White Blood Cell Image Classifier

Capstone Project

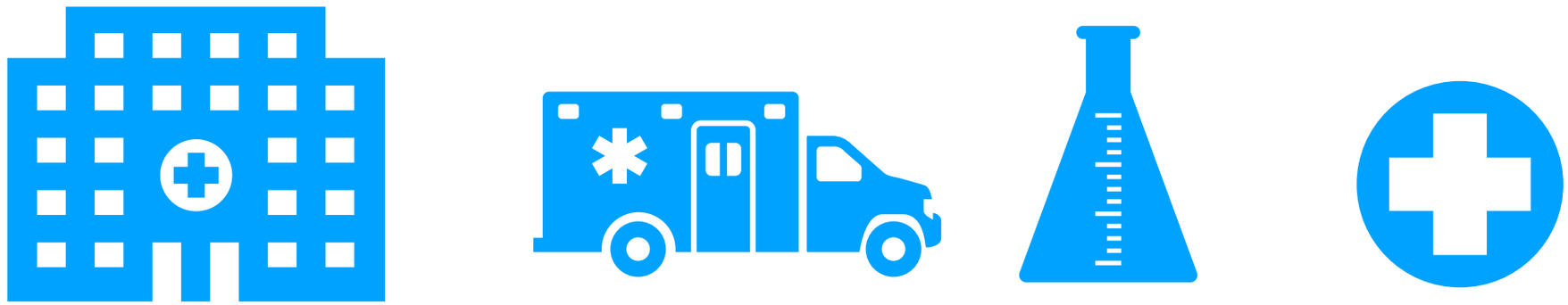
Michal Czapski
czapski.michal@gmail.com

Contents

Introduction

Blood cell classification is laborious work done manually by pathologist that could be automated to save time and resources

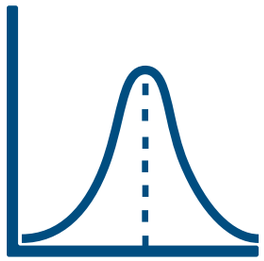
Automated process of image classification could be used by medical companies and institutions that could retrieve more information about blood related diseases or use it for other medical applications that require fast analysis



Hospitals | Clinics | Cell Laboratories | Medical Companies

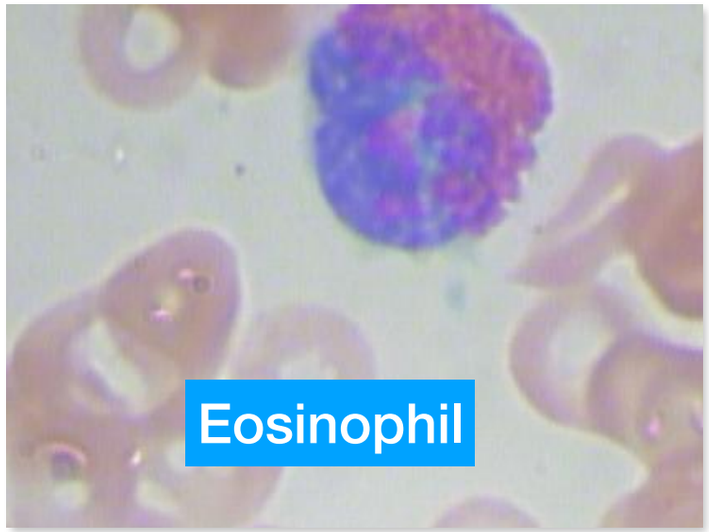
Samples Collection

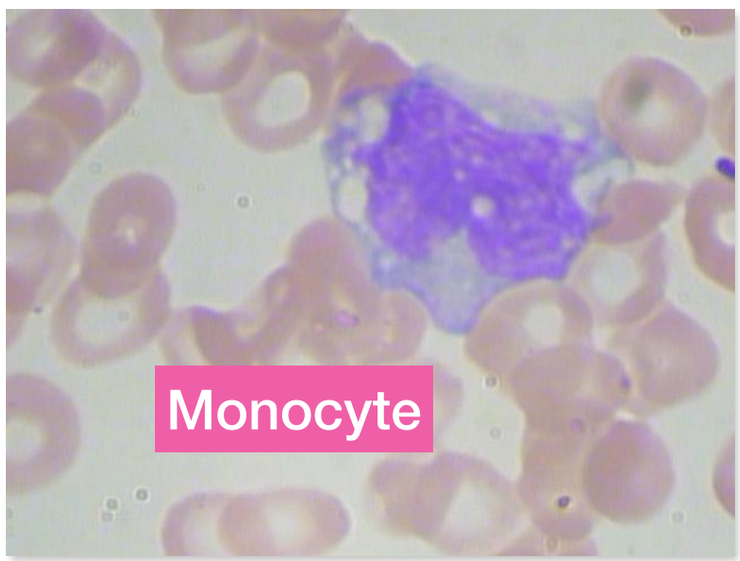
Automated Image Classification

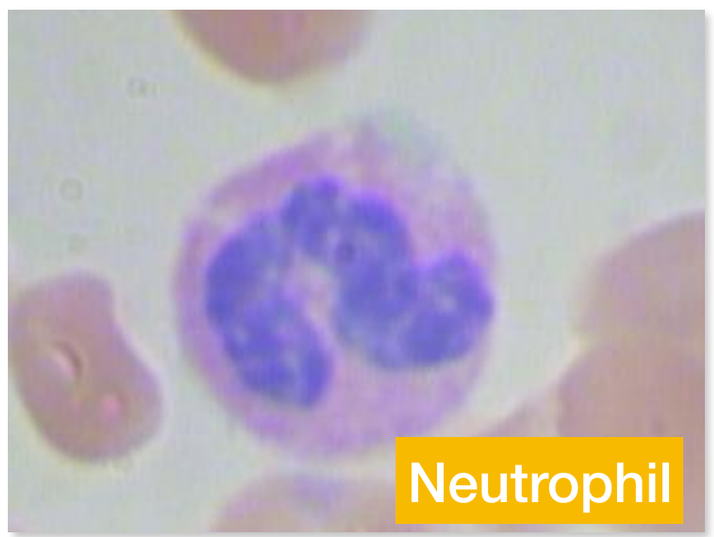


Decision

The goal of this study was to build a an optimized image classifier that can classify four types of white blood cells with accuracy around 90%



