



PPE DETECTION

Project Report for CIDL 2022/2023

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Introduction

PPE Detection has a crucial role in ensuring the safety of workers, significantly reducing the risk of occupational accidents and illnesses.



This project explores the application of CNNs in the detection of PPE, comparing a custom-built CNN to a pre-trained CNN.

Dataset

Dataset was downloaded from Roboflow and consists of 1000 images depicting the various protection devices and a csv file containing annotations for each image.

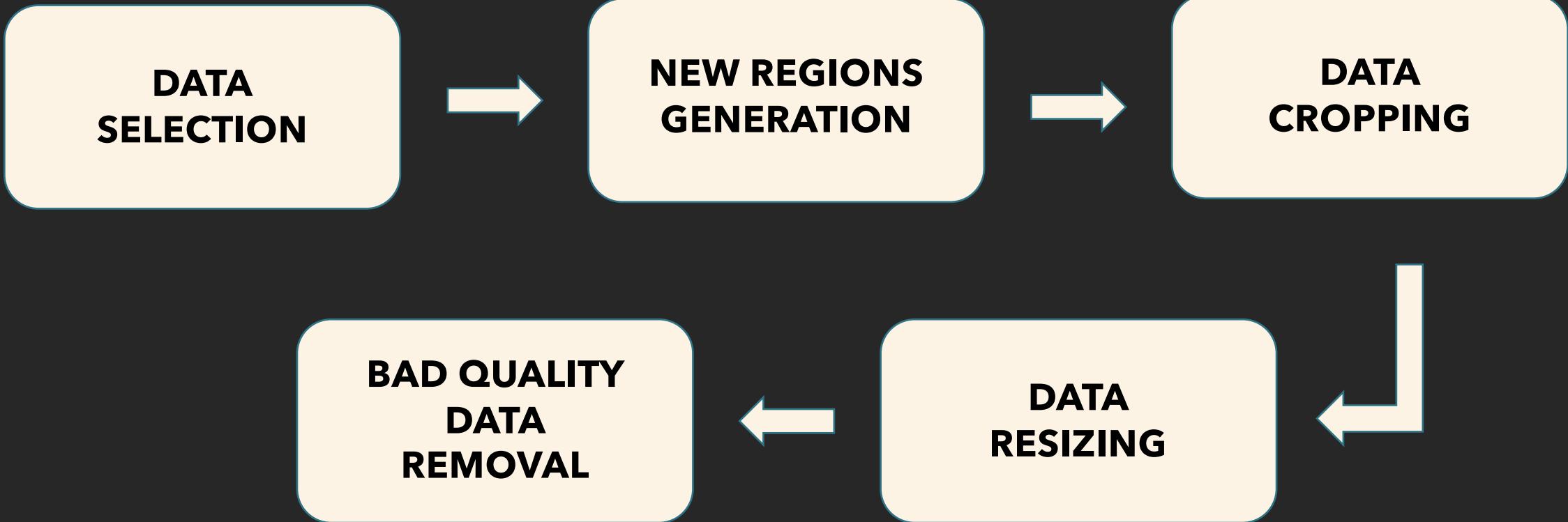


Images are already divided into training, test and validation set and in the table are shown the volumes of each class in the three sets as each image can contain more than one object

	Worker	Visibility vest	Helmet	Total
Training Set	1950	890	1791	4631
Validation Set	298	153	264	715
Test Set	641	333	577	1551
Total	2889	1376	2632	6897



Pre-Processing

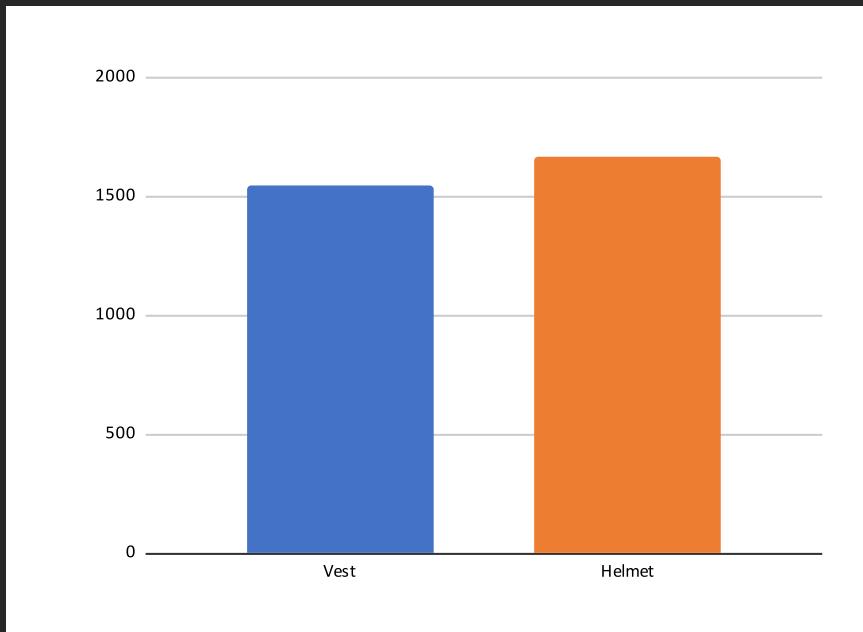
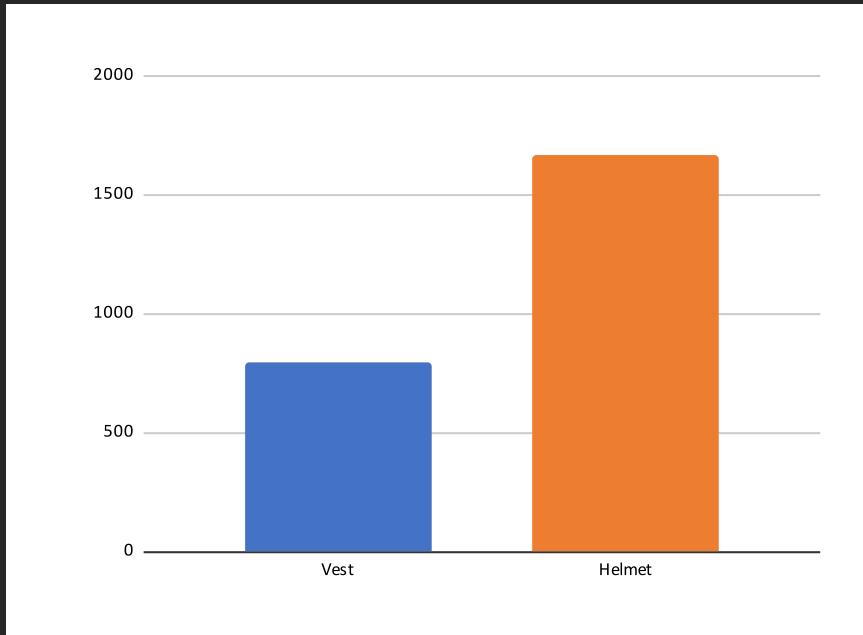






