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Deep Neuro-Fuzzy Logic Technique for Brain Meningiomasa Prediction

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***Abstract*— Simulation approaches based on Deep Learning (DL) techniques have several computational stages that present information at various levels of complexity. DL has exploded in popularity over the last decade, mainly in medical image analysis, information retrieval, and computational biology. As a result, DL has effectively transformed and enhanced detection, forecast, and treatment in various medical sectors, including pathological, brain tumors, lung disease, the stomach, heart, and eye. This study introduces a unique classification fuzzy logic-based and deep neuro (DNFLT) method compared with an SVM classifier for accurate segmentation of various brain tumors. According to the experimental observations, the suggested brain tumor classification approach is more resilient than other conventional methodologies of performance indicators, sensitivities, specificity, and correctness.**

Keywords—Fuzzy System, Deep Learning, Medical Imaging, Tumor Analysis, Classification.

I. INTRODUCTION

Due to the intricacy of tumor areas and the sensitivity ratio, robust separation and forecasting of brain tumors using biomedical image analysis strategies are challenging in terms of exactness and delay rate. However, because of the value of individual life and the existence of sickness, the high level of performance estimates is exceptionally high. Furthermore, many studies offered a variety of approaches to recognizing brain cancers in their early stages and the categorization of tumors in diverse parts of the brain. Still, it is incredibly challenging and time-consuming to detect such tumors [1]. At present, novel deep learning-based algorithms are being developed to determine the phases of brain tumors, advise ontological sufferers about the intricacy, and notify patients depending on the sensitivity.

Using Bio-Medical image analysis processes to describe these image analysis tasks[2]. However, because of the employment of traditional methodologies such as SVM, Fuzzy Logic, and other classification methods, the major predictions of such kinds of cancer detection over bio-medical imaging are producing incomplete accuracy levels, and the findings are regarded as uncertain. Traditional machine learning algorithms create responses based on train and test methods. The testing phase feed is the current scenario source image obtained from the MRI of the ontological patient[3]. The training phase intake is some form of pictures, which examine under numerous conditions for different processes. The final classification model relies on the methodology employed in the technique, and thus the resulting accuracy varies depending on the field observations during the platform's training stage. ML system refers to the training phase with features relationship testing.

A brain tumor is a collection of abnormal cells that grow inside or outside the mind. Due to the inherent structure of photographs, it is a demanding and challenging task. The brain has a complex system, and precise division is critical for recognizing tumors, edema, and necrosis regions and providing correct medication. Many types of exams, such as computed tomography (CT), positron emission tomography (PET), and magnetic resonance imaging (MRI), are necessary to detect and treat this cancerous condition as soon as feasible. Each imaging method has its image processing system, which provides valuable data; the first and most efficient and accurate is MRI [4]. Oncologists, radiologists, and other health researchers spend considerable effort segmenting health pictures to provide successful therapies for practical health diagnoses. With numerous disparities, MRI scanners can provide various images that emphasize distinct essential characteristics of interior skeletal anatomy in the same body segment [5].

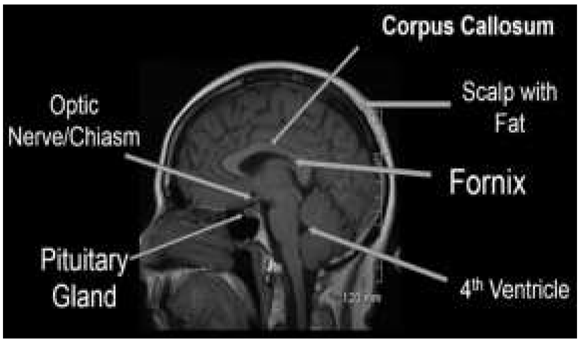

Fig. 1. Human Brain MRI

Because the living body can make up millions of cells, we know that cells proliferate, evolve, and split to generate new tissues and organs. Environmental factors may cause cells to expand abnormally, culminating in tumor growth. Tumors are divided into two types: malignant and benign tumors. Benign brain tumors are cancer cells that don't propagate to other cells, making them less hazardous. On the other hand, malignant tumors are masses of cancerous cells that spread to other cells and organs. A tumor is a collection of cells that create a tissue that lacks regular tissues supervision and grows uncontrollably. According to reports from most advanced nations, over 300 people have died due to having a brain tumor in the last decade, and the number is sure to rise year by year [6].

