THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

DATS6203 Final Project

Predicting Invasive Ductal Carcinoma in Tissue Slices

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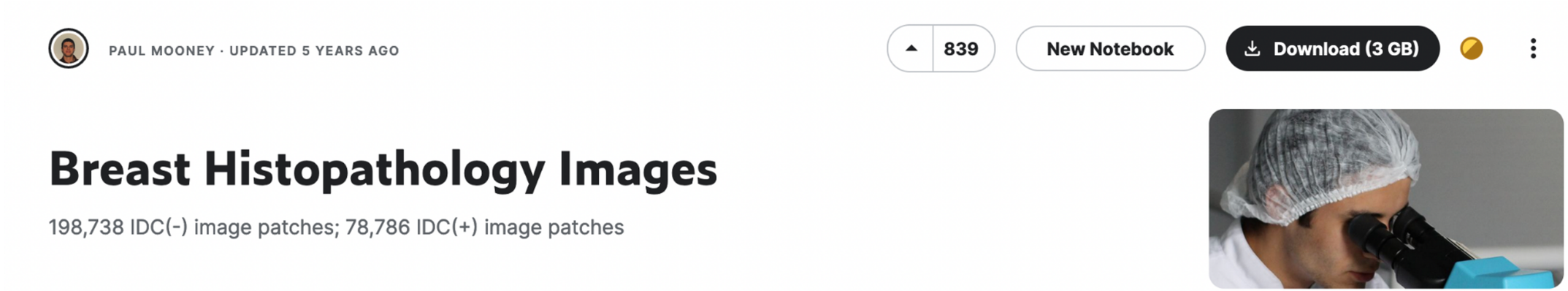
Dec. 13, 2022

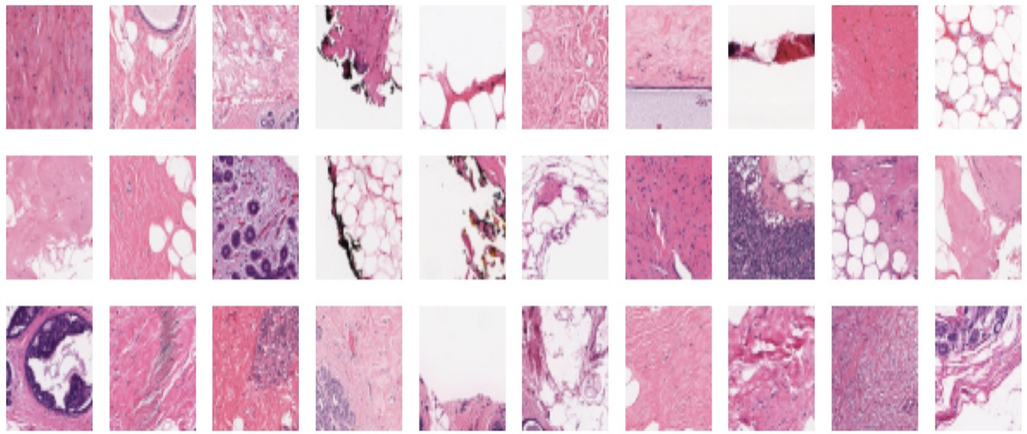
Dataset



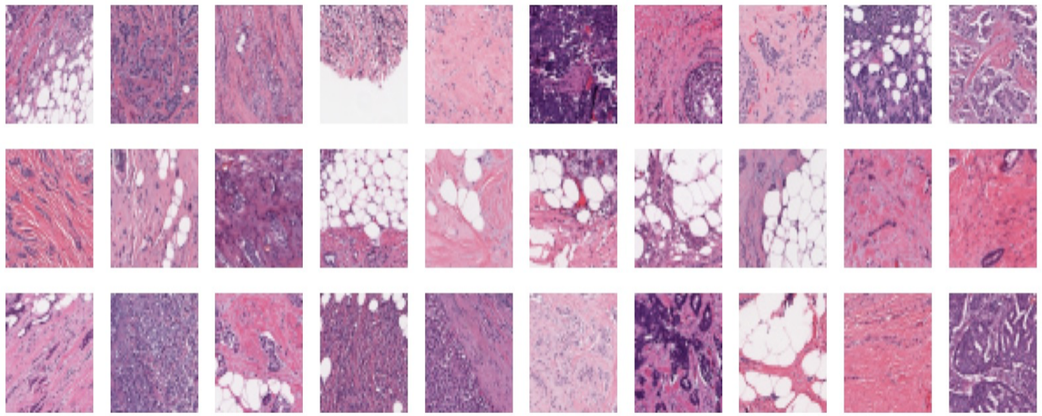
- **slide images of Breast Cancer (BCa) specimens scanned at 40x**
  - 271 Patient ID
  - 198,738 IDC(-) image patches
  - 78,786 IDC(+) image patches

