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Medical Image Analysis Using Convolutional Neural Networks

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Abstract
Medical data can be expressed in many different ways such as texts, electronic health records, images and videos. The tool utilized plays an important role for the quality of the data. With time changing and some situations changing, data has different attributes. These are affected by other factors too, which cannot be considered. A very important element of medical data is medical imaging. Medical image examination is an important quality that assists medical practitioners in making sound decisions in modern healthcare systems. Diagnosis of many diseases, such as diabetic retinopathy detection, brain tumor, lung cancer etc., relies greatly on medical image analysis. Various medical image analysis includes: image classification, image segmentation and detection, image denoising, etc. This study addresses the challenges in medical image classification. To enhance the quality of an image that offers appropriate images or information, image processing is a method that converts an ordinary image to a digital form.
Keywords: *examination, high performance, Convolutional Neural Networks*

1. INTRODUCTION

Medical image processing is a field of image signal processing in which the signals are medical images. The medical images can be CT, MRI, fMRI, X-ray etc. based on the application. The neural network for medical image processing was applied 20 years ago; requirements of neural networks have increased by order of magnitude during the past five years [1]. Most reviews have come up in recent times highlighting the significance of in-depth education in medical image analysis and many current studies in this area involve image segmentation, image classification, images identification in important anatomical regions like the brain, heart, Pullmans, abdomens, breast, prostate and musculature, as well as image reconstruction within image recordings [2]. Every application has its own singular feature, which typically intersects with multiple research software pipelines. Medical image processing for clinical examination and treatment can be described as an image analysis of body regions, tissues or organs. It is one of the technologies employed to create the image of a human body. Imaging processes are part of the radiology, nuclear medicine and optical imagery disciplines [9]. Medical imaging processing involves an image display, enhancement, and analysis that takes pictures using equipment like MRI, X-ray, nuclear medicine, ultrasound, optical imaging, and computed tomography (CT) scanners [3].

2. REVIEW OF LITERATURE

Many applications are aimed at the image processing method, like document processing, movie industry, medical imaging, forensic research and analysis and military remote sensing. The image processing is classified into several types like optical image processing and analogue image processing. Medical image processing and analysis is applied to the scientific branch of medicine for diagnosis of all kinds of diseases. Medical images reveal significant aspect of medical treatment and diagnosis since they give information regarding the anatomy of patients. Medical image processing involves the composition of medical signals, image formation, image processing, and image display for medical analysis based on feature extraction. [13]. Some of the basic methods of image processing are search, blurring and filtering, noise cleaning, and outlining, texture analysis. Image processing includes four chief fields, viz. image analysis, visualisation, information management, and formation of images. Noise in images may generate misleading information that is to be removed from the image. Pre-processing is required to enhance the contrast of an input image for sharpening it [10]. Much noise, such as poor background, is there in the picture taken by sensors and cameras that impacts the segmentation accurately [4]. The pre-processing techniques operate on the photographs captured and convert them efficiently. For searching efficiently, the images selected will be resized and cropped. [5]. At the data processing phase computer methods are utilized to carry out digital images. Numerous processes, such as image improvement, colour space conversion, image size and so on, occur in the pre-processing phase. The noise present in the images can generate wrong data that can be rectified in the image processing. The image view is highly beneficial for the disease diagnosis. The image analysis gives minute details about the image that aids in noise reduction.

3. MATERIALS AND METHODS

Medical imaging systems are employed to examine the human body in a suitable way at the macro and micro levels, like organ level and cell level. Medical image processing is a very active research field. Internal medical imaging devices are employed to identify parts of the human body. Medical images are of prime significance because of correct diagnosis and treatment of diseases within the health care system. The visualization of the internal body structures, e.g., the CT scanner, MRI, was achieved by the hardware [11]. These images are mapped to a pixel made up of discrete brightness and colour values. Two domains of application, i.e., machine perceptions and the augmentation of pictorial information for human understanding, were central to the applicability and urgency of image processing. The analysis of medical imaging enhances the accuracy and reliability of medical images. Medical imagery is indeed an applied science that utilizes the concepts of imaging science in treating and diagnosing disease [6].
The success of machine learning algorithms is based on a quality feature engineering aspect done manually, while deep learning is enabled with auto extraction of features. CNNs identify the relevant features of images inexorably and regardless of human effort. Deep CNNs are most frequently utilized for image classification for medical purposes. The convolution layers in the CNN architecture help to retrieve image attributes such as edges, points, textures, etcThe convolution layer computes a sum of the dot product of inputs and weights, which is then supplied as input to an activation function to create a non-linear output. The pooling layers help to reduce the image size by retaining only the most important features of the model. This helps enhance the classification effectiveness and reduce floating point operations. Average pooling and max pooling are two forms of pooling layers present in CNN. Max pooling and average pooling layers are the two. A flattened layer is found following the convolution layers, which convert the 2-D image to a vector of 1D. Dense layers consisting of many hidden nodes are followed thereafter. The multi-class classification scores are then produced by applying a Softmax activation function in the final layer.

