香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

Handwritten Digit and Signal Recognition for Children

EIE4512 2023-24 Summer

2024/7

Group 1

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01

PART 01

Part1
Motivation

Motivation

> "In today's digital era, labor costs are increasingly expensive, and the digitalization of early childhood education has become an inevitable trend. To save parents and teachers from spending time on simple homework correction, we aim to design a program that can check children's answers of simple handwritten calculation."

02

PART 02

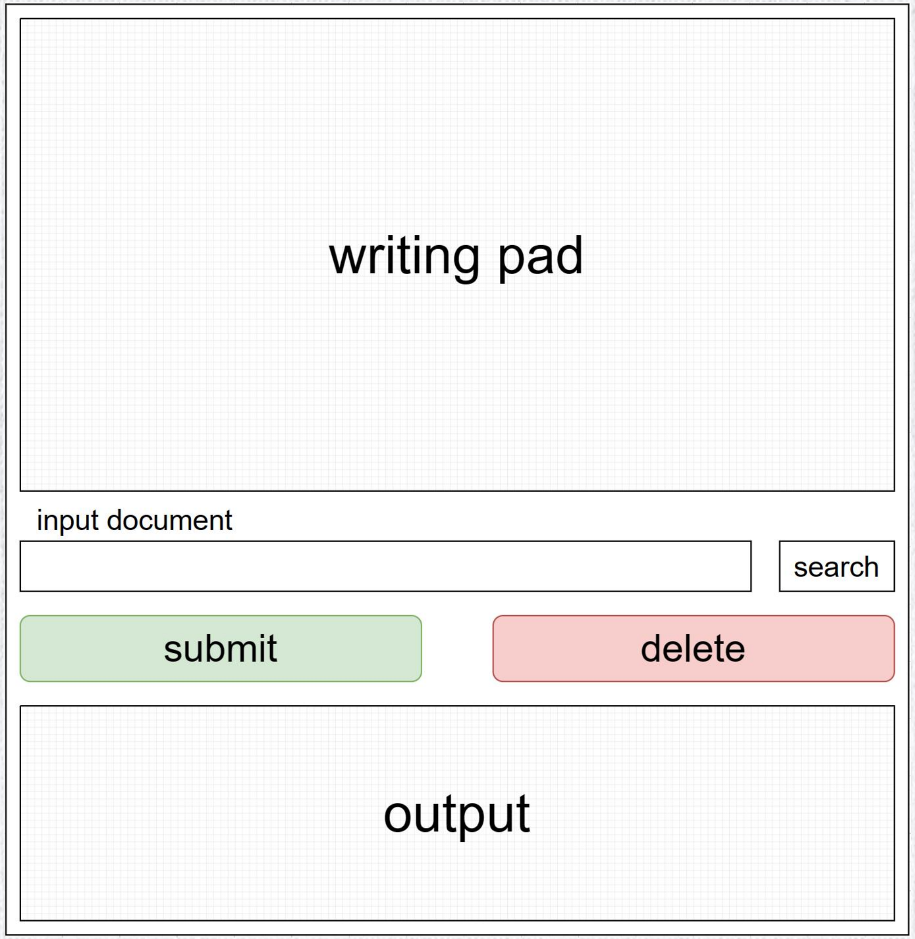
Part2
Goal

02 Goal

The goal of our project is to create a simple and easy-to-use handwritten recognition and calculation product.

The front-end part includes:

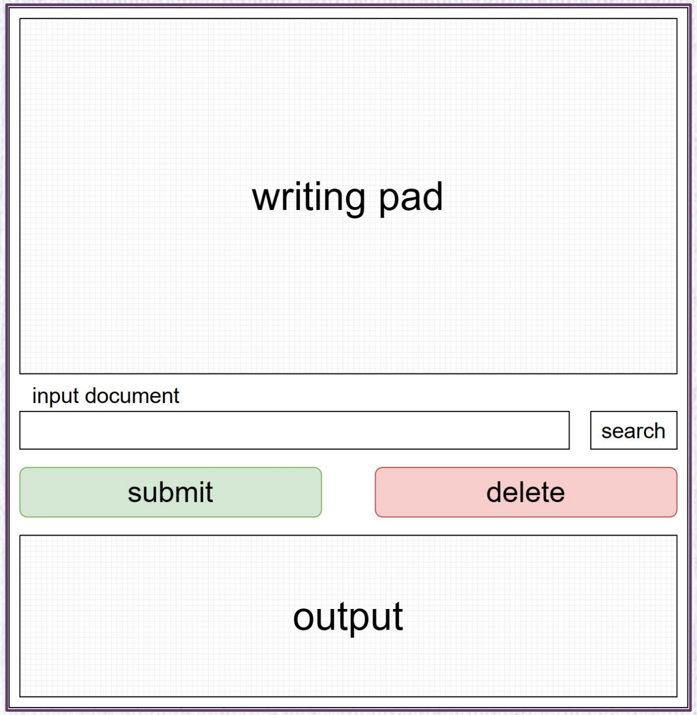
1. Handwriting board
2. Optional file input
3. Text result output



