



TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

# PUPPY MASTER

DATA SCIENCE II / TU DARMSTADT

DeadLock



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# TEAM STRUCTURE



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DATA COLLECTION

DATA AUGMENTATION



Jian Jiang



Haoyue Zhu

MODEL TRAINING

MODEL EVALUATION



Keren Zhou



Ruize Xia

UI IMPLEMENTATION

PROJECT IMPLEMENTATION



Xiaoyan Xue

# PROJECT OVERVIEW

- **DOGS: MOST POPULAR PETS**
- Dogs are the most popular pet in the U.S. (65.1 million U.S. households own a dog)
- Essential dog expenses cost an average of \$1,533 annually.
- 42% of dog owners got their pets from a store, while 38% of dog owners got their pets from an animal shelter or rescue.



Most Popular Pets in the U.S. by Number of Households (in Millions)



1. The "small animal" category includes pets such as hamsters, gerbils, rabbits, guinea pigs, chinchillas, mice, rats, and ferrets.

Data source: American Pet Products Association

Source: Forbes Advisor • Get the data • Embed

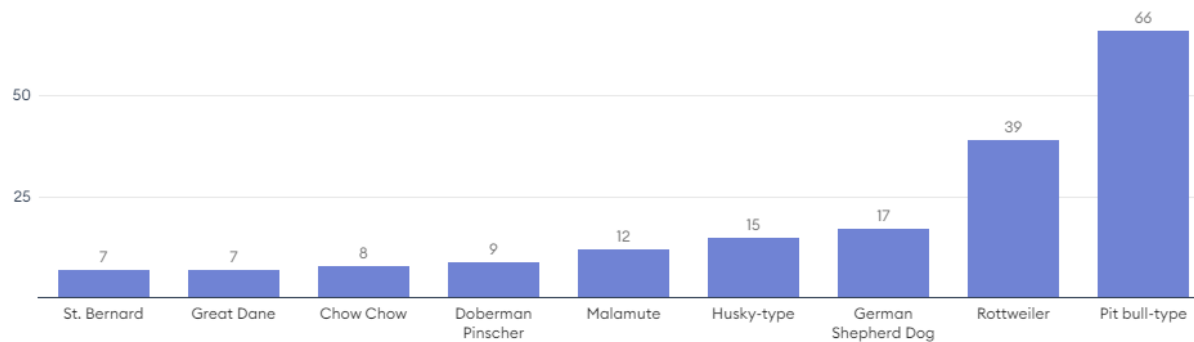
Forbes ADVISOR

# PROJECT OVERVIEW

- **DOGS BITING: POTENTIAL RISK AROUND YOU**
- Every year, an estimated 4.5 million people are bitten by dogs in the United States.
- 15.55% of dog bites were committed by stray dogs rather than pets.

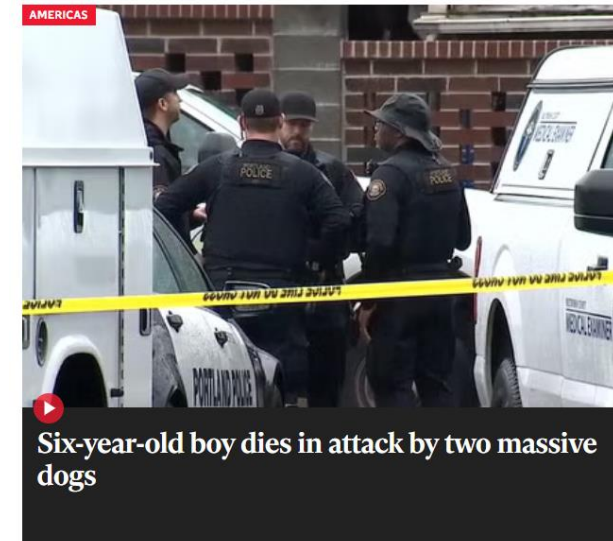
## Fatal Dog Attacks by Breed

Source: American Veterinary Medical Association (AVMA), 1979 - 1998.



Source: Forbes Advisor • Embed

Forbes ADVISOR



bulls



**CRIME**  
Two people arrested  
after woman  
seriously injured in  
XL Bully attack



**CRIME**  
'Pitbull' attacks girl in  
park as father 'prises  
dog off her head'



**HOME NEWS**  
Baby seriously  
injured in dog attack  
by family's own pet



**CRIME**  
Boy, 5, hospitalised  
after 'Staffordshire  
Bull Terrier' attack

**CRIME**  
Man and woman taken to hospital  
after dog attack

**HOME NEWS**  
Man 'seriously injured' after dog  
attack in Sunderland



# PROJECT OVERVIEW

- IN CHINA: SOCIAL REFLECTIONS BROUGHT BY A 2-YEAR-OLD GIRL AS VICTIM OF DOG BITING

## CHINA DOGS MANAGEMENT STATUS

PUBLIC



BASIC KNOWLEDGE

GOVERNMENT



LOCAL LEGALS

DOGS



TRAINING COURSES

CHINA / SOCIETY

Update: Owner of the dog that mauled a 2-year-old infant girl placed under criminal detention

By Global Times

Published: Oct 17, 2023 05:51 PM Updated: Oct 17, 2023 05:47 PM



# PROJECT OVERVIEW

## ■ What?

A system that offers a quick and simple classification tool for breeds of the dogs.

