QS STARS RATED FOR EXCELLENCE 2012

Fpt University

TRƯỜNG ĐẠI HỌC FPT

A Deep Learning Model for Helmet Detection and Automatic License Plate Recognition

Supervisor: Bui Van Hieu

Team: AIP409_G4

Hoa Lac Campus
20 December 2023

MY TEAM

Bui Van Hieu
Instructor

Pham Trung Hieu
Leader

Vu Van Nghiep
Member

Table of contents

01. Introduction

1.1 Problem & motivation
1.2 Related works
1.3 Contributions

1.1 Problem and motivation

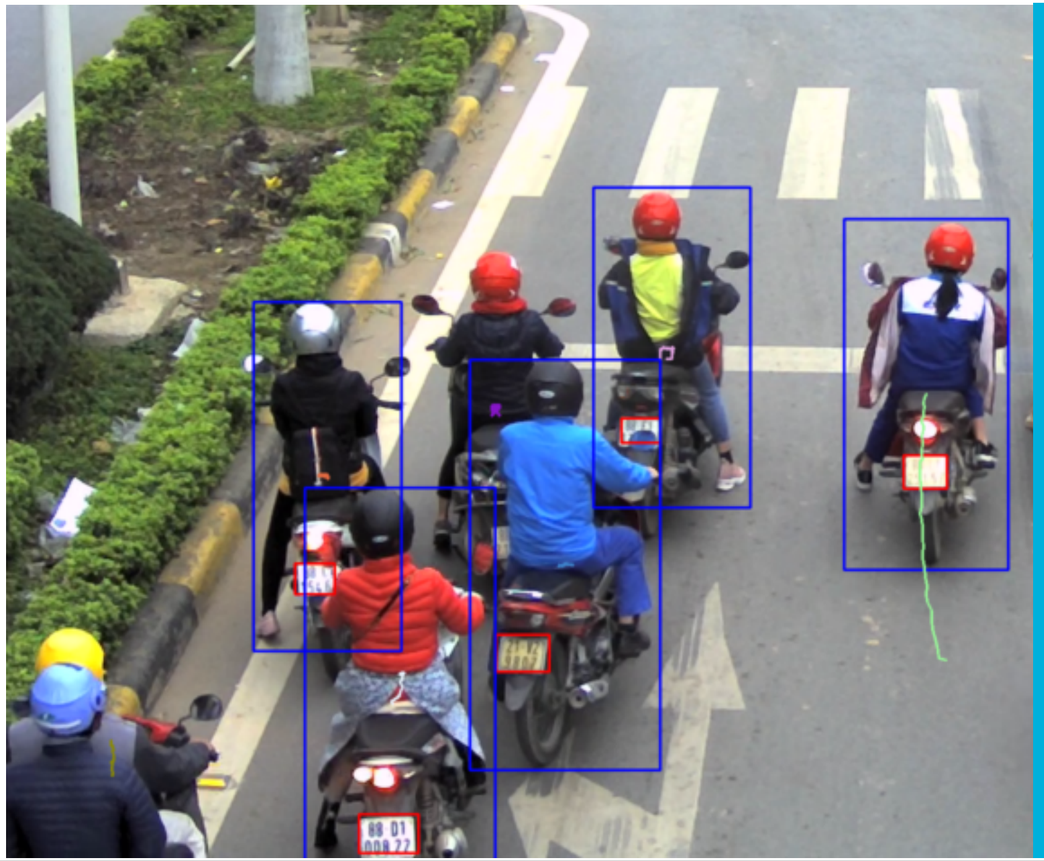
- About 1.35 million people died and more than 50 million were injured in road traffic accidents worldwide every year.
- 78% are due to head trauma.
- Wearing a helmet reduces the risk of death by 42% and the risk of injury by 69%.

Problem 01: Overlapping heads or license plates

In complex traffic environments, A and B are motorcyclist:

- How to assign head area and license plate to A?
- A's head area is in the box of B
- A's license plate is in the box of B

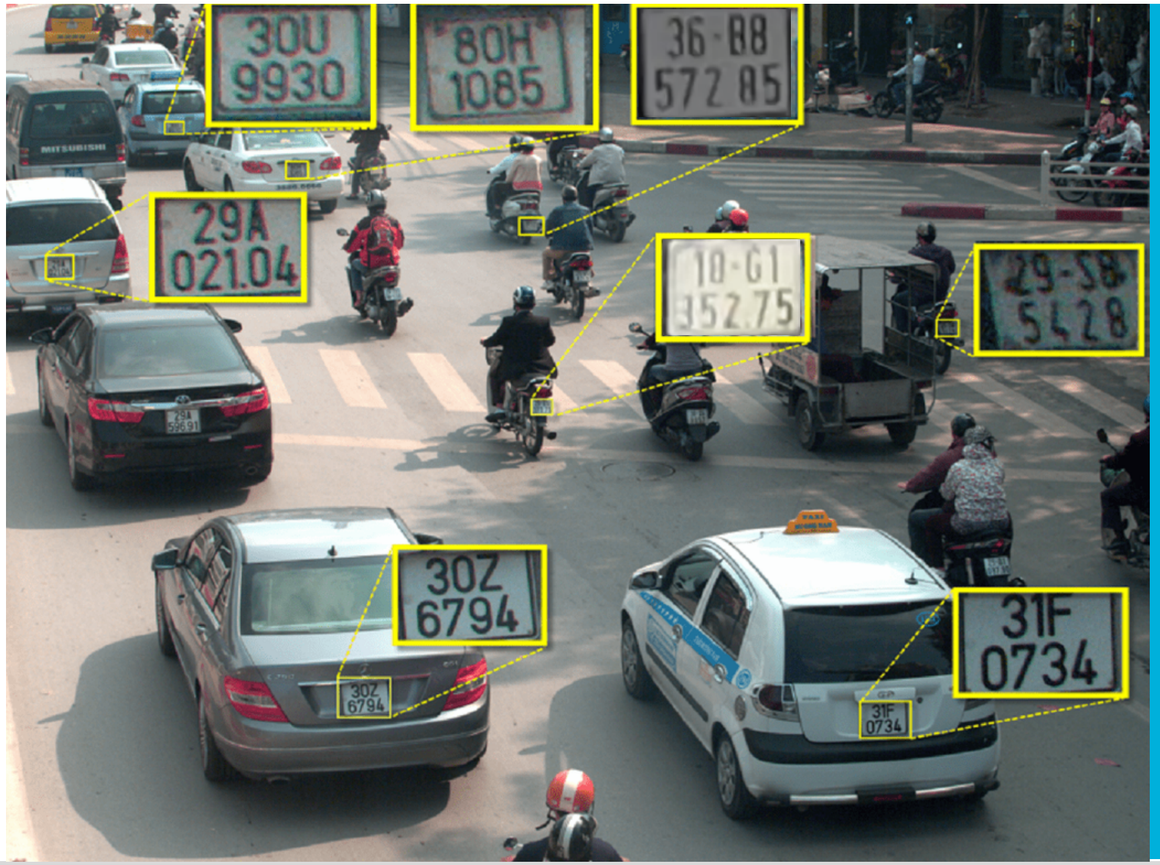
=> unclear positioning of violators and corresponding license plates.



Problem 02: External conditions lead to the extraction of incorrect information

- Small image size
- Low resolution
- Different aspect ratios
- Different shooting angles

=> Post-processing steps are required



Helmet Detection and Automatic License Plate Recognition

Helmet detection

- Distinguish between people wearing helmets and without helmets.
- Distinguish motorcyclists from pedestrians.

License plate extraction

- Recognize license plates with different ratios and many different formats
- Distinguishing characters with high similarity

1.2 Related works

2019
YOLOv3

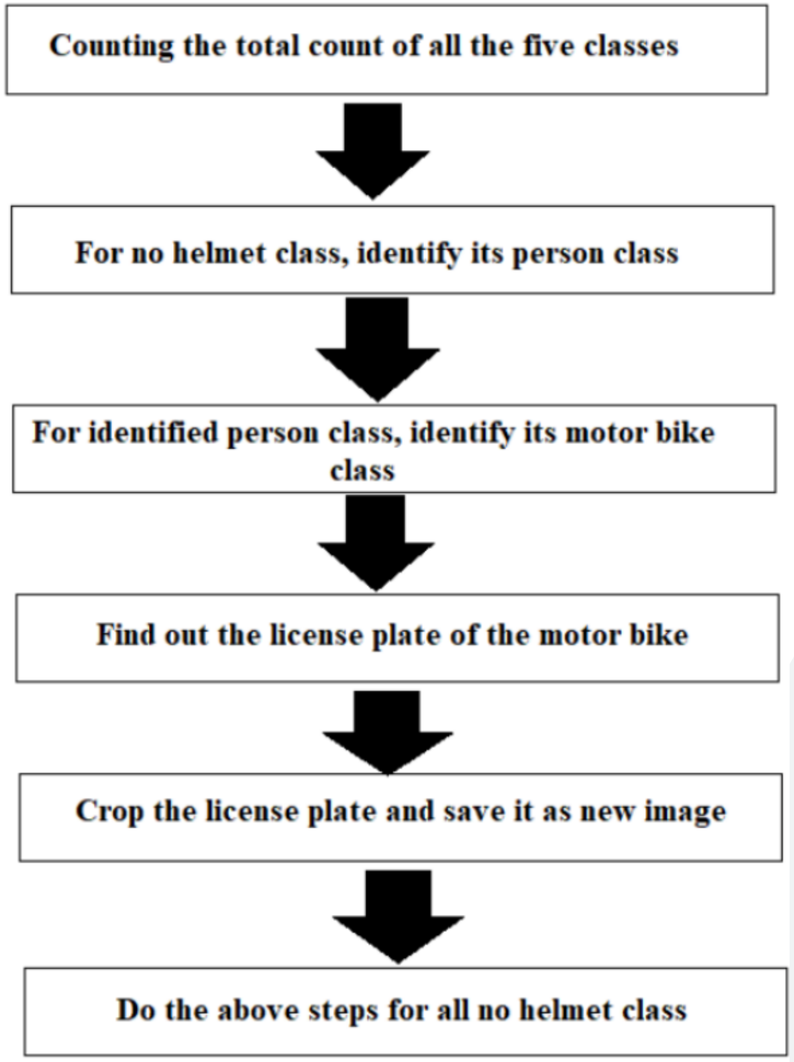


Plate #1

	Plate	Confidence
-	KA41EM0395	89.353058
-	KA41M0395	80.161301
-	KA416M0395	79.876579
-	KA41KM0395	79.874893
-	KA41BM0395	79.874687

Advantage:

- Propose a good processing pipeline
- Apply post-processing techniques to increase accuracy

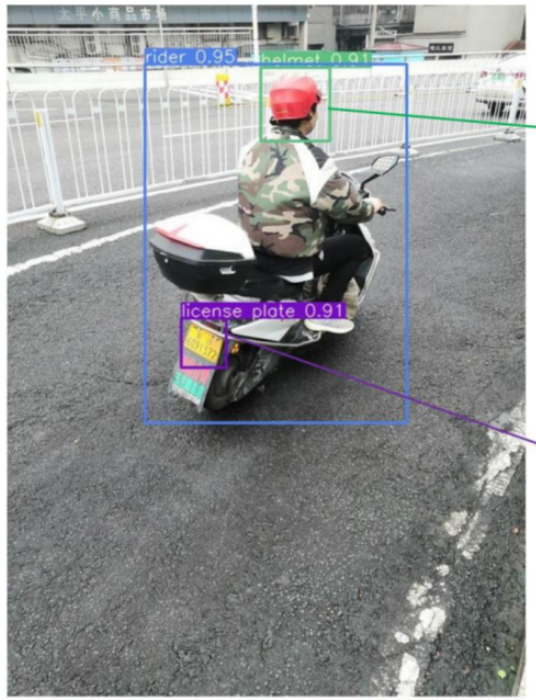
1.2 Related works

2020
YOLOv2

Advantage:

- Propose a threshold to minimize false positives

1.2 Related works



The center point of the target box is located in the upper 1/2 area of a rider target box, keep the target box

The center point of the target box is located in the lower 1/3 area of a rider target box, keep the target box

Advantage:

- Combine the advantages of the previous two methods and improve it

Defect:

- Cannot be recognized properly in heavy traffic conditions

2023

SG-YOLOv5

1.3 Contribution

01

Consolidate and develop methods from previous articles to address limitations in detecting head areas and license plates.

