Behind the Pixels: A Novel Machine Learning Platform for Enhanced CNN Image Classification Through Adaptive Preprocessing Techniques

Tejas R. Annapareddy, Jacob E. Lee, Minghui Zhang

I. Introduction

CONVOLUTIONAL Neural Networks (CNNs) have revolutionized image classification tasks. In [1], for example, researchers trained a CNN to classify traffic signs to reduce the number of tasks that the driver needs to do when driving. Moreover, in [2], a CNN was trained to detect rust of steel. However, CNNs' performance can be significantly impacted by the quality and characteristics of input images (i.e., training data). This research proposal aims to investigate the effects of various image preprocessing techniques, with a focus on edge detection, on the accuracy of CNN models for image classification. By developing an adaptive preprocessing pipeline, we seek to optimize CNN performance across diverse datasets and application domains.

II. Literature Review

A. Background

Much effort has been put into constructing CNN models that aim to aid in the medical process of detecting various cancers. A recent study found that, among 12 breast cancer detecting models, the accuracies of those models range from 85.5% to 97.8% [3]. With breast cancer being a common type of cancer, other common cancers, such as brain cancer, likely have models with similar ranges of accuracies. With the hope of employing these models on a large scale to aid doctors, improving the accuracies of these cancer detecting models would allow them to be used with higher confidence and lower the possibility of misdiagnoses.

B. Edge Detection

The first image preprocessing technique examined in this study is edge detection. The edge detection technique is a computer algorithm that targets boundary information of objects in images by analyzing pixel mutations of images [4]. That is, the algorithm detects discontinuities of brightness in images and reflects the information gathered in a new image Figure 1.

Specifically, we chose the Canny edge detection algorithm because it is resistant to noise and random variations in color or brightness and is capable of detecting weak edges [5]. Since medical images are likely to contain very weak edges of body tissues and potentially noise, the Canny edge detection algorithm is appropriate for this task.

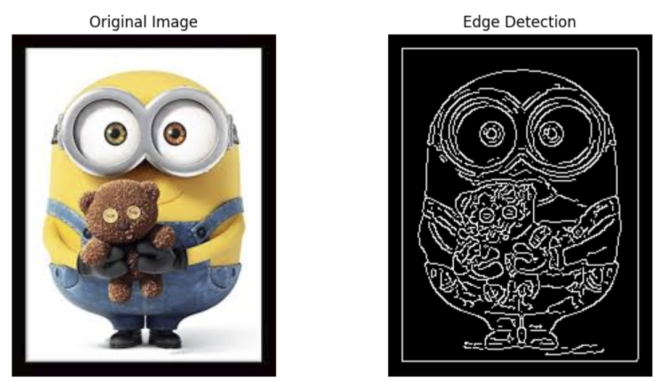
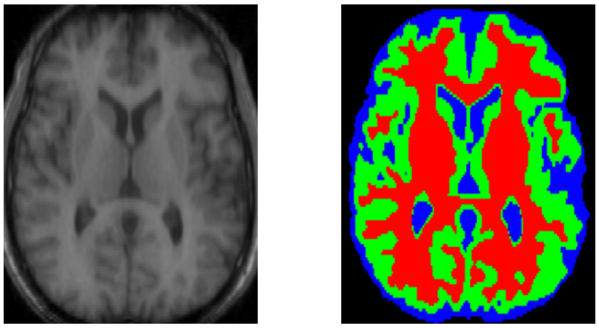


Fig. 1. A minion image before and after edge detection image processing

C. Image Segmentation

The other image processing technique we examine is image segmentation technique. As technology continues to advance, image segmentation is used in a wide spectrum of fields, ranging from object detection in autonomous cars[6] to medical



(a) Axial slice (b) Tissue segmentation

Fig. 2. A scan of a brain before and after image segmentation

images processing[7]. Image segmentation partitions an image into distinct regions or segments to simplify its analysis. This process groups pixels based on characteristics like color, intensity, or texture, making it easier to isolate specific objects or areas within an image [8]. In medical imaging, segmentation helps identify tumors by distinguishing them from surrounding healthy tissues [9]. For instance, in

III. Rationale

Since improving the performance of cancer detecting models is beneficial for wider, futuristic deployment of these CNN models, in this study, image preprocessing techniques, including edge detection and image segmentation, would be utilized to preprocess the images used for training and testing of CNN models. The accuracies and other indicators of performance, such as F1 score, of these models that incorporate these image preprocessing techniques will be compared to those of a regular CNN.