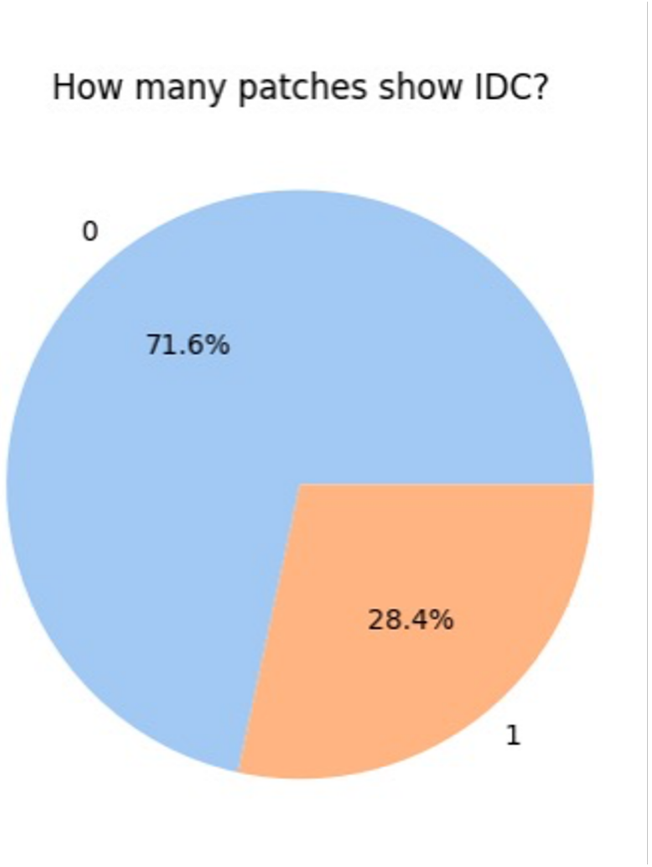
Exploratory Data Analysis

Negative



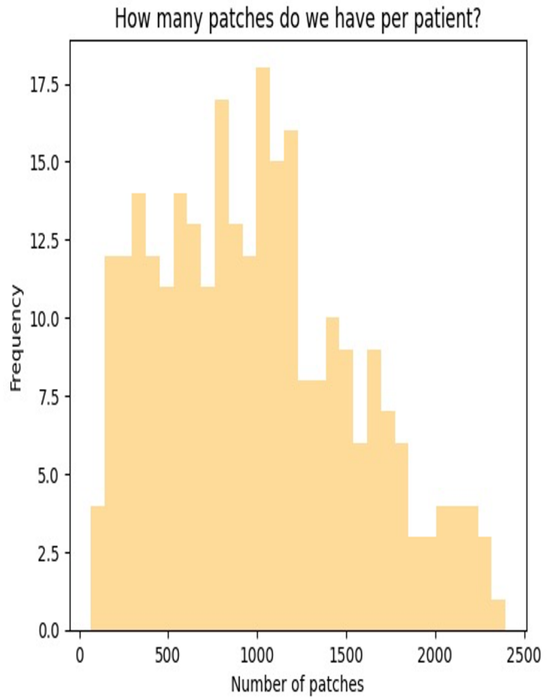
Positive

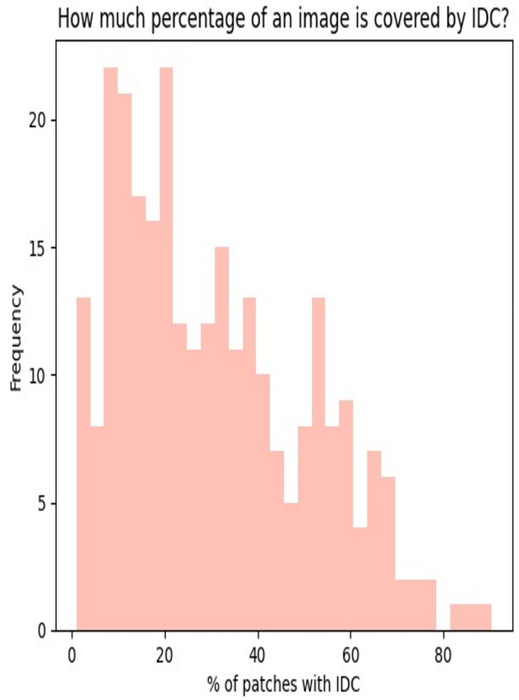


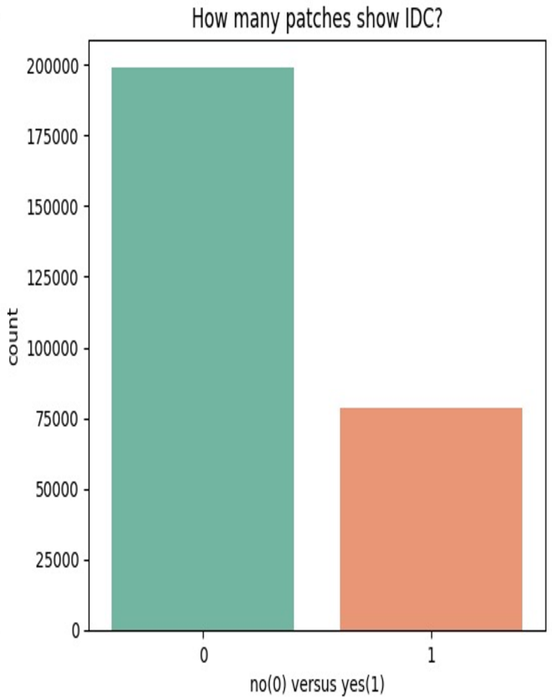


Exploratory Data Analysis

SUBTITLE





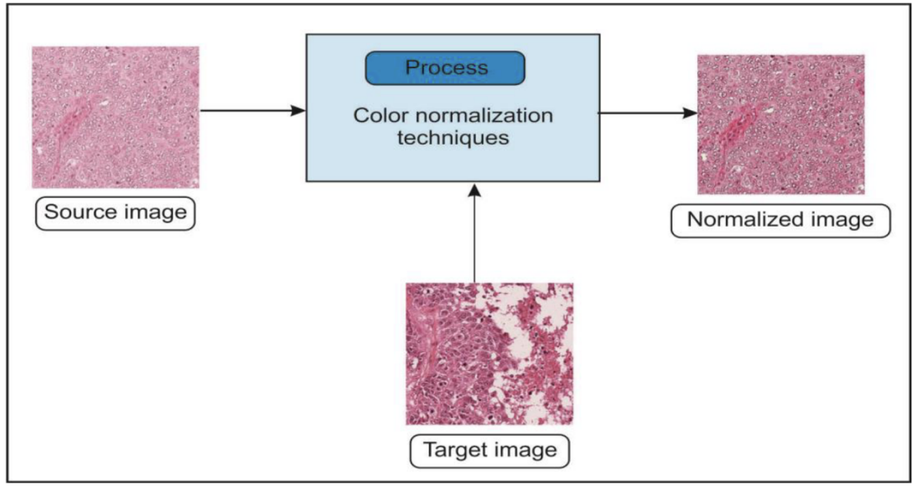


Data Augmentation

- Two directions:

Image diversity Increase
E.g., *'Imaug'* and *'Skimage'* packages

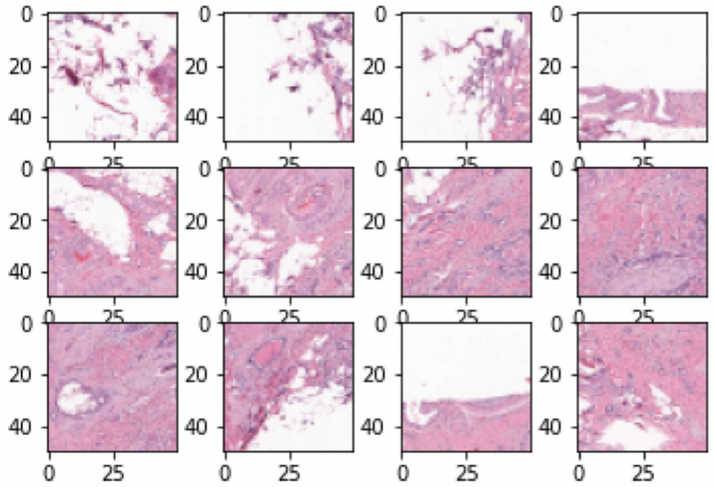
Image Color Normalization
E.g., 'Pix2Pix, cGAN



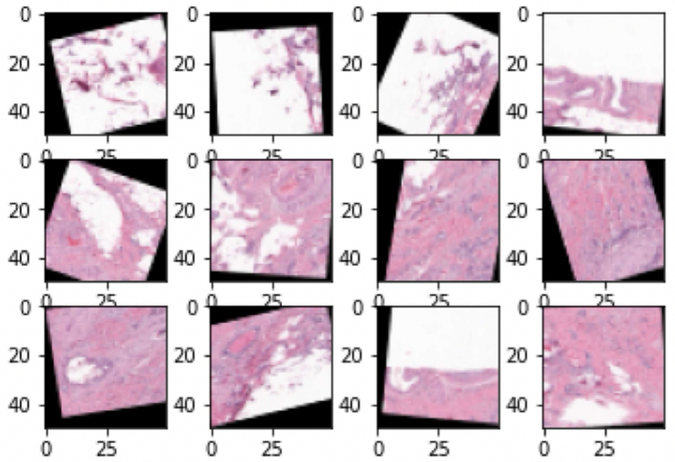
Data Augmentation

Imaug:

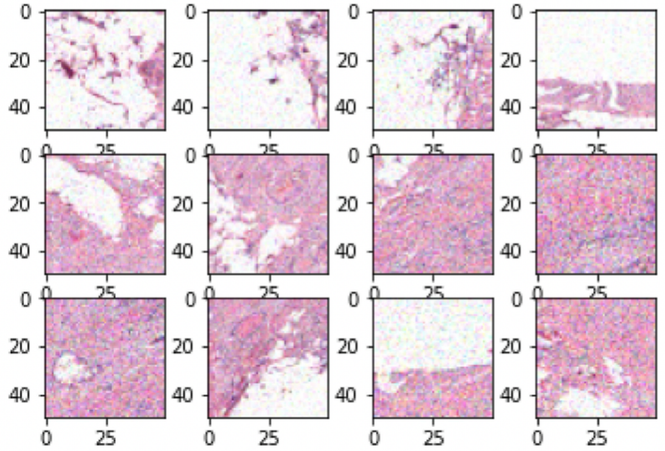
Examples



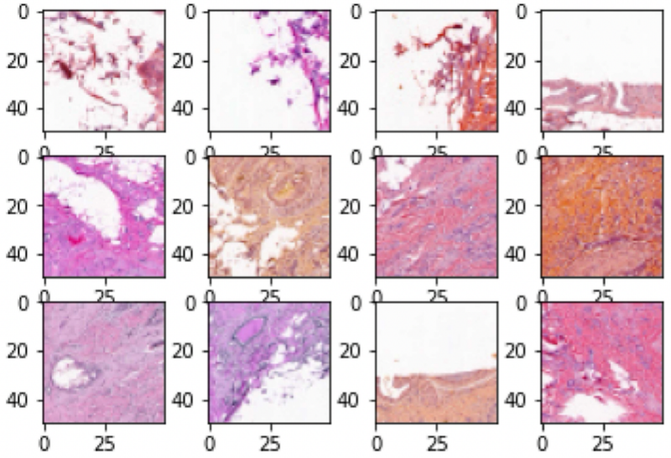
Original Image



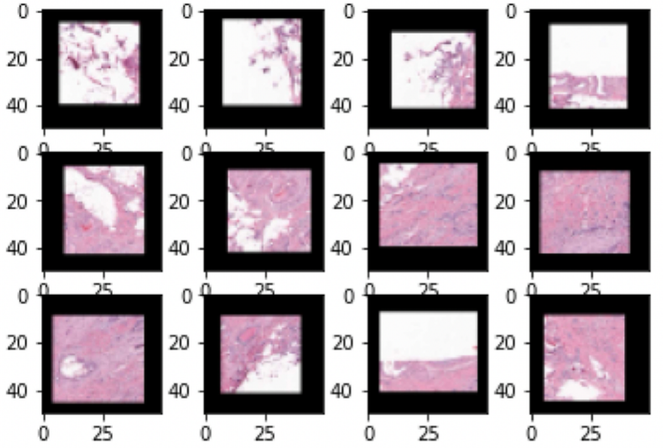
iaa.arthmetic.Affine



iaa.arthmetic.AdditiveGaussianNoise



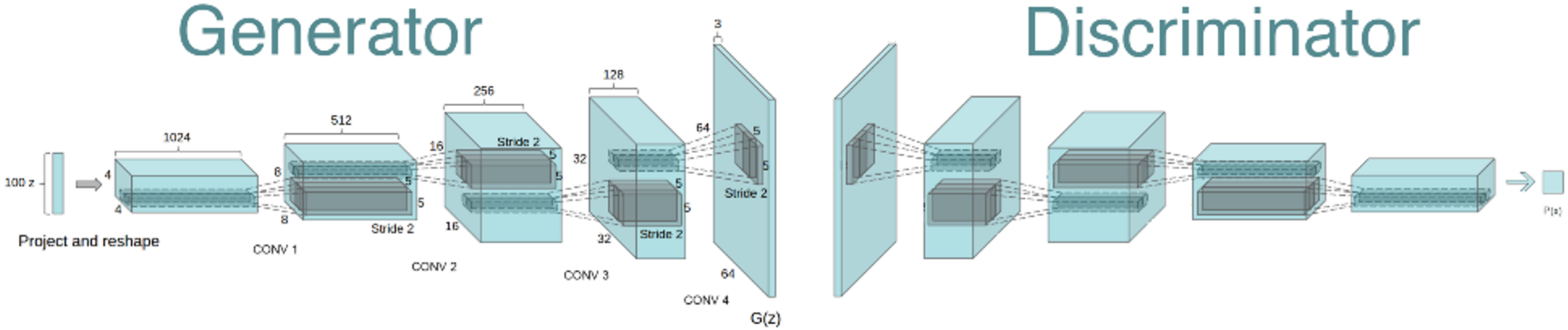
iaa.color.MultiplyHueAndSaturation



iaa.size,CropAndPad

Data Augmentation

Generative adversarial Network (GAN)

