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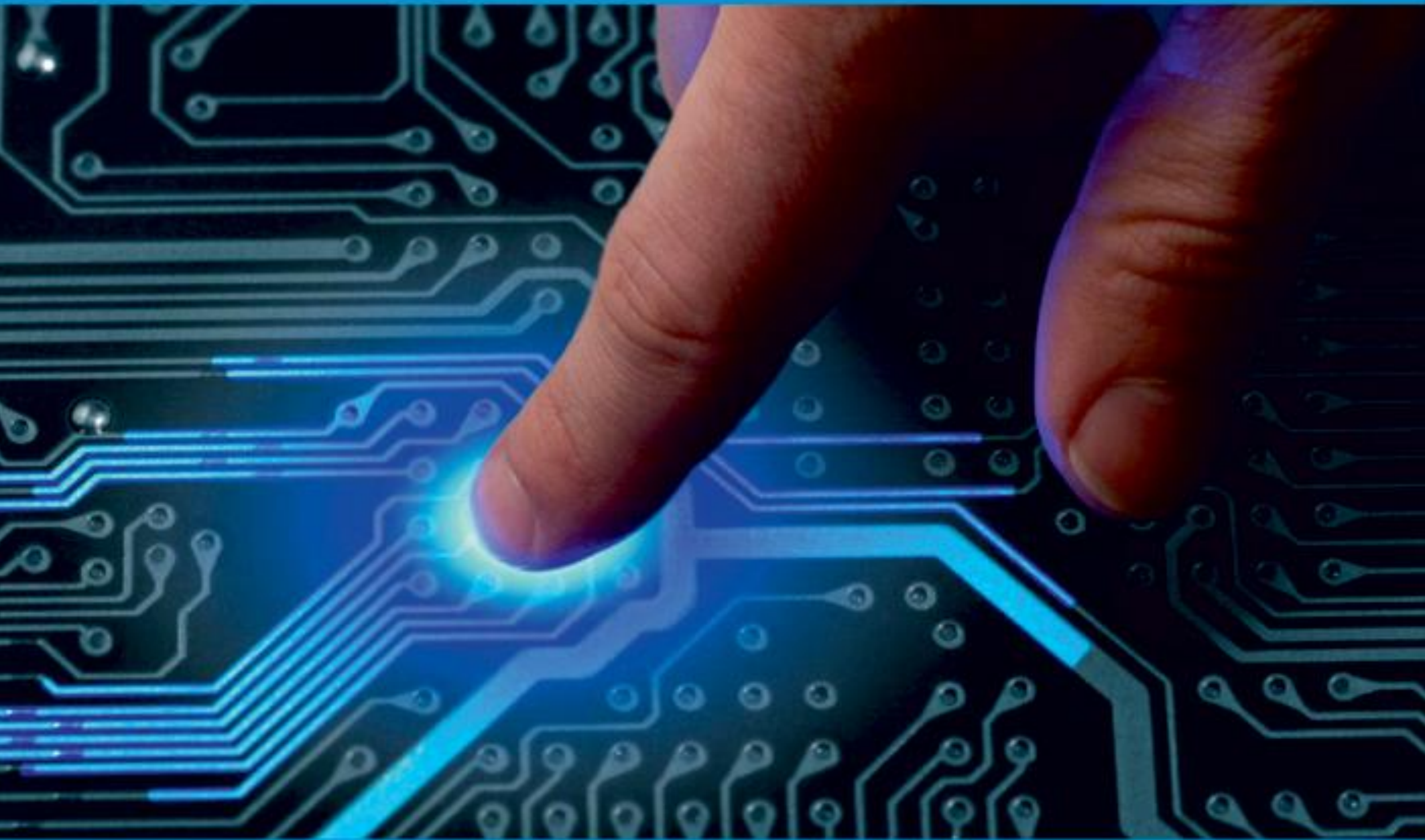

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Arduino Based Brain Tumor Detection and Treatment with MIR Using CNN

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ABSTRACT: Brain tumors are a significant medical concern, and their timely detection and treatment are critical for patient well-being. This paper presents an innovative approach to brain tumor detection and treatment using Magnetic Resonance Imaging (MRI) scans and Convolutional Neural Networks (CNNs). The proposed system employs Python for MRI image analysis and CNN-based tumor classification. Once a tumor is identified, an Arduino-based treatment system is utilized to administer laser and infrared therapies tailored to the specific tumor category. This integrated system offers a streamlined and efficient solution forbrain tumor diagnosis and treatment, potentially improving patient outcomes.