IV. Methodology

The Cancer Imaging Archive (TCIA) is a service which de-identifies and hosts a large publicly available archive of crowd-sourced medical images of cancer. We use automation scripts to convert this data into a CNN-friendly format. For this project, we utilized Google Colab for its integration with Google Drive and its cloud computing features. Colab allows us to run our model in the cloud instead of locally on our machines. This allows us to use enterprise level equipment to run out

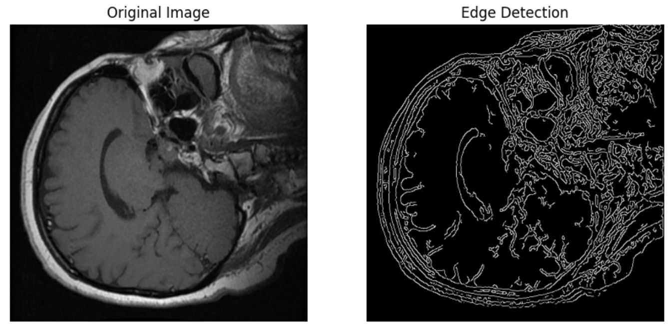


Fig. 3. A sample of medical image of brain tumor used in Google Colab machine learning training

V. Conclusion

Our research relates to the optimization of CNN-based image classification models. By investigating the effects of preprocessing techniques, such as edge detection and image segmentation, we aim to enhance the accuracy and reliability of these models. The use of the Canny edge detection algorithm, known for its resistance to noise and sensitivity to weak edges, holds promise for improving medical image analysis.

Our future work will focus on refining the preprocessing techniques and evaluating their impact on different CNN models. Additionally, we will explore the scalability of our proposed methods to other medical imaging applications.

Appendix A
Website

https://behind-the-pixels.github.io/

References

[1] N. Jmour, S. Zayen, and A. Abdelkrim, "Convolutional neural networks for image classification," pp. 397–402, 2018. DOI: 10.1109/ASET.2018.8379889.

[2] H. Lyu, "Research on corrosion recognition method of steel based on convolutional neural network," pp. 507–511, 2023. DOI: 10.1109/ICISCAE59047.2023.10393077.

[3] K. Patel, S. Huang, A. Rashid, B. Varghese, and A. Gholamrezanezhad, "A narrative review of the use of artificial intelligence in breast, lung, and prostate cancer," en, *Life (Basel)*, vol. 13, no. 10, Oct. 2023.

[4] R. Sun, T. Lei, Q. Chen, *et al.*, "Survey of image edge detection," *Frontiers in Signal Processing*, vol. 2, Mar. 2022. DOI: 10.3389/frsip.2022.826967.

[5] B. Tian and W. Wei, "Research overview on edge detection algorithms based on deep learning and image fusion," *Security and Communication Networks*, vol. 2022, pp. 1–11, Sep. 2022. DOI: 10.1155/2022/1155814.

[6] B. De Brabandere, D. Neven, and L. Van Gool, "Semantic instance segmentation for autonomous driving," Jul. 2017.

[7] I. Rizwan I Haque and J. Neubert, "Deep learning approaches to biomedical image segmentation," *Informatics in Medicine Unlocked*, vol. 18, p. 100 297, 2020, ISSN: 2352-9148. DOI: https://doi.org/10.1016/j.imu.2020.100297. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S235291481930214X.

[8] R. Anand, R. K. Mishra, and R. Khan, "Chapter 9 - plant diseases detection using artificial intelligence," M. A. Khan, R. Khan, and M. A. Ansari, Eds., pp. 173–190, 2022. DOI: https://doi.org/10.1016/B978-0-323-90550-3.00007-2. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B9780323905503000072.

[9] D. Jha, M. A. Riegler, P. Halvorsen, and D. Johansen, "Medical image segmentation using deep learning," n.d. Accessed: 16 December 2024. [Online]. Available: https://experiments.springernature.com/articles/10.1007/978-1-0716-3195-9_13.