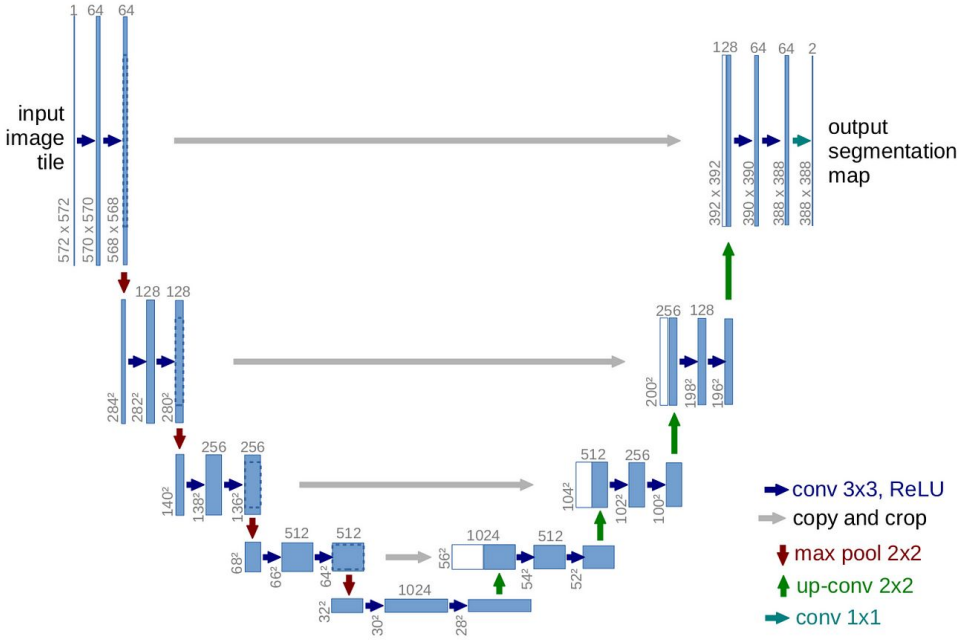
Retinal Vessel Segmentation

Parthiv A Dholaria 2021078
Utsav Garg 2021108

INDRAPRASTHA INSTITUTE *of*
INFORMATION TECHNOLOGY
DELHI

ML Model: UNet

The U-Net architecture is a deep learning model specifically designed for semantic segmentation tasks. It follows an encoder-decoder structure where the encoder, captures contextual information by progressively downsampling the input image and learning spatial hierarchies



Experiment

We have used basic U-Net architecture to train our segmentation model. To compare the result of randomized scaling techniques we have done two separate training. One with the dataset with original images, and one with images that have scaled before feeding them in the model for training. The technique used for scaling are discussed in the later slides:

Other Training Hyperparameters:

- **Number of Epochs:** 150
- **Loss function used:** Binary Cross Entropy (BCE) + Dice Loss
- **Train Loader Batch Size:** 2
- **Transformation:** A centre 960x960 crop has been done on images to fit the U-Net.

Randomized scaling Techniques

- **Random Brightness scaling:**
  - Adjust pixel intensity randomly by multiplying the image with a factor randomly sampled between between 0.80 and 1.6.
  - Rationale : Helps the model generalize better to images with different brightness levels.

- **Random Contrasting using CLAHE:**
  - CLAHE is applied with a varying clip limit randomly chosen for each image.
  - Rationale : Helps in reducing dependence on specific contrast levels that may vary across images.

- **Random Gaussian Noise addition:**
  - Add Gaussian noise with a mean of zero and a standard deviation that is randomly chosen.
  - Rationale : To see whether CLAHE is resistant to Noise or not.

Randomized scaling Techniques : Results

- We randomly sampled 10 images and analysed Green Channel isolation + CLAHE filtering on grey scale images with and without random brightness scaling.

Setup\Metrics	accuracy	Sensitivity	Specificity	F1	SSIM	PSNR
Without scaling	0.9114	0.3777	0.9698	0.5420	0.7239	10.1236
With scaling	0.9163	0.3983	0.9707	0.5626	0.7355	10.2677

Randomized scaling Techniques : Results

- We randomly sampled 10 images and analysed Green Channel isolation + CLAHE filtering on grey scale images with and without random CLAHE clipping.

Setup\Metrics	accuracy	Sensitivity	Specificity	F1	SSIM	PSNR
Without clipping	0.9280	0.5071	0.9614	0.6607	0.7971	11.4131
With clipping	0.9145	0.4352	0.9641	0.5958	0.7404	10.3739

Inference from Scaling techniques

- We ran the inference test for 10 randomly selected images and averaged out the result. For Random Brightness scaling : F1 improved by 2% , rest all metrics (sensitivity,specificity,PSNR,SSIM) showed a slight improvement.

- CLAHE filtering by Randomly clipping shows a degradation in F1 as well as all the other metrics.

- Hence , Green Channel isolated followed by random factor multiplication and CLAHE is resistant to intensity scaling and is the best method to move forward with.

- CLAHE filtering with random clipping , Addition of Random Gaussian Noise , Intensity normalisation do not perform well for segmentation.

Other Randomized Scaling Used

- Used **random sampling** to select the subset of images used during one interaction of training.
- Introduced **dropout layer** during Model Training: Randomly sets a fraction of neurons to zero during each training iteration.
- We used **random optimization** technique Adam in hyperparameter tuning incorporate randomness in parameter updates or search spaces.
- Also included **data augmentation** with random transformations such as cropping, flipping, and rotation in images and random brightness inclusion to increase the size and diversity of the training set.

Comparing Results

Dataset	Accuracy	Sensitivity	Specificity	F1	SSIM	PSNR
Original Dataset	0.9634	0.6191	**0.9903**	0.7543	0.8721	62.5135
Scaled Dataset (50%)	0.9678	0.6643	0.9901	0.8354	0.8743	62.8732
Scaled Dataset	**0.9703**	**0.7647**	0.9869	**0.8614**	**0.8884**	**63.4093**

Since we used only a portion of the images in 50% of the dataset. The running time for each epoch was reduced with the same proportion. The preprocessing scaling was separately done before training the model.

Conclusion and Future Work

- Among the pre-processing techniques evaluated, random brightness scaling combined with Green Channel isolation and CLAHE filtering demonstrated notable improvements in key metrics, confirming its effectiveness in handling intensity variations in the dataset.
- The scaled dataset achieved superior performance, particularly in F1 score and sensitivity, indicating the value of effective pre-processing in semantic segmentation tasks.
- UNET works better after scaling the dataset.
- Future work could focus on exploring additional augmentation techniques and advanced architectures to further refine segmentation accuracy and robustness. We can explore other randomized scaling techniques to make our dataset even more scale invariant.

Thank you