a new trend in machine learning. Deep learning having huge potential is used to tackle complex problems like image analysis, speech and language by giving machines the power to learn about features of the data [1]. The use of the neural network has helped deep learning in getting optimized outcomes. Deep learning is very adaptive in nature. For example, Facebook uses deep learning to find friends in pictures automatically and suggests the user to tag them. Talking about medical fields, the capacity to digital gen has doubled every 40 months since the 1980s. 80.5% of hospitals in the US

have adopted at least a basic EHR system since 2014 [2]. Patient's EHR contains medical images which are usually analyzed by human radiologist. The limitations here are speed, exhaustion and experiences. It takes years and money to train the radiologists. A delayed result of diagnosis may also cause harm to patients. Hence, it's a better idea to carry out medical image analysis by proficient and automated deep learning algorithms.

A. CONVOLUTIONAL NEURAL NETWORK AND TRANSFER LEARNING

CNNs have wide applications in image analysis in the medical field. The Convolutional neural network is one of a class of deep neural networks, which are used for various computer vision tasks and is gaining interest from a variety of domains. CNN is similar to human brain neural networks with learnable weights and biases. Each neuron receives several inputs, takes a weighted sum from the inputs and pass it through an activation function gives an output. CNN is well suited to implement image recognition tasks. Image-based CADs (Computer Aided Diagnosis) with the help of CNN can differentiate various kinds of lung abnormalities such as lung nodules [3]. Gulshan et al. [4], Esteva et al. [5], and Ehteshami Bejnordi et al. [6] validated the potential of CNN for diabetic retinopathy screening, skin lesion classification, and lymph node metastasis detection, respectively.

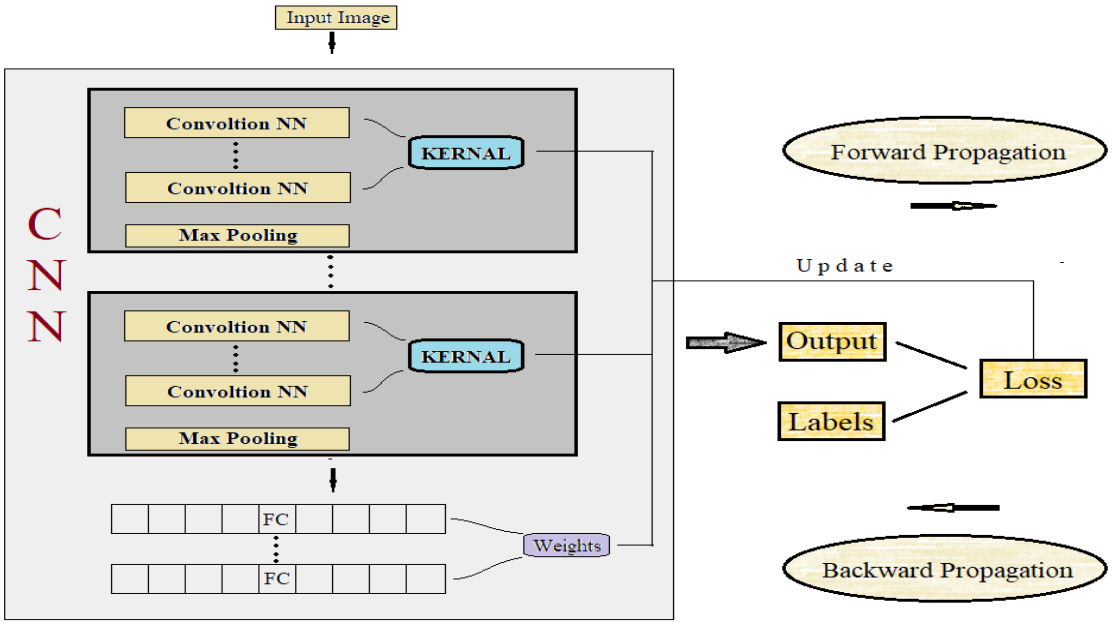

Fig.1 Convolutional neural network

The challenges of using CNN to medical imaging tasks are small dataset and over-fitting. This limitation can be overcome by a methodology called transfer learning. Transfer learning is an effective strategy to train a network on a small dataset, where a network is pre-trained on an extremely large dataset, such as ImageNet, which has 1.4 million images with 1000 classes, which are then reused and applied to the given task of interest [7]. Many examples