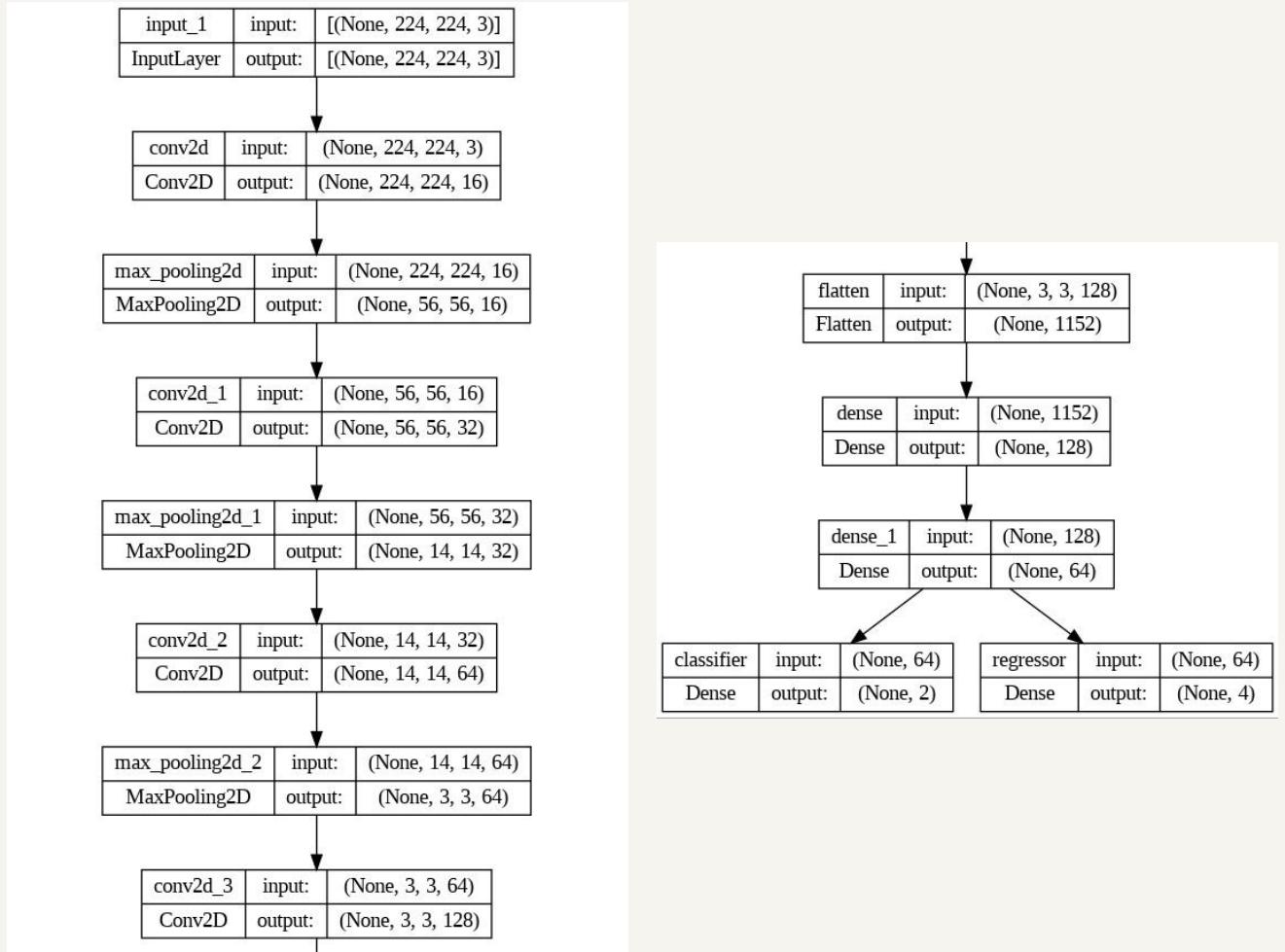
*Bad quality data
removal*

Data Augmentation



CNN from scratch

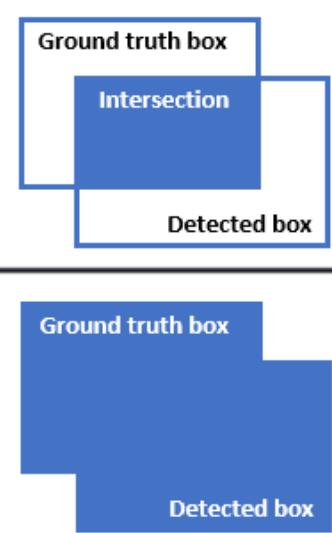
Standard CNN



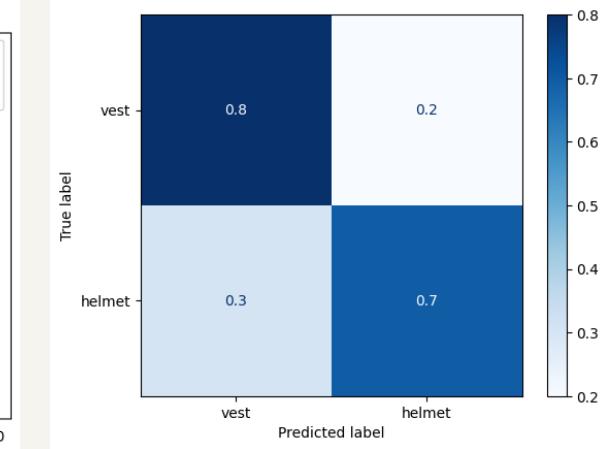
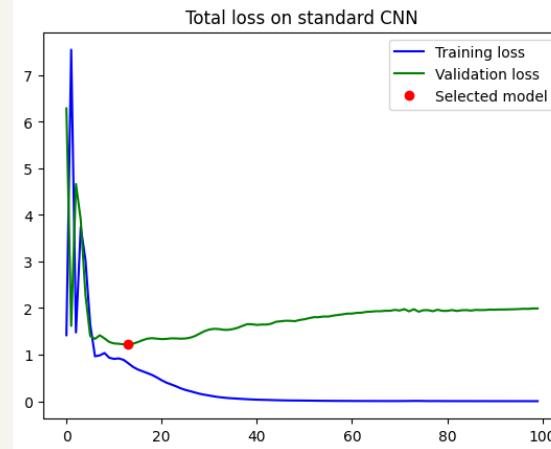
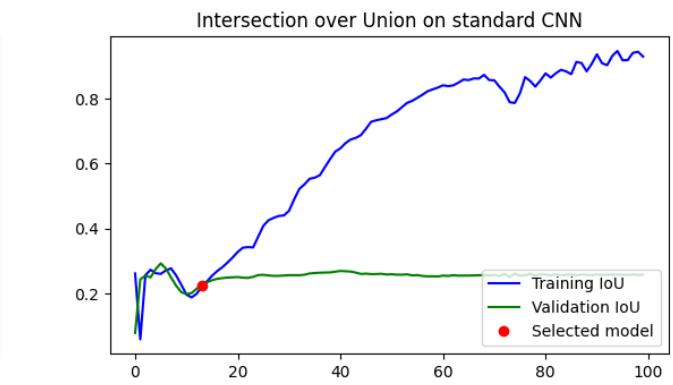
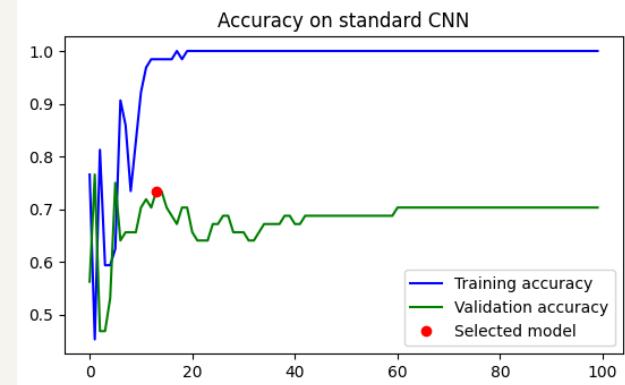
```
=====
Total params: 253670 (990.90 KB)
Trainable params: 253670 (990.90 KB)
Non-trainable params: 0 (0.00 Byte)
```

Standard CNN

$$\text{Accuracy} = \frac{\text{Red} + \text{Dark Blue}}{\text{Red} + \text{Light Red} + \text{Dark Blue} + \text{Light Blue}}$$

