Ahmedabad University

Road Marking Detection and Classification using UAV Images

CSE 541 Computer Vision
End-Semester Presentation

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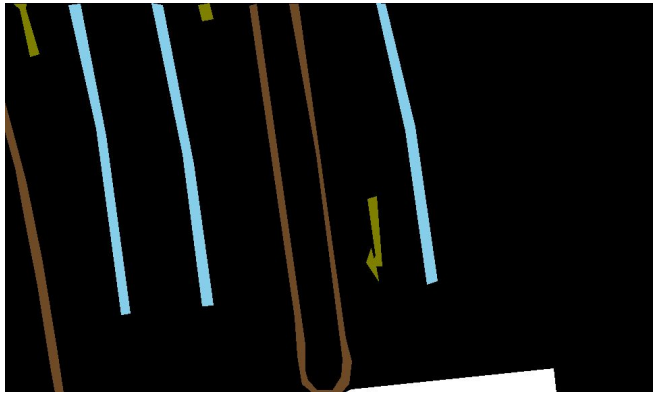
Group - 5

Problem Statement

- Detect Road Marking using the segmentation approach.
- Determining their sizes and multiclass classification.
- Why to do this?
  - Upcoming technology of self-driving cars.
  - Helps in analysing traffic

Dataset Explanation



- AU Drone Dataset

Color	Label
	Zebra Crossing
	Lane Marking
	Lane Edges
	Traffic Sign
	Background

Methodology Used: Image Segmentation

- It is an approach to divide an image into a segments based on some similarity.

- How does Segmentation works?
  - It does Pixel-level comparison on adjacent points, to classify pixels into a categories.
  - The masks are created for each class.

https://viso.ai/wp-content/uploads/2021/03/image-segmentation-example-1060x397.jpg

One Hot Encoding

- To deal with multiclass segmentation,
  we performed One Hot Encoding on the masks.

- In One Hot Encoding,
  we change categorical data into binary vector,
  whether the road marking is present or not.

