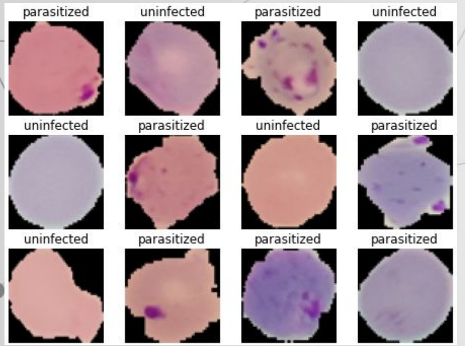
Deep Learning *CNN Project*
Malaria Image Detection

PROFESSIONAL EDUCATION



Alvin Kuo, April, 2022

0 KEY TAKEAWAYS

Overview of the Malaria Detection Project

1 OVERVIEW OF THE PROBLEM

CNN Solves the Malaria RBC Detection Issues with 99% Successful Rate

2 APPROACH FOR THE SOLUTION

ANN/CNN. Data Augmentation
Hyperparameter Fine-tuning
Transfer Learning

3 KEY FINDINGS

The Best Model is From the Base Model
Data Augmentation Has Potential
Pre-trained Model Saves Time and Efforts

4 KEY INSIGHTS

The Best Model For This Project Does Not Necessarily Need to Be Very Deep or Super Sophisticated

5 BUSINESS RECOMMENDATIONS

We Have All Kinds of Recommendations to Fit in Various Business Considerations

6 NEXT STEPS

Production, Data Augmentation and more Pre-trained Models and Mislabelling Data
Infrastructure, Streamlining and Resources Relocation

1 OVERVIEW OF THE PROBLEM

CNN Automation Beats Human Eyes, Save Time and Flexible Anytime Anywhere

Can CNN Automation Perform Better than Human Eyes?

Yes, We have more than 4 models can beat the traditional 95.8% recall/sensitivity rate

Can CNN Save Time and Efforts?

Yes, our model runs 25K+ images with less than 1 minute. Human eyes may need at least 3 second per image, which takes 75K second, equal to one man non-stop working 8 hours for 3 days.

Can CNN be Applied Anytime Anywhere?

Yes. CNN's model could be ran whenever the computing devices could have internet connection The web-based Jupyter or Colab would be utilized anytime anywhere

Can CNN Offer Options for Decision-maker Pick & Choose?

Yes. We ran 11 models to find out a portfolio to meet various measurements of success

2 APPROACH FOR SOLUTION SUMMARY

Base and Deeper CNN, Augmentation, VGG 16 and DenseNet 121 Outshine
Our Innovation: Always Dual Match to Compare in Search for the Best Model

ANN Model
Experiment with ANN to solve spatial problem

Base CNN Model
Foundation to explore various direction to fine-tuning the model

Deeper CNN Model
Purely more and deeper layers model

Model + Augmentation
Data Augmentation to test the power of learning

Regularization + Activation Function
Further Hyper parameter fine-tuning and overfitting examination

VGG 16 & VGG 16 + Aug.
Famous 2014 16-convolution-layer model to start transfer learning

VGG 19
19-convolution-layer modified version to test the deeper power

ResNet 50 & ResNet 50 + Aug.
2015: 50-layer residual network using 3-layer bottleneck block in summation

ResNet 101
101-layer residual network using more 3-layer block in summation

DenseNet 121 & DenseNet 121 + Aug.
2017: 121-layer CNN with efficiency and less parameters in concatenation

DenseNet 201
201-layer CNN with efficiency and less parameters in concatenation

2 SOLUTION VALIDATION

Recall as our Top Measurements. F1 Score/Test Accuracy Follow to Validate the Solution Design

Base and Deeper CNN Model perform the best from Recall, F1 score or Test Accuracy with 98-99%

Base CNN model + Data Augmentation offers a clue with potential to perform well. It's all 98%

Model Name	Recall	F1 Score	Test Accuracy	Total Layers	Trainable Parameters (M)	Epochs	Time (sec)*
ANN Model	58%	62%	64%	**4**	**1.58**	30*	**62***
Base CNN Model	**99%**	**99%**	**99%**	**11**	**1.05**	9	**36**
Deeper CNN Model	**98%**	**98%**	**98%**	**22**	**0.04**	10	**41**
Batch Normalization + LeakyReLU	**95%**	**97%**	**97%**	**11**	**0.55**	4	**13**
Base Model + Data Augmentation	**98%**	**98%**	**98%**	**13**	**1.06**	10	594
VGG 16	**97%**	**95%**	**95%**	26	14.70	7	**96**
VGG 16 + Data Augmentation	**98%**	80%	87%	26	14.70	6	392
VGG 19	**96%**	91%	91%	26	20.00	7	**116**
ResNet 50	87%	76%	73%	62	23.58	9	194
ResNet 50 + Data Augmentation	44%	54%	63%	62	23.58	10	645
ResNet 101	83%	73%	69%	113	42.55	7	246
DenseNet 121	**95%**	**96%**	**96%**	130	6.95	10	**141**
DenseNet 121 + Data Augmentation	**95%**	**96%**	**96%**	130	6.95	8	**114**
DenseNet 201	94%	**95%**	**95%**	213	18.09	10	400

