

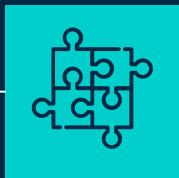
Age, Gender, and Ethnicity

Prediction and Classification – CNN

Group1

Group member: Rayna Liu, Zheyue Wang

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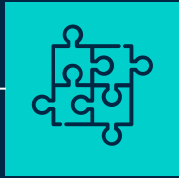
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01. Introduction

In recent years, the extraction of age, gender, and ethnicity from face images has been widely used in many applications, including biometrics, security controls, and entertainment.

Convolutional Neural Network has achieved remarkable success in face recognition, image classification, and object recognition. Our final project uses the Convolutional Neural Network (CNN) on face recognition tasks for age estimation and ethnicity and gender classification.

- ❑ Data Overview
- ❑ Description of the Dataset
 - ❑ Age
 - ❑ Ethnicity
 - ❑ Gender
- ❑ Sample Images

Data Overview

- ❑ This dataset includes a csv of facial images labeled based on age, gender, and ethnicity from Kaggle.
- ❑ Includes 27,305 rows and 5 columns: age, ethnicity, gender, image name, and pixels of the image.

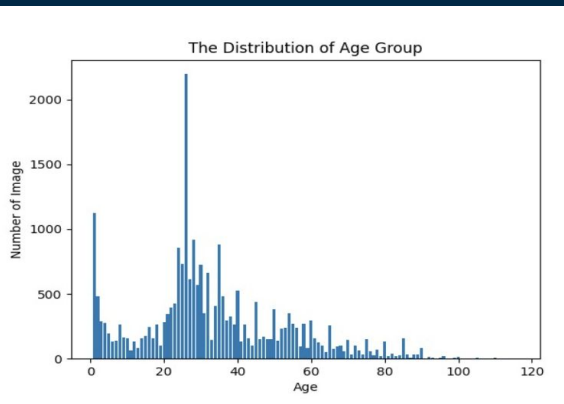
```
Data columns (total 5 columns):  
#   Column      Non-Null Count  Dtype  
---  -  
0    age         23705 non-null   int64  
1    ethnicity    23705 non-null   int64  
2    gender       23705 non-null   int64  
3    img_name     23705 non-null   object  
4    pixels       23705 non-null   object  
dtypes: int64(3), object(2)
```

	↕ age	↕ ethnicity	↕ gender	↕ img_name	↕ pixels
0	1	2	0	20161219203650636.jpg.chip.jpg	[129. 128. 128. ... 146. 146. 146.]
1	1	2	0	20161219222752047.jpg.chip.jpg	[164. 74. 111. ... 182. 170. 148.]
2	1	2	0	20161219222832191.jpg.chip.jpg	[67. 70. 71. ... 112. 111. 108.]
3	1	2	0	20161220144911423.jpg.chip.jpg	[193. 197. 198. ... 235. 239. 246.]
4	1	2	0	20161220144914327.jpg.chip.jpg	[202. 205. 209. ... 167. 163. 161.]
5	1	2	0	20161220144957407.jpg.chip.jpg	[195. 198. 200. ... 105. 119. 140.]

Description of the Dataset

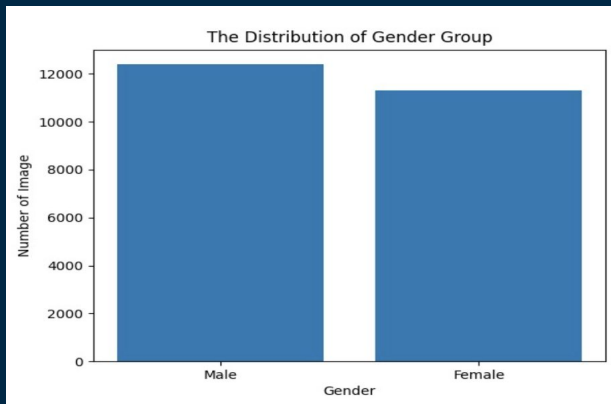
Age

- Range of 1 to 116
- Most of data is concentrate on 26 to 40 years old



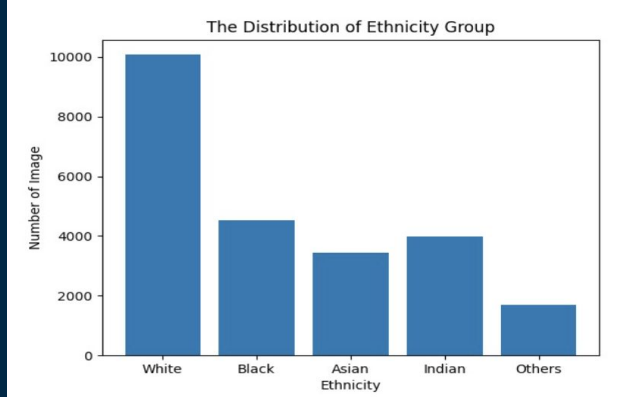
Gender

- 0 : Male
- 1 : Female



Ethnicity

- 0 : White
- 1 : Black
- 2 : Asian
- 3 : Indian
- 4 : Others
(Hispanic, Latino, Middle Eastern)



Sample Images



Age: 24, Ethnicity: 2, Gender: F



Age: 55, Ethnicity: 0, Gender: M



Age: 24, Ethnicity: 2, Gender: F



Age: 23, Ethnicity: 2, Gender: F



Age: 73, Ethnicity: 0, Gender: F



Age: 38, Ethnicity: 0, Gender: F



Age: 35, Ethnicity: 0, Gender: F



Age: 17, Ethnicity: 4, Gender: M



Age: 21, Ethnicity: 2, Gender: F



Age: 26, Ethnicity: 2, Gender: M



Age: 18, Ethnicity: 4, Gender: M



Age: 28, Ethnicity: 0, Gender: F



Age: 16, Ethnicity: 1, Gender: M



Age: 40, Ethnicity: 3, Gender: F



Age: 32, Ethnicity: 3, Gender: F



Age: 1, Ethnicity: 2, Gender: M

Sample Images





02. Deep Learning Network – CNN

The Convolutional Neural Network (CNN) is a multi-layer feedforward Network, which has the excellent capability of feature extraction of images.