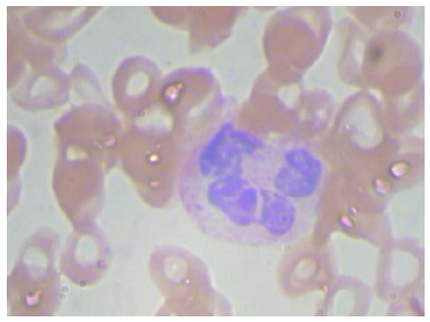




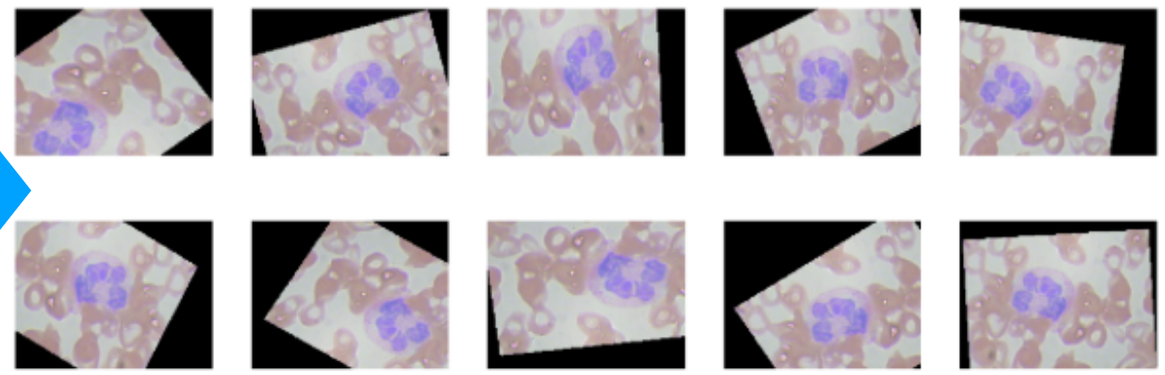
Data Set

Image argumentation techniques were used to increase the number of original 366 images of four classes that differ significantly in number per class.

Image Augmentation



- Rotation
- Width / Height Shift
- Shear
- Zoom
- Rescaling (1/255)
- Vertical /Horizontal Flip



