Tensorflow-Tiled-Image-Segmentation-Pre-Augmented-CHASEDB1-Retinal-Vessel (2025/02/13)

This is the third experiment of Tiled Image Segmentation for **CHASEDB1 Retinal Vessel** based on the latest Tensorflow-Image-Segmentation-API, and a **pre-augmented tiled dataset** Augmented-Tiled-CHASEDB1-ImageMask-Dataset.zip, which was derived by us from the following dataset:

CHASE_DB1 retinal vessel reference dataset

In this experiment, we retried image segmentation for the CHASEDB1 retinal vessel using our Tile Image Segmentation method to improve the segmentation performance of the previous unsatisfactory results from the Tensorflow-Image-Segmentation-Retinal-Vessel

Please see also our experiments:

- Tensorflow-Tiled-Image-Segmentation-Pre-Augmented-HRF-Retinal-Vessel based on **High-Resolution Fundus (HRF) Image Database**.
- Tensorflow-Tiled-Image-Segmentation-Pre-Augmented-DRIVE-Retinal-Vessel based on **DRIVE: Digital Retinal Images for Vessel Extraction**
- Tensorflow-Tiled-Image-Segmentation-Pre-Augmented-STARE-Retinal-Vessel baased on **STructured Analysis of the Retina**.

Experiment Strategies
As demonstrated in our experiments Tensorflow-Tiled-Image-Segmentation-Pre-Augmented-STARE-Retinal-Vessel and Tensorflow-Tiled-Image-Segmentation-Pre-Augmented-IDRiD-HardExudates , the Tiled Image Segmentation based on a simple UNet model trained by a tiledly-splitted images and masks dataset, is an effective method for the large image segmentation over 4K pixels. Furthermore, as mentioned in Tensorflow-Tiled-Image-Segmentation-Pre-Augmented-STARE-Retinal-Vessel, it is difficult to precisely segment Retinal Blood Vessels in small images using a simple UNet model, because these vessels are typically very thin. Therefore, we generate a high-resolution retinal image dataset by upscaling the original images and use it to train the UNet model to improve segmentation performance.

In this experiment, we employed the same strategies in this project as we did in the STARE-Retinal-Vessel.

1. Enlarged Dataset
We generated a 3x enlarged dataset of 28 JPG images and masks, each with 2997x2880pixels, from the original CHASEDB1 999x960 pixels JPG image and PNG mask files using bicubic interpolation.

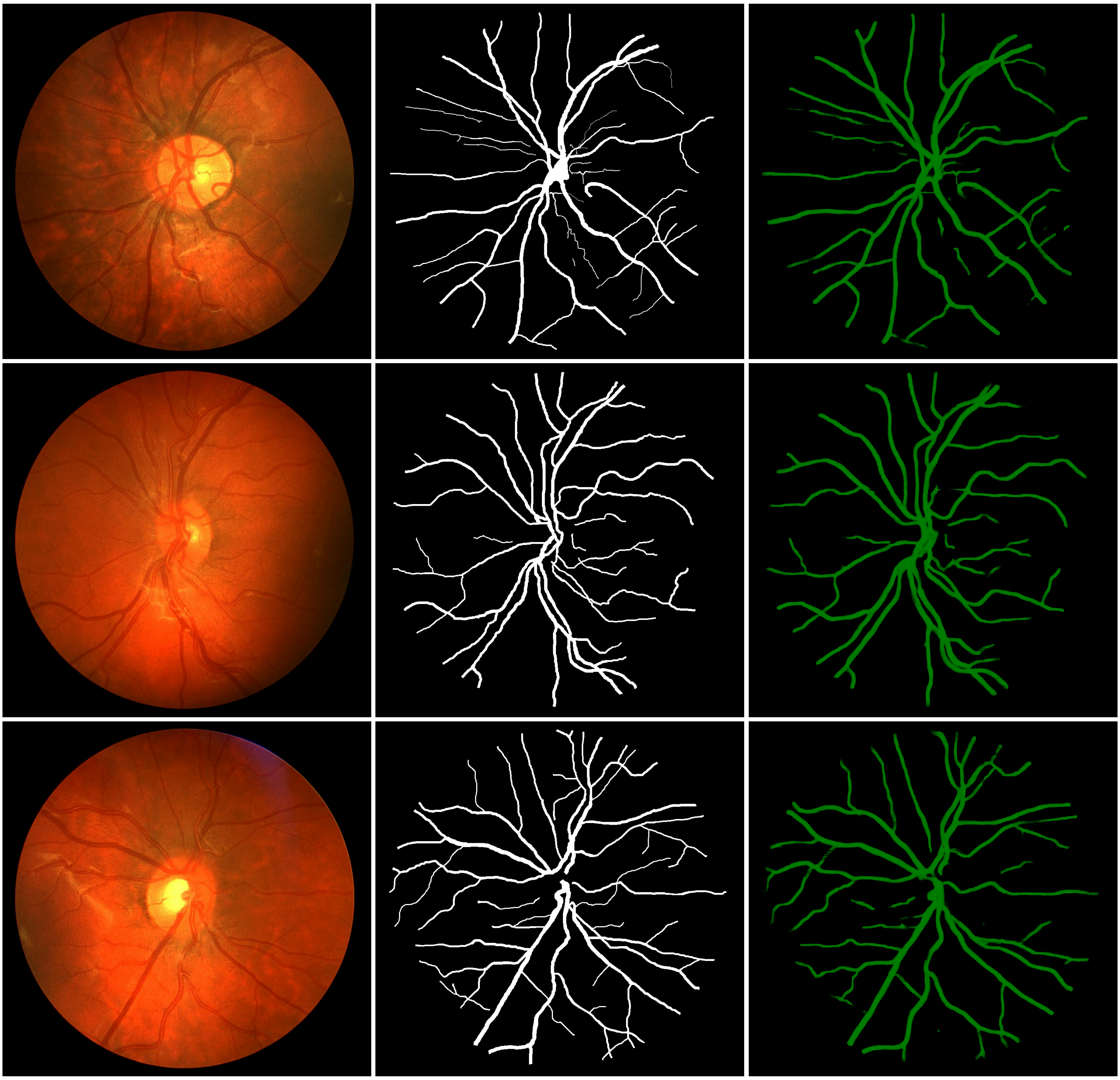
2. Pre Augemtned Tiled CHASEDB1 ImageMask Dataset
We generated a pre-augmented image mask dataset from the enlarged dataset, which was tiledly-splitted to 512x512 pixels and reduced to 512x512 pixels image and mask dataset.