The remainder of this paper highlights Similar Research in Section 2, the proposed framework techniques in-depth information with appropriate algorithm stream in Section 3, the outcomes with decisions part of the research work in Section 4, and the conclusion drawn in Section 5.

II. RELATED WORKS

An automatic approach utilizes to recognize and categorize Medical images [7]. This process relies on the Super Pixel (SP) Technique and how each SP is classified. The ERT classification is matched to the SVM algorithm to categorize each SP into tumor and healthy. The 19 MRI FLAIR pictures and the BRATS 2012 information can use in this technique. The findings suggest that this technique, which employs the ERT classification, performs well. In [8], a CNN containing three tiny kernels is used to detect a tumor using an automated classifier model. At BRATS Challenging task 2013, the technique was ranked first with the full, base, and boosting areas in dice resemblance and correlation measures (0.88, 0.83, 0.77).

Alexnet modeling CNN is used in [9] to simultaneously diagnose MS and healthy tumors. CNN successfully classified 98.67 percent of the pictures into three main categories. In [10] suggest a Fuzzy multistage C-Means (FCM) architecture for segmenting tumor cells from MRI scan. An efficient and productive strategy that uses CNNs for feature extraction and classification describes in [11]. Image-Net was processed to separate characteristics in the suggested technique. The classification performance was 97.5 percent, and the recognition accuracy was 84 percent. In paper [12] explores the Multistage MRI pictures in tumor categorization. It compares with DL structures and essential artificial neural outcomes. The findings show that when reaching neurons, the system performance depending on the specificity and sensitivity of CNN, increased by 18%.

A DL-based supervised algorithm is implemented in [13] to identify synthetic aperture radar (SAR) picture alterations. This innovation research a database with the right amount of data and variety for training the DBN with image pixels and pictures generated by implementing morphological operators. This detection rate shows that it can use DL-based techniques to solve saliency detection challenges. The article presents a fully autonomous brain cancer categorization structure based on DNN [14]. They created the suggested networks with low-grade and high-grade glioma illness pictures in mind. A new DNFLT architecture developed in this work which is the result of a core network, is used as an additional information source for the following Network in the suggested cascade design.

The categorization in this article [15] demonstrates with the help of a CNN with Probabilistic-NN. Because the picture collection BRATS13 is employed, we discovered an architecture that relies on CNN of both 7X7 pixel and 3X3 pixel in a covering way and creates a fell architecture, so the method is prepared to divide a tumor exactly in a powerful technique. In addition, a PNN is used to detect tumors and analyze the effects of the activities. The proposed method provisions, including neighborhood and overall features[16], include exceptional CNN and PNN models that are not that far off from the standard concepts used in image analysis and framework visual acuity processes. The conceptual model agreements with neighborhood and common characteristics.

III. SYSTEM MODEL

The broad description of the suggested method and procedure is explained and elaborated in Fig.2. The recommended approach splits into three stages: pre-processing, character recognition, and categorization, contributing to an intense separation stage that affects forecasting accuracy. First, the predictive control model's performance ratio is improved using standard fuzzy logic techniques. Then, we design and develop the cognitive brain tumor diagnosis system using a deep neural network model that will help the healthcare industry in a novel way. Finally, we trained the algorithm and tested it using the BRATS collection, an internationally accepted data source for training systems to detect tumor cells and deliver the best accuracy when combined with correct forecasting methodologies.

