2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

A WIRELESS SENSOR SYSTEM FOR DETECTING DIABETIC RETINOPATHY TO AVOID ACCIDENTS

REPALLE DURGA BHAVANI[1], V. THANUSHA[2], M. RAMYA[3], PULI AKSHAYA[4]

[1]Assistant Professor, Department of ECE, Mallareddy Engineering College For Women
[2,3,4]UG Scholar, Department of ECE, Mallareddy Engineering College For Women

ABSTRACT - : Traditional fundus image-based diabetic retinopathy (DR) grading depends on the examiner's experience, requiring manual annotations on the fundus image and also being time-consuming. Wireless sensor networks (WSNs) combined with artificial intelligence (AI) technology can provide automatic decision-making for DR grading application. However, the diagnostic accuracy of the AI model is one of challenges that limited the effectiveness of the WSNs-aided DR grading application. Regarding this issue, we propose a WSN architecture and a parallel deep learning framework (HybridLG) for actualizing automatic DR grading and achieving a fundus image-based deep learning model with superior classification performance, respectively. In particular, the framework constructs a convolutional neural network (CNN) backbone and a Transformer backbone in a parallel manner. A novel lightweight deep learning model named MobileViT-Plus is proposed to implement the Transformer backbone of the HybridLG, and a model training strategy inspired by an ensemble learning strategy is designed to improve the model generalization ability. Experimental results demonstrate the state-of-the-art performance of the proposed HybridLG framework, obtaining excellent performance in grading diabetic retinopathy with strong generalization performance. Our work is significant for guiding the studies of WSNs-aided DR grading and providing evidence for supporting the efficacy of the AI technology in DR grading applications.

I. INTRODUCTION

Diabetic Retinopathy (DR) is a progressive eye condition that arises as a result of prolonged diabetes mellitus, and it can often lead to blindness if left untreated. Diabetes mellitus is a chronic metabolic disorder characterized by high blood glucose levels, which can have widespread effects on the body, including the eyes. One of the most significant complications of diabetes is DR, which is caused by damage to the blood vessels in the retina. If left undiagnosed and untreated, DR can lead to severe visual impairment or blindness. Timely detection through regular screening of fundus images can significantly reduce the risk of visual loss caused by DR. DR is mainly categorized into two types: Proliferative Diabetic Retinopathy (PDR) and Non-Proliferative Diabetic Retinopathy (NPDR). NPDR is typically observed in the early stages of DR and is further classified into three stages based on its severity: mild, moderate, and severe NPDR. NPDR occurs when blood vessels in the retina leak fluid, causing the retina to become swollen. Symptoms of NPDR include microaneurysms, exudates, and hemorrhages. Microaneurysms are small, weakened areas in the retinal blood vessels that can leak fluid; exudates refer to lipid deposits within the retina; and hemorrhages involve bleeding caused by the rupture of blood vessels. On the other hand, PDR is a more advanced and severe form of DR, where abnormal new blood vessels grow in the retina, which can ultimately lead to blindness if not treated promptly. Research indicates that 90% of diabetic patients can avoid DR-related blindness through timely diagnosis and intervention. Early detection of DR is crucial for effective treatment and preventing its progression. Traditionally, DR detection is performed by ophthalmologists who visually examine fundus images for signs of the disease. While this method is effective, it has limitations due to the scarcity of trained professionals and the increasing number of patients. As a result, the need for automated systems for DR detection has become more critical. Automated DR detection systems can help alleviate the workload on ophthalmologists and provide timely and accurate diagnosis. Recently, deep learning-based models, particularly Convolutional Neural Networks (CNNs), have shown promising results in medical image analysis, including DR detection. These models can automatically extract relevant features from retinal images and classify them into different stages of DR with high accuracy. CNNs are particularly useful for analyzing raw fundus images and generating predictions about the presence and severity of DR, reducing the need for human intervention. Given the effectiveness of CNNs in this area, this paper proposes a novel approach that combines transfer learning and stacking techniques for the automatic detection and grading of DR. Transfer learning enables the use of pre-trained models on large datasets, allowing the model to leverage learned features and adapt to the DR detection task. Stacking, an ensemble learning method, combines the predictions of multiple models to improve the overall accuracy and robustness of the system. By utilizing these advanced techniques, the proposed model aims to automatically analyze fundus images, identify the presence of DR, and grade its severity with higher precision and efficiency compared to existing methods. The rest of the paper is organized as follows: Section II provides a detailed literature survey on existing methods for DR detection. Section III explains the various pre-trained models used and the concept of stacking in detail. Section IV summarizes the proposed model for DR detection and grading. Section V presents the experimental evaluation of the model, including its performance metrics. Finally, Section VI concludes the paper and discusses ideas for future work.