02 Goal

Pipline

Input from Handwritten
Board or document



Output to the expected
part of the frontend page

Read the input image

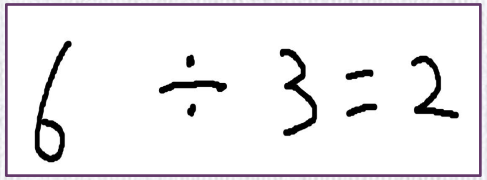
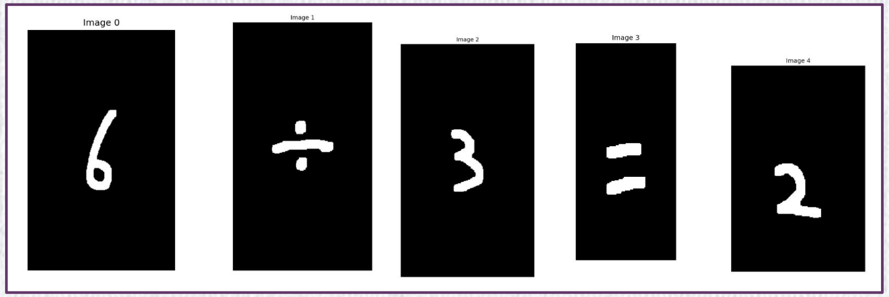
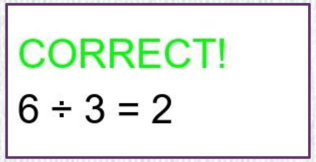


Image after processing



Separated Images



CORRECT!