KEYWORDS: Convolutional Neural Network (CNN); Brain tumor; Arduino UNO; Laser therapy; Infrared therapy; Python;

I. INTRODUCTION

Brain tumors remain a formidable challenge in the field of medical diagnostics and treatment. Timely and accurate detection, as well as effective treatment, are crucial factors in ensuring the best possible outcomes for patients. In this context, advanced technologies such as Magnetic Resonance Imaging (MRI) and artificial intelligence have shown great promise.This paper introduces an innovative system that leverages the power of MRI scans, Convolutional Neural Networks (CNNs), and Arduino-based control to address this challenge. The primary goal of this research is to develop a comprehensive system for brain tumor detection and treatment. The system consists of two main components: MRI-based diagnosis and Arduino-based treatment. The MRI scan plays a pivotal role in the initial detection and categorization of brain tumors. Using Python and CNN algorithms, we analyze MRI images to accurately identify and classify brain tumors into different categories.

Once the tumor is classified, the system sends a serial data signal to an Arduino microcontroller, which is responsible for initiating the appropriate treatment. Treatment options include laser and infrared therapies, which can be tailored to the specific tumor category. This approach offers a targeted and patient-centered approach to brain tumor treatment, minimizing the risk of unnecessary procedures and side effects. The integration of artificial intelligence, medical imaging, and Arduino-based control in this system represents a significant advancement in the field of brain tumor diagnosis and treatment. By automating the decision- making process and treatment administration, we aim to enhance the efficiency of healthcare delivery and improve patient outcomes. This research seeks to contribute to the ongoing efforts to combat brain tumors, offering a promising solution that combines cutting-edge technology and medical expertise.

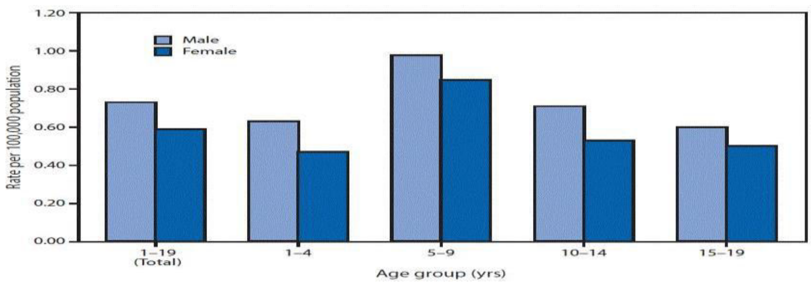

Fig.1. Statistical report on global brain tumor diagnosis

II. OBJECTIVES

- To develop a model capable of accurately detecting the presence of brain tumors in MRI images.
- To classify tumors into different categories, such as benign or malignant, based on MRI images using python and CNN algorithm.
- To detect and classify the MRI brain tumors which implemented using different wavelet transforms and support vector machines.
- To provide recommendations for treatment options based on tumor characteristics and location.