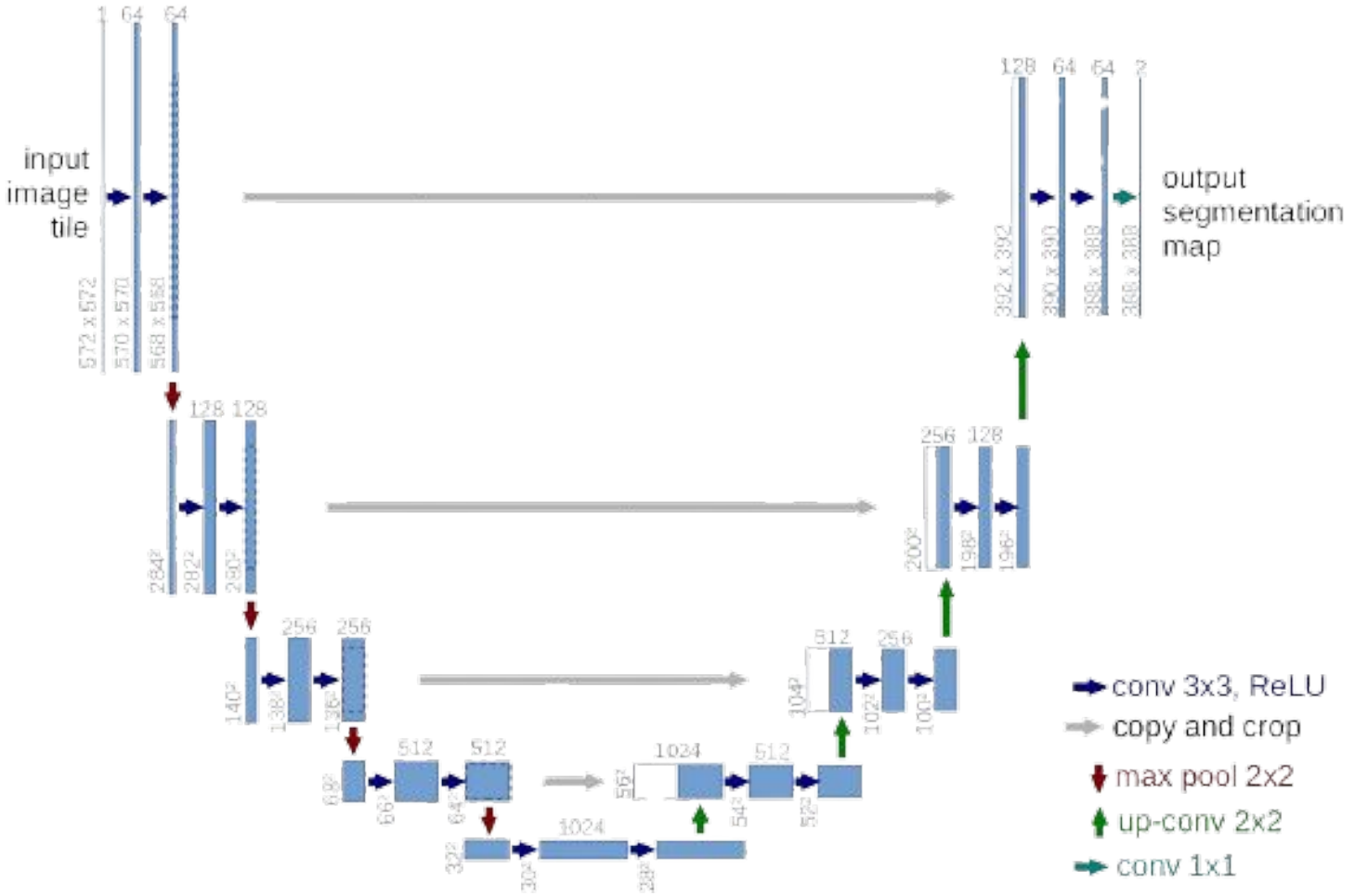
Color	Label	Binary Label
	Zebra Crossing	[1,0,0,0,0]
	Lane Marking	[0,1,0,0,0]
	Lane Edges	[0,0,1,0,0]
	Traffic Sign	[0,0,0,1,0]
	Background	[0,0,0,0,1]

https://viso.ai/wp-content/uploads/2021/03/image-segmentation-example-1060x397.jpg

Deep Learning model used: U-Net

Input Image

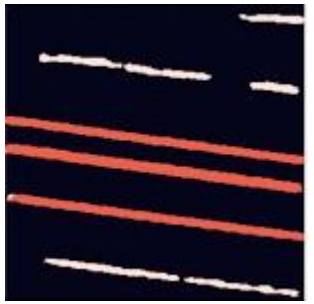
256 x 256 x 3



Ground Truth

256 x 256 x 5

Output Image



256 x 256 x 5

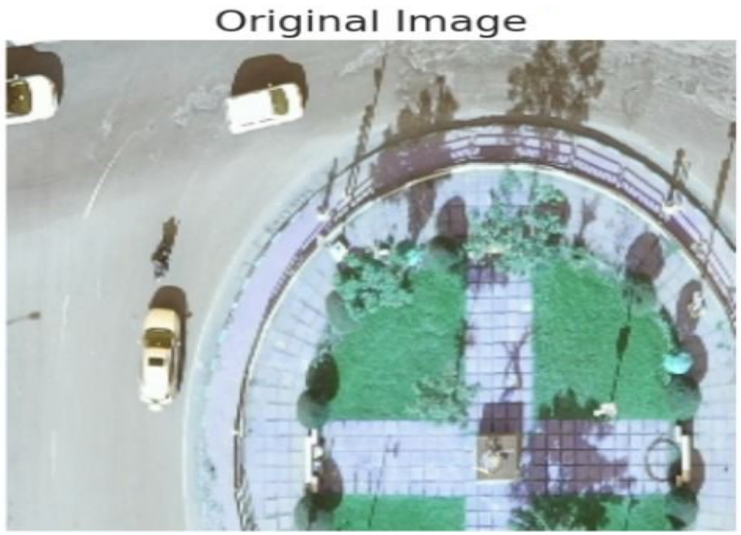
[1] Ronneberger, O., Fischer, P, &Brox, T.(2015, May 18). U-NET: Convolutional Networks for Biomedical Image Segmentation.