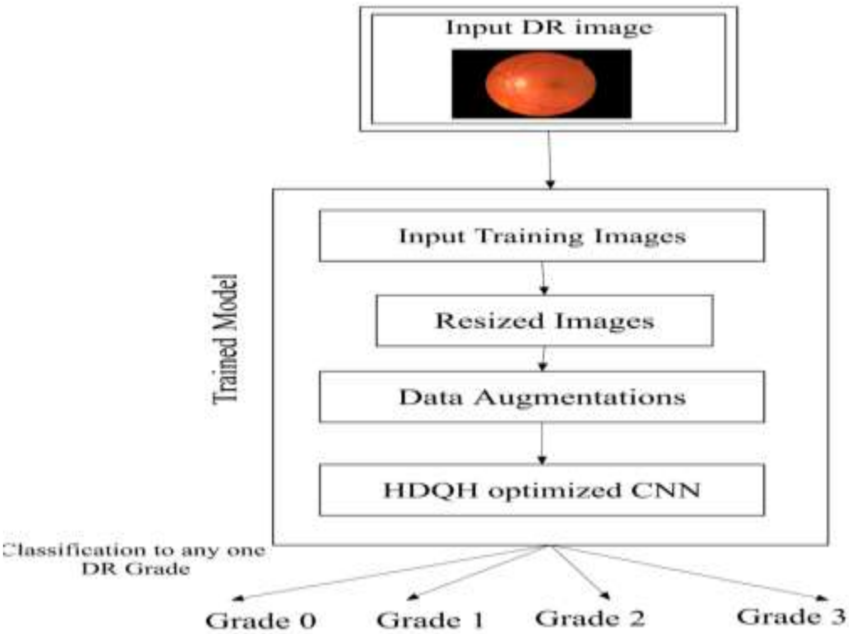
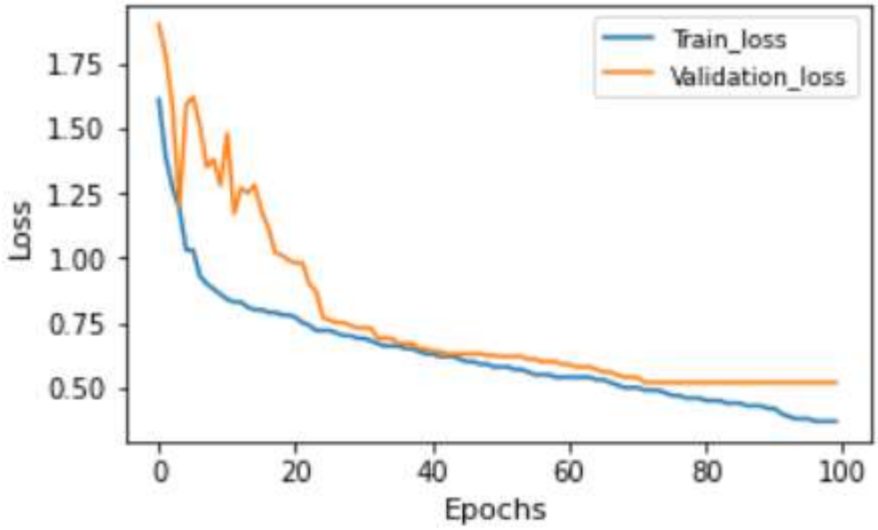


Figure 1: Proposed diagram

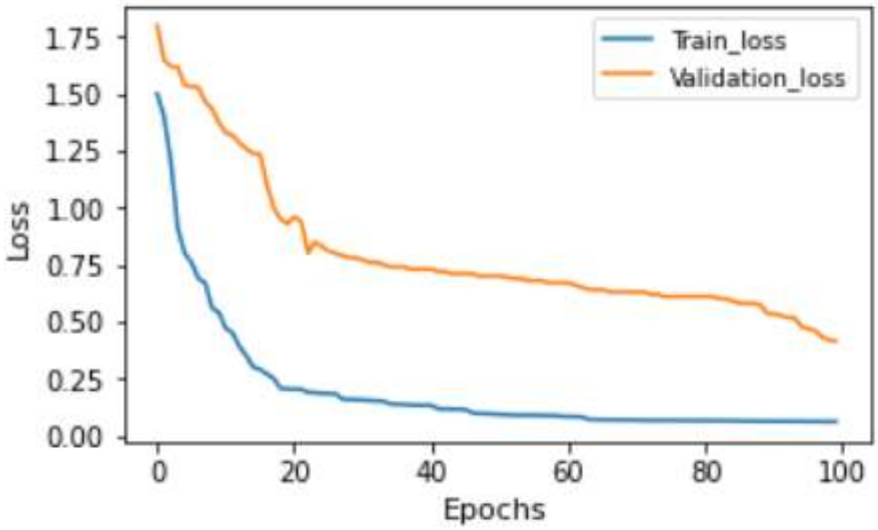
This analysis evaluates the performance of medical imaging through the application of various convolutional neural network classifications. Deep learning techniques facilitate the automated learning of features that are predictable based on classification objectives. Consequently, numerous research efforts are concentrated on adapting deep learning techniques for medical image analysis applications, which often involve a limited number of annotated training datasets [7]. The automation of medical image analysis and diagnosis is now standard in all modern diagnostic facilities. A significant portion of research contributions has focused on the detection of abnormalities across various modalities of medical images utilizing computer-aided diagnosis systems (CADs).