## ■ Why?

1. Dog owners sometimes know little for the breed of their dogs
2. Quick warning for the danger breeds

## ■ Whom?

1. Dog owners who want more information.
2. Anyone who finds a dog nearby and worries about the potential risk of biting.
3. Chinese police and community staff that is responsible for managing dogs



# DATA COLLECTION & AUGMENTATION

Haoyue Zhu  
Jian Jiang















# DATA COLLECTION

## Original Dataset: Stanford Dogs Dataset

Images of 120 breeds of dogs from around the world.

- Number of categories: 120
- ~150 images per class
- Total images: 20,580
- Annotations: Class labels, Bounding boxes

|   |                               |                  |     |
|---|-------------------------------|------------------|-----|
|    | n02085620-Chihuahua           | 2024/01/13 10:29 | 文件夹 |
|    | n02085782-Japanese_spaniel    | 2024/01/13 10:29 | 文件夹 |
|    | n02085936-Maltese_dog         | 2024/01/13 10:29 | 文件夹 |
|    | n02086079-Pekinese            | 2024/01/13 10:29 | 文件夹 |
|   | n02086240-Shih-Tzu            | 2024/01/13 10:29 | 文件夹 |
|  | n02086646-Blenheim_spaniel    | 2024/01/13 10:29 | 文件夹 |
|  | n02086910-papillon            | 2024/01/13 10:29 | 文件夹 |
|  | n02087046-toy_terrier         | 2024/01/13 10:29 | 文件夹 |
|  | n02087394-Rhodesian_ridgeback | 2024/01/13 10:29 | 文件夹 |
|  | n02088094-Afghan_hound        | 2024/01/13 10:29 | 文件夹 |
|  | n02088238-basset              | 2024/01/13 10:29 | 文件夹 |
|  | n02088364-beagle              | 2024/01/13 10:29 | 文件夹 |

# DATA COLLECTION

## • Problems:

1. Small datasets, large amount of classes (~150/breed -> 120 classes ).
2. Few extra features except images themselves
3. High similarities in the appearance of some breeds
4. Computing resources limit with hundreds of thousands of images



Australian Terrier



Airedale Terrier



Lakeland Terrier



## • Solutions?

1. Process data augmentation to get more samples.
2. Use **Image Batch Processor** in **MATLAB** for processing multiple images simultaneously.
3. Add more features such as age and weight to improve dataset (in the future)

# DATA AUGMENTATION

## • Why?

Data augmentation can improve the generalization and robustness of the deep learning model.

## • How?

We can apply various transformations to the existing images.

Rotation, Flip, Contrast Adjustment, Color Jittering, Gaussian Noise, Sharpen...

# DATA AUGMENTATION

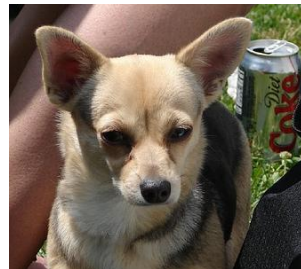
## Functions decided to use:

- **Grayed:** Focus the model on variations in intensity rather than color.
  - **Flip/Mirrored:** Become robust to position variations.
  - **Blurred:** Removing noise and details of the images
  - **Gaussian:** Become robust to noise.
  - **Sharpened:** Enhancing the fine details and edges in an image.
- 
- **Augmented dataset:**
  - **$20K * 6 = 120K$  images for training!**



# DATA AUGMENTATION

ID - Dataset



Original



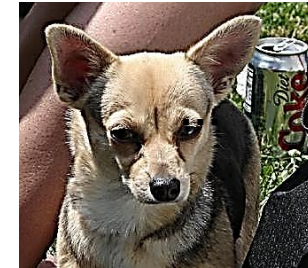
Grayed



Blurred



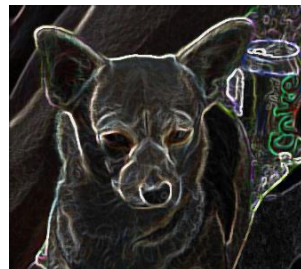
Gaussian



Sharpened

...

OOD - Dataset



...

- Due to computing resource we own, the scale of dataset is limited.

