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Surface Crack Detection and Segmentation Using Visual and Combined RGB and IR Images

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Visual and Thermal Sensors for Bridge Inspection

- Visual sensors are most common type of sensors which is used for bridge defect detection, classification and quantification.
- Thermal sensors overcomes limitations of RGB sensors such as adverse environmental conditions, dust and vibrations effect but blurred details, noise and low resolution are its own challenges.
- Fusing thermal and RGB images to a single image takes advantage of both imagery techniques.

Data Acquisition and Annotation

- FLIR C5 camera is used to capture two set of images from surface cracks; RGB and combined
- 242 RGB and combined images are captured from bridge deck surface cracks
- ImgLab online tool is used to perform polygon image annotation
- Annotated images are fed into Mask R-CNN for object detection and instance segmentation

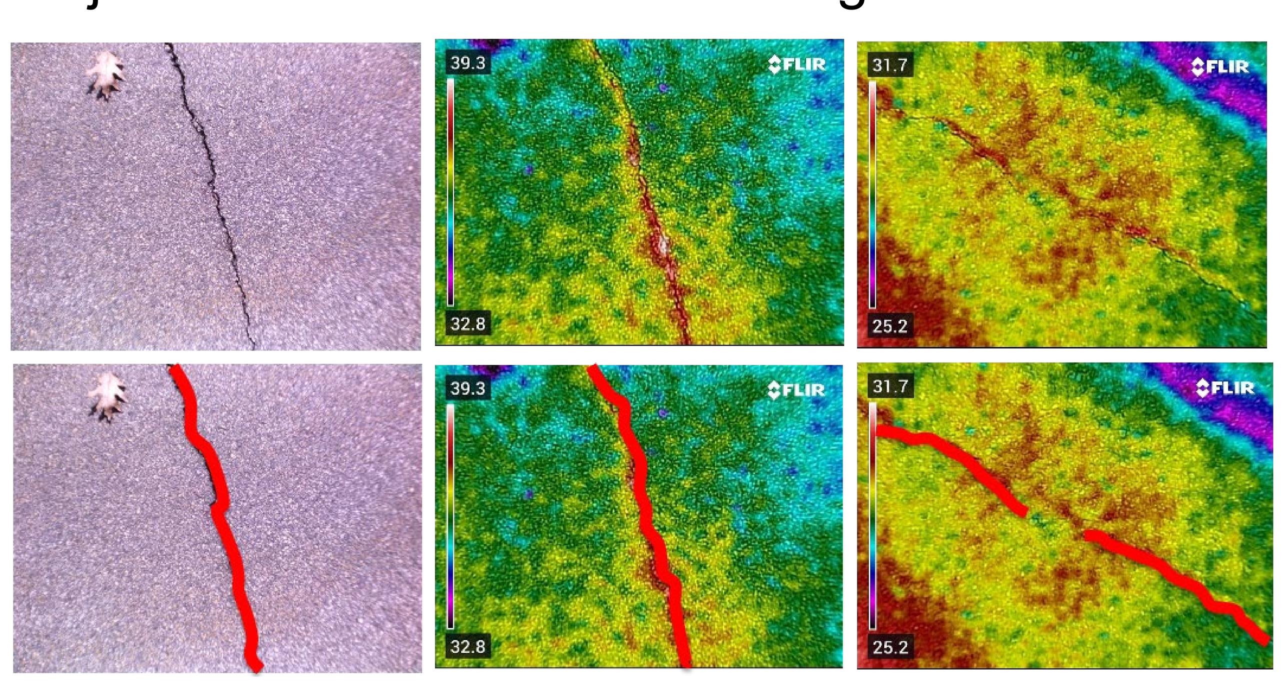

Fig. 1. Samples of original and annotated RGB and combined images

Mask R-CNN

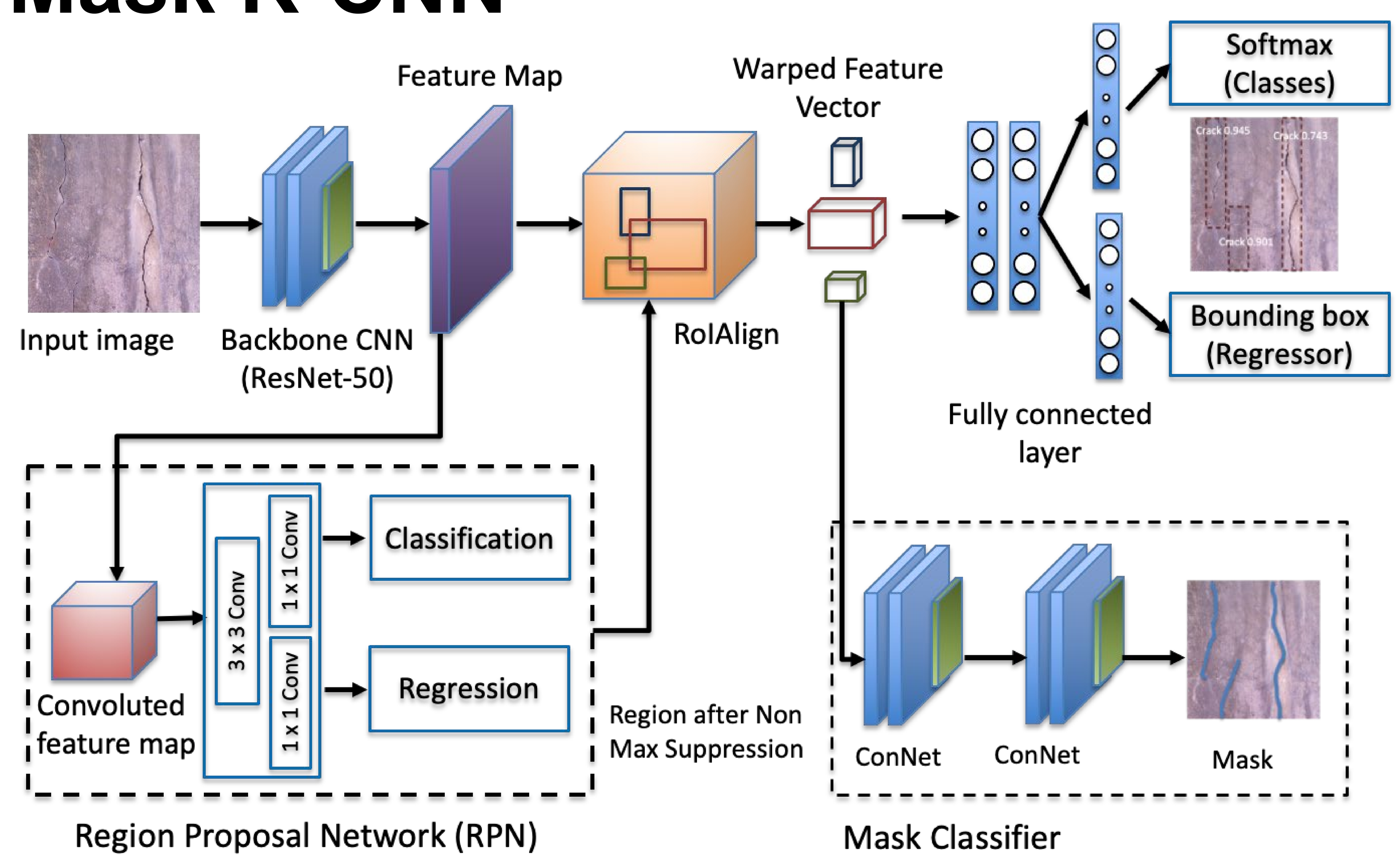

Fig 2. Mask R-CNN architecture

Model implementation, Training and Testing

- Mask R-CNN repository by Matterport, a 3D virtual-tour software company is used
- ResNet-50 architecture and a Feature Pyramid Network (FPN) is its backbone
- “Dataset” class is modified to suit our own cracks dataset
- Pre-trained weights options: COCO, ImageNet
- The code was written in the Python 3 programming language and the Keras and TensorFlow deep-learning libraries
- The network is trained using real-life images of cracks
- The data is split into 169 images for the training set and 73 images for the test set