3. Train Segmention Model
We trained and validated a TensorFlow UNet model by using the **Pre Augmented Tiled CHASEDB1 ImageMask Dataset**

4. Tiled Image Segmentation
We applied our Tiled-Image Segmentation inference method to predict the CHASEDB1 Retinal Vessel for the mini_test images with a resolution of 2997x2880pixels of the Enlarged Dataset.

Actual Tiled Image Segmentation for Images of 2997x2880 pixels
As shown below, the inferred masks look similar to the ground truth masks.

Input: image	Mask (ground_truth)	Prediction: inferred_mask



In this experiment, we used the simple UNet Model TensorflowSlightlyFlexibleUNet for this CHASEDB1Segmentation Model.
As shown in Tensorflow-Image-Segmentation-API. you may try other Tensorflow UNet Models:

- TensorflowSwinUNet.py
- TensorflowMultiResUNet.py
- TensorflowAttentionUNet.py
- TensorflowEfficientUNet.py
- TensorflowUNet3Plus.py
- TensorflowDeepLabV3Plus.py

1. Dataset Citation

The dataset used here has been taken from the following web site of Kingston University Research
CHASE_DB1 retinal vessel reference dataset
Fraz, Muhammad Moazam [Creator], Remagnino, Paolo, Hoppe, Andreas, Uyyanonvara, Bunyarit, Rudnicka, Alicja R [Creator], Owen, Christopher G [Creator] and Barman, Sarah A [Creator] (2012)
CHASE_DB1 retinal vessel reference dataset. [Data Collection]

Official URL: https://doi.org/10.1109/TBME.2012.2205687

Lay Summary

A public retinal vessel reference dataset CHASE_DB1 made available by Kingston University, London in collaboration with St. George's, University of London. This is a subset of retinal images of multi-ethnic children from the Child Heart and Health Study in England (CHASE) dataset. This subset contains 28 retinal images captured from both eyes from 14 of the children recruited in the study. In this subset each retinal image is also accompanied by two ground truth images. This is provided in the form of two manual vessel segmentations made by two independent human observers for each of the images, in which each pixel is assigned a "1" label if it is part of a blood vessel and a "0" label otherwise. Making this subset publicly available allows for the scientific community to train and test computer vision algorithms (specifically vessel segmentation methodologies). Most importantly this subset allows for performance comparisons - several algorithms being evaluated on the same database allows for direct comparisons of their performances to be made.

2 Augmented-Tiled-CHASEDB1 ImageMask Dataset

If you would like to train this CHASEDB1 Segmentation model by yourself, please download the pre-augmented dataset from the google drive Augmented-Tiled-CHASEDB1-ImageMask-Dataset.zip, expand the downloaded ImageMaskDataset and put it under **./dataset** folder to be

```
./dataset
└─Augmented-Tiled-CHASEDB1
    ├─test
    │  ├─images
    │  └─masks
    ├─train
    │  ├─images
    │  └─masks
    └─valid
        ├─images
        └─masks
```

This is a 512x512 pixels pre augmented tiles dataset generated from 2997x2880 pixels 28 **Enlarged-images** and their corresponding **Enlarged-masks**.

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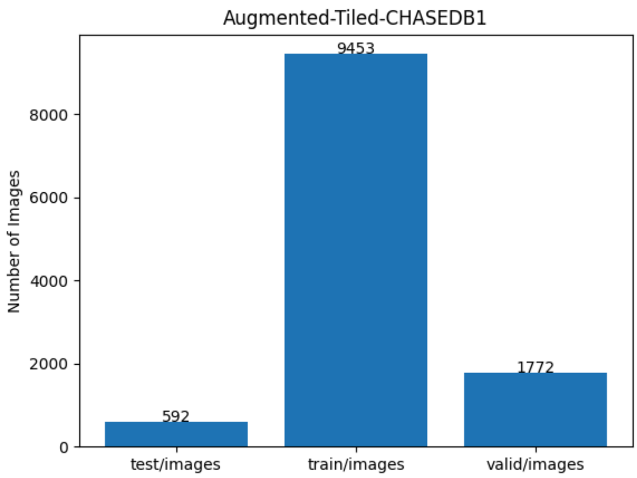
The folder structure of the original **CHASEDB1/training** dataset is the following.

```
./CHASEDB1
  ├─ Image_01L.jpg
  ├── Image_01L_1stHO.png
  ├── Image_01L_2ndHO.png
  ├── Image_01R.jpg
  ├── Image_01R_1stHO.png
  ├── Image_01R_2ndHO.png
 ...
  ├── Image_14L.jpg
  ├── Image_14L_1stHO.png
  ├── Image_14L_2ndHO.png
  ├── Image_14R.jpg
  ├── Image_14R_1stHO.png
  └── Image_14R_2ndHO.png
```

We used the *_2ndHO.png as the ground truth (mask)files for our dataset, and excluded all black (empty) masks and their corresponding images to generate our tiled dataset from the original CHASEDB1.
On the derivation of the dataset, please refer to the following Python scripts.