# DATA AUGMENTATION

**Example:**  
**Grayed**  
**dataset**





# MODEL TRAINING & EVALUATION

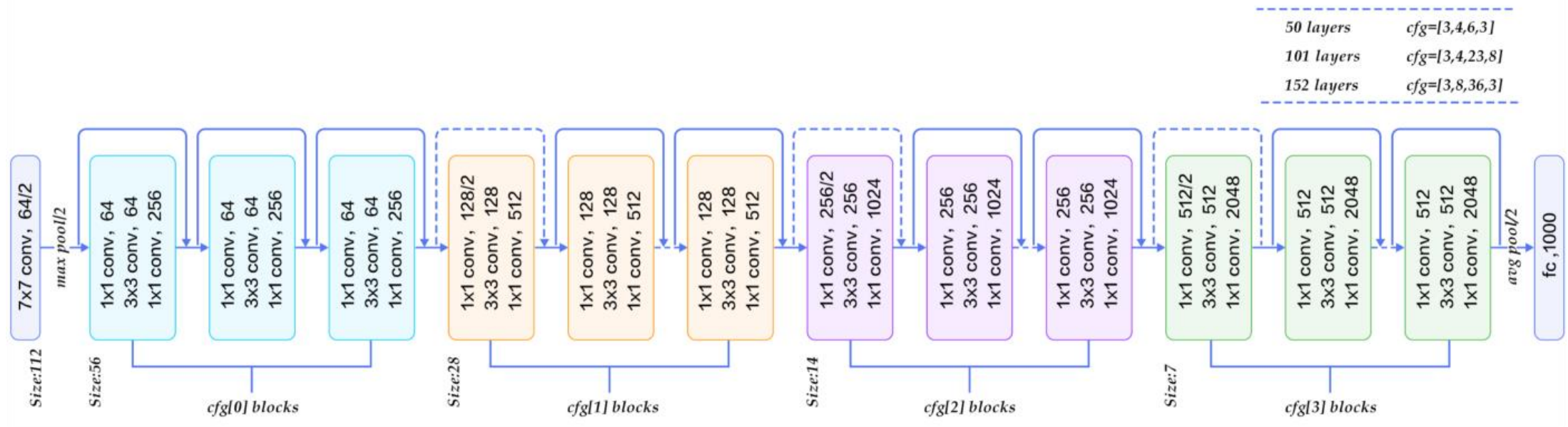
Keren Zhou

Ruize Xia



# WHAT IS RESNET

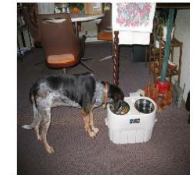
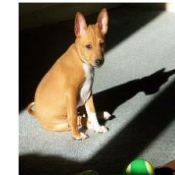
- Short for Residual Networks, is a classical convolutional CNN architecture for deep learning.
- Composed of residual blocks. Each block contains a shortcut connection that skips one or more layers.



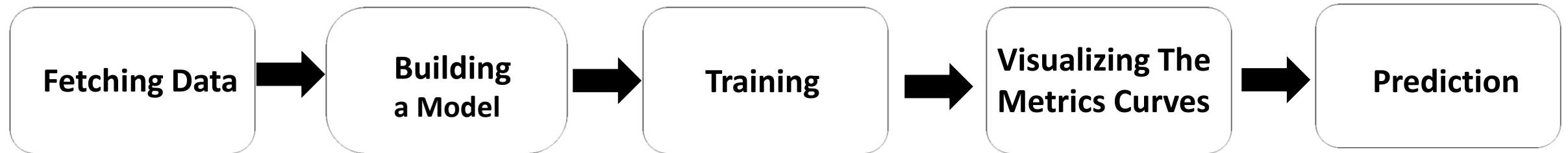


# WHY RESNET50

- Addressing Gradient Issues:  
gradient vanishing or exploding
- Alleviating Degradation Issues:  
deeper networks
- Efficient Model Training:  
accelerating backpropagation
- Transfer Learning

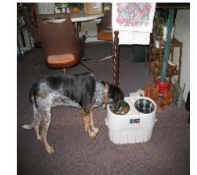


# WORK FLOW



# BUILDING A MODEL

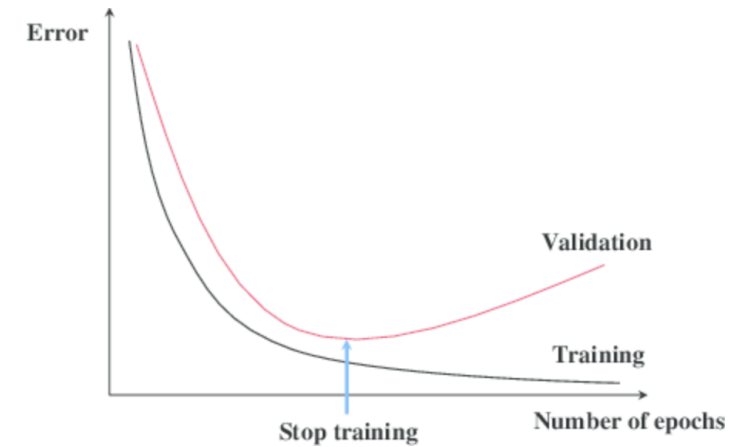
- Rescaling Layer
- Pre-trained Model
- Dropout Layer
- Dense Layer
- Adam Optimizer
- Loss



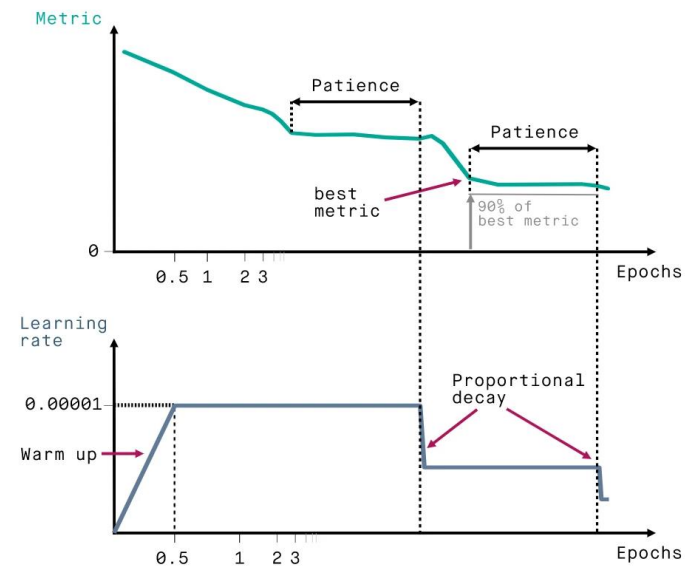
# TRAINING

## Callbacks:

- **ModelCheckpoint:** This callback saves the model weights after every epoch if the validation loss improves.
- **EarlyStopping:** This callback stops the training process if the validation loss doesn't improve for a certain number of epochs.
- **ReduceLROnPlateau:** This callback monitors a quantity and if no improvement is seen for a 'patience' number of epochs, the learning rate is reduced.