II. LITERATURE SURVEY

A. C. Szegedy, S. Ioffe, V. Vanhoucke, and A. Alemi, "Inception-v4, inception-resnet and the impact of residual connections on learning," arXiv preprint arXiv:1602.07261, 2016. The paper "Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning" by C. Szegedy, S. Ioffe, V. Vanhoucke, and A. Alemi, published in 2016, presents the evolution of the Inception architecture and introduces the Inception-v4 model and Inception-ResNet, which integrate residual connections into the Inception framework. The authors explore how these new architectures perform in terms of accuracy, efficiency, and their ability to handle complex image recognition tasks. The key innovation in Inception-v4 and Inception-ResNet is the incorporation of residual connections, which were popularized by the ResNet architecture. These connections allow gradients to flow more easily through deep networks, thus improving training performance and enabling the creation of

International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

much deeper models without the problem of vanishing or exploding gradients. The paper discusses the significance of these residual connections, noting that they enable the model to learn more complex features by effectively passing information across layers, leading to better feature extraction and a reduction in the computational complexity. The authors provide a comprehensive analysis of Inception-v4 and Inception-ResNet's performance on the ImageNet dataset, comparing them to earlier versions of the Inception model. They report that Inception-v4 achieves state-of-the-art results on the ImageNet Large Scale Visual Recognition Challenge (ILSVRC), demonstrating superior performance in terms of accuracy and computational efficiency. The combination of residual connections and the Inception design allows for a better balance between depth and computational resources, which is crucial for handling large-scale image recognition tasks. The paper also provides insights into the architectural design of both models, highlighting their modular and flexible structure, which can be adjusted to suit different computational environments. The introduction of Inception-ResNet, a hybrid model that combines Inception modules with residual connections, marks a significant advancement in convolutional neural network (CNN) design, contributing to improved learning and performance in deep neural networks.

B. K. He, X. Zhang, S. Ren, and J. Sun, "Spatial pyramid pooling in deep convolutional networks for visual recognition," IEEE transactions on pattern analysis and machine intelligence, vol. 37, no. 9, pp. 1904–1916, 2015. The paper "Spatial Pyramid Pooling in Deep Convolutional Networks for Visual Recognition" by K. He, X. Zhang, S. Ren, and J. Sun, published in 2015, introduces a novel method called Spatial Pyramid Pooling (SPP) to improve the performance of deep convolutional neural networks (CNNs) in visual recognition tasks. The key problem addressed by the authors is the fixed input size requirement of CNNs, which typically limits the ability of these networks to handle images of varying resolutions. Traditional CNNs require images to be resized to a fixed dimension before being processed, which can lead to loss of important spatial information. To overcome this issue, the authors propose the Spatial Pyramid Pooling layer, which can handle images of different sizes without the need for resizing. This technique involves pooling features from different spatial scales and aggregating them, which allows the network to preserve spatial hierarchies and context, improving its ability to recognize objects at multiple scales.The paper demonstrates that incorporating Spatial Pyramid Pooling into deep networks leads to significant improvements in object recognition tasks. By applying the SPP layer, the network can better utilize information from both global and local image regions, leading to improved performance without the need for drastic image resizing. The authors evaluated the approach on standard benchmark datasets such as the PASCAL VOC and MS COCO, showing that their method outperformed conventional CNN architectures. They also highlighted the versatility of SPP by integrating it into several existing deep learning frameworks, such as the AlexNet and VGG networks. The results of these experiments demonstrate the effectiveness of the Spatial Pyramid Pooling technique in capturing multi-scale information and

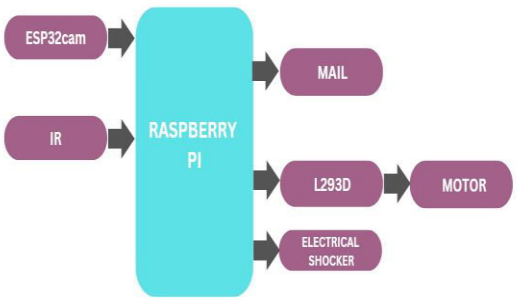
2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

enhancing the generalization capability of deep networks. The paper contributes to the field of visual recognition by providing a more flexible approach for processing images of varying sizes, enabling CNNs to handle a wider range of input data and improve overall accuracy.