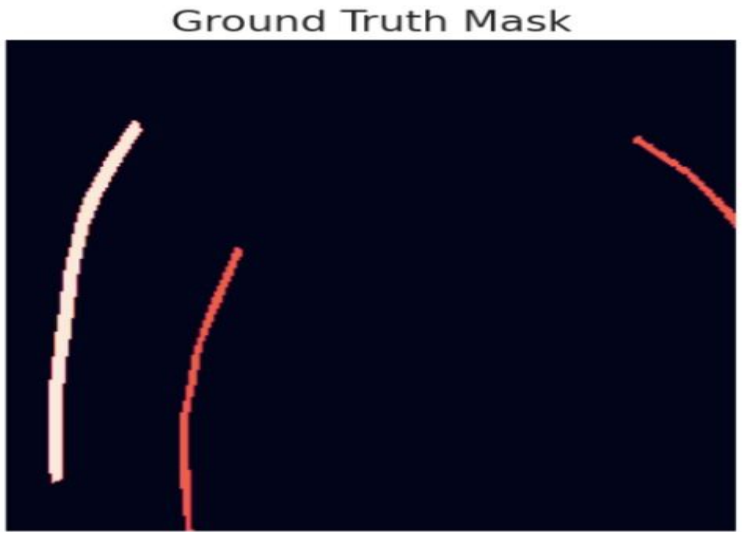
Multiclass Segmentation - Results (1/2)