02

A post-processing method was developed, which facilitates the discrimination and tracking of multiple objects within a single frame. This technique also increases the accuracy of extracting license plate information.

03

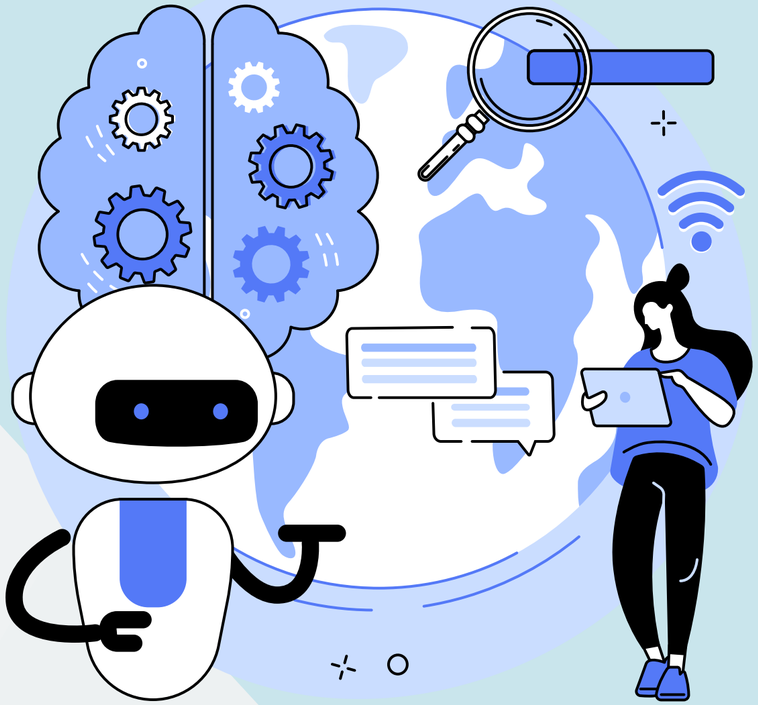
Creat a novel public dataset, comprising a total of 6562 images include 4 classes: motorcyclist, helmet, no_helmet, and license plate, each image annotated with precise bounding boxes.

04

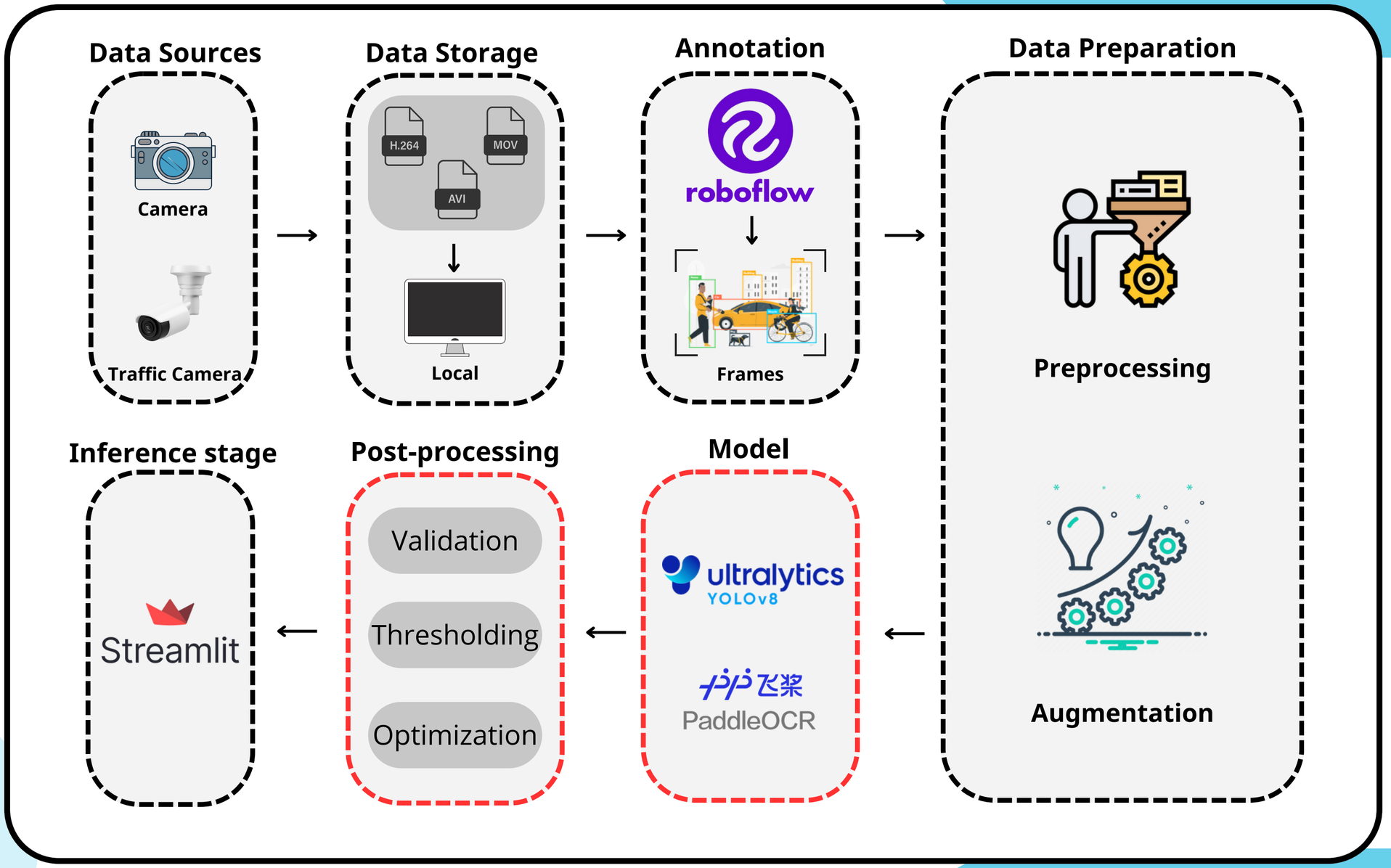
Create a website with a friendly and easy-to-use interface so users can upload videos, run model and adjust parameters for an intuitive look.

02. METHODOLOGY

2.1 Overview Pipeline
2.2 Object Detection
2.3 Optical Character Recognition
2.4 Post-processing Technique

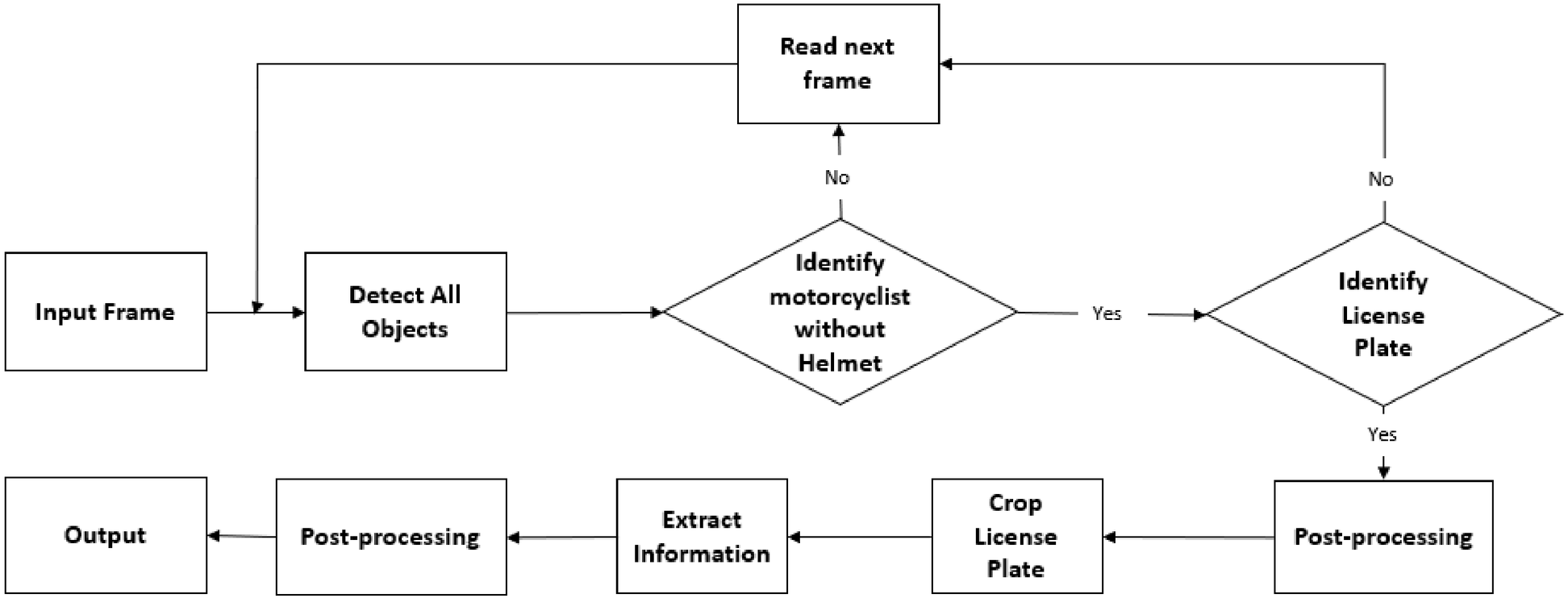


2.1 Overview Pipeline



WORKFLOW OVERVIEW

2.1 Overview Pipeline



2.1 Overview Pipeline

What is YOLO?