6 ÷ 3 = 2

CNN proceed result

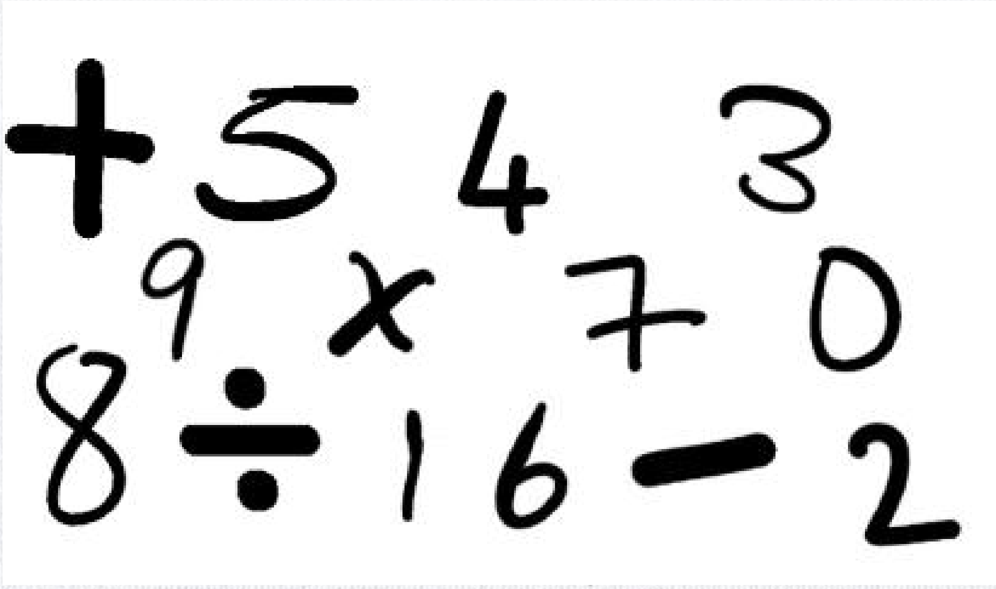
03

PART 03

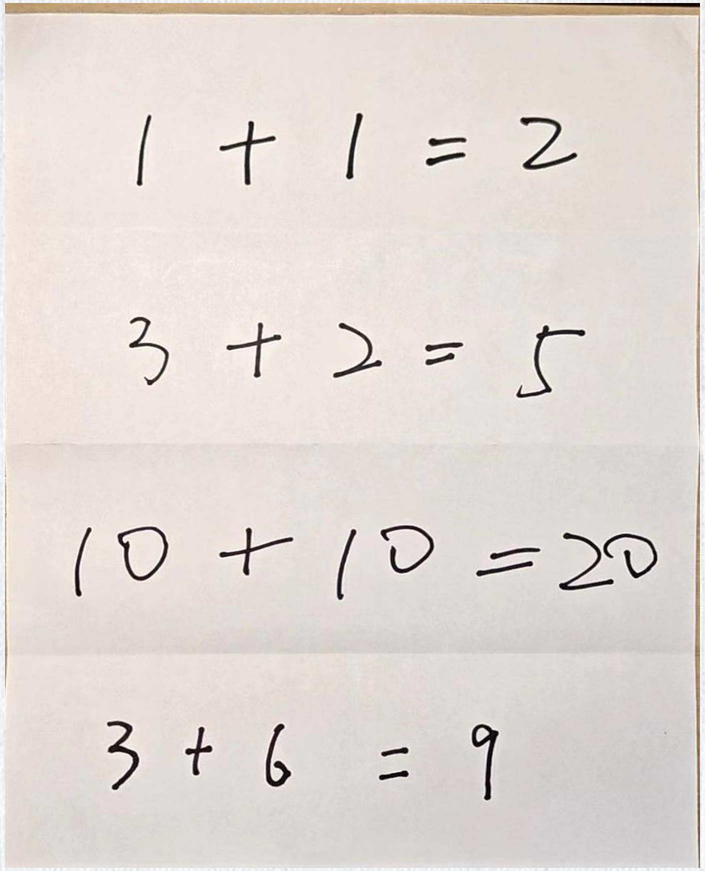
Part3
Datasets

03 Datasets

The dataset combine with two parts:
1. *Mathematics Symbols Data* collected from the Internet
2. Numbers of children's handwriting pictures collected by ourselves.



