

Object Detection of Potholes using R-CNN

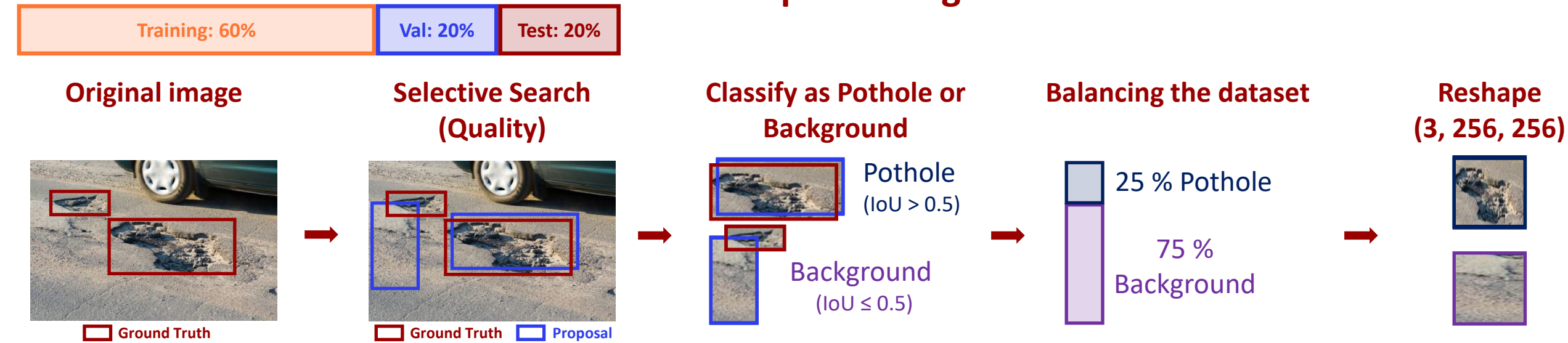
Objective

The objective is to predict potholes on roads using object detection

Sample Training Images with Bounding Boxes



Data Preprocessing



Conclusion

In conclusion, the best IoU threshold to decide whether a proposal is a pothole is 0.5. To fight the class imbalance, we balanced the data set to 25% potholes and 75% background. We found the best performing model to be based on a frozen ResNet 18 architecture, where the final layers are removed and replaced with a feedforward neural network (FFNN) for predicting both the class and location of the boundary box. Experimenting with different values for NMS and different weighting of the loss functions resulted in a model where the regression loss (MSE) was weighted 15 times higher than the classification loss (CE) achieving a mean average precision (mAP) of 0.8.

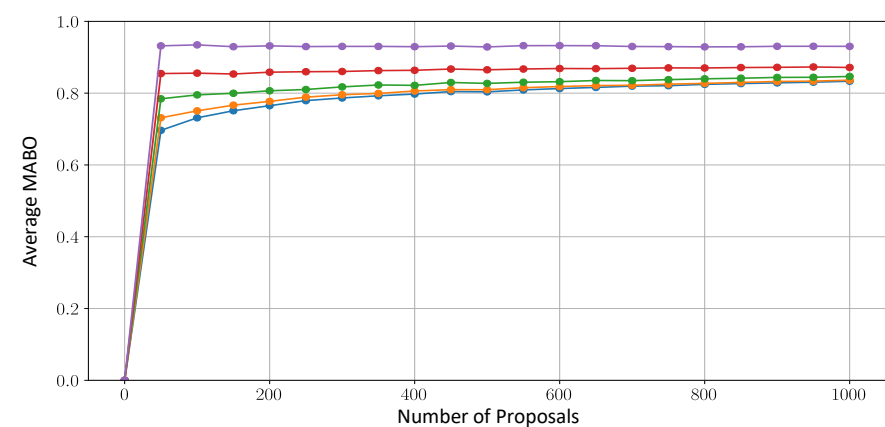
Number of Proposals

Maximum number of proposals: 500

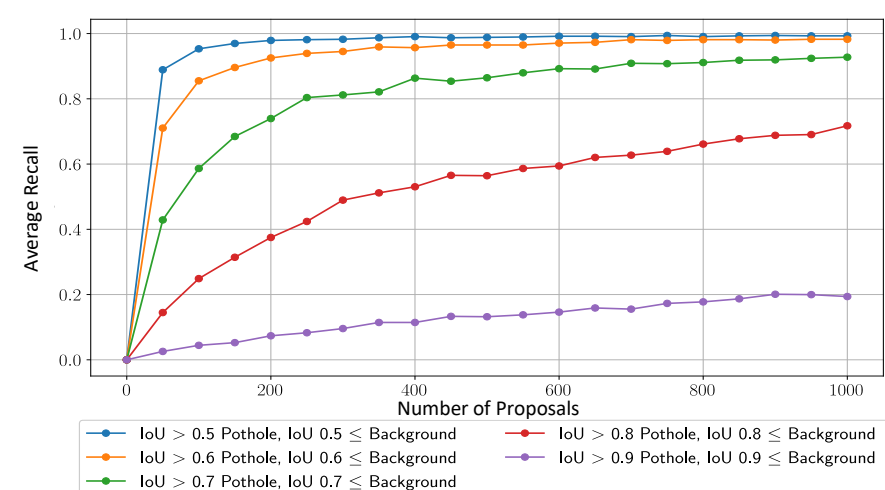
Threshold: IoU > 0.5 (Pothole)