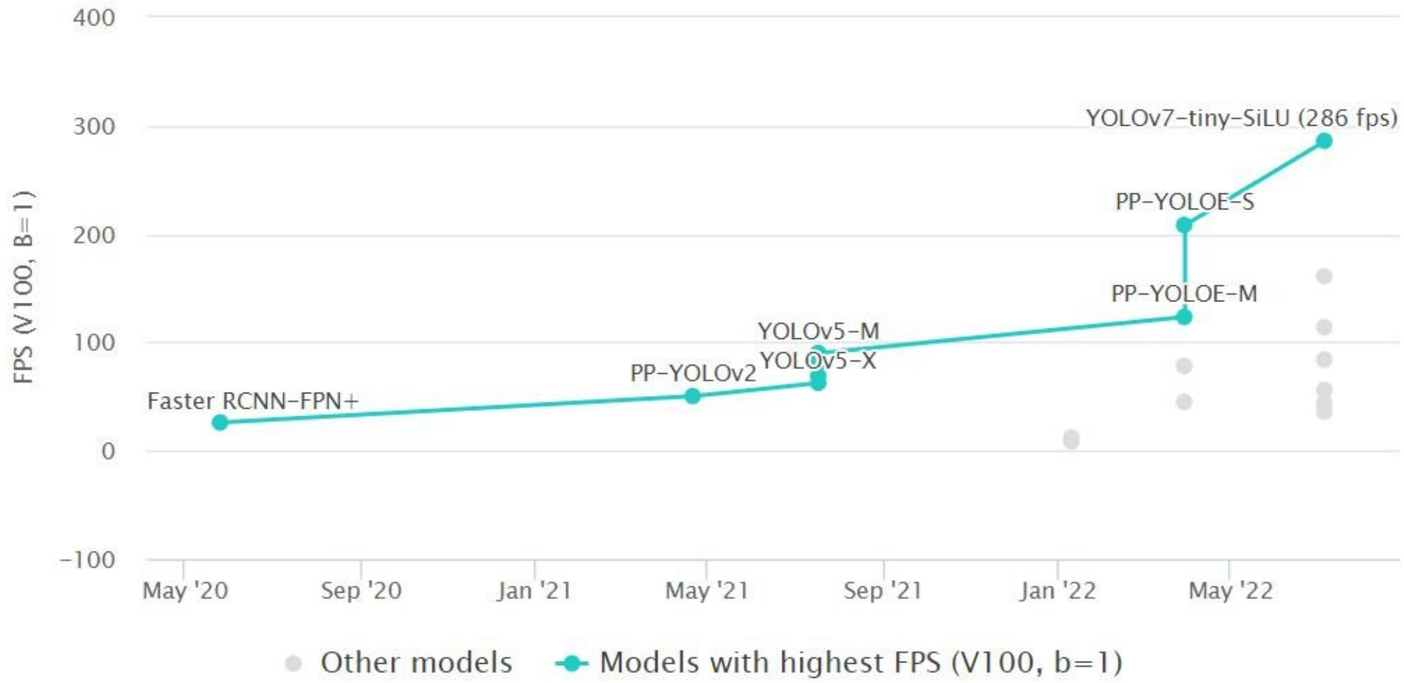
Joseph Redmon

2.2 Object Detection

Why should we use YOLOv8?

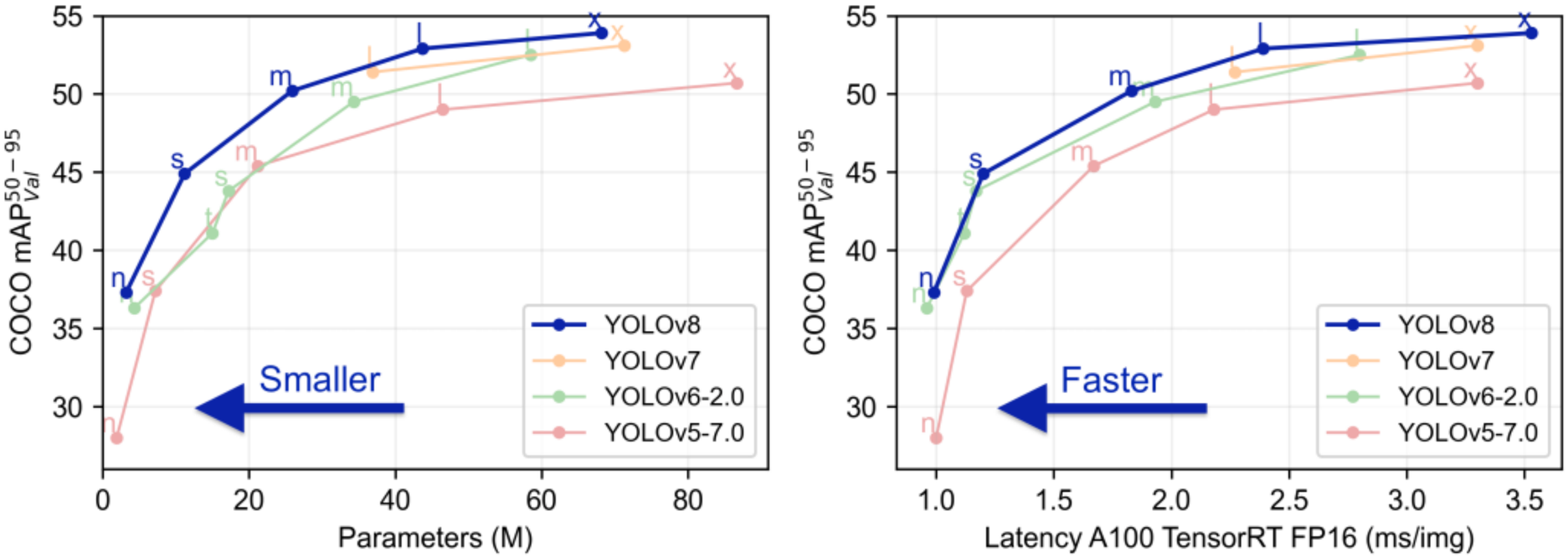
On the MS COCO dataset, an important benchmark metric is inference time (ms/Frame, lower is better) or Frames per Second (FPS, higher is better).

Model	Inference time (ms)
YOLOv7	3.5
YOLOv4	12
YOLOv3	29
Mask R-CNN	333



The fastest real-time object detection algorithm (Inference time)

Why should we use YOLOv8?



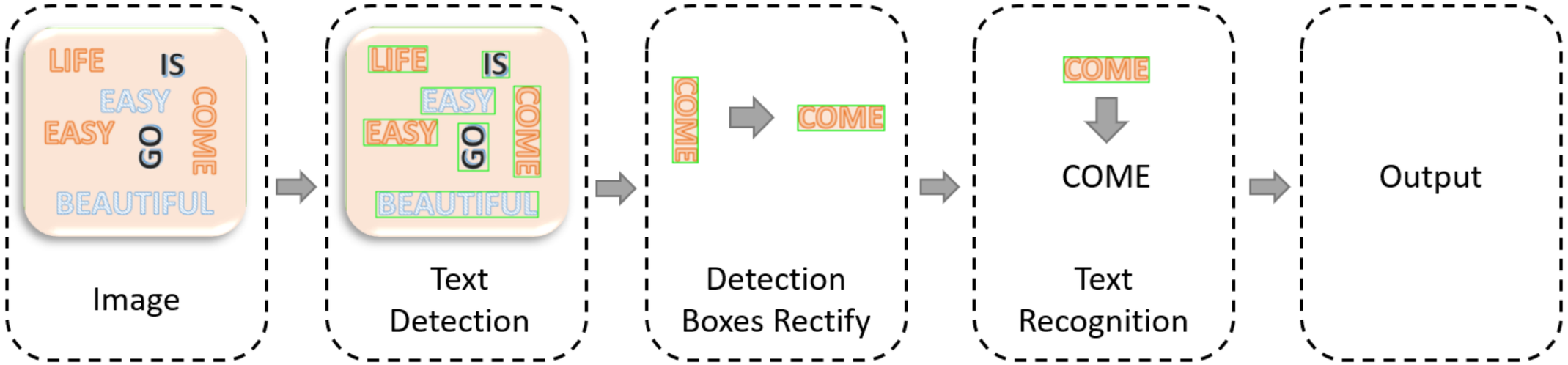
The fastest real-time object detection algorithm (Inference time)

2.3 Optical Character Recognition

PP-OCRv4

Text Detection: DB model (DB-Resnet50)

Text Recognition: SVTR_LCNet



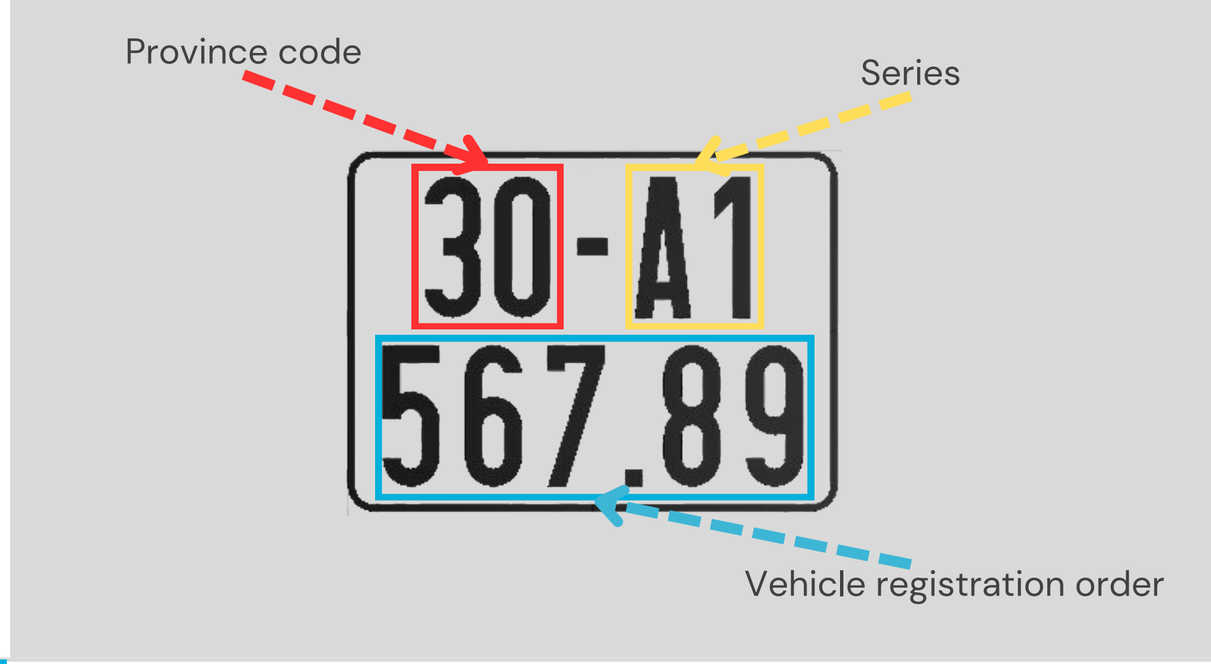
Output


```
[[[454.0, 256.0], [594.0, 256.0], [594.0, 319.0], [454.0, 319.0]], ['KHUVUC', 0.64736557]]
[[[608.0, 251.0], [744.0, 253.0], [743.0, 317.0], [607.0, 314.0]], ['CACHLY', 0.97865313]]
[[[242.0, 283.0], [395.0, 280.0], [395.0, 308.0], [242.0, 311.0]], ['KHUVUCCACHLY', 0.99591464]]
[[[264.0, 311.0], [383.0, 311.0], [383.0, 353.0], [264.0, 353.0]], ['DACBIET', 0.99107796]]
```