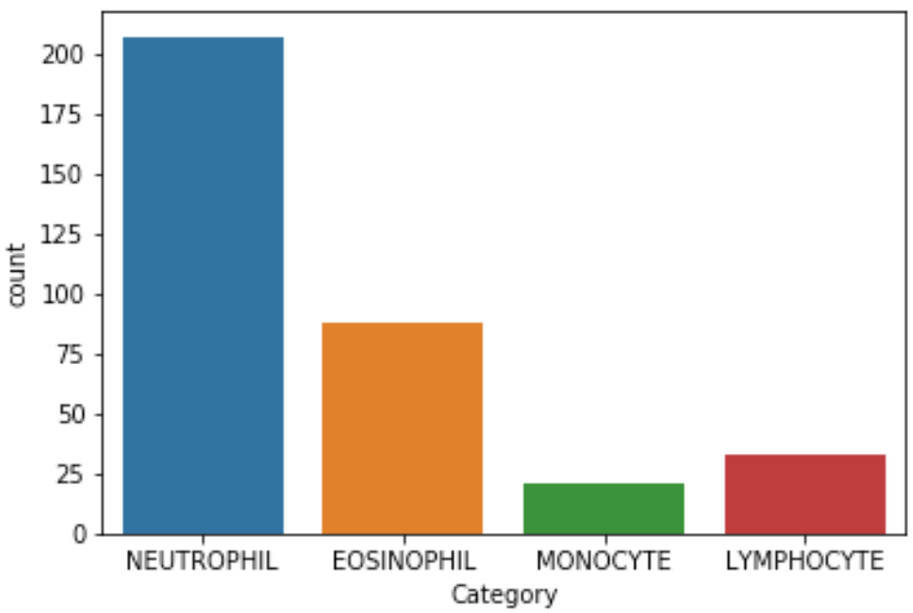


Image Augmentation

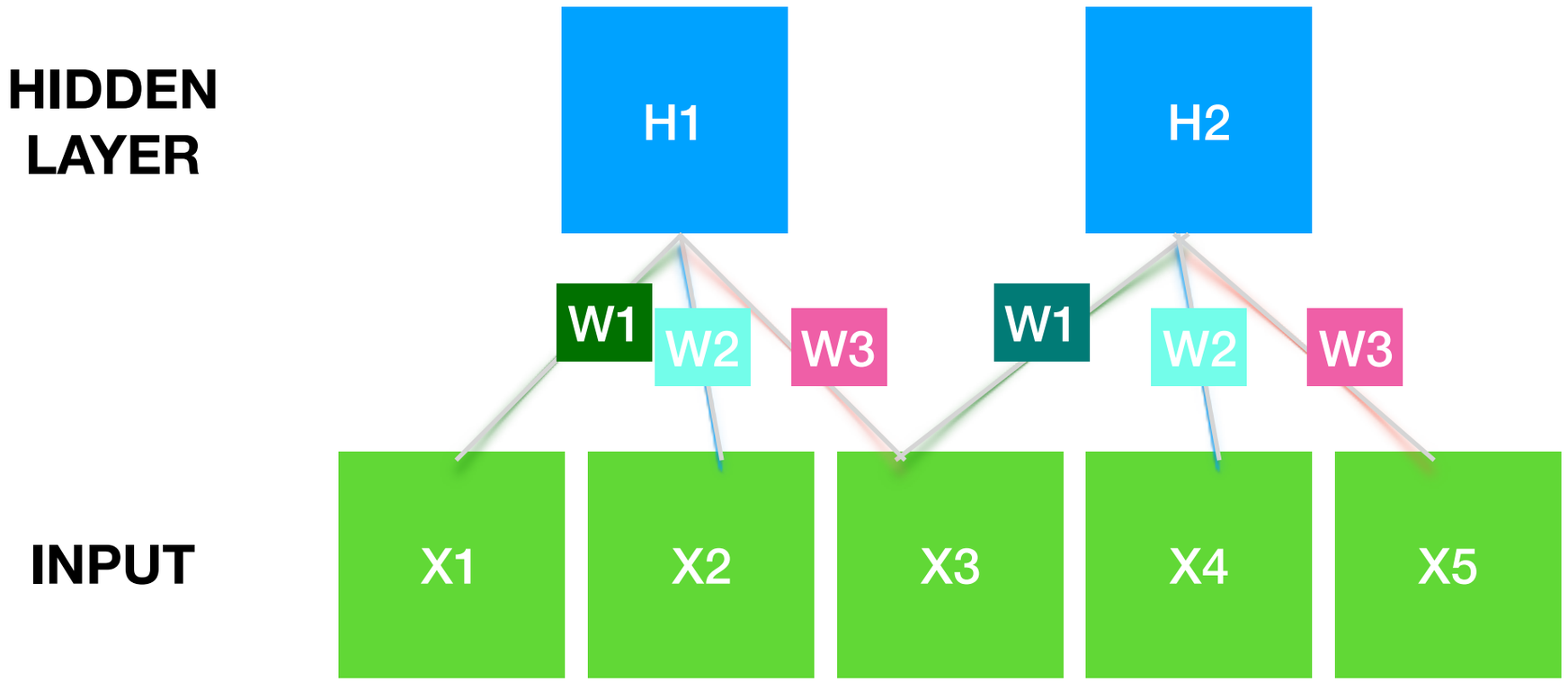
Random

Around 2600 images per class decided into
train / validation / test sets in ratio
60:20:20

Image Classification

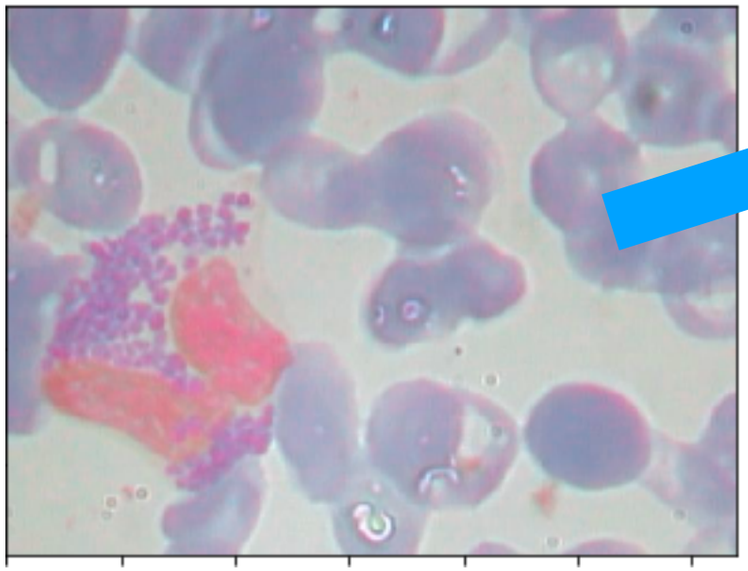
Convolutional Neural Networks

A convolutional neural network is a class of deep, artificial neural networks that found application mostly in image and sound analysis, whose main feature is significant parameter drop through weight sharing between neurons



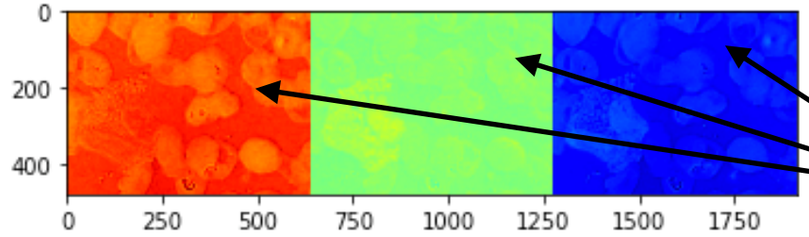
Learning Process

CNN layers' output visualization technique of untrained simple network (C-R-P) demonstrated how image is processed from layer to layer