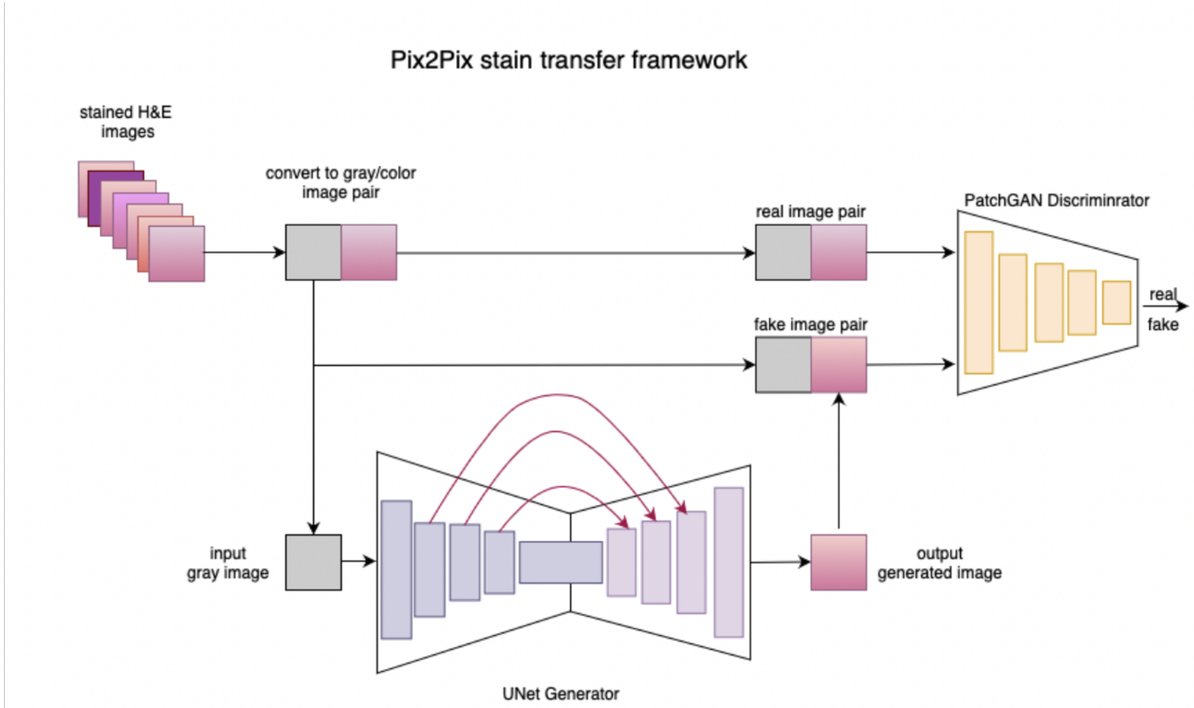


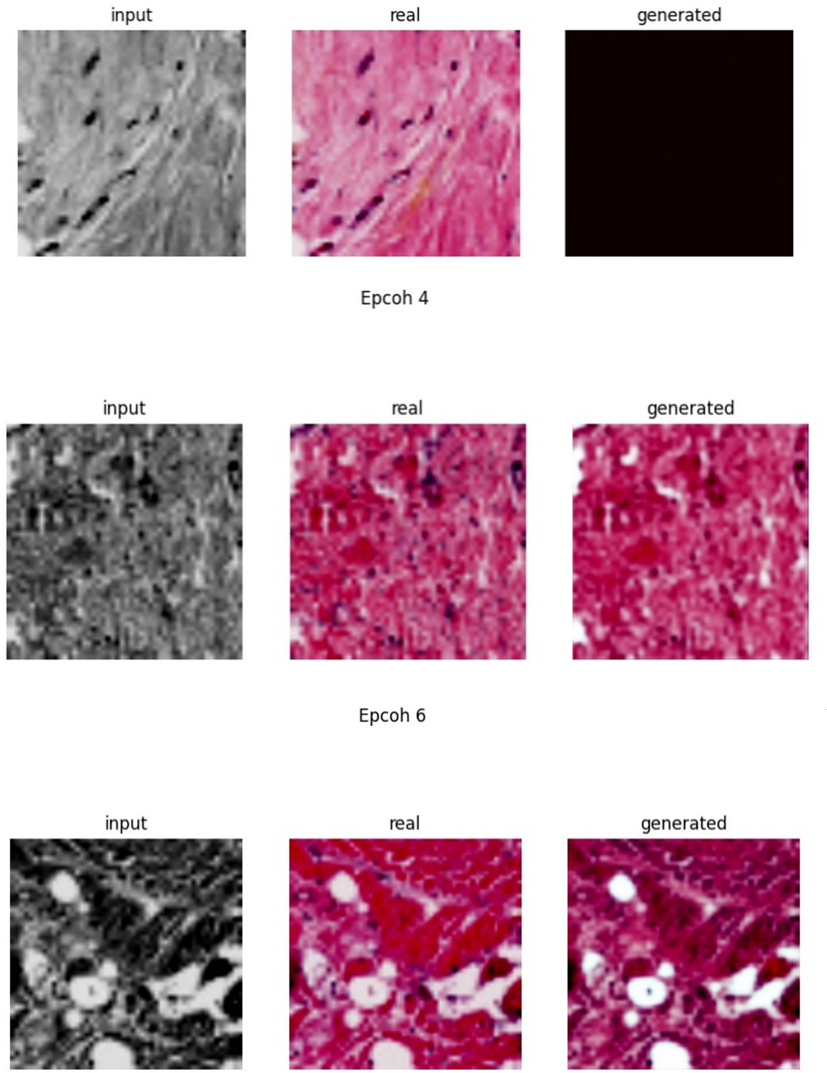
$$V(D,G) = \frac{1}{m}\sum_{i=1}^{m}[logD(x_i) + log(1 - D(G(z_i)))] \quad (1)$$

$$\min_G \max_D V(D,G) = \mathbb{E}_{x\sim p_{data}\ (x)}\left[logD(x)\right] + \mathbb{E}_{z\sim p_z\ (z)}\left[log(1 - D(G(z)))\right] \quad (2)$$