One vector includes the following information:

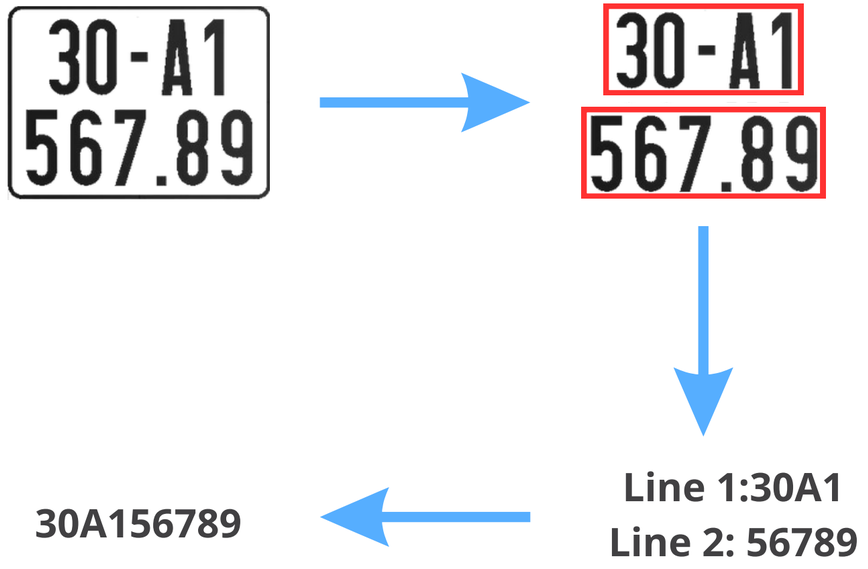
- Text position: Coordinates of the bounding boxes around the detected text (top-left, top-right, bottom-left, bottom-right).
- Content of the text
- Score

License Plate Recognition



Overview

- PaddleOCR detect and extract each line.
- A License Plate includes 8 or 9 characters



License Plate Recognition

Letter	Number
I	1
Z	2
J	3
A	4
S	5
G	6
B	8
D	0

- The third character is always A
- The third character is recognized as N

=> conversion based on similarity

4 main formats

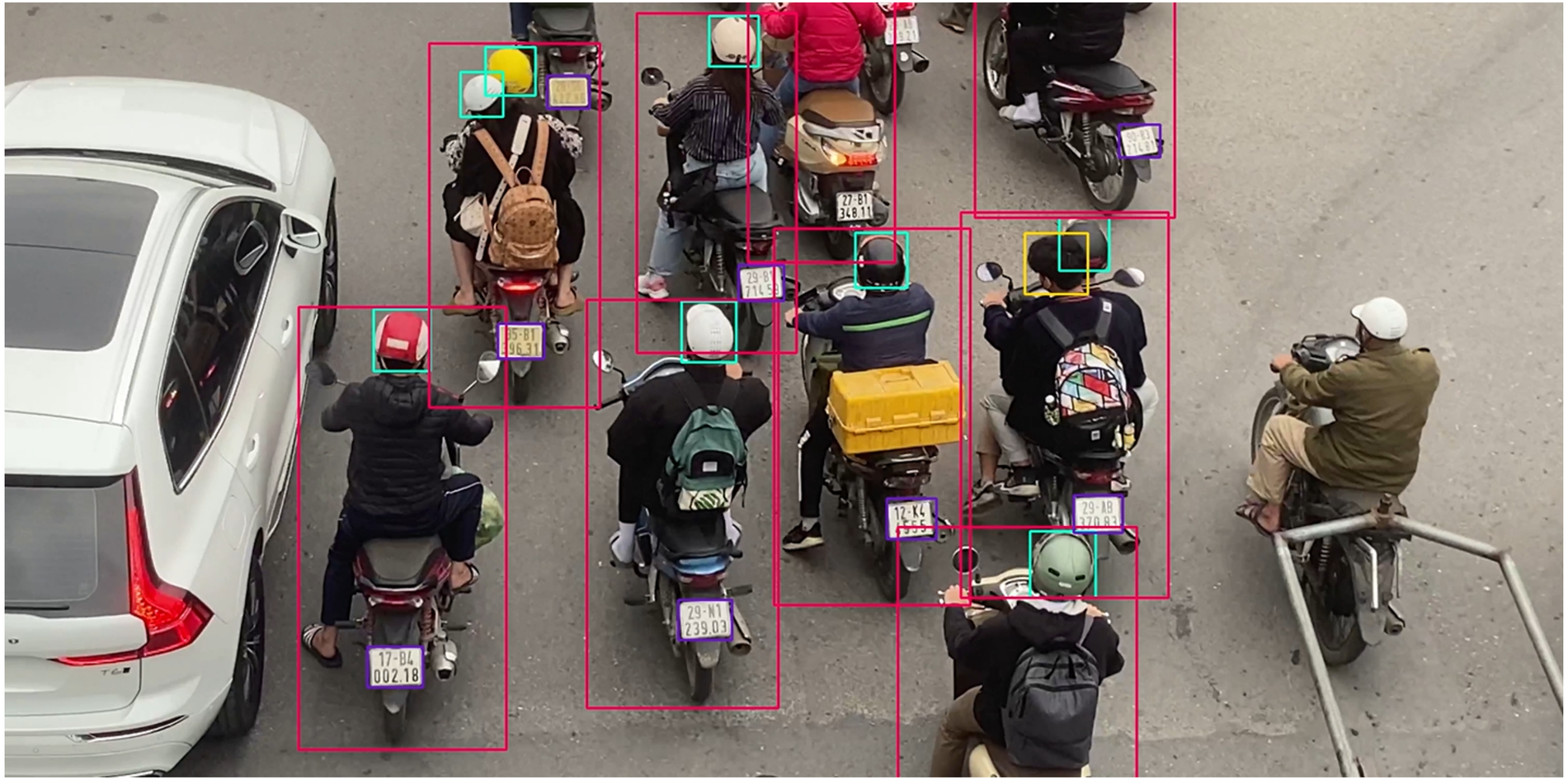
- NN-AN NNN.NN
- NN-AA NNN.NN
- NN-AN NNNN
- NN-AA NNNN

A : A, B, C, D, E, F, G, H, K, L, M, N, P, S, T, U, V, X, Y, Z

N : 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

2.4 Post-processing Technique

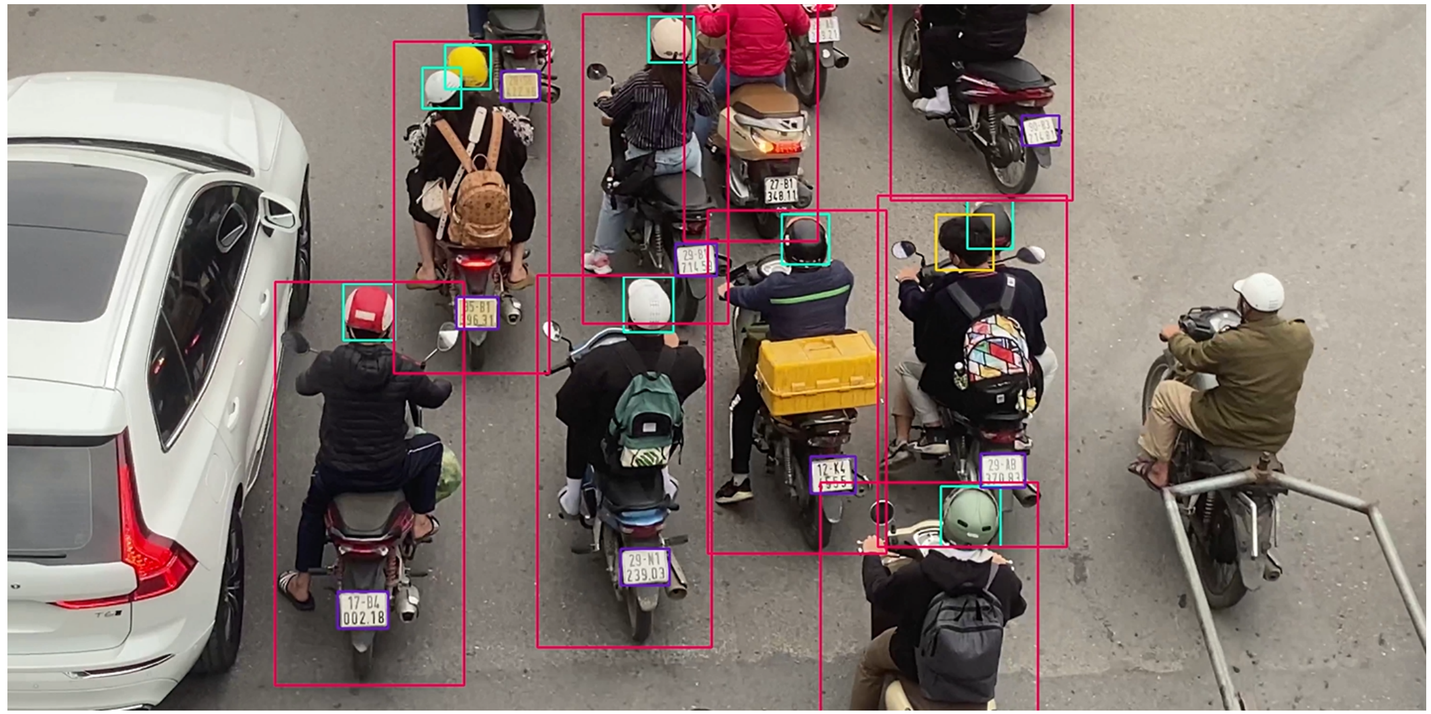
Which head belongs to which motorcycle?
Which license plate belongs to which motorcycle?



2.4 Post-processing Technique

Calculate the percentage of intersection area between two bounding boxes to find motorcyclist from head.

$$CIP = \frac{\text{intersection area}}{\text{union area}}$$

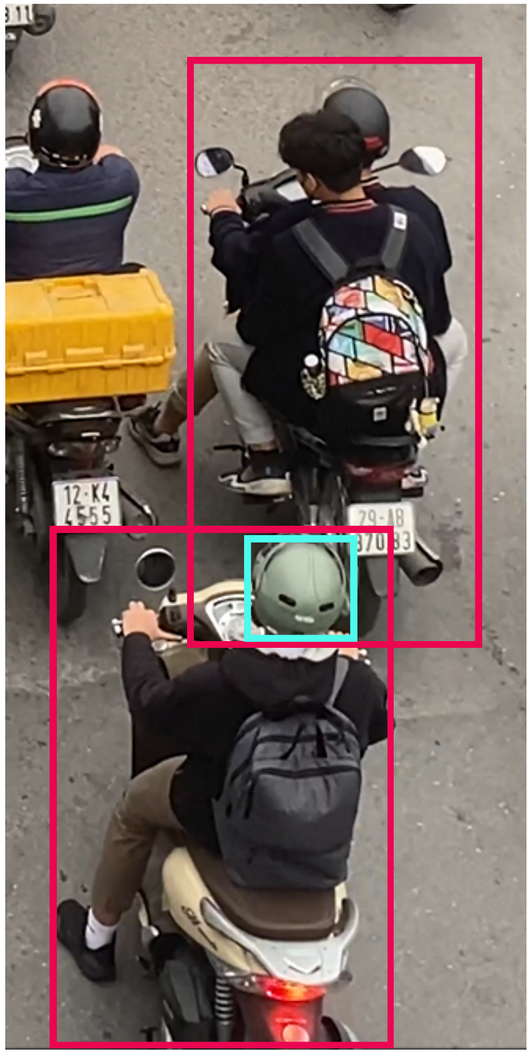


CIP needs to be greater than the threshold of 0.947 to be considered that the two bounding boxes have intersected.