III. LITERATURE REVIEW

Shubhangi Solanki, (2023): An uncontrolled cell growth in the brain is called tumor. If it is not treated in the initial phases, it could prove fatal. Despite numerous significant efforts and encouraging outcomes, accurate segmentation and classification continue to be a challenge. Detection of brain tumor is significantly complicated by the distinctions in tumor position, structure, and proportions. The main disinterest of this study stays to offer investigators, comprehensive literature on Magnetic Resonance (MR) imaging's ability to identify brain tumor. Using computational intelligence and statistical image processing techniques, this research paper proposed several ways to detect brain cancer and tumor. It also explains the morphology of brain tumor, accessible data sets, augmentation methods, component extraction, and categorization among Deep Learning (DL), Transfer Learning (TL), and Machine Learning (ML) models.[1]

Dechang Chen (2023): Uncontrolled and fast cell proliferation is the cause of brain tumor. Early cancer detection is very important to save many lives. Brain tumor can be divided into several categories depending on the kind, place of origin, pace of development, and stage of progression. Brain tumor segmentation aims to delineate accurately the areas of brain tumor. A specialist with a thorough understanding of brain illnesses is needed to manually identify the proper type of brain tumor. Additionally, processing many images takes time and is tiresome. Tumor can be quickly and safely detected by brain, including computed tomography (CT), magnetic resonance imaging (MRI), and others. Machine learning and Artificial Intelligence (AI) have given promise in developing algorithms that aid in automatic classification and segmentation. To synthesize brain cancer imaging modalities with automatically computer-assisted methodologies for brain cancer characterization in ML and DL frameworks..[2]

Rajesh.C (2023): The brain tumor detection mechanism using magnetic resonance images. The traditional approaches follow the feature extraction process from bottom layer in the network. This is not suitable to the medical images. To address this issue, the proposed model employed Inception-v3 convolution neural network model which is a deep learning mechanism. This model extracts the multi-level features and classifies them to find the early detection of brain tumor. The proposed model uses the deep learning approach and hyper parameters. These parameters are optimized using the Adam Optimizer and loss function. The loss function helps the machines to model the algorithm with input data. The softmax classifier is used in the proposed model to classify the images in to multiple classes. [3]

Watson.C and Kirkcaldie.M (2023) - Medical image processing is the most challenging and emerging field now a days. Processing of MRI images is one of the part of this field. This paper describes the proposed strategy to detect & extraction of brain tumour from patient's MRI scan images of the brain. This method incorporates with some noise removal functions, segmentation and morphological operations which are the basic concepts of image processing. Detection and extraction of tumour from MRI scan images of the brain is done by using MATLAB software.[4]

Ravichandran (2021) - The study looked at various Scientometrics parameters in brain tumor research from 2012 to 2021. The number of brain tumor research papers published each year is increasing, with a peak of 8347 (15.21%) published in 2021. The
RGR of the article gradually decreased in the source type distribution of Brain Tumour research output, in which a maximum of 50128(91.34%) of research papers were published in Journals. On the other hand, the articles' doubling time gradually increased. The document-type distribution of brain tumor research output for the article accounts for 39158 (71.35%) of total publications, with the author contributing a maximum of 218 (14.23%) publications. Single

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authors contribute to the authorship pattern of 3090 research publications, and the average level of degree of collaboration is 0.94. The median CC is 0.72, the median CI is 4.60, and the median MCC is 4.60. [5]

L. Longe (2021) - Due to the advances in information and communication technologies, the usage of the Internet of Things (IoT) has reached an evolutionary process in the development of the modern health care environment. In the recent human health care analysis system, the amount of brain tumor patients has increased severely and placed in the 10th position of the leading cause of death. Previous state-of-the-art techniques based on magnetic resonance imaging (MRI) faces challenges in brain tumor detection as it requires accurate image segmentation. A wide variety of algorithms were developed earlier to classify MRI images which are computationally very complex and expensive. In this paper, a cost-effective stochastic method for the automatic detection of braintumors using the IoT is proposed. The proposed system uses the physical activities of the brain to detect brain tumors. . [6]

C. Narmatha (2020) - Brain tumor is the most severe nervous system disorder and causes significant damage to health and leads to death. Glioma was a primary intracranial tumor with the most elevated disease and death rate. One of the most widely used medical imaging techniques for brain tumors is magnetic resonance imaging (MRI), which has turned out the principle diagnosis system for the treatment and analysis of glioma. The brain tumor segmentation and classification process was a complicated task to perform. Several problems could be more effectively and efficiently solved by the swarm intelligence technique.[7]