are there where transfer learning is truly valuable. One example is visual categorization[8] where the aim was to solve some typical problems likeview divergence in action recognition tasks and concept drifting in image classification tasks. Nowadays, many models pre-trained on the ImageNet challenge dataset are widely open to the public and readily and can be accessed with their learned kernels and weights, such as AlexNet [9], VGG [10], ResNet [11], and DenseNet [12]. Basically, there are two ways to pretrained a network, one is fixed feature extraction and the other one is fine-tuning.

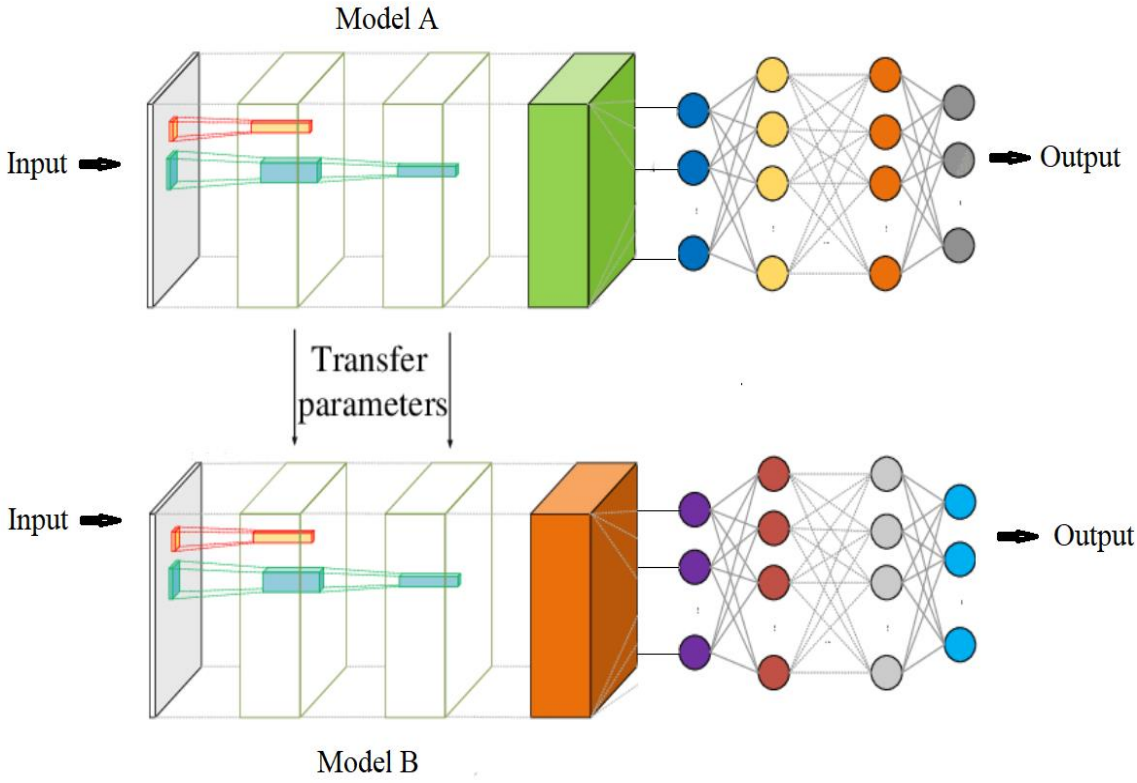

Fig. 2 Transfer learning

Table 1: Survey on journals and books of deep learning for medical imaging

Type	**Author**	**Title**	**Publication year**	**Published in**
Journal	Daniele Ravì, Charenceong [13]	Deep Learning for Health Informatics	2017	IEEE Journal of Biomedical and health informatics.
Journal	N. Deepika, P. Vinupritha, D. Kathirvelu [14]	Classification of Lobar Pneumonia by Two Different Classifiers in Lung CT Images	2018	International Conference on Communication and Signal Processing