2.4 Post-processing Technique

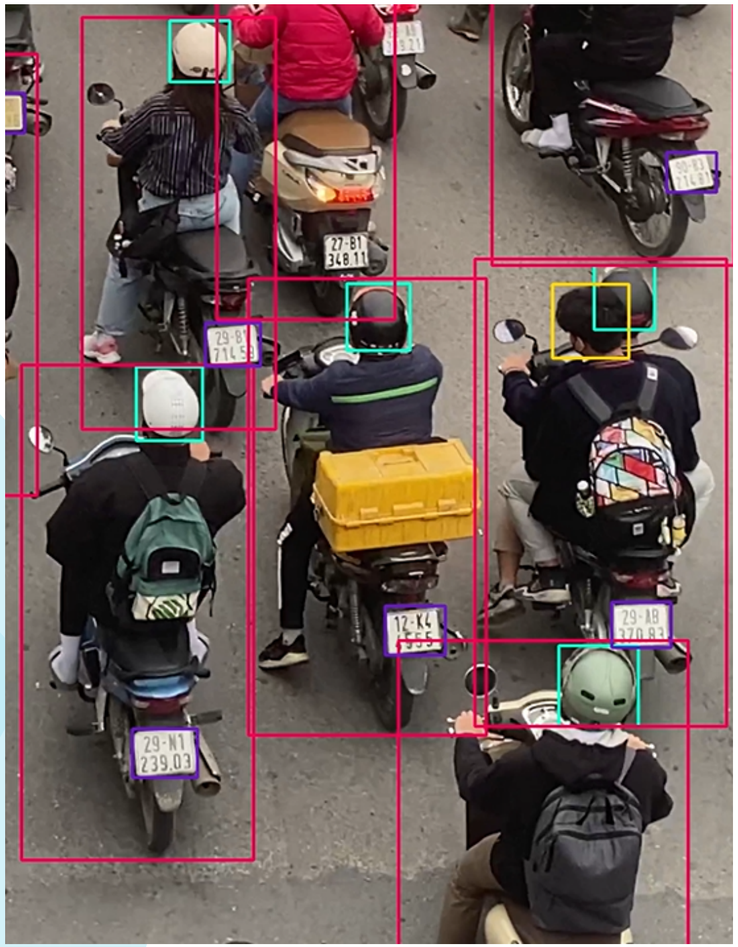
We can easily observe that:

- The bounding box of the person's head in the image is within the bounding boxes of the two motorcycles.
- The position of the head bounding box is not appropriate compared to the motorcycle located above.



2.4 Post-processing Technique

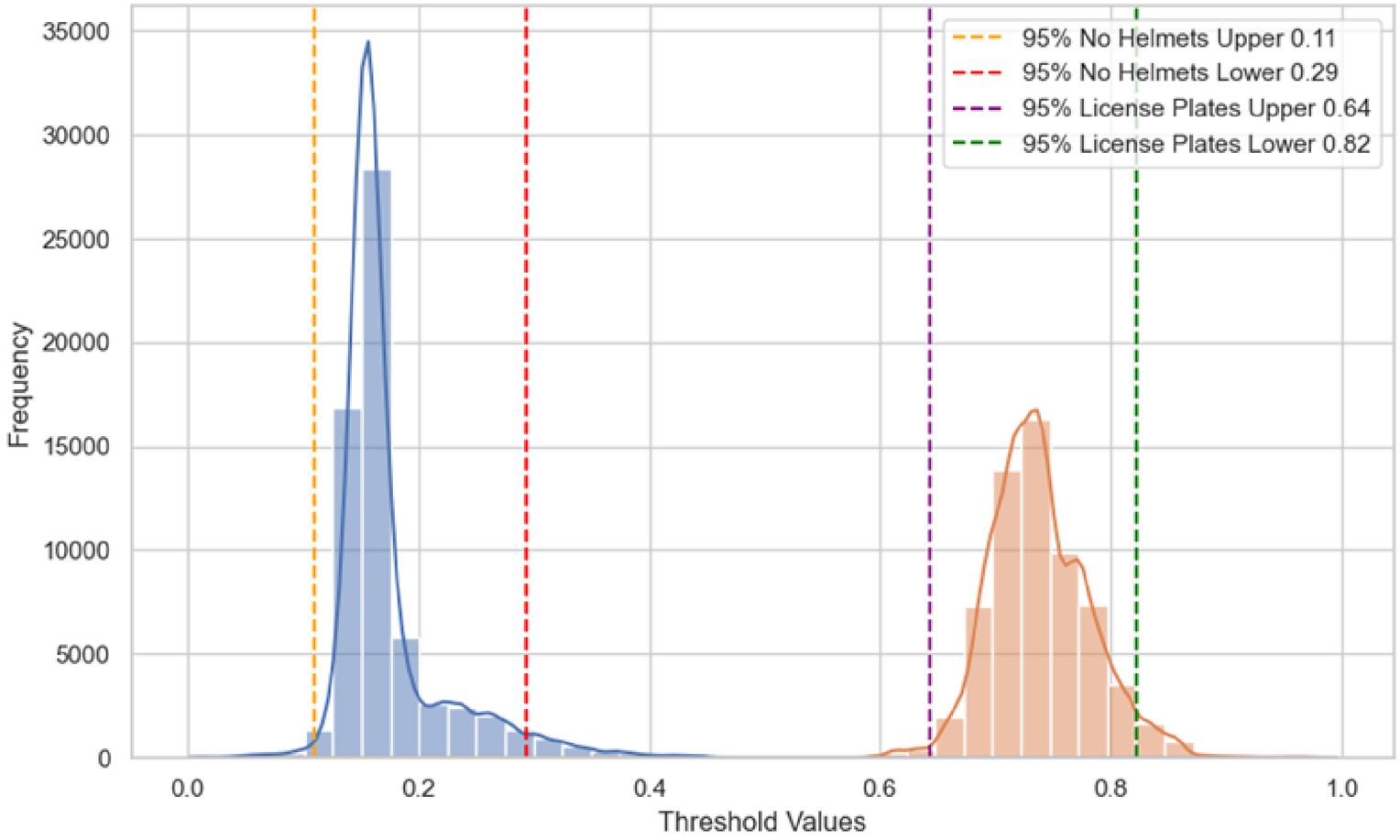
The next issue is that one head can correspond to two motorcycles. Similarly, one motorcycle can have two license plates.



$$HHB = \frac{\text{Height of no\_helmet}}{\text{Height of motorcyclist}}$$

2.4 Post-processing Technique

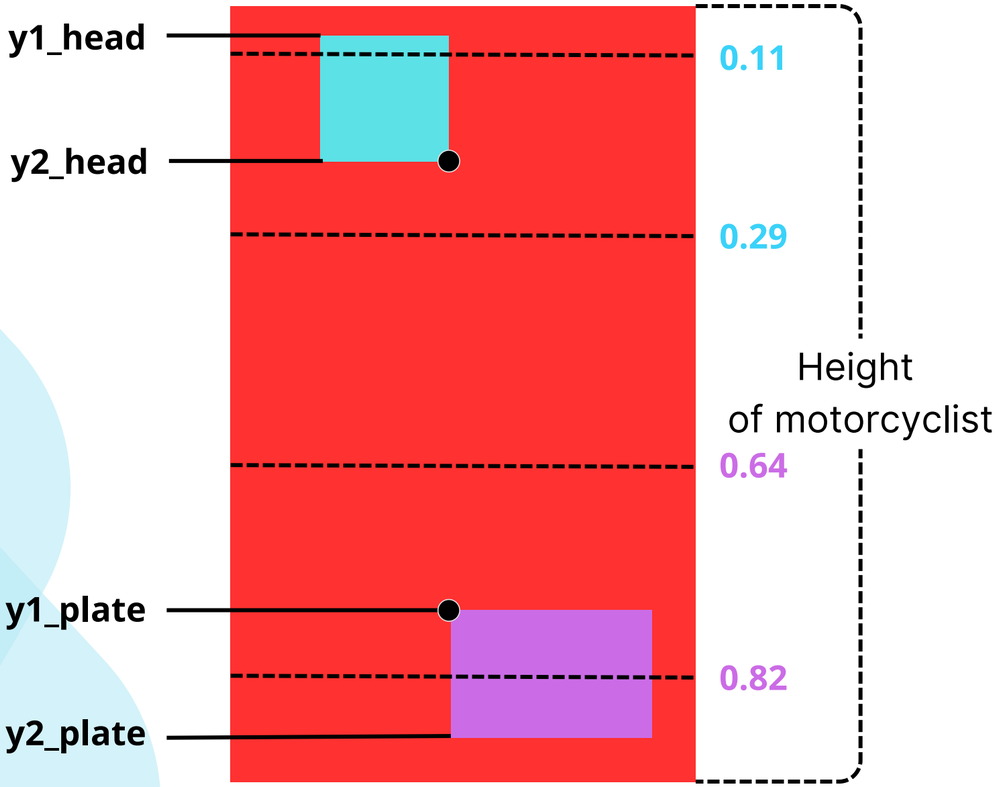
- 95% of the bounding box data for “No Helmets” falls within the range from 0.11 to 0.29.
- 95% of the bounding box data for “License Plates” falls within the range from 0.64 to 0.82.

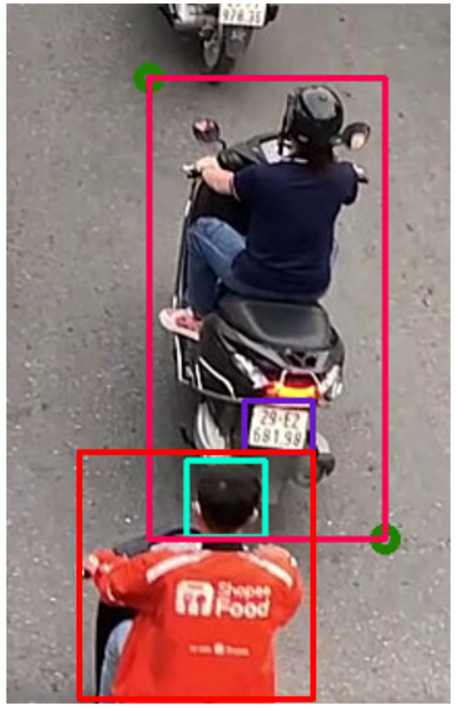


Histogram of threshold values for no_helmet and license plate

2.4 Post-processing Technique

- y2_head must satisfy the condition of being within the range from 0.11 to 0.29.
- y1_plate must satisfy the condition of being within the range from 0.64 to 0.82.





