





Introduction

Convolutional Neural Network

Transfer Learnin;

Data

Training and Finetuning

Result

Deficienc

# Presented By:

## Subhajit Barh

**Department of Mathematics** 

(Computer Science and Data Processing)

Indian Institute of Technology Kharagpur







### Contents in Brief

Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional

Transfer

\_\_\_\_\_\_

Dun

Training and Finetuning

Result

7

References

Introduction

2 Convolutional Neural Network

3 Transfer Learning

4 Data

5 Training and Finetuning

6 Result

7 Deficiency

8 Improvement

9 References





#### What is Diabetic Retinopathy?

Detecting Diabetic Rtinopathy using Deep Learning

Introduction

What is DR

Detecting DR

Detecting DR using L

Convolutional
Neural Network

Transfer Learning

Data

raining an ïnetuning

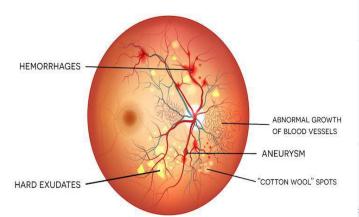
Result

Deficiency

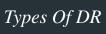
Improvemen

Reference.

Diabetic retinopathy (DR), also known as diabetic eye disease, is a medical condition in which damage occurs to the retina due to diabetes mellitus. It is a leading cause of blindness. Diabetic retinopathy affects up to 80 percent of those who have had diabetes aged 20 years or more.









#### Introductio

What is DR

Detecting DR

Detecting DR using De

Convolutional

Transfer

Learning

Training ar

Finetuning

n ...

Improvemer

References

Depending on severity we can devide Diabetic Retinopathy in 5 categories

0 - No DR

/ - Mild

2 - Moderate

3 - Severe

4 - Proliferative DR





#### Detecting Diabetic Retinopathy

Detecting Diabetic Rtinopathy using Deep Learning

Introductio

What is DR

Detecting DR using D

Convolutional

Transfer

LCC IIII

Training ar

Result

Deficienc

Improvemen

Reference:

#### Manual Detection

Detecting Daiabetic Retinopathy is currently done by a method called Dilated eye exam . In this method the doctor administers drops in patient's eye and take pictures of the retina. After reviewing the image doctor have to manually conclude about the presence or advance of the disease . The doctor or experts generally looks for abnormalities in the blood vessels, optic nerve, retina, or formation of new blood vessels, retinal detachment, scar tissue etc .



#### Detecting Diabetic Retinopathy

Detecting Diabetic Rtinopathy using Deep Learning

Introductio

What is DR

Detecting DR using D

Convolutional

Transfer Learning

Data

raining an

Result

Deficienc

Improvemen

References

#### Manual Detection

Detecting Daiabetic Retinopathy is currently done by a method called Dilated eye exam . In this method the doctor administers drops in patient's eye and take pictures of the retina. After reviewing the image doctor have to manually conclude about the presence or advance of the disease . The doctor or experts generally looks for abnormalities in the blood vessels, optic nerve, retina, or formation of new blood vessels, retinal detachment, scar tissue etc .

#### **Automated Detection**

An automated tool for grading severity of diabetic retinopathy would be very useful for accerelating detection and treatment. We will use a Deep learning convolutional neural network model to detect Diabetic Retinopathy with minimum human intervention .



#### Detecting DR using Deep Learning

Detecting Diabetic Rtinopathy using Deep Learning

Introductio

Detecting DR

Detecting DR using Dee

Convolutional
Neural Network

Transfer Learning

D =4=

aining an netuning

Resuli

Deficienc

Improvemen

Reference

We will use Convolutional Neural Network along with transfer Learning to detect and categorize the presence of diabetic Retinopathy



#### What is Convolutional Neural Network

Detecting Diabetic Rtinopathy using Deep Learning

Introductio

Convolutional Neural Network

What is CNN

Back Propagat

Gradient Desc

Transfer Learnin

Data

Training an

Result

Deficienc:

Improvemen

Reference

#### **CNN**

CNN(convolutional Neural Network) is an neural network architecture which works really well with Images. Each Convolution Layer Consists of mainly three sub layers.