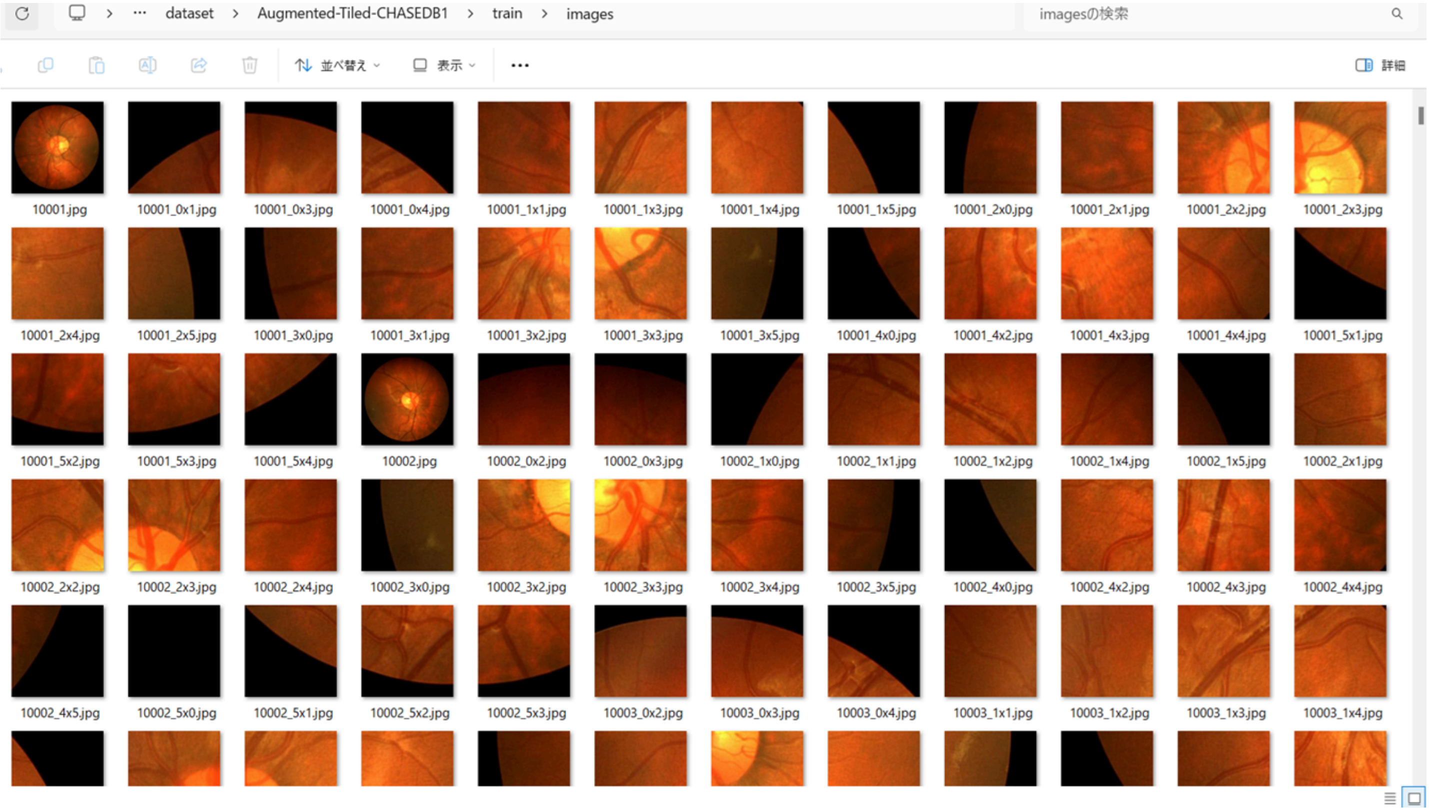
- Preprocessor.py
- TiledImageMaskDatasetGenerator.py
- split_tiled_master.py

Augmented-Tiled-CHASEDB1 Statistics



As shown above, the number of images of train and valid datasets is enough to use for a training set of our segmentation model.

Train_images_sample



Train_masks_sample

3 Train TensorflowUNet Model

We have trained CHASEDB1 TensorflowUNet Model by using the following **train_eval_infer.config** file.
Please move to ./projects/TensorflowSlightlyFlexibleUNet/Augmented-Tiled-CHASEDB1 and run the following bat file.

```
>1.train.bat
```

, which simply runs the following command.

```
>python ../../../src/TensorflowUNetTrainer.py ./train_eval_infer.config
```

Model parameters

Enabled Batch Normalization.
Defined a small **base_filters=16** and large **base_kernels=(9,9)** for the first Conv Layer of Encoder Block of [TensorflowUNet.py]() and a large num_layers (including a bridge between Encoder and Decoder Blocks).

```
[model]
base_filters   = 16
base_kernels   = (9,9)
num_layers     = 8
dilation       = (3,3)
```

Learning rate

Defined a small learning rate.

```
[model]
learning_rate  = 0.00007
```

Online augmentation

Disabled our online augmentation tool.

```
[model]
model         = "TensorflowUNet"
generator     = False
```

Loss and metrics functions

Specified "bce_dice_loss" and "dice_coef".

```
[model]
loss           = "bce_dice_loss"
metrics        = ["dice_coef"]
```

Learning rate reducer callback

Enabled learing_rate_reducer callback, and a small reducer_patience.

```
[train]
learning_rate_reducer = True
reducer_factor     = 0.4
reducer_patience   = 4
```

Dataset class

Specified ImageMaskDataset class.

```
[dataset]
datasetclass  = "ImageMaskDataset"
resize_interpolation = "cv2.INTER_LINEAR"
```

Early stopping callback

Enabled early stopping callback with patience parameter.

```
[train]
patience      = 10
```

Tiled inference

We used 2997x2880pixels enlarged images and masks generated by [Preprocessor.pys]()as a mini_test dataset for our TiledInference.

```
[tiledinfer]
overlapping   = 64
images_dir    = "./mini_test/images"
output_dir    = "./mini_test_output_tiled"
```