## Early Stopping

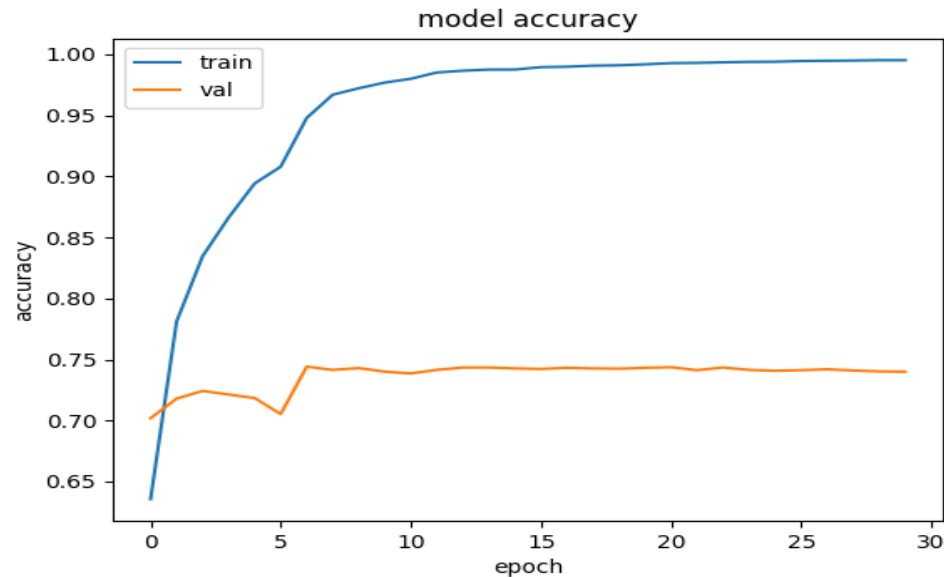


## Reduce Learning Rate

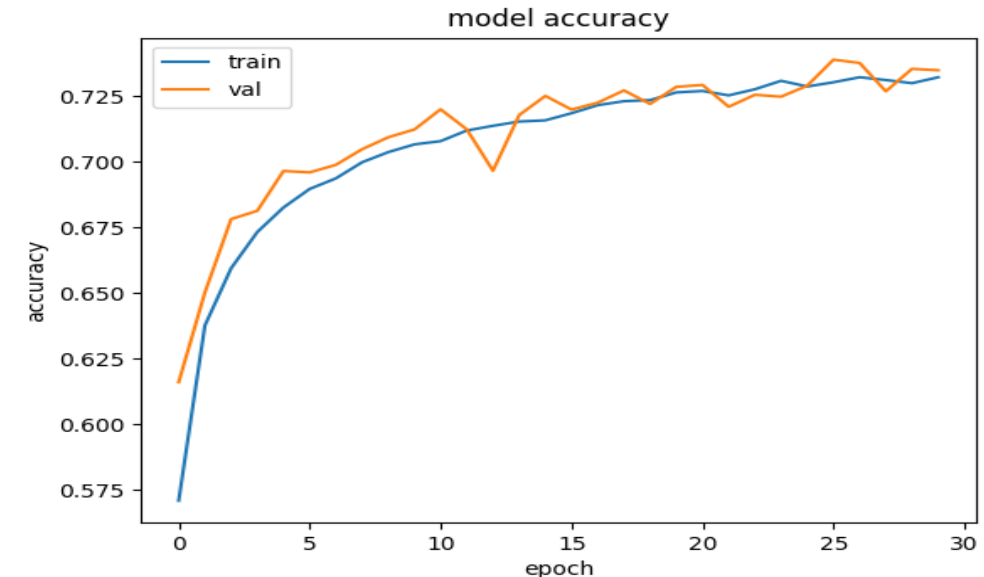


# VISUALIZING THE METRICS CURVES

- After the cross-validation, we can see.....