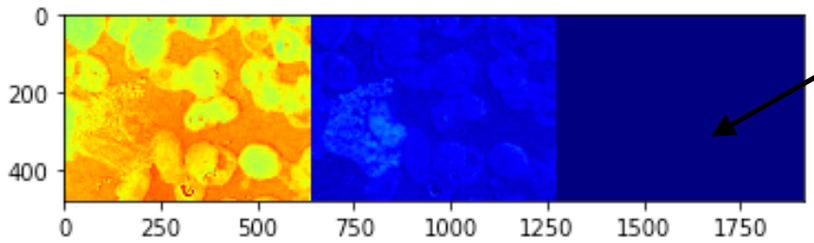
INPUT

CONVOLUTIONAL LAYER 3 X 3 X 3



3 filters

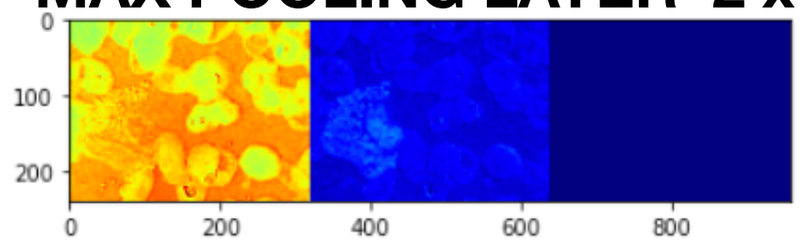
RELU LAYER



Zero'ing negative activations

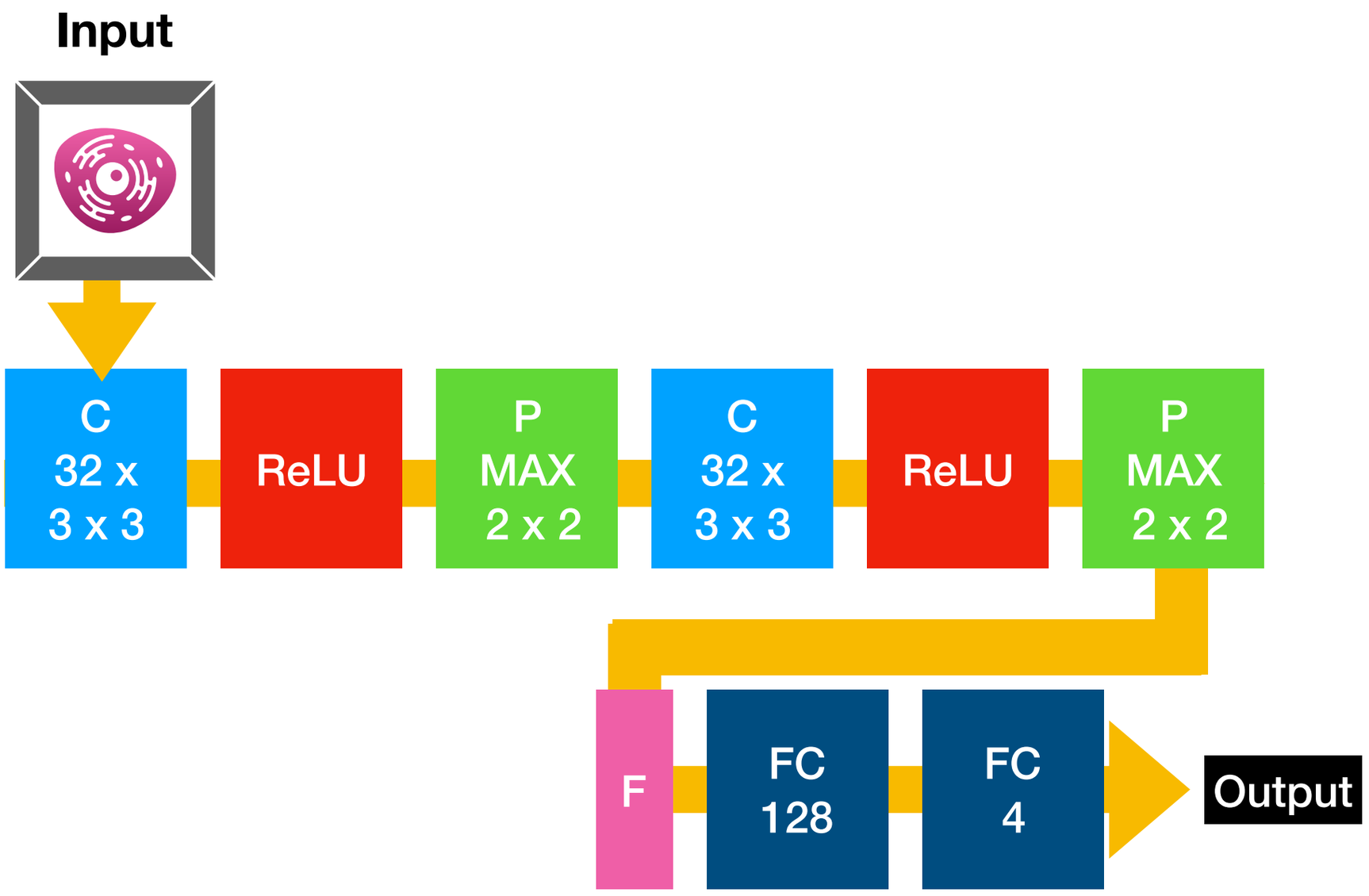
Dimension change

MAX POOLING LAYER 2 x 2



Initial Model

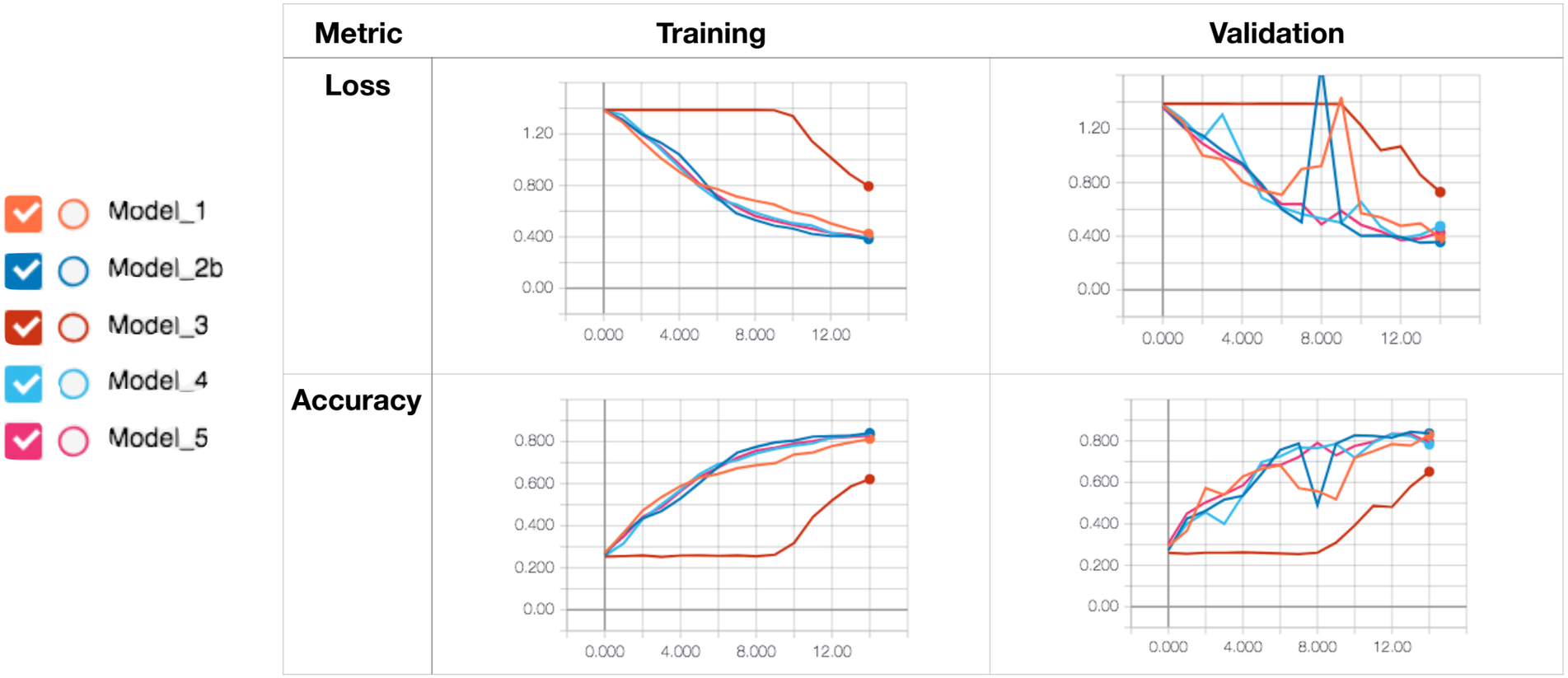
The initial model comprised of simple architecture based on most common practices i.e. several stacks of convolutional, ReLU and pooling layers followed by fully connected layers for final classification.