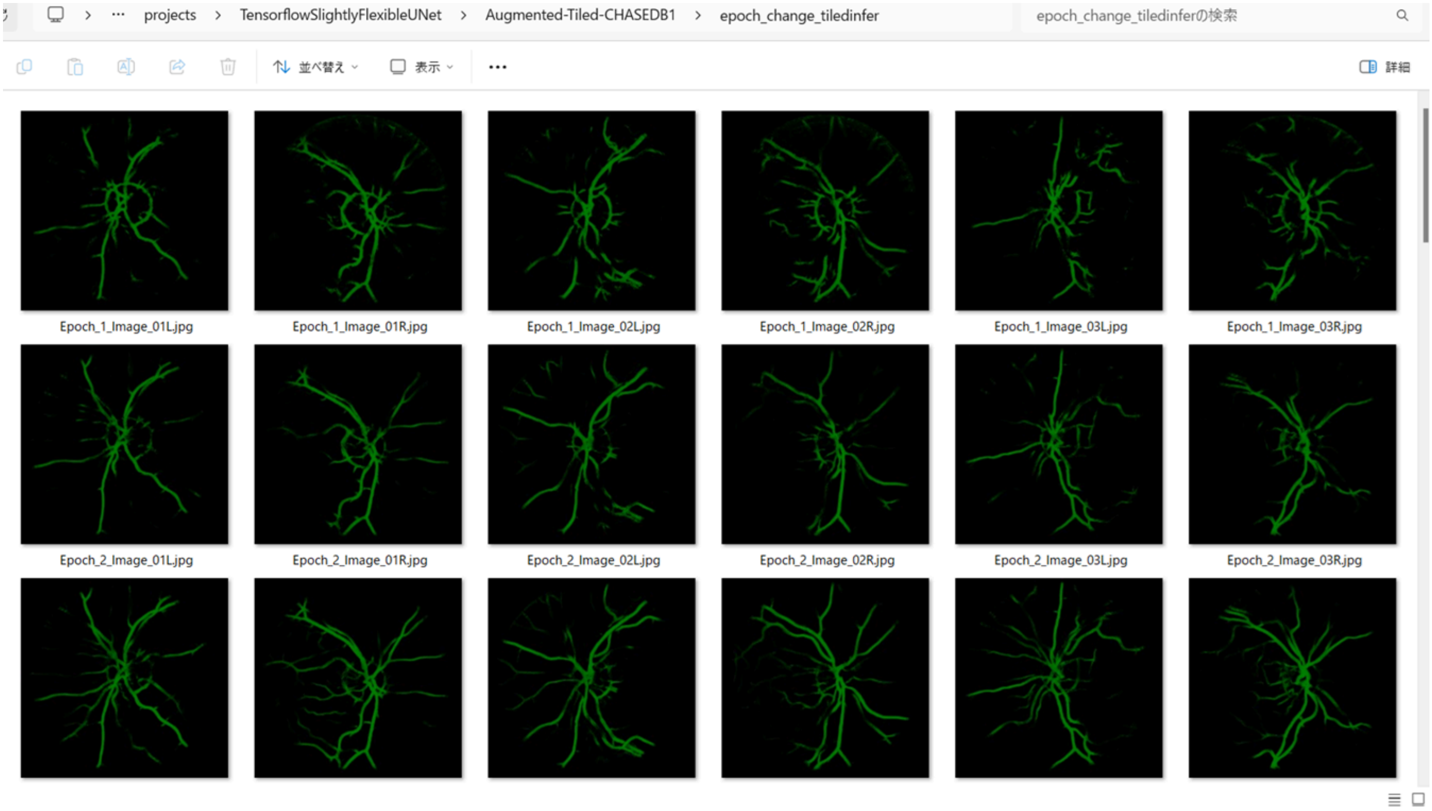
Epoch change inference callbacks

Enabled epoch_change_infer callback.

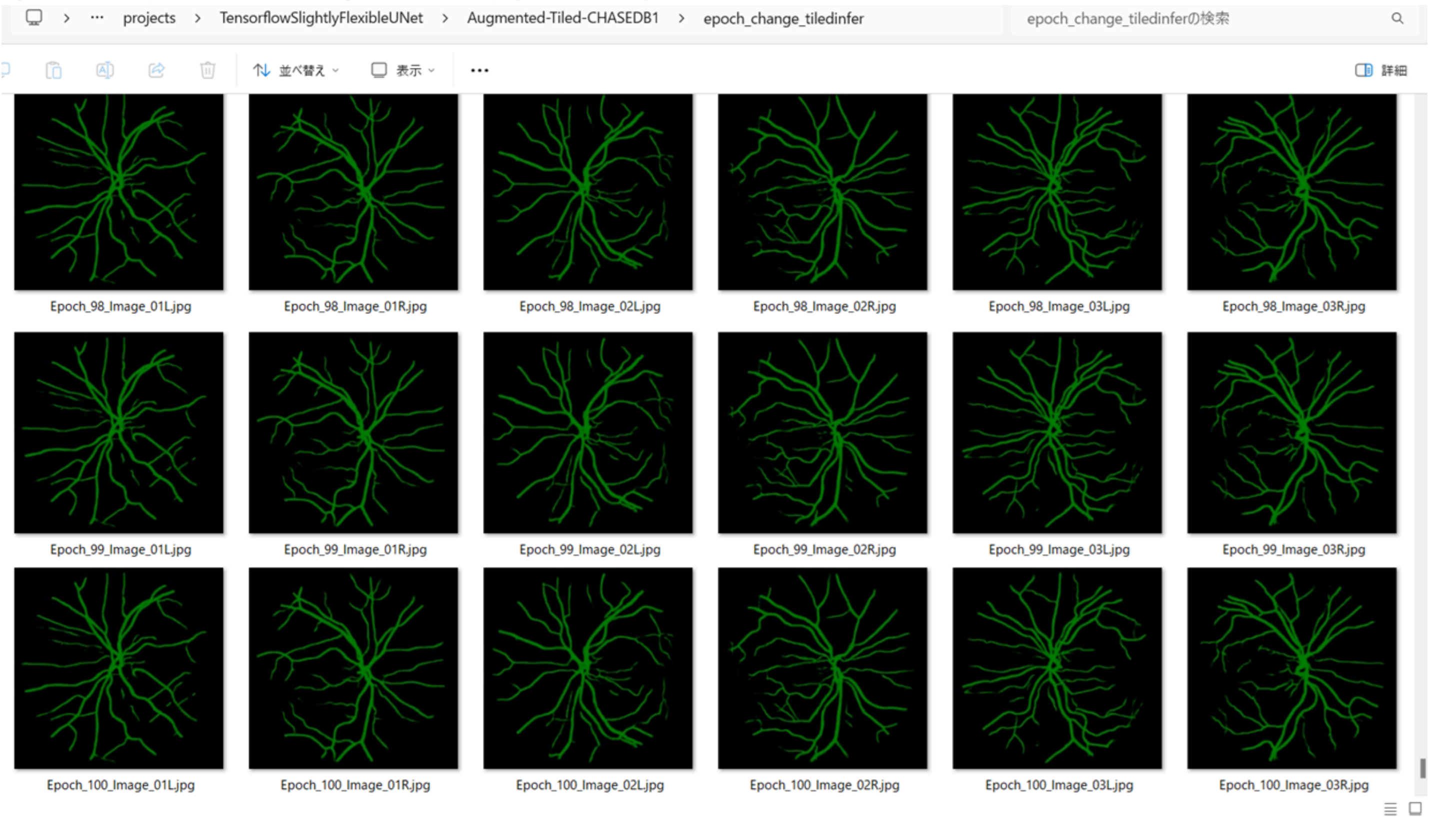
```
[train]
epoch_change_infer      = False
epoch_change_infer_dir  = "./epoch_change_infer"
epoch_change_tiledinfer = True
epoch_change_tiledinfer_dir = "./epoch_change_tiledinfer"
num_infer_images       = 6
```

By using this callback, on every epoch_change, the epoch change tiledinfer procedure can be called for 6 images in **mini_test** folder. This will help you confirm how the predicted mask changes at each epoch during your training process.