Mathematics Symbols Data



Children’ s handwriting

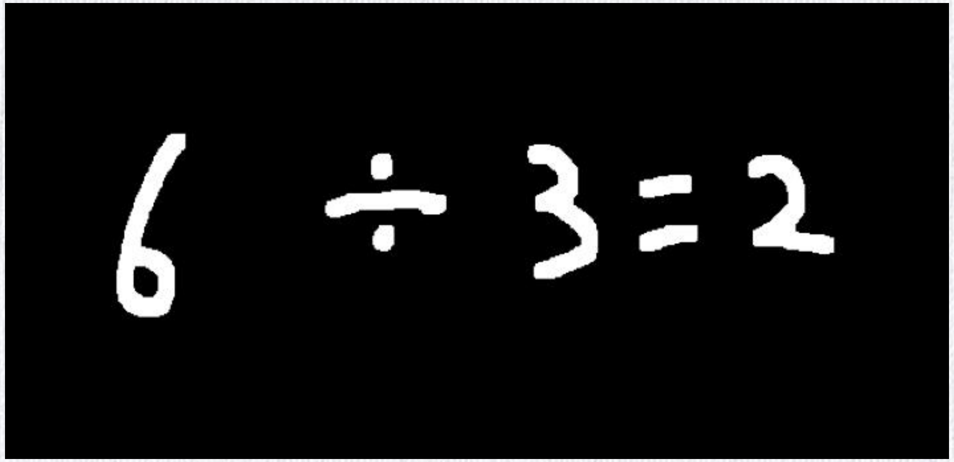
04

PART 04

Part4

Methodology

1. OpenCV
Preprocessing



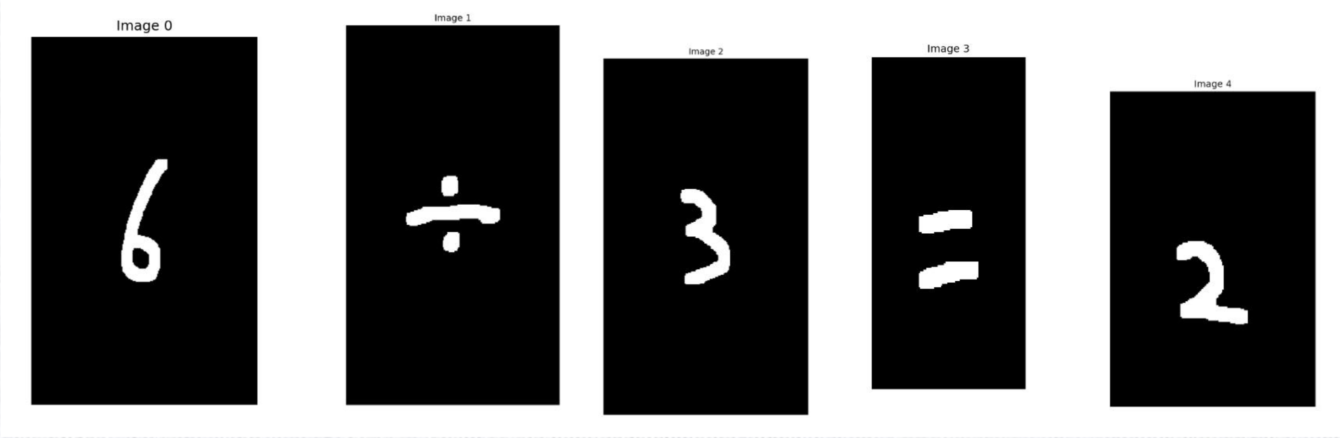
Mathematics Symbols Data

1. Preprocessing of Input Image

The input image is subjected to a series of operations including Gaussian blurring, edge detection, and dilation and erosion to facilitate subsequent processing.

04 Methodology

1. OpenCV Splitting



Separated Images

2. Using contour recognition to split equations into individual numbers and symbols.

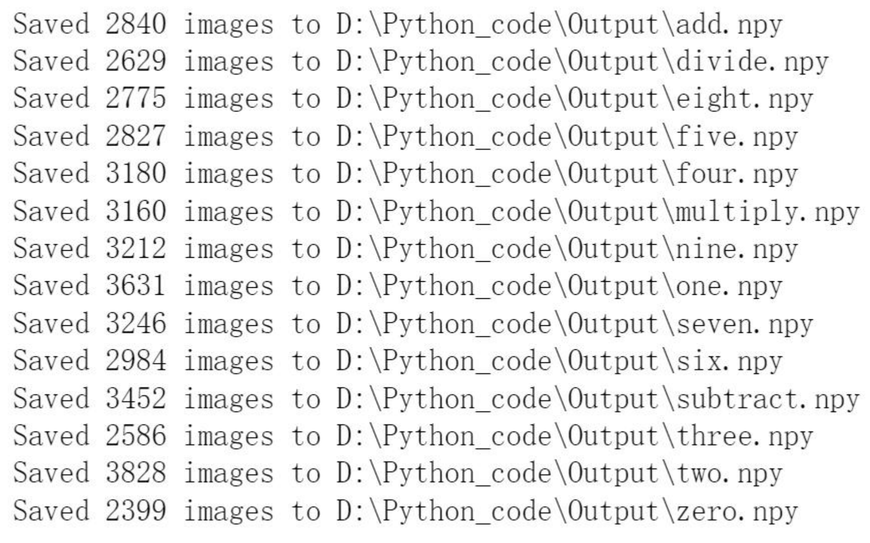
Contour recognition is used to obtain correctly sized bounding boxes, which are then used to crop the image to obtain individual images. However, traditional contour recognition treats division signs and equal signs as multiple objects, resulting in multiple bounding boxes. Therefore, we identify division signs and equal signs by detecting the distance between each contour and considering two contours that are too close to each other as one.