In this project, we used two CNN models to do face recognition tasks, one for age estimation, the other for ethnicity and gender classification.

- ❑ Age Model
- ❑ Ethnicity & Gender Model

Why two Models?

Age Model

- Regression
- Architecture inspiration from VGG model

Gender & Ethnicity Model

- Classification
- Multiple-Label Classification



Age Model

Input Shape

2,304 pixels (48,48,1)



Convolved Layers

11 layers:

4 with max pooling & normazling
7 stacked convoluted layer



Flatten Layer

4 layer + dropout



Activation Function

ReLU function



Training Algorithm

Adam



Ethnicity & Gender Model

Input Shape
2,304 pixels (48,48,1)



Convolved Layers

6 layers:
2 with pooling & normazling
4 stacked convolved layer
with normalizing

Flatten Layer
11 layers with dropout
and normalizing



Activation Function

ReLU function
Sigmoid in the output layer



Output Shape

One-hot encoded 7 labels
(Ex. White female: [1,0,0,0,0,0,1])



Training Algorithm

Adam

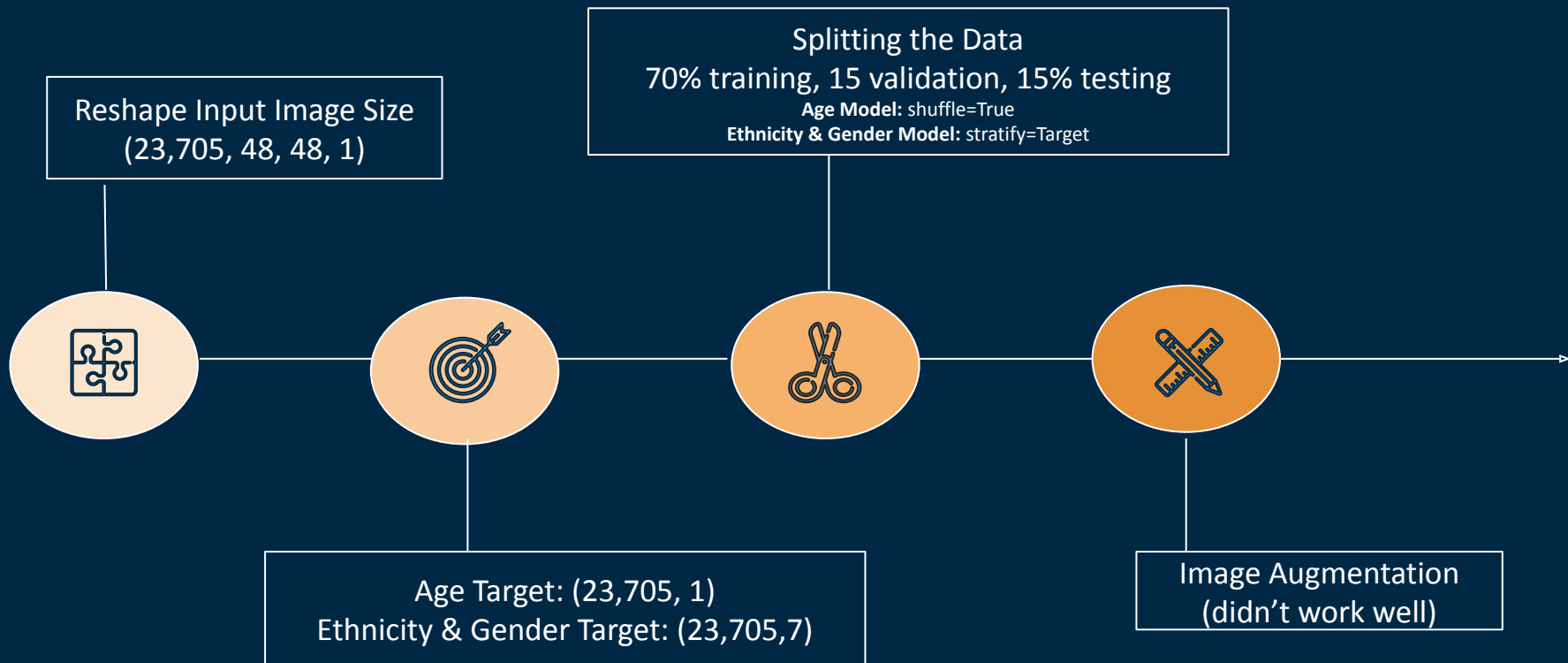




03. Experimental Setup

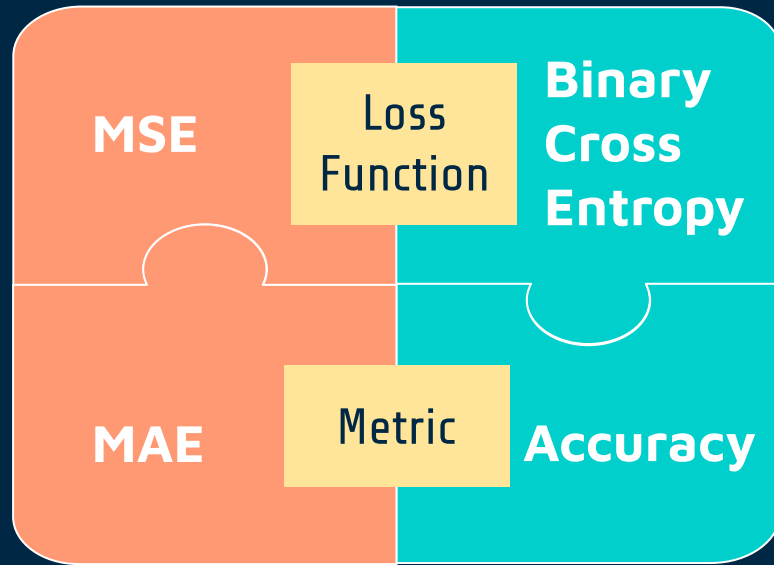
- ❑ Data PreProcessing
- ❑ Framework & Performance
- ❑ Mini-Batches Selection
- ❑ Training Parameters
- ❑ Overfitting & Extrapolation