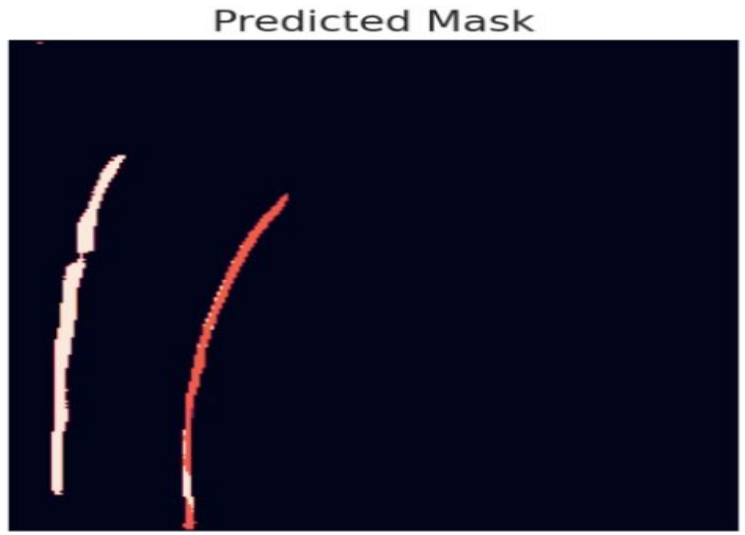
- For evaluating the multiclass segmentation model performance, we utilized Intersection over Union (IoU) and the loss function as categorical loss.

```
Epoch 46/50
46/46 ━━━━━━━━━━━━━━━━━━━━ 0s 610ms/step - accuracy: 0.9838 - iou_coef: 0.9303 - loss: 0.0468
Epoch 46: iou_coef improved from 0.93073 to 0.93090, saving model to unet_multiclass_iou.keras
46/46 ━━━━━━━━━━━━━━━━━━━━ 34s 677ms/step - accuracy: 0.9838 - iou_coef: 0.9303 - loss: 0.0468 - val_accuracy: 0.9669 - val_iou_coef: 0.9030 - val_loss: 0.0
965
Epoch 47/50
46/46 ━━━━━━━━━━━━━━━━━━━━ 0s 612ms/step - accuracy: 0.9823 - iou_coef: 0.9298 - loss: 0.0480
Epoch 47: iou_coef improved from 0.93090 to 0.93136, saving model to unet_multiclass_iou.keras
46/46 ━━━━━━━━━━━━━━━━━━━━ 35s 677ms/step - accuracy: 0.9823 - iou_coef: 0.9298 - loss: 0.0479 - val_accuracy: 0.9679 - val_iou_coef: 0.9122 - val_loss: 0.0
872
Epoch 48/50
46/46 ━━━━━━━━━━━━━━━━━━━━ 0s 611ms/step - accuracy: 0.9833 - iou_coef: 0.9337 - loss: 0.0433
Epoch 48: iou_coef improved from 0.93136 to 0.93233, saving model to unet_multiclass_iou.keras
