Deep Learning based Automated Diagnosis of Ocular Toxoplasmosis in Fundus Images using Convolutional Neural Network

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Introduction -

Toxoplasmosis is a parasitic infection caused by the parasite Toxoplasma gondii. It's a prevalent infection that affects millions of people around the world.

The parasite can enter the body by contaminated food or water, or from contact with infected animals, particularly cats.

While most people with toxoplasmosis have no symptoms, the illness could cause flu-like symptoms in other people.

The parasite can infect the eyes in some circumstances, causing a condition known as ocular toxoplasmosis. This can lead to vision loss and other eye issues.

Problem Statement-

- The lack of an automated system for identifying ocular pictures hinders accurate and efficient diagnosis.
- Improving diagnostic tools in ocular health is crucial to meeting the increased demand for rapid and accurate diagnosis .
- The lack of an automated approach contributes to delays and probable mistakes in diagnosing eye diseases.
- This gap in automated diagnoses reduces the overall effectiveness of diagnostic systems, negatively impacting patient outcomes in ocular health.

Research Objective-

- Build a unique custom CNN model using deep learning specifically for identifying ocular toxoplasmosis.
- Establish an efficient system for classifying eye images, accurately differentiating between healthy and unhealthy conditions.
- Enhance precision and accuracy in disease classification, with a primary focus on faster prediction for improved efficiency.
- Share the discoveries with medical practitioners, emphasizing how they practically contribute to advancing the diagnosis and treatment of ocular toxoplasmosis within the medical domain.

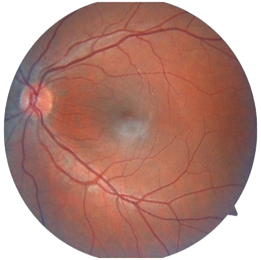
Data Description

- We collected pictures of eyes from the Hospital de Clínicas in Asuncion, Paraguay, and Niños de Acosta Nú General Pediatric Hospital.

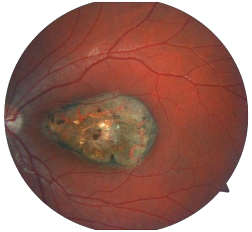
- Ocular Toxoplasmosis (OT) Fundus Images Dataset has multiple categorization such as   active, active-Inactive, healthy and inactive contains 68, 111, 160 and 251 respectively. Total count of image is 590.

