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Customized CNN for Classification of Cho Cells

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Abstract: Deep learning techniques such as Convolutional Neural Network have shown great promise in microscopic medical image classification tasks. Advancements in technology and research have indeed supported radiologists in detecting variabilities and other characteristics of microscopic medical images with improved accuracy and performance. In this paper we proposed variant of CNN for the Classification of CHO cells, evaluated on IICBU-2008 benchmark dataset and results are obtained for classification of CHO cells with 5 different classes with Accuracy 95.8 Precision 94.18, Recall 94.23 and F1 Score 94.2.

Keywords: Chinese Hamster Ovary (CHO) cells, Convolutional Neural Network (CNN), Classification, Microscopic Medical Images.

1. Introduction

In past few years microscopic images are used rapidly in medical, biomedical research and other areas because just beyond the limits of human sight, is an unseen universe that microscope can explore. Nowadays microscopes are used in medical field for this purpose. Cells inside human body is a dynamic network of structure, tubes and our bodies are constantly fighting off different cancer cells. The microscope helps in finding the structure of the diseased cell and from that we can classify the normal and diseased cells. Microscopic medical images play a vital role in determination and disease diagnosis. In microscopic medical applications there are many image data is to be analyzed, classified, stored and retrieved. Researches have used image processing, machine learning, deep learning and computer vision techniques to automate analysis, segmentation, recognition and classification of microscopic medical images, due to this the medical doctors can use these automate systems in medical field to diagnosis of patients. Classification have been performed in different pathology works like breast cancer, lung cancer, brain tumor, brain cancer, acute leukemia and colon cancer etc. [1]. Microscopic medical analysis includes automatic detection of tumors, detection of cancerous cells and early detection of deadly diseases.

Microscopic medical image classification is the significant issue in the computer vision field and image recognition which classify the images of different groups to help in further research. Basically, classification works in 2 stages, first we need to extract features from the images, in the second stage model is build based on the features extracted and then classify the images. In past the professionals used their experience to extract images feature for classification of images which requires more time. If the classification is done properly in future, it will help the doctors to diagnose the disease and it will also help researcher in future study.

In the present digital era usage and success rate of machine learning and deep learning are high in computer aided diagnosis, analysis, identification and classification, due to this researcher shows enormous interest in using these tools in analyzing serious medical related issues which are obtained from different imaging sources. In recent years many CNN architectures are developed and designed to classify the microscopic images.

Chinese Hamster Ovary (CHO) originated from Chinese hamster has been used in research for more than hundred years [2]. The use of CHO cells in biopharmaceutical production is attributed to several advantages. firstly, CHO cells have a high productivity for recombinant biologics, making them a preferred choice for large scale manufacturing, they have been extensively used for the production of therapeutic proteins, antibodies and vaccines. Secondly, CHO cells can grow robustly in chemically defined and protein free media. This feature simplifies the cultivation process and reduces the risk of contamination by animal derived components, ensuring product safety and regulatory compliance. Thirdly, CHO cells have a well-established safety track record as the have been used in industrial bioprocessing and bio medical flied for several decades. Researcher can now study the genes,

pathways, cell structure and metabolic networks involved in CHO cell metabolism, CHO cell Classification, which provides insight into their physiological behavior. The computational model allows researchers to simulate and predict cellular behavior under different conditions. The goal of the proposed method is to generate a successful algorithm for classification of microscopic medical images.

In this proposed work IICBU-2008 Benchmark dataset is used for the experimentation purpose, the dataset consists 332 images of five different classes. In preprocessing augmentation is used to increase size of the dataset. The Figure.1 shows different images of CHO cells classes.

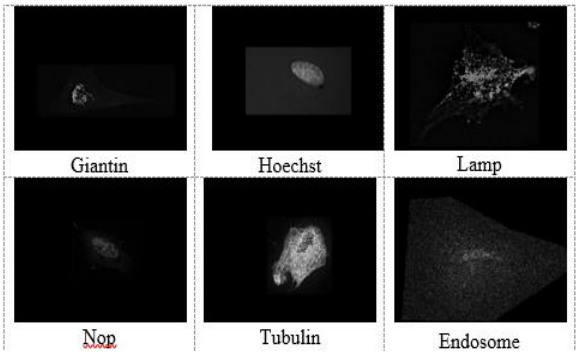

Figure.1: Example images of CHO cell classes

The paper is organized as follows: Section 2 Related work of different classification methods are addressed. Section 3 proposed method of the study. Section 4 Comparative analysis. Finally, section 5 interpretation of the work.

2. Related Work

An overview of related work for classification of microscopic medical images is presented in this section.

Chaitali Raje et.al [3] describes the importance of automatic image processing techniques in the detection of leukemia from microscopic images of human blood. The proposed system utilizes various techniques to detect leukemia and the goal is to overcome the constraints of manual visual inspection which can be time consuming and tiring for hematologist. The approach has shown promising results even with varying image quality.