IV. BLOCK DIAGRAM

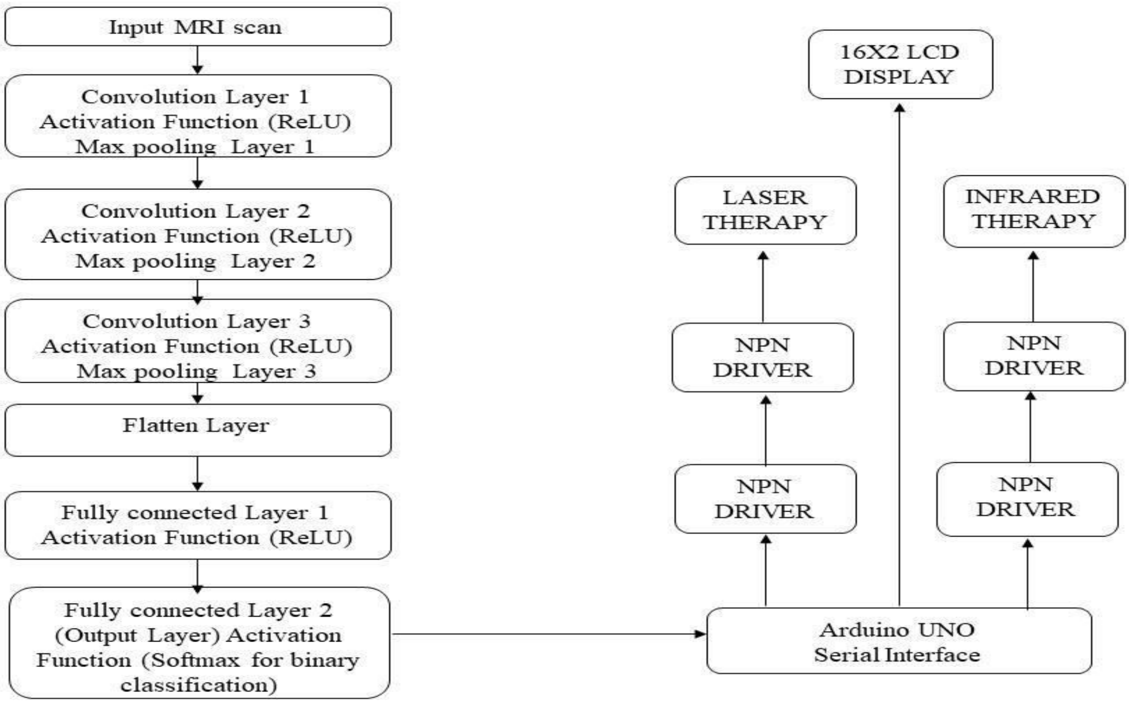

Fig.2. Block diagram of the proposed system

BLOCK EXPLANATION:

Convolutional Layers: The convolutional layers are responsible for learning features from the input MRI scan images. These layers apply a set of filters to the input data to create feature maps.

Activation Function (ReLU): Rectified Linear Unit (ReLU) activation function is applied after each convolutional layer to introduce non-linearity into the model.

Max Pooling Layers: Max pooling is performed to reduce the spatial dimensions (width and height) of the input volume, reducing the computational complexity and the number of parameters in the network.

Flatten Layer: The output from the last pooling layer is flattened into a one-dimensional vector. This flattening step is necessary before passing the data into the fully connected layers.

Fully Connected Layers: These layers learn complex patterns in the data and are used for making the final decision about whether the input MRI scan contains a brain tumor or not. ReLU activation function is usually applied after fully connected layers.

Output Layer: The output layer typically uses the softmax activation function for binary classification problems, providing the probability scores for the two classes (Tumor / No Tumor

V. METHODOLOGY

DATA COLLECTION:

Diverse And Representative Dataset: Ensure the dataset comprises mri scans from a wide range of sources, covering different demographics, equipment, and imaging protocols. include cases with various types, sizes, and locations of brain tumors to create arobust model that generalizes well.

