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# A TEMPLATE FOR THE *arxiv* STYLE

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A PREPRINT

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## ABSTRACT

Diabetic retinopathy is an eye disease that can affect people suffering diabetes. It causes damage to the blood vessels of the eyes, deteriorates the eyesight and can lead in the worst case to blindness of the patient. It is important to detect the disease in an early stage to mitigate it as good as possible with an early treatment. Analyzing images of eyes and classify the severity of diabetic retinopathy is a challenging task that requires expert knowledge. To assist doctors and medical personnel, a classification model shall be trained to classify the severity automatically.

## 1 Introduction

Diabetic retinopathy is a complication of diabetes, which can cause damage the retina of the eye. If not detected early, this damage may cause vision impairment or even blindness. To treat this condition successfully, it has to be detected at an early stage, which is difficult due to minimal to no early warning signs. Furthermore, the different grades can only be distinguished by a trained professional due to its subtle symptoms. Examples are leaking blood vessels, fatty deposits or retinal swelling. Since this task is difficult even for trained professionals, an algorithm for automatic detection of the diabetic retinopathy grade is necessary. This is the goal of this paper.

Dataset

## 2 Object Classification

### 2.1 Problem analysis

To tackle the problem of diabetic retinopathy detection, several methods are possible. Because the dataset consists of ordinally scaled data of 5 classes, regression could be used to estimate the serverity of a case. In addition, a the problem can be handled as a classification problem after one-hot-encoding the labels. As a third option, one can define a threshold to define problematic diabetic retinopathy and non-problematic diabetic retinopathy and can handle the problem as a binary classification. Further, only binary and multiclass classification are analyzed.

A binary classification has the advantage of higher accuracy, but lacks details, because the network only outputs 0 or 1 and no information about the exact serverity of the disease. Metrics are also easy to implement, because precision, recall and f1-score are standard implementations and nicely interpretable.

A multiclass classification has typically a lower accuracy, because the network needs to pick the right class among several classes. It provides the benefit of receiving richer information, i.e. the exact serverity of the disease. Evaluating a multiclass classification problem becomes harder, because missclassifications can vary in their error. Classifying a class 1 as class 2 is for example less problematic than classifying class 1 as class 5.

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\*Use footnote for providing further information about author (webpage, alternative address)—*not* for acknowledging funding agencies.

## 2.2 Architecture

VGG, Resnet, Weight freeze / unfreeze, GAP, Flatten, Dense Layers

## 2.3 Weight initialization

Weight initialization refers to the initial values of parameters that are used in specific neural network layers. Changing the initialization of the layers changes the starting point for the optimization process and potentially also the performance. Keras initializes the weights of dense layers with the Glorot uniform initializer, which draws samples from a truncated uniform distribution. Generally the goal is to avoid vanishing and exploding gradients, even better is if the variance of layer outputs is approximately one. [paper KUMAR] Specifically for the ReLU activation function, this is achieved with the He initialization, which draws from a normal distribution with the following parameters. [paper HE]

$$\mu = 0 \quad (1) \quad \sigma^2 = 2/N \quad (2)$$

This led to a faster training and performance increase of X percent.

## 2.4 Augmentation

Within the input pipeline three main types of augmentation are applied. The goal is to make feature extraction easier for the network and increase the amount of input images which reduces overfitting.

### - Graham preprocessing:

1. rescale the eye radius to 300 pixels
2. subtract the local average color such that the local average gets mapped to gray
3. clip the image to remove boundary effects

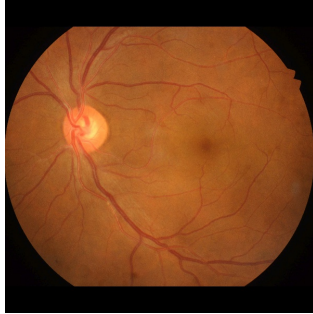


Figure 1: original image



Figure 2: graham preprocessed image

- **Color jittering:** Slight random changes to brightness, hue, saturation or contrast.
- **Random cropping:** Crop a window that is slightly smaller than the image. Then resize to original size again.

## 2.5 Dataset Balancing

Two types of dataset balancing were evaluated. First class-balancing and second oversampling.

## 2.6 Training

Adam, SGD, Momentum, Learning rate decay

## 2.7 Metrics

Training deep neural networks requires some performance metrics indicating the success or failure of the model fitting. Accuracy is easy to understand and to implement, but not suited for imbalanced data, because it doesn't take into account how well each single class is predicted. To overcome this, precision (how accurate was the model with its prediction) and recall (how thorough is a model with its prediction) can be used. Especially a combination of both, the f1-score is a metrics that indicates how well a classifier handles different classes.

For the diabetic retinopathy dataset, the f1-score comes with a drawback. The dataset is ordinaly scaled, which means predicting a wrong class is not equally bad. As an example is predicting class 4 for the true class 0 much worse than predicting a 1. The f1-score would count both missclassifications equally, while the Quadratic Weighted Kappa (QWC) metric takes the distance of the classification error into account.

### 3 Experiments

#### 3.1 Procedure

The training of the deep neural network classifier requires the selection of suitable hyperparameters that differ from problem to problem. A useful strategy to find a good set of hyperparameters are parameter sweeps. Weights&Biases is a python library that enables the easy implementation of sweeps.

Hyperparameter optimization requires besides training and test dataset a third, the validation dataset, to evaluate the model after hyperparameter tuning and to avoid overfitting on the hyperparameters. Because the given dataset only contains training and test data, the original training dataset was split into 80% training data and 20% validation data.

In total, x sweeps consisting of x runs and x epochs were performed during the project.

#### 3.2 Hyperparameter selection

The following parameters show a big effect on the performance of the neural network on the validation data, why they are selected for the final classifier.

Balancing

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#### 3.3 Grad cam

### 4 Results

best binary + multiclass performance; color coded confusion matrix

### 5 Headings: first level

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#### 5.1 Headings: second level

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$$\xi_{ij}(t) = P(x_t = i, x_{t+1} = j | y, v, w; \theta) = \frac{\alpha_i(t) a_{ij}^{w_t} \beta_j(t+1) b_j^{v_{t+1}}(y_{t+1})}{\sum_{i=1}^N \sum_{j=1}^N \alpha_i(t) a_{ij}^{w_t} \beta_j(t+1) b_j^{v_{t+1}}(y_{t+1})} \quad (3)$$

##### 5.1.1 Headings: third level

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## 6 Examples of citations, figures, tables, references

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The documentation for natbib may be found at

<http://mirrors.ctan.org/macros/latex/contrib/natbib/natnotes.pdf>

Of note is the command `\citet`, which produces citations appropriate for use in inline text. For example,

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\citet{hasselmo} investigated\dots
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produces

Hasselmo, et al. (1995) investigated...

<https://www.ctan.org/pkg/booktabs>

### 6.1 Figures

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### 6.2 Tables

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### 6.3 Lists

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<sup>2</sup>Sample of the first footnote.



Figure 3: Sample figure caption.

Table 1: Sample table title

Part		
Name	Description	Size ( $\mu\text{m}$ )
Dendrite	Input terminal	$\sim 100$
Axon	Output terminal	$\sim 10$
Soma	Cell body	up to $10^6$

## References

- [1] Siddharth Krishna Kumar. On weight initialization in deep neural networks. *arXiv:1704.08863*, 2017.
- [2] name. title. In *Frontiers in Handwriting Recognition (ICFHR), 2014 14th International Conference on*, pages 417–422. IEEE, 2014.