Active

Active-Inactive



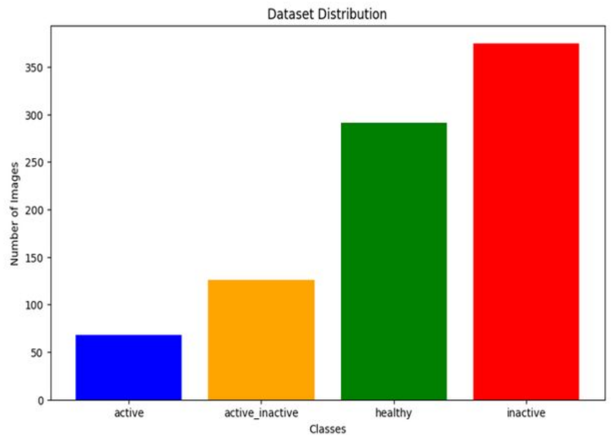
Healthy

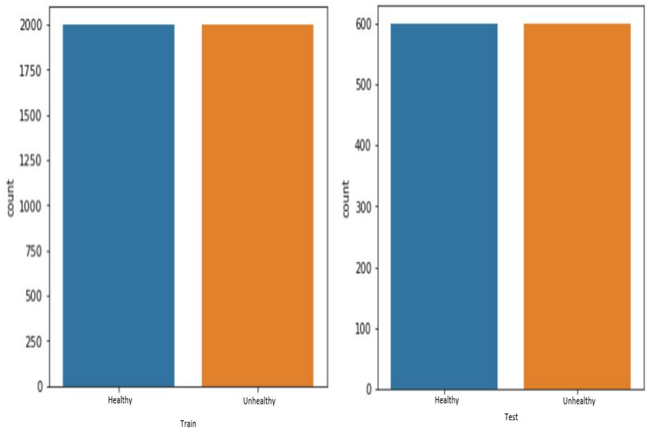


Inactive

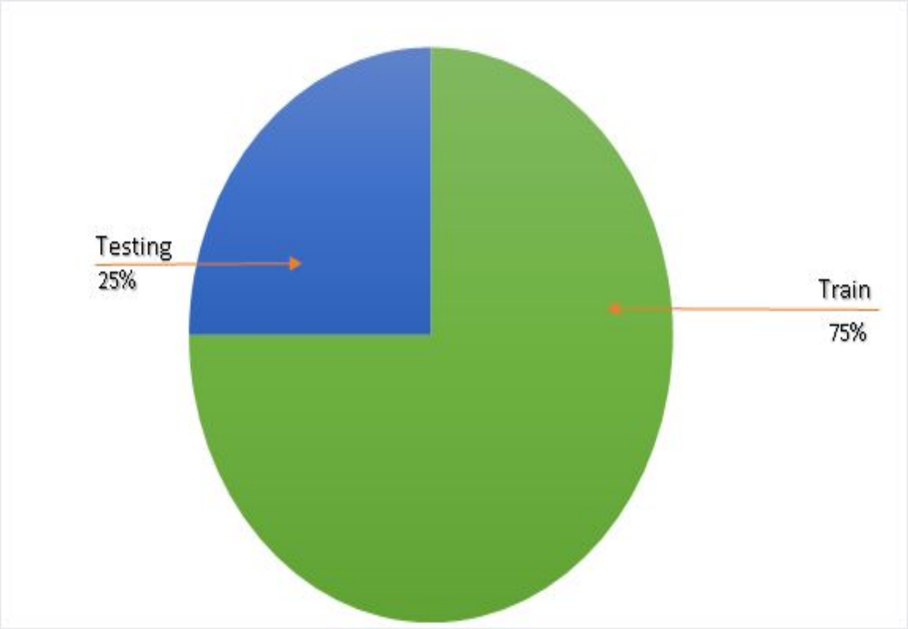
Data Augmentation

Due to the small number and Imbalanced dataset, we perform augmented data to increase number of images and balance. Moreover, for better result we convert multiclass to binary classification Which are healthy and Unhealthy. After Augmentation Total Size of data will be 5200. Where train contains 4000 and test contain 1200.





Data Splitting



Literature Review and Related Works

- **Parra et.al[1] used ResNets to detect OT from fundus images obtained 93% accuracy**
- **E.Abdel Maksoud et al.[2] detect ocular diseases from color fundus images**
- **D.Abeyrathna[3] introduces a segmentation network fine-tuning technique that enhances network performance using Mask R-CNN by clustering predictions and labeled training instances**
- **M. S. Khan et al.[4] study on eye disease classification converts multi-class classification problem into binary tasks using balanced data-sets.**

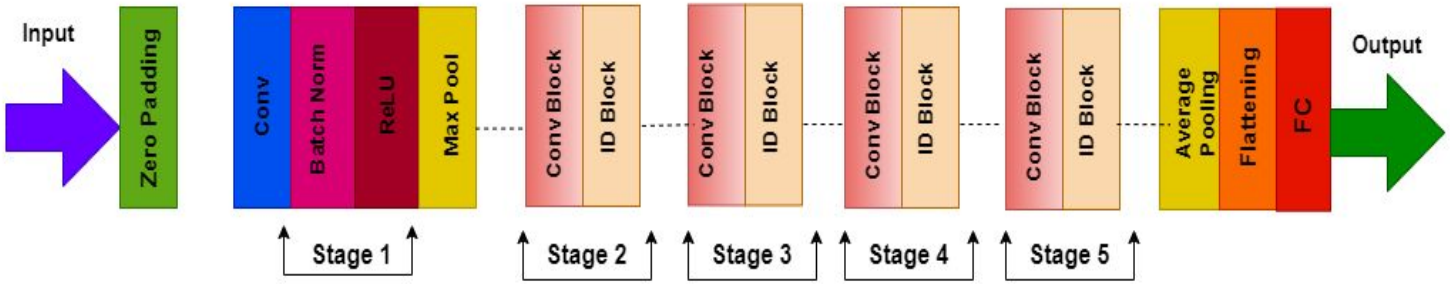
Applied Models

- ❖ Customize Model
- ❖ VGG16 Model
- ❖ VGG19 Model
- ❖ Mobilenet Model
- ❖ ResNet50 Model
- ❖ Ensemble model

