CLASSIFCATION AND SEGMENTATION IN BRAIN TUMOR DETECTION

Shubh Aggarwal	Nandita Singhal	Anshul Srivastava	Sudhanshu Dwivedi	Nidhi Pandey
Department of CSE	*Department of CSE*	*Department of CSE*	*Department of CSE*	*Department of CSE*
SRMIST	SRMIST	SRMIST	SRMIST	SRMIST
NCR, India	NCR, India	NCR, India	NCR, India	NCR, India
sa3866@srmist.edu.in	ns1320@srmist.edu.in	as1348@srmist.edu.in	sd8250@srmist.edu.in	nidhip@srmist.edu.in

***Abstract*—** The presence of a brain tumor is a critical and hazardous issue that hinders the proper functioning of the human body. An unnatural and uncontrolled growth in brain cells is called a brain tumor. It is really necessary to detect brain tumors at an early stage otherwise it may become very difficult to find the complexity of brain tumors in time. Detecting brain tumors is critical for prolonging and saving patients' lives, and therefore, advanced techniques for detecting them are necessary in the medical field [1]. Magnetic Resonance Imaging (MRI) is a crucial tool for examining organs and structures inside the human body, using large magnetic and radio waves. Although several existing methods, such as Random Forest, Fuzzy C-Mean, Artificial Neural Network (ANN), and Wavelet transform, have been used to detect brain tumors, their accuracy is inadequate and execution time is longer. In this project, we utilize image classification and segmentation methods to analyze images more effectively, employing algorithms such as CNN (Convolution Neural Network), U-net Architecture, Max-pooling, Up-sampling, Down-sampling, and Data augmentation, which efficiently detect brain tumors in less execution time. Initially, we obtain data from various sources and then use CNN image classification to preprocess the images, which improves accuracy. Image classification is a process that simply involves the extraction of features from the image for observing some patterns and useful information in dataset [2]. After that extraction of essential features using the segmentation method is done, CNN U-net architecture, max-pooling, up- sampling, and data augmentation methods were applied which helps accurately to detect the location and shape of brain tumors. The experimental results show that the above used methods for brain tumor detection achieve better accuracy with lower execution time than other existing methods for the detection of brain tumors.

***Index Terms*—Brain tumor, Deep learning, Convolutional neural network, Magnetic resonance imaging, Feature extraction, U-net model.**

I. INTRODUCTION

A brain tumor is a life- threatening problem because it can affect the healthy part of the brain. The human body is made up of various types of cells, each with a distinct role. These cells grow and divide in a regulated manner, generating new cells that contribute to the body's overall health and function. However, when certain brain cells lose their ability to control their growth, they begin to proliferate uncontrollably [3]. This results in the formation of a tumor, which is a mass of tissue composed of excess cells that do not adhere to the body's usual growth patterns.

A brain tumor is an abnormal cluster of cells that develops within the brain. Brain Tumors are complex. The human brain is widely regarded as the most critical organ in the body, as it oversees and regulates various functions such as emotions, memory, senses, thought, speech, physical movement, and more. Any kind of mishap will change the functioning of the human body and will result in an irregular routine thus, the unchecked proliferation of cells in the form of

brain tumors can cause a reduction in brain tissue size, damage to neurons, and disruption of brain function. Three types of brain tumors that frequently occur in affected areas are meningioma, acoustic neuroma, and glioma, all of which have a high degree of malignancy. Glioma is another form of brain tumor that develops in the spinal cord and glial tissue. Brain tumors are broadly classified into two categories: Benign and Malignant. Benign tumors are these tumors that arise in brain cells and rarely spread to other organs due to which it is least destructive in nature and can be cured surgically [4]. It is non-cancerous and does not revert occurs. Malignant tumors are those tumors that arise in another part of the body and commonly spread to other organs which are highly destructive and dangerous in nature. It can be cured with radiation and chemotherapy with some special therapies. It is cancerous in nature and may revert once cured. In many developing nations, a shortage of skilled medical professionals and limited understanding of tumors can make it difficult and time-consuming to make decisions based on MRI scans and increased accuracy.