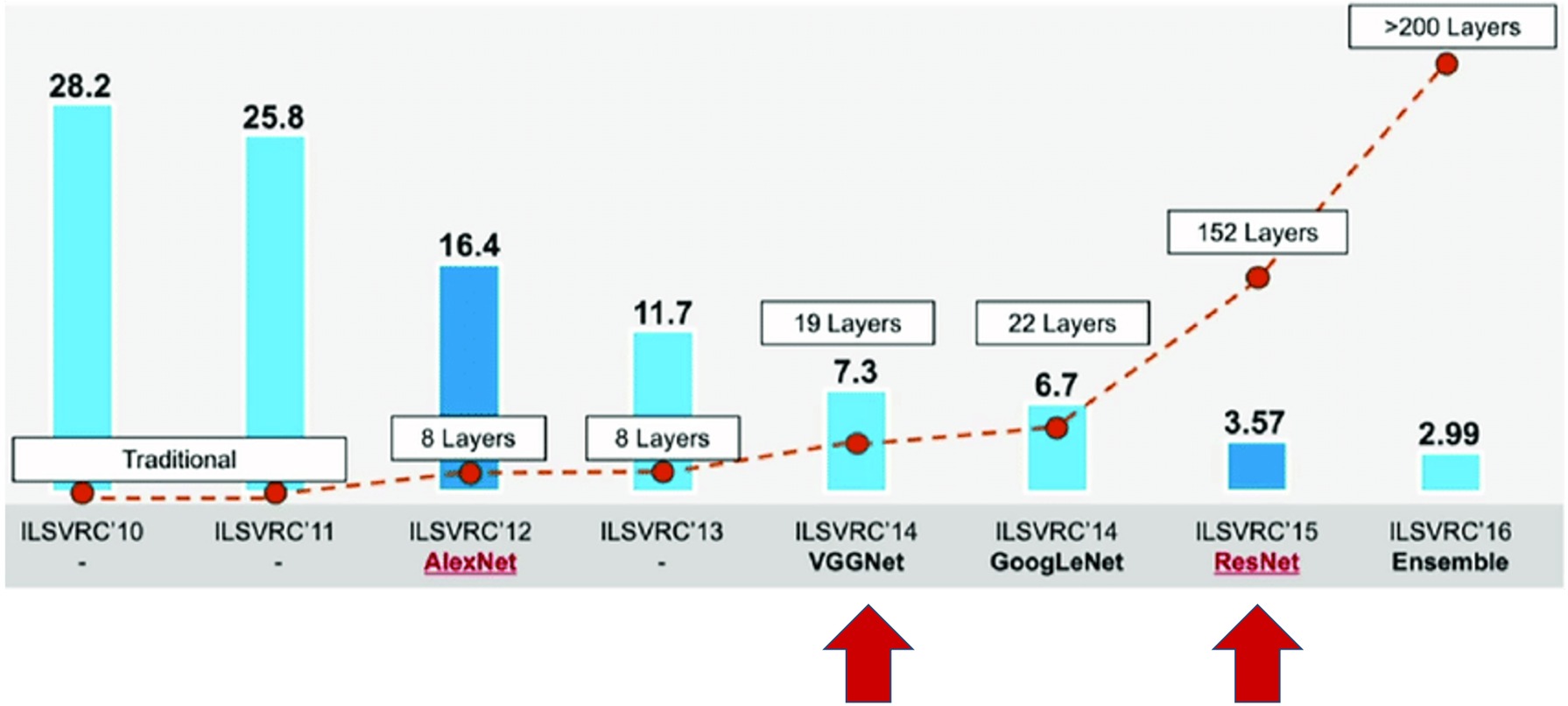
Data Augmentation

- Image color normalization
  Pix2Pix

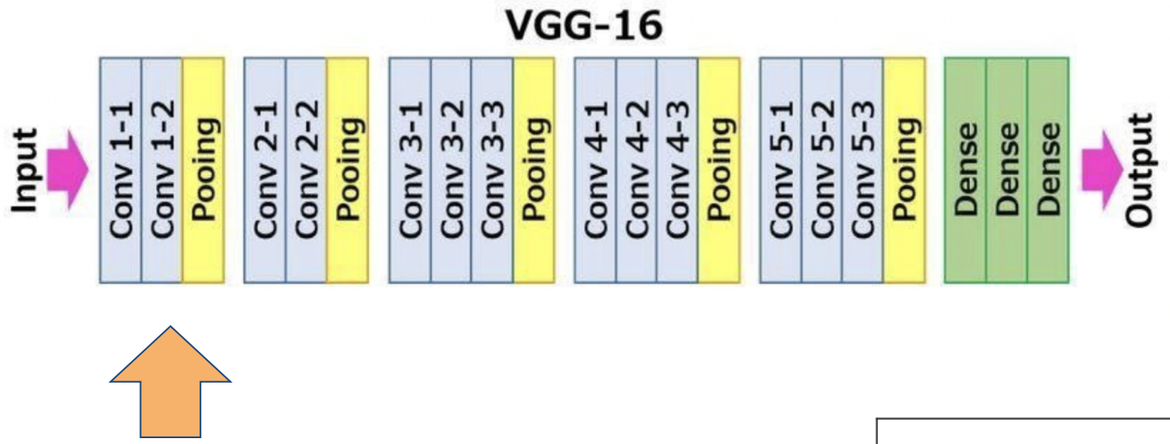




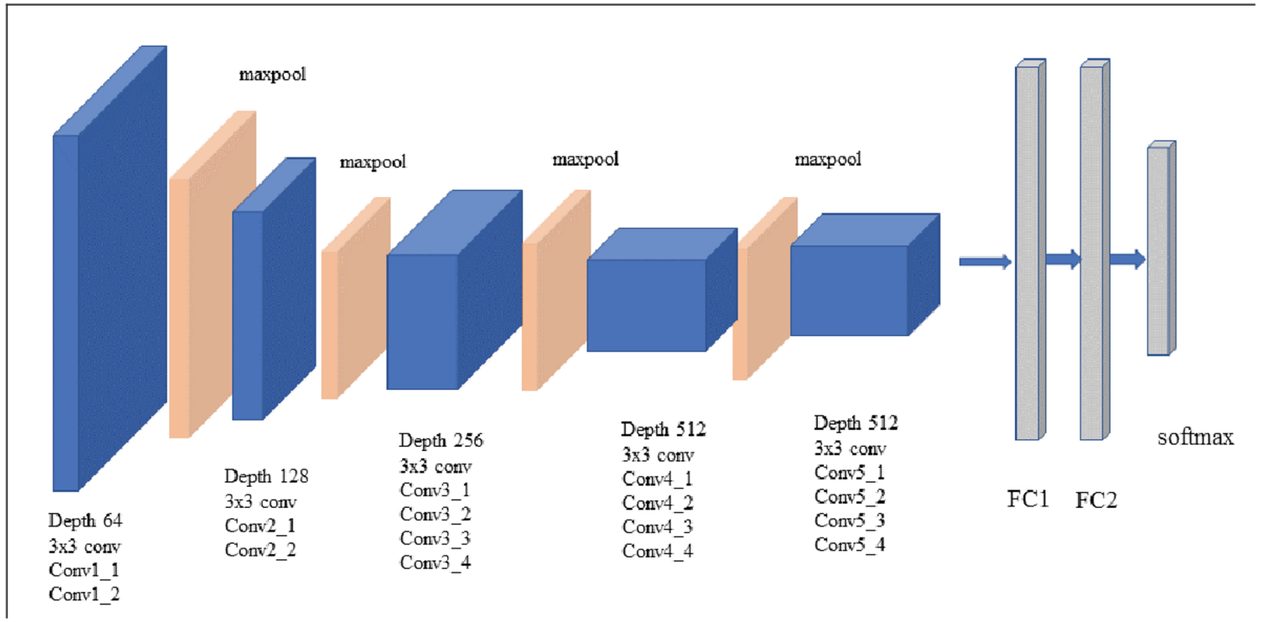
Model Selection



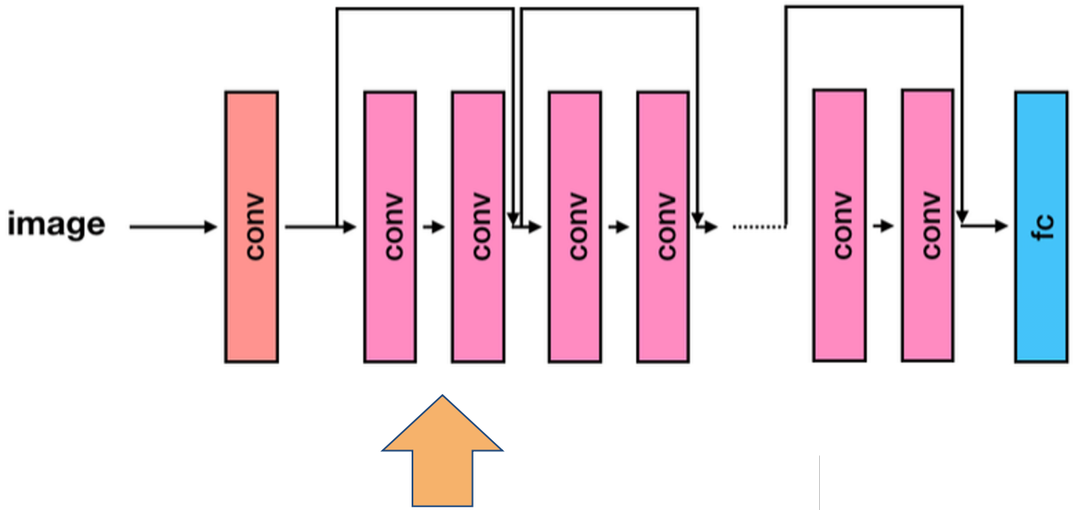
VGG16



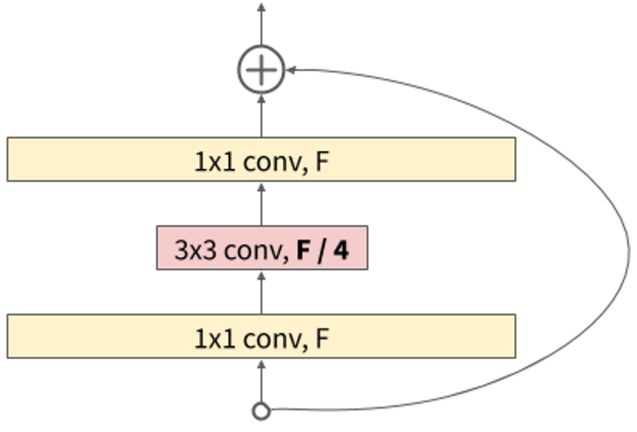
A Block: Conv layer + Pool layer