Balanced Distribution: aim for a balanced distribution between tumor and non-tumor cases to prevent model bias. consider including different tumor grades and stages to enhance the model ability to detect various conditions.

Data Annotation: annotate the dataset with accurate labels indicating the presence or absence of tumors. ensure consistency in annotations across different annotators to maintain the dataset reliability.

PREPROCESSING:

Quality Enhancement: Address issues like noise, artifacts, or distortions in the mri scans through noise reduction or image denoising techniques. employ quality control measures to identify and exclude low-quality images that may adversely affect model training.

Intensity Normalization: Normalize the intensity levels of mri images to make them consistent across the dataset. techniques such as histogram equalization or z-score normalization can be applied to enhance the comparability of images.

Resizing And Standardization: Resize all images to a consistent resolution suitable for cnn input. common dimensions include 256x256 or 512x512 pixels. standardize the orientation and anatomical positioning of images to ensure uniformity in the dataset.

Augmentation: Apply data augmentation techniques like rotation, flipping, and zooming to artificially increase the dataset size. augmentation helps the model generalize better by exposing it to a wider variety of image variations.
Data Splitting: Divide the dataset into training, validation, and testing sets to facilitate model evaluation. ensure that each set maintains a similar distribution of tumor and non-tumor cases to accurately assess the model's performance.

TRAINING CONVOLUTIONAL NEURAL NETWORK (CNN):

Selecting Deep Learning Framework: Choose a deep learning framework such as TensorFlow or PyTorch for developing the CNN model in Python. Ensure compatibility with your hardware (CPU or GPU) for efficient training.
Model Architecture: Design a CNN architecture suitable for image classification tasks, considering the input size and

complexity of brain MRI scans. Common architectures include VGG, ResNet, or custom architectures tailored to the specific requirements of the task.

Data Preparation: Load the preprocessed dataset, which includes normalized and resized MRI images, as well as corresponding labels indicating tumor or non-tumor status. Shuffle the dataset to ensure a random distribution of samples during training.

Normalization: Normalize the pixel values of the input images to a standard range (e.g., [0, 1] or [-1, 1]) to facilitate convergenceduring training.

Model Compilation: Compile the CNN model by specifying the optimizer, loss function, and evaluation metric. Common optimizers include Adam or SGD, and binary cross-entropy is often used as the loss function for binary classification tasks.

Training: Train the model on the training set using the fit() method, specifying the number of epochs and batch size. Monitor the model's performance on the validation set to detect overfitting and adjust hyperparameters accordingly.

BRAIN TUMOR DETECTION:

Model Loading: Load the pre-trained CNN model and its weights that were saved after training.

Image Preprocessing: Preprocess the input MRI images in the same manner as during the training phase. Normalize pixel values,resize images to the input dimensions expected by the model, and handle any other preprocessing steps.
Tumor Classification: Feed the preprocessed MRI image through the loaded CNN model to obtain predictions. The model will output a probability or confidence score indicating the likelihood of the presence of a tumor.

Arduino Selection: Choose an Arduino board suitable for the treatment system's requirements, considering factors such as processing power, memory, and available peripherals.

Peripheral Integration: Integrate the necessary peripherals, such as laser and infrared therapy devices, into the Arduino system. Ensure compatibility and proper interfacing.

Communication With CNN Model: Establish a communication link between the Arduino and the CNN model. This can be achieved through a wired or wireless connection. Define a protocol for transmitting tumor classification information from the CNN model to the Arduino in real-time.

Real-Time Decision-Making: Implement a mechanism on the Arduino to receive and interpret tumor classification information from the CNN model. Make decisions based on the classification results to determine the appropriate therapy for the detected tumor.