Model Optimization

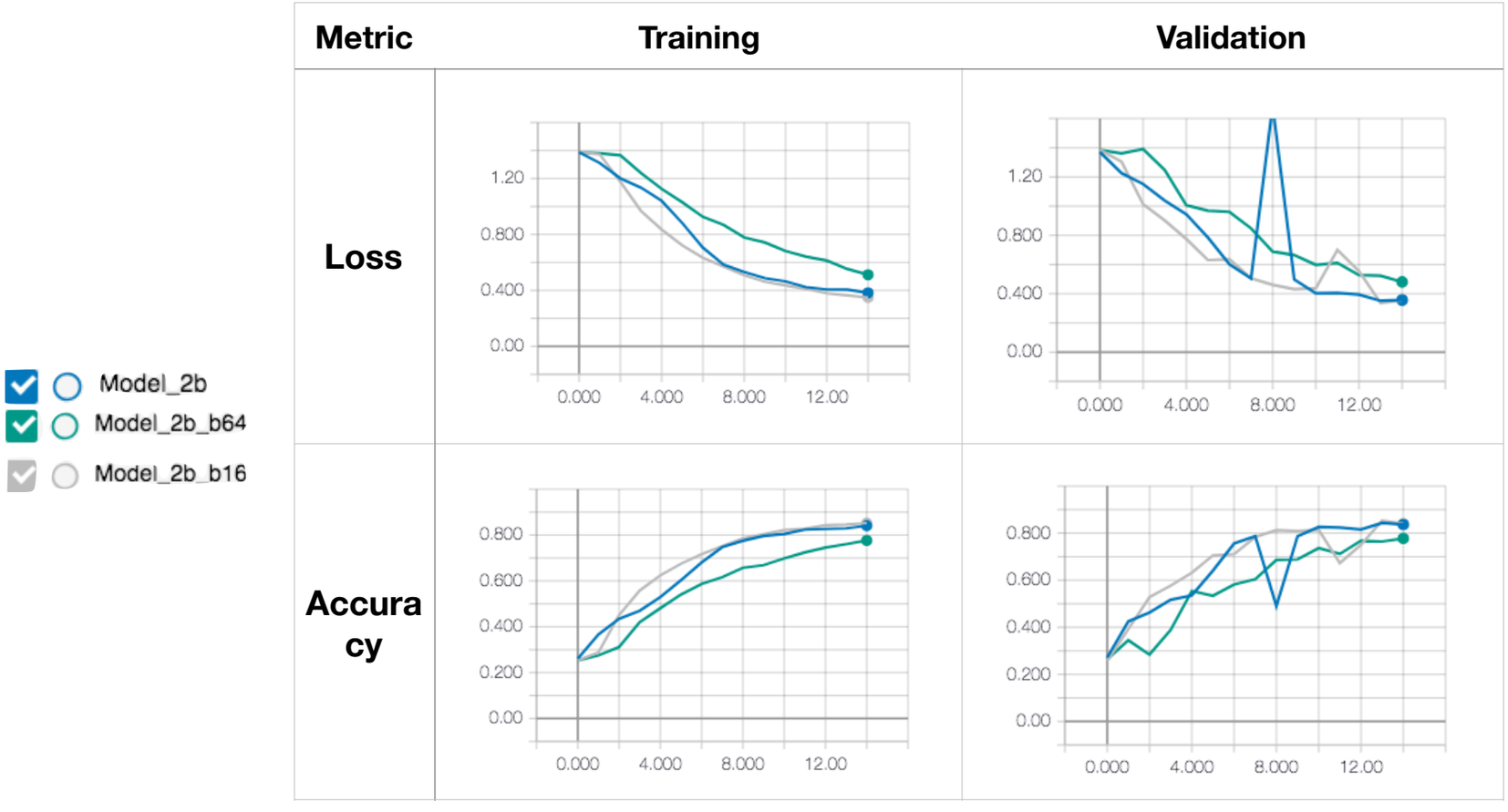
The initial model with additional C-R-P stack proved to have the lowest validation loss in contrary to the initial model with two additional C-R-P stacks to have the highest loss.

Step	Description	Architecture	Model name	Validation Loss	Next step
1	Initial model	CRP-CRP-F-FC-FC	model_1	0.50	increase capacity
2	add CRP	CRP-CRP-CRP-F-FC-FC	model_2b	**0.40**	increase capacity
3	add CRP	CRP-CRP-CRP-CRP-F-FC-FC	model_3	**0.72**	go back to step 2
4	add FC to model_2b	CRP-CRP-CRP-F-FC-FC-FC	model_4	0.46	go back to step 2
5	add D to model_2b	CRP-CRP-CRP-F-FC-D-FC	model_5	0.42	go back to step 2