C. G. Huang, Z. Liu, L. Van Der Maaten, and K. Q. Weinberger, "Densely connected convolutional networks," in Proceedings of the IEEE conference on computer vision and pattern recognition, 2017, pp. 4700–4708. The paper "Densely Connected Convolutional Networks" by G. Huang, Z. Liu, L. Van Der Maaten, and K. Q. Weinberger, presented at the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) in 2017, introduces DenseNet, a novel architecture for convolutional neural networks (CNNs). DenseNet is designed to address the issue of vanishing gradients and feature reuse in deep networks by employing dense connections between layers. In a typical CNN, each layer receives input from the previous layer and passes its output to the next layer. However, this architecture does not allow direct access to earlier layers, which can hinder gradient flow during backpropagation and limit the effective reuse of features. DenseNet solves this by ensuring that each layer receives inputs from all preceding layers, resulting in direct connections between each pair of layers. The authors demonstrate that this dense connectivity also enhances feature reuse, as each layer has access to features from all previous layers, making the network more compact and reducing the number of parameters compared to traditional CNNs. In their experiments, the authors evaluate DenseNet on several benchmark datasets, including CIFAR-10, CIFAR-100, and ImageNet, and show that it outperforms other state-of-the-art CNN architectures in terms of accuracy and efficiency. DenseNet achieves competitive or superior results with fewer parameters than other deep learning models, making it a more resource-efficient alternative. The paper also explores the impact of different design choices, such as the number of layers and the growth rate, on the model's performance. Additionally, the authors discuss how the DenseNet architecture can be integrated with existing neural network frameworks and provide insights into its applicability for tasks like object classification, segmentation, and detection. The DenseNet approach has since become influential in deep learning research, particularly for applications requiring highly efficient networks that retain performance across various tasks. By fostering feature reuse and improving gradient flow, DenseNet has contributed significantly to the ongoing advancement of CNNs and remains a key innovation in the field of computer vision.

III.IMPLEMENTATION

BLOCK DIAGRAM



POWER SUPPLY

A **regulated power supply** transforms unregulated AC (Alternating Current) into a stable DC (Direct Current). It guarantees consistent output despite variations in input. A regulated DC power supply is also known as a linear power supply, it is an embedded circuit and consists of various blocks

- **Regulated Power Supply Definition**: A regulated power supply ensures a consistent DC output by converting fluctuating AC input.
- **Component Overview**: The primary components of a regulated power supply include a transformer, rectifier, filter, and regulator, each crucial for maintaining steady DC output.
- **Rectification Explained**: The process involves diodes converting AC to DC, typically using full wave rectification to enhance efficiency.
- **Filter Function**: Filters, such as capacitor and LC types, smooth the DC output to reduce ripple and provide a stable voltage.
- **Regulation Mechanism**: Regulators adjust and stabilize output voltage to protect against input changes or load variations, essential for reliable power supply

SENSORS

Sensors are used for sensing things and devices etc. A device that provides a usable output in response to a specified measurement. The sensor attains a physical parameter and converts it into a signal suitable for processing (e.g. electrical, mechanical, optical) the characteristics of any device or material to detect the presence of a particular physical quantity. The output of the sensor is a signal which is converted to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance, etc

IR SENSOR

In the electromagnetic spectrum, the infrared portion divided into three regions: near infrared region, mid infrared region and far infrared region.

In this blog we are talking about the IR sensor working principle and its applications.

What is an IR Sensor?

IR sensor is an electronic device, that emits the light in order to sense some object of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations.

Fig: Ir Sensor

RPI –PICO

A Raspberry Pi Pico is a low-cost microcontroller device. Microcontrollers are tiny computers, but they tend to lack large volume storage and peripheral devices that you can plug in (for example, keyboards or monitors).

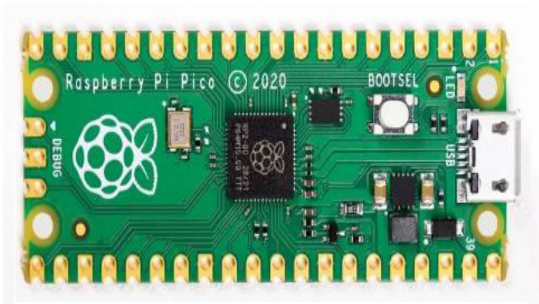
A Raspberry Pi Pico has GPIO pins, much like a Raspberry Pi computer, which means

2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

it can be used to control and receive input from a variety of electronic devices

Raspberry Pi Foundation is well known for its series of single-board computers (Raspberry Pi series). But in **January 2021 they launched their first micro-controller board known as Raspberry Pi Pico**.