Data Preprocessing



Framework & Performance

Age Model

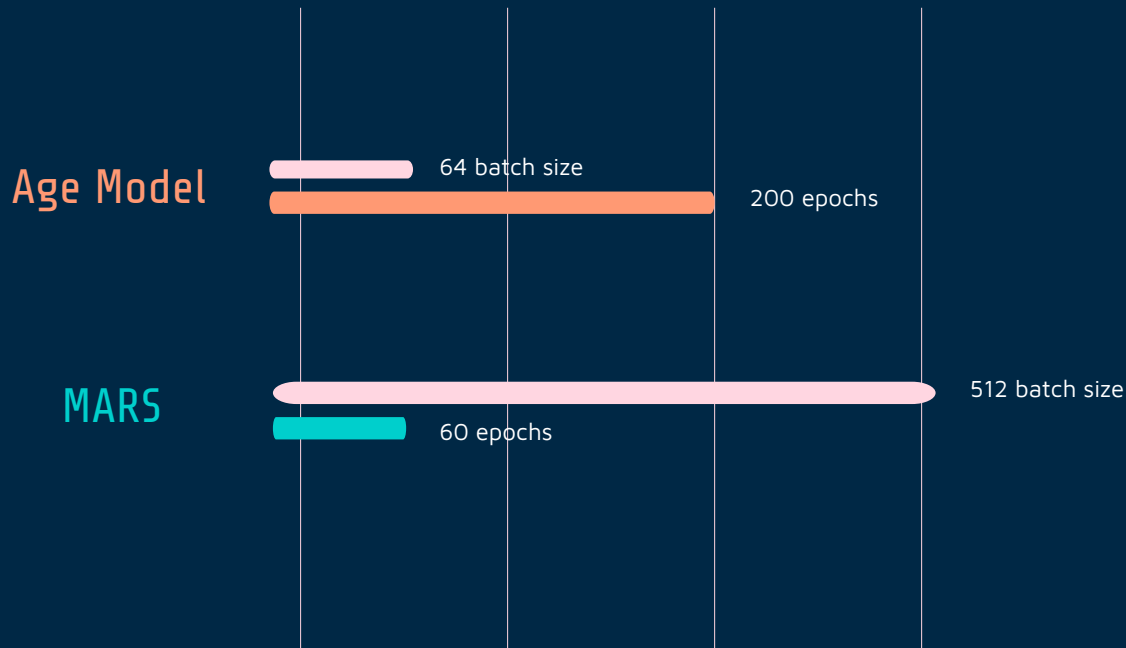


Ethnicity & Gender Model

Keras

Mini-Batches Selection

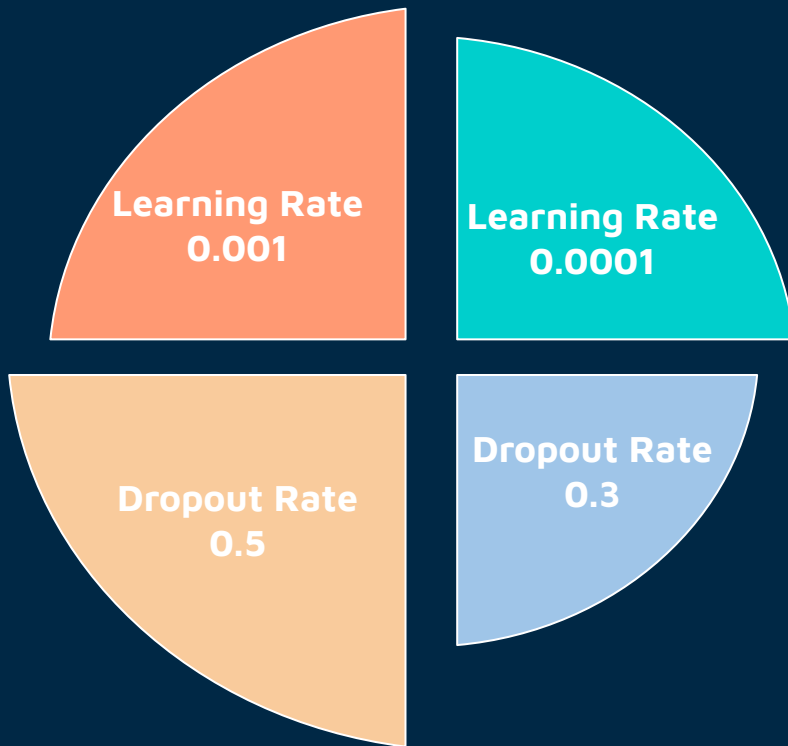
- Based on the suggestion from the article *How to Choose the Right Mini-Batch Size in Deep Learning* and the memory of our GPU, we were using a power of 2 as the mini-batch size, and we were going to try 64,128,256,512.



Training Parameters

Age Model

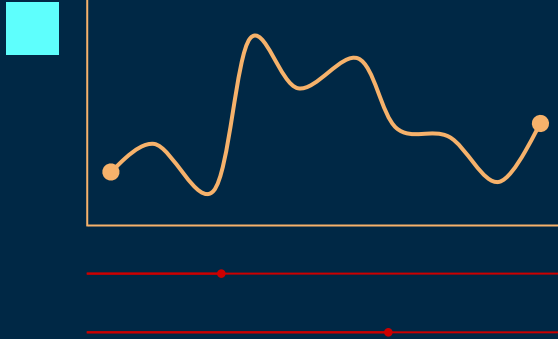
- ❑ Lower learning rate need more epochs, take a longer time to train
- ❑ Use performance scheduling to adjust learning rate
- ❑ Large dropout rate because large number of neurons



Ethnicity & Gender Model

- ❑ Smaller learning rate because the model converge to large accuracy within 100 epochs
- ❑ Use performance scheduling to adjust learning rate
- ❑ Large dropout rate because large number of neurons

Overfitting & Extrapolation



Early Stopping

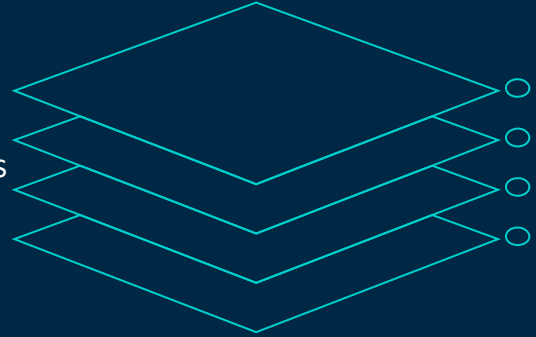
Age Model: stop when the validation loss stops improving for 25 consecutive epochs