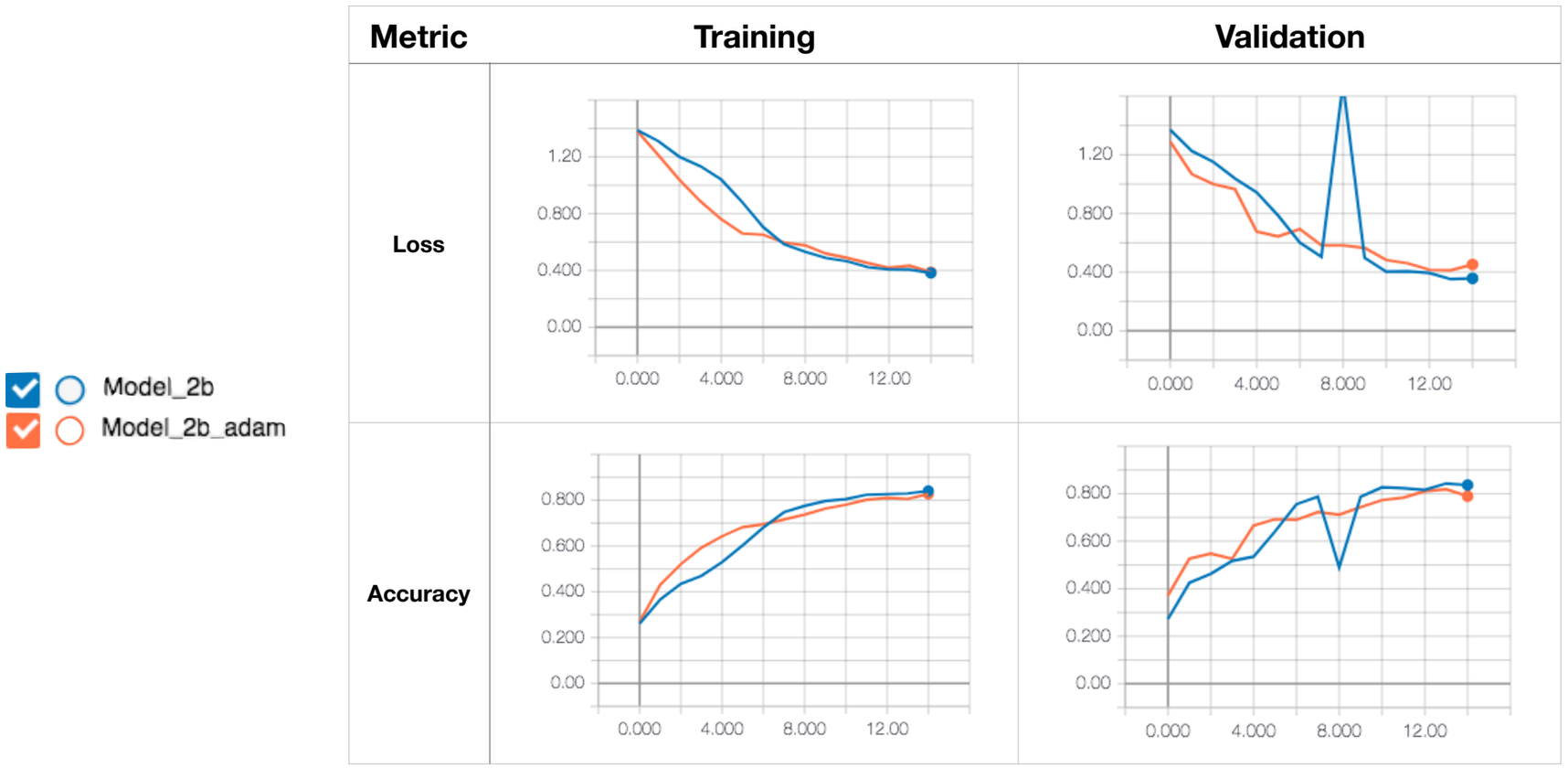
The increase in batch size increased the validation loss, on the other hand, the decrease in batch size speeded up the learning process, but the final result was 5% worse that the original batch size

Batch size	Model name	Validation loss	Next step
32	model_2b	0.40	increase batch size
64	model_b64	0.53	decrease batch size
16	model_b16	0.42	go back to batch size = 32



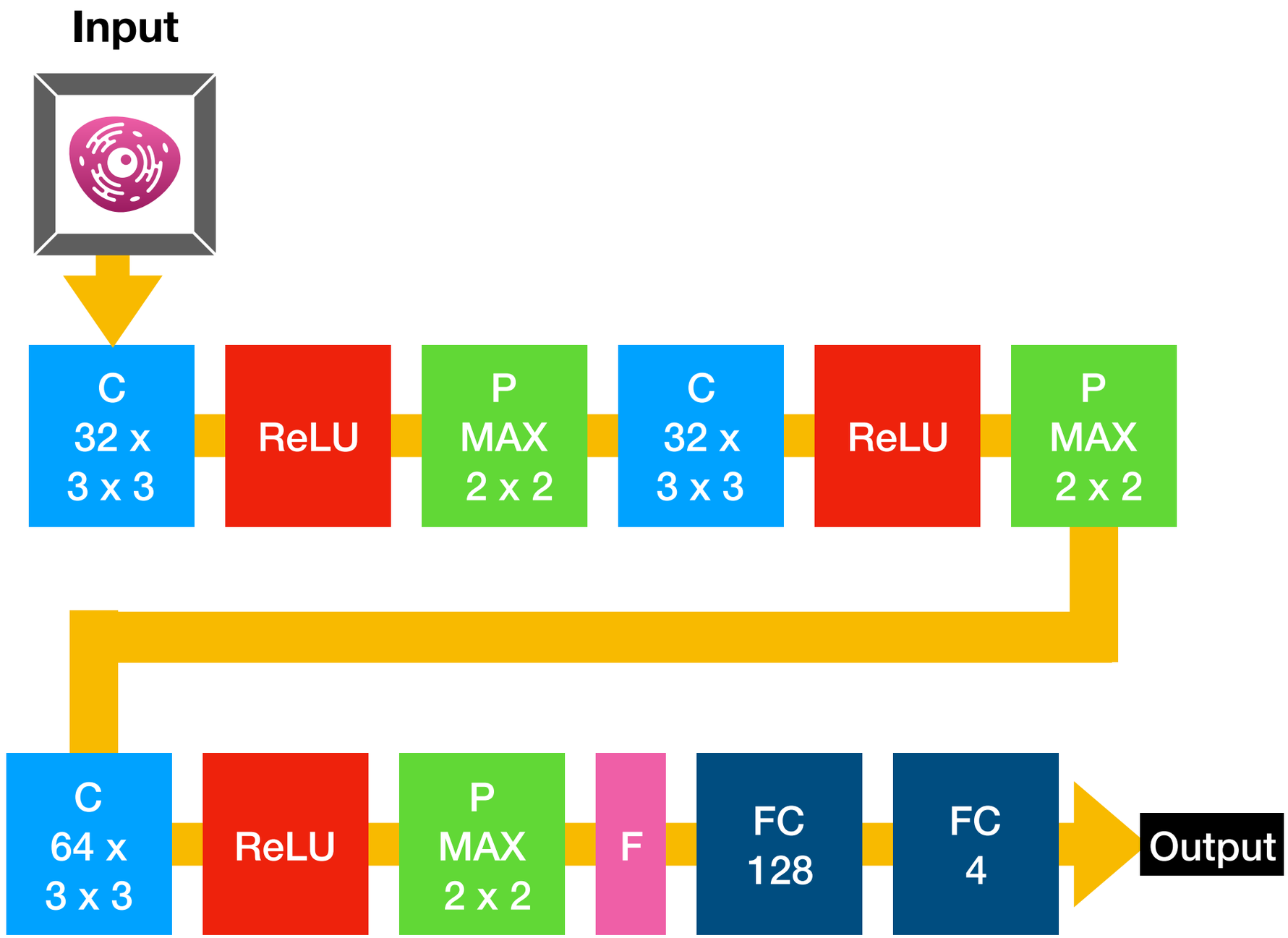
Even though Adam optimizer generally is recommended when training a new network, and the training process went faster, Adadelta achieved lower final validation loss

