Semantic Mapping of Underwater Caves: Deep Learning of Underwater Speleothems and Other Structures

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Introduction

- Very little underwater cave exploration using robotics.
- We use the YOLOv5s CNN to detect stalagmites, stalactites, columns, and divers.
- Trained model for use on AQUA2 underwater cave mapping missions.

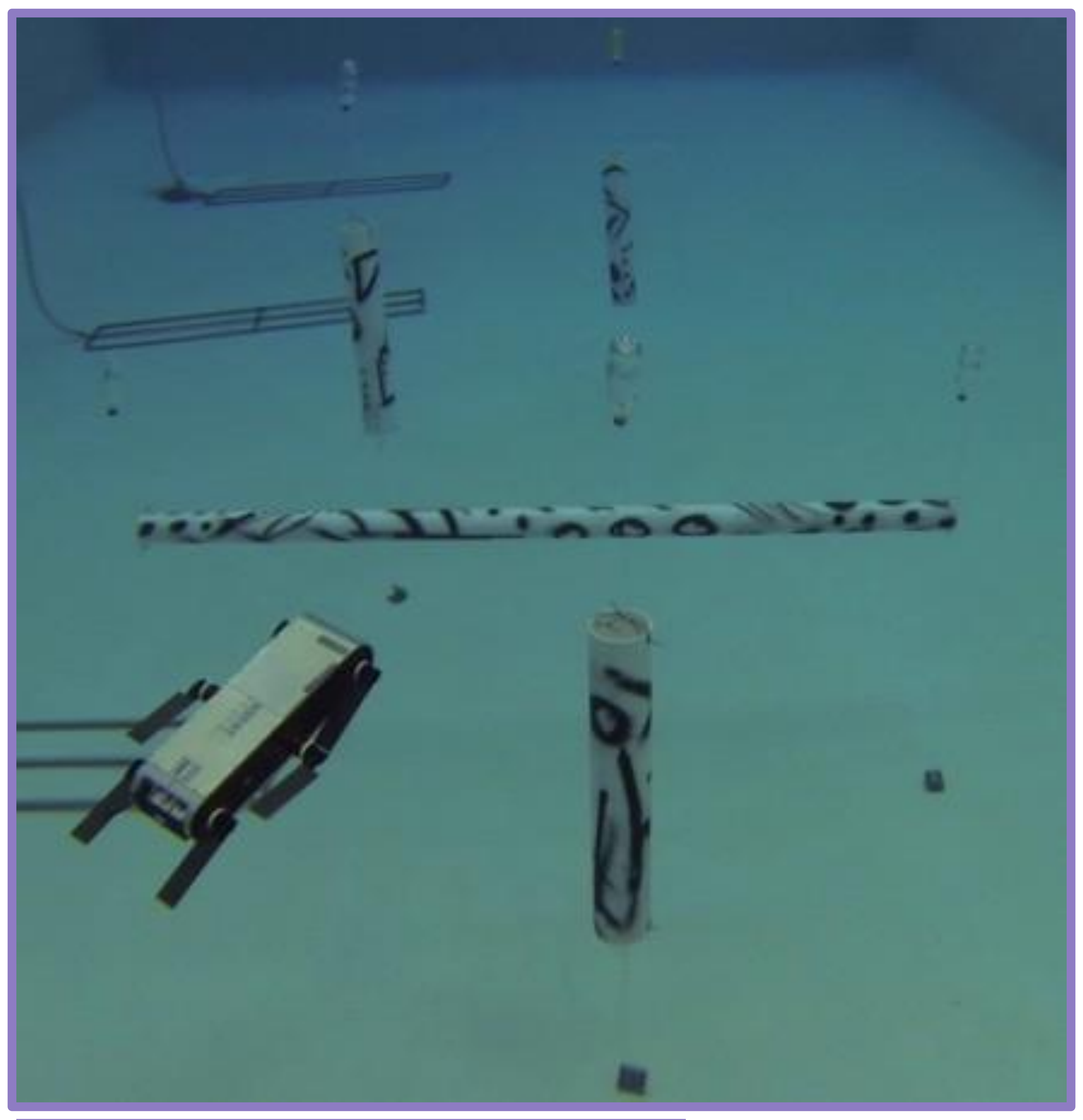


Fig. 1: AQUA2 attempting an obstacle course at University of South Carolina [1].

Methods

- YOLOv5s trained on 20,000 hand labeled underwater cave images.
- Mosaic and HSV augmentations applied to input images.
- Trained weights to run on AQUA2 using camera feed as inputs.
- Output bounding box and class id fed to semantic mapping algorithm.