(a)

(b)

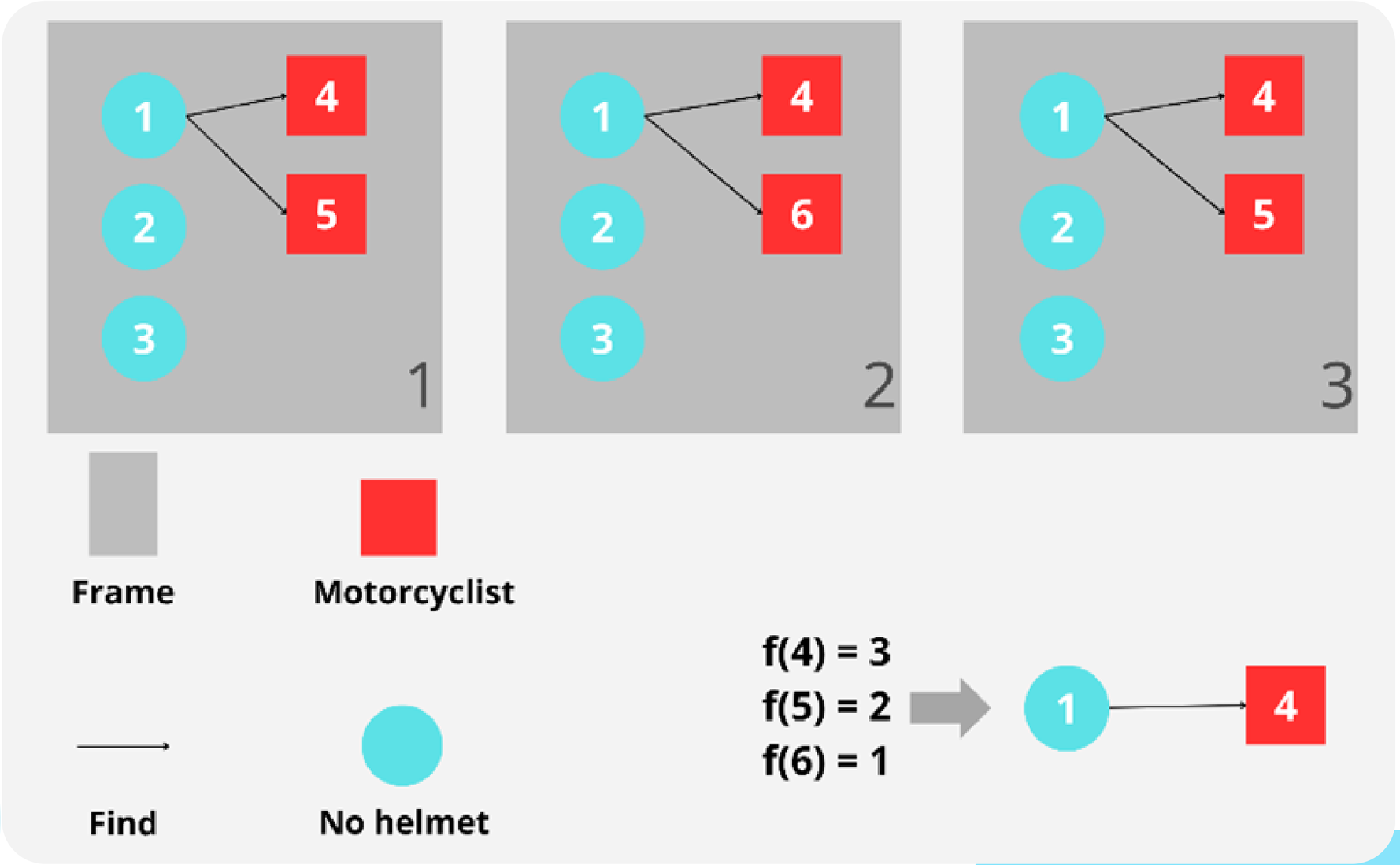
2.4 Post-processing Technique

The CIP and HHB methods may behave inaccurately in cases of diagonal angles and two individuals riding motorcycles in parallel.

We will examine a sequence of frames and objects appearing in the video.

2.4 Post-processing Technique

Identify motorcycles by determining the frequency of appearance.



2.4 Post-processing Technique

The result after post-processing on the sequence of frames where objects appear.

2.4 Post-processing Technique

Filter license plate information for each line by selecting the highest score.

Frame	License plate line top	License plate line bottom	Score line top	Score line bottom
1	35B2	**47480**	0.82	**0.87**
2	**35B2**	47430	**0.90**	0.73
3	35BZ	47480	0.67	0.81

Final output: 35B2-47480

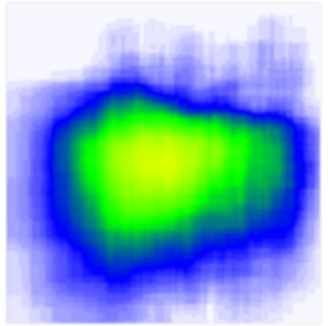
03.
Experiment and Result

3.1 Data collection
3.2 Implementation
3.3 Result and Analysis

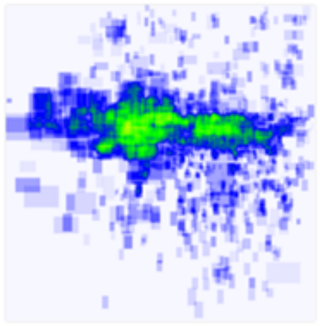
3.1 Data collection

- Source: phone camera, internet, traffic camera.
- Resolution: 2560x1440.
- Different traffic situations: crowded roads, sparse roads, camera angles from left to right and right to left.

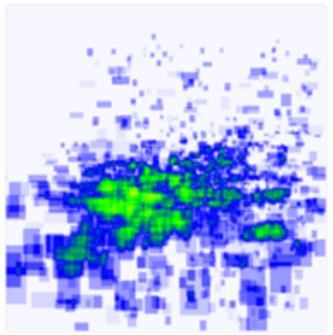
Heatmap annotations



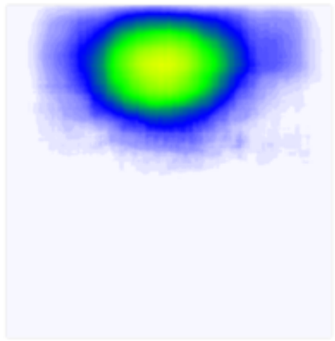
motorcyclist



helmet



license plate



no_helmet

	Image	Ratio
Train	5248	80%
Validation	984	15%
Test	330	5%
Total	**6562**	**100%**

3.1 Data collection

- Brightness: between -10% and +10%.
- Blur: up to 0.25px .
- Rotation: between -5° and +5°.
- Resize to 800x800.

3.2 Implementation

GPU

Tesla P100-PCIE_16GB

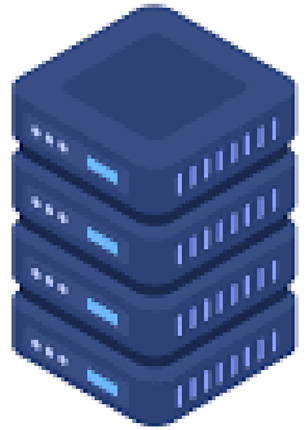
CPU

Intel Xeon E-2300

Language

Python 3.10

kaggle



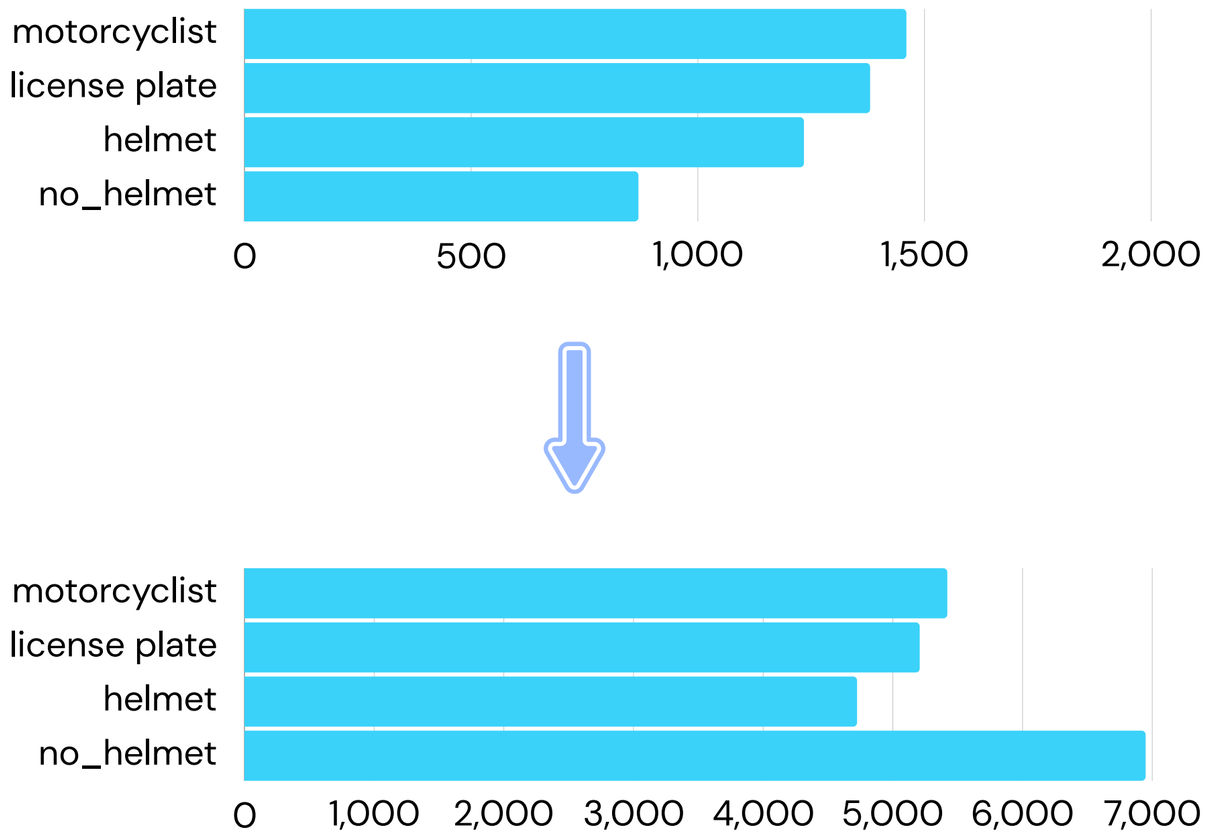
Hyperparameters

- Epoch: 120
- Batch_size: 16
- Input shape : 800x800
- Learning rate: 0.01

1.3 Result

Helmet and License plate Detection

- The original data set included photos taken from the phone camera for not very positive results, mAP is 78%.
- Reasons: data imbalance
- Solution: add more picture contain no_helmet class