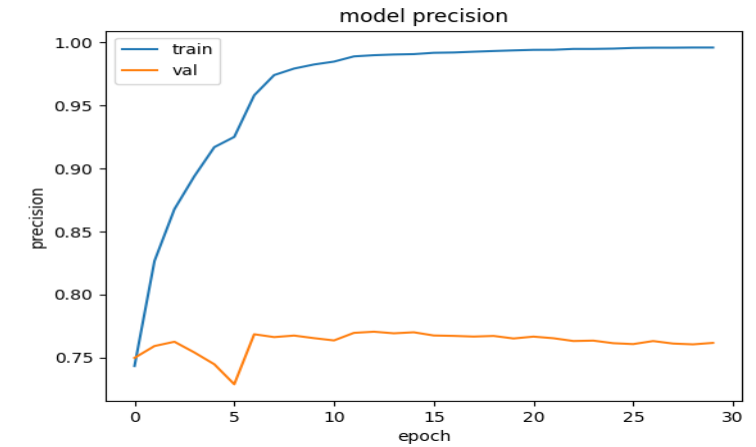
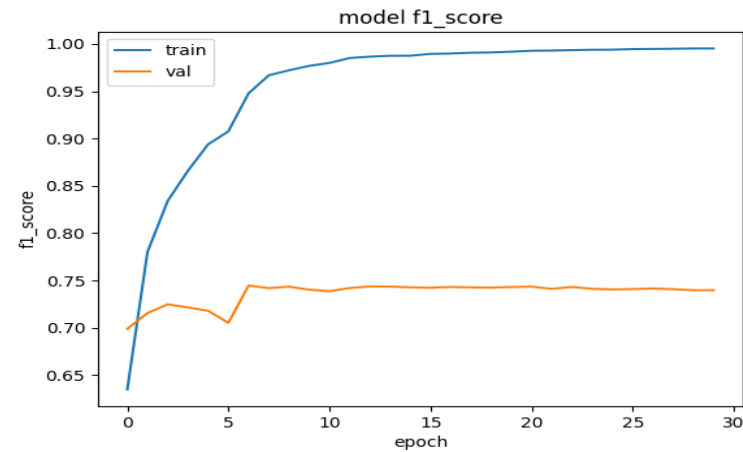
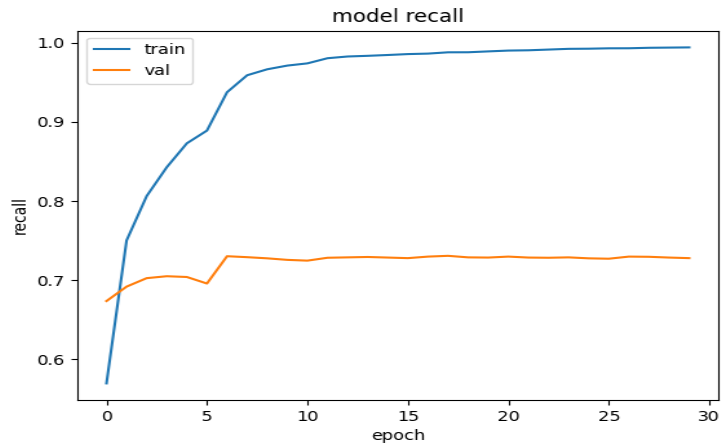
Without Data Augmentation



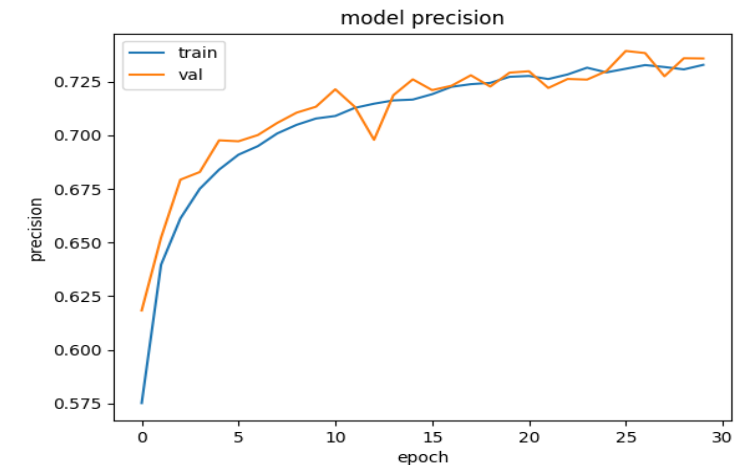
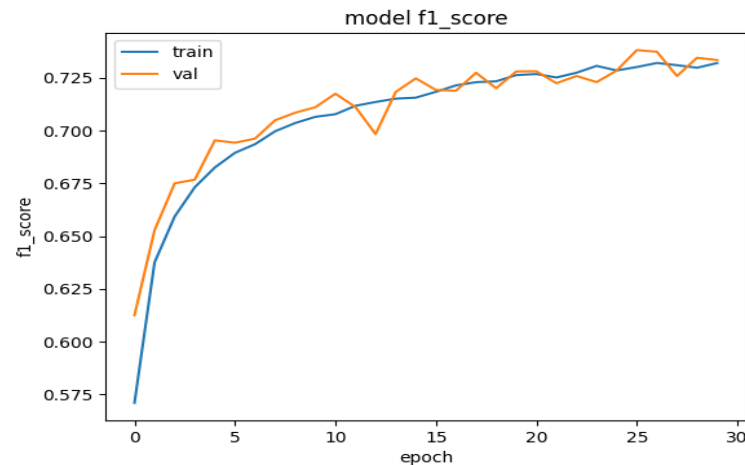
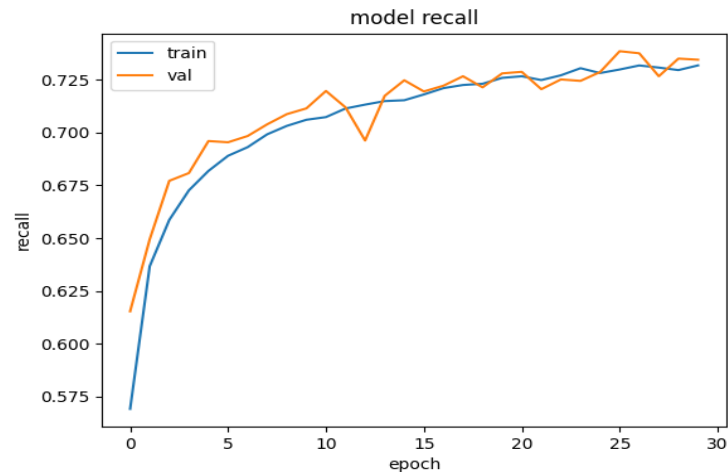
With Data Augmentation