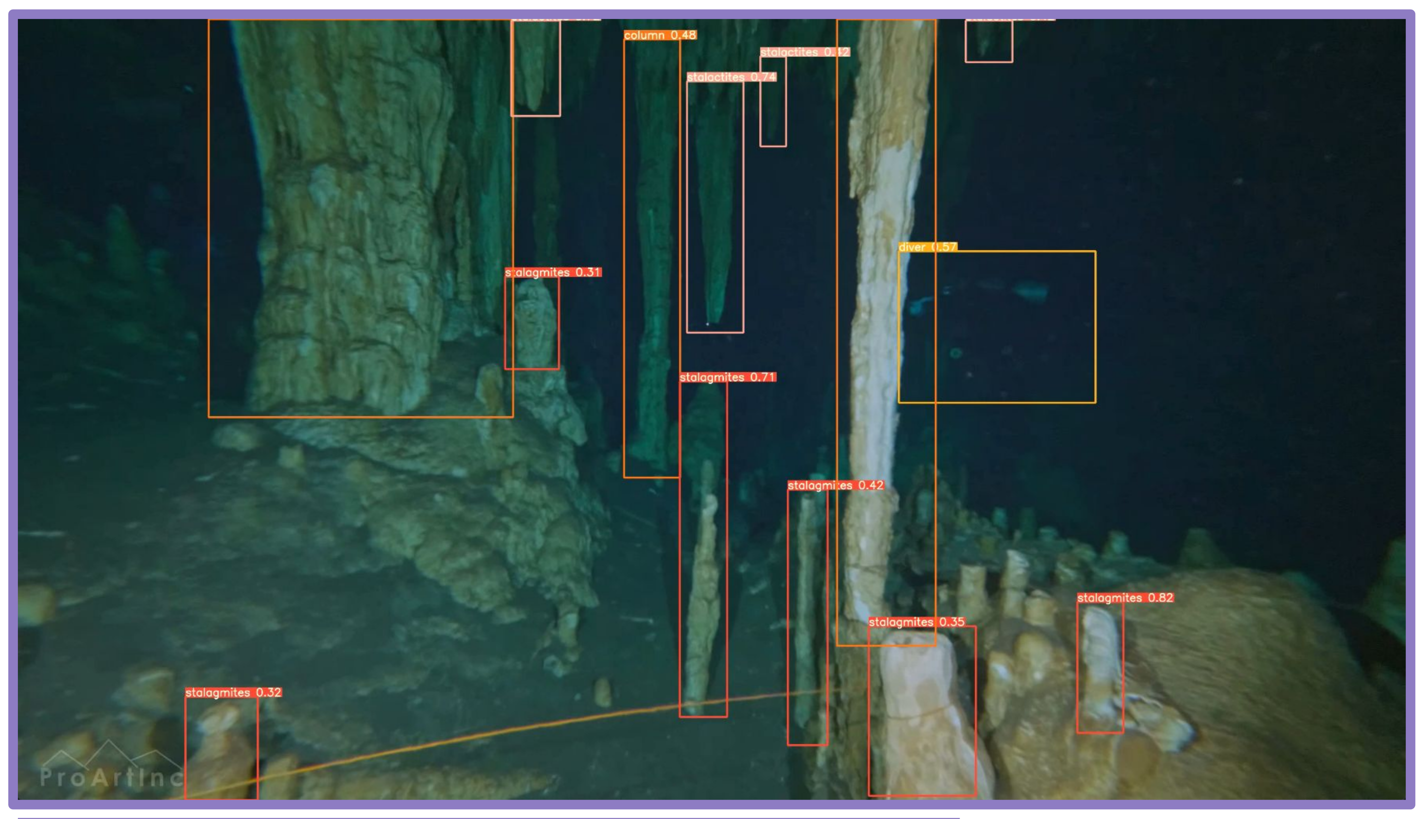
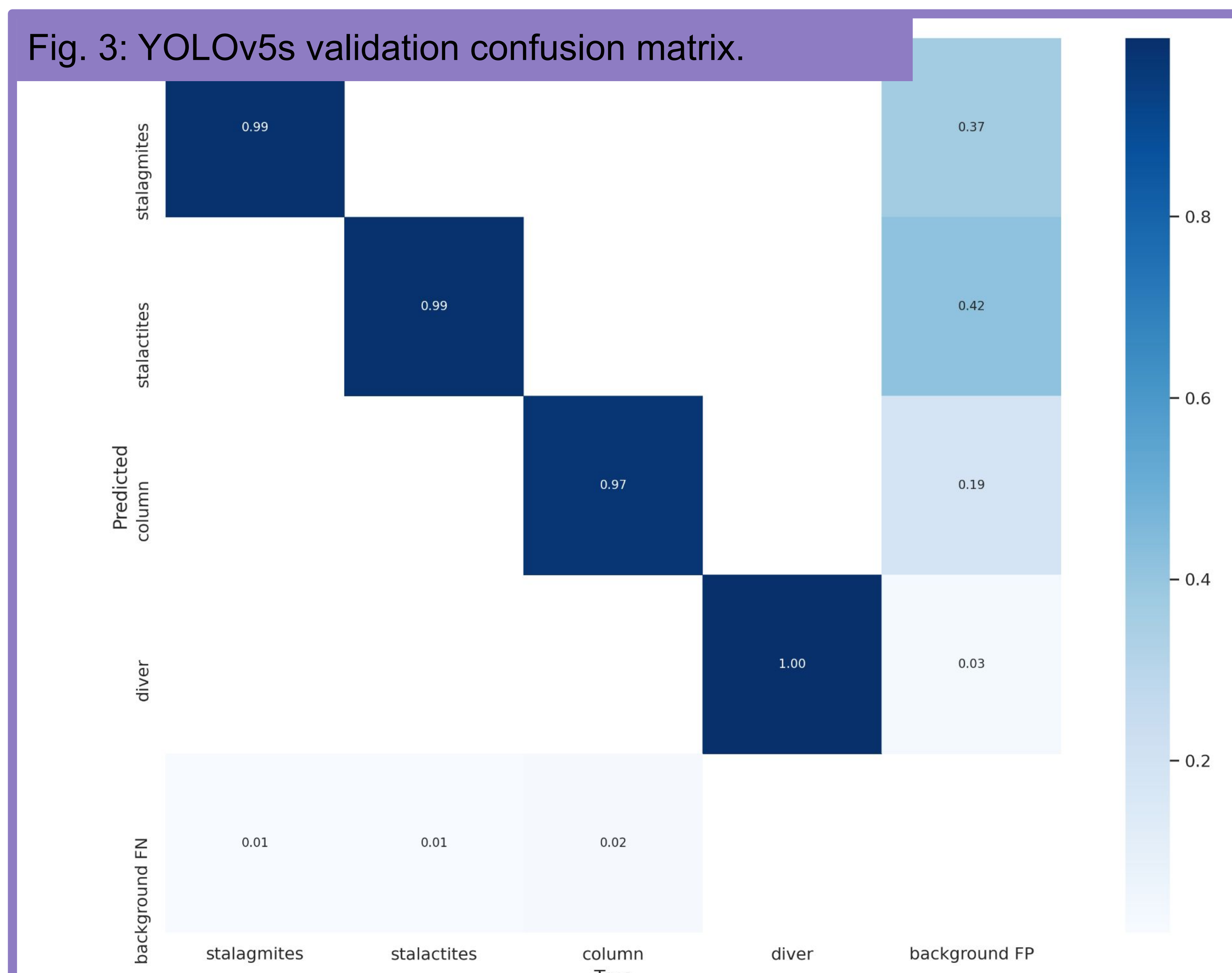