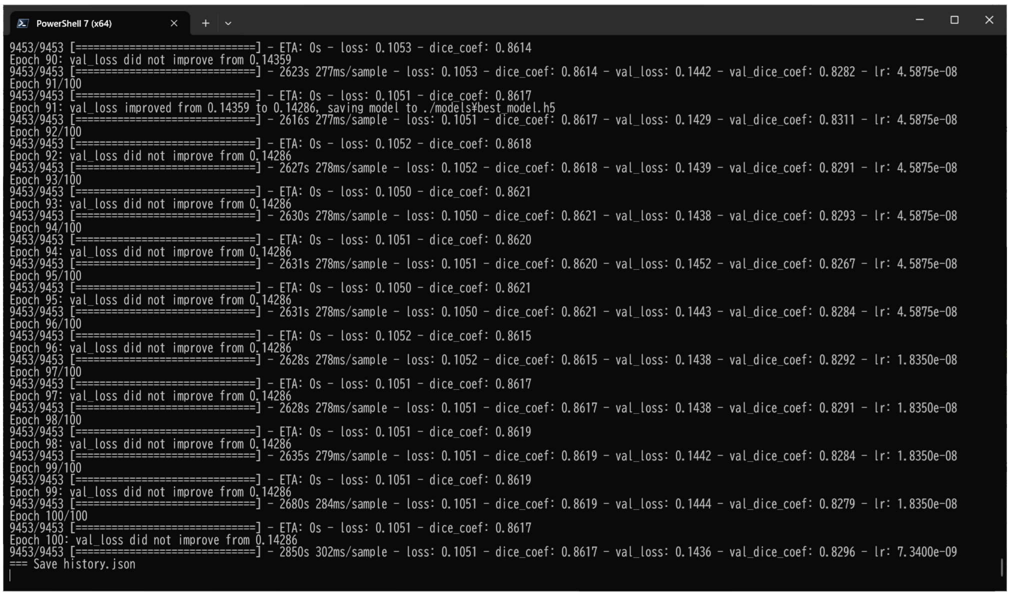
Epoch_change_inference output at starting (1,2,3)



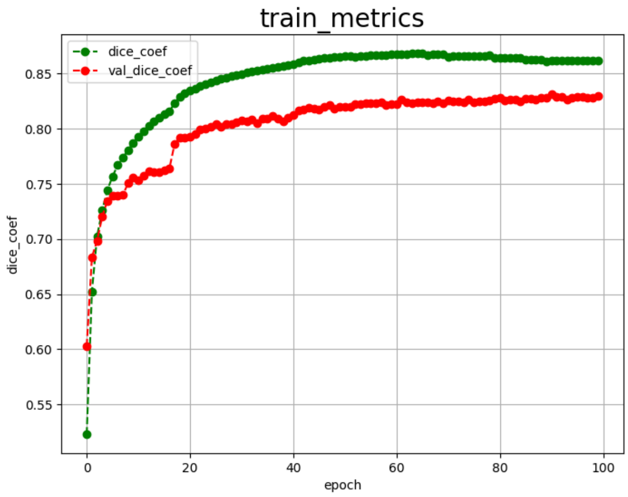
Epoch_change_inference output at ending (98,99,100)



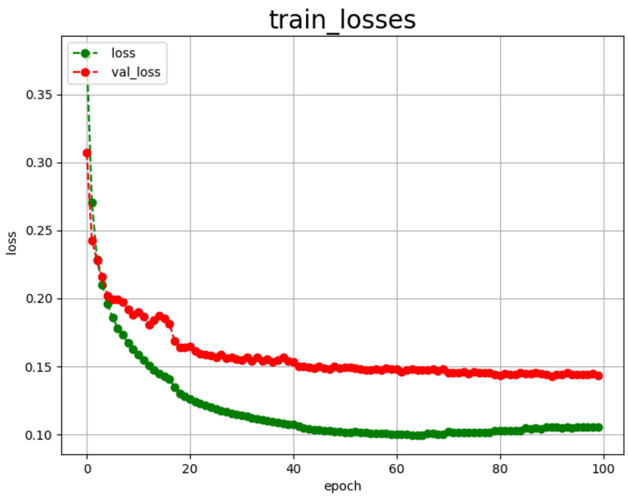
In this experiment, the training process was terminated at epoch 100.



train_metrics.csv



train_losses.csv



4 Evaluation

Please move to a **./projects/TensorflowSlightlyFlexibleUNet/Augmented-Tiled-CHASEDB1** folder, and run the following bat file to evaluate TensorflowUNet model for CHASEDB1.

```
./2.evaluate.bat
```

This bat file simply runs the following command.

```
python ../../../src/TensorflowUNetEvaluator.py ./train_eval_infer_aug.config
```

Evaluation console output:

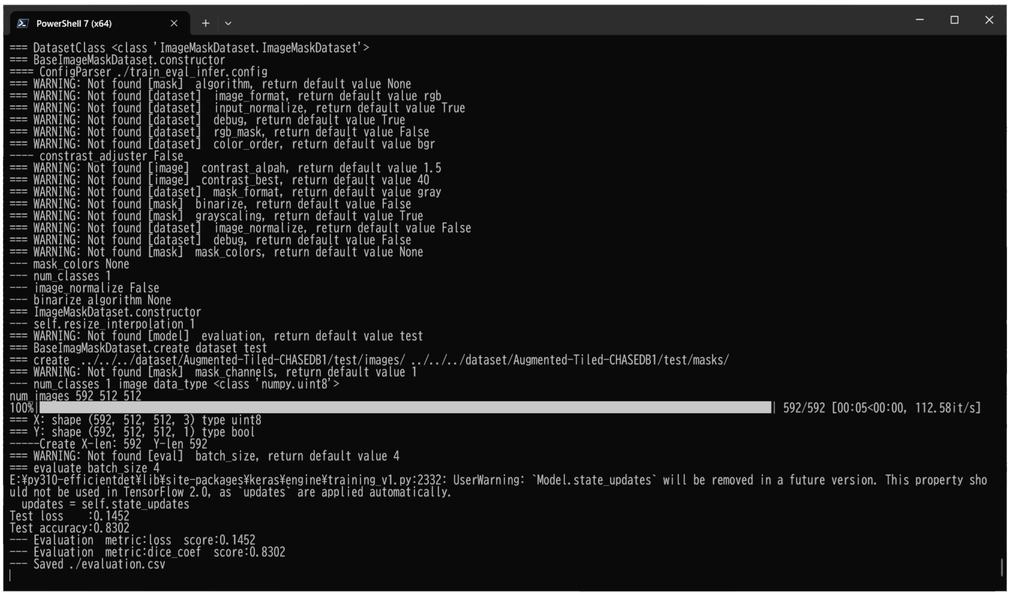


Image-Segmentation-CHASEDB1 evaluation.csv
The loss (bce_dice_loss) to this Augmented-Tiled-CHASEDB1/test was not so low, and dice_coef not so high as shown below, which were better than our second experiment Tensorflow-Image-Segmentation-Retinal-Vessel .

```
loss,0.1452
dice_coef,0.8302
```

5 Tiled inference

Please move to a **./projects/TensorflowSlightlyFlexibleUNet/Augmented-Tiled-CHASEDB1** folder
,and run the following bat file to infer segmentation regions for images by the Trained-TensorflowUNet model for CHASEDB1.