				(ICCSP)
Journal	Justin Ker, LipoWang, Jai Rao, Tchoyoson Lim [15]	Deep Learning Applications in Medical Image Analysis	2017	IEEE Volume 6
Book	Le Lu,Yefeng Zheng, Gustavo Carneiro ,Lin Yang [16]	Deep Learning and Convolutional Neural Networks for Medical Image Computing	2017	Springer
Book	Cardoso, Arbel, Carneiro, Syeda-Mahmood [17]	Deep Learning in Medical Image Analysis and Multimodal Learning for Clinical Decision Support	2017	Springer
Book	Carneiro, Mateus, D., Loïc, Bradley, A., Tavares, J.M.R.S. [18]	Deep Learning and Data Labeling for Medical Applications	2017	Springer
Review	Pranav Rajpurkar , Jeremy Irvin , Robyn L. Ball [19]	Deep learning for chest radiograph diagnosis	2018	Standford ML CheXNext
Journal	Qian Wang, YinghuanShi, Dinggang Shen[20]	Machine Learning in Medical Imaging	2017	EMB magazine
Journal	Yaniv Bar, IditDiamant, Lior Wolf, Sivan Lieberman [21]	Chest pathology detection using deep learning with non-medical training	2015	IEEE 12th International Symposium on Biomedical Imaging (ISBI)
Book	S. Kevin Zhou, Hayit Greenspan and Dinggang Shen [22]	Deep Learning for Medical Image Analysis	2017	Science Direct

B. MEDICAL IMAGE ANALYSIS METHODS

Wilhelm Conrad Roentgen in 1895 discovered X-ray radiations and since then the field of medical imaging has developed rapidly. The analysis of patient's data using image modalities has increased drastically like CT scanning, Chest X-rays, MRT, Ultrasound, PET etc [23]. Ritter and Homeyer [24] have explored a lot of examples of medical image processing that goes beyond simple image enhancements. They explained Image Processing Using MeVisLab, Advance image processing and dynamic imaging. Medical image fusion is a one of a kind of new technology which can be applied in clinic diagnosis, computer assistance diagnosis, surgery plan design, radiation therapy etc. Yang, W., & Liu, J.-R. [25] gave a perfect definition of how Medical image fusion is a combination of a variety of modern science and technology. It has a rapid development in industries since the 1990s because of its use in telemedicine, surgery navigation system and other aspects.

Talking about medical image databases, Li, C. H., & Yuen, P. C. [26] described a Regularized Colour Clustering algorithm to find a solution for colour clustering problem in the medical image database. He applied this algorithm to an image database of colour tongue images. The algorithm gave optimized results for extracting important distinct or abnormal colour clusters without raising the overall cluster compactness.