VGG 16 pre-trained model performing with 95-97% still qualifies to beat the traditional approach

DenseNet 121 pre-trained model performing with 95-96% could be invested more time and resource to see the potential as a plan B

3 KEY FINDINGS

The Best Model For This Project Does Not Need to Be Very Deep or Super Sophisticated

Deeper Does not Mean Better

We always tested deeper model on top of the base model while depper model in VGG, ResNet and DenseNet. (Dual to compare). The Deeper one does not beat the original one.

More-Complex Does Not Promise Stronger Result

We always test the more complex one (complicated in layers, blocks, structure), but The ones which are more complex do not perform stronger in this case.

Hyperparameter Fine-tuning Requires Trial and Error

We explore 20+ options to finetune all kinds of hyper parameters with at least 2, sometimes 5+ options to test the direction. We may start from a general/popular basis for two directions, then trial and error afterward

Pre-trained Model Has Great Potential

The pre-trained models with the solid paper, award-winning experiences, large-scale testing save us a great amount of time instead of starting from scratch. We focus on top level layers tuning only.

4 KEY INSIGHTS

Malaria Detection Demonstrates the Power of Deep Learning and CNN

Pick the Base Model for Simplicity and Low Maintenance with the Best Performance - The logic we suggest to pick the base model since it works the best in Recall (Our recommended measurement due to avoid false negative is the top priority) and also in precision, too. Easy to modify if model needs modification with newer data.

Malaria Red Blood Cell Image - Fundamentally, the image has been Giemsa-stained with a pure and specific color. The spots to be detected/learned as infected are in various shape. Computer won't get it from any rotation, texture, or flip. It's 2 classes but not 10, or 1,000 classes to detect. So the level of this image classification may not need a super deep or sophisticated model.

The process of trial and error for the tuning in hyperparameters - It is the most time-consuming for us to come out if the model works and performs the best for us to pick and choose. This process may improve with more fundamental knowledge of every parameter and general usage to start and go with a specific direction. However, trial-and-error is still required in certain level.

The benefit of pre-trained model is obvious - However, it also requires the understanding of the strength and the weakness of every pre-trained model to explain the result. Our DenseNet performs better than ResNet could indicate this process is in favor of less (trainable) parameters

5 KEY RECOMMENDATIONS

Pick the Base Model
Prep for Infrastructure Readiness, Streamlining the Process and Relocate the Resources

Pick Base or Deeper Model as the Best Model to Implement is our Key Recommendation

Computing Hardware Readiness:
From a low-tier smartphone to any tablet, laptop to PC

Internet Access Readiness:
From WiFi to 5G/4G/3G to Starlink

Software/Application Readiness - Jupyter/Colab

key recommendations to implement the solution

key actionables for stakeholders

CNN Malaria Detection is part of the screening process to classify the red blood cell for infection. Action items include:

Streamlining the whole screening process
Preparing for the infrastructure of the CNN automation
Relocate the resources of manpower after CNN automation build-up

Defense for cybersecurity, data Management and potential Data loss, and Crisis Management for the process paused/outrage by hardware, software or internet access issues

6 KEY NEXT STEPS

Implementation while More Model Explorations to Try

Different Production/Cloud Provider

Compare time, expense and performance AWS, Microsoft Azure or GCP Since Cloud Provider could offer efficiency of production including:
1) Data storage and retrieval 2) Frameworks and tooling 3) Feedback and iteration