Brain tumor commonly of four types such as Metastatic, Meningioma, Glioblastoma, Astrocytoma. Metastatic tumors are the most frequently diagnosed brain tumors in adults. The occurrence of brain metastases takes place as cancerous cells migrate from their original location to the brain. Although any cancer cell has the potential to spread to the brain, lung, breast, kidney, and melanoma cancers are the most probable to result in brain metastases. As these metastatic brain tumors progress, they may exert pressure on brain tissue and interfere with the proper functioning of brain cells. Symptoms, such as headache, personality changes, seizures, and memory loss [5]. The treatment options for metastatic brain tumors may involve a range of approaches, such as surgery, chemotherapy, radiation therapy or combination of these methods. Although meningioma tumors develop in the meninges, the membranes that surround the skull and vertebral canal, they can have a significant impact on the brain's function. These tumors can cause a range of disabilities, including hearing and vision impairment, memory loss, and seizures. While meningioma tumors are not strictly speaking brain tumors, their growth in the surrounding membranes can still affect brain function. As it increases with age, tumors develop slowly, so symptoms could develop bit by bit over time. Glioblastoma is the ordinary primary brain tumor, which is also called as third most common of all brain tumors, which mean it generates in brain. Astrocytes are cells that provide support to nerve cells and they give rise to glioblastoma, which can affect people of any age but tends to occur more frequently in older adults and men. Symptoms of glioblastoma include recurring headaches, vomiting, nausea, seizures, and vision problems. Unfortunately, there is no definitive cure for glioblastoma, also known as glioma, but treatment options are available to slow down the growth of the cancer and alleviate symptoms. Tumors in astrocytes develop in the glial cells, which are star-shaped cells situated in the cerebrum of the brain. There are two types of grades in astrocytoma that is high grade and low grade. Low-grade astrocytoma grows slowly which is called (Grade I & II) and high-Grade astrocytoma comes with more aggressive which is called (Grade III & IV) [6].

The primary objective is to achieve improved accuracy in identifying the presence of a brain tumor in the brain by detecting its location, shape, and size. To collect the infected images from the data-source. Next, images processed to extract their features for tumor identification which comes under in image classification. Then, a supervised deep learning model such as CNN, which is commonly employed in image recognition and computer vision, is utilized to detect the tumor's presence. As Classification and Segmentation play a vital role in detecting brain tumors with better accuracy. Radiology is a complex field that requires a thorough understanding of medical and biomedical science to achieve precise tumor identification. As a result, the shortage of skilled radiologists necessitates the implementation of a tumor detection program. The (MRI) and biomedical image processing facilitates findings and precise localization of tumors. Image segmentation and classification approach was developed to detect tumor area and size using MRI images as input. This is a challenging task due to the wide range of tumor tissues found in different patients, and the similarity between normal tissues often complicates the process [7]. That is why it is most important to get proper knowledge of brain tumors for detecting brain tumors with better

accuracy. The process of feature extraction involves using small filters on the input patterns and selecting the most important features, which are then used to train the classification network. Next, the paper outlines the structure of the proposed method, which includes techniques such as max-pooling, up-sampling, and data augmentation. The training and performance of the network are then presented. Afterward, fine-tuning is applied to improve the input and enhance the accuracy of the model.

Then segmentation occurs which is the most important part of the detection and is also called the heart for detection [8]. After that, algorithms are applied that extracts the necessary features which show where the abnormality exists in the brain so that we can easily and accurately detect or find the location, shape, and size of the brain tumor which is the main goal of this project. The proposed algorithm (CNN encoder-decoder, U-net, pooling, sampling, data augmentation) is utilized for the classification and segmentation which gives the expected results.