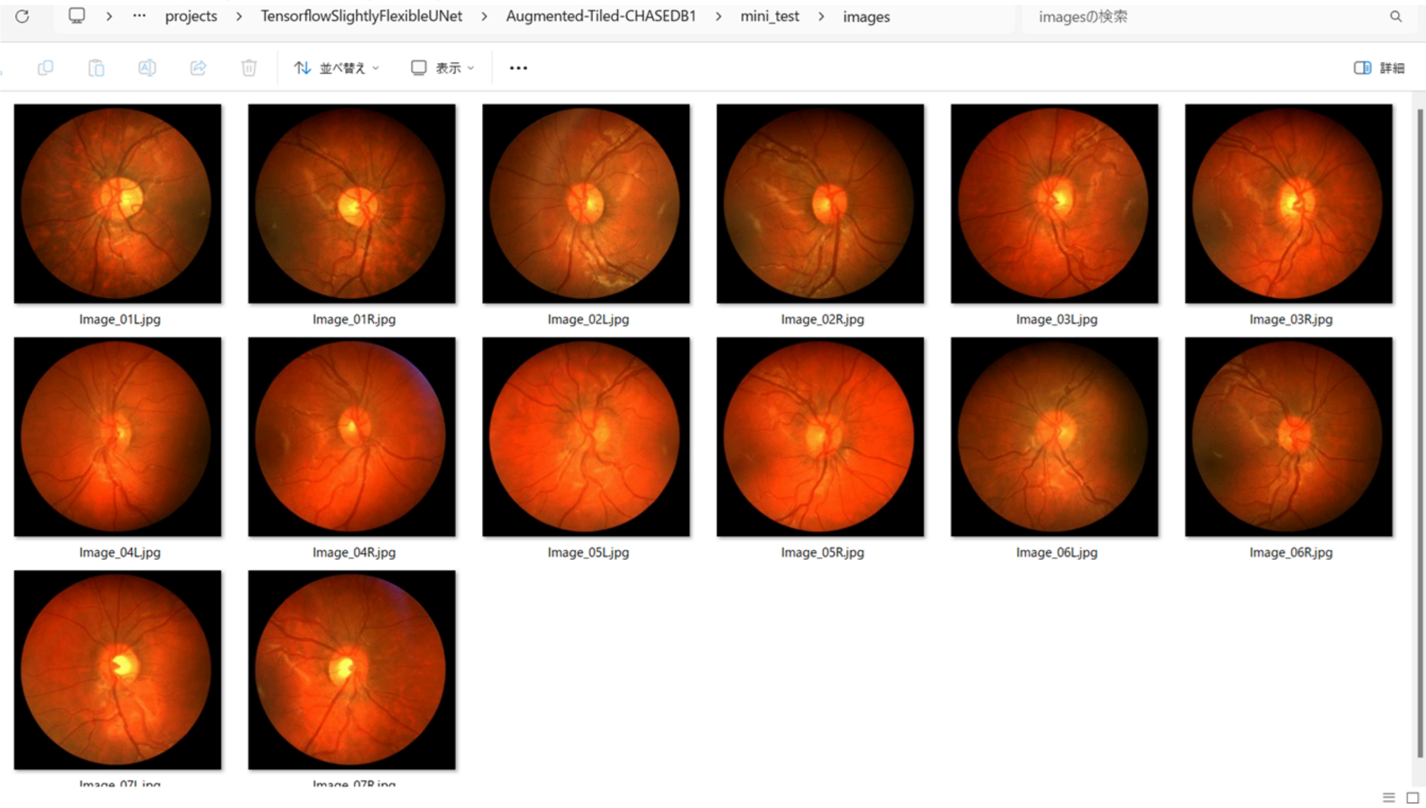
```
./4.tiled_infer.bat
```

This simply runs the following command.

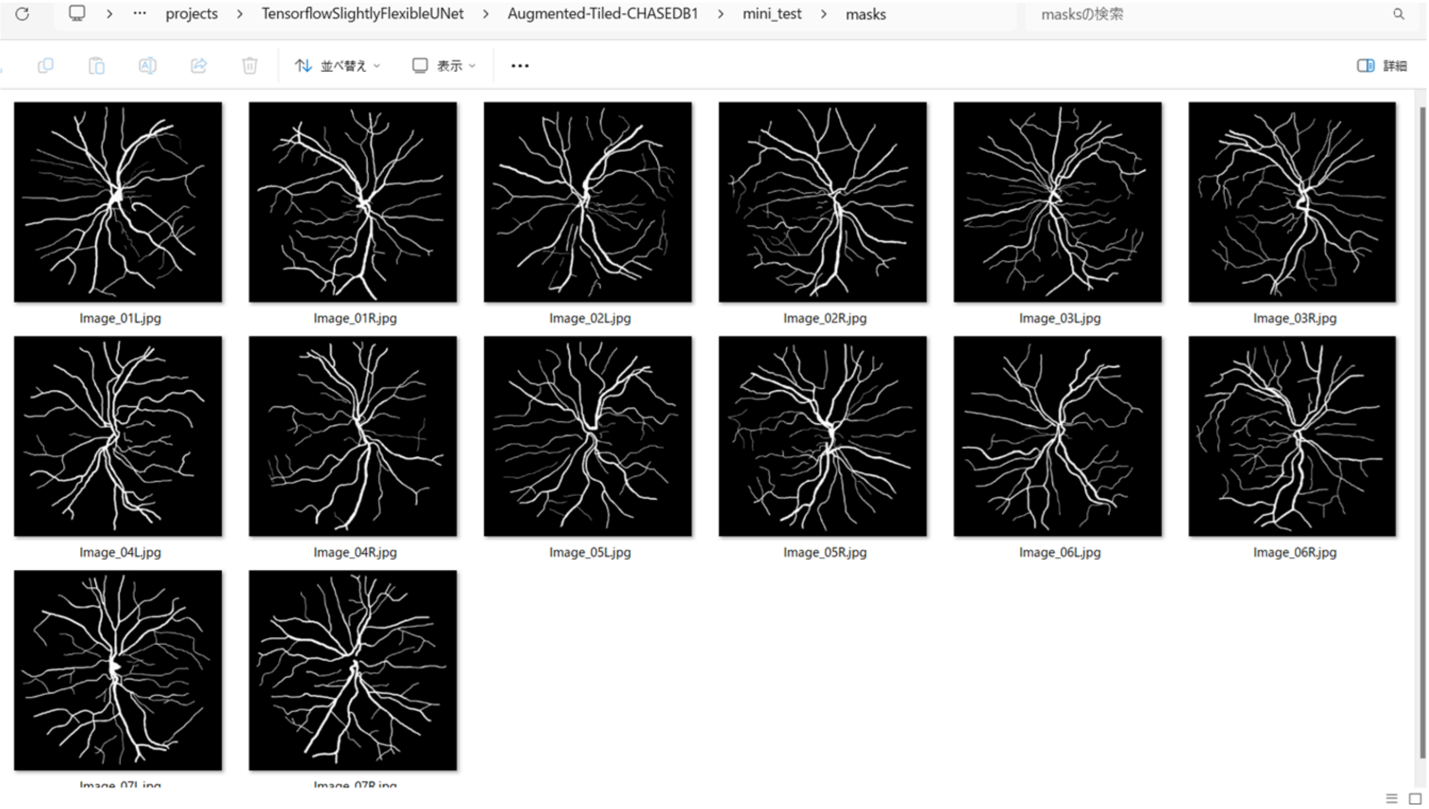
```
python ../../../src/TensorflowUNetTiledInferencer.py ./train_eval_infer.config
```