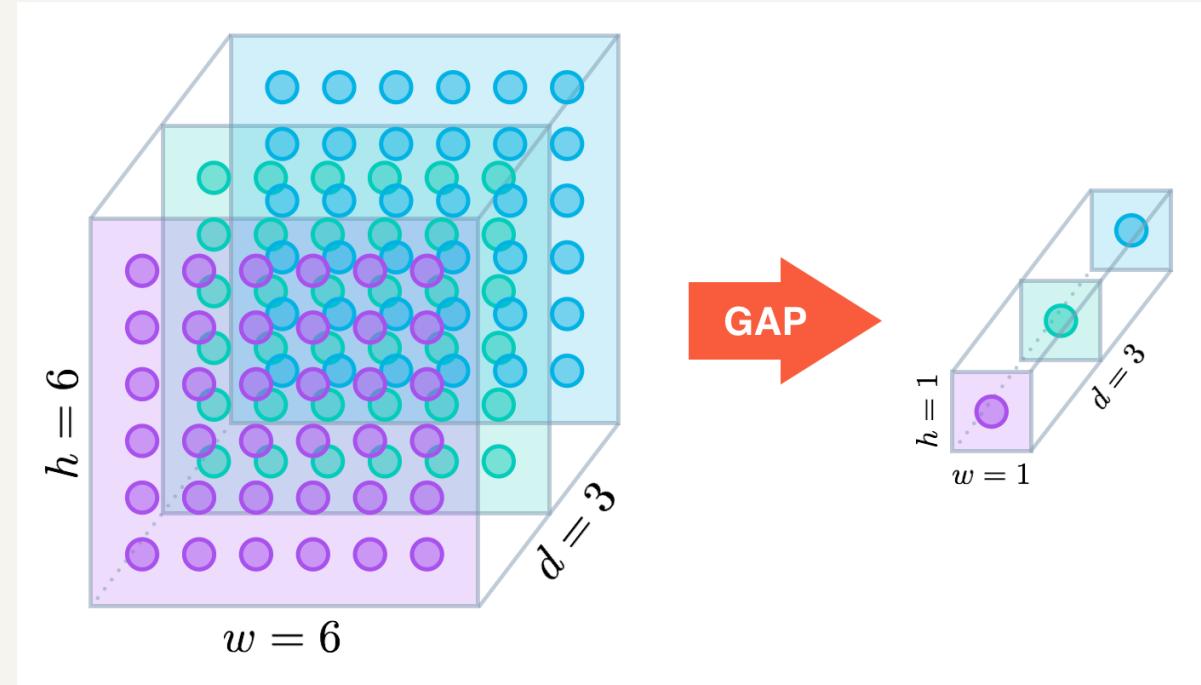
$$\text{IoU} = \frac{\text{Area of Overlap}}{\text{Area of Union}} = \frac{\text{Intersection}}{\text{Ground truth box} + \text{Detected box}}$$