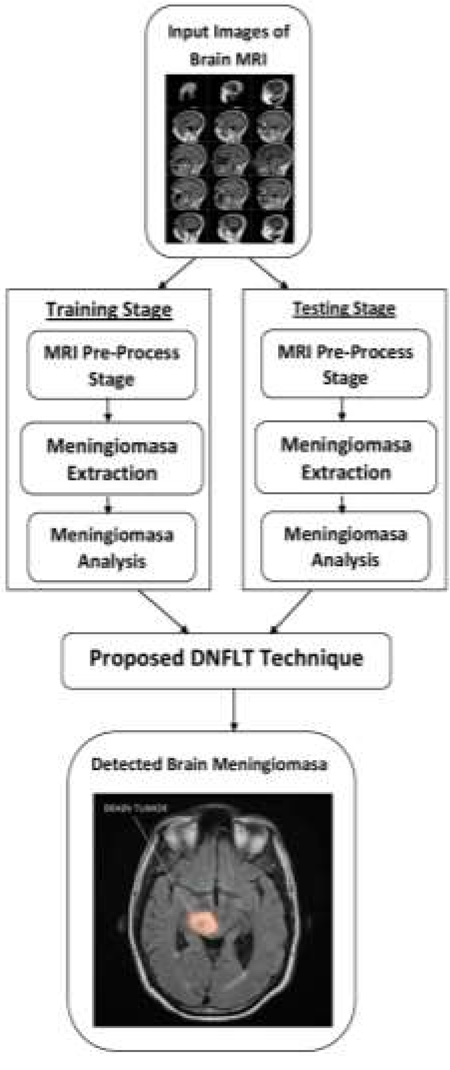

Fig. 2. The Proposed DNFLT System Model

IV. PROPOSED TECHNIQUE (DNFLT)

DNFLT is a type of machine learning that has become increasingly effective in recent years. In other words, training is referred to as be deep-neuro structure. It is those old neuron networks that have evolved into systems and processes. These models are data-driven, and the feature selection technique creates automatically without our intervention, which gives them their precision and good performance in different domains. It is, in reality, a combination of nerve-based approaches that discovers feature extraction to our raw data using deep learning with fuzzy logic.

A. MRI Pre-Processing Stage

Image analysis, the postulated pre-processing structure of brain MR images, is vital in the medical field. This phase resizes the raw MRI brain picture as per the suggested DNFLT algorithm's protocol, including grayscale image translation logic. Next, convert the original image to a monochromatic representation with 512 X 512 pixels for more analysis. The changed result in different levels and the initial threshold levels were kept separate for subsequent investigation. Finally, the picture is converted into binary code using the im2gray linear function over the image analysis tool. Algorithm-1 perfectly demonstrates the pre-processing strategy with suitable pseudocode.

TABLE I. ALGORITHM FOR PRE-PROCESSING STAGE

Algorithm : MRI Pre-Processing Stage

Start

Step 1: Take the raw input image out from directories or the MRI scanning directly.

I = imread([num2str(pCoefff) '.jpg']);

Step 2: Create a for loop to create some specimens and call the testing characteristic collection to produce a loop from the picture features' beginning to finish.

create an integer value p

create picture coefficients are represented by the variable pCoeff.

Loop for pCoefff = p to Image.features cd 'Test'

Step 3: Use the recovered bits to adjust the input image.

Step 4: Transform the shrunk picture (Step-3) into grey level form and determine the amount of pixels after converting (p = piresize(i,[512,512]);

level = grey-level(In); in = rgb2gray(p);

Step 5: Do picture filtering with bitwise state translation of a scaled grey MRI image.

Step 6: Picture has been appropriately pre-processed with all characteristics (Pmask = double(pigray(p,T));

Pmask should be returned;

Finish

B. Meningiomasa Extraction and Analysis

A clustering approach is centralized grouping. This approach features a duplication mechanism that iteratively seeks to get locations as centroids, the identical average spots corresponding to every region, for a fixed clustering. First, allocate every test data set to a group with minimal separation between the information and the cluster's centroid. Choose the centroids randomly in the simple version of this procedure. Then, according to the level of resemblance, the points are assigned to the cluster centers and form new clusters. Use a first clustering algorithm to retrieve features from the data in this research. Finally, obtain the picture using the proposed similarity measure to the image depicted in Figure 1.

Multiple classifiers were analyzed using evaluation metrics to categorize split segments into cancer on the test datasets:

1. Perform the binary classifier problems using a Deep neuro and a quadratic discretization. Following that, train KNN with five neighboring components to test classification results.
2. Use a Decision Tree (DT) to generate interrelation characteristics depending on raw data on test data. DT constructs a tree-like structure and labels its branches and boundaries with features and tags. Random forest (RF) is a combined method that uses 200 DT classifications.
3. The Naive Bayes (NB) classifier, belonging to the statistical family, obtains the advantages of special categories of inter-features correlation.