Infrastructure Build-up

Related hardware, software and internet access

Defense with Reliability

Cybersecurity, data management, precocious actions for crisis management

Different Pre-trained model

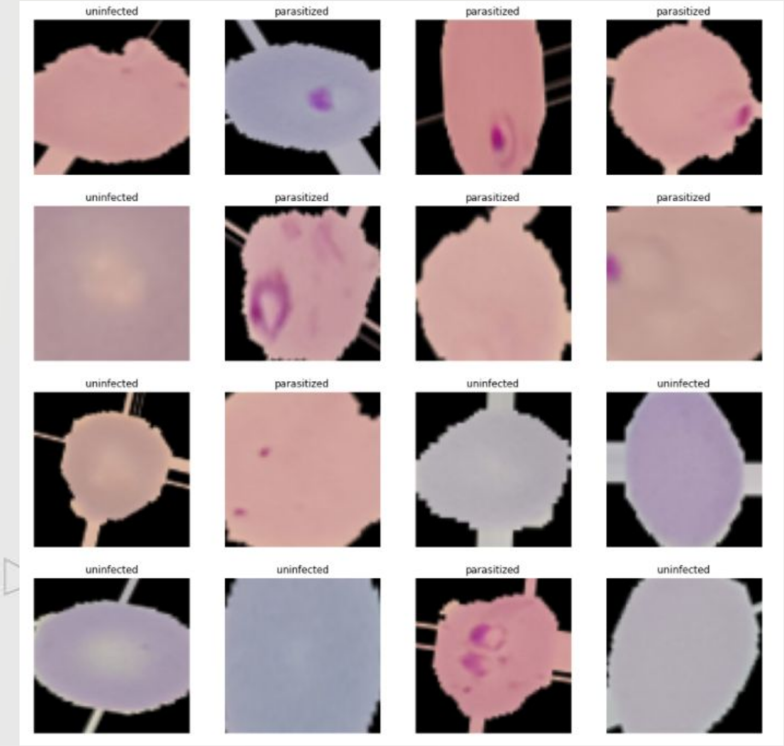
Compare performance with Mask R-CNN, U-Net Inception, EfficientNet and AlexNet