Standard CNN

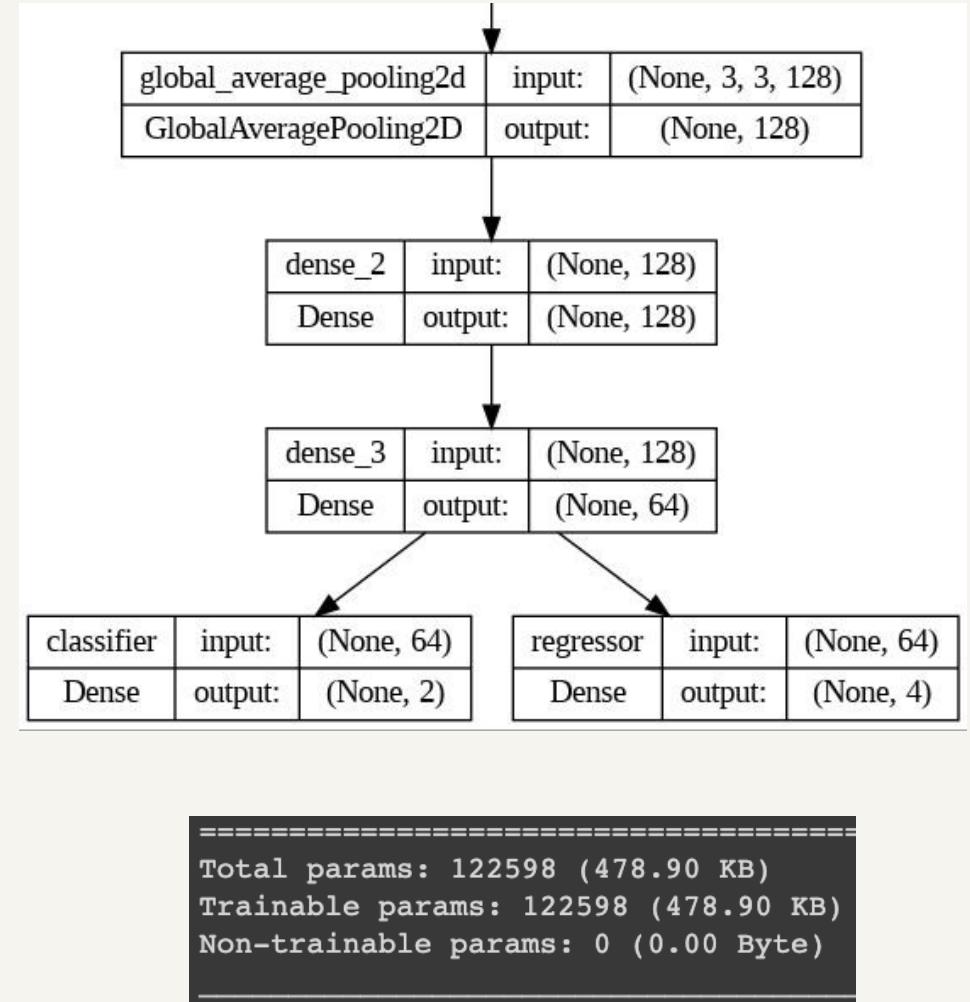


	Train	Validation	Test
Accuracy	98,4 %	73,4 %	70,3 %
IoU	22 %	22 %	19 %

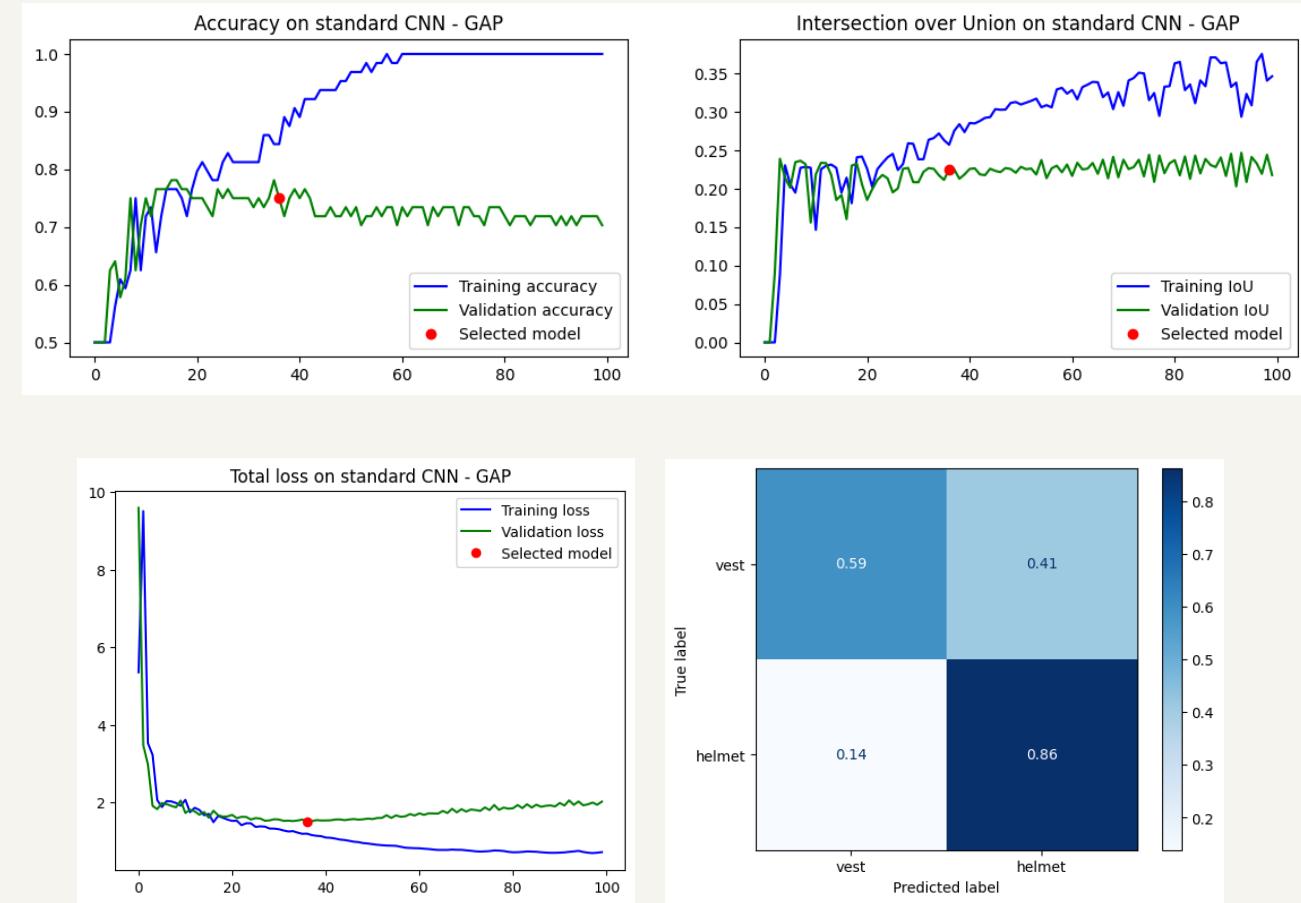
Standard $CNN - GAP$



Standard *CNN - GAP*

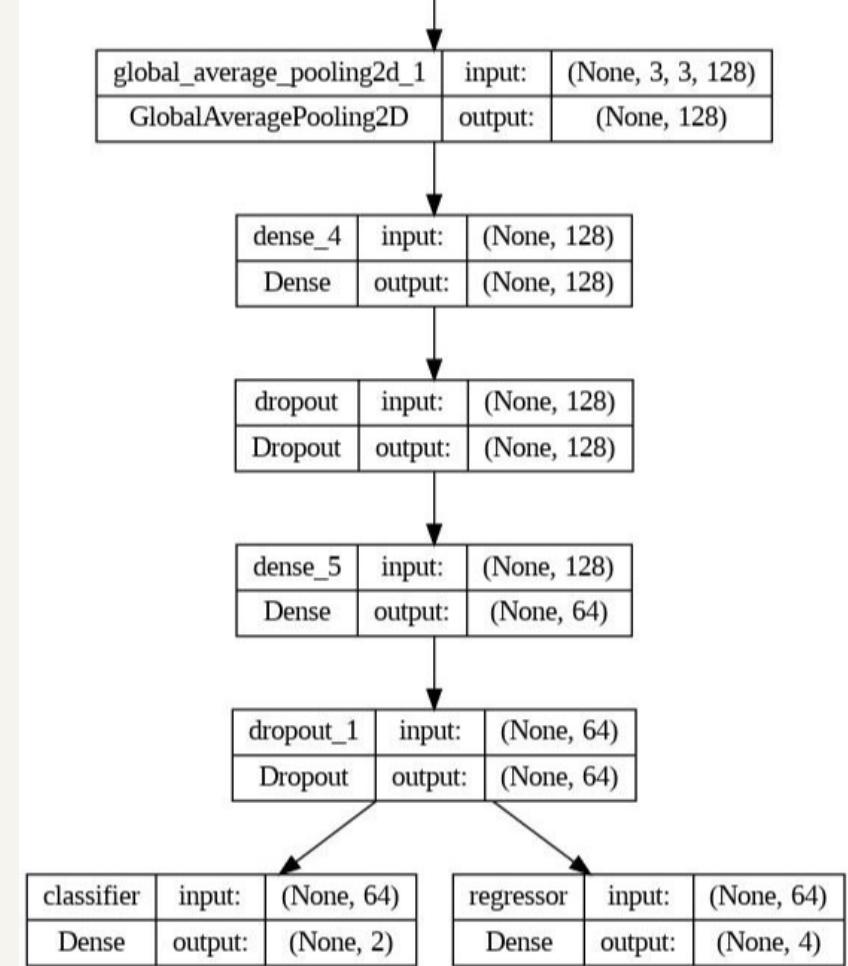


Standard CNN - GAP



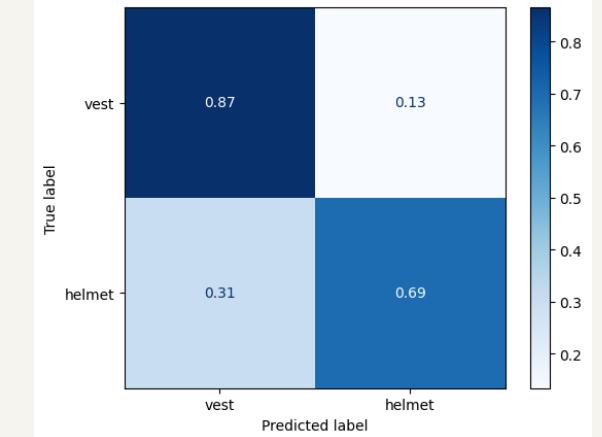
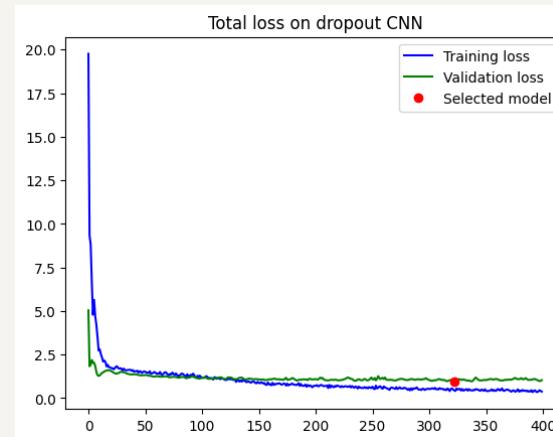
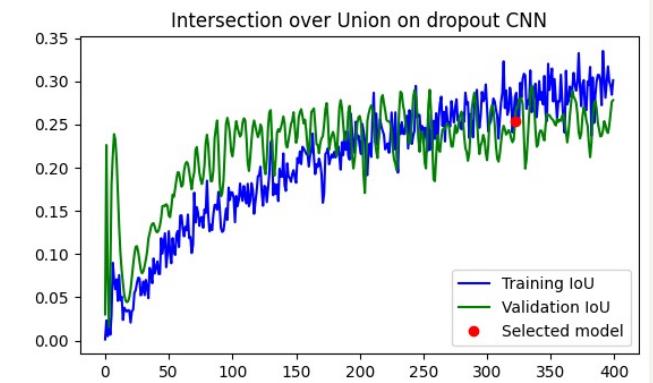
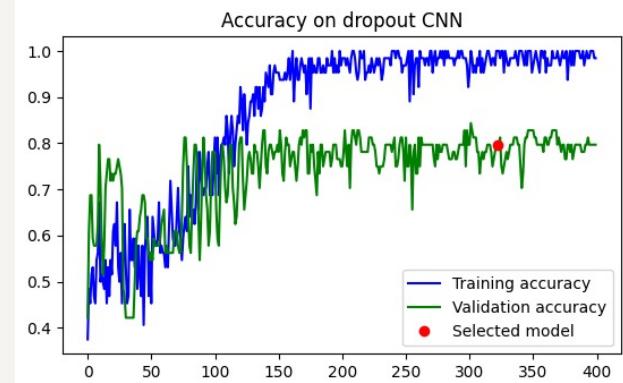
	Train	Validation	Test
Accuracy	88,4 %	75 %	74 %
IoU	25,7 %	22,5 %	20,9 %

Dropout CNN



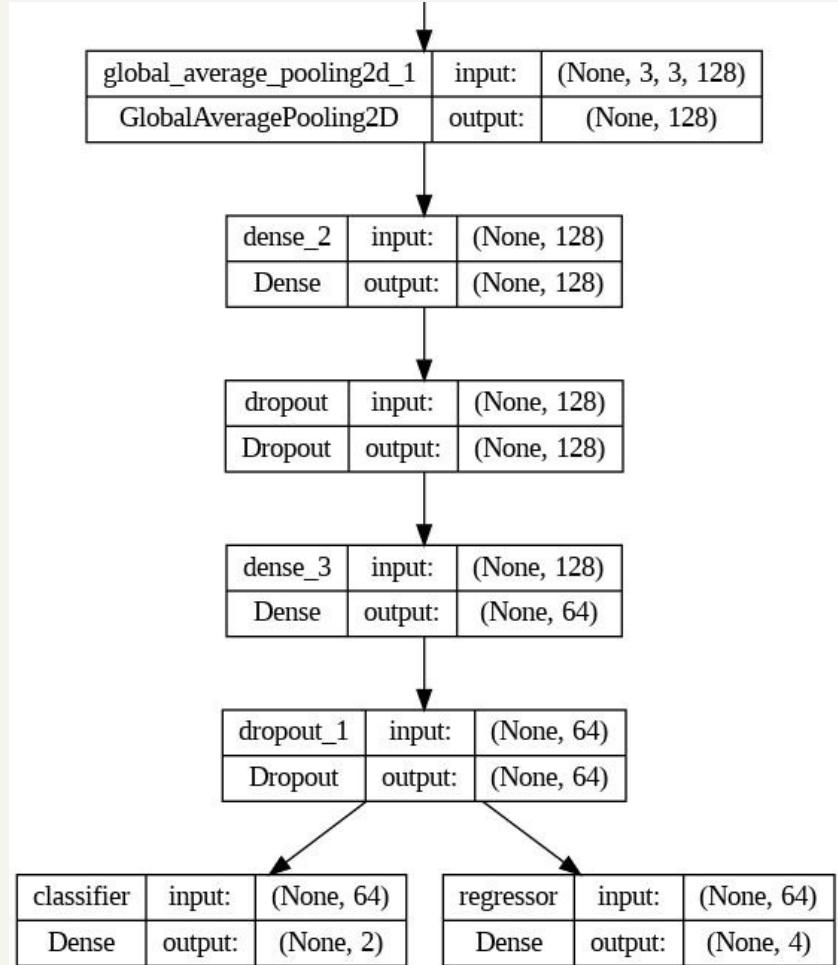
```
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Total params: 122598 (478.90 KB)
Trainable params: 122598 (478.90 KB)
Non-trainable params: 0 (0.00 Byte)
```