RESNET18



Residual Unit



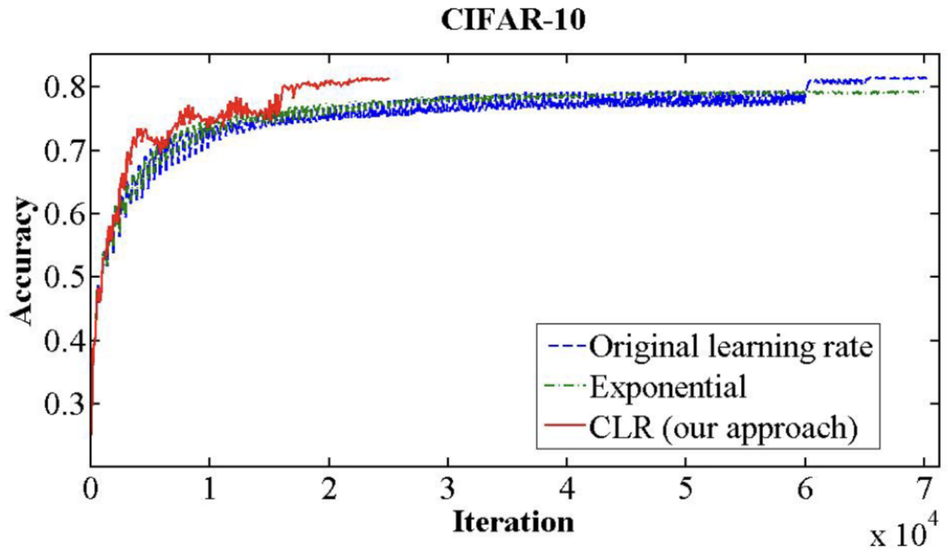
ResNet bottleneck

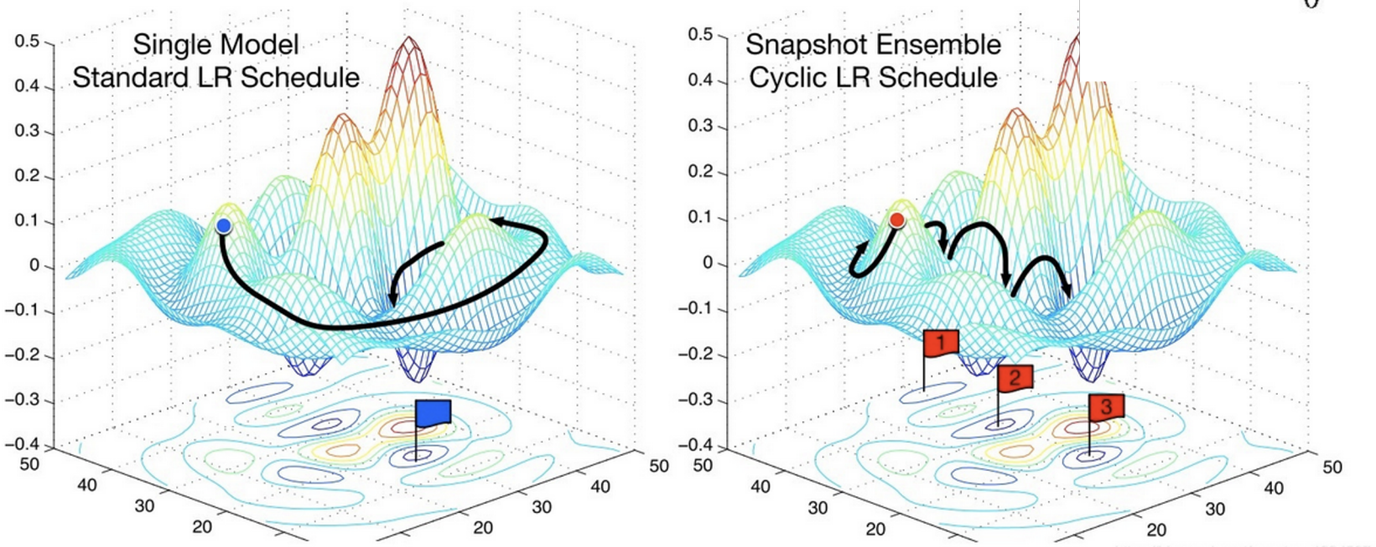
- **Input : x**
- **Output : H(X)**
- **H(x) = F(x) + x**
- **Residual: F(x) = H(x) - x**

Cyclical Learning Rates

Setting learning rate

- **Cyclical Learning rate (CLR)**
  - Escape saddle point