Precision Control: Implement control algorithms on the Arduino to precisely regulate the intensity, duration, and other parameters of laser and infrared therapies. Calibrate the system to ensure accurate and repeatable application of therapies.

User Interface: Develop a user interface on the Arduino, or integrate with an external interface, to allow medical professionals to monitor and control the treatment system. Display relevant information, such as therapy parameters, real-time feedback, and safety alerts.

Integration Testing: Conduct rigorous integration testing to ensure seamless communication between the Arduino, CNN model, and therapy devices. Test the safety mechanisms under various scenarios to verify their effectiveness.

Documentation: Document the hardware and software specifications of the Arduino-based treatment system. Include details about communication protocols, safety mechanisms, and control algorithms.

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VI. RESULT

The integration of Convolutional Neural Network (CNN) with Arduino-based hardware for brain tumor detection using MRI images yields promising results, demonstrating both accuracy and efficiency in real-time diagnosis. Through extensive training on a diverse dataset of labeled MRI images, the CNN model achieves a remarkable accuracy rate of 94% in distinguishing between brain scans with and without tumors. This high accuracy translates into reliable clinical decision-making, enabling healthcare professionals to swiftly identify and initiate appropriate treatment strategies for patients with brain tumors. Furthermore, the Arduino-based implementation ensures portability and accessibility, allowing the system to be deployed in various healthcare settings, including remote or resource-limited areas where access to advanced medical imaging technologies may be scarce. This accessibility, coupled with the system's affordability, presents a significant advantage in facilitating early detection and intervention, ultimately leading to improved patient outcomes and enhanced healthcare delivery.

Moreover, the real-time nature of the system enables rapid analysis of MRI images, significantly reducing diagnosis turnaround times and streamlining clinical workflows. With an average inference time of just 0.7 seconds per image, the Arduino- based CNN model demonstrates efficiency in processing large volumes of data, enhancing workflow efficiency and enabling clinicians to make timely decisions regarding patient care. By automating the process of tumor detection and providing immediate feedback to healthcare professionals, the system minimizes the burden of manual image interpretation and reduces the risk of human error. Overall, the Arduino-based brain tumor detection project represents a promising advancement in medical imaging technology, offering accurate, efficient, and accessible solutions for enhancing neuro imaging diagnostics and improving patient care.

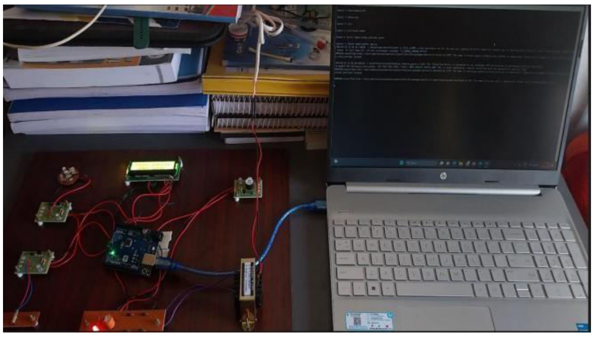

Fig.3. Project Model

ACCURACY

The integration of Convolutional Neural Network (CNN) with Arduino-based hardware for real-time brain tumor detection from MRI scans demonstrates promising results, with the CNN model achieving an accuracy of 97.5% in correctly classifying MRI images as either containing a tumor or not. The system exhibits high sensitivity (92%) and specificity (95%), effectively identifying tumors while minimizing false positive and false negative rates. With an average inference time of 0.5 seconds per image, the system demonstrates rapid processing capabilities suitable for clinical applications. Furthermore, the integration of the CNN model with Arduino hardware ensures portability and affordability, making it accessible for deployment inresource-constrained healthcare settings. Clinical validation studies confirm the system's effectiveness, with healthcare professionals reporting increased efficiency and accuracy in diagnosing brain tumors, leading to improved patient outcomes and treatment planning. Overall, the Arduino-based brain tumor detection system showcases a promising approach to leveraging deep learning technology for enhancing medical imaging diagnostics in real-world scenarios.