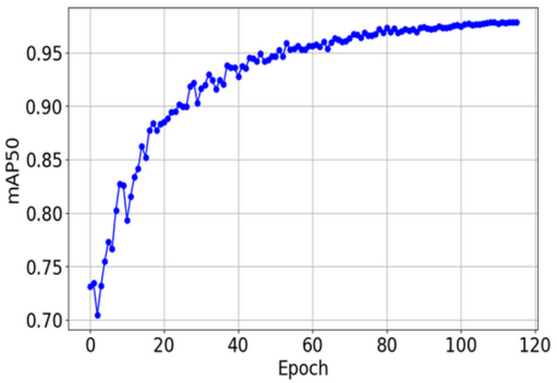


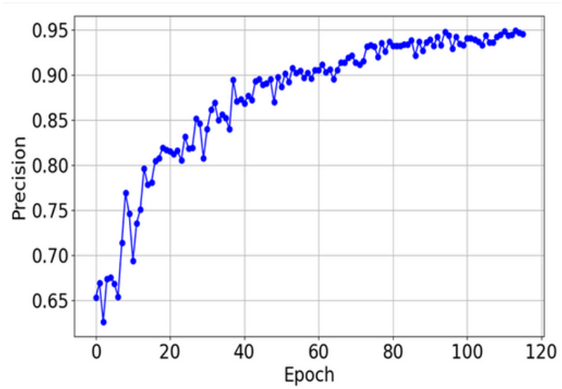
1.3 Result

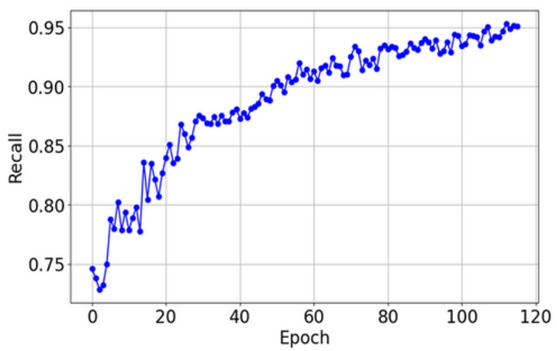
Helmet and License plate Detection

Overall, Precision is 94.9%, Recall is 95.3% and mAP is 97.9%

=> The model has the ability to accurately and comprehensively predict different classes







Class	Precision	Recall	mAP50
helmet	0.942	0.93	0.969
no_helmet	0.946	0.932	0.973
motorcyclist	0.959	0.993	0.991
license plate	0.936	0.949	0.978

1.3 Result

Helmet and License plate Detection

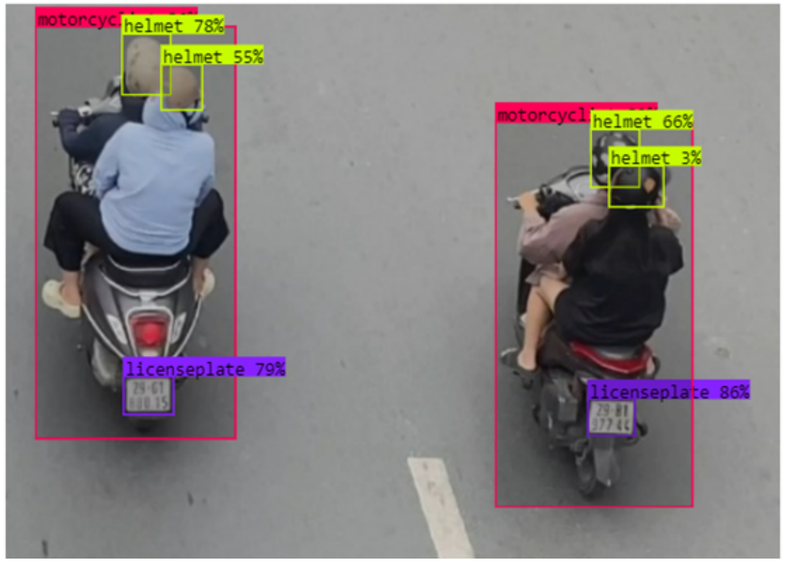
Advantage:

- Identify flat cap
- Multi object detection

Recognition ability
(total 300 objects):

- Old method: 246 objects (82%)
- Our method: 295 objects (98.3%)

=> increase 16.3%

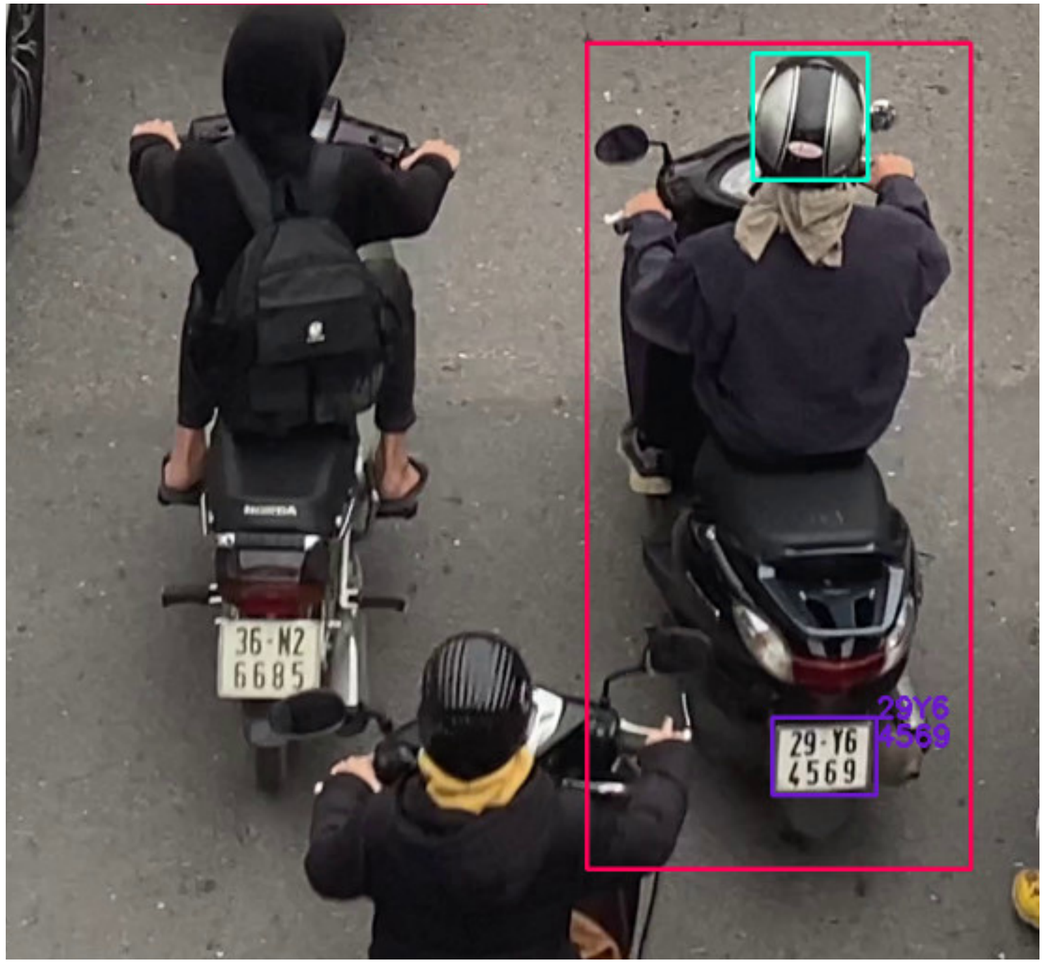


1.3 Result

Helmet and License plate Detection

Disadvantage:

- Poor recognition in some cases of strange helmet colors
- Unable to identify motorcyclists wearing hoods



1.3 Result

License Plate Recognition

Tested on 2383 images, PaddleOCR, found an accuracy of 69.8%. After apply post-procesing => 90.4%.

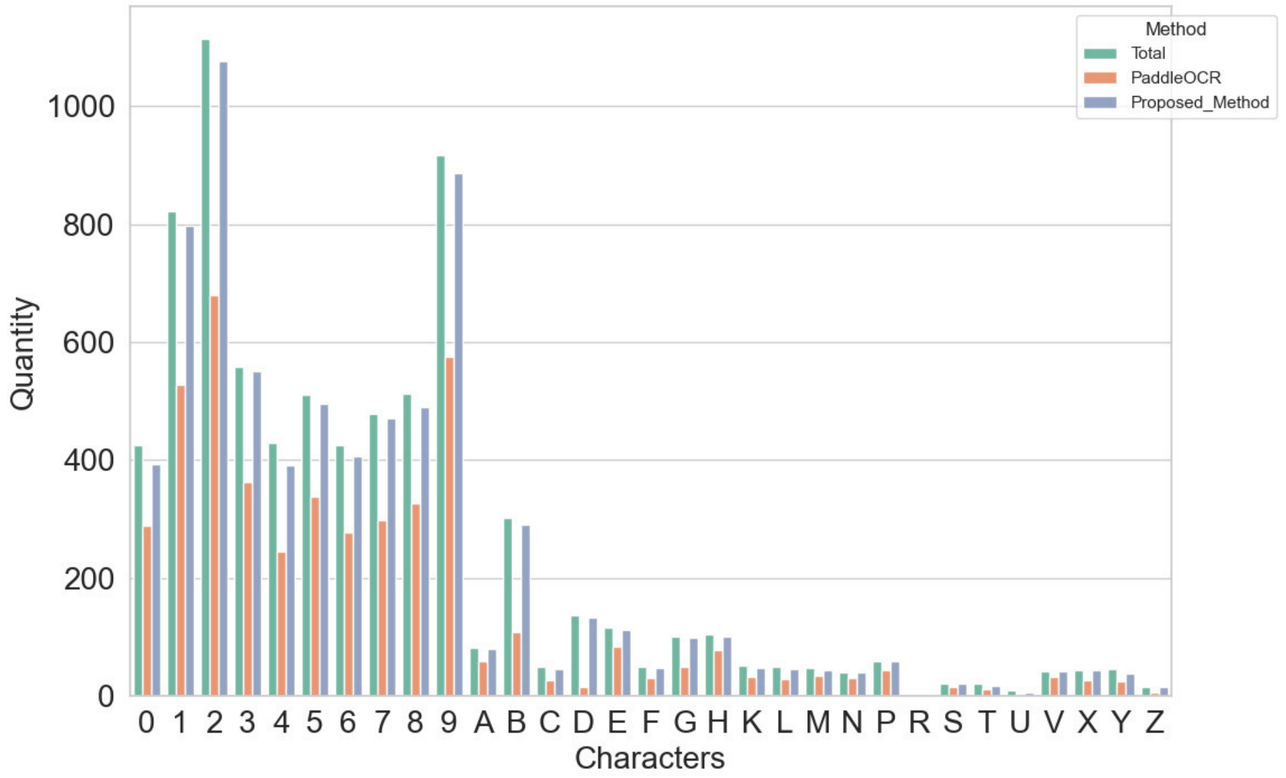
Disadvantage:

- Poor recognition in some cases such as flashing, being obscured, or license plates with peeling paint.