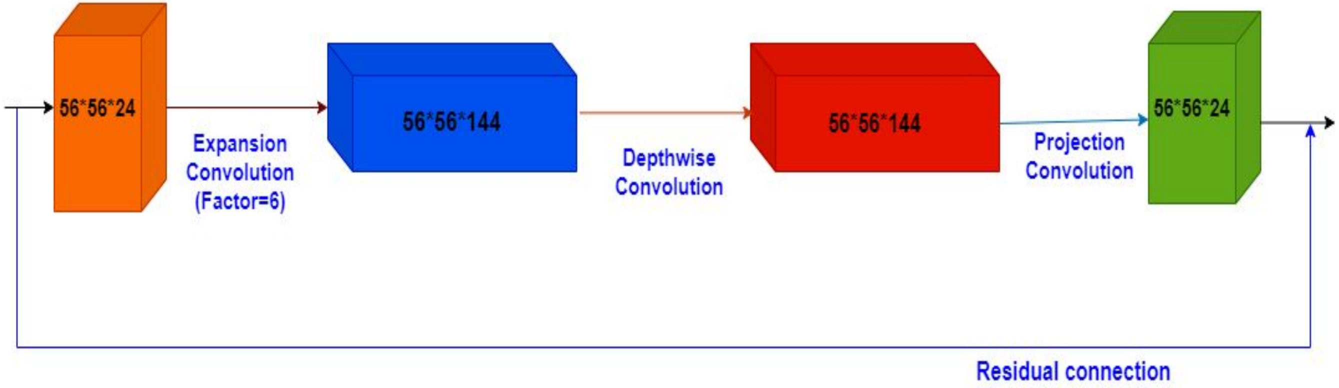
Custom Model Architecture

- **Convolutional Layers**: It has four 2D Convolutional layers where for filter size are 128, 32, 64 and 128.
- **Max Pooling Layers**: After each batch normalization layer Pooling layer or Max pooling layer has added.
- **Batch Normalization Layers**: We used the Batch Normalization layer following each convolution layer. In 35 essence, this layer normalizes activation, which speeds up and stabilizes our customized CNN model.
- **Flatten Layers:** The model's Flatten layer flattens 2D feature maps into a 1D vector, facilitating data transfer from convolutional layers to fully connected layers for processing and classification.
- **Output Layer:** The model uses three dense layers for feature extraction and transformation, with the first providing a high-dimensional representation, the second providing a compact representation, and the final producing binary classification probabilities.