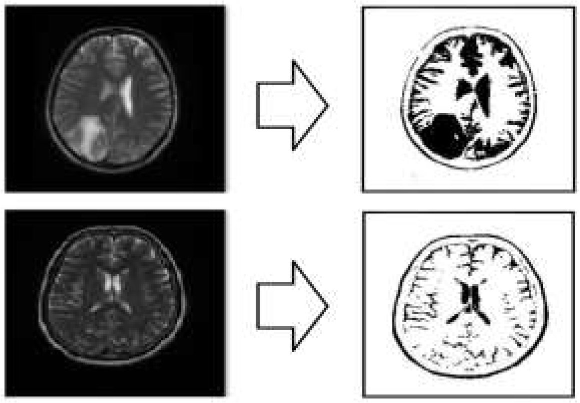

Fig. 3. Image Extraction and Analysis

C. DNFLT Technique

The suggested DNFLT technique estimates the tumor detection portion by anticipating cancer's early phases and therefore saving an individual's life. DNFLT technique combines fuzzification with dynamic feature extraction techniques to forecast cancer cells accurately. Also, the recommended DL technique uses the BRATS database to train the process and identify the accuracy rate. This technique saved many people's lives. The resulting accuracy is relatively high, as indicated in the findings and discussion part for Studying and analyzing brain cancer cells with correct testing situations. When using the DNFLT approach, Previously, no feature extraction techniques were used when submitting the pictures to the CNN. The raw images are initially 212x212 pixels in size. The Alexnet design, which consists of 5 Neural networks and three sub-sampling levels, Normalization layers, Connected layer, FC layers, and finally, the classifying level [21], was used to recognize and analyze the pictures. There are 4000 neurons in the ultimately linked groups. This layer contains classes: brain cancer patients and healthy patients.

V. RESULTS AND DISCUSSIONS

The suggested model develops an automated tumor identification and classification system to categorize the raw MR image into healthy, benign, and cancerous. The DNFLT technique uses to extract characteristics, which are then used to classify the data. In addition, a Deep Neuro detection model is used to classify images. Each step in the suggested paradigm performs using distinct techniques. The idea is pre-processed with adaptive filters, producing better outcomes than the median filter.

TABLE II. RESULTS ON MENINGIOMASA DATASET

MRI Brain Image	Sen (%)	Spe (%)	Acc (%)
1	97.41	98.23	98.21
2	97.34	98.47	98.36
3	97.62	98.65	98.44
4	97.53	98.79	98.59
5	97.69	98.53	98.68
6	97.47	98.16	99.75
7	97.38	98.45	99.83
8	97.62	98.27	99.92
9	97.57	98.91	99.11
10	97.38	98.47	99.25
Average	97.50	98.49	99.01

The medical database includes 60 Meningiomasa brain 3D MRI pictures and 110 healthy brain 3D MRI images in tests mode. But, Table 3 shows the simulation findings of the first 10 Meningiomasa brains 3D MRI scans for the reader's convenience. On Meningiomasa brain MRI images, the suggested technique obtains 97.5 percent Sen, 98.5 percent Spe, and 99.0 percent Acc.

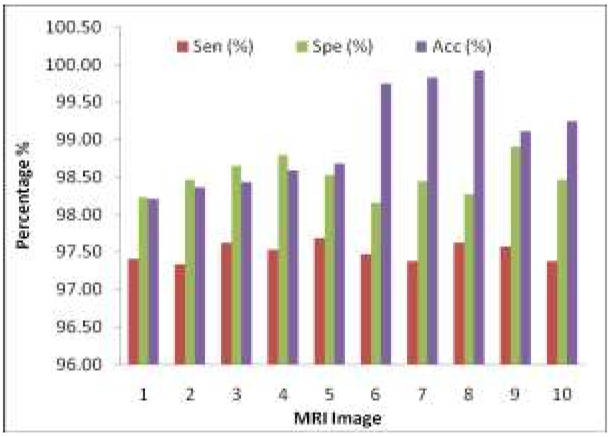

Fig. 4. Sensitivity(Sen), Specificity(Spe) and Accuracy(Acc) percentage results on MRI Raw Image.