04 Methodology

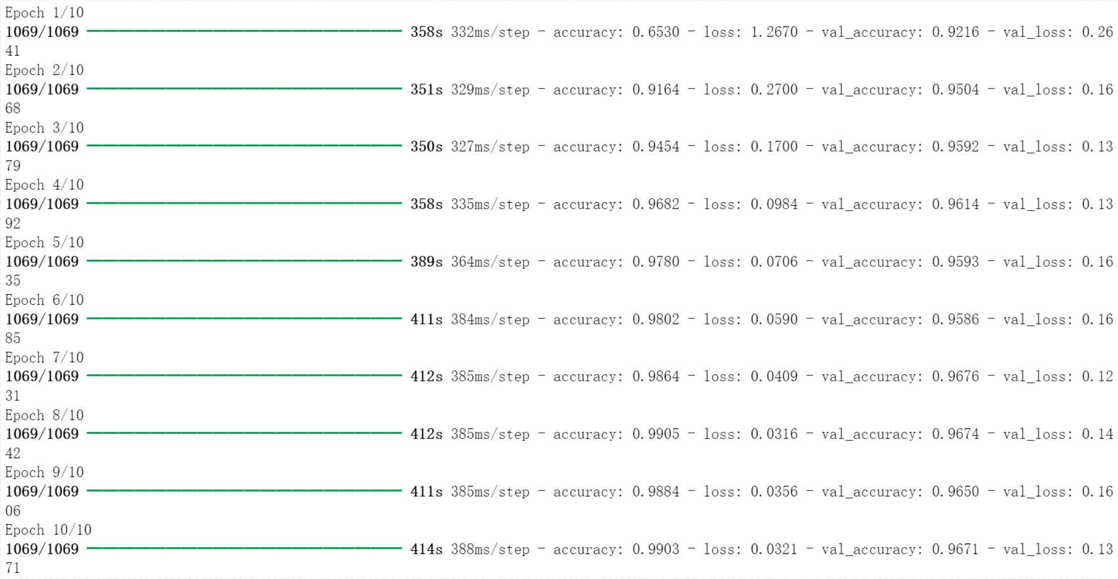
2. CNN Trainning

1. Process the data by collecting them to npy files of NumPy array.

2. Build and train a convolutional neural network (CNN) model named CNN_result.h5 to classify the images.



```
Saved 2840 images to D:\Python_code\Output\add.npy
Saved 2629 images to D:\Python_code\Output\divide.npy
Saved 2775 images to D:\Python_code\Output\eight.npy
Saved 2827 images to D:\Python_code\Output\five.npy
Saved 3180 images to D:\Python_code\Output\four.npy
Saved 3160 images to D:\Python_code\Output\multiply.npy
Saved 3212 images to D:\Python_code\Output\nine.npy
Saved 3631 images to D:\Python_code\Output\one.npy
Saved 3246 images to D:\Python_code\Output\seven.npy
Saved 2984 images to D:\Python_code\Output\six.npy
Saved 3452 images to D:\Python_code\Output\subtract.npy
Saved 2586 images to D:\Python_code\Output\three.npy
Saved 3828 images to D:\Python_code\Output\two.npy
Saved 2399 images to D:\Python_code\Output\zero.npy
```



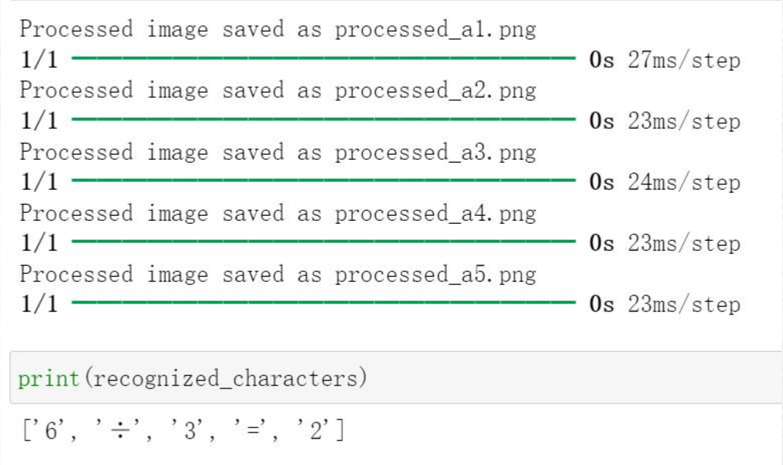
```
Epoch 1/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 358s 332ms/step - accuracy: 0.6530 - loss: 1.2670 - val_accuracy: 0.9216 - val_loss: 0.26
41
Epoch 2/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 351s 329ms/step - accuracy: 0.9164 - loss: 0.2700 - val_accuracy: 0.9504 - val_loss: 0.16
68
Epoch 3/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 350s 327ms/step - accuracy: 0.9454 - loss: 0.1700 - val_accuracy: 0.9592 - val_loss: 0.13
79
Epoch 4/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 358s 335ms/step - accuracy: 0.9682 - loss: 0.0984 - val_accuracy: 0.9614 - val_loss: 0.13
92
Epoch 5/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 389s 364ms/step - accuracy: 0.9780 - loss: 0.0706 - val_accuracy: 0.9593 - val_loss: 0.16
35
Epoch 6/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 411s 384ms/step - accuracy: 0.9802 - loss: 0.0590 - val_accuracy: 0.9586 - val_loss: 0.16
85
Epoch 7/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 412s 385ms/step - accuracy: 0.9864 - loss: 0.0409 - val_accuracy: 0.9676 - val_loss: 0.12
31
Epoch 8/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 412s 385ms/step - accuracy: 0.9905 - loss: 0.0316 - val_accuracy: 0.9674 - val_loss: 0.14
42
Epoch 9/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 411s 385ms/step - accuracy: 0.9884 - loss: 0.0356 - val_accuracy: 0.9650 - val_loss: 0.16
06
Epoch 10/10
1069/1069 ━━━━━━━━━━━━━━━━━━━━ 414s 388ms/step - accuracy: 0.9903 - loss: 0.0321 - val_accuracy: 0.9671 - val_loss: 0.13
71
```

2. CNN
Recognition

1. Read and preprocess the input images to fit the size of model.

2. Use trainned CNN model to recognize the characters in the image.

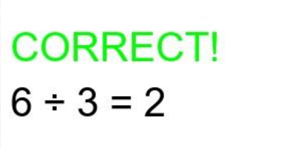
3. Check the calculations and output the result to the front dne.



```
Processed image saved as processed_a1.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
Processed image saved as processed_a2.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 23ms/step
Processed image saved as processed_a3.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 24ms/step
Processed image saved as processed_a4.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 23ms/step
Processed image saved as processed_a5.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 23ms/step
```

```
print(recognized_characters)
```

```
['6', '÷', '3', '=', '2']
```



CORRECT!