- Epochs: 30
- Batches: 32
- Optimizer: Adam with learning rate of 1e-4
- After augmentation Multi-class balanced accuracy: 0.732 (train) / 0.734 (validation)

# VISUALIZING THE METRICS CURVES



Without Data Augmentation



With Data Augmentation

# PREDICTION

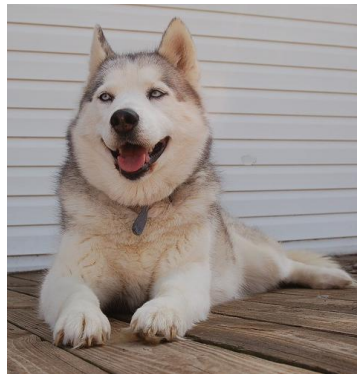


True Label: Basenji

Probabilities 0.35 followed by 0.31 is not convincing!

```
Top-5 probabilities index: [101, 22, 99, 115, 7, 72, 21]
basenji 0.35082543
Ibizan_hound 0.313001
Siberian_husky 0.16691078
standard_poodle 0.14125994
toy_terrier 0.017830562
schipperke 0.0029041918
whippet 0.0026659945
```

Model Without Data Augmentation



True Label: Eskimo Dog

Correct, but 0.62 may not be believable enough!

```
Eskimo_dog 0.6243399
groenendael 0.21147579
schipperke 0.114172645
Maltese_dog 0.018629553
Japanese_spaniel 0.012133966
Boston_bull 0.0037243296
Siberian_husky 0.003451676
```

Model Without Data Augmentation

Perfectly predicted!

```
Top-5 probabilities index: [101, 89, 81, 37, 117, 64, 16]
basenji 1.0
Appenzeller 3.1463307e-29
Border_collie 5.9079163e-33
Wire-haired_fox_terrier 2.5320116e-34
dingo 1.043943e-34
Brittany_spaniel 4.0015025e-36
English_foxhound 2.930387e-37
```

Model With Data Augmentation

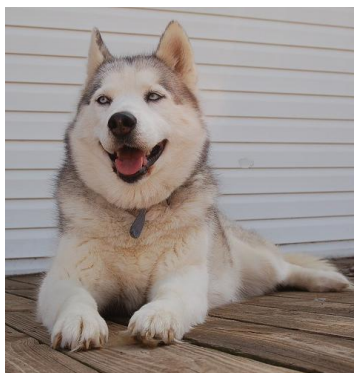
```
malamute 1.0
Siberian_husky 2.6761482e-08
Eskimo_dog 1.6537591e-09
Pembroke 2.0893867e-21
Norwegian_elkhound 4.8210217e-24
German_shepherd 3.526097e-25
Samoyed 1.0228321e-30
```

Model With Data Augmentation

Also make some mistakes sometimes?

# PREDICTION

- Thresholds?



True Label: Eskimo Dog

How to determine whether the probability is convincing enough?  
How to determine the object belongs to the dataset (OOD Detection)?

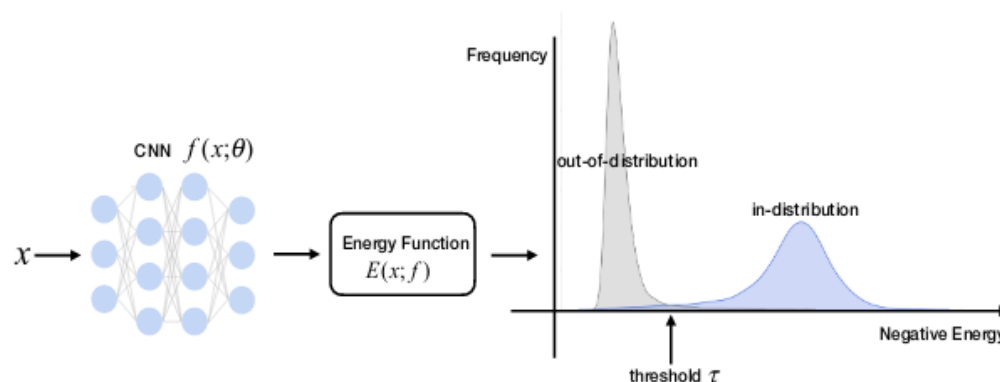
```
Eskimo_dog 0.6243399
groenendael 0.21147579
schipperke 0.114172645
Maltese_dog 0.018629553
Japanese_spaniel 0.012133966
Boston_bull 0.0037243296
Siberian_husky 0.003451676
```

Model Without Data Augmentation

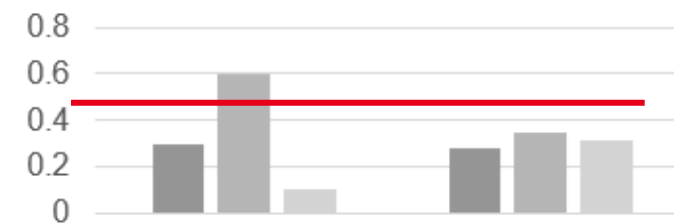
ID - Dataset



OOD - Dataset



Energy Loss



Max Softmax Probability



# PREDICTION

- Mistakes?