2962
00669

29G2
00669

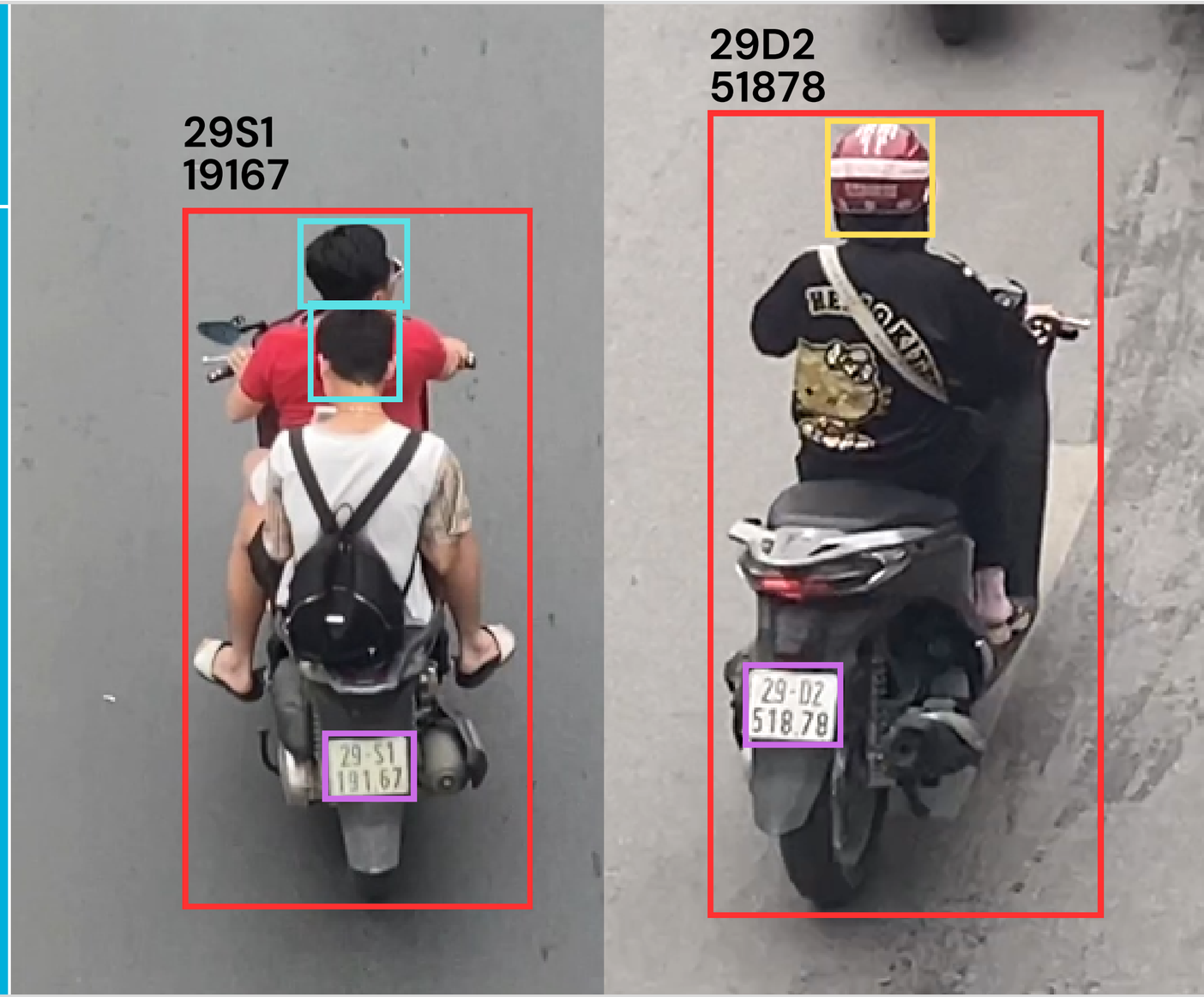
39B1
69098



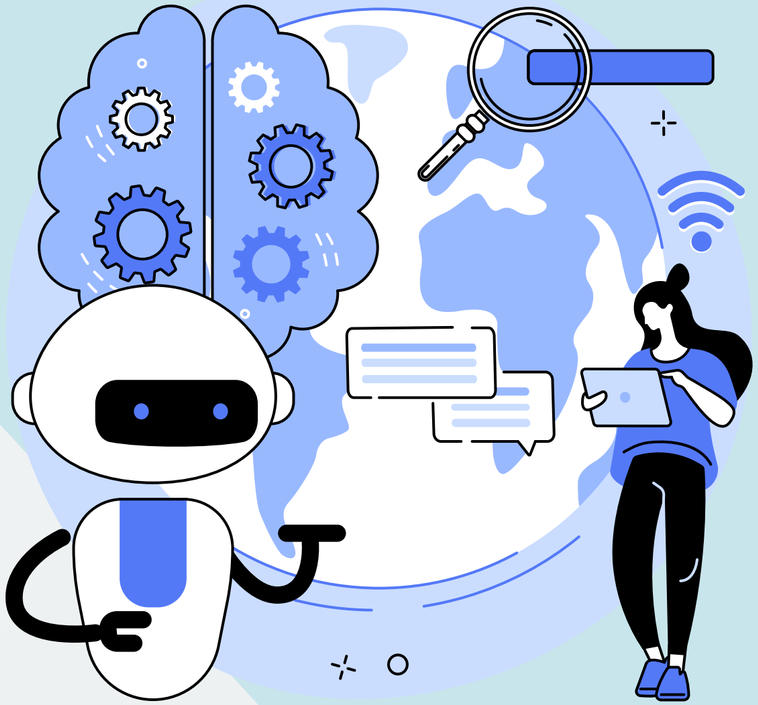
1.3 Result

Overall results

Our model successfully identifying 208 out of the 220 motorcyclist.
=> Accuracy: 94.55%



04.
Web Application Deployment

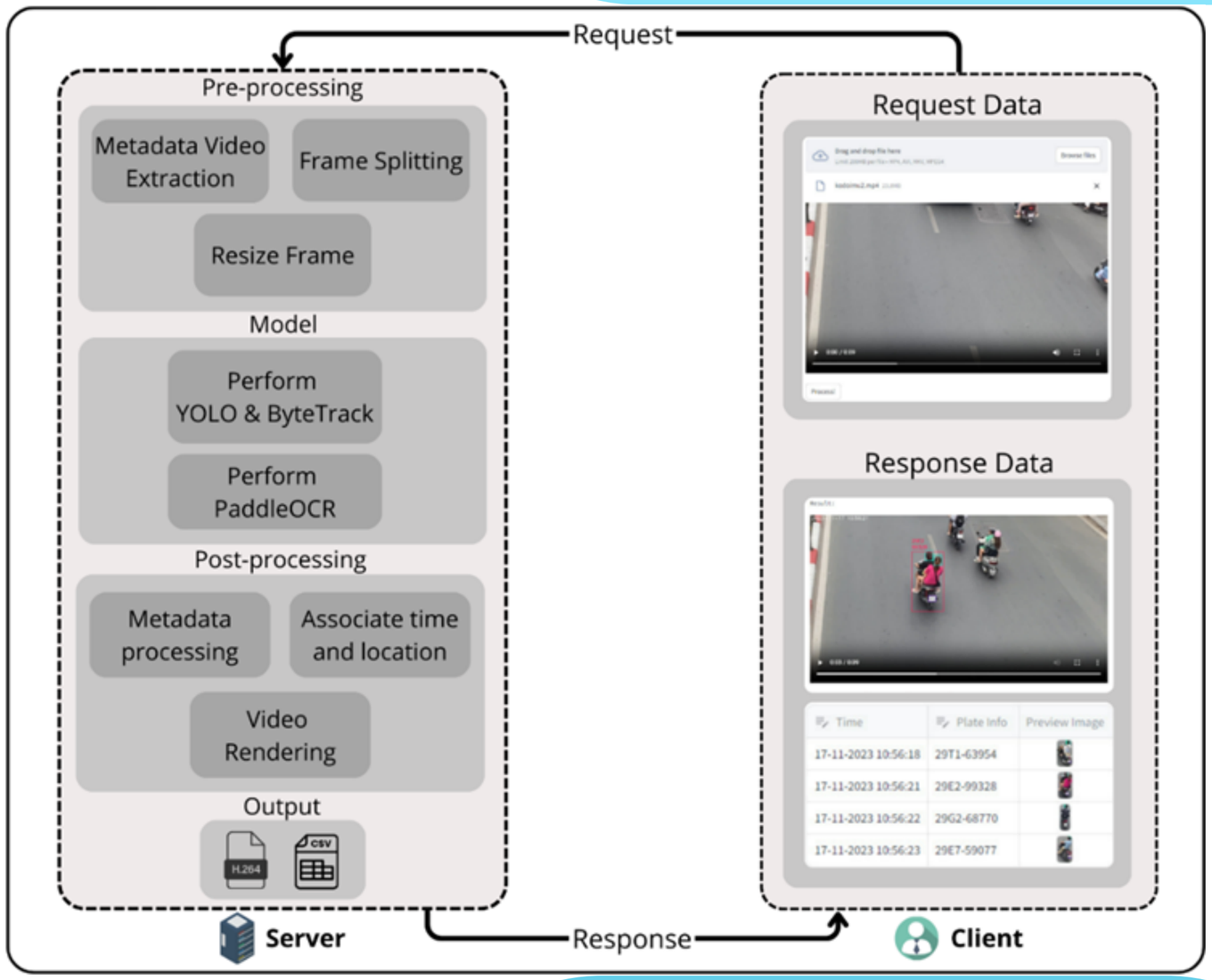


4.1 System Architecture
4.2 HDALPR System

4.1 System Architecture

It comprises key components:

- Frontend
- Backend
- Model Inference Engine



4.2 HDALPR System

Menu

- Home
- Upload
- Tasks
- Settings
- About

HELMET DETECTION AND AUTOMATIC LICENSE PLATE RECOGNITION SYSTEM

Chào mừng đến với trang chủ của chúng tôi!

Chúng tôi rất vui mừng chào đón bạn tới "Helmet Detection and Automatic License Plate Recognition System" - một dự án đầy thách thức và đầy sáng tạo. Tại đây, chúng tôi tận hưởng việc phát triển và nâng cấp hệ thống nhận diện mũ bảo hiểm và tự động nhận diện biển số xe, nhằm đảm bảo an toàn và hiệu quả trong việc quản lý giao thông và bảo vệ người tham gia.

Dự án của chúng tôi không chỉ là sự kết hợp giữa công nghệ và sáng tạo, mà còn là một cam kết vững chắc về an ninh và tiện ích. Chúng tôi hy vọng rằng hệ thống của chúng tôi sẽ đóng góp vào việc tạo ra môi trường giao thông an toàn và hiệu quả cho cộng đồng.

Hãy cùng chúng tôi trải nghiệm sức mạnh của công nghệ và đóng góp vào sứ mệnh làm thay đổi thế giới của chúng tôi. Cảm ơn bạn đã thăm trang của chúng tôi và hãy khám phá thêm về những cải tiến và tính năng mới nhất của dự án!

Conclusion

Our proposed method has overall accuracy about 94.55%.

Outstanding advantages of the method:

- Track and distinguish the head area and license plate of each vehicle
- Significantly improved accuracy compared to old methods
- Propose a meticulous post-processing technique

Future work:

- Distinguishing poor quality helmets
- Increase recognition ability in different weather types