- 1 Convolution layer
- 2 Pooling Layer
- 3 Fully Connected Layer





Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional Neural Networ

What is CNN

Transfer

Data

Training and Finetuning

Result

Deficienc<sub>.</sub>

References

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

<b>1</b> <sub>×1</sub>	1,0	<b>1</b> <sub>×1</sub>	0	0
O <sub>×0</sub>	<b>1</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	1	0
0,1	O <sub>×0</sub>	<b>1</b> <sub>×1</sub>	1	1
0	0	1	1	0
0	1	1	0	0

**Image** 

4	



Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional Neural Networ

What is CNN

Transfer

Data

Training and Finetuning

Result

Deficienc<sub>:</sub>

....p. 10 1 cm c.

References

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

1	<b>1</b> <sub>×1</sub>	1,0	<b>0</b> <sub>×1</sub>	0
О	<b>1</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	0
0	<b>O</b> <sub>×1</sub>	1,0	<b>1</b> <sub>×1</sub>	1
0	0	1	1	0
0	1	1	0	0

Image

4	3	





Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional Neural Network

What is CNN

Transfer

Data

Training and Finetuning

Result

Deficienc:

- -

References

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

1	1	<b>1</b> <sub>×1</sub>	0,0	<b>O</b> <sub>×1</sub>
0	1	<b>1</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	0,
0	0	<b>1</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	1,
0	0	1	1	0
0	1	1	0	0

Image

4	3	4





Detecting Diabetic Rtinopathy using Deep Learning

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

1	1	1	0	0
0,1	<b>1</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	1	0
<b>O</b> <sub>×0</sub>	<b>O</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	1	1
0,	O <sub>×0</sub>	<b>1</b> <sub>×1</sub>	1	0
0	1	1	0	0

Image

4	3	4
2		



Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional Neural Network

What is CNN

Transfer

Learnii

Training and Finetuning

Resuli

Deficienc<sub>.</sub>

Dafavanaa

References

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

1	1	1	0	0
0	<b>1</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	0
0	<b>O</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	1
0	<b>O</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	0
0	1	1	0	0

Image

4	3	4
2	4	



Detecting Diabetic Rtinopathy using Deep Learning

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

1	1	1	0	0
0	1	<b>1</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	<b>O</b> <sub>×1</sub>
0	0	<b>1</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	1,
0	0	<b>1</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	<b>0</b> <sub>×1</sub>
0	1	1	0	0

Image

4	3	4
2	4	3



Detecting Diabetic Rtinopathy using Deep Learning

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

1	1	1	0	0
0	1	1	1	0
<b>O</b> <sub>×1</sub>	<b>O</b> <sub>×0</sub>	1,	1	1
<b>O</b> <sub>×0</sub>	<b>0</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	1	0
O <sub>1</sub>	1,	1,	0	0

Image

4	3	4
2	4	3
2		



Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional Neural Network

What is CNN

Transfer

Data

Training and Finetuning

Resuli

Deficienc

ımprovemei

References

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

1	1	1	0	0
0	1	1	1	0
0	<b>O</b> <sub>×1</sub>	1,0	1,	1
0	<b>O</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	<b>1</b> <sub>×0</sub>	0
0	1,	1,	O <sub>1</sub>	0

Image

4	3	4
2	4	3
2	3	



Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional
Neural Network

What is CNN

Transfer

Learnii

....

Training and Finetuning

Result

Deficienc<sub>.</sub>

Improvemer

References

In convolution layer the filter(a smaller dimentional matrix) moves to the right with a certain Stride Value till it parses the complete width. Moving on, it hops down to the beginning (left) of the image with the same Stride Value and repeats the process until the entire image is traversed. In each step it computes the dot product with the original matrix and thus constructs the output matrix.