Starting from Scratch of Image Labelling

Miss-labelling Images

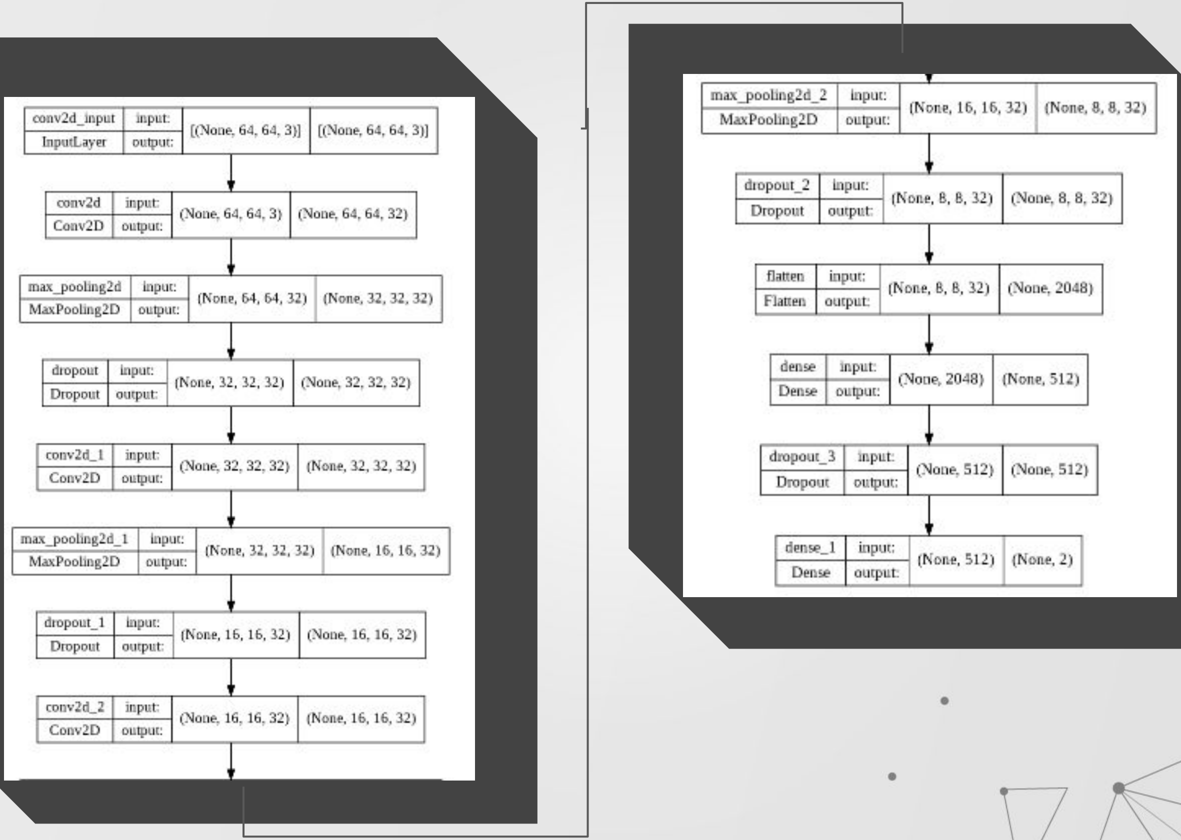
APPENDIX 1 - Data Augmentation Images

Data Augmentation Images from the Model 3 after flip, rotation and more



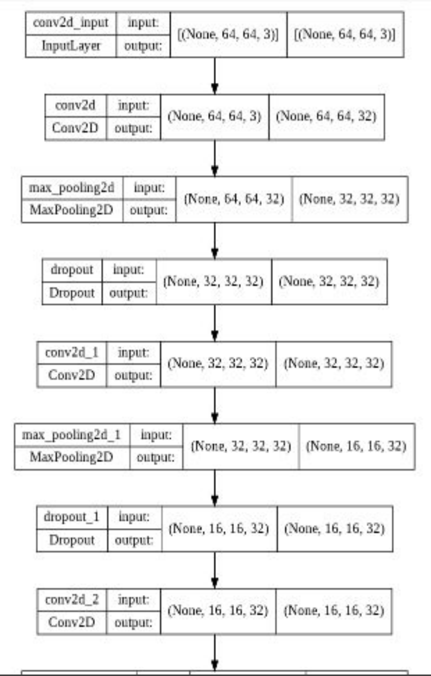
APPENDIX 2 - Base Model

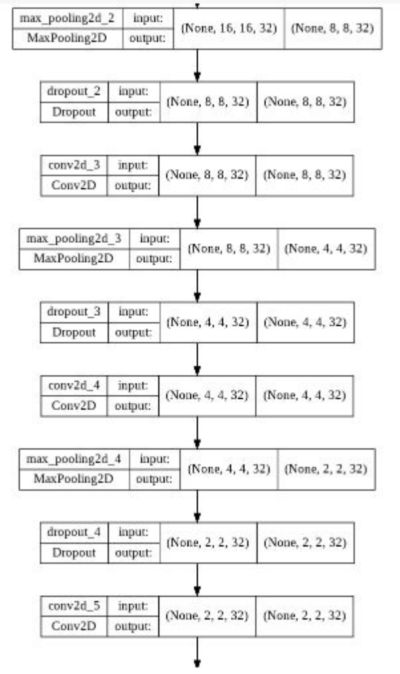
The 13-layer base model demonstrates the simplicity and the power of the model

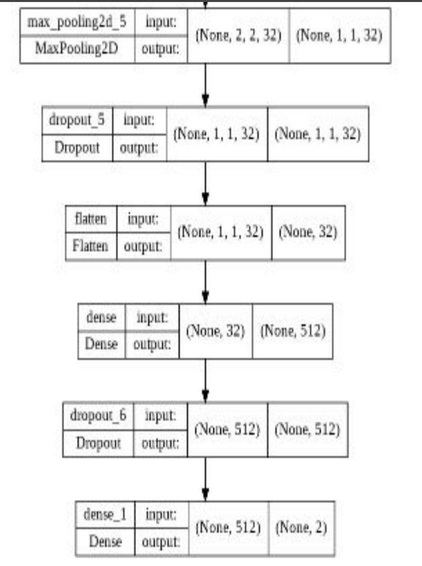


APPENDIX 3 - Deeper Model

The 22-layer base model tests and shows the deeper model also guarantee better result