6 ÷ 3 = 2

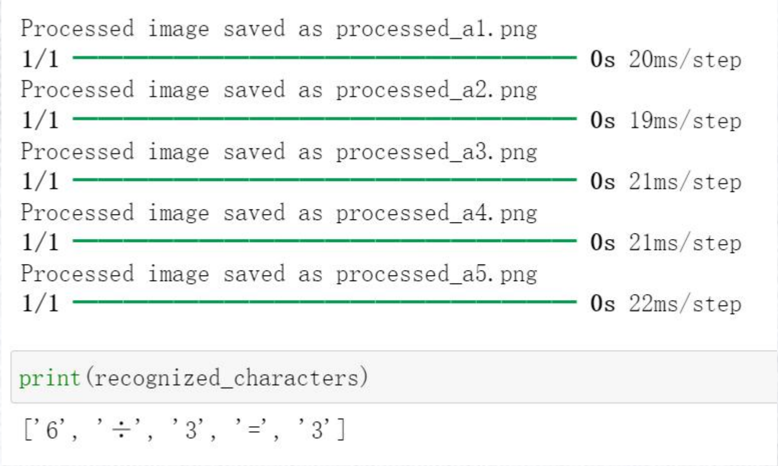
04 Methodology

2. CNN Recognition

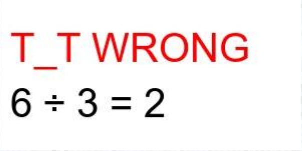
1. Read and preprocess the input images to fit the size of model.

2. Use trainned CNN model to recognize the characters in the image.

3. Check the calculations and output the result to the front dne.



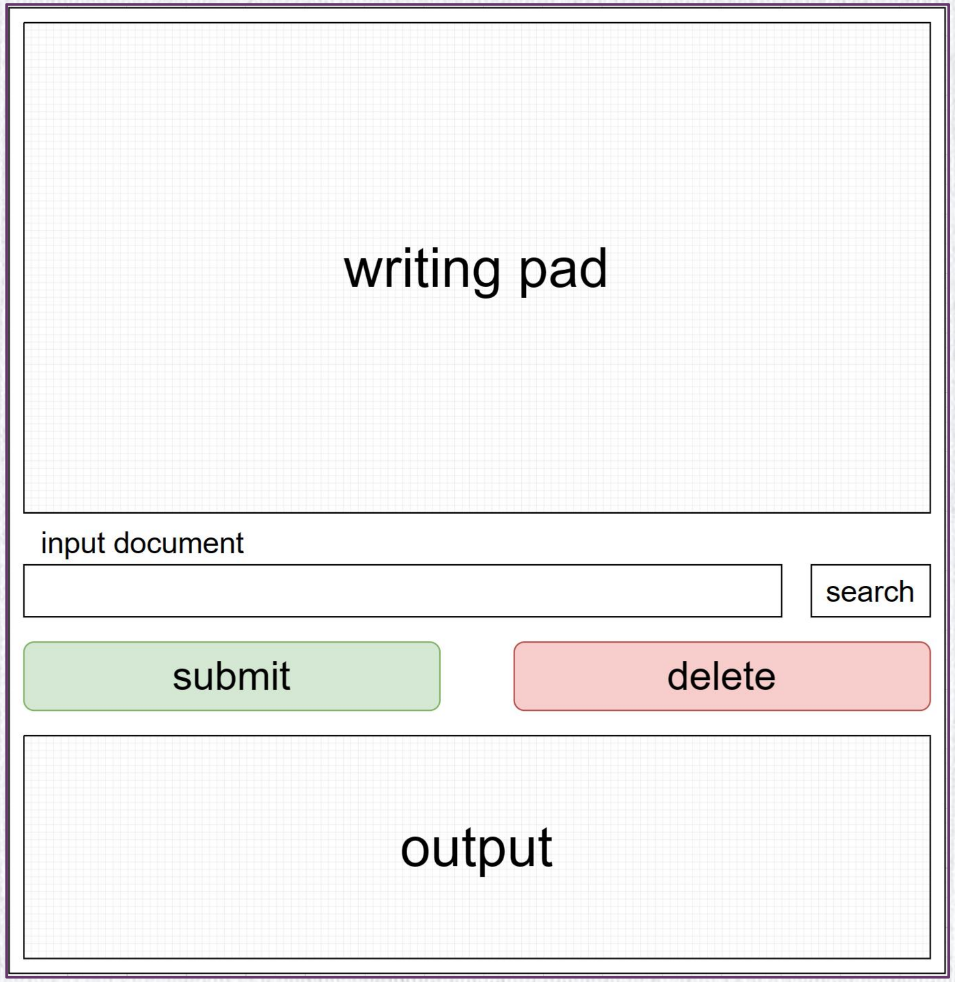
```
Processed image saved as processed_a1.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 20ms/step
Processed image saved as processed_a2.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 19ms/step
Processed image saved as processed_a3.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 21ms/step
Processed image saved as processed_a4.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 21ms/step
Processed image saved as processed_a5.png
1/1 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0s 22ms/step

print(recognized_characters)

['6', '÷', '3', '=', '3']
```