1	1	1	0	0
0	1	1	1	0
0	0	<b>1</b> <sub>×1</sub>	1,0	1,
0	0	<b>1</b> <sub>×0</sub>	<b>1</b> <sub>×1</sub>	0,
0	1	1,	O <sub>0</sub>	Q <sub>1</sub>

Image

4	3	4
2	4	3
2	3	4



Introduction

Convolutional Neural Network

What is CNN

Back Propagation

Transfer Learnin

Date

Training and Finetuning

Result

Deficienc<sub>.</sub>

Improvemen

Reference:

Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

Introduction

Convolutional
Neural Networ

What is CNN
Back Propagation

Transfer Learnin

D ...

Training and Finetuning

Result

Deficienc<sub>.</sub>

Improvemen

Reference.

Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1



Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

Introduction

Convolutional Neural Network

What is CNN

Back Propagation

Transfer Learnin

Date

Training and Finetuning

Result

Deficienc<sub>.</sub>

Improvemen

Reference.

Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

Introduction

Convolutional Neural Networ

What is CNN
Back Propagation

Transfer Learnin

Date

Training and Finetuning

Result

Deficienc

тирто чете.

References

Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

Introduction

Convolutional Neural Network

What is CNN
Back Propagation

Transfer Learnin

Date

Training and Finetuning

Result

Deficienc<sub>.</sub>

Improvemen

Reference.

Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

Introduction

Convolutional Neural Network

What is CNN
Back Propagation

Transfer Learnin

Date

Training and Finetuning

Result

Deficienc

Improvemen

Reference.

Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

Introduction

Convolutional
Neural Network

What is CNN
Back Propagation

Transfer Learnin

Data

Training and Finetuning

Result

Deficienc

Improvemen

Reference.

Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

Similar to the Convolutional Layer, the Pooling layer is responsible for reducing the spatial size of the Convolved Feature

3.0	3.0	3.0
3.0	3.0	3.0
3.0	2.0	3.0

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1



### Fully Connected Layer

Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional

What is CNN
Back Propagation

Transfe Learnin

Date

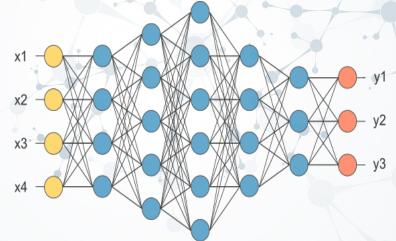
Training an Finetuning

Result

Deficienc

.

The fully connected layer is nothing but a ordinary perception based network. Here we flattened our matrix into vector and feed it into a fully connected layer like any other neural network.







#### Back Propagation and Optimization

Detecting Diabetic Rtinopathy using Deep Learning

Introductio

Convolutional Neural Networi

Back Propagation
Gradient Descer

1 ransje Learnii

Data

Training and Finetuning

Resuli

Deficienc

Improvemen

References

All those filters have weights. Those weights and percepton weights in FC layers must be learned using back-propagation . In each iteration we update those weights using our optimizer. Here we used Gradient Descent optimizer. But in future we can use optimizers like adam or adaguard etc.





Introduction

Convolutional

What is CNN

Back Propagation

Gradient Descer

D ...

Training an

Result

Deficienc

Improvemen

Reference.

#### Gradient Descent

Gradient descent is a iterative optimization algorithm for finding the minimum of a function. To find a local minimum of a function using gradient descent, one takes steps proportional to the negative of the gradient (or approximate gradient) of the function at the current point



Cost function or error function can be an indicatior of how accurate our model is and optimizer uses that to optimize our model. Here we will use MSE loss. Which is defined as

$$J(w,b) = \frac{1}{M} \sum (h_{(w,b)}(x^{(i)}) - y^{(i)})^2 \tag{1}$$

Then we calculate gradients of the cost function as below

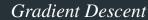
$$\nabla_{w}J = \frac{\partial}{\partial w}J(w,b) \tag{2}$$

$$\nabla_b J = \frac{\partial}{\partial b} J(w, b) \tag{3}$$

Then we update the weights using the formula as below

$$w' = w - \alpha \nabla_w J \tag{4}$$

$$b' = b - \alpha \nabla_b J \tag{5}$$





Introduction

Convolutional

iveurai iveiwor

Back Propagatio

Gradient Descen

Transfer Learning

Date

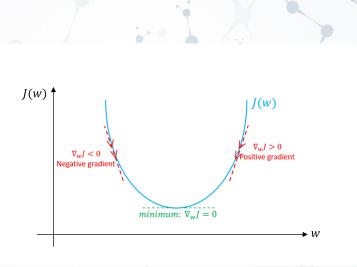
Training and Finetuning

Result

Deficiency

Improvement

Reference.