Optimizer	Model name	Validation Loss	Next step
Adadelta	model_2b	0.40	change optimizer
Adam	model_2b_adam	0.45	move back to Adadelta

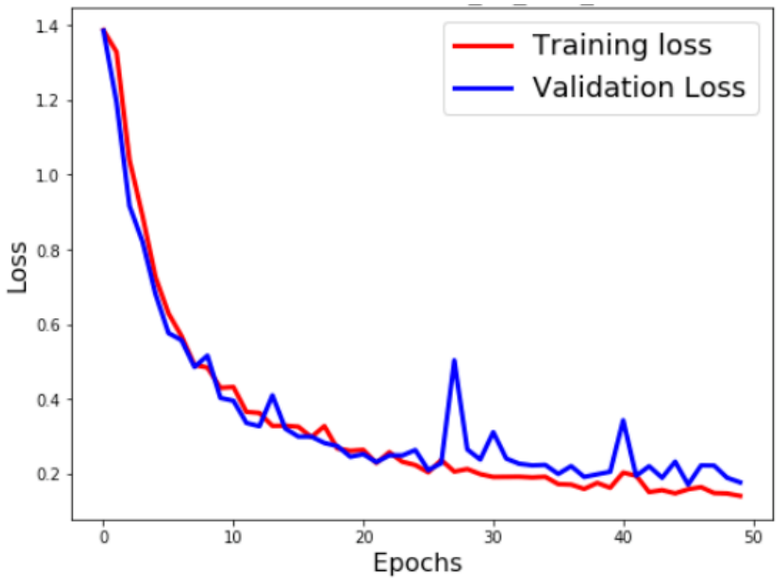


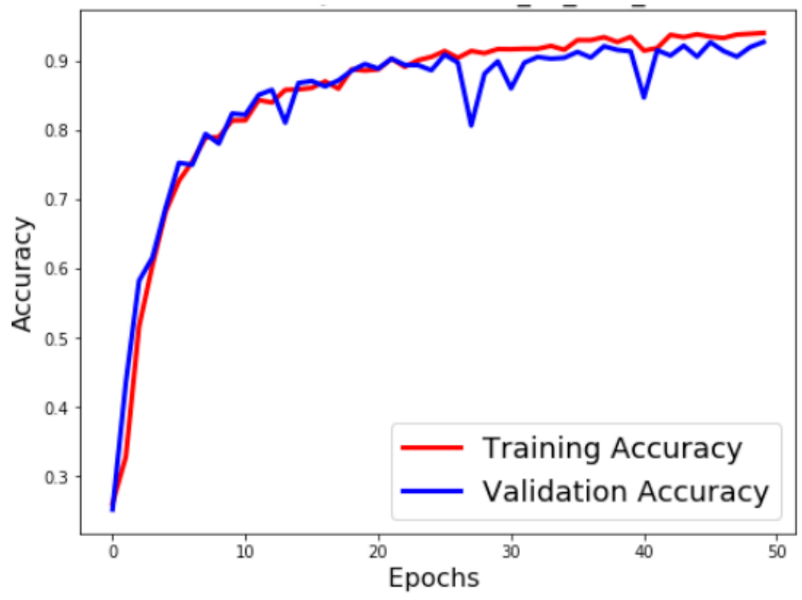
Final Model

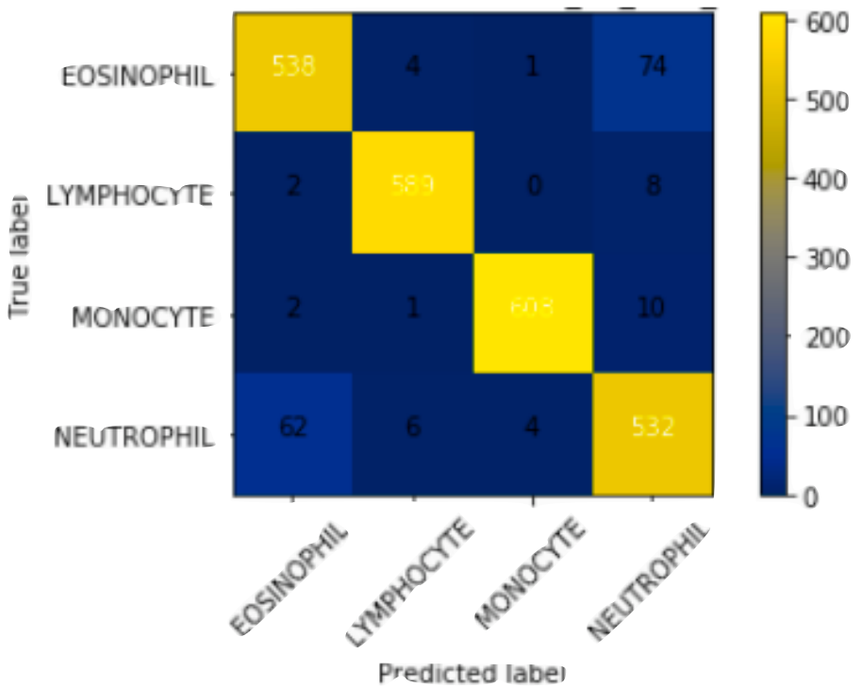
The final model comprised of 3 CRP stacks, one flatten layer and two fully connected layers, trained during 50 epochs on the batch size = 30.



The final model despite of its simple architecture achieved accuracy above 90% on testing set, which is comparable to the results, found online, achieved on more complex models.