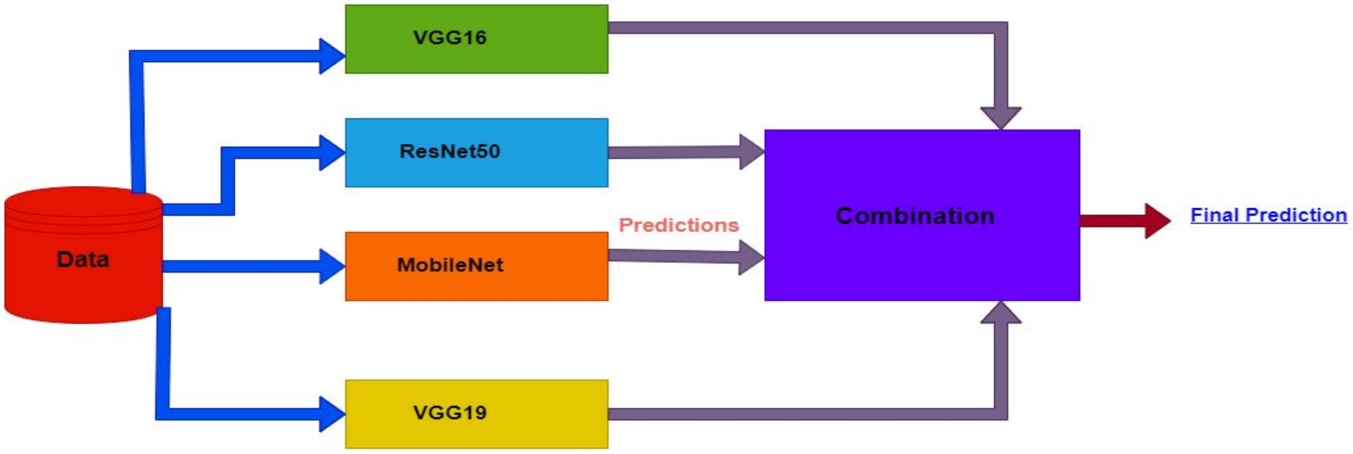
Resnet 50 Model Architecture



MobileNet Model Architecture



Ensemble Model Architecture