### What is Transfer Learning

Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional Neural Network

Transfer Learnin

What is Transfer Learnin

Date

Training an

Resul

Deficienc

Improvemen

Reference

Transfer learning is a process in which we make use of the knowledge gained while solving one problem and applying it to a different but related problem.



Introduction

Convolutional Neural Network

Transfer Learning

Pretrained Mode

Data

Training and

Resul

Deficiency

Improvemen

Reference

Here we use a pre-trained big model named resnext101(44 million parameters) which was trained by facebook on Imagenet. We take the resnext101 model chop the last layer down and add our custom regression layer to classify the images.





Introduction

Convolutional Neural Network

Transfer Learning

Data

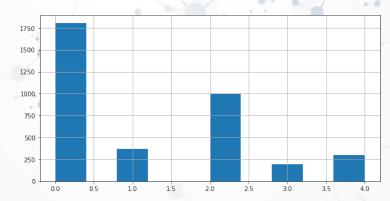
Training and

Result

Dejicienc

D -f -----

Asia Pacific Tele-Ophthalmology Society (APTOS) and Aravind Eye Hospital of India published a dataset of retina images through Kaggle. The Data-set can be found on https://www.kaggle.com/c/aptos2019-blindness-detection/data With quick exploration we can visualize the data as follows







Introduction

Convolutional Neural Network

Transfer Learning

Date

Training and

Trainining
FineTuning

Resul

Deficiency

Improvemen

Reference.

First we train the model freezing the base layers. we do this for 30 epochs we used

- 1 Gradient Descent as Optimizer
- 2 learning rate=0.001
- 3 cost function is Mean Square Error



Introduction

Convolutional Neural Network

Transfer Learning

Data

Training and Finetuning

FineTuning

Resul

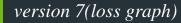
Dejiciency

Improvemen

Reference:

Then we fine Tune the whole model for another 30 epochs. Here we unfreeze the base layer

- 1 Gradient Descent as Optimizer
  - learning rate=0.0001
- 3 cost function is Mean Square Error





Introduction

Convolutional

Transfe

Learnii

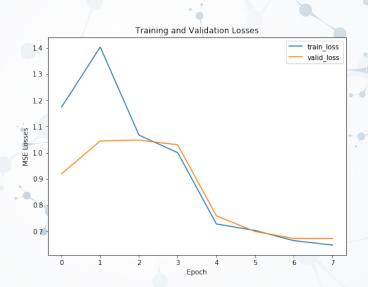
Data

Training and Finetuning

Result

Deficienc

Improvemen







Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional

Transfer

Бешпи

Training ar

Finetuning

Result

Deficienc





## version 49(loss graph)

Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional

Transfei

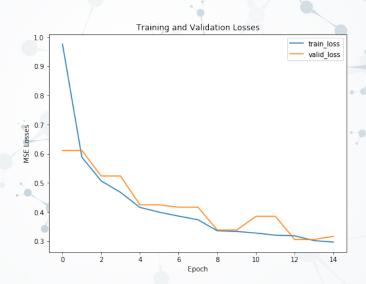
Data

Training and Finetuning

Result

Deficienc<sub>.</sub>

Improvemer



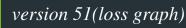


# version 49(Confusion Matrix)

Detecting Diabetic Rtinopathy using Deep Learning

Result







Introduction

Convolutional

Transfe.

