Fovea Segmentation using Deep Learning

Project Report

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Dataset

We have trained the model on five datasets to perform binary segmentation. The datasets consist of coloured retina images and their corresponding masks:

1. Drive: **40** datapoints
2. Messidor: **180** datapoints
3. IDRiD: **58** datapoints
4. diaretdb0: **127** datapoints
5. diaretdb1: **79** datapoints

Preprocessing

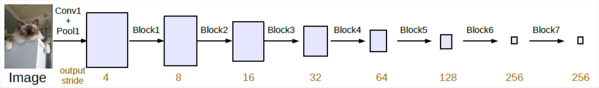
- For feature extraction for the deep learning model, we apply **bilateral filter** $\rightarrow$ two iterations of **dilation** $\rightarrow$ one iteration of **erosion**.
- For image augmentation we perform **shuffling, rotation, scaling, shifting and brightness contrast**.
- The images and masks are resized to 512×512 **dimensions** while training.
- We also added **cropping** to increase the number of datapoints by 20%.

Literature Review

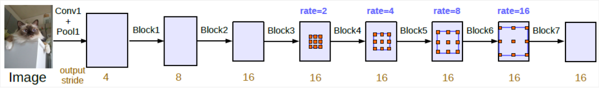
1. Paper 1: Tan et al
   - Converted RGB to **LUV** then processing on L to RGB
   - LReLU, softmax, Xavier initialization is used
   - **7-layer** custom network is trained
2. Paper 2: Sedai et al
   - 2 stage approach is used: **coarse network** followed by **fine network**
   - ImageNet pre-trained **VGG-16** model is used
   - **Class balanced cross entropy loss** is used to fix the imbalance problem

Architecture

- We trained a **DeepLabV3+** model with **EfficientNet-B3** as the backbone.
  - DeepLabV3+ is a refinement of DeepLabV3 which uses atrous convolution. Atrous convolution is a powerful tool to explicitly adjust the filter's field-of-view as well as control the resolution of feature responses computed by Deep Convolution Neural Network.
  - We use **encoder depth of 5** which refers to the number of stages used in encoder. The number of d**ecoder channels used is 256**.



(a) Going deeper without atrous convolution.



(b) Going deeper with atrous convolution. Atrous convolution with $rate > 1$ is applied after block3 when $output\_stride = 16$.

Figure: DeepLab V3+

Loss

- **Binary Cross Entropy Loss**
  $L_{BCE} = y \log(y_{hat}) + (1 - y) \log(1 - y_{hat})$
- **Dice Loss**
  $L_{Dice} = 1 - \frac{2TP}{2TP+FN+FP}$
- **Tversky Loss**
  $L_{Tversky} = 1 - \frac{TP}{TP+\alpha FN+\beta FP}$ where, $\alpha + \beta = 1$
- **Focal Tversky Loss**
  $L_{FTL} = (L_{Tversky})^{\gamma}$ where, γ controls the non-linearity of the loss.
- **Final Loss**
  $L_f = \lambda L_{BCE} + (1 - \lambda) L_{FTL}$ where, λ is the weight parameter.

Semi-supervised pipeline

Algorithm 1: Semi-supervised classification train loop

Input: Sample image
Output: Class of the given image

for $epoch \leftarrow 0$ **to** E **do**
  if $epoch < E_i^\alpha$ **then**
    $\alpha \leftarrow \alpha_i$
  else if $epoch < E_f^\alpha$ **then**
    $\alpha \leftarrow \frac{\alpha_f - \alpha_i}{E_f^\alpha - E_i^\alpha} * (epoch - E_i^\alpha) + \alpha_i$
  else
    $\alpha \leftarrow \alpha_f$
  end if
  Run the model on train set
  $loss \leftarrow BCE(l, \hat{l}) + \alpha * BCE(u_{epoch}, u_{epoch-1})$
  Generate the pseudo labels for unlabeled data
  Evaluate the model on validation set
end for

Figure: Semi-supervised algorithm

Evaluation and Results

Method	F1	MIoU	Sens	Spec	Acc
non-DL	0.804	0.688	0.816	**0.998**	0.996
Ours	**0.824**	**0.705**	**0.917**	0.997	**0.997**
Tan et al	-	-	0.885	0.991	-
Sedai et al	0.810	-	-	-	-

Table: Metrics Comparison

Image - Mask - Prediction

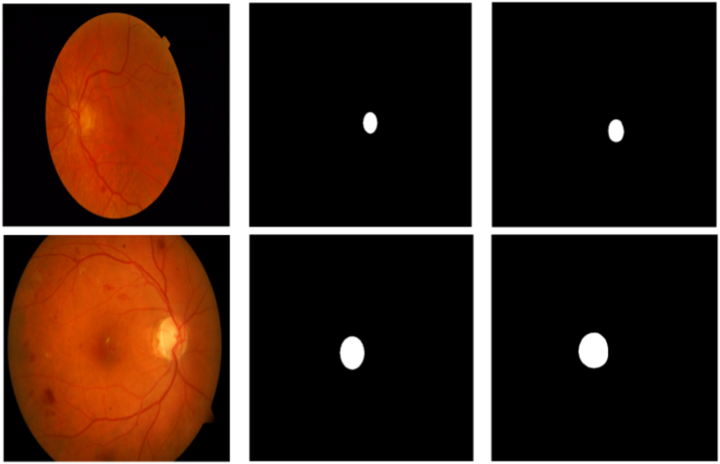


Figure: Image, Mask and Prediction (left to right)

Discussion

- We were able to get **state-of-the-art results** for fovea segmentation using our **semi-supervised segmentation method**.
- All our work for this **2.5 month** project has been summarised in our **5 bi-weekly reports** in detail.
- We are currently working on **AMD classification** and are aiming to perform equally well on that task.