Dong Liu et.al [4] addresses the limitations of existing Local Binary Patterns (LBP) based method for microscopic medical image classification. To overcome the drawbacks proposes an adaptive approach which considers two local context of each pixel and adjusts the neighborhood radius accordingly. This strategy uses spatial arrangements of local patterns and creates histogram that presents the distribution of these patterns in differential spatial locations. By incorporating spatial information, the proposed method aims to improve the discriminative power of the image recognition task.

Eka Miranda et.al [5] states that images in medical informatics consists of digital representations of physical objects captured using various imaging modalities. Exploring and analyzing this medical image data poses significant challenges in terms of extracting valuable insights and making accurate diagnosis of specific disease. The authors provide a review of state of art methods employed in diagnosing diseases, it emphasizes the importance of developing feasible approaches for computer aided diagnosis.

Hadi Rezaeilouyeh et.al [6] presents the potential technique for early detection cancer by leveraging CNN's and incorporating shearlet features this framework showcases the potential of using deep learning technique to improve cancer diagnosis. These advancements have the potential to assist physicians in efficiently identifying cancerous tissues and cells at early stages, ultimately contributing to improved patient outcomes in medical image analysis field.

Ahmed S. Negm et.al [7] presents a decision support system for automatic recognition of acute leukemia. The decision support system consists of several stage, the first step is panel selection which involves choosing the appropriate image processing techniques and algorithms for the task. Next the system applies k means clustering for image segmentation, which helps the leukemia cell based on their characteristics. After segmentation of the image the system performs feature extraction and image refinement, feature extraction involves extracting the relevant information from the segmentation cells, while image refinement aims to enhance the quality and clarity of the images. The system demonstrates excellent performance and accuracy, indicating its potential for further research in leukemia.

Yu Wang et.al [8] highlights the potential of using artificial intelligence, particularly CNNs to assist

pathologist in diagnosis of liver diseases based on microscopic medical images. The study finding suggests that CNN can provides accurate classification results, a comparative study was conducted. The results demonstrate the superiority of CNN in terms of classification accuracy.

Aryan Mobiny et.al. [9] proposes a variant of capsule network offer a more efficient approach by incorporating part-whole relationship into the network architecture. Capsules are groups of neurons that represents specific properties or features of an object and their activation levels indicate the properties of object in the input data. Capsnets provides a valuable alternative to CNN, particularly when dealing with limited training samples. These advancements have the potential to enhance cell biology research by facilitating the automatic and accurate classification.

Laith Alzubaidi et.al [10] proposes a transfer learning technique to overcome the drawbacks of traditional computer aided techniques and optimize performance, it leverages knowledge from pretrained models. To reduce the risk of overfitting and improve generalization, several data augmentation techniques are utilized. The model gives better results by utilizing the transfer learning and data augmentation.

Chiagoziem C. Ukwuoma et.al [11] proposes a successful application of an attention mechanism based deep learning method for breast cancer classification. To evaluate performance the author used ICIAR2018 dataset which is a commonly used dataset for research in breast cancer. The attention-based model is effective in accurately classifying breast cancer in microscopic medical images and surpasses existing methods

Zahangir Alom et.al [12] Proposed model for segmentation, classification and detection of Nuclei, this model used two combined CNN for classification. experimentation conducted on freely available dataset and results are compared with existing methods the proposed method gives higher accuracy.

3. Proposed Method

To classify the microscopic CHO cell images, a variant of CNN is proposed. The architecture of the proposed method is depicted in Figure. 2.

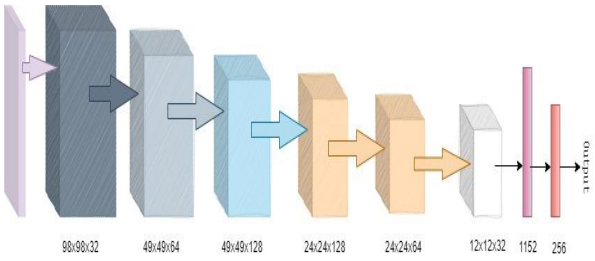

Figure. 2: Block diagram of the proposed method

Input Size: The CNN accepts 100x100 sized images as input. This means that the images have a resolution of 100 pixels in both width and height.

Convolutional Layer: Each layer in this architecture has a convolutional kernel of size 3x3. Convolution involves sliding the kernel over the input image to perform element-wise multiplication followed by summation, producing a feature map that represents different patterns in the image.

ReLU Activation Function: After the convolution operation, for model activation Rectified Linear Unit (ReLU) is used. ReLU keeps all the positive values unchanged and set zero to all the negative values.