46/46 ━━━━━━━━━━━━━━━━━━━━ 35s 679ms/step - accuracy: 0.9833 - iou_coef: 0.9337 - loss: 0.0433 - val_accuracy: 0.9555 - val_iou_coef: 0.8959 - val_loss: 0.1
236
Epoch 49/50
46/46 ━━━━━━━━━━━━━━━━━━━━ 0s 613ms/step - accuracy: 0.9831 - iou_coef: 0.9310 - loss: 0.0464
Epoch 49: iou_coef did not improve from 0.93233
46/46 ━━━━━━━━━━━━━━━━━━━━ 34s 666ms/step - accuracy: 0.9831 - iou_coef: 0.9310 - loss: 0.0464 - val_accuracy: 0.9683 - val_iou_coef: 0.9148 - val_loss: 0.0
689
Epoch 50/50
46/46 ━━━━━━━━━━━━━━━━━━━━ 0s 611ms/step - accuracy: 0.9851 - iou_coef: 0.9329 - loss: 0.0438
Epoch 50: iou_coef improved from 0.93233 to 0.93269, saving model to unet_multiclass_iou.keras
46/46 ━━━━━━━━━━━━━━━━━━━━ 35s 678ms/step - accuracy: 0.9851 - iou_coef: 0.9329 - loss: 0.0438 - val_accuracy: 0.9745 - val_iou_coef: 0.9171 - val_loss: 0.0
662
Restoring model weights from the end of the best epoch: 50.
```

Results(2/2)







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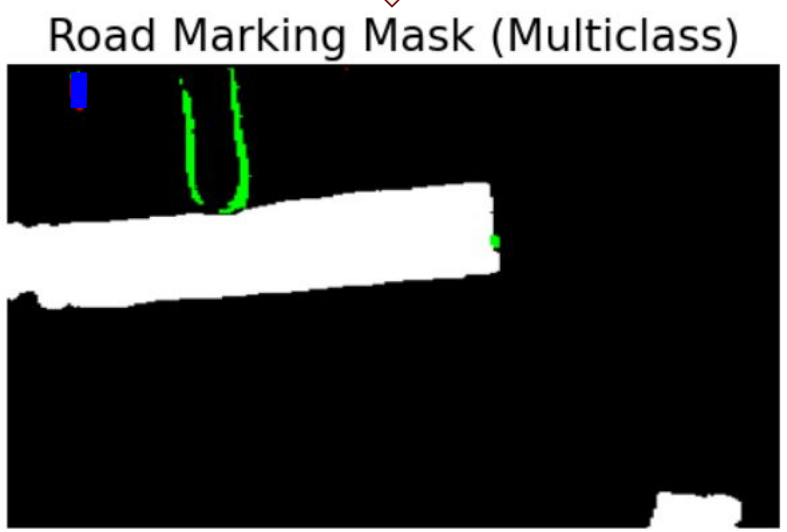
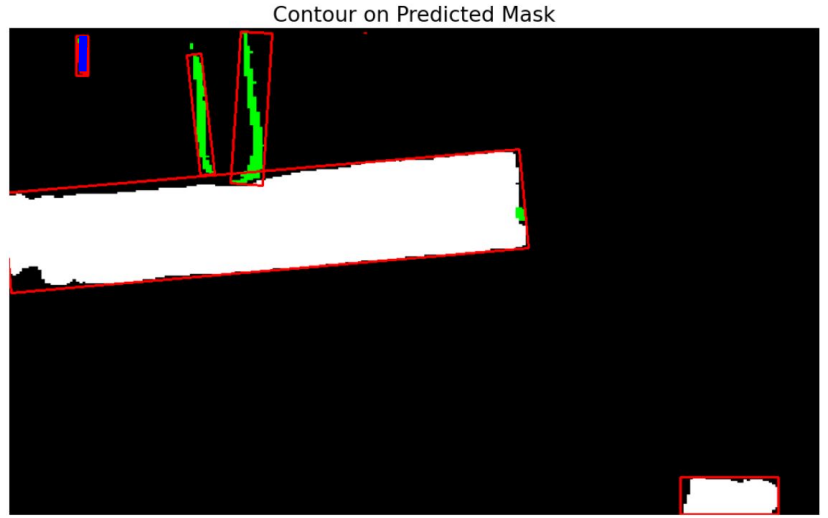
Early Stopping Criteria: IOU_Coef