Ethnicity & Gender Model: stop when the validation accuracy stops improving for 30 consecutive epochs

Dropped Out

Age Model: add dropout layer after the last two flatten layers

Ethnicity & Gender Model: add dropout layer after every flatten layer





04. Result

- ❑ Model Accurate
- ❑ Analyse the Result
- ❑ Show Incorrectly Age Image
- ❑ Show Incorrectly Ethnicity & Gender Image
- ❑ Application

Model Accurate

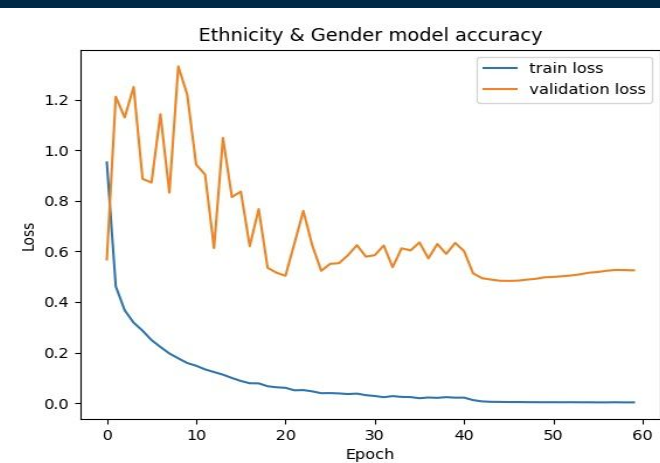
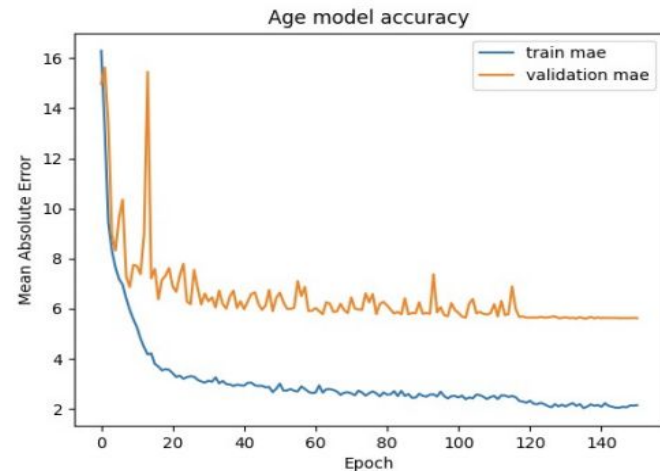
1. We use MAE to measure a accuracy of age models
2. We use test accuracy to measure gender and ethnicity accuracy.



Age model: 6.059



Gender and ethnicity model: 66%



Sample Predictions Images



Sample Prediction Images



[Real]: Age:36 Ethnicity:0 Gender:1
[Pred]: Age:36 Ethnicity:4 Gender:0



[Real]: Age:44 Ethnicity:3 Gender:0
[Pred]: Age:45 Ethnicity:3 Gender:0



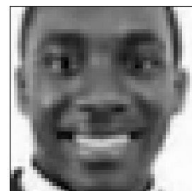
[Real]: Age:34 Ethnicity:1 Gender:0
[Pred]: Age:35 Ethnicity:1 Gender:0



[Real]: Age:85 Ethnicity:3 Gender:1
[Pred]: Age:72 Ethnicity:1 Gender:1



[Real]: Age:32 Ethnicity:0 Gender:0
[Pred]: Age:30 Ethnicity:0 Gender:0



[Real]: Age:38 Ethnicity:1 Gender:0
[Pred]: Age:32 Ethnicity:1 Gender:0



[Real]: Age:45 Ethnicity:3 Gender:0
[Pred]: Age:45 Ethnicity:3 Gender:0



[Real]: Age:28 Ethnicity:1 Gender:1
[Pred]: Age:31 Ethnicity:1 Gender:1



[Real]: Age:23 Ethnicity:2 Gender:0
[Pred]: Age:29 Ethnicity:2 Gender:0



[Real]: Age:27 Ethnicity:2 Gender:1
[Pred]: Age:23 Ethnicity:2 Gender:1



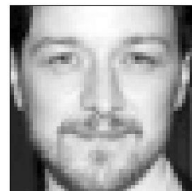
[Real]: Age:90 Ethnicity:0 Gender:0
[Pred]: Age:95 Ethnicity:0 Gender:0