II. LITERATURE SURVEY

Amjad Rehman Khan and others presented a research paper on Classification of brain tumors through deep learning and the use of synthetic augmentation in segmentation and k-mean clustering in the year 2020 and this paper work recommending methods mainly in 3 steps using MRI data model. Furthermore, the synthetic data augmentation concept is used for better classification accuracy One approach to enhance the available data for classifier training is to utilize synthetic data augmentation techniques. A fine CNN model can be used to classify brain tumors into their respective categories, i.e., malignant or benign. The CNN model typically involves a sequence of operations, including convolution, The overall accuracy before data augmentation is 90.03% and after synthetic augmentation is 94.06%. Effectiveness for the proposed method has been verified experimentally with improved overall accuracy, by incorporating various data augmentation techniques as mentioned in [9]. In a research paper by R. Meena Prakash and others published in 2019, they employed a Convolutional Network for finding of brain tumors in MR image. To improve segmentation accuracy, data augmentation was employed, and an optimal learning rate was selected to prevent overfitting. Although multi-grade tumor classification is not currently possible, future methods may broaden the scope of tumor classification for MRI brain images, allowing for better analysis and treatment planning. The proposed automated method for tumor detection in images initializes the CNN model with arguments learned from a vast image database [10]. In 2021, a research paper was presented by Shaveta Arora and Meghna Sharma on the classification of brain tumors from images using deep learning techniques. The aim of the research paper is to utilize theproposed approach, which involves associating data features with MRI images. Texture-based selection technique of the gray-level co-occurrence matrix is employed to select features. Pre-processing techniques, including feature selection, cleaning, standardization, and normalization are applied to the images. While deep learning models provide better accuracy in classification compared to basic machine learning techniques, the accuracy can be further improved by applying optimization algorithms and hyperparameter tuning. The paper presents the training and validation accuracy results and a comparative analysis of machine learning classification models such as Support Vector Machine (SVM) and Random Forest Classifier with deep learning models such as VGG16, Inception_V3, and ResNet are found. [11] Mahbubur Rahman and others presented their in 2021, a study was conducted on the detection of brain tumors in MRI images using a combination of super pixels. This paper proposes an improved approach for brain tumor detection that utilizes a template-based K-means algorithm along with super pixels and principal component analysis (PCA). The proposed method is capable of efficiently detecting brain tumors in a shorter amount of time. The approach begins by extracting important features using both super pixels and PCA which skillfully detects human brain tumors in much lesser execution time. At first, they extract essential features using both super pixels and PCA. Then, image enhancement is done which helps to improve accuracy and thus

provides public access to brain MRI images. We selected a dataset that includes 3929 brain MRI images, comprising 1373 tumor images and 2556 non-tumor images [13]. The tumor-type brain images are assigned a value of 1 in the dataset, while the no-tumor MRI images.

III. METHODOLOGY

A. Data preprocessing

The MRI image can be colorful or grayscale which is received from the dataset. First, we prepossess the MR images by filtering and sharpening them for getting better results. Next, the detection process involves segmentation, which is the critical step and commonly referred to as the detection's core. The necessary features are then extracted to identify the location of the abnormality in the brain. Subsequently, the processing is carried out to estimate the mean deviation, variance, and covariance of the images that help in the detection scheme [14]. Finally, the proposed models like CNN are utilized for the classification which gives the expected results. Next, the detection process involves segmentation, which is the critical step and commonly referred to as the detection's core. The necessary features are then extracted to identify the location of the abnormality in the brain. Subsequently, the processing is carried out to estimate the mean deviation, variance, and covariance.

B. Deep Learning

Deep learning is a subset of machine learning (ML) that uses artificial neural networks to model and solve complex problems. It is inspired by the structure and function of the human brain, where the neural network is composed of multiple layers of interconnected nodes or neurons that can learn from data. Deep learning has been used to achieve state-of-the-art performance on a wide range of tasks, such as image recognition, speech recognition, natural language processing, and game playing. It has also been applied to other fields, such as drug discovery, finance, and autonomous driving.

C. Classification

Image classification using Convolutional Neural Networks (CNNs) is a popular application of deep learning that involves training a neural network to classify images into one or more predefined categories. This task is achieved by training a CNN on a labeled dataset of images, where each image is assigned to one of the categories. To train a CNN for image classification, a large dataset of labeled images is typically used, such as the ImageNet dataset, which consists of over a million images belonging to 1,000 different categories [15]. The training process involves feeding the images into the network, adjusting the weights of the connections between neurons to minimize the difference between the predicted and true labels, and repeating this process until the network reaches a satisfactory level of accuracy.

D. Feature Extraction

Feature extraction is a technique used in machine learning to transform raw data into a set of features that are relevant for a specific task, such as classification or regression. In other words, feature extraction is the process of selecting and identifying important characteristics, patterns, or features from the input data, which can help to simplify the problem and improve the accuracy of the ML model [16].

E. Convolution neural network

A Convolutional Neural Network (CNN) is a type of deep neural network that is designed to process and analyze data with a grid-like structure, such as images, videos, and audio signals. It is inspired by the way the visual cortex of the human brain processes visual information, by learning and detecting features at multiple spatial scales. A CNN consists of multiple layers of interconnected nodes, including convolutional layers, pooling layers, and fully connected layers. The convolutional layers are the most important part of the CNN and perform feature extraction by applying a set of learnable filters to the input data, with each filter producing a feature map [17]. The pooling layers then down-sample the feature maps by summarizing the values in each local region, reducing the dimensionality and preserving the spatial structure. Finally, the fully connected layers combine the extracted features to produce a final output.