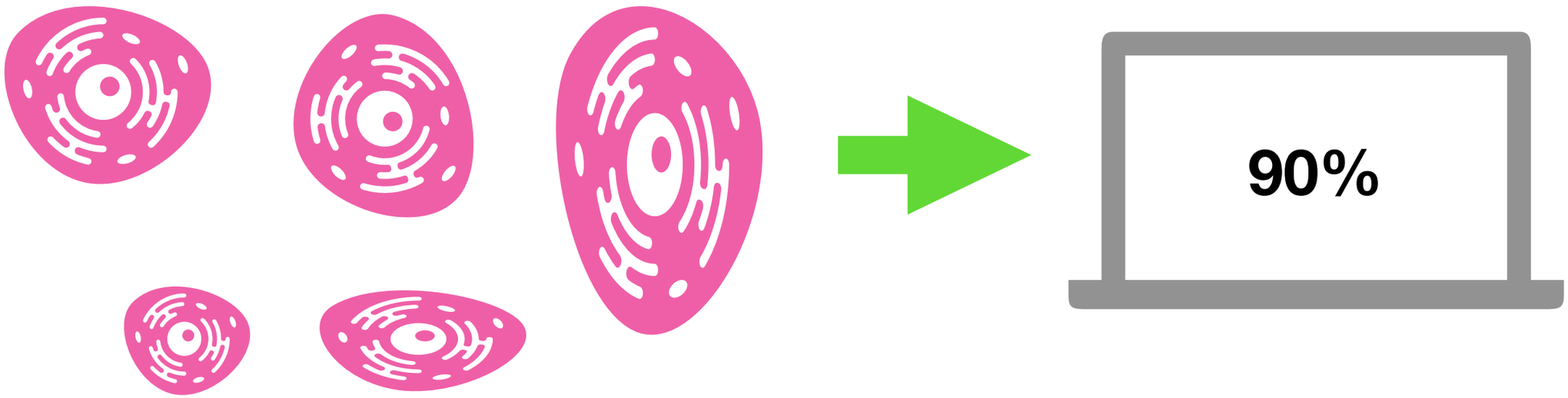


Class	Precision	Recall	F-score	Support
Eosinophil	0.89	0.87	0.88	617
Lymphocyte	0.98	0.98	0.98	599
Monocyte	0.99	0.98	0.99	621
Neutrophil	0.85	0.88	0.87	604
Average / Total	***0.93***	***0.93***	***0.93***	***2441***

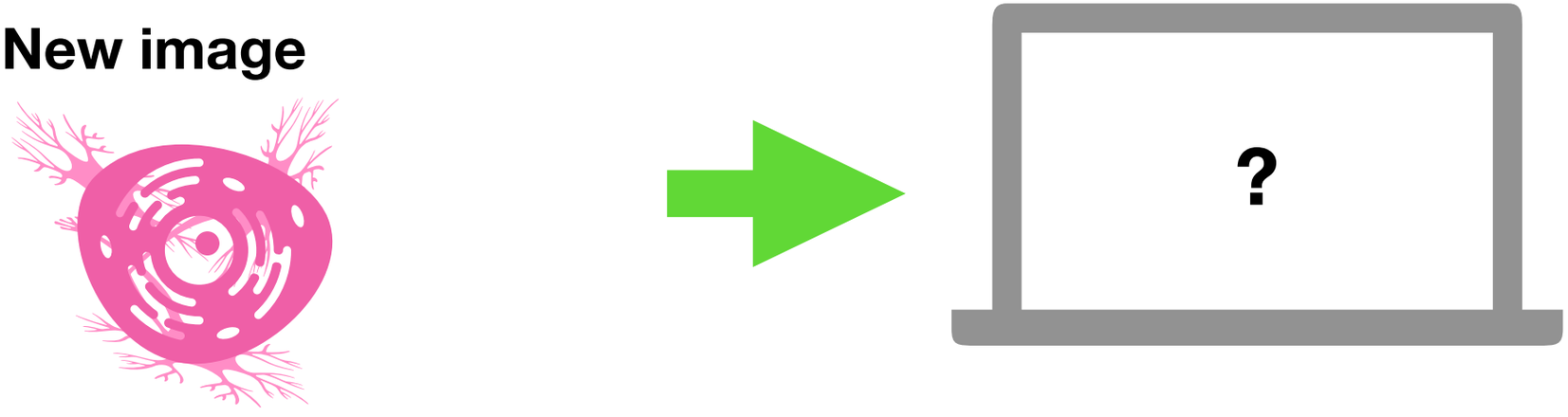
Assumptions and Limitations

Small number of original images might have on impact the classifier’s robustness and accuracy as well as on the model optimization results

Original augmented data set

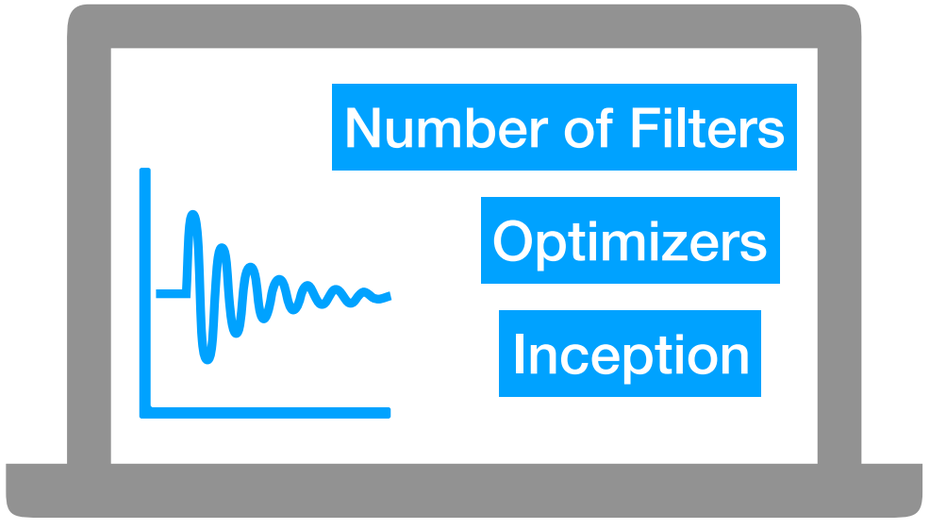


New image



Recommendations

There is many other parameters that could be tested to improve the classifier even more



Adding more classes to the training could make the classifier more versatile

Transfer learning and fine-parameter tuning of the top layers could help to achieve even better result