Dropout CNN



	Train	Validation	Test
Accuracy	100 %	79,7 %	78,6 %
IoU	28,2 %	25,4 %	22,3 %

Tuning CNN



```
=====
Total params: 122598 (478.90 KB)
Trainable params: 122598 (478.90 KB)
Non-trainable params: 0 (0.00 Byte)
```

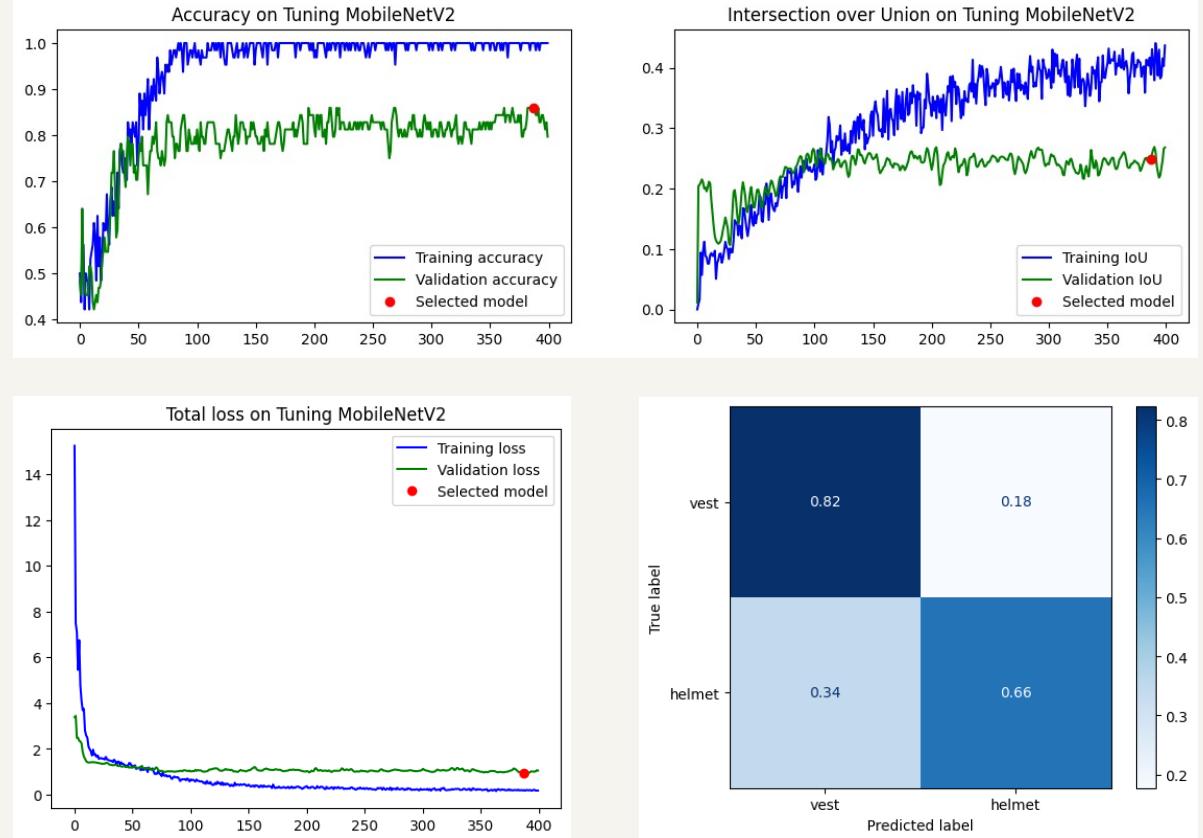
Tuning CNN

	Values	Step
<i>Learning Rate</i>	1e-2, 1e-3, 1e-4, 1e-5	-
<i>Dropout Rate</i>	0.3 – 0.8	0.1
<i>Loss Classifier Weight</i>	1.0 – 10.0	1
<i>Loss Regressor Weight</i>	10.0 – 20.0	1

TUNING
→

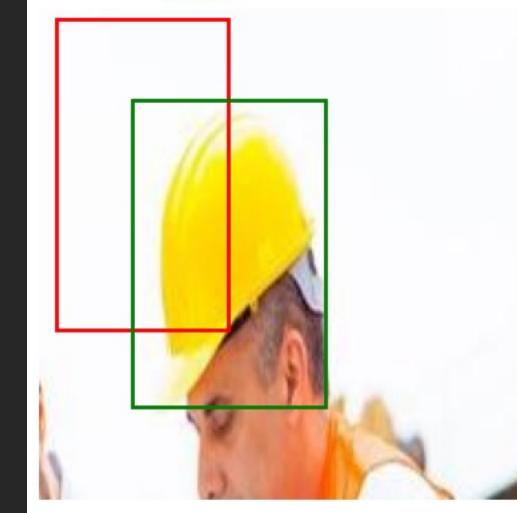
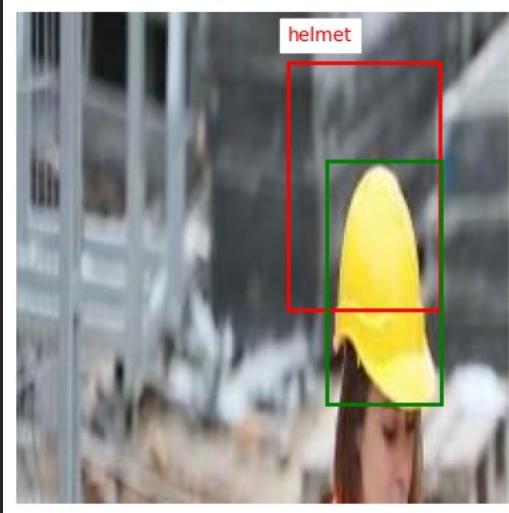
<i>Best value</i>
1e-4
0.4
1.0
10.0