F. Segmentation

Image segmentation refers to the process of partitioning an image into multiple distinct and homogeneous regions based on certain predefined

criteria. In the case of brain tumor analysis, segmentation involves identifying and separating abnormal tissue from normal brain tissue. Here, the pooling method is used for image segmentation. Three types of pooling operations exist, including max-pooling, min-pooling, and average pooling [18]. Max-pooling is a type of pooling operation. The batch size is determined based on the filtered size, which is decided according to the image size. Here, we choose the average-pooling and max-pooling methods for our project because the utilization of the average-pooling technique results in an image with reduced sharpness, which could make it difficult to identify certain features.

G. U-net Model

U-Net is a convolutional neural network (CNN) primarily designed for fast and accurate segmentation of biomedical images. It heavily relies on convolutional layers and its architecture is adapted to work with smaller input images, resulting in more precise segmentations. On a state-of-the-art GPU, segmenting a 512x512 image takes less time than other methods. The architecture of U-Net is derived from the "fully convolutional network" proposed by Long, Shelhamer, and Darrell. The main concept involves compressing a typical contracting network with successive layers, where pooling operations are substituted with up-sampling operators to increase the resolution of the output. To standardize the data, the process of data augmentation involves rotating the image by 45 degrees clockwise and zooming it, thereby producing an equivalent quantity of training images. Trying different orientations of the same image. The image is converted into RGB. It has 256 representations, from 0 to 255 [19]. Then scaling follows which helps to get better input and increase accuracy. Then we will construct the final model using the u-net and CNN encoder-decoder models with their respective methods like max-pooling, average pooling, up-sampling, and a custom model using assembling and giving the hyper-parameters. Finally, we will run the output model.

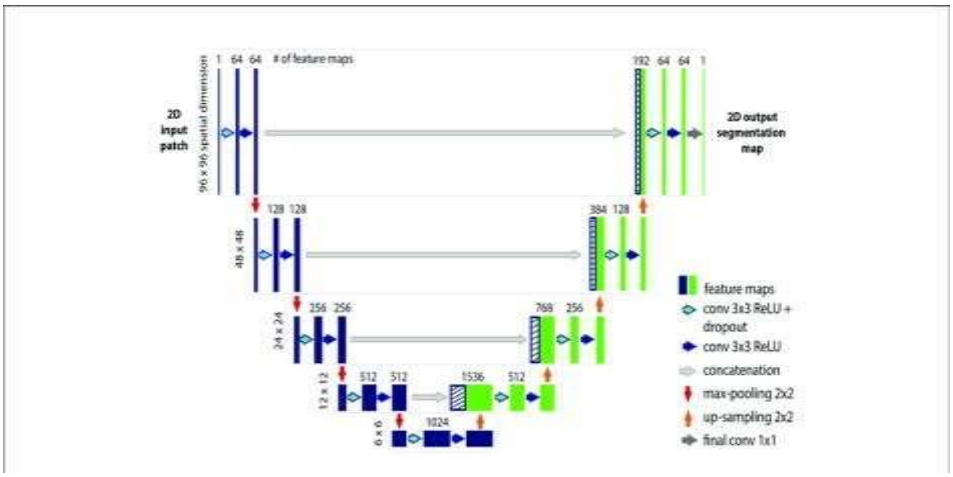

Fig. 1. U-NET Model [20]

IV. SIMULATION RESULTS AND DISCUSSIONS

The CNN U-net model managed to accurately categorize the images into tumor patient and normal patient tumors with precision of 99.15%. The CNN-based image classification algorithm enables automatic feature selection in images, contributing to higher accuracy additionally we employed different techniques further approach. There were a total of 3929, images in our dataset out of which 2556 images were non-tumor images and 1373 images were tumor images. According to the results of the CNN on the initial images, in order to improve the network performance a combination of Clustering algorithm for feature extraction and CNN is used.

Fig. 2. Tumour classified only in specific area

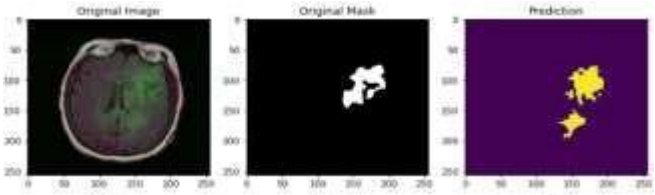

Fig. 3. Model classifying tumour in every possible part.