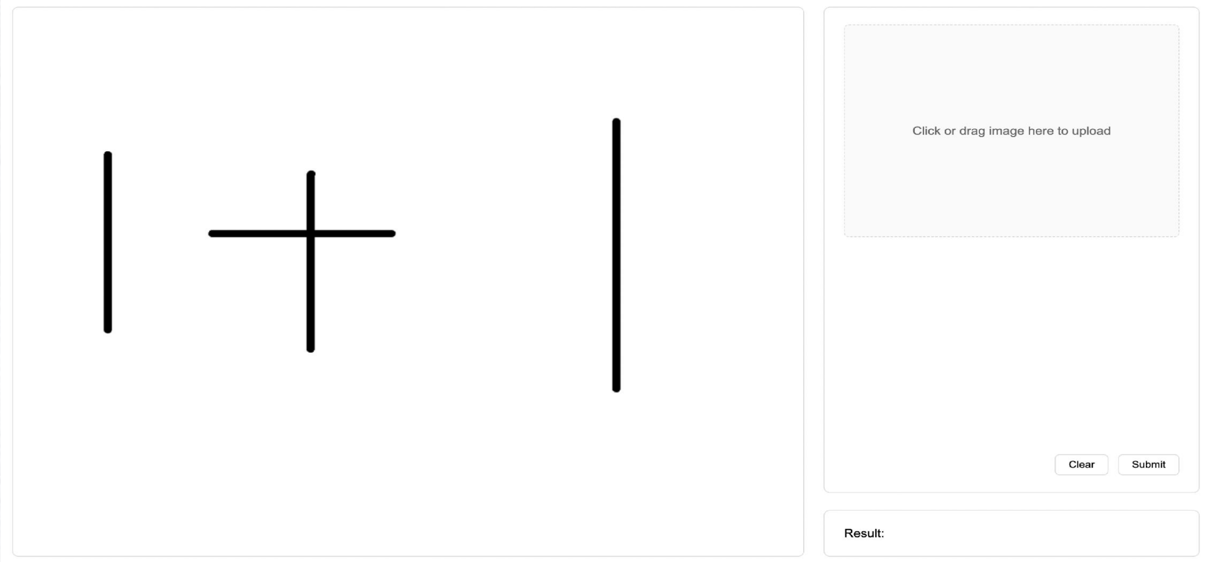


T_T WRONG

6 ÷ 3 = 2

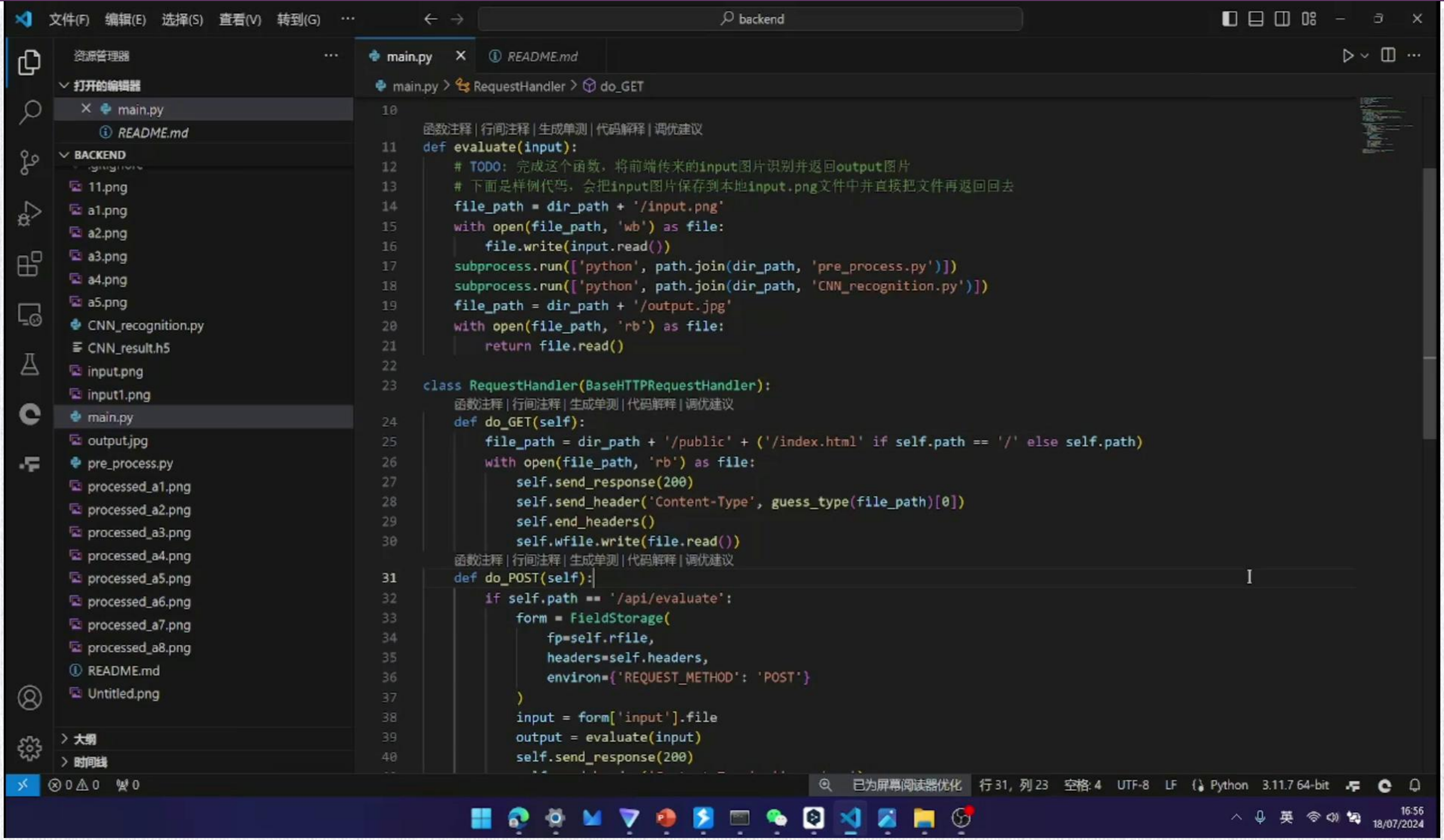
3. Front End





1. Complete the HTTP front-end code using the React framework.
2. Use the canvas context to track mouse movement and complete image drawing.
3. Implement image uploading using an input dom element with type=file.
4. Use a simple Python server and HTTP API to obtain the uploaded image from the front-end, call the algorithm, and return the resulting image.

Video Presentation



```python

def evaluate(input):
    # TODO: 完成这个函数，将前端传来的input图片识别并返回output图片
    # 下面是样例代码，会把input图片保存到本地input.png文件中并直接把文件再返回回去
    file_path = dir_path + '/input.png'
    with open(file_path, 'wb') as file:
        file.write(input.read())
    subprocess.run(['python', path.join(dir_path, 'pre_process.py')])
    subprocess.run(['python', path.join(dir_path, 'CNN_recognition.py')])
    file_path = dir_path + '/output.jpg'
    with open(file_path, 'rb') as file:
        return file.read()

class RequestHandler(BaseHTTPRequestHandler):
    def do_GET(self):
        file_path = dir_path + '/public' + ('/index.html' if self.path == '/' else self.path)
        with open(file_path, 'rb') as file:
            self.send_response(200)
            self.send_header('Content-Type', guess_type(file_path)[0])
            self.end_headers()
            self.wfile.write(file.read())
    def do_POST(self):
        if self.path == '/api/evaluate':
            form = FieldStorage(
                fp=self.rfile,
                headers=self.headers,
                environ={'REQUEST_METHOD': 'POST'}
            )
            input = form['input'].file
            output = evaluate(input)
            self.send_response(200)
```

香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

Thank you for Watching

Appendix: Reference

CNN reference:
https://cloud.tencent.com/developer/article/2398369

Dataset 1 of images of numbers & operators to train for maths expression solver:
https://www.kaggle.com/datasets/amitamola/mathematics-symbols-data/data

Dataset 2 of images of numbers & operators to train:
Collected by Teammates