Canadian Eskimo Dog



Alaskan Malamute



Siberian Husky



**Even difficult for human experts sometimes!**



# USER INTERFACE & PROJECT IMPLEMENTATION

Xiaoyan Xue

# PROJECT STRUCTURE

## TECH STACKS

### DATABASE

#### MATLAB

Batch Processor

#### MYSQL

Breed

Record

Prediction

### BACK-END

#### JAVA

Swagger

Redis

SpringBoot

MyBatis

#### Python

Tensorflow

Numpy

Matplotlib

Scikit-learn

### FRONT-END

HTML5

CSS3

#### JavaScript

React

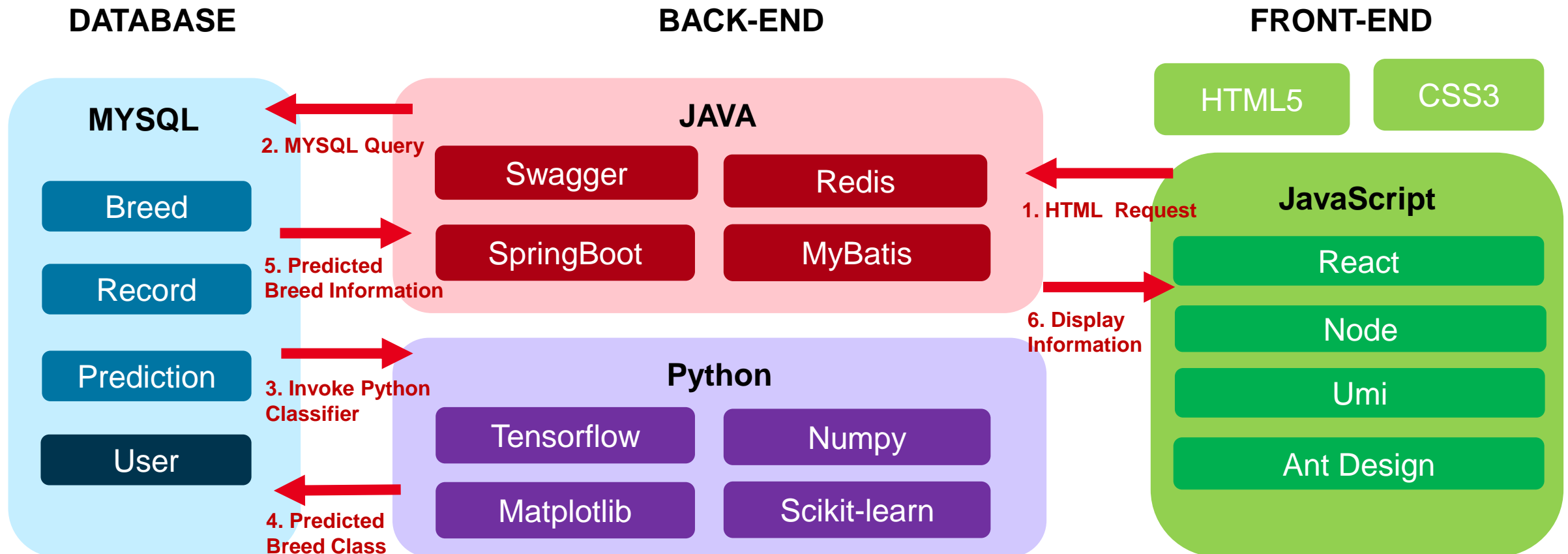
Node

Umi

Ant Design

# PROJECT STRUCTURE

## DATA FLOW



# PROJECT STRUCTURE

## DATABASE

Breed

| breed      |              |
|------------|--------------|
| Fields     |              |
| Field      | Type         |
| id         | int          |
| name       | varchar(50)  |
| annotation | char(10)     |
| origin     | varchar(30)  |
| height     | varchar(50)  |
| weight     | varchar(50)  |
| coat       | varchar(50)  |
| colour     | varchar(50)  |
| life_span  | varchar(50)  |
| link       | varchar(256) |
| image_name | varchar(30)  |

- Stored basic breed information
- Can be added/updated with more dataset
- Link for Wikipedia needs auto-checking regularly.

Prediction

| prediction |      |
|------------|------|
| Fields     |      |
| Field      | Type |
| id         | int  |
| record_id  | int  |
| breed_id   | int  |

- Stored model prediction results
- Connected with Breed and Record table with breed.id and record.id

Record

| record     |              |
|------------|--------------|
| Fields     |              |
| Field      | Type         |
| id         | int          |
| name       | varchar(30)  |
| height     | varchar(30)  |
| weight     | varchar(30)  |
| coat       | varchar(50)  |
| colour     | varchar(50)  |
| age        | varchar(30)  |
| image_name | varchar(256) |

- Stored record information which user inputs.