VGG19 ARCHITECTURE

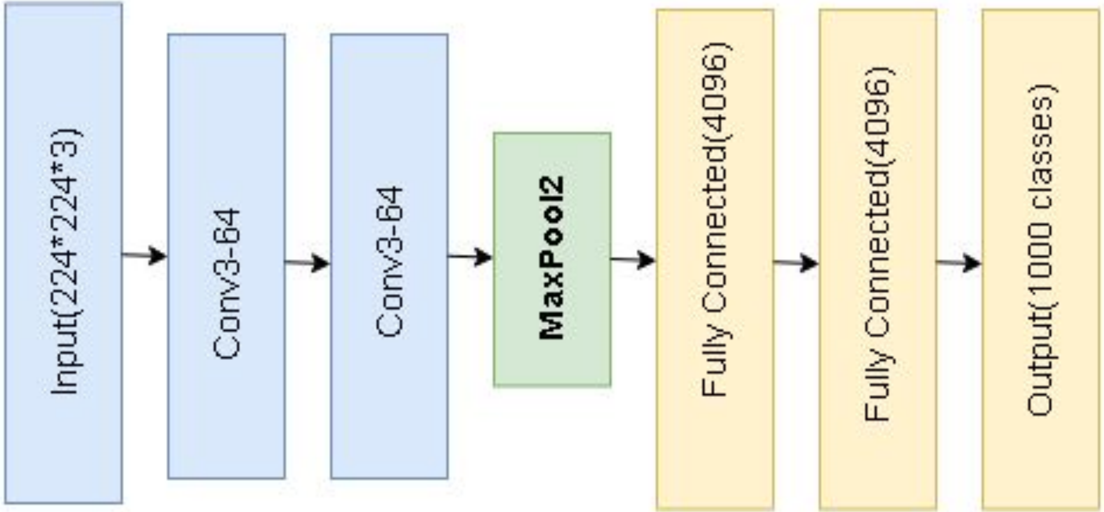
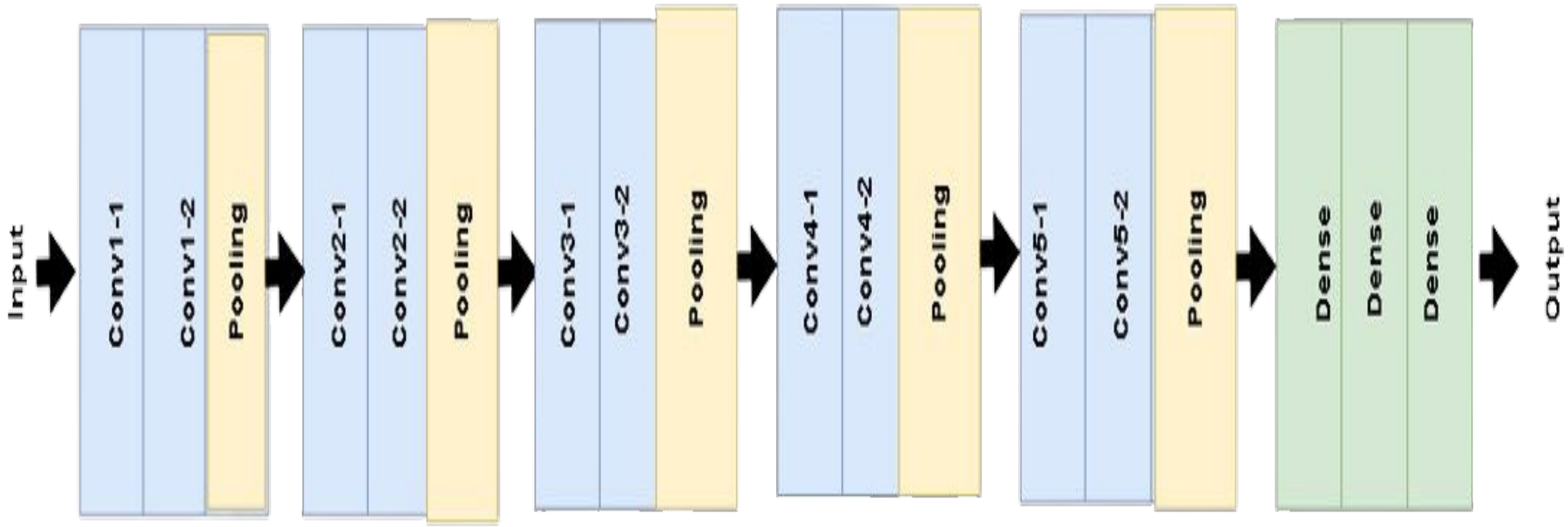
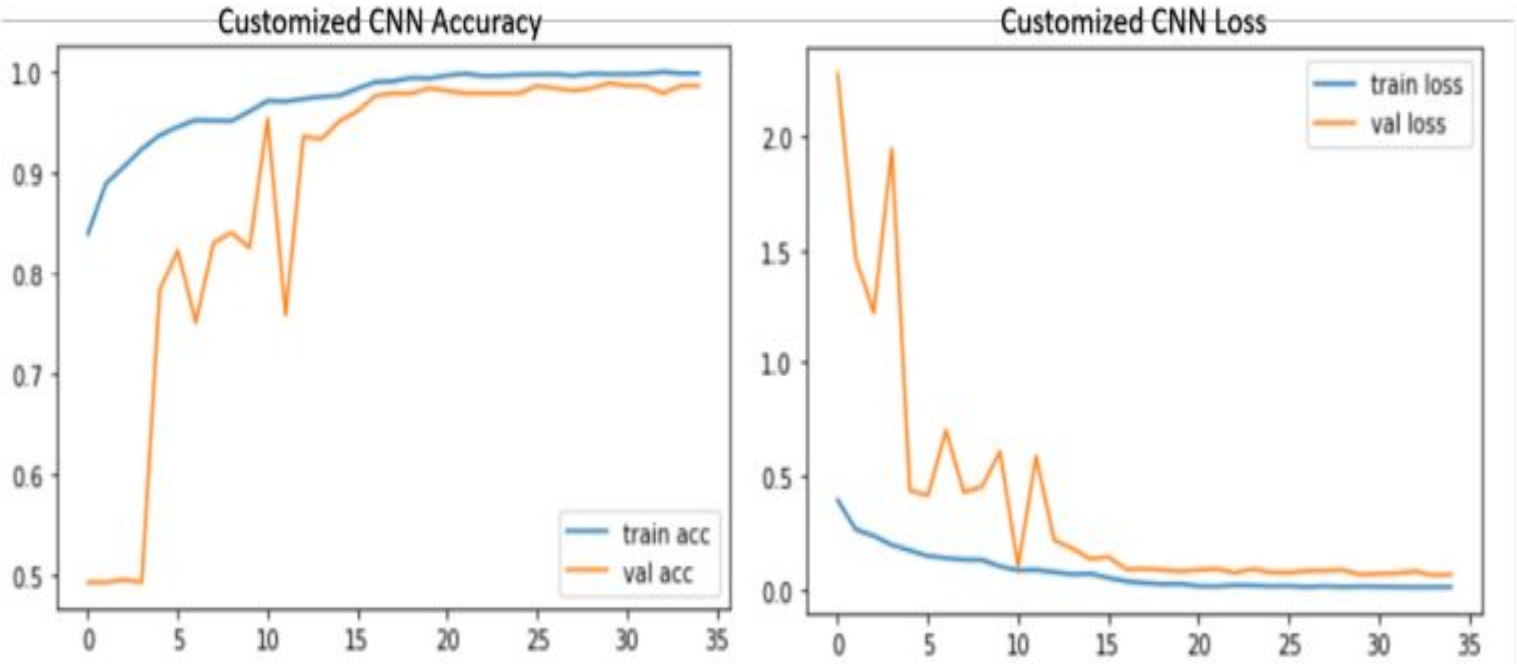