Fig. 4. Depicts the results in chart for first 10 Meningiomasa brains 3D MRI scans from 60 sample images.

TABLE III. RESULTS ON MENINGIOMASA DATASET

Techniques	Total Samples	Acc	Sen	Spe
DNFLT	60	99.3%	97.33%	98.6%
SVM	60	91.90%	89.23%	79.5%

The suggested model achieves 99.30 percent accuracy, 97.33 percent specificity, 98.60 percent sensitivity, and a precision of 94.44 percent, as shown in Tab. 2. Based on these findings, the proposed method outperforms traditional machine learning approaches such as SVM, which correctly classifies images into three classifications (Good, Mild, and Cancerous) with 91.90 percent accuracy.

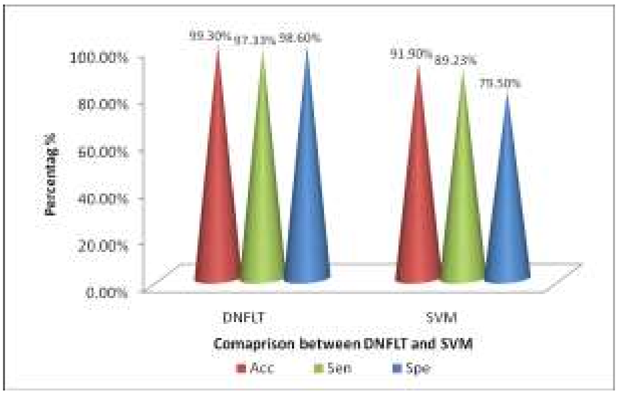

Fig. 5. Comaprision chart bewteen DNFLT and SVM.

The suggested results are compared to simulation studies from old methodologies over both datasets in this paper. Even though the recommended and traditional approaches will use the same database, conventional treatments do not understand the sequence of the pictures, the amount of slicing, or even which subset of the dataset. As a result, the techniques employed in traditional approaches are simulated on the same set of brain MR images used in the suggested method reported in this article. Furthermore, within the same sequence of pictures and the same quantity of segments in each sample, the numerical simulations of conventional techniques are contrasted with the modeling performance of the suggested approach. The simulation outcomes vary depending on the image database because of the pixel brightness and image capture procedures.

VI. CONCLUSIONS AND FUTURE ENAHNACEMENT

This work successfully analyzes a DNFLT-based brain cancer identification and forecasting technique with empirical findings. This study uses two different supported methods, Fuzzy Logic and Deep Neural Learning, combining those characteristics in a novel way to formulate a new machine learning method for extracting features that enhance forecast accuracy over the existing technique. The DNFLT technique begins by examining the MRI in steps of preprocessing, feature extraction, and analysis to manipulate the brain tumor. Then, with the support of the BRATS database, the learning methodology assumes the consecutive probabilistic ratio, and the testing phase confirms the predictive performance through graphical results throughout the following section. DNFLT's method demonstrates the categorization and predictive logic in an accurate and concise plan in the end. Further, the project can be improved or altered by enhancing the suggested DNFLT Algorithm's accuracy in aspects by employing other optimization methods such as Linear Square Optimizing to achieve good exactness and by applying such optimizing reasoning and logic to optimize the processing time.

REFERENCES

[1] Díaz-Pernas, F.J.; Martínez-Zarzuela, M.; Antón-Rodríguez, M.; González-Ortega, D. "A Deep Learning Approach for Brain Tumor Classification and Segmentation Using a Multiscale Convolutional Neural Network," Healthcare, vol. 9, no. 153, 2021. https://doi.org/10.3390/ healthcare9020153

[2] G. Ramkumar, R. Thandaiah Prabu, N. Phalguni Singh et al., "Experimental analysis of brain tumor detection system using Machine learning approach," Materials Today: Proceedings, 2021. https://doi.org/10.1016/j.matpr.2021.01.246

[3] D. Dhinakaran, D. A. Kumar, S. Dinesh, D. Selvaraj and K. Srikanth, "Recommendation System for Research Studies Based on GCR," 2022 International Mobile and Embedded Technology Conference (MECON), Noida, India, 2022, pp. 61-65, doi: 10.1109/MECON53876.2022.9751920.