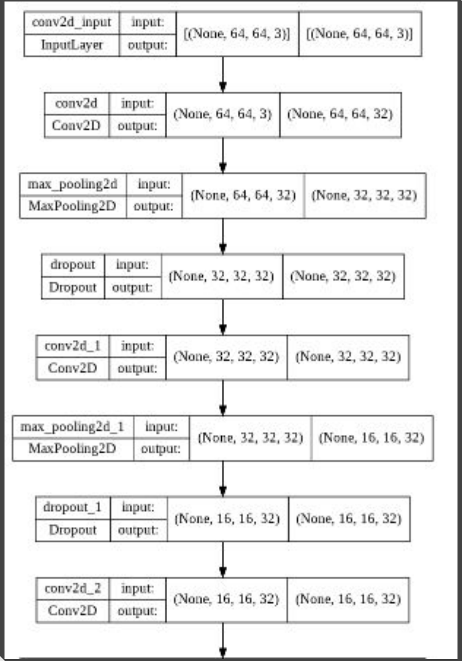


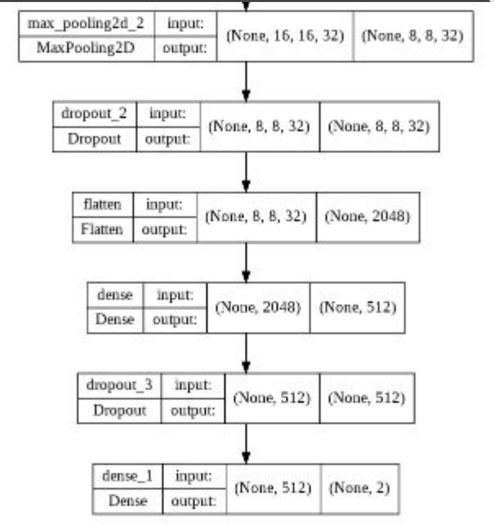




APPENDIX 4 - Base Model + Augmentation

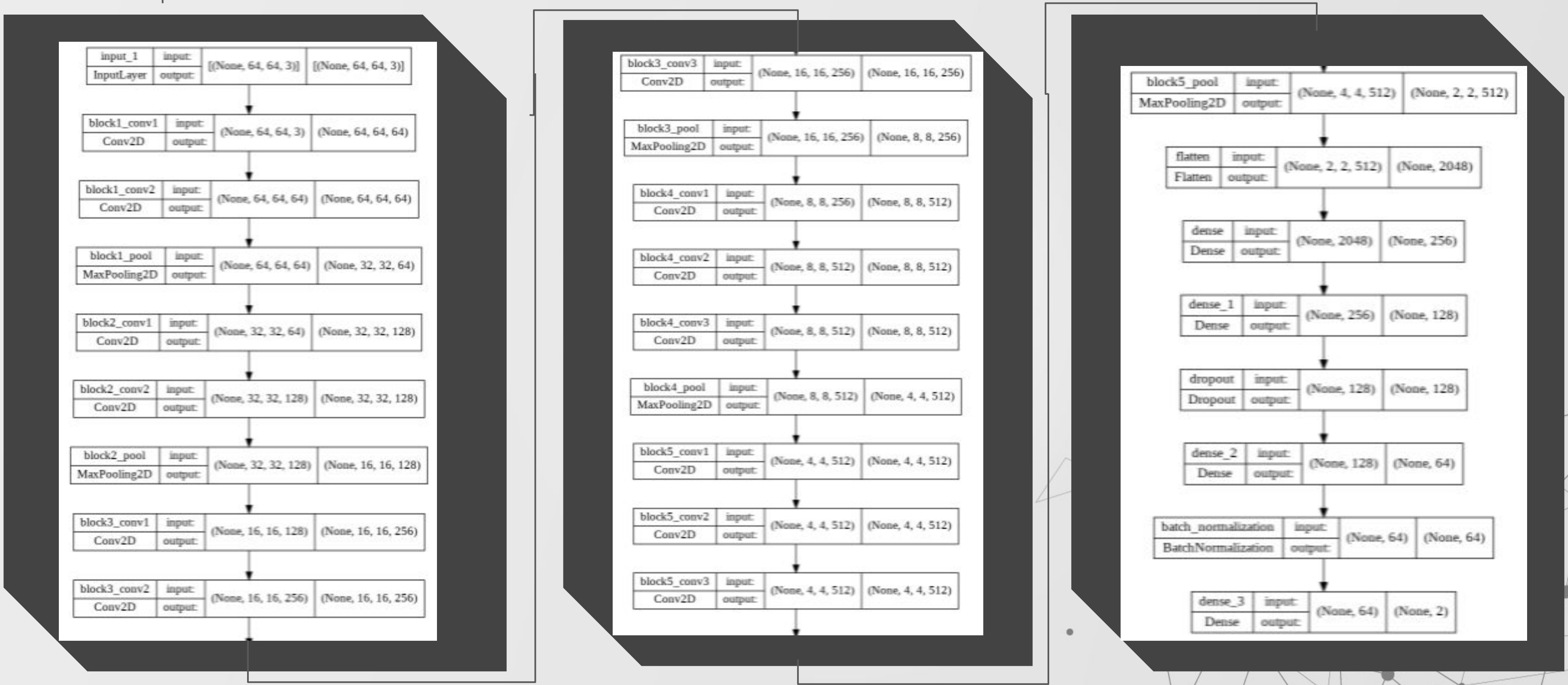
The 13-layer base model with data augmentation explores the possibility for better detection





APPENDIX 5 - VGG16: Pre-trained model

The 26-layer VGG16 provides another window to leverage the pre-trained model



THANKS

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