It is built around **the RP2040 Soc, a very fast yet cost-effective microcontroller chip packed with a dual-core ARM Cortex-M0+ processor.** M0+ is one of the most power-efficient ARM processorRaspberry Pi PICO board



Raspberry Pi PICO board

Fig: Raspberry Pi Pico Board

Raspberry **Pi Pico is a small, fast, and versatile board that at its heart consists of RP2040**, a brand-new product launched by Raspberry Foundation in the UK. It can be programmed using MicroPython or C language.

DESCRIPTION

The paper titled "A Deep Learning Based Approach for Automated Diabetic Retinopathy Detection and Grading" presents an advanced methodology to automate the detection and grading of Diabetic Retinopathy (DR) using deep learning techniques, particularly Convolutional Neural Networks (CNNs). Diabetic Retinopathy is a leading cause of blindness in diabetic patients, and timely detection is crucial for preventing visual impairment. The conventional approach for diagnosing DR involves manual examination of retinal images by ophthalmologists, a process that is not only time-consuming but also prone to human error, especially with the increasing number of patients. This paper addresses these challenges by proposing a fully automated system that can efficiently detect and grade DR based on retinal fundus images. The proposed system leverages deep learning techniques to analyze retinal images and automatically classify them into different stages of DR, ranging from no DR to severe stages of the disease. The approach involves training a deep convolutional neural network to extract relevant features from retinal images, and the model is designed to be capable of handling various complexities such as different image resolutions and the presence of various artifacts in the images. The paper emphasizes the use of data augmentation and transfer learning techniques to improve the model's performance. Data augmentation helps to increase the diversity of training data by applying transformations such as rotations and flips, which makes the model more robust and less prone to overfitting. Transfer learning, on the other hand, involves using pre-trained models on large datasets, which can be fine-tuned on the target DR dataset. This approach helps to speed up the training process and improves the model's accuracy by leveraging knowledge from previously learned features in general image classification tasks. The paper also explores various deep learning architectures, including popular CNN models, and evaluates their effectiveness in detecting

DR. The authors use a dataset of retinal fundus images, including a variety of diabetic retinopathy stages, to train and test their model. Through rigorous experimentation, they show that the deep learning-based approach not only outperforms traditional machine learning methods but also achieves high accuracy in detecting and grading DR. The system's ability to handle large datasets and provide reliable results highlights its potential for real-world deployment, particularly in resource-limited settings where access to trained ophthalmologists may be limited. Furthermore, the model's automatic grading system can classify DR into multiple severity categories, which can assist healthcare professionals in making better-informed decisions regarding treatment options for patients. In conclusion, this paper proposes a highly effective and efficient deep learning-based solution for the detection and grading of diabetic retinopathy, demonstrating the power of advanced neural network models in the healthcare domain. The proposed approach not only reduces the burden on medical professionals but also ensures early detection of DR, which is critical for preventing blindness in diabetic patients. The integration of deep learning into DR screening systems has the potential to revolutionize diabetic retinopathy management, providing timely and accurate results that could significantly improve patient outcomes worldwide.