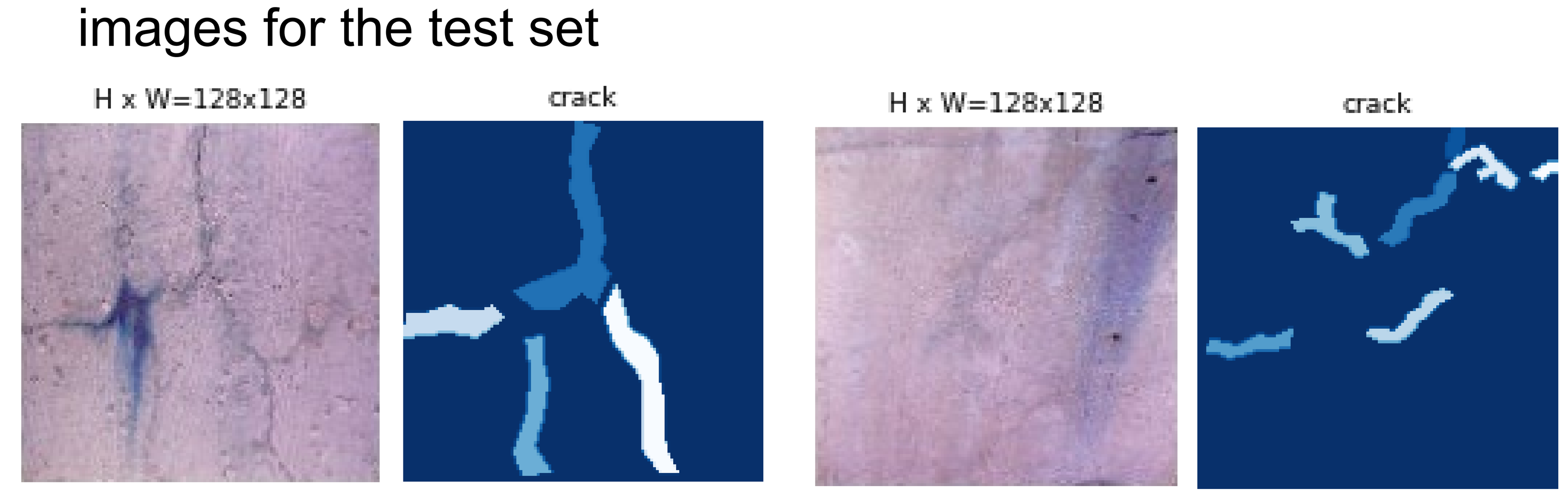

Fig 3. Samples of original images and corresponding mask

Performance measure

- Loss functions are designed considering the task of each output layer: classification and regression layers in the RPN, box-classification, box-regression layers in the classification stage, and the output layer of the mask branch

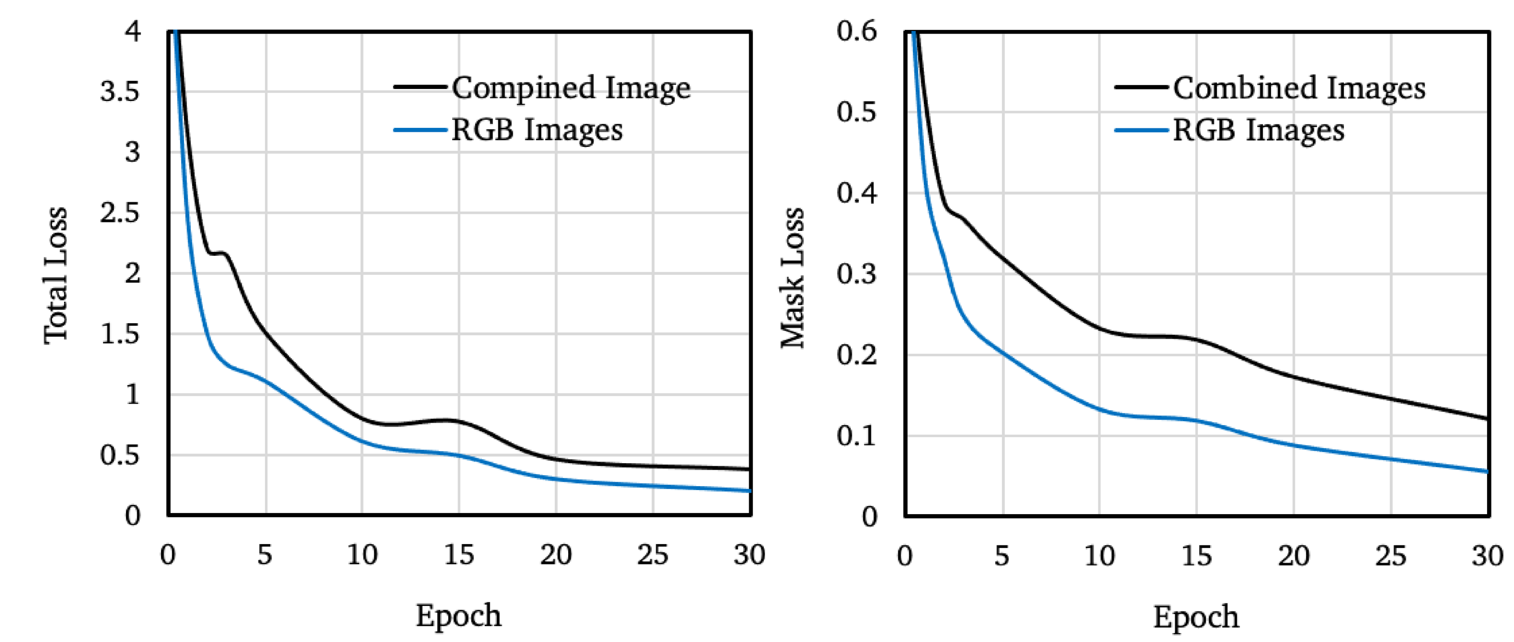

Fig 4. Total and Mask Loss

Conclusions

- Mask R-CNN model may replace the existing visual inspection of concrete structures with high accuracy.
- The mAP values for RGB and combined images are 0.27 and 0.21 respectively.
- Quantity and quality of the training data and annotation affects the accuracy of results.
- Original Mask R-CNN is developed for COCO dataset which is a simple data compared to cracks
- Backbones with higher model capacities, such as ResNet-101 might improve accuracy of the model
- Future works: Multi-class defect detection and adding edge detection filters such as Sobel filter to the network for efficient performance

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