Tuning CNN

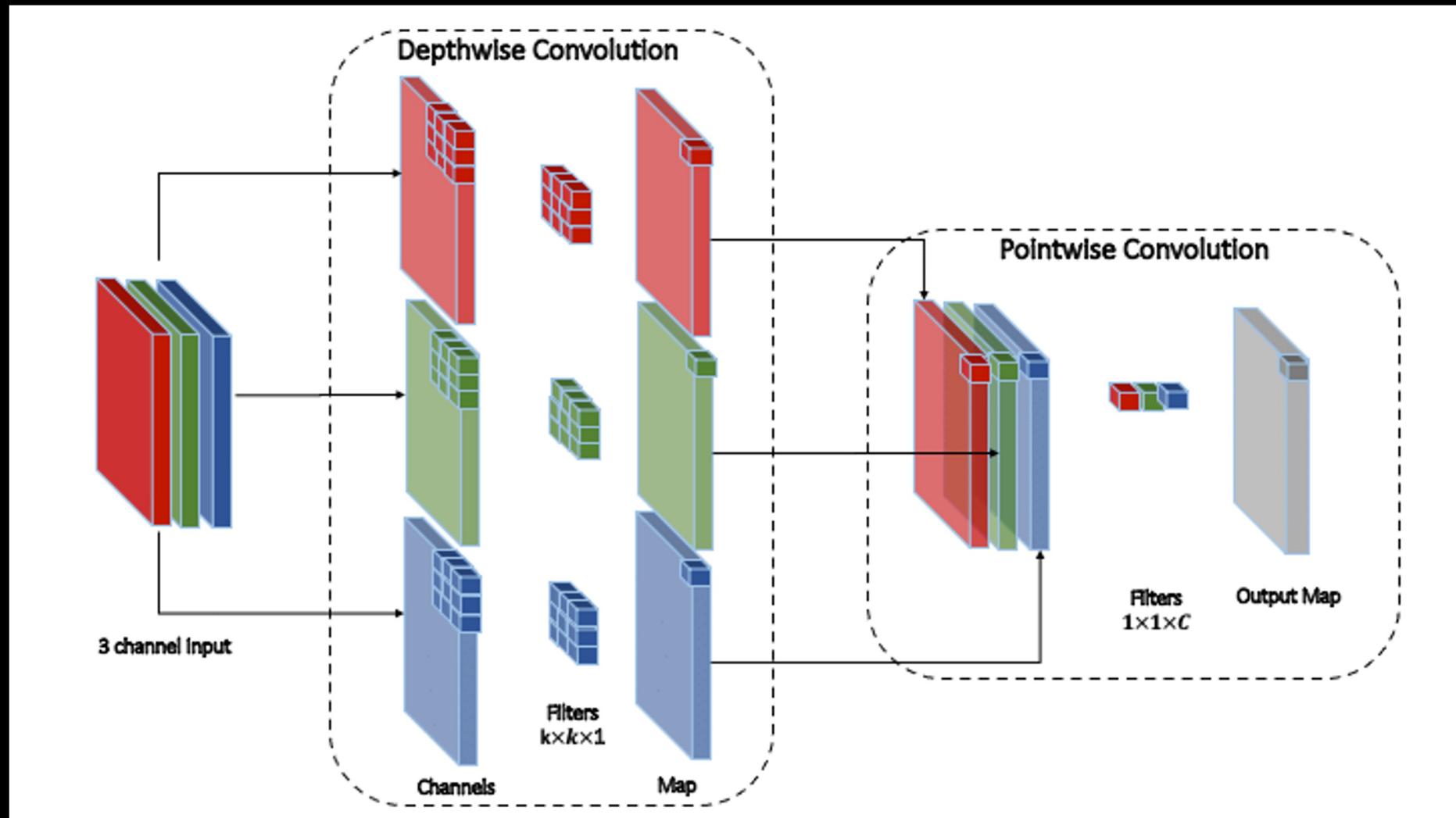


	Train	Validation	Test
Accuracy	100 %	85,9 %	78,1 %
IoU	38,9 %	24,9 %	25,9 %

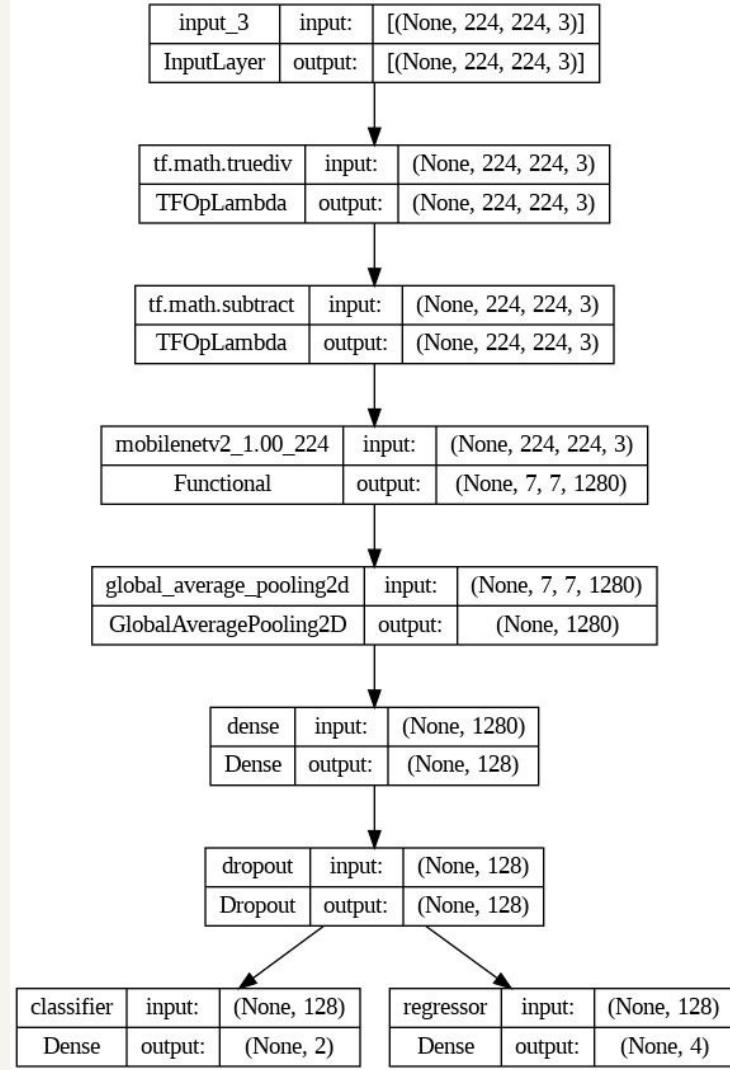
Tuning CNN Results



MobileNetV2

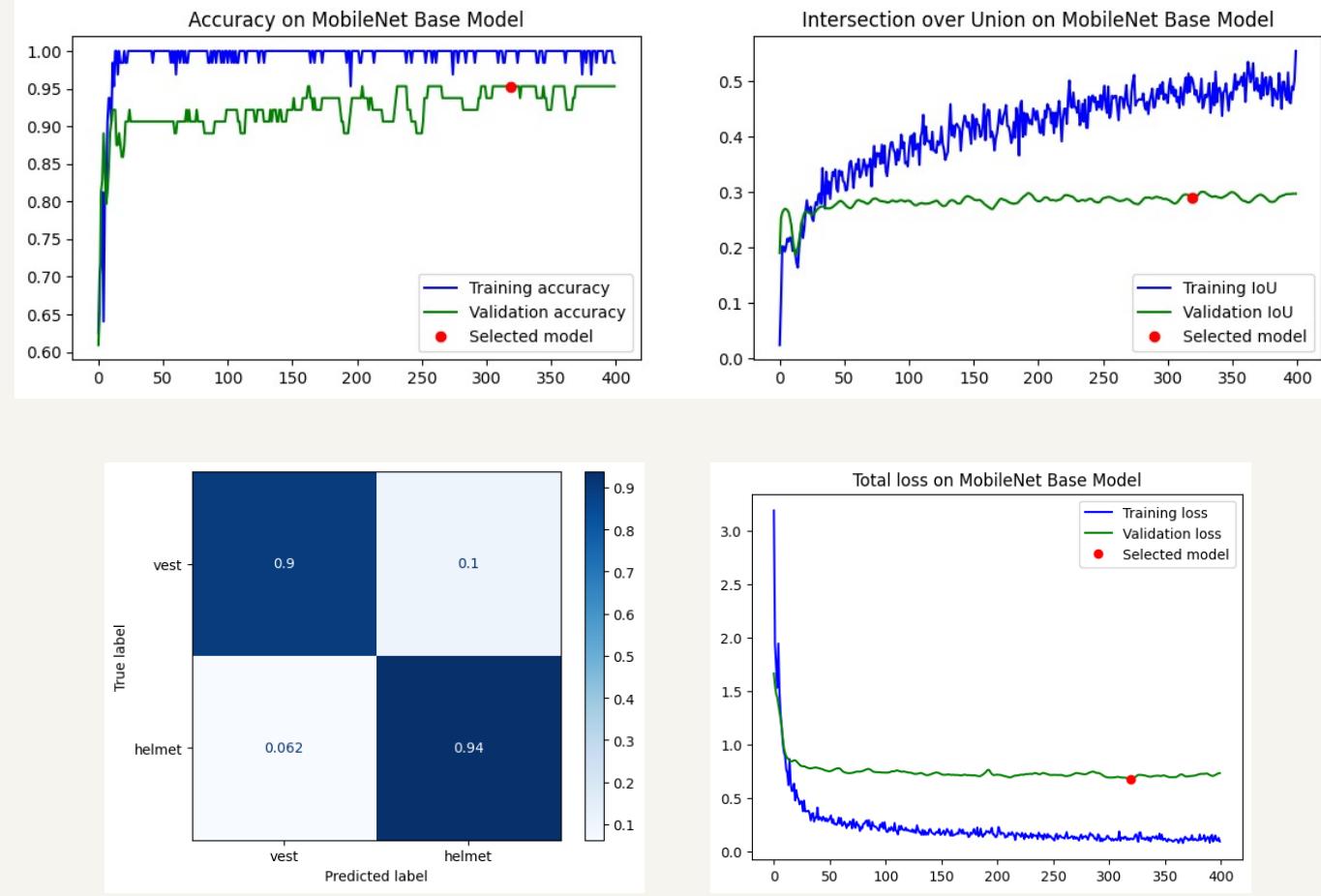


MobileNet First Experiment



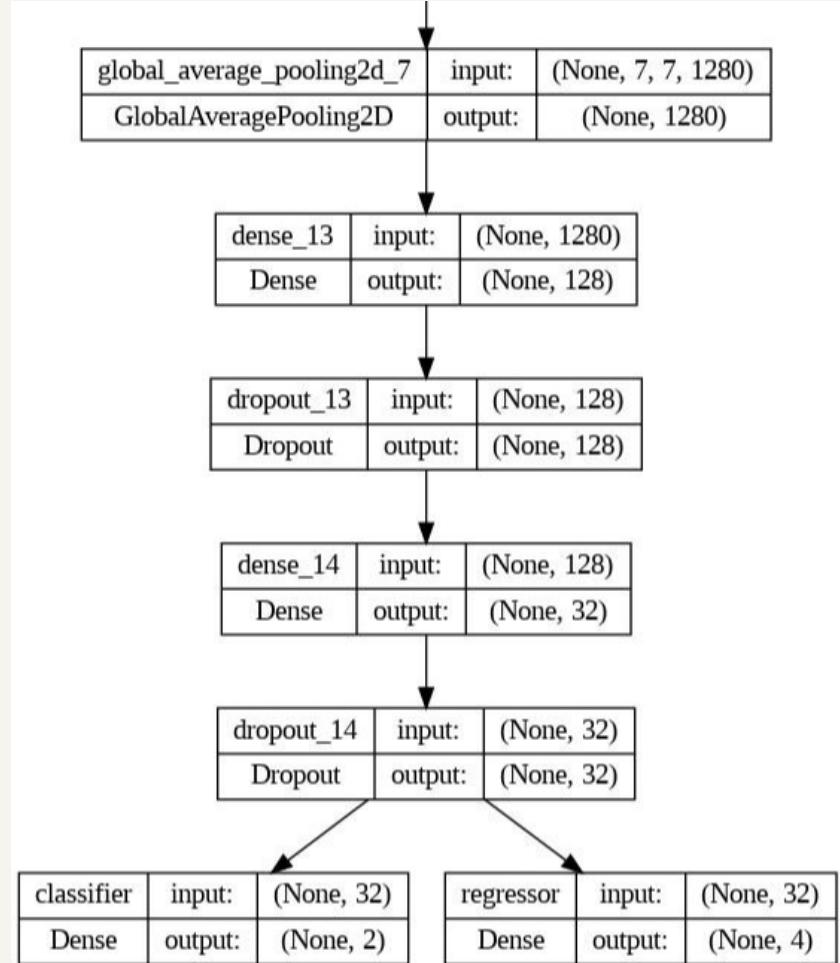