CONCLUSION

In conclusion, the automated Diabetic Retinopathy (DR) identification and grading system developed using transfer learning and stacking demonstrates remarkable performance, achieving an accuracy of 99.5% for the identification task and 99.6% for the grading task on the IDRiD (Indian Diabetic Retinopathy Image Dataset) dataset. Despite the relatively small size of the dataset, the combination of transfer learning and stacking techniques has proven to be highly effective in improving the accuracy and robustness of the system. Transfer learning, which utilizes pre-trained models on large datasets and fine-tunes them for DR detection and grading, played a crucial role in overcoming the challenges associated with limited data. By leveraging knowledge from pre-trained models, the proposed system was able to generalize well, even with fewer images, making it a valuable tool for automated DR detection in real-world settings, where acquiring large annotated datasets may be challenging. The use of stacking, an ensemble learning technique, further enhanced the model's performance by combining the strengths of multiple models, ensuring more reliable and consistent predictions. This combination of techniques not only improves the accuracy of DR identification and grading but also reduces the risk of overfitting, which is a common issue in deep learning models trained on small datasets. The results of this study suggest that the proposed system can be a viable and effective alternative to manual screening, reducing the workload on ophthalmologists and making DR detection more accessible, especially in regions with limited access to healthcare professionals. While the current system has yielded promising results, there is potential for even greater performance improvements with the use of larger and more diverse datasets. By training the model on a broader range of retinal images from diverse demographics, the system's ability to generalize across various populations could be further enhanced, ensuring better detection and grading of DR in different clinical settings. In addition to expanding the dataset, further exploration of more sophisticated stacking methods and additional deep learning techniques could be employed to fine-tune the system and improve its overall efficacy. For instance, experimenting with different combinations of models, optimizing hyperparameters, or incorporating other advanced techniques like attention mechanisms or multi-task learning could lead to further gains in performance. Additionally, future work could focus on the integration of the system into real-time clinical settings, where it can assist healthcare professionals in diagnosing DR at an early stage, allowing for timely intervention and preventing severe vision impairment or blindness. Furthermore, with the increasing availability of large-scale medical image datasets and advancements in machine learning, there is a growing opportunity to develop even more accurate and efficient models for DR detection and grading. In conclusion, the research demonstrates the power of transfer learning and stacking in addressing the challenges of automated DR detection and grading, offering an effective and scalable solution for early diagnosis, which is critical for preventing blindness in diabetic patients.

REFERENCES

[1] J. C. Javitt, L. P. Aiello, Y. Chiang, F. L. Ferris, J. K. Canner, and S. Greenfield, "Preventive eye care in people with diabetes is cost-saving to the federal government: implications for health-care reform," Diabetes care, vol. 17, no. 8, pp. 909–917, 1994.

[2] K. S. Arun, V. Govindan, and S. M. Kumar, "Enhanced bag of visual words representations for content based image retrieval: a comparative study," Artificial Intelligence Review, 53, pp. 1615–1653, 2020.

[3] K. S. Arun and V. Govindan, "A context-aware semantic modeling frame-work for efficient image retrieval," International Journal of Machine Learning and Cybernetics, vol. 8, no. 4, pp. 1259–1285, 2017.

[4] W. Zhang, J. Zhong, S. Yang, Z. Gao, J. Hu, Y. Chen, and Z. Yi, "Automated identification and grading system of diabetic retinopathy using deep neural networks," Knowledge-Based Systems, vol. 175, pp. 12–25, 2019.

[5] P. Porwal, S. Pachade, R. Kamble, M. Kokare, G. Deshmukh, V. Sahasrabuddhe, and F. Meriaudeau, "Indian diabetic retinopathy image dataset (idrid): a database for diabetic retinopathy screening research," Data, vol. 3, no. 3, p. 25, 2018.

[6] A. Benzamin and C. Chakraborty, "Detection of hard exudates in retinal fundus images using deep learning," in 2018 Joint 7th International Conference on Informatics, Electronics & Vision (ICIEV) and 2018 2nd International Conference on Imaging, Vision & Pattern Recognition (icIVPR). IEEE, 2018, pp. 465–469.

[7] M. Jena, S. P. Mishra, and D. Mishra, "Detection of diabetic retinopathy images using a fully convolutional neural network," in 2018 2nd International Conference on Data Science and Business Analytics (ICDSBA). IEEE, 2018, pp. 523–527.

[8] E. V. Carrera, A. Gonzalez, and R. Carrera, "Automated detection of diabetic retinopathy using svm," in 2017 IEEE XXIV International Conference on Electronics, Electrical Engineering and Computing (INTERCON). IEEE, 2017, pp. 1–4.

[9] Y. Wu and Z. Hu, "Recognition of diabetic retinopathy based on transfer learning," in 2019 IEEE 4th International Conference on Cloud Computing and Big Data Analysis (ICCCBDA). IEEE, 2019, pp. 398–401.

[10] T. Karim, M. S. Riad, and R. Kabir, "Symptom analysis of diabetic retinopathy by micro-aneurysm detection using nprtool," in 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST). IEEE, 2019, pp. 606–610.

[11] S. Kajan, J. Goga, K. Lacko, and J. Pavlovicˇova´, "Detection of diabetic retinopathy using pretrained deep neural networks," in 2020 Cybernetics & Informatics (K&I). IEEE, pp. 1–5.

[12] J. Wang, R. Ju, Y. Chen, L. Zhang, J. Hu, Y. Wu, W. Dong, J. Zhong, and Z. Yi, "Automated retinopathy of prematurity screening using deep neural networks," EBioMedicine, vol. 35, pp. 361–368, 2018.