Fig:VGG19 Architecture

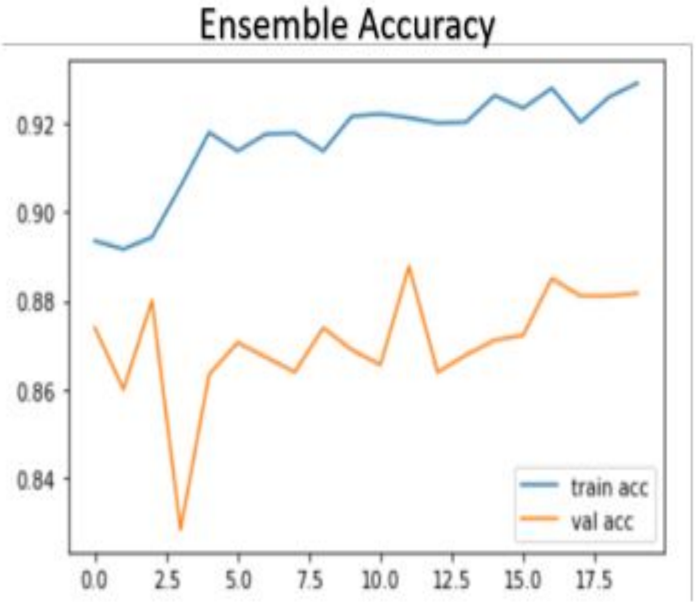
VGG16 ARCHITECTURE

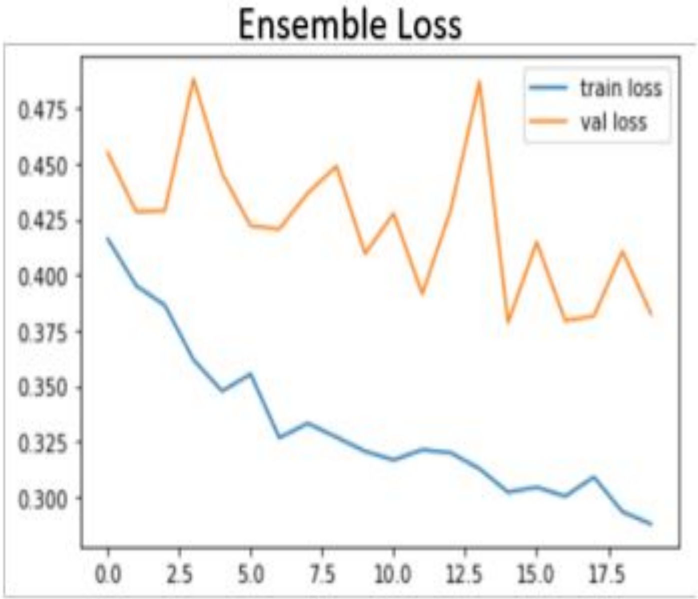


Customize Model Result

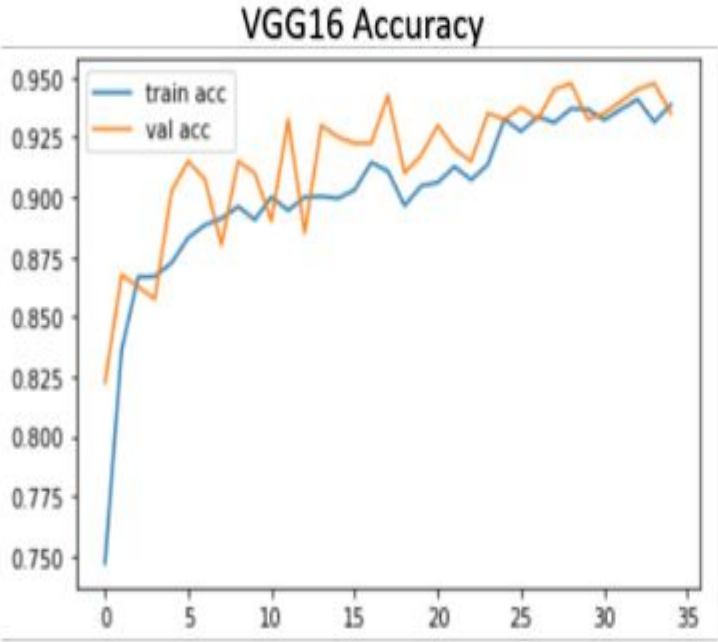


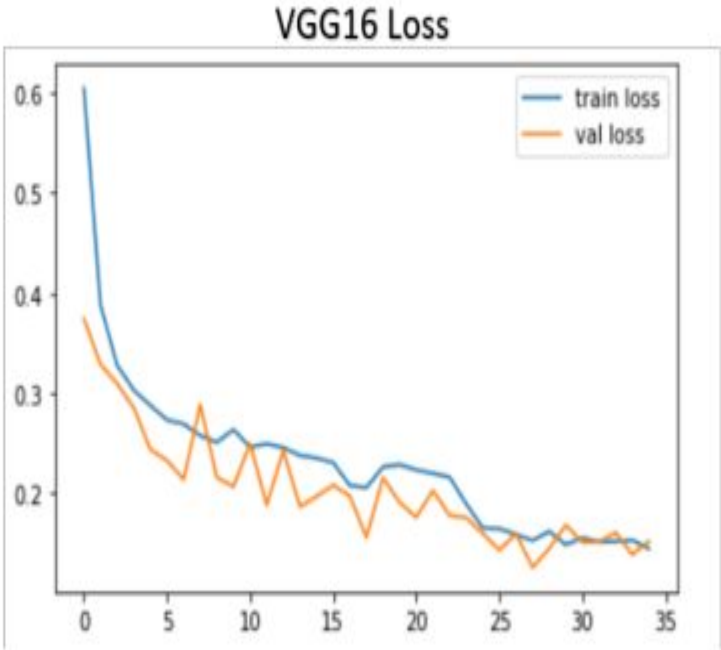
Ensemble Model Result



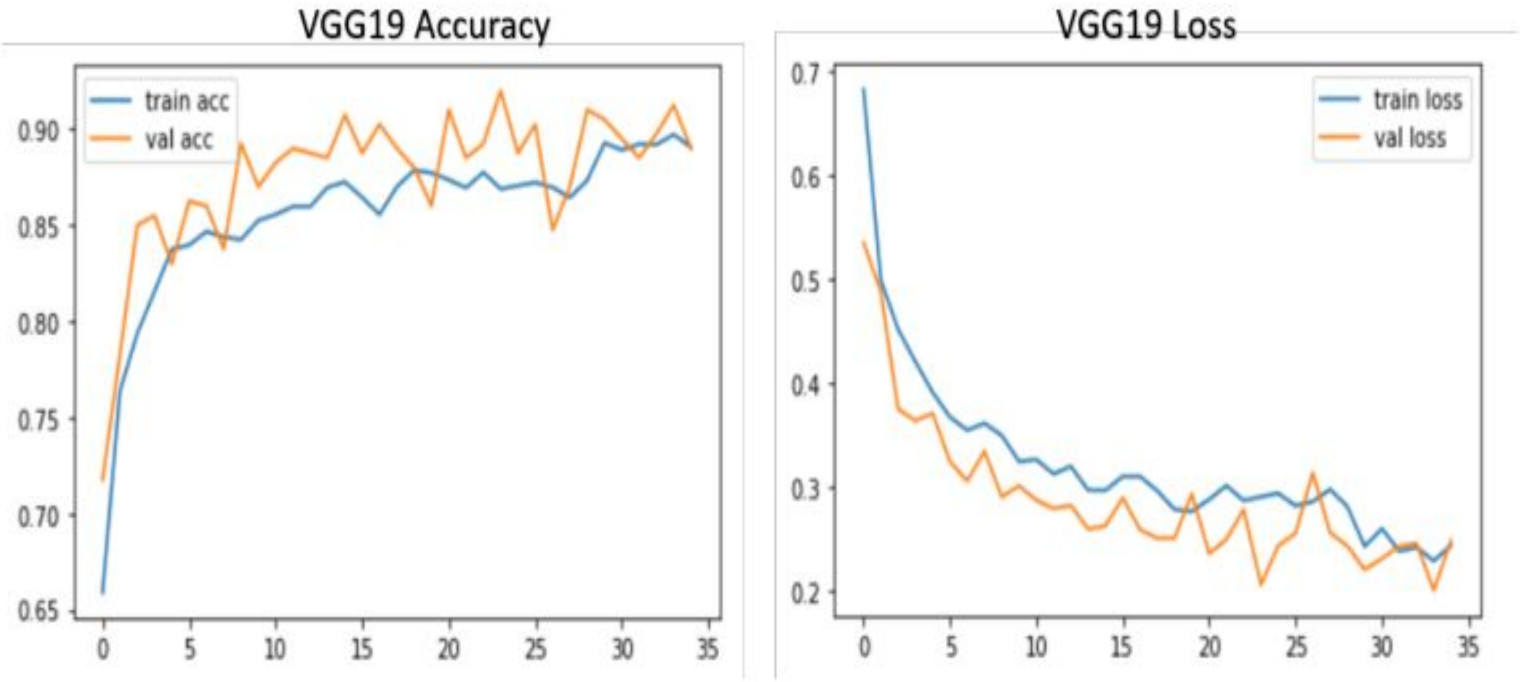


VGG16 Model Result

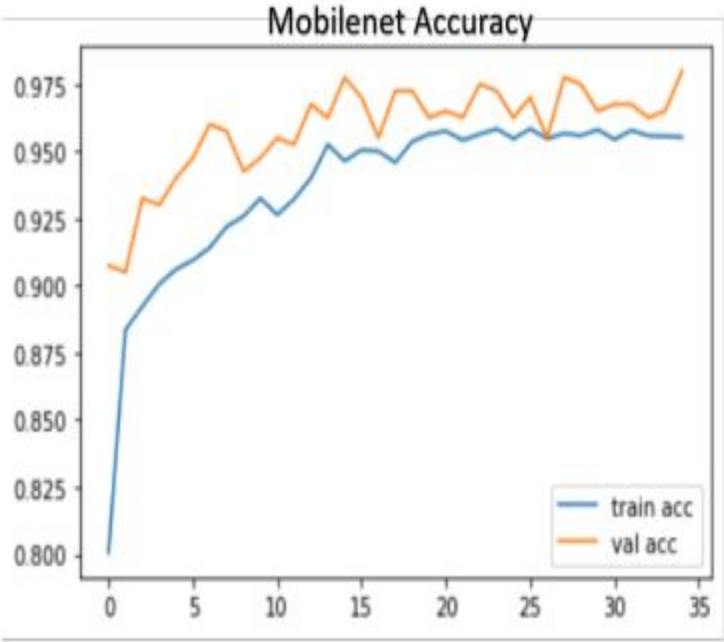


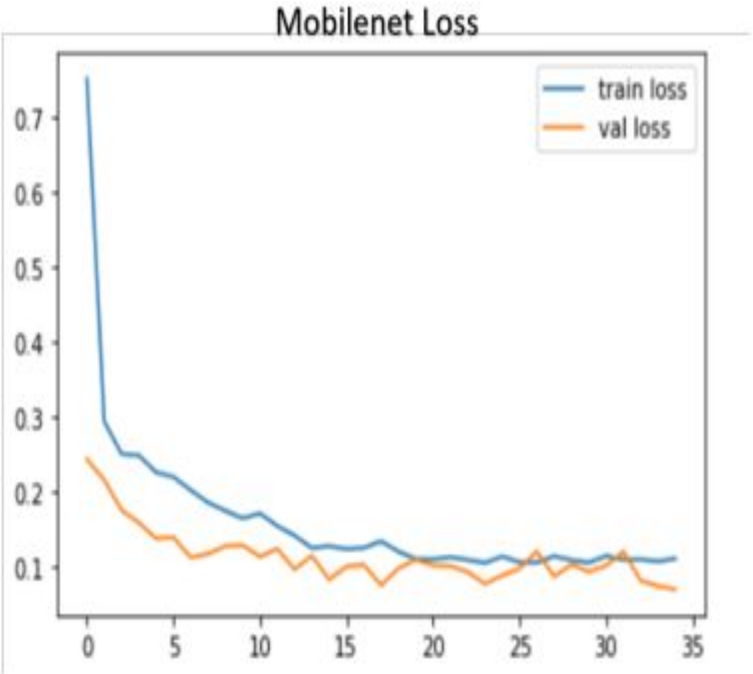


VGG19 Model Result

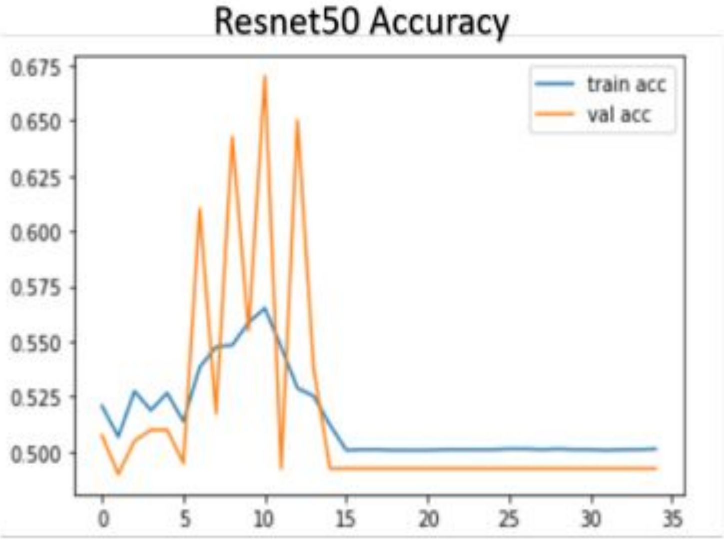


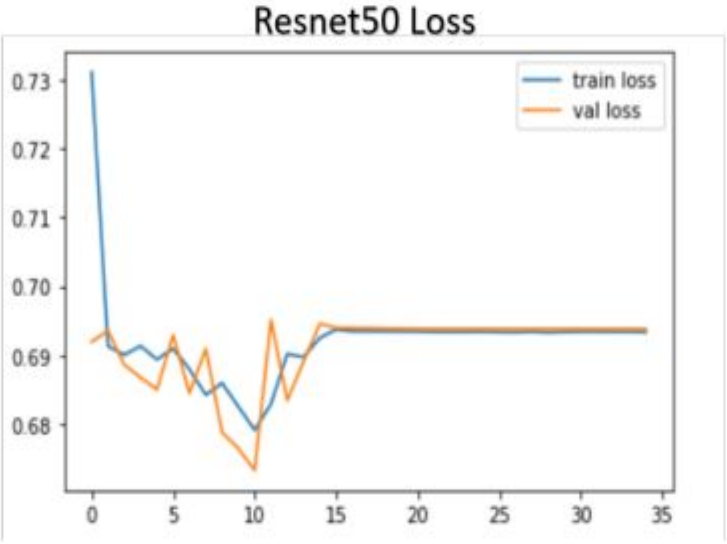
Mobilenet Model Result





ResNet50 Model Result





Result of Models

MODEL	Accuracy	Loss
Customized CNN	95%	0.11
VGG16	94%	0.19