[4] Balasubramaniam, Vivekanadam. "Artificial Intelligence Algorithm with SVM Classification using Dermascopic Images for Melanoma Diagnosis." Journal of Artificial Intelligence and Capsule Networks 3, no. 1 (2021): 34-42.

[5] Himaja Byale, Dr Lingaraju G M and Shekar Sivasubramanian, "Automatic Segmentation and Classification of Brain Tumor using Machine Learning Techniques," International Journal of Applied Engineering Research, vol. 13, No. 14, pp. 11686-11692, 2018.

[6] Bashar, Abul. "Survey on evolving deep learning neural network architectures." Journal of Artificial Intelligence 1, no. 02 (2019): 73-82.

[7] S. Arun and K. Sudharson. "DEFECT: discover and eradicate fool around node in emergency network using combinatorial techniques." Journal of Ambient Intelligence and Humanized Computing, 1-12, 2020. doi: https://doi.org/10.1007/s12652-020-02606-7.

[8] Javaria Amin, Muhammad Sharif, Mudassar Raza, Tanzila Saba, Muhammad Almas Anjum, "Brain tumor detection using statistical and machine learning method," Computer Methods and Programs in Biomedicine, vol. 177, pp. 69-79, 2019, https://doi.org/10.1016/j.cmpb.2019.05.015.

[9] Usman, K., Rajpoot, K. Brain tumor classification from multi-modality MRI using wavelets and machine learning. Pattern Anal Applic 20, 871–881 (2017). https://doi.org/10.1007/s10044-017-0597-8

[10] D. Dhinakaran and P. M. Joe Prathap, "Preserving data confidentiality in association rule mining using data share allocator algorithm," Intelligent Automation & Soft Computing, vol. 33, no.3, pp. 1877–1892, 2022. DOI:10.32604/iasc.2022.024509.

[11] K.Sudharson, A. M. Ali and N.Partheeban, "NUITECH – Natural user interface technique foremulating computer hardware", International Journal of Pharmacy & Technology, vol. 8, no. 4, pp. 23598-23606, 2016.

[12] Stijn Bonte, Ingeborg Goethals, Roel Van Holen, "Machine learning based brain tumour segmentation on limited data using local texture and abnormality," Computers in Biology and Medicine, vol. 98, pp. 39-47, 2018, https://doi.org/10.1016/j.compbiomed.2018.05.005.

[13] Fatih Özyurt, Eser Sert, Derya Avcı, "An expert system for brain tumor detection: Fuzzy C-means with super resolution and convolutional neural network with extreme learning machine," Medical Hypotheses, vol. 134, 2020,109433, https://doi.org/10.1016/j.mehy.2019.109433.

[14] Jiang, Yizhang; Zhao, Kaifa; Xia, Kaijian; Xue, Jing; Zhou, Leyuan; Ding, Yang; Qian, Pengjiang (2019). A Novel Distributed Multitask Fuzzy Clustering Algorithm for Automatic MR Brain Image Segmentation. Journal of Medical Systems, 43(5), 118–. doi:10.1007/s10916-019-1245-1

[15] D. Dhinakaran, P.M. Joe Prathap, D. Selvaraj, D. Arul Kumar and B. Murugeshwari, "Mining Privacy-Preserving Association Rules based on Parallel Processing in Cloud Computing," International Journal of Engineering Trends and Technology, vol. 70, no. 3, pp. 284-294, 2022. https://doi.org/10.14445/22315381/IJETT-V70I3P232.

[16] K. Sudharson and V. Parthipan, " A Survey on ATTACK – Anti terrorism technique for adhoc using clustering and knowledge extraction," Advances in Computer Science and Information Technology. Computer Science and Engineering. CCSIT 2012. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, Springer, Berlin, Heidelberg, pp 508-514, vol 85, 2012.

[17] S. Gupta and M. Gupta, "Deep Learning for Brain Tumor Segmentation using Magnetic Resonance Images," 2021 IEEE Conference on Computational Intelligence in Bioinformatics and Computational Biology (CIBCB), 2021, pp. 1-6, doi: 10.1109/CIBCB49929.2021.9562890.