Maxpooling: Maxpooling is used for down-sampling the feature maps. It helps in reducing the spatial dimensions while retaining important features. A typical maxpooling operation with a pool size of 2x2 will take the maximum value from a 2x2 window and move the window by 2 pixels, effectively halving the spatial dimensions.

4. Result and Discussion

For the purpose of experimentation, we have used 322 images of CHO cell collected from the IICBU-2008 benchmark dataset in which 60% images are used for training, 20 % images are used for validation and 20% for testing purpose. The proposed method gives better accuracy compared to previous methods when evaluated using different metrices are shown in Table 1, results are tabulated in Table 2, model accuracy, model loss and confusion matrix, of the proposed model is depicted in Figure.3, Figure.4 and Figure.5 respectively.

Table 1: Classification Report

Sl. No.	Metric	Score
	Precision	94.18
	Recall	94.23
	F1 Score	94.20

Table 5.1 shows the classification report of the proposed model. the model achieved a high level of Precision and Recall, both exceeding 94%, and the F1 Score, which balances these metrics is also around 94%. These results suggest that your model is performing well in correctly identifying positive instances and minimizing false positives, making it effective for the classification.

Table 1: Comparison results with previous models

Sl. No.	Classification Methods	Accuracy
	CNN	93.55
	FFNN	87.7
	SVM	88.2
	Proposed	95.8

Table 2 shows the accuracy of different models generated using different combinations of layers, batch size and epochs, as the batch size increases the training accuracy and validation accuracy improve. Overfitting of the model can be controlled by adjusting the frozen layers in the network. Adaptive optimization is used for model optimization from the confusion matrix, it is observed that we can get better accuracy for the model by optimization.

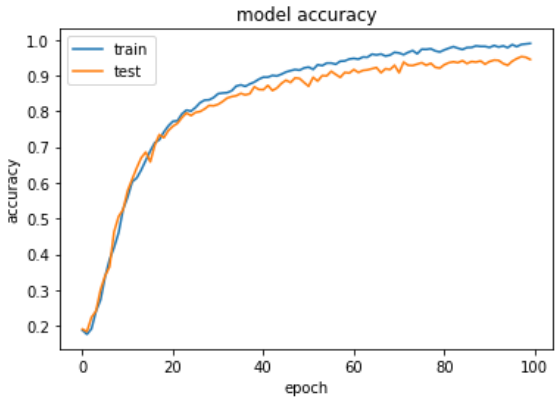

Figure.3. Model accuracy history.

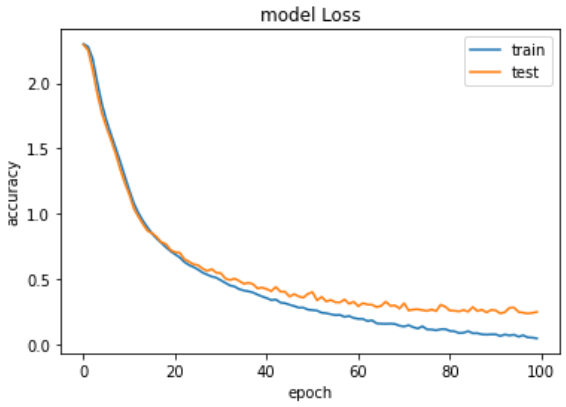

Figure.4. Model loss history.

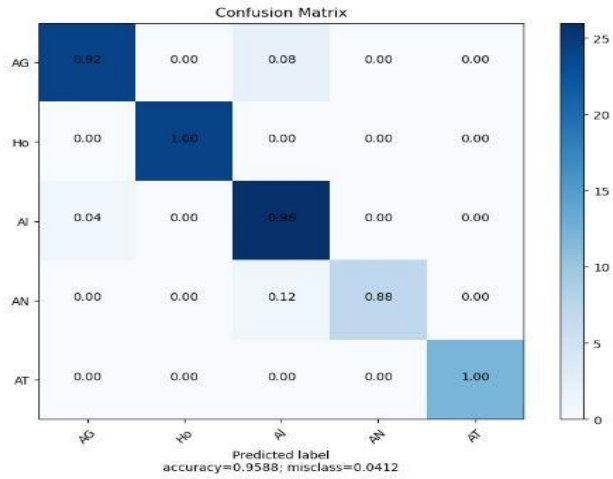

Figure.5. Confusion Matrix of proposed model

5. Conclusion

In this paper proposed a deep learning-based CNN is used for classification of CHO cell images into one of the categories, evaluated on IICBU-2008 benchmark dataset and results are obtained for classification of CHO cells with accuracy 95.8, precision 94.18, Recall 94.23 and F1score 94.2. Proposed framework has achieved better performance in classification compared to existing methods. Further in future this work can be extend to classification of CHO cell images of Different classes and GUI can be used to present the output interactively, also a hybrid system can be developed for classification purpose.

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