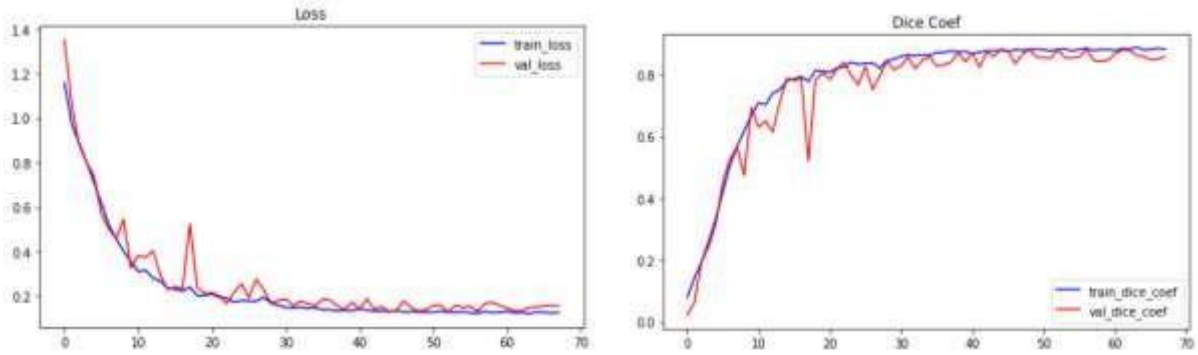

Fig. 4. Model Performance

V. CONCLUSION

Our study proposes a novel method that combines image classification algorithms with the CNN and image segmentation using the CNN-U-net architecture. The CNN-based image classification algorithm enables automatic feature selection in images, contributing to higher accuracy. Additionally, we employed different techniques further approach. There were a total of 3929 images in our dataset out of which 2556 images were non-tumor images and 1373 images were tumor images. First of all image classification was performed for extracting useful features from the image. After that model was trained and it was run up to 20 epochs. At the very first epoch, the loss was about 0.4875% and the model accuracy was about 0.7424% when the model was trained more it was seen that the loss was decreasing and the accuracy of the model was increasing and it provide the highest accuracy of 0.9915%.

Once all the important features have been extracted from the image using image classification, image segmentation was performed. For image segmentation U-net architecture of CNN was used, The U-Net (CNN) that has been display to quickly and accurately segment images, particularly in the area of biomedical segmentation. It follows a U-shaped architecture that consists of four encoder blocks on the left-hand side and four decoder blocks on the right-hand side. Encoder receives input image and then extracts useful features from that image using multiple convolutional layers and then down-samples it using max pooling. The decoder then up-samples the features using the transpose convolutional layer and concatenate them, as a result of which we get a segmentation mask as the output from this network. By the use of both techniques that is image classification and image segmentation, we can detect the location and size of the tumor in the brain, by creating a mask over the tumor region which helps us to identify whether a person has a brain tumor or not. This method helps a doctor to identify the tumor.

In future, there are some other advanced classification and segmentation algorithms that can be used to achieve an accuracy upto 100%. In deep learning algorithms a lot data is required for model training which is a drawback, to overcome this, advanced algorithms should be used that can give better accuracy in limited training data.

REFERENCES

[1] Akkus Z, Kostandy P, Philbrick KA, Erickson BJ (2019) "*Robust brain extraction tool for CT head images"*. Neurocomputing 392:189–195.

[2] Halimeh Siar, Mohammad Teshnehlab, "*Diagnosing and Classification Tumors and MS Simultaneous of Magnetic Resonance Images Using Convolution Neural Network"*, 7th Iranian Joint Congress on Fuzzy and Intelligent Systems (CFIS), 2019.

[3] Chilamkurthy S, Ghosh R, Tanamala S, Biviji M, Campeau NG, Venugopal VK, Mahajan V, Rao P, Warier P (2018) "*Deep learning algorithms for detection of critical findings in head ct scans: a retrospective study".* Lancet 392(10162):2388–2396.

[4] P. Afshar, K. N. Plataniotis and A. Mohammadi, *"Capsule networks for brain tumor classification based on MRI images and course tumor boundaries*" in arXiv:1811.00597, 2018

[5] Website, Cancer.Net, "*Brain Tumor: Symptoms and signs" cancer.net* access available on url https://www.cancer.net/cancer-types/brain-tumor/symptoms-and-signs

[6] Ramzan, F., Khan, M. U. G., Rehmat, A., Iqbal, S., Saba, T., Rehman, A., & Mehmood, Z. (2020). "*A deep learning approach for automated diagnosis and multi-class classification of Alzheimer's disease stages using resting-state fMRI and residual neural network"s*. Journal of Medical Systems, 44(2), 37.