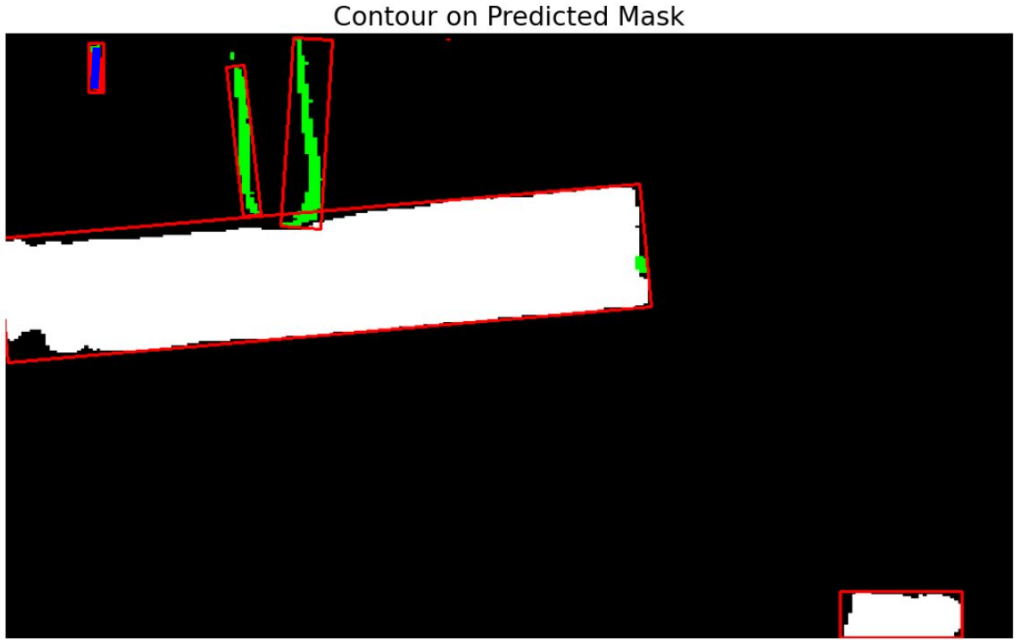
Contour across Predicted Mask

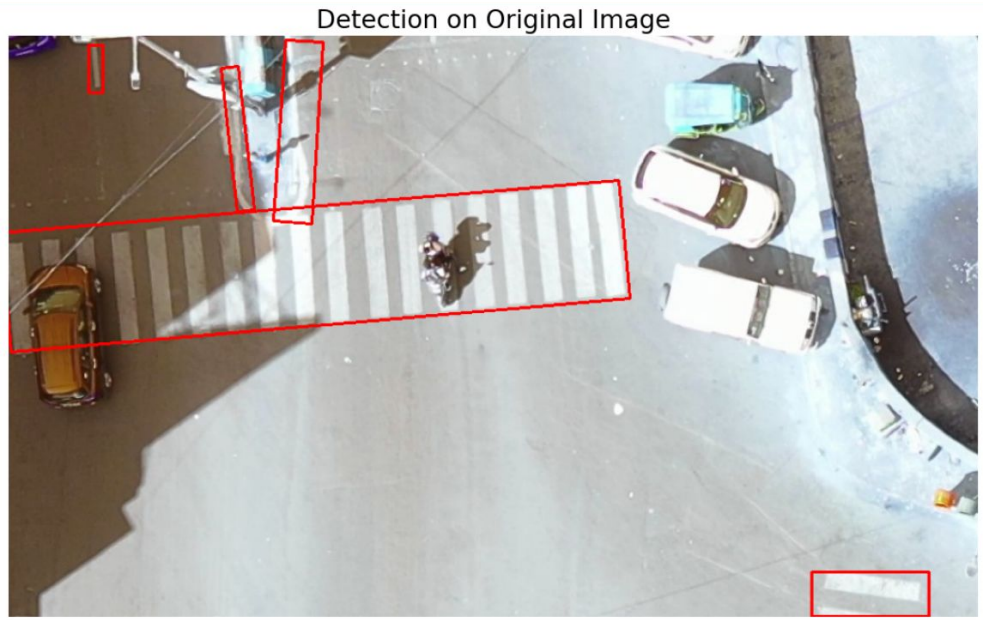
Color	Label	Binary Label
	Zebra Crossing	[1,0,0,0,0]
	Lane Marking	[0,1,0,0,0]
	Lane Edges	[0,0,1,0,0]
	Traffic Sign	[0,0,0,1,0]
	Background	[0,0,0,0,1]