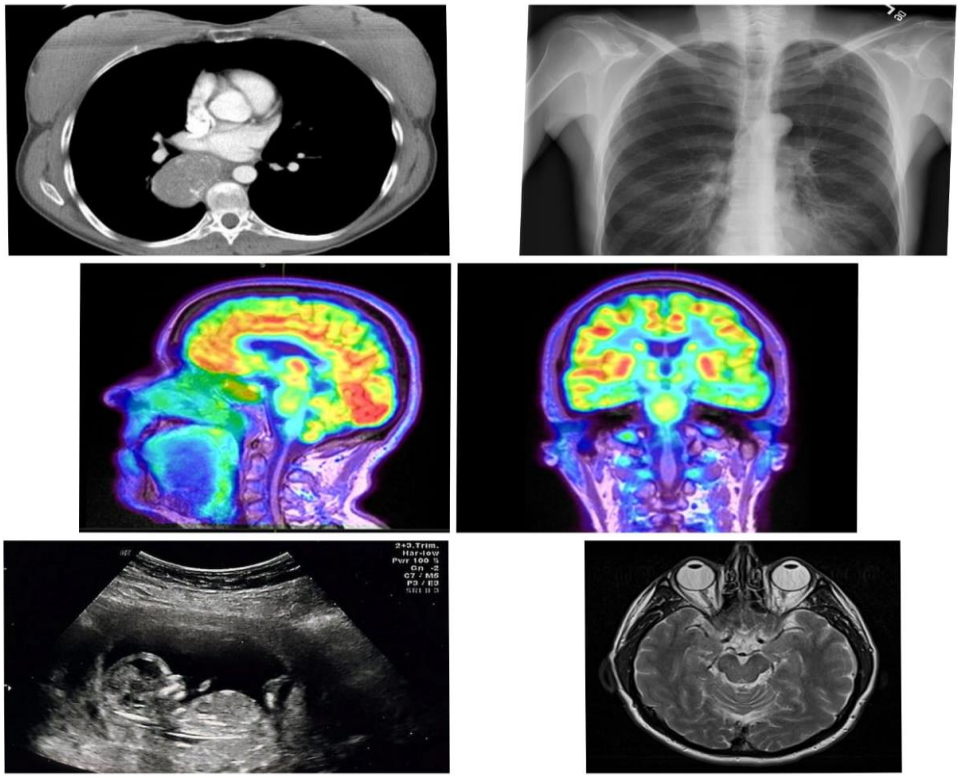

Fig. 3A collection of medical images illustrating medical images, from left to right, top to bottom: CT showing fibrous tumour of the pleura, pneumonia affected chest X-ray, Brain-Scans-PET-MR, Fetal ultrasound image, MRI Head Brain Normal

C. DIAGNOSIS ASSISTED BY MACHINE LEARNING

In recent decades, Computer has entered the medical field and clinics. Every medical record is digitalized. Three-dimensional images of the full body can be obtained now with the help of machine learning and deep learning [27]. New deep learning methodologies and applications are demanded with advances in medical imaging. Machine learning driven methods that automatically process 2-dimensional or 3-dimensional image scans to recognize clinical signs like tumours or grazes or determine likely diagnoses have been published by Suchi Saria, Atul Butte, [28] and rest are making their place in the market rapidly. They demonstrated the power of deep learning in Radiologic diagnoses and also in clustering for the discovery of disease subtypes. Another focus was on reducing medication errors via anomaly detection. According to Gordon D Schiff [29], three-quarters of the chart-

reviewed alerts produced by the screening system, which were found to be completely valid in which the potential medication errors were recognized. Out of these valid alerts, the bulks (75.0%) were found to be useful in flagging possible medication errors. As a result, it was found that this method has the potential to be merged into clinical use.

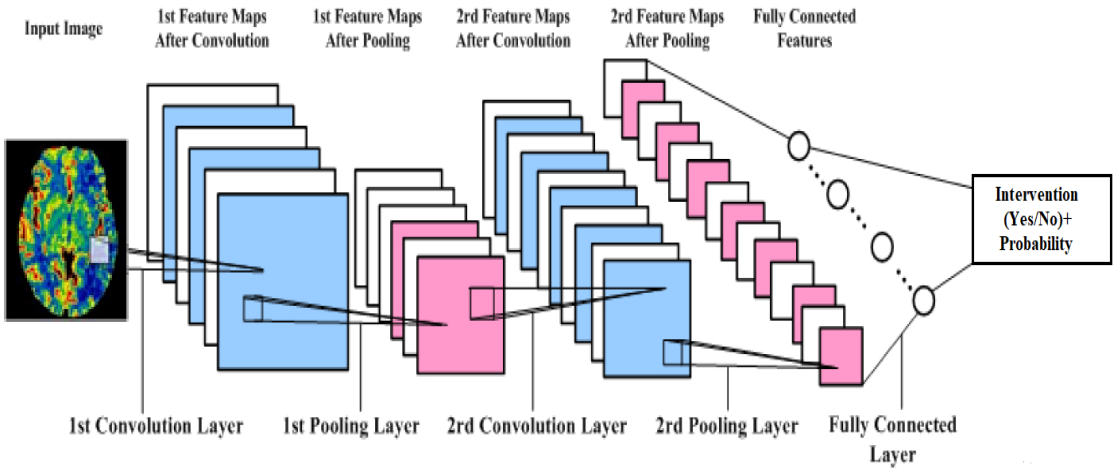

Fig. 4 An input image of an abnormal MRI brain is run through a Schematic illustration of a CNN. Feature extraction of the input image is performed via the Convolution, and pooling layers, before classificationby the fully connected layer[30].