4. RESULTS AND DISCUSSION

As the depth of the neural network increases, its performance improves; however, this enhancement necessitates a larger dataset for optimal results. In the realm of medical imaging diagnostics, particularly for rare diseases, the scarcity of data poses a significant challenge, potentially leading to issues with vanishing gradients. This study implements data augmentation techniques to generate numerous images from a limited number of samples, thereby addressing these challenges.



(a)



(b)

Figure 2: Train loss and Validation loss

However, the interpretation process is challenging due to the considerable variability of these structures. This complexity drives the creation of image analysis tools, such as Computer-Aided Detection (CAD) systems, which assist in the diagnosis of medical images. CAD systems support radiologists in various tasks, including the detection of breast masses, polyps, and lung nodules, which is the primary focus of this dissertation.

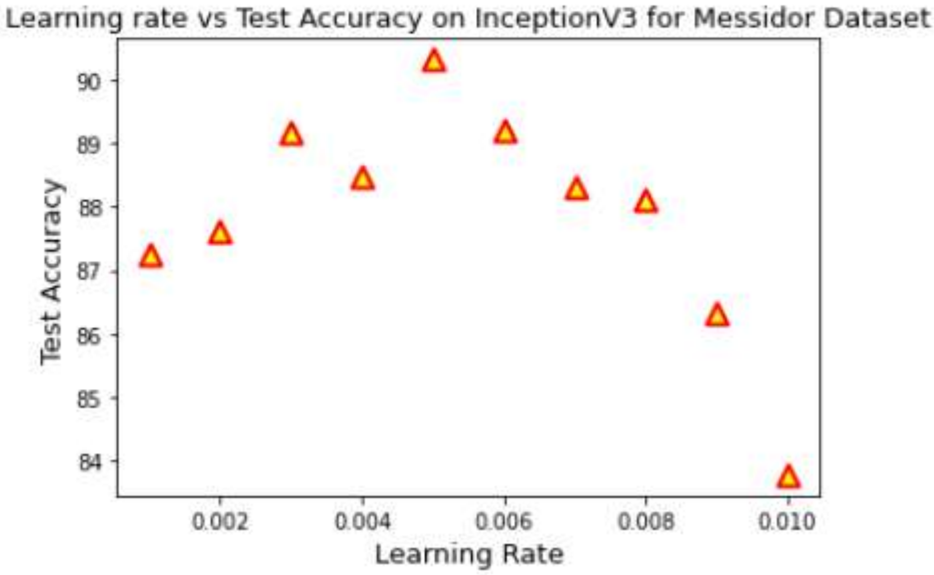


Figure 3: Effect of learning rate

Currently, there is an increase in the number of intricate medical imaging tests that are difficult to interpret promptly and accurately [15]. Nevertheless, deep learning technology is anticipated to aid radiologists in delivering more precise diagnostic reports. Literature indicates that deep learning-based technologies have been introduced within the field of radiology. The application of deep learning in medical image analysis is expected to facilitate technological advancements that reduce the burden of repetitive tasks, rather than replacing radiologists [12]. The development of deep learning for effective medical applications in radiology is a necessary technological advancement [8]. Recent innovations, driven by extensive annotated datasets such as ImageNet, have propelled the progress of deep learning in medical imaging. Consequently, the active involvement of radiologists is vital for the creation of large annotated medical image datasets [15]. Additionally, ethical and legal considerations must be meticulously addressed when utilizing patient medical images in the implementation of deep learning for medical image classification.

5. CONCLUSION

Moreover, the issue of data imbalance arises from the lack of test cases for specific subclasses. Some researchers have identified data augmentation as a viable solution; however, there remains significant potential for further exploration in this area. The challenges outlined previously have yet to be comprehensively addressed, presenting ongoing opportunities for research, despite the notable successes reported in deep learning. Current trends indicate that data augmentation is likely to attract considerable interest from researchers, particularly in the realm of medical imaging, as it enables the generation of a larger volume of augmented images from original images with corresponding annotations. The advancement of both hardware and software, alongside techniques related to deep learning applications for predicting radiological images—such as lesion detection and evaluation—has begun to be explored. While previous studies have yielded numerous promising outcomes, various challenges persist in radiological practice. Furthermore, legal liability concerns may arise when implementing deep learning systems in certain radiological contexts without the oversight of a radiologist. Lastly, the design of data models with numerous parameters can easily lead to overfitting, especially when the dataset size is limited.

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