  - Converge faster
  - Improve model performance

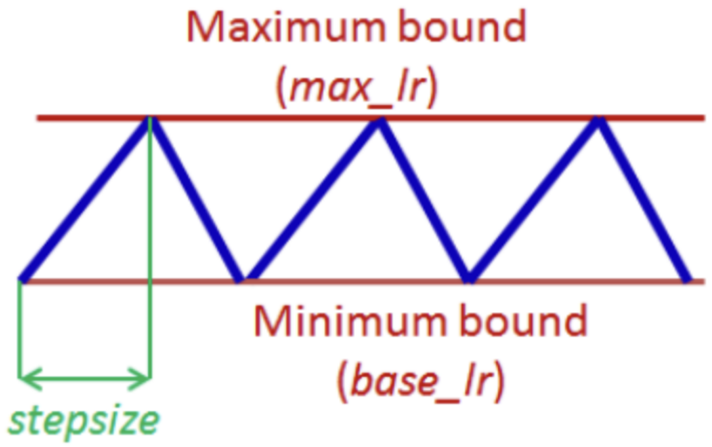


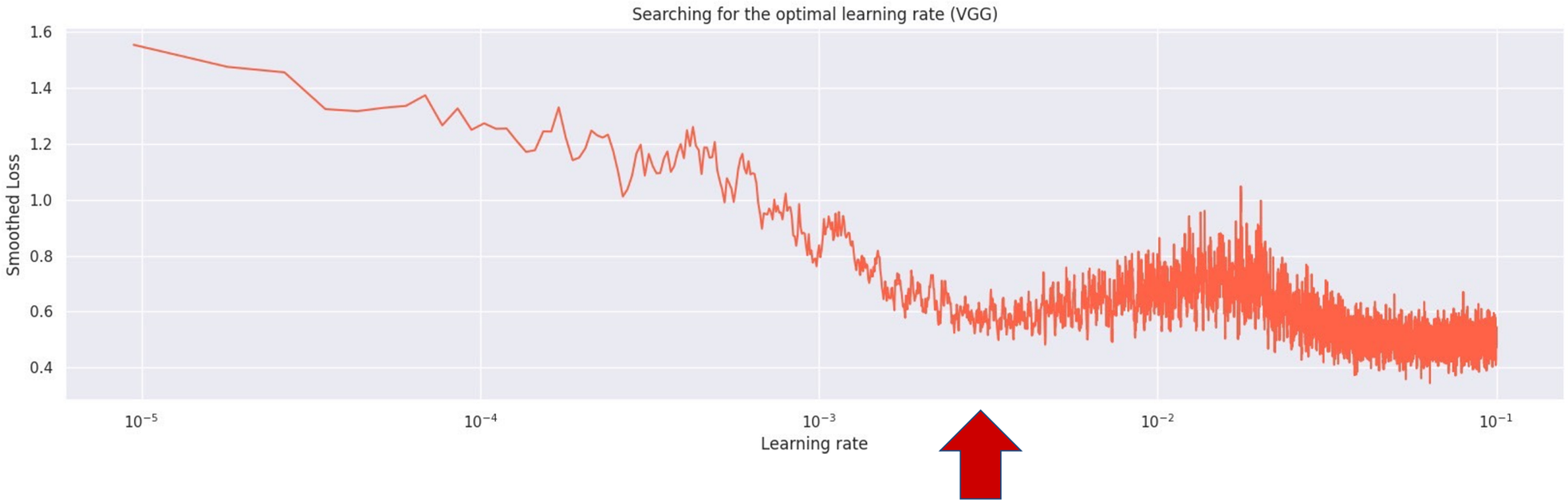


Cyclical Learning Rates

Search the learning rate

- **Parameters in CLR**
  - Maximum bound
  - Minimum bound
  - Stepsize = 2 * iterations in each epoch
  - Mode: *'triangular'*