[7] Ramzan, F., Khan, M. U. G., Iqbal, S., Saba, T., & Rehman, A. (2020). "*Volumetric segmentation of brain regions from MRI scans using 3D convolutional neural networks"*. IEEE Access, 8, 103697–103709

[8] Rehman, A., Khan, M. A., Mehmood, Z., Saba, T., Sardaraz, M., & Rashid, M. (2020). "*Microscopic melanoma detection and classification: A framework of pixel-based fusion and multilevel features reduction"*. Microscopy Research and Technique, 83(4), 410–423. https://doi.org/ 10.1002/jemt.23429.

[9] Ronneberger, O., Fischer, P., & Brox, T. (2015) "*U-net: convolutional networks for biomedical image segmentation"*. Medical Image Computing and Computer-Assisted Intervention—MICCAI 2015. Lecture Notes in Computer Science. Medical Image Computing and Computer-Assisted Intervention–MICCAI 2015.

[10] Zoph, B., Vasudevan, V., Shlens, J., & Le, Q. V. (2018) "*Learning transferable architectures for scalable image recognition".* Proceedings of the IEEE

Computer Society Conference on Computer Vision and Pattern Recognition. doi: https://doi.org/10.1109/CVPR.2018.00907

[11] Javed, R., Rahim, M. S. M., & Saba, T. (2019). "*An improved framework by mapping salient features for skin lesion detection and classification using the optimized hybrid features".* International Journal of Advanced Trends in Computer Science and Engineering, 8(1), 95–101.

[12] Khan, M. A., Javed, M. Y., Sharif, M., Saba, T., & Rehman, A. (2019). "*Multi-model deep neural network-based features extraction and optimal selection approach for skin lesion classification"*. 2019 international conference on computer and information sciences (ICCIS) (pp. 1–7). IEEE.

[13] Website, Datasets, "*Brain Mri-segmentation*", access available on url www.Kaggle.com, https://www.kaggle.com/datasets/mateuszbuda/lgg-mri-segmentation.

[14] Iqbal, S., Khan, M.U.G., Saba, T. Mehmood, Z. Javaid, N., Rehman,A., Abbasi, R. (2019*) "Deep learning model integrating features and novel classifiers fusion for brain tumor segmentation",* Microscopy Research and Technique, 82(8); 1302-1315, https://doi.org/10.1002/jemt.23281

[15] Ejaz, K., Rahim, M. S. M., Bajwa, U. I., Rana, N., & Rehman, A. (2019). "*An unsupervised learning with feature approach for brain tumor segmentation using magnetic resonance imaging".* Proceedings of the 2019 9th Interna□tional Conference on Bioscience, Biochemistry and Bioinformatics (pp. 1–7).

[16] Khan, M. A., Ashraf, I., Alhaisoni, M., Damaševicˇius, R., Scherer, R.,Rehman, A., & Bukhari, S. A. C. (2020). "*Multimodal brain tumor classification using deep learning and robust feature selection: A machine learning application for radiologists*". Diagnostics, 10, 565.

[17] Khan, M. A., Sharif, M., Akram, T., Raza, M., Saba, T., & Rehman, A. (2020). "*Hand-crafted and deep convolutional neural network features fusion and selection strategy: An application to intelligent human action recognition"*. Applied Soft Computing, 87, 105986.

[18] Ramzan, F., Khan, M. U. G., Iqbal, S., Saba, T., & Rehman, A. (2020). "*Volumetric segmentation of brain regions from MRI scans using 3D convolutional neural networks"*. IEEE Access, 8, 103697–10370

[19] Mashood Nasir, I., Attique Khan, M., Alhaisoni, M., Saba, T., Rehman, A., & Iqbal, T. (2020). "*A hybrid deep learning architecture for the classification of superhero fashion products: An application for medical-tech classification"*. Computer Modeling in Engineering & Sciences, 124(3),1017–1033.

[20] website, ResearchGate, "*A U-net Deep Learning Framework*", researchgate.net, accessavailable on url https://www.researchgate.net/figure/Illustration-of-the-U-net-architecture-The-figure-illustrates-the-U-net-architecture_fig2_331406702.