---

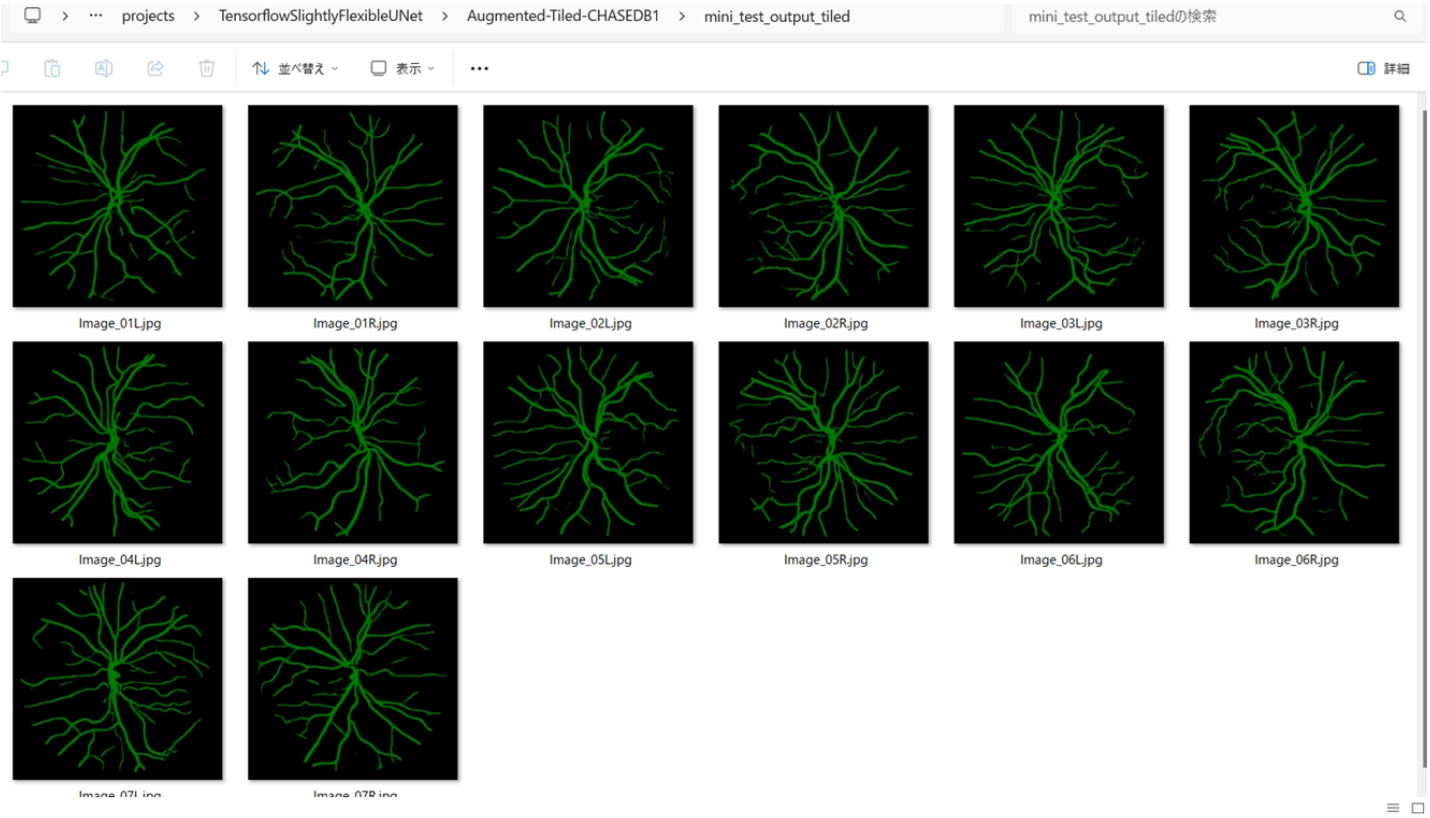
mini_test_images (2997x2880pixels)



mini_test_mask(ground_truth)