# PROJECT STRUCTURE

## BACKEND

| BreedController Breed information Controller Breed Controller |             | ▼                                   |
|---|-------------|-------------------------------------|
| GET   | /breed/{id} | Query breed information by breed id |
| GET   | /breed/all  | Fuzzy query all matches breeds      |

| DogImageController Python util controller Dog Image Controller |            | ▼               |
|--|------------|-----------------|
| POST   | /python/py | Run python file |

| PredictionController Prediction information controller Prediction Controller |                  | ▼                                   |
|--|------------------|-------------------------------------|
| POST   | /prediction      | Add a new prediction                |
| GET  | /prediction/{id} | Query by prediction id              |
| GET  | /prediction/all  | Fuzzy query all matches predictions |

| RecordController Record information controller Record Controller |                    | ▼                               |
|--|--------------------|---------------------------------|
| POST   | /record            | Add a new record                |
| GET  | /record/{id}       | Query by record id              |
| DELETE   | /record/{id}       | Delete a record by id           |
| GET  | /record/all        | Fuzzy query all matches records |
| POST   | /record/attachment | Upload record image             |



# UI DISPLAY

## FRONTEND



# DEMO DISPLAY!



# RELATED WORK

# RELATED WORK



## Data

- Dataset: More high quality dataset for model training.
- Augmentation: Use bounding box in the annotation to get position information more precisely.

## Model

- Training: More variety of models such as DenseNet, InceptionNet and ResNet-152, which can use majority voting.
- Training: More Epochs, different hyperparameters research such as MC dropout

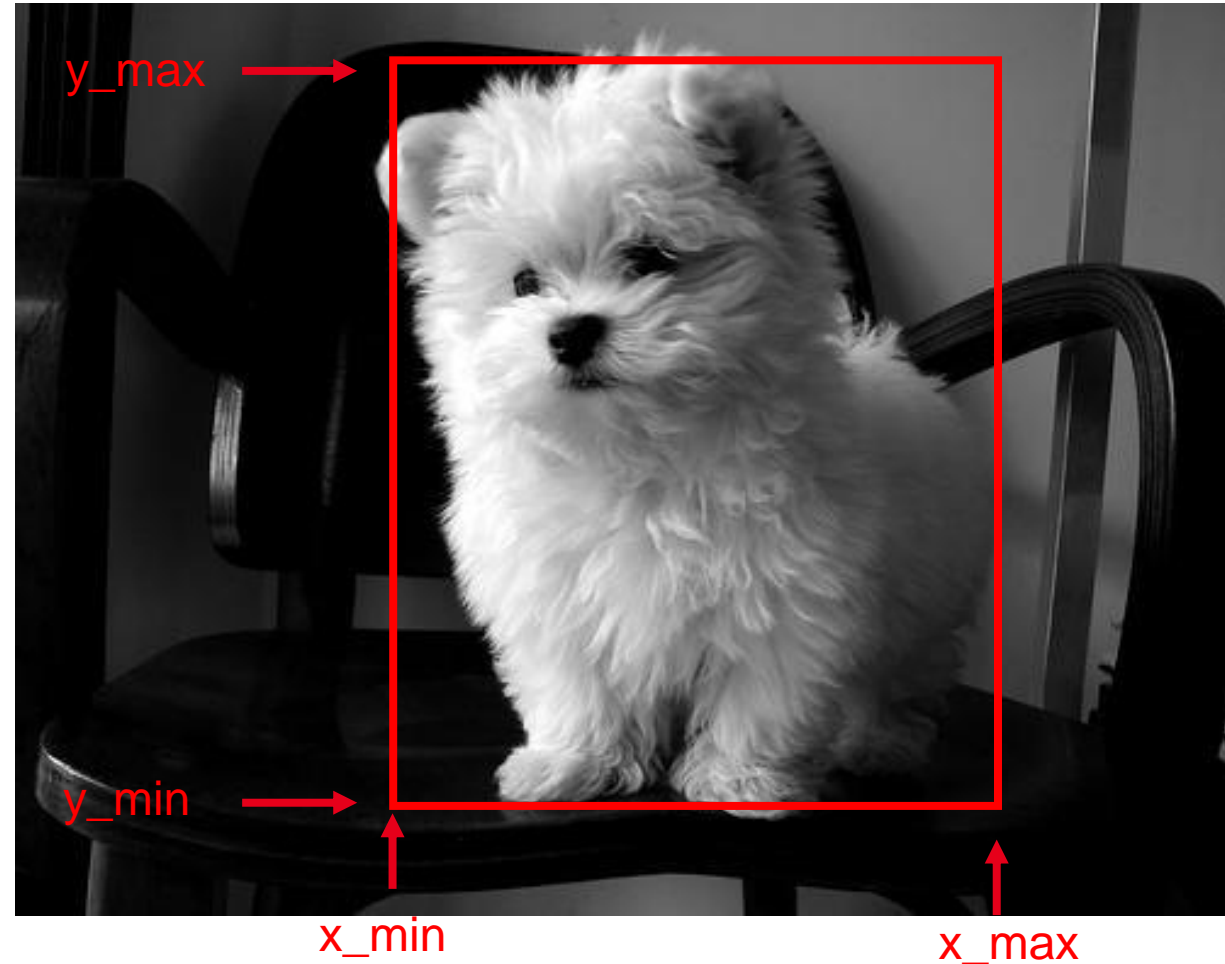
## UI

- More user-friendly functionalities: archives, alarms, etc.
- More platforms supported

# RELATED WORK

## BOUNDING BOX

- Data Augmentation: Use bounding box to get precise dog positions in the image.
- It helps to identify the breed information and extract useful features for model training.
- Randomly cropping to full backgrounds also can be prevented with the help of bounding boxes.







# THANKS FOR WATCHING!

*Any questions?*

DATA SCIENCE II / TU DARMSTADT

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