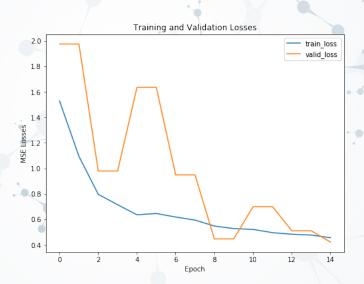
Data

Training and Finetuning

Result

Deficiency

Improvemen







# version 51(Confusion Matrix)

Detecting Diabetic Rtinopathy using Deep Learning

Result







Introduction

Convolutional

Transfe

Data

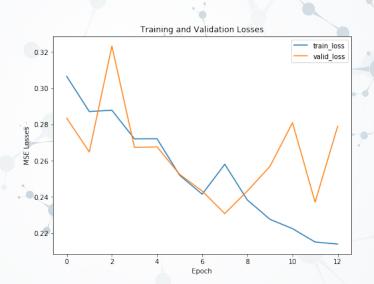
Training an

Result

Deficienc:

Improvemer

Reference.







# ic

Detecting Diabetic Rtinopathy using Deep Learning

Introduction

Convolutional
Neural Network

Transfer

Data

Training and Finetuning

Result

Deficienc

Improvemen

Reference.







Introduction

Convolutional

Transfe

Learni

Data

Training an Finetuning

Result

Deficienc

Improvemen





## *version 26(Fine tuned Confusion Matrix)*



Result

0.99 0.01 0.00 0.00 0.00 No DR 0.37 0.04 0.01 0.02 1 - Mild 0.00 0.08 0.20 0.00 0.4 0.00 0.00 0.15 0.12 0.2 0.46 0.32 0.00 0.01 0.20 - Proliferative DR - 0.0 1 - Mild 0 - No DR 2 - Moderate 3 - Severe 4 - Proliferative DR





Introduction

Convolutional Neural Network

Transfer Learnin

Data

Training and Finetuning

Resuli

Deficiency

Improvemen

Reference:

 This model is very slow .Without GPU it takes more than 5 minutes to predict single image





Introductio

Convolutional Neural Network

Transfer Learnin

Data

Training and Finetuning

Result

Deficiency

Improvemen

- This model is very slow .Without GPU it takes more than 5 minutes to predict single image
- This model is very big .lt is almost 2 GB in size. Which makes it impossible for Deployment







Introductio

Convolutional Neural Network

Transfer Learnin

Data

Training and Finetuning

Result

Deficiency

Improvemen

- This model is very slow .Without GPU it takes more than 5 minutes to predict single image
- This model is very big .lt is almost 2 GB in size. Which makes it impossible for Deployment





### Room for Future Improvements

Detecting Diabetic Rtinopathy using Deep Learning

Improvement

for pre-trained model we can use something like efficient-net which is significantly smaller



#### Room for Future Improvements

Detecting Diabetic Rtinopathy using Deep Learning

Introductio

Convolutional Neural Network

Transfer Learnin

Data

Training and Finetuning

Resuli

Deficienc

Improvement

Reference:

- for pre-trained model we can use something like efficient-net which is significantly smaller
- 2) We can use Heat-Map of model and overlay it on the top of existing picture to help human experts to conclude





#### Room for Future Improvements

Detecting Diabetic Rtinopathy using Deep Learning

Introductio

Convolutional Neural Network

Transfer Learnin

Data

Training and Finetuning

Resuli

Deficienc

Improvement

Reference:

- for pre-trained model we can use something like efficient-net which is significantly smaller
- 2) We can use Heat-Map of model and overlay it on the top of existing picture to help human experts to conclude



Introductio

Convolutional Neural Networ

Transfer Learning

Date

Training and Finetuning

Result

Deficienc

References

#### Preprocessing the Image

https://www.kaggle.com/ratthachat/aptos-eye-preprocessing-in-diabetic-retinopat

- Dataset https://www.kaggle.com/c/ aptos2019-blindness-detection
- Gradient Descent https://towardsdatascience.com/ understanding-the-mathematics-behind-gradient
- Transfer Learning https://towardsdatascience.com/ what-is-transfer-learning-8b1a0fa42b4
- MeNext
  https://github.com/facebookresearch/ResNeXt