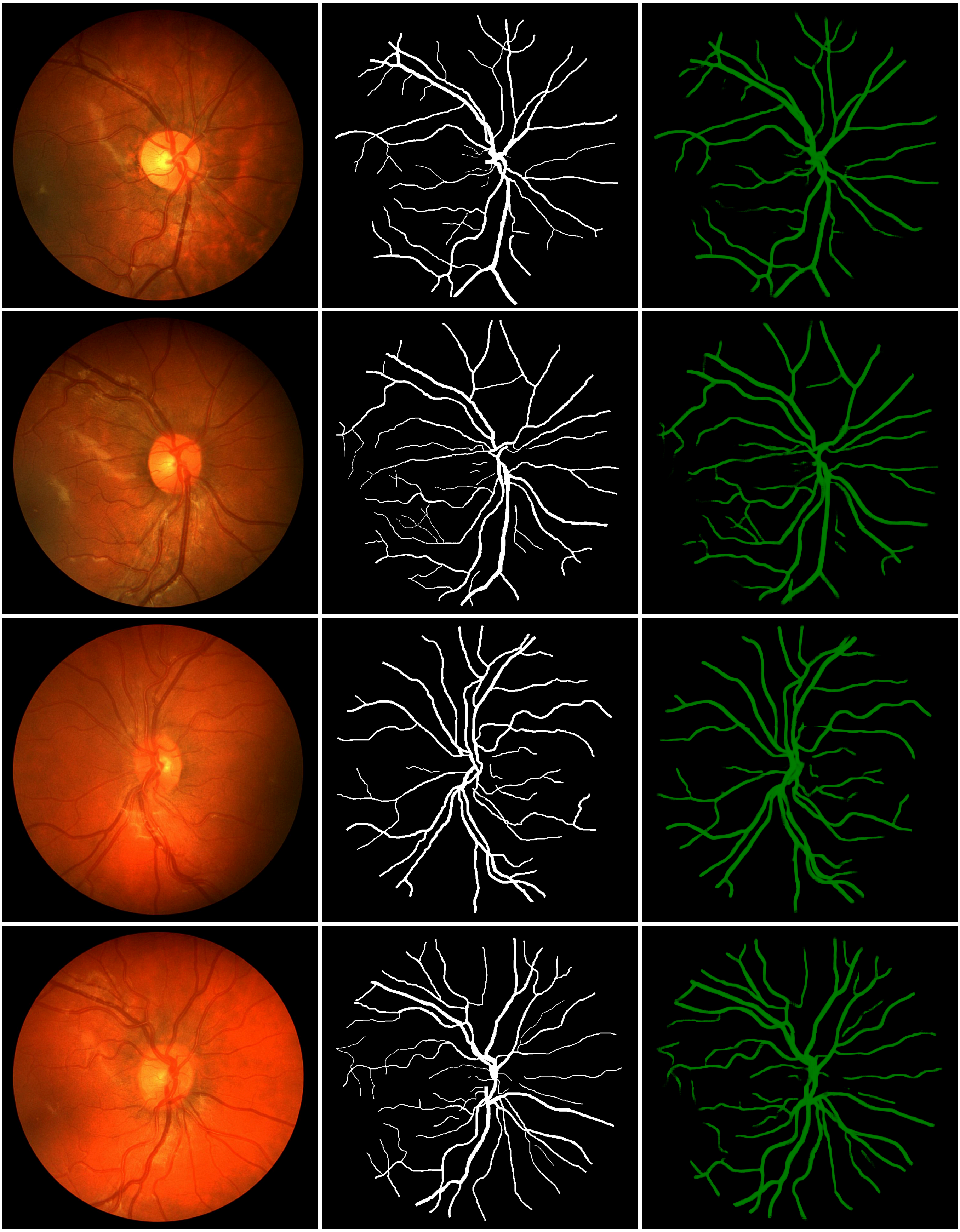


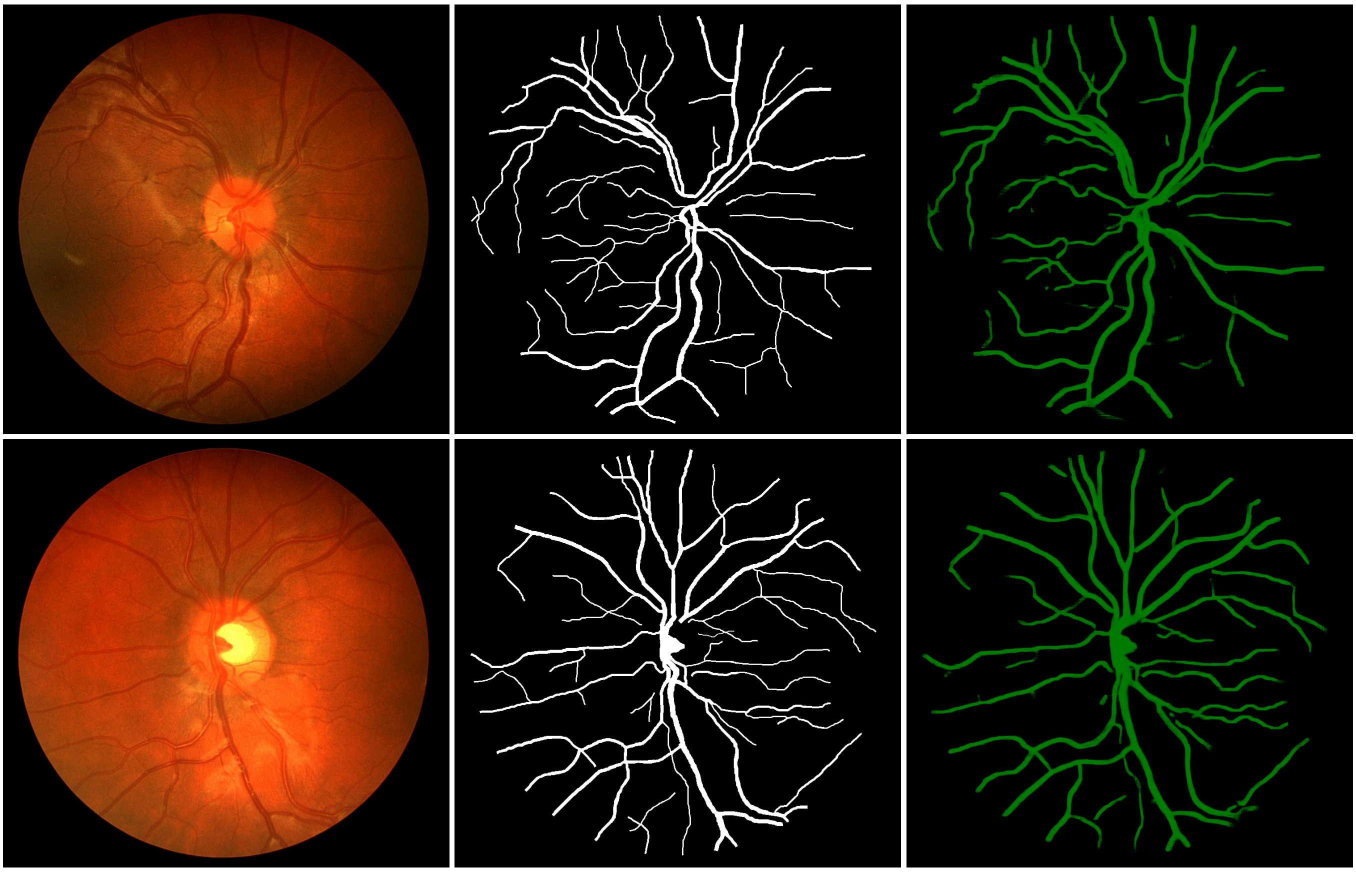
Tiled inferred test masks (2997x2880pixels)



Enlarged images and masks of 2997x2880pixels

Image **Mask (ground_truth)** **Tiled-inferred-mask**





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