Fig. 2: YOLOv5s output frame consisting of bounding boxes, class predictions, and confidence values.

Experiment Results

- Using HSV augmentation reduced overall mAP but increased diver specific detection.
- Visual inspection of Stalagmite and Stalactite detection is promising.
- Column detection confused in some instances where ceiling and floor of underwater cave not visible.
- Diver detection weak due to lack of training data and variation in equipment across caves.

Fig. 3: YOLOv5s validation confusion matrix.



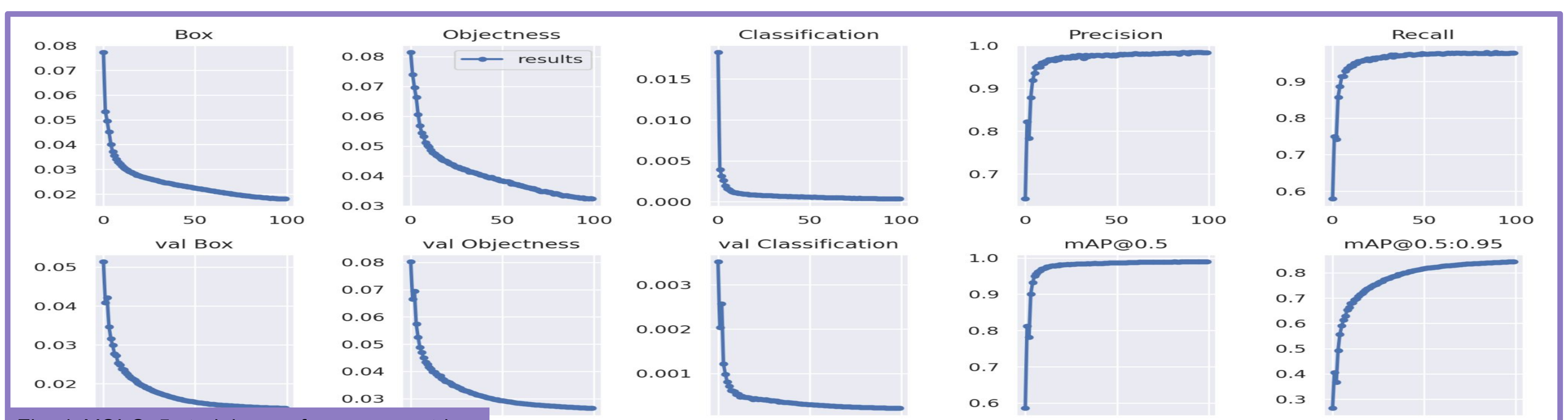


Fig. 4: YOLOv5s training performance metrics.

Discussion

- Overall best performance came from using only Mosaic augmentation.
- More quantity and variation of training data will improve performance.
- For the purposes of aiding the semantic mapping algorithm, current performance is satisfactory.