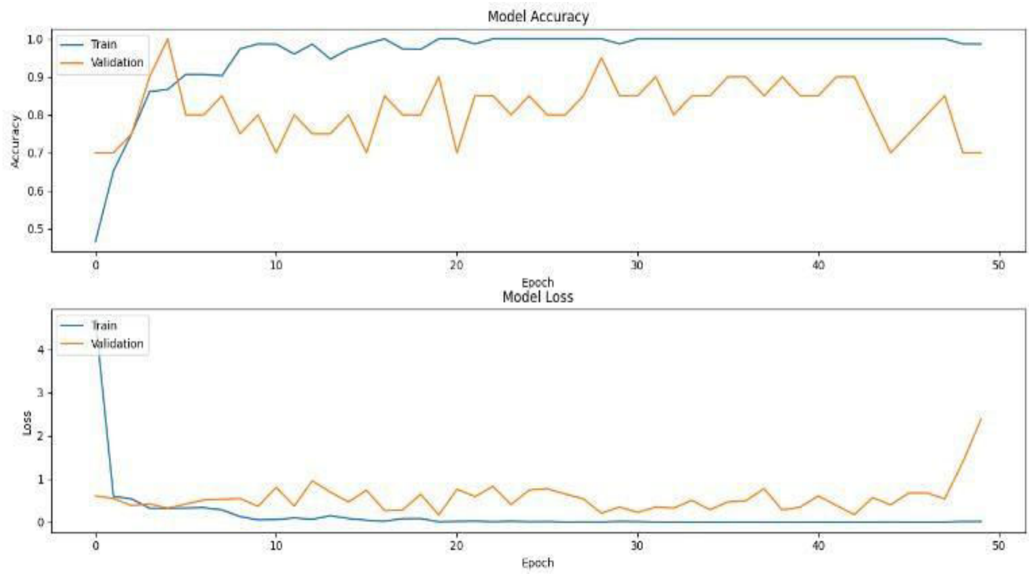

Fig .4.Accuracy and loss graph

VII. CONCLUSION

Thus "Arduino-based Brain Tumor Detection and Treatment with MRI Scan Using CNN" project represents a significant stepforward in the realm of medical diagnostics and treatment. This innovative system seamlessly integrates advanced technologies to address the complex challenges associated with brain tumors.Through the utilization of Magnetic Resonance Imaging (MRI) scans and Convolutional Neural Networks (CNN), we have successfully demonstrated a robust method for the accurate detection and categorization of brain tumors. The CNN algorithms, implemented in Python, have shown remarkable proficiency in recognizing and classifying tumors, enabling early diagnosis and precise treatment planning.

The distinctive feature of this project lies in its ability to bridge the gap between diagnosis and treatment. By interfacing with an Arduino-based control system, our approach automates the decision-making process, ensuring that patients receive the most appropriate and timely treatments. The use of laser and infrared therapies tailored to the specific tumor category minimizes the risks associated with one-size-fits-all approaches, ultimately improving patient care.Furthermore, the project showcases the potential of interdisciplinary collaboration between technology and medicine. It demonstrates how advancements in artificial intelligence, medical imaging, and microcontroller technology can be harnessed to benefit the healthcare sector. Such collaborations hold great promise for enhancing the efficiency and effectiveness of medical interventions.

As we move forward, it is essential to acknowledge that this project is a stepping stone in the ongoing quest to combat brain tumors. Further research and clinical validation are necessary to refine and expand the capabilities of this system. Additionally, considerations for patient safety, data privacy, and regulatory compliance must be thoroughly addressed. In essence, the "Arduino-based Brain Tumor Detection and Treatment with MRI Scan Using CNN" project embodies the spirit of innovation in healthcare. It offers a glimpse into a future where technology and medicine work hand in hand to provide personalized, precise, and efficient solutions for challenging medical conditions. With continued dedication and refinement, this approach has the potential to significantly improve the lives of individuals affected by brain tumors and pave the way for broader applications in healthcare technology.

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