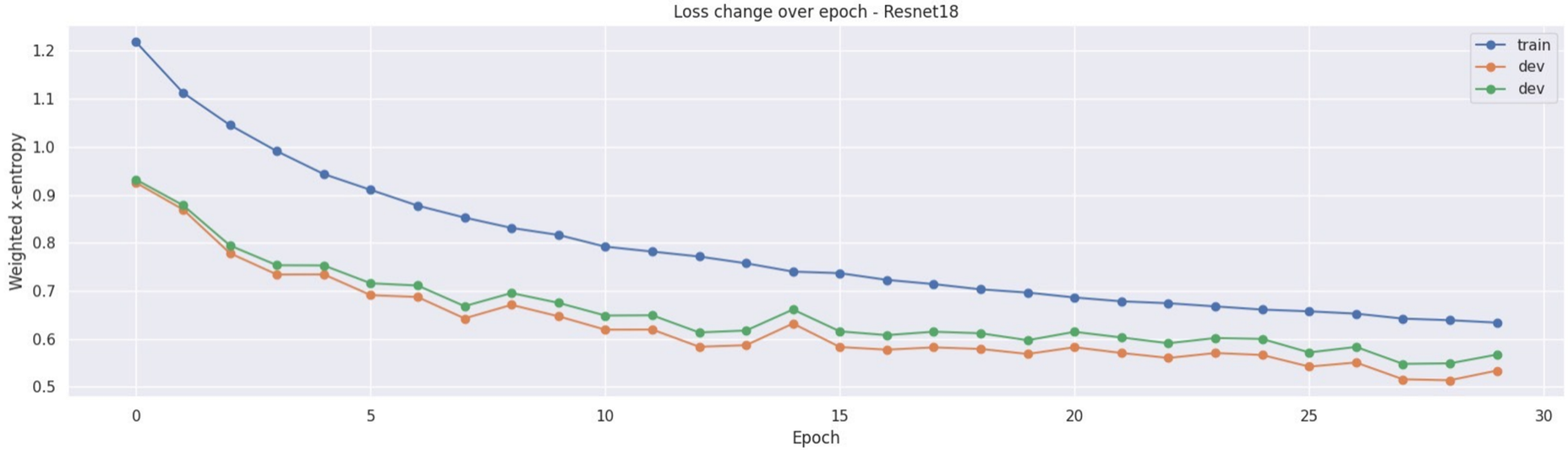
Training Process

Parameter	Value
Epoch	30
Batch Size	32
Learning Rate	max_lr = 0.06 min_lr = 1e-6
Optimizer	SGD
Criterion	CrossEntopyLoss (weighted)
Evaluation Metrics	F1-Score

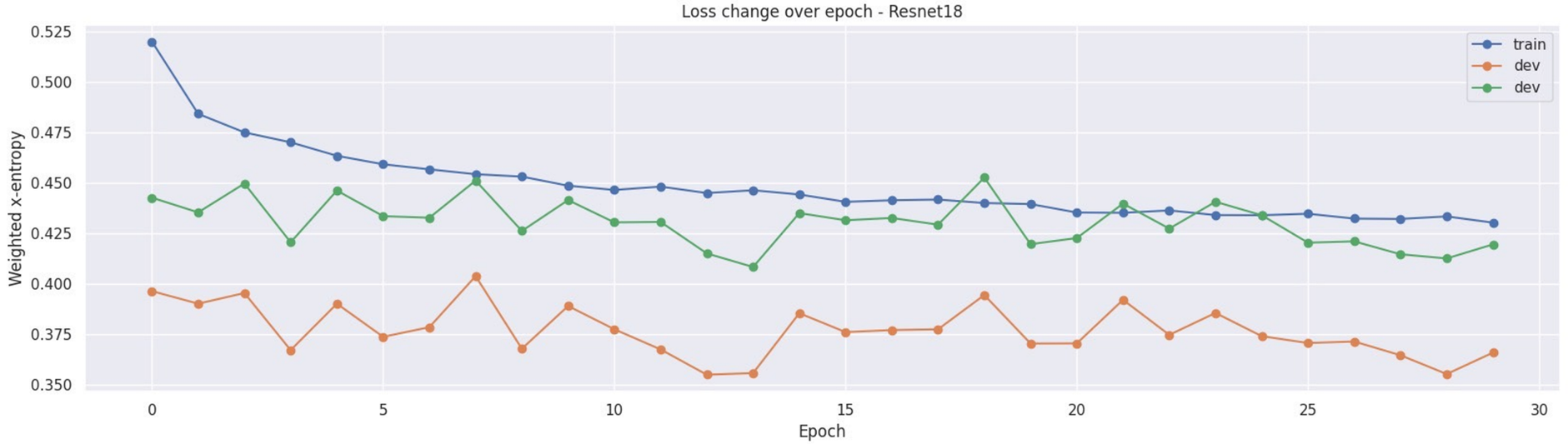
Model	CRL
ResNet18	Yes
ResNet18	No
VGG16	Yes
VGG16	No

Results
RESNET18

CLR = True



CLR = False



Summary

Model	CRL	Validation Accuracy	Training Time
ResNet18	Yes	0.85%	265m51s
ResNet18	No	0.77%	270m41s
VGG16	Yes	0.79%	390m44s
VGG16	No	0.73%	393m43s

- ResNet18 had better accuracy and less training time than VGG16.
- Cyclical learning rate method helped to improve the accuracy on the validation set and converged faster both on VGG16 and ResNet18.
- With the Cyclic learning rate method, the training process was more stable.

Limitation and Future Work

- Only the image diversity increase methods on data augmentation was applied
- To generate color normalized images by using GAN and add them into the training set.
  Find the proper ratio of generated images and originals images to get a better performance.

Q & A