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Total params: 2422726 (9.24 MB)
Trainable params: 164742 (643.52 KB)
Non-trainable params: 2257984 (8.61 MB)
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MobileNet First Experiment



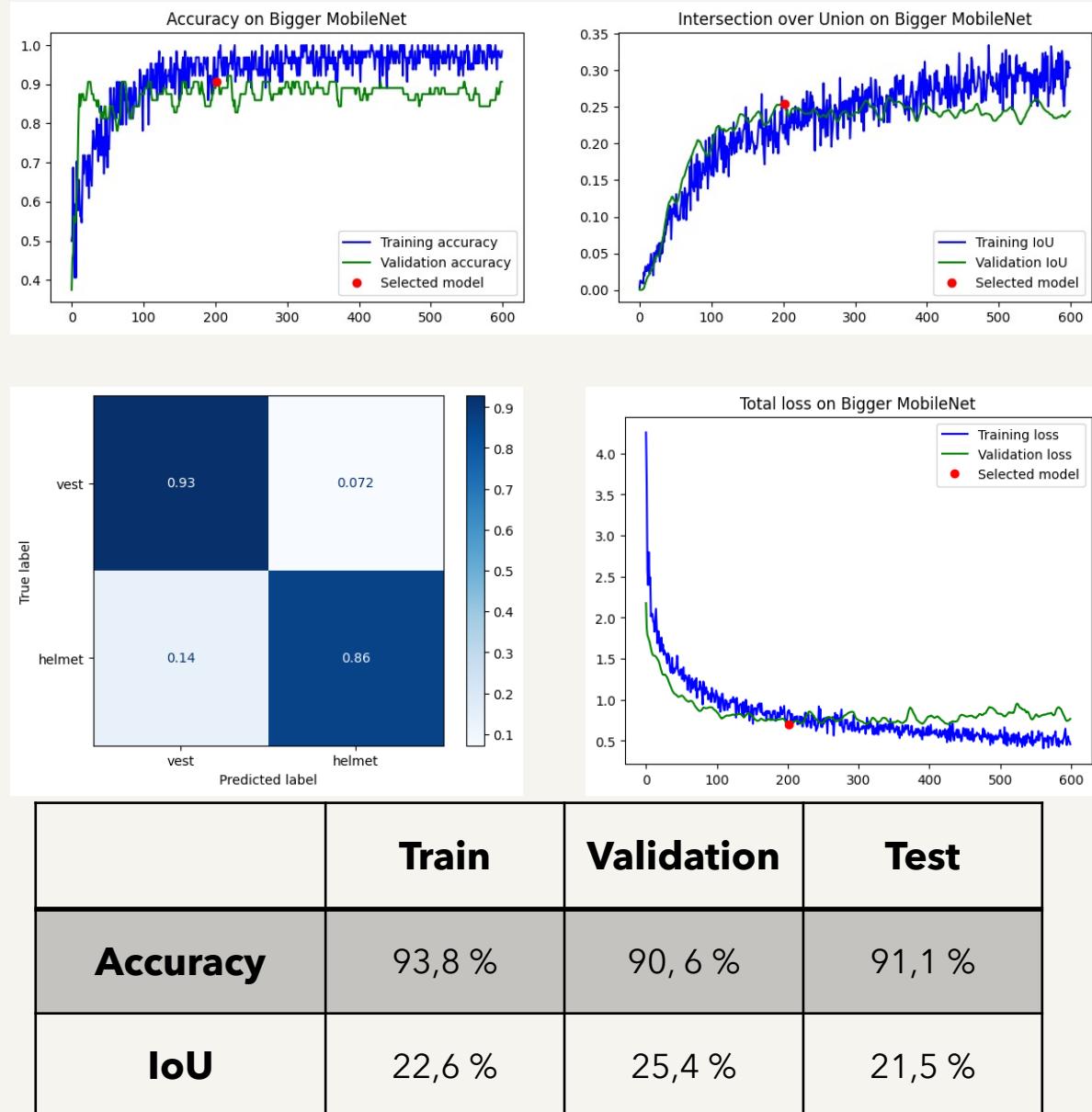
	Train	Validation	Test
Accuracy	100 %	95,3 %	93,2 %
IoU	50 %	29 %	24,5 %