IoU ≤ 0.5 (Background)

Average MABO vs. Number of Proposals for Different IoU Thresholds



Average Recall vs. Number of Proposals for Different IoU Thresholds



Parameters

Loss: $w_1 \cdot \text{MSE} + \text{BCE}$

Optimizer: Adam

Epochs: 50

Input shape: 3 x 256 x 256

FFNN:

ReLU, dropout, BatchNorm

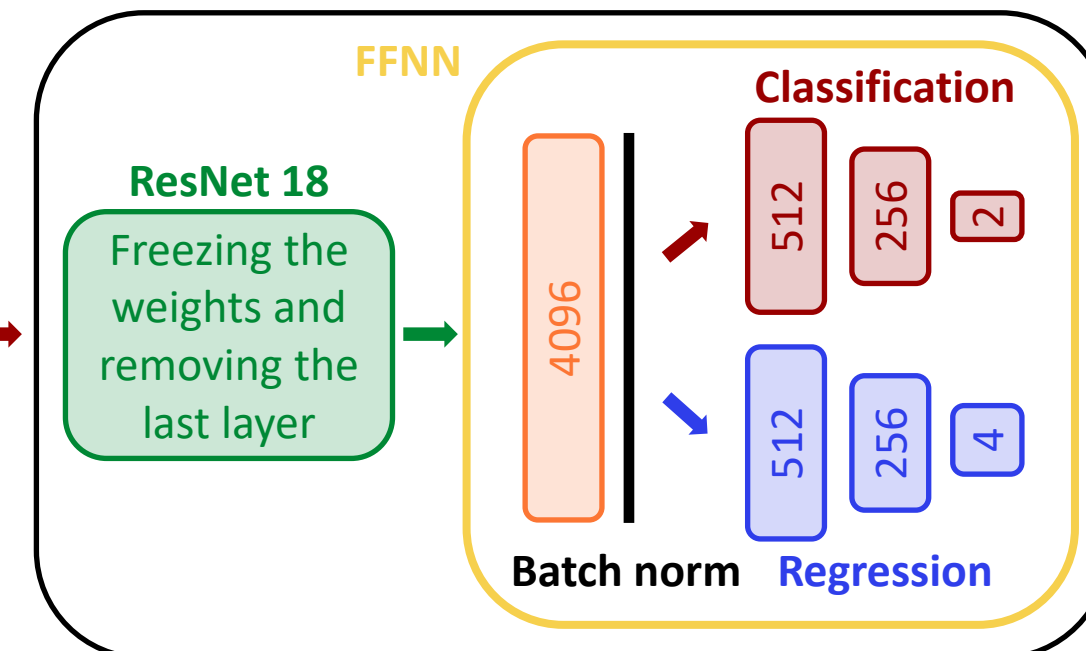
L2 norm: 1e-5

Early stopping with patience 10

Image



Training



Predictions

Pothole (1)
Background (0)

Loss function

Cross Entropy

If the class is Pothole

t_x, t_y, t_h and t_w

MSE

Future Work

- More combinations of NMS, loss weights and other parameters
- Other models like Fast R-CNN

References

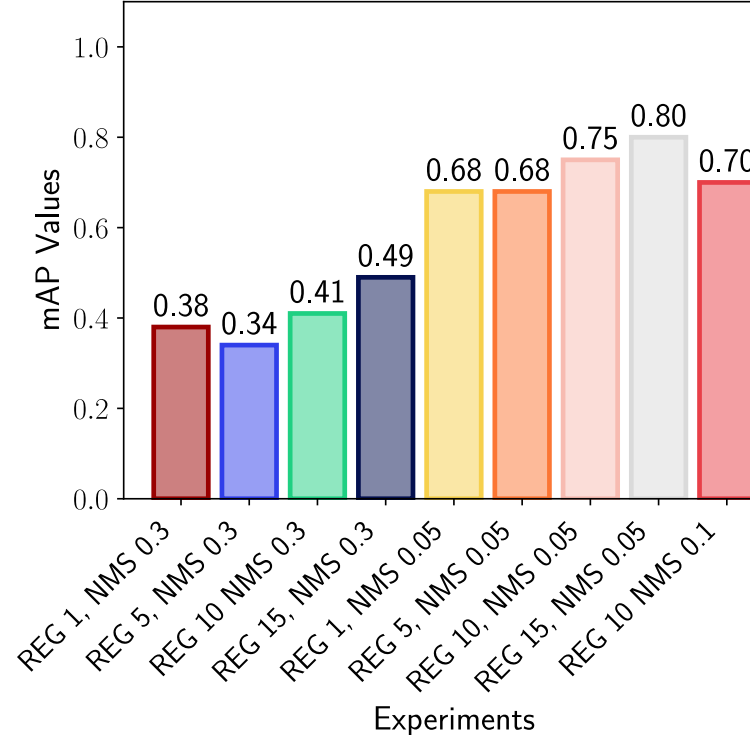
[1] Uijlings, J. R. R., van de Sande, K. E. A., Gevers, T., & Smeulders, A. W. M. (2013). Selective Search for Object Recognition

[2] Medium Park, S. (2021, October 22). Implementing R-CNN object detection on VOC2012 with PyTorch. CodeX.