[Real]: Age:54 Ethnicity:3 Gender:0
[Pred]: Age:53 Ethnicity:3 Gender:0



[Real]: Age:30 Ethnicity:3 Gender:1
[Pred]: Age:26 Ethnicity:3 Gender:1



[Real]: Age:27 Ethnicity:0 Gender:0
[Pred]: Age:29 Ethnicity:0 Gender:0

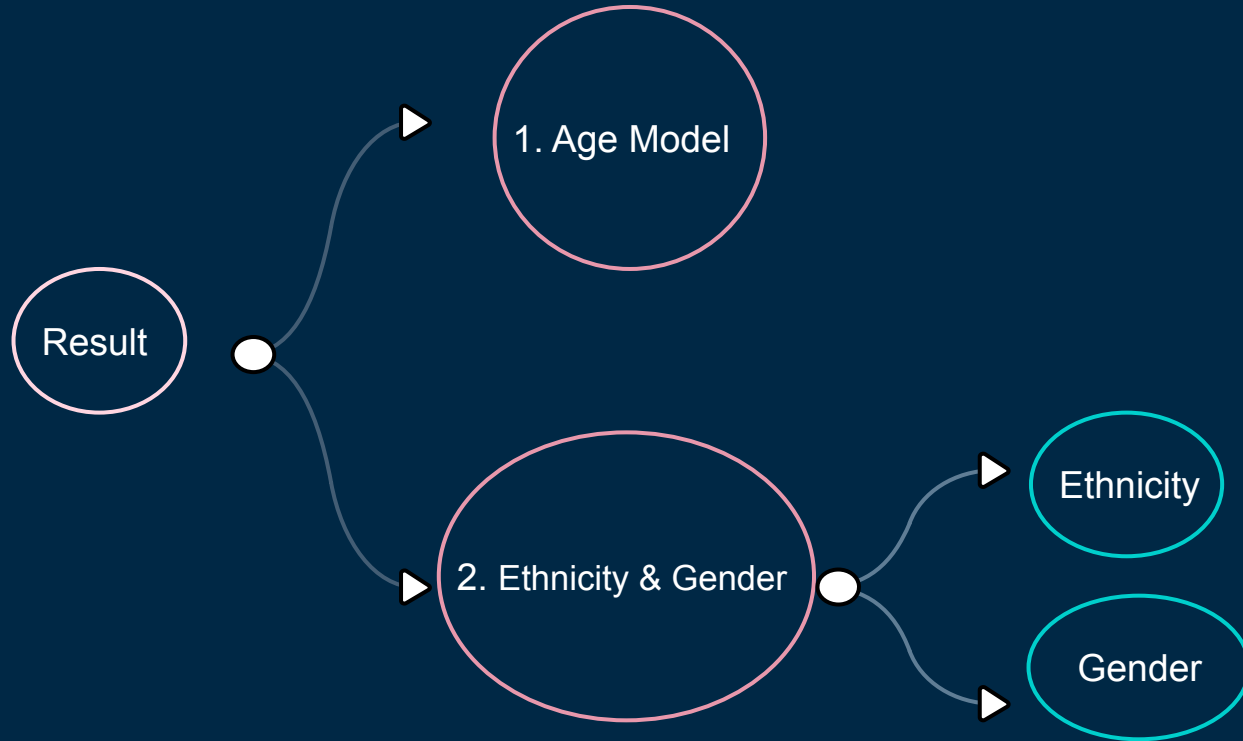


[Real]: Age:47 Ethnicity:0 Gender:0
[Pred]: Age:46 Ethnicity:0 Gender:0



[Real]: Age:45 Ethnicity:3 Gender:1
[Pred]: Age:45 Ethnicity:3 Gender:1

Analyse the Result



Analyse the Result

Age Model

- The 41-50 age group has the highest prediction probability in accuracy . which is 48.456%.
- One possible reason is that the sample size of the 41-50 age group is comparatively less to other age groups.

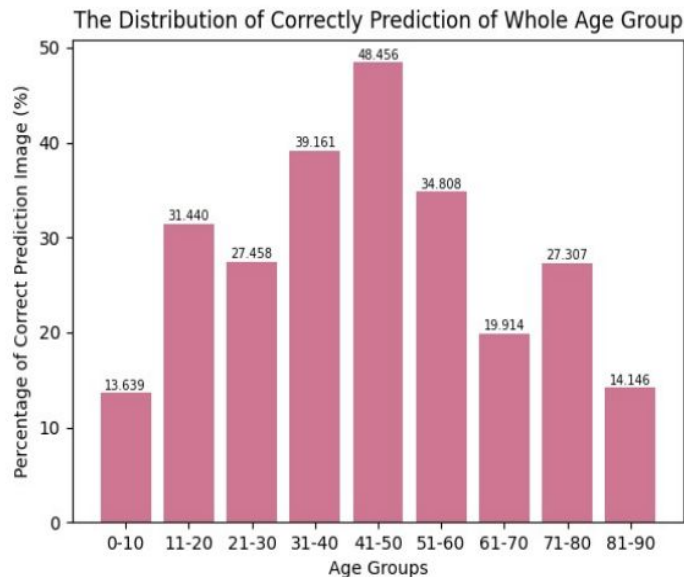


Figure 8: The Distribution of correct prediction



Analyse the Result



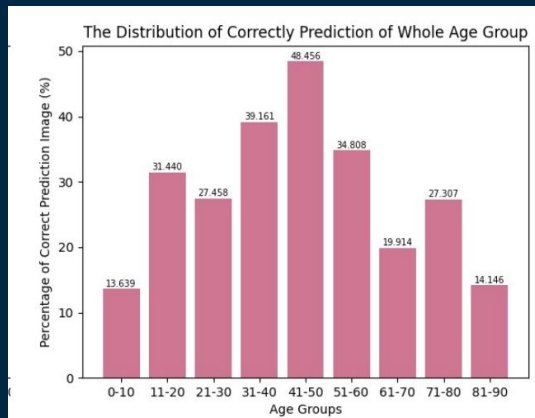
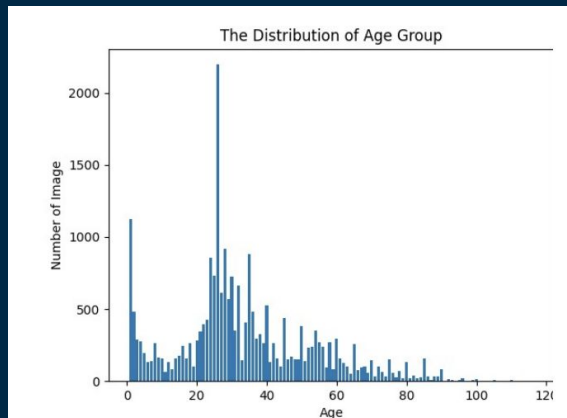
Compare age distribution
and correct prediction
distribution



Sample data of 20 - 40 age is
higher.