MobileNet Second Experiment

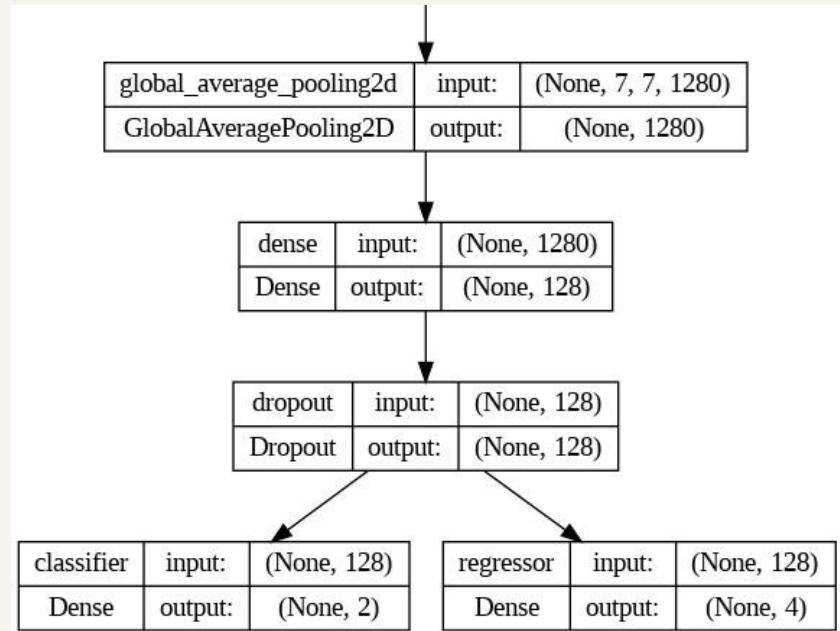


```
=====
Total params: 2426278 (9.26 MB)
Trainable params: 168294 (657.40 KB)
Non-trainable params: 2257984 (8.61 MB)
```

MobileNet Second Experiment



Tuning MobileNet



```
=====
Total params: 2426278 (9.26 MB)
Trainable params: 168294 (657.40 KB)
Non-trainable params: 2257984 (8.61 MB)
```

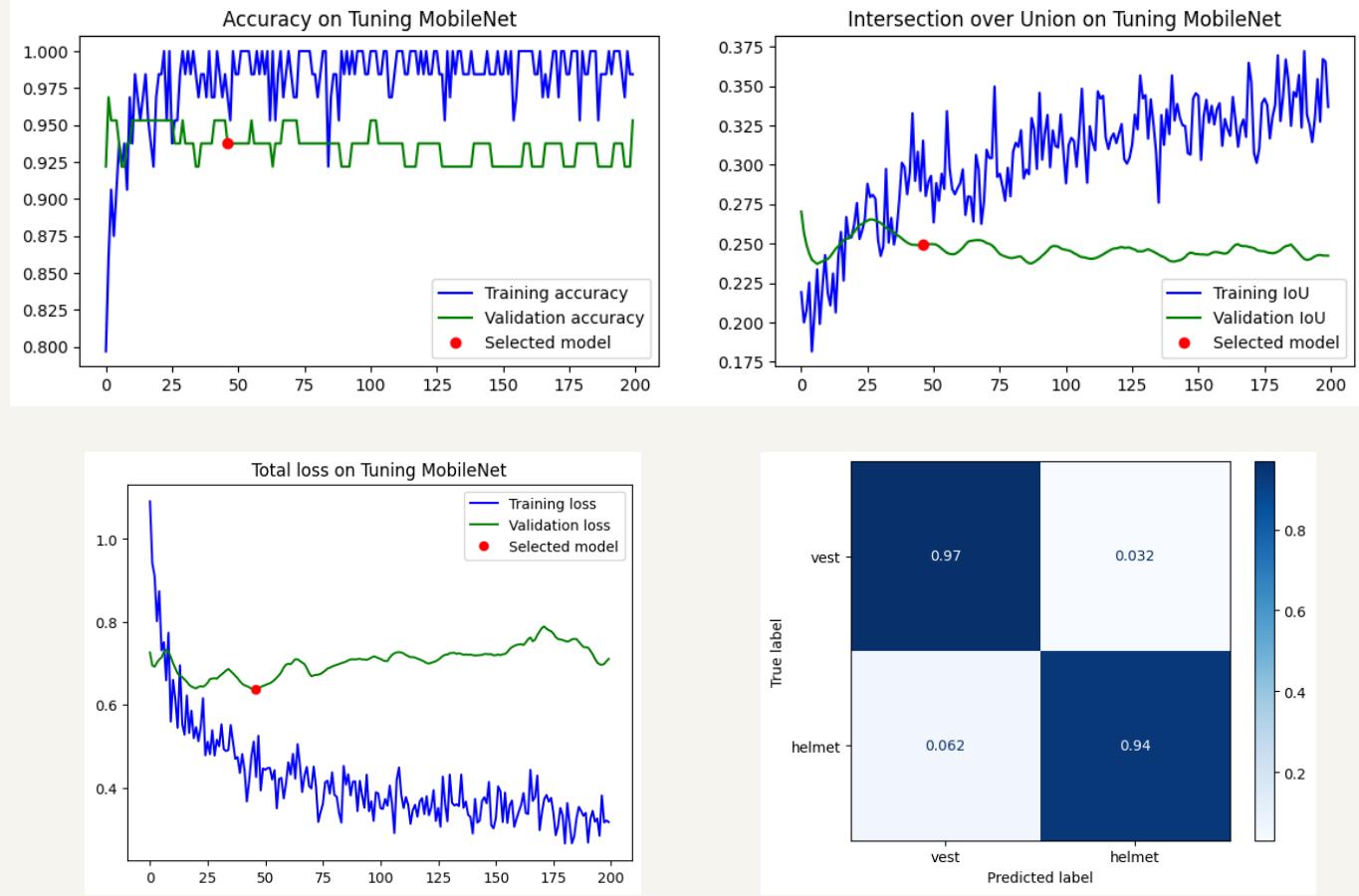
Tuning MobileNet

	Values	Step
<i>Learning Rate</i>	1e-2, 1e-3, 1e-4, 1e-5	-
<i>Dropout Rate</i>	0.3 – 0.8	0.1
<i>Loss Classifier Weight</i>	1.0 – 10.0	1
<i>Loss Regressor Weight</i>	10.0 – 20.0	1

TUNING
→

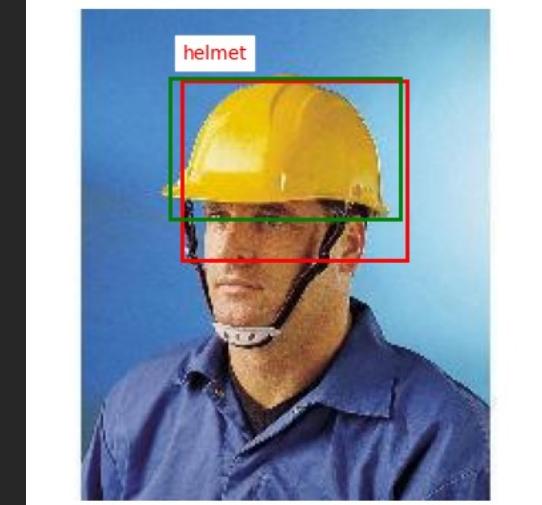
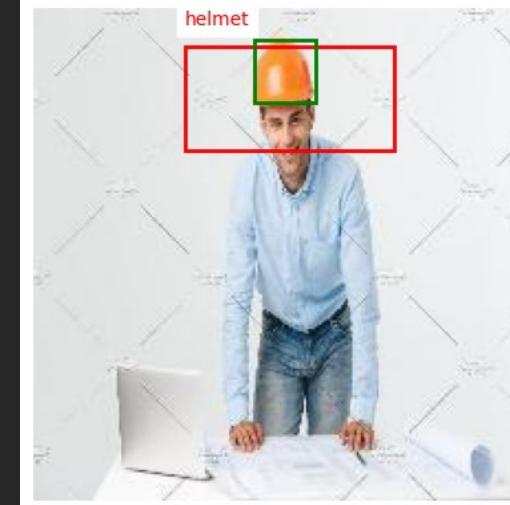
<i>Best value</i>
1e-4
0.5
1.0
11.0

Tuning MobileNet



	Train	Validation	Test
Accuracy	96,9 %	93,8 %	96,4 %
IoU	31,5 %	24,9 %	24 %

Tuning MobileNet Results



Conclusions

Conclusions

The results showed notable performance advantages when using pre-trained networks compared to started from scratch but, despite better performances, there's still room for improvement in the bounding box detection for the applicability in real systems.

Two-step Detection and Classification: it involves an initial detection of PPE targets, followed by a classification within the identified region.

Multi-Target Detection: it involves to expand project's capabilities to detect images containing multiple PPE targets. To achieve this advanced object detection model can be adopted, such as Faster R-CNN and YOLO.