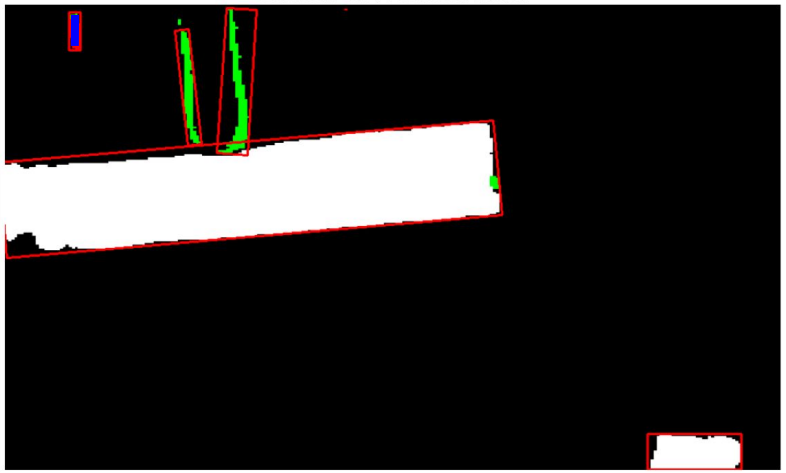
Bounding Box across input image



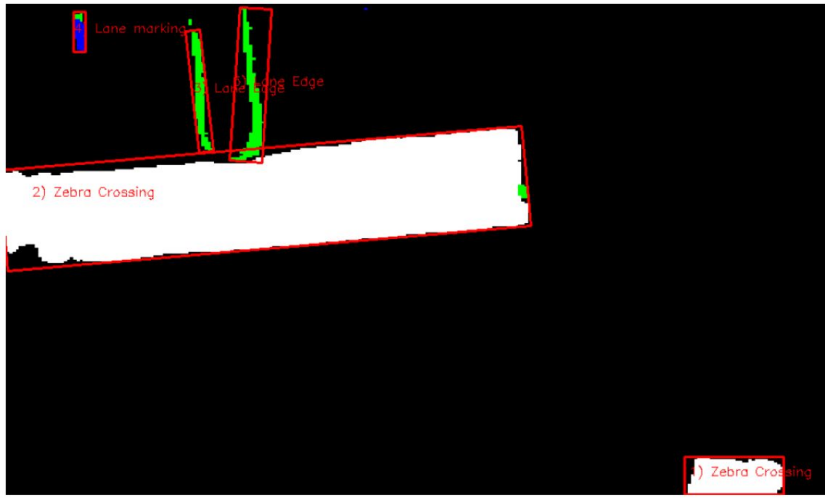


Classification of Road Marking

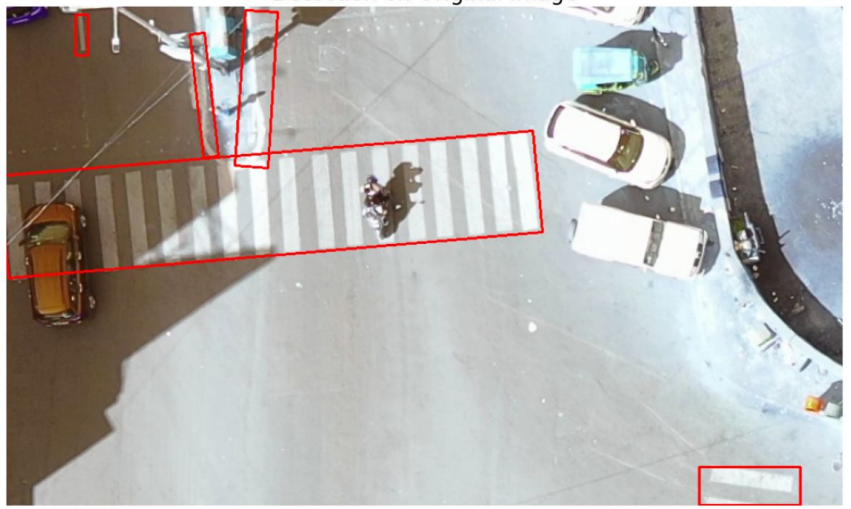
Contour on Predicted Mask



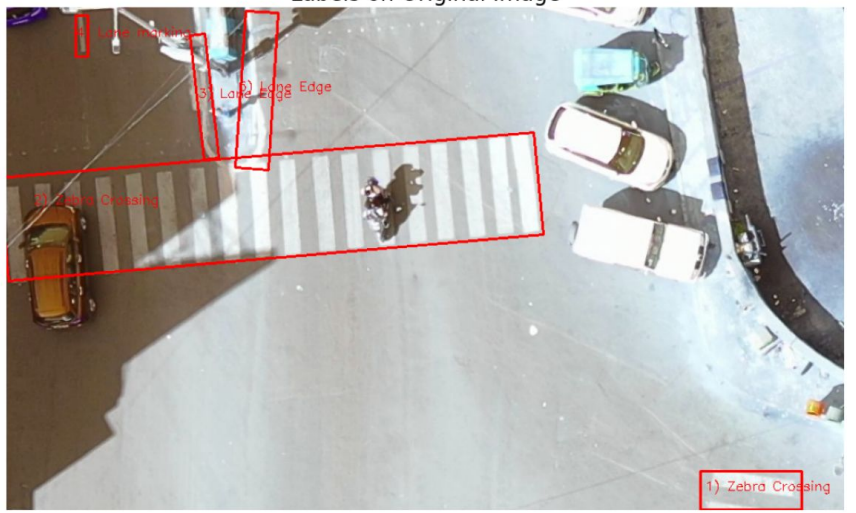
Label on Predicted Mask



Detection on Original Image



Labels on Original Image



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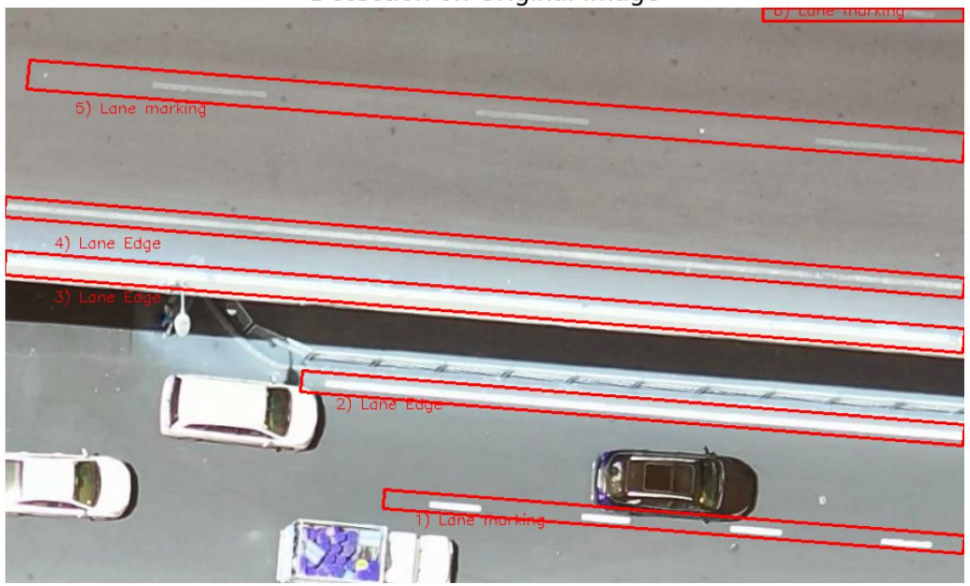
One Last Step: Area Thresholding

Results on Testing data

Detection on Original Image


```
Mark 1:'Zebra Crossing'  Width = 157.03px, Height = 111.02px,
Mark 2:'Lane Edge'  Width = 15.03px, Height = 382.05px,
Mark 3:'Lane Edge'  Width = 13.00px, Height = 123.00px,
Mark 4:'Lane Edge'  Width = 603.00px, Height = 17.00px,
Mark 5:'Zebra Crossing'  Width = 167.00px, Height = 384.00px,
Mark 6:'Lane Edge'  Width = 78.00px, Height = 8.00px,
```

Detection on Original Image




```
Mark 1:'Lane marking'  Width = 19.03px, Height = 582.82px,
Mark 2:'Lane Edge'  Width = 21.10px, Height = 665.20px,
Mark 3:'Lane Edge'  Width = 24.02px, Height = 963.16px,
Mark 4:'Lane Edge'  Width = 20.02px, Height = 963.41px,
Mark 5:'Lane marking'  Width = 29.15px, Height = 938.84px,
Mark 6:'Lane marking'  Width = 201.00px, Height = 13.00px,
```

Future Possibilities

- Upgrading U-Net Architecture
- Determining Original Mark Dimensions

References

[1] Ronneberger, O., Fischer, P., & Brox, T. (2015, May 18). U-NET: Convolutional Networks for Biomedical Image Segmentation. arXiv.org. https://arxiv.org/abs/1505.04597

[2] Guan, H., Lei, X., Yu, Y., Zhao, H., Peng, D., Marcato, J., & Li, J. (2022). Road marking extraction in UAV imagery using attentive capsule feature pyramid network. International Journal of Applied Earth Observation and Geoinformation, 107, 102677. https://doi.org/10.1016/j.jag.2022.102677

[3] Bhavsar, Y. M., Zaveri, M., Raval, M. S., & Zaveri, S. B. (2023). Vision-based Investigation of Road Traffic and Violations at Urban Roundabout in India using UAV Video: A Case Study. Transportation Engineering (Oxford), 14, 100207. https://doi.org/10.1016/j.treng.2023.100207

Thank You