Age 26: Sample size above 2000

Age 0: Sample size above 1000



If Sample size reduce,
accuracy of prediction
might also improve



Analyse the Result

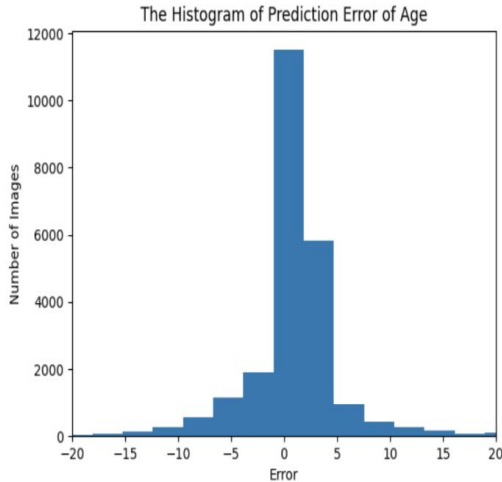


Figure 10: The histogram of prediction error of age

Normal Distribution

Average error : less than
5 years old

If real age is 28, model
predict: 26 to 31

Analyse the Result

2. Ethnicity

- 1. We have 5 different ethnic types.
- 2. White, Black, Asian, Indian have relatively high predict accuracy, as all these 4 types above 90% predict accuracy

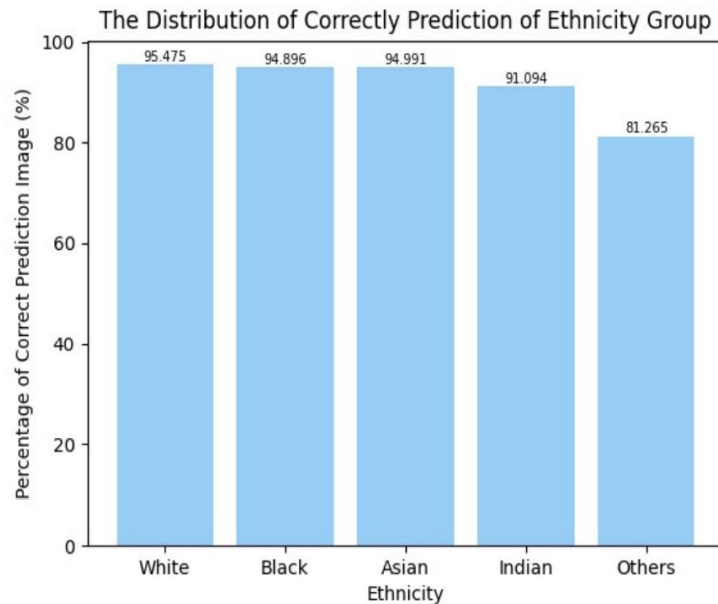


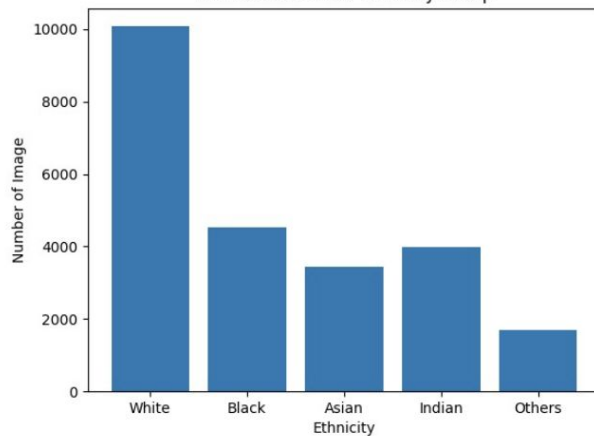
Figure 12: The Distribution of prediction ethnicity

Analyse the Result

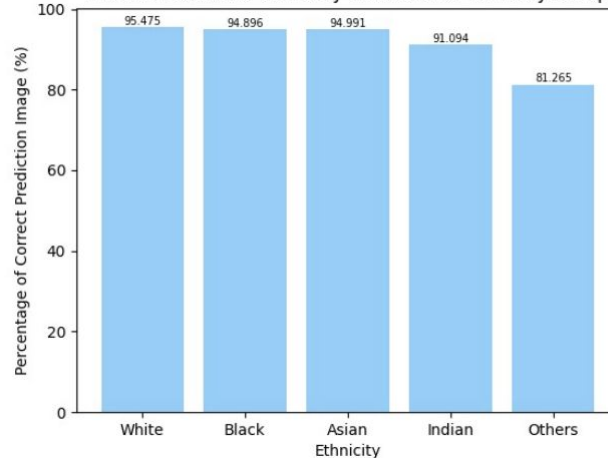
Compare ethnicity distribution and correct prediction distribution

The major the white people and the minor others.

The Distribution of Ethnicity Group

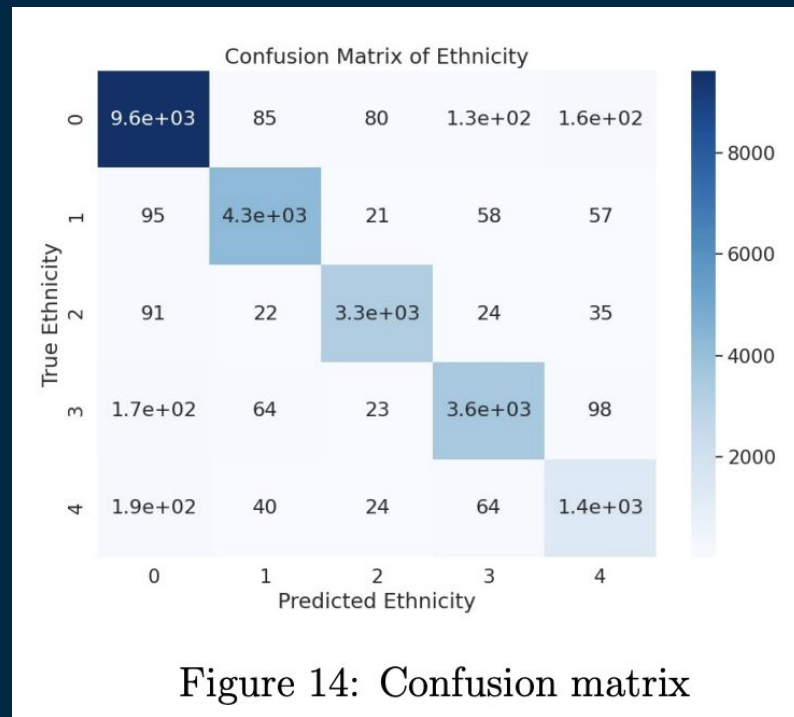


The Distribution of Correctly Prediction of Ethnicity Group



Analyse the Result

Predict correct		
White: around 9600.	Data distribution: the data sample of white is significantly higher than others	even has 9600 images of white predict correctly, still has 170 images are classified as India, and 190 images predict as others.
Black: around 4300.		
Asian: around 3300.		
Indian: around 3600.		
Other: around 1400.		



