Object Detection of Potholes using R-CNN

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Objective

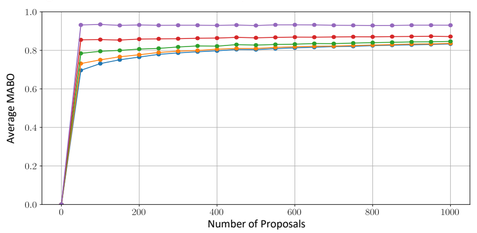
The objective is to predict potholes on roads using object detection

Sample Training Images with Bounding Boxes

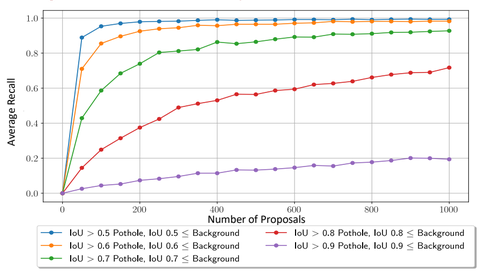
Number of Proposals

Maximum number of proposals: 500
Threshold: IoU $>$ 0.5 (Pothole)
IoU $\leq$ 0.5 (Background)

Average MABO vs. Number of Proposals for Different IoU Thresholds



Average Recall vs. Number of Proposals for Different IoU Thresholds



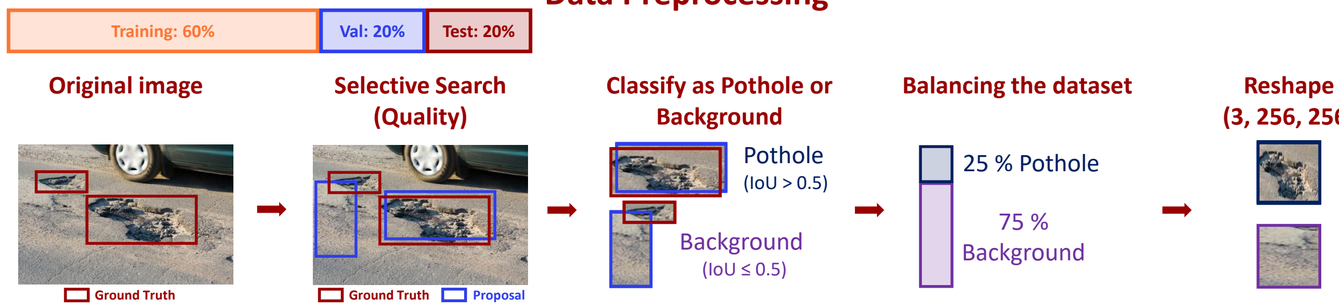
References

[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

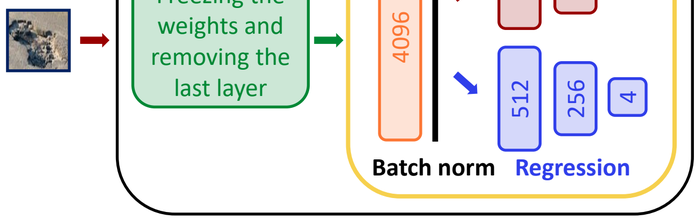
Data Preprocessing



Training

Parameters

Loss: $w_1 \cdot \mathrm{MSE} + \mathrm{BCE}$
Optimizer: Adam
Epochs: 50
Input shape: 3 x 256 x 256
FFNN:
ReLU, dropout, BatchNorm
L2 norm: 1e-5
Early stopping with patience 10



Conclusion

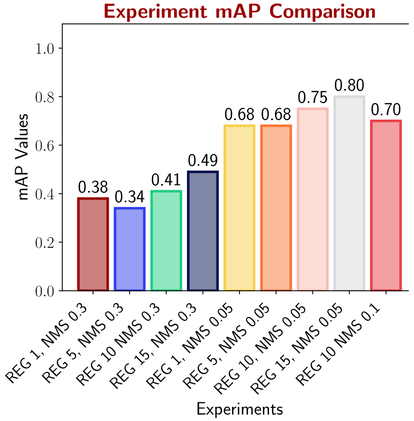
In conclusion, the best IoU threshold to decide whether a proposal is a pothole is 0.5. To fight the class imbalance, we balanced the data set to 25% potholes and 75% background. We found the best performing model to be based on a frozen ResNet 18 architecture, where the final layers are removed and 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.

Future Work

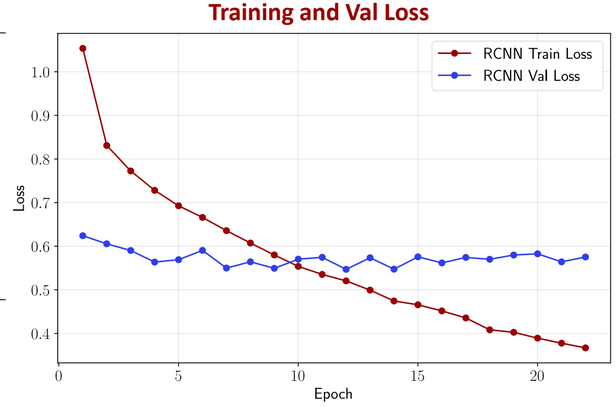
- More combinations of NMS, loss weights and other parameters
- Other models like Fast R-CNN

Results

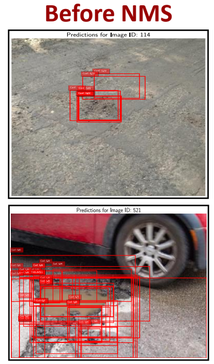
Experiment mAP Comparison



Training and Val Loss



Before NMS



After NMS

Precision-Recall Curve