VGG19	93%	0.24
Mobilenet	92%	0.13
Ensemble Model	92%	0.28
Resnet50	50%	0.70

Comparison of Previous Work

Approaches	Models	Accuracy
Customized CNN	CNN	95%
E.Abdel Maksoud et.al[9]	ML-CNN	94.3%
Parra et.al[2]	Resnet	93%
E.Abdel Maksoud	Mobilenet	92%
D.Abeyrathna et.al[22]	Mask R-CNN	66%

Conclusion-

- Utilized a custom CNN model for effective ocular toxoplasmosis detection.
- Despite limited data, maximized its utility to enhance detection accuracy.
- Exploring the potential of a fusion model for improved detection in future studies.

References:

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2. O. Ouda ,E. Abdel Maksoud, A. a. A. El-Aziz and M. Elmogy, " Multiple ocular disease diagnosis using FundUS images based on Multi-Label Deep Learning Classification," in (Electronics, June.2022),vol .11,pp. 1966, doi: 10.3390/electronics11131966.
3. D.Abeyrathna et al., "Directed Fine Tuning Using Feature Clustering for Instance Segmentation of Toxoplasmosis Fundus Images," In IEEE 20th International Conference on Bioinformatics and Bioengineering (BIBE), Cincinnati, OH, USA, 2020, pp. 767-772, doi:10.1109/BIBE50027.2020.00130.
4. khan and M.S,"Deep Learning for Ocular Disease Recognition : an Inner-Class balance," in (Computational Intelligence and Neuroscience,2022),pp. 1–12.