Analyse the Result

3. Gender Model



→ the accuracy for gender was more than 95 %
both on male and female

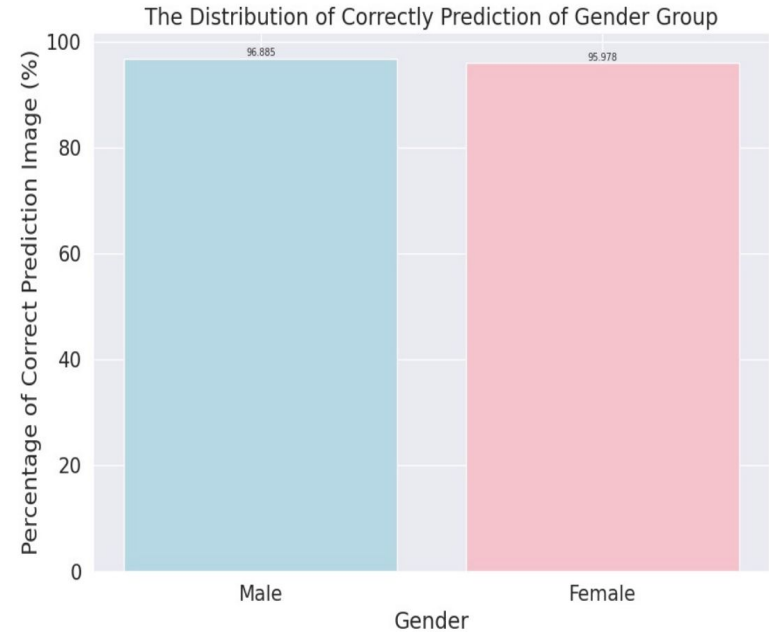


Figure 16: The Distribution of Correct prediction

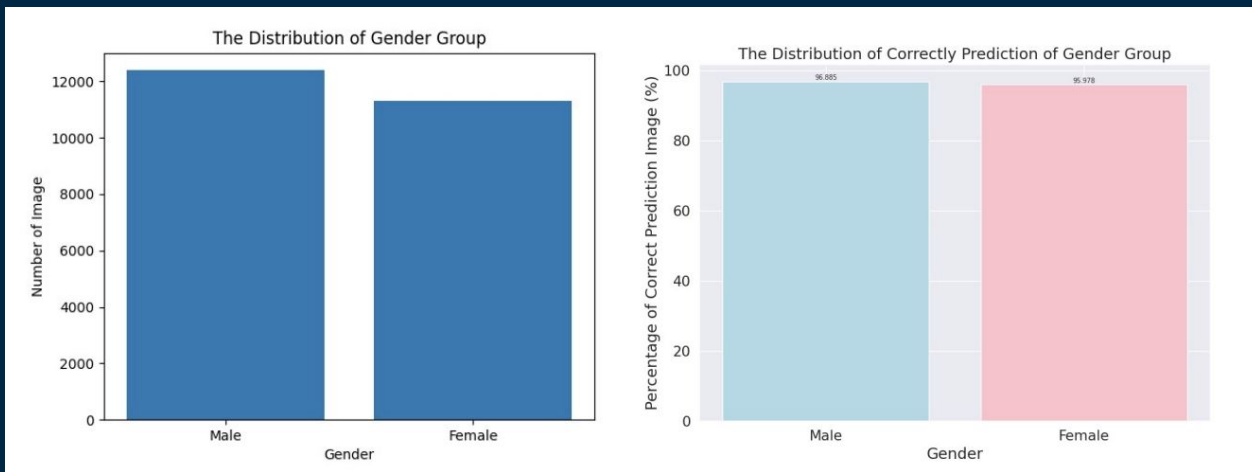


Analyse the Result

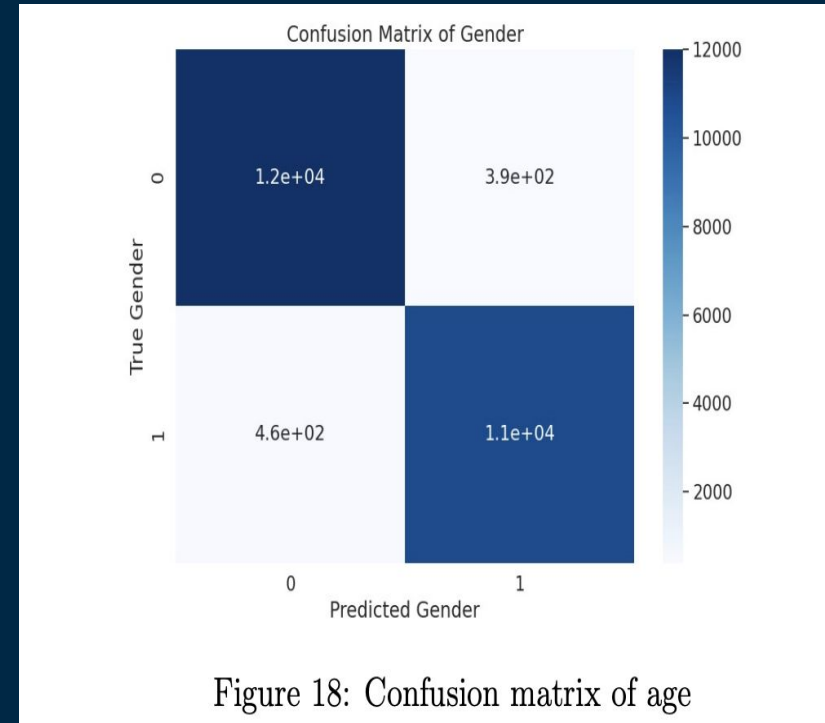
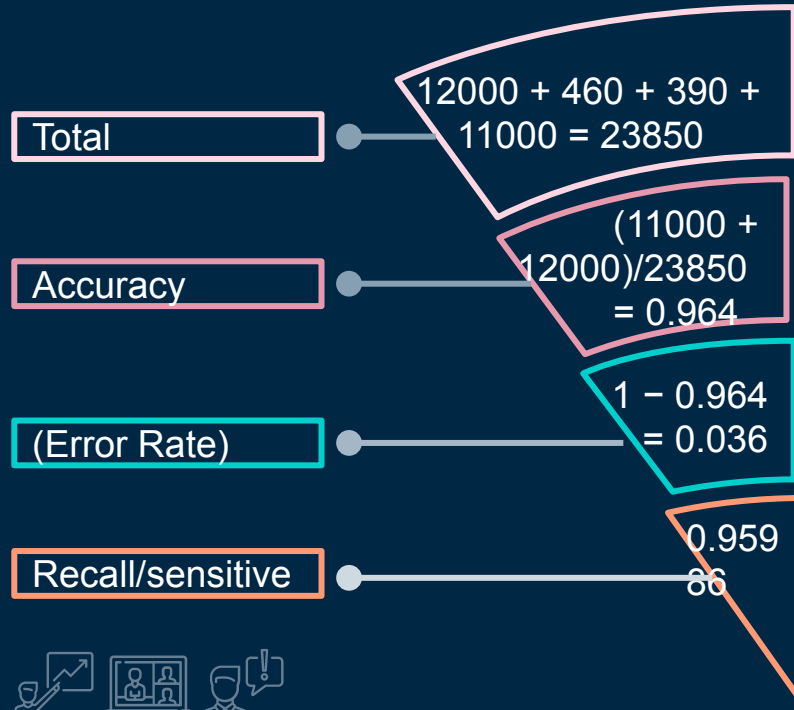