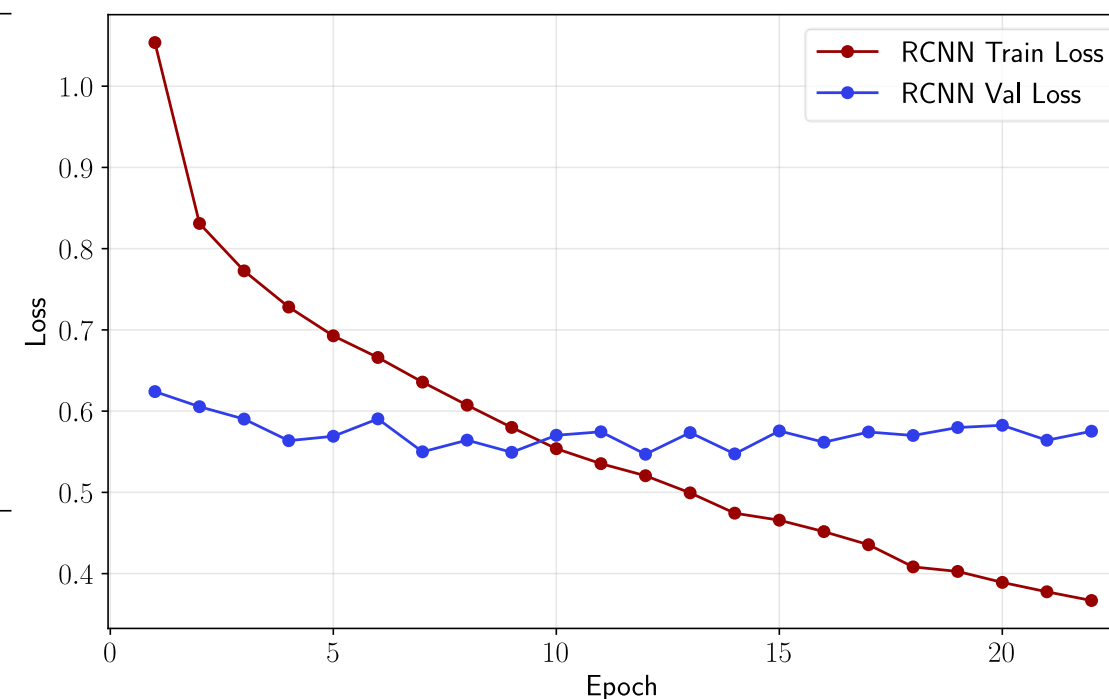
ChatGPT: Used for code debugging, more complicated styling of plots, explanation of complicated topics

Results

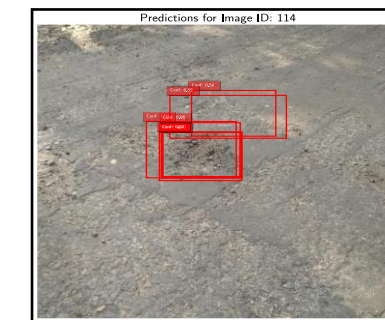
Experiment mAP Comparison



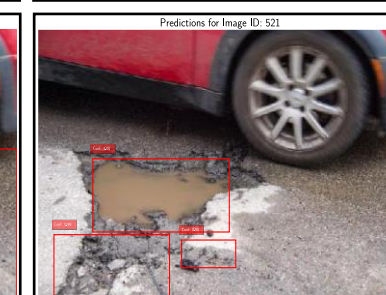
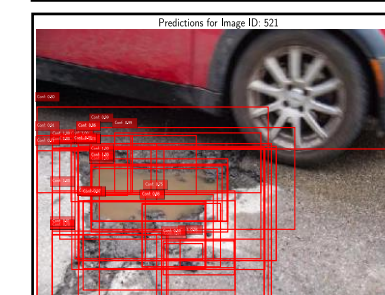
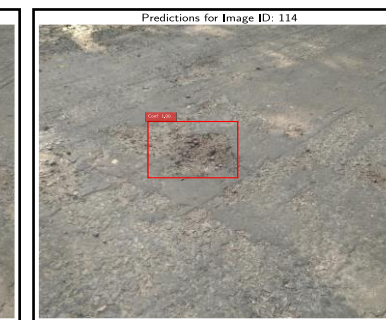
Training and Val Loss



Before NMS



After NMS



Precision-Recall Curve