[18] Chen, Joy Iong Zong, and S. Smys. "Social Multimedia Security and Suspicious Activity Detection in SDN using Hybrid Deep Learning Technique." Journal of Information Technology 2, no. 02 (2020): 108-115..

[19] Manoharan, Samuel. "Supervised Learning for Microclimatic parameter Estimation in a Greenhouse environment for productive Agronomics." Journal of Artificial Intelligence 2, no. 03 (2020): 170-176S.

[20] A. Kadir Al-Nahiun, F. Mahbub, R. Islam, S. B. Akash, R. R. Hasan and M. A. Rahman, "Performance Analysis of Microstrip Patch Antenna for the Diagnosis of Brain Cancer & Tumor using the Fifth-Generation Frequency Band," *2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS)*, 2021, pp. 1-6, doi: 10.1109/IEMTRONICS52119.2021.9422503.

[21] K. Sudharson and V. Parthipan, "SOPE: Self-organized protocol for evaluating trust in MANET using Eigen Trust Algorithm," 2011 3rd International Conference on Electronics Computer Technology, Kanyakumari, India, pp. 155-159, 2011.

[22] M. Rizwan, A. Shabbir, A. R. Javed, M. Shabbir, T. Baker and D. Al-Jumeily Obe, "Brain Tumor and Glioma Grade Classification Using Gaussian Convolutional Neural Network," in *IEEE Access*, vol. 10, pp. 29731-29740, 2022, doi: 10.1109/ACCESS.2022.3153108.

[23] K. Sudharson, M. Akshaya, M. Lokeswari and K. Gopika, "Secure Authentication scheme using CEEK technique for Trusted Environment," 2022 International Mobile and Embedded Technology Conference (MECON), Noida, India, pp. 66-71, 2022.

[24] J. Aruna Jasmine, V. Nisha Jenipher, J. S. Richard Jimreeves, K. Ravindran and D. Dhinakaran, "A traceability set up using digitalization of data and accessibility," International Conference on Intelligent Sustainable Systems (ICISS), IEEE Xplore, Tirunelveli, India, pp. 907-910, 2021. DOI: 10.1109/ICISS49785.2020.9315938.

[25] A. Hossain et al., "A YOLOv3 Deep Neural Network Model to Detect Brain Tumor in Portable Electromagnetic Imaging System," in IEEE Access, vol. 9, pp. 82647-82660, 2021, doi: 10.1109/ACCESS.2021.3086624.

[26] M. Arbane, R. Benlamri, Y. Brik and M. Djerioui, "Transfer Learning for Automatic Brain Tumor Classification Using MRI Images," *2020 2nd International Workshop on Human-Centric Smart Environments for Health and Well-being (IHSH)*, 2021, pp. 210-214, doi: 10.1109/IHSH51661.2021.9378739.

[27] Dhaniya, R.D., Umamaheswari, K.M. Brain tumor identification and classification of MRI images using data augmented support vector machine. Cogn Neurodyn (2022). https://doi.org/10.1007/s11571-021-09774-y

[28] N. Bodapati, A. Divya, N. Triveni, N. Indiradevi and K. Yamini, "Brain Tumor Detection On MR Images Using Improved Support Vector Machine," *2022 International Conference on Electronics and Renewable Systems (ICEARS)*, 2022, pp. 1022-1029, doi: 10.1109/ICEARS53579.2022.9752093.

[29] Vadhnani, S., Singh, N. Brain tumor segmentation and classification in MRI using SVM and its variants: a survey. Multimed Tools Appl (2022). https://doi.org/10.1007/s11042-022-12240-4

[30] Hassan, W.A., Ali, Y.H., Ibrahim, N.J. (2022). Brain Tumours Classification Using Support Vector Machines Based on Feature Selection by Binary Cat Swarm Optimization. In: Liatsis, P., Hussain, A., Mostafa, S.A., Al-Jumeily, D. (eds) Emerging Technology Trends in Internet of Things and Computing. TIOTC 2021. Communications in Computer and Information Science, vol 1548. Springer, Cham. https://doi.org/10.1007/978-3-030-97255-4_8