Compare gender distribution
and correct prediction
distribution

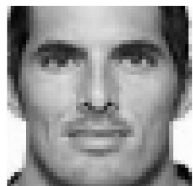
The importance of stratification is demonstrated here to allow both male and female colleagues to be accurately predicted.



Analyse the Result



Incorrectly Age Images



Real Age:[28] Pred Age:[29.]



Real Age:[65] Pred Age:[64.]



Real Age:[26] Pred Age:[28.]



Real Age:[1] Pred Age:[0.]



Real Age:[32] Pred Age:[17.]



Real Age:[29] Pred Age:[30.]



Real Age:[4] Pred Age:[0.]



Real Age:[32] Pred Age:[28.]



Real Age:[28] Pred Age:[36.]



Real Age:[25] Pred Age:[26.]



Real Age:[3] Pred Age:[14.]



Real Age:[45] Pred Age:[46.]



Real Age:[54] Pred Age:[53.]



Real Age:[34] Pred Age:[44.]



Real Age:[18] Pred Age:[25.]



Real Age:[28] Pred Age:[29.]



Incorrectly Age Image

- ❑ For most adults, the margin of error for age prediction was about a year.
- ❑ Our age model could hardly predict the age of children (less than 5) accurately.





Incorrectly Ethnicity & Gender Image

- Like the age model, the ethnicity & gender model is inaccurate in predicting a child's ethnicity and gender.



Incorrectly Images



[Real] Ethnicity:3 Gender:0
[Pred] Ethnicity:1 Gender:1



[Real] Ethnicity:3 Gender:1
[Pred] Ethnicity:1 Gender:0



[Real] Ethnicity:1 Gender:0
[Pred] Ethnicity:3 Gender:1



[Real] Ethnicity:2 Gender:0
[Pred] Ethnicity:0 Gender:1



[Real] Ethnicity:0 Gender:1
[Pred] Ethnicity:2 Gender:0



[Real] Ethnicity:2 Gender:0
[Pred] Ethnicity:4 Gender:1



[Real] Ethnicity:4 Gender:0
[Pred] Ethnicity:3 Gender:1



[Real] Ethnicity:3 Gender:1
[Pred] Ethnicity:4 Gender:0



[Real] Ethnicity:4 Gender:0
[Pred] Ethnicity:0 Gender:1



[Real] Ethnicity:3 Gender:1
[Pred] Ethnicity:1 Gender:0



[Real] Ethnicity:1 Gender:1
[Pred] Ethnicity:0 Gender:0



[Real] Ethnicity:1 Gender:1
[Pred] Ethnicity:4 Gender:0



[Real] Ethnicity:3 Gender:1
[Pred] Ethnicity:2 Gender:0



[Real] Ethnicity:4 Gender:1
[Pred] Ethnicity:0 Gender:0



[Real] Ethnicity:4 Gender:1
[Pred] Ethnicity:1 Gender:0



[Real] Ethnicity:1 Gender:0
[Pred] Ethnicity:0 Gender:1

Application

Prediction Images from Google Image



[Pred]: Age:[32.] Ethnicity:['Asian'] Gender:['M']



[Pred]: Age:[52.] Ethnicity:['White'] Gender:['M']



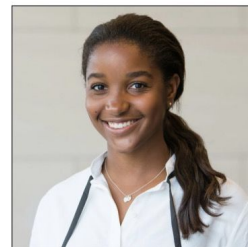
[Pred]: Age:[30.] Ethnicity:['White'] Gender:['F']



[Pred]: Age:[63.] Ethnicity:['White'] Gender:['F']



[Pred]: Age:[28.] Ethnicity:['Asian'] Gender:['F']



[Pred]: Age:[37.] Ethnicity:['Black'] Gender:['M']





05. Summary & Conclusion

- ❑ We have presented the two 2-dimensional Convolutional Neural models for age estimation and ethnicity and gender classification with face images. After repeat training of the model, we found that the MAE of age is stable at about 5.7 and that the accuracy of race and gender at the same time is maintained at about 50%.
- ❑ One of the biggest challenges in age estimation is that humans age grows at different rates, with different races and genders showing different characteristics at the same age, So we looked up some literature and worked hard to develop a deep neural network to let it catch up with the age characteristics as much as possible.
- ❑ In the future, we suggest going out to change the channel from 1 to 3 and use the pre-trained model to improve the accuracy.



06. References

- ❑ [Kaggle: Age, Gender & Ethnicity Prediction](#)
- ❑ [Deep Convolutional Neural Network for Estimation](#)
- ❑ [How to choose the right mini-batch size in deep learning](#)
- ❑ [Amir-jafari: Deep Learning](#)
- ❑ [Gentle Introduction to the Adam Optimization Algorithm for Deep Learning](#)
- ❑ [Google image](#)
- ❑ [Training a TensorFlow model to recognize emotions](#)
- ❑ [Building powerful image classification models using very little data](#)

Do you have any questions?

THANKS

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