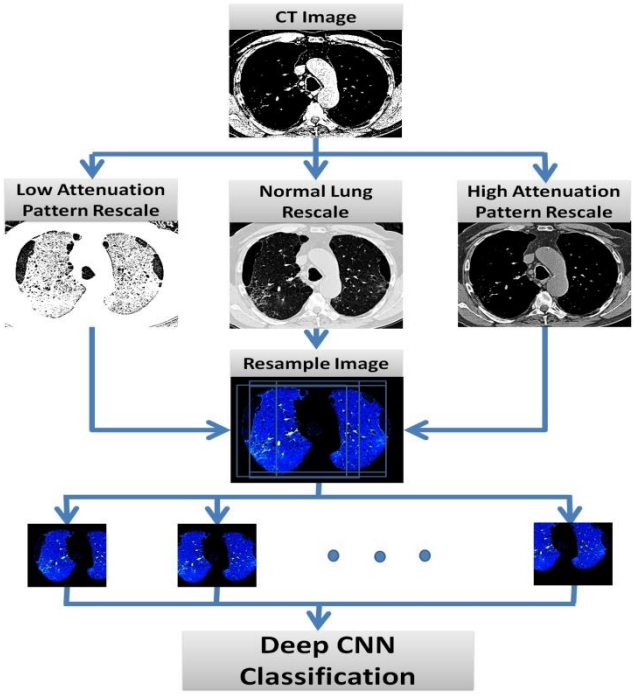

Fig. 5 Deep learning for classification of CT attenuation patterns for lung diseases, in particular, ILD (interstitial lung diseases)[31].

2. MEDICAL IMAGE ANALYSIS METHODS

The field of medical imaging has developed so rapidly that everyone who is involved in it needs to frequently update their knowledge in order to stay up to date with the developments. This section of the paper deals with the applications within medical image analysis. It is divided into the following categories:

A. ANNOTATION

Whenever an AI product is built, one has to go through a few stages like annotation, data preparation and model building. If we talk about annotation, it is nothing but a process of labelling the data on images that contains definite objects such as trees, animals, human, vehicles, objects to make it detectable by the machine. K. Grünberg et al. [32] described the annotation of medical images that were done in the VISCERAL project. He explained about different annotation software and its evaluation.

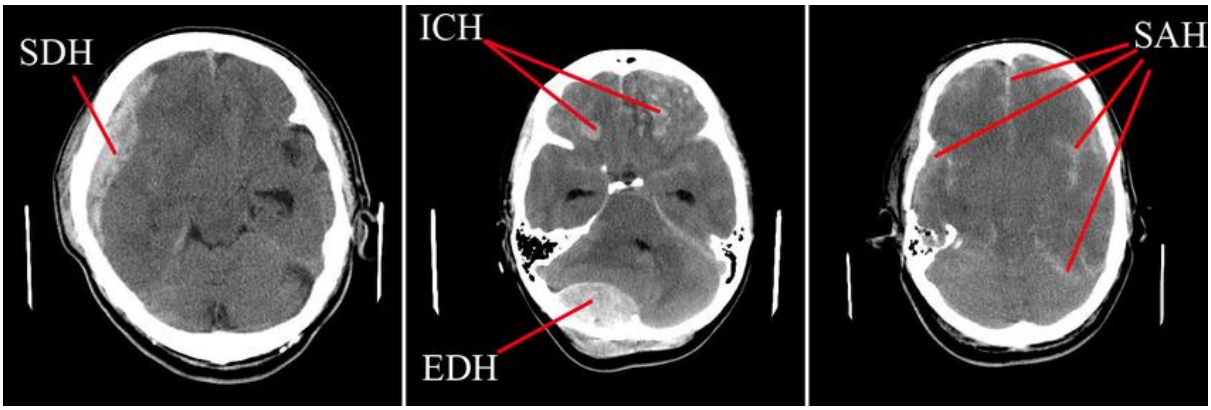

Fig. 6 Annotation results of brain CT images[33].

Input	Author	Title	Publishing year	Published in
14410 X-Ray datasets	Tizhoosh, H. R. [34]	Barcode annotations for medical image retrieval	2015	IEEE International Conference on Image Processing (ICIP)
IRMA radiographic image	Wojnar, A, Pinheiro, A. M. G. [35]	Annotation of medical images using the SURF descriptor.	2012	IEEE International Symposium on Biomedical Imaging (ISBI).
Chest radiograph	Tao, Y., Peng, Z., Krishnan, A., & Zhou, X. S. [36]	Robust Learning-Based Parsing and Annotation of Medical Radiographs.	2011	IEEE Transactions on Medical Imaging
DiaretDB1	Ujjwal,	An assistive	2015	IEEE 12th International

dataset	Chakravarty, A.,Sivaswamy, J. [37]	annotation system for retinal images.		Symposium on Biomedical Imaging

Table 2: Survey on annotation in medical images

B. CLASSIFICATION

Classification in medical is also known as CAD (computer-aided diagnosis) which helps in classifying with the help of radiograph images. In classification, the lesions are described in two or more classes. Classification is basically used in medicine to detect a particular disease's presence. Many examples have been given in several journals and books.

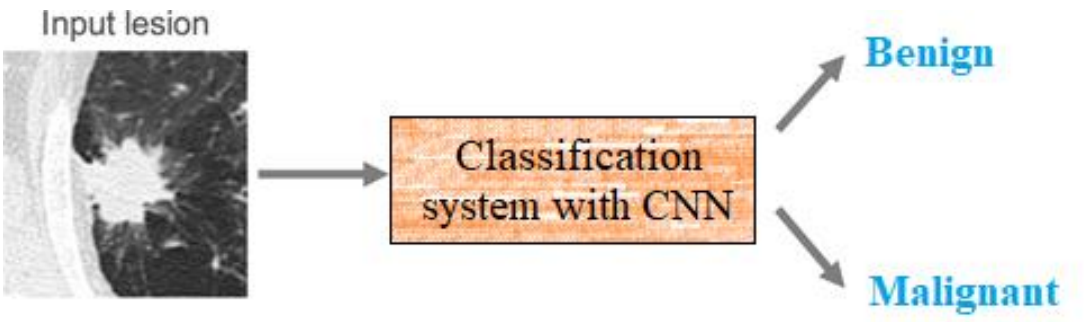

Fig. 7A schematic diagram of a classification system with CNN.

Table 3: Survey on the classification of medical images

C. SEGMENTATION

Segmentation is a method of splitting a digital image into a number of segments. The goal of segmentation is to simplify and change the depiction of an image into something that is more significant and easier to analyze. In this process, there is automatic or semi-automatic detection of boundaries within 2D or 3D image. In the case of medical images, it faces a lot of challenges because of the high variability in images. The result of the segmentation process is used in further diagnostic visions such as cell counting, automatic measurement of organs etc.

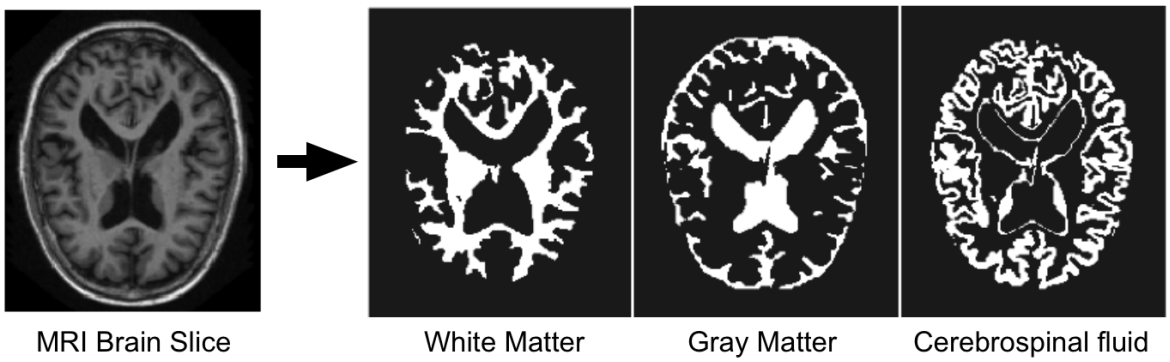

Fig. 8 Brain MRI image segmentation[44].

Table 4: Survey on medical image segmentation

Input	Author	Title	Publishing year	Published in
Heterogeneous brain MR image dataset	Ribbens, A., Hermans, J., [45]	Unsupervised Segmentation, Clustering, and Groupwise Registration of Heterogeneous Populations of Brain MR Images	2014	EEE Transactions on Medical Imaging
chest CT images	Huilin Gao, Lihua Dou, Wenjie Chen, Gang Xie [46]	The applications of image segmentation techniques in medical CT images	2011	Proceedings of the 30th Chinese Control Conference
Radionuclide ventriculography image dataset	Ben Fadhel, Y., Ktata, S., &Kraiem, T. [47]	Cardiac Scintigraphic Images Segmentation Techniques	2016	IEEE 2nd International Conference on Advanced Technologies for Signal and Image Processing (ATSIP)
42 lung CT scan data sets	Bianca Lassen, Jan-Martin Kuhnigk,OlaFriman [48]	Automatic segmentation of lung lobes in ct images based on fissures, vessels, and bronchi	2010	IEEE International Symposium on Biomedical Imaging: From Nano to Macro

D. REGRESSION

Since the field of medicine is becoming more complex, and with the increasing use of computer programs that aid the doctors in patient management, regression analysis is very

useful for giving the necessary formulas for such computer aids. Mostly non-parametric regression and multiple linear regressions are used in medical research. Regression is commonly used to the test hypothesis, to select variables from prediction models, or to generate prediction formulas. Thus it is necessary to learn more about regression techniques in medicines.

Table 5: Survey on regression analysis on medical images

Input	Author	Title	Publishing year	Published in
Spine images from 113clinical subjects including both disc and vertebral structures, and from both MRI and CT modal-Ities	Wang, Z., Zhen, X., Tay, K., Osman, S., Romano, W., & Li, S. [49]	Regression Segmentation for M3 Spinal Images	2015	IEEE Transactions on Medical Imaging, 34(8), 1640–1648
MR images of 145 subjects	Xue, W., Islam, A., Bhaduri, M., & Li, S. [50]	Direct Multitype Cardiac Indices Estimation via Joint Representation and Regression Learning	2017	IEEE Transactions on Medical Imaging, 36(10), 2057–2067
greyscale ultrasound images	WalidSharabati, Xi Bowe [51]	Robust Weighted Regression for Ultrasound Image Super-Resolution	2018	IEEE International Conference on Multimedia & Expo Workshops (ICMEW)

3. CONCLUSIONAND FUTURE SCOPE

A. CONCLUSION

In conclusion, through our survey, it is very clear that the evolution of medical imaging using deep learning has been critical to modern medicine. Without medical imaging, it would be impossible to know about the human body or issues surrounding it without any surgery. Medical image processing and deep learning tools can help radiologists in assessing whether a subject is developing a particular disease. We saw that diagnosis of certain things would not be possible without medical image analysis like CT, X-Ray, and MRI scans. Also, deep learning has given easy access to medical imaging technologies. We know that medical research would be extremely limited without being able to see the incredibly small building blocks that makeup everything and deep learning plays a great role in accomplishing this. Medical imaging will benefit immensely from deep learning methods, as deep learning has shown remarkable performance in medical regular imaging research compared to conventional machine learning techniques. In this paper, we touched a brief

description of CNN and transfer learning. We surveyed many journals and books regarding deep learning in medical image processing. Also, we saw many deep learning applications in medical imaging and concluded with the advantages of deep learning in the medical field.

B. FUTURE SCOPE

Deep learning in medical imaging is here to stay. We can find many future directions for deep learning in medical data analysis. It will be an essential field for diagnosis and prognosis in the era of precision medicine. As deep learning researchers and practitioners gain more experience, it will become easier to classify problems according to what solution approach is the most practical like best approached using deep learning techniques end-to-end, or best tackled by a combination of deep learning with other techniques. Future researchers in medical imaging can integrate deep learning experts in addition to clinical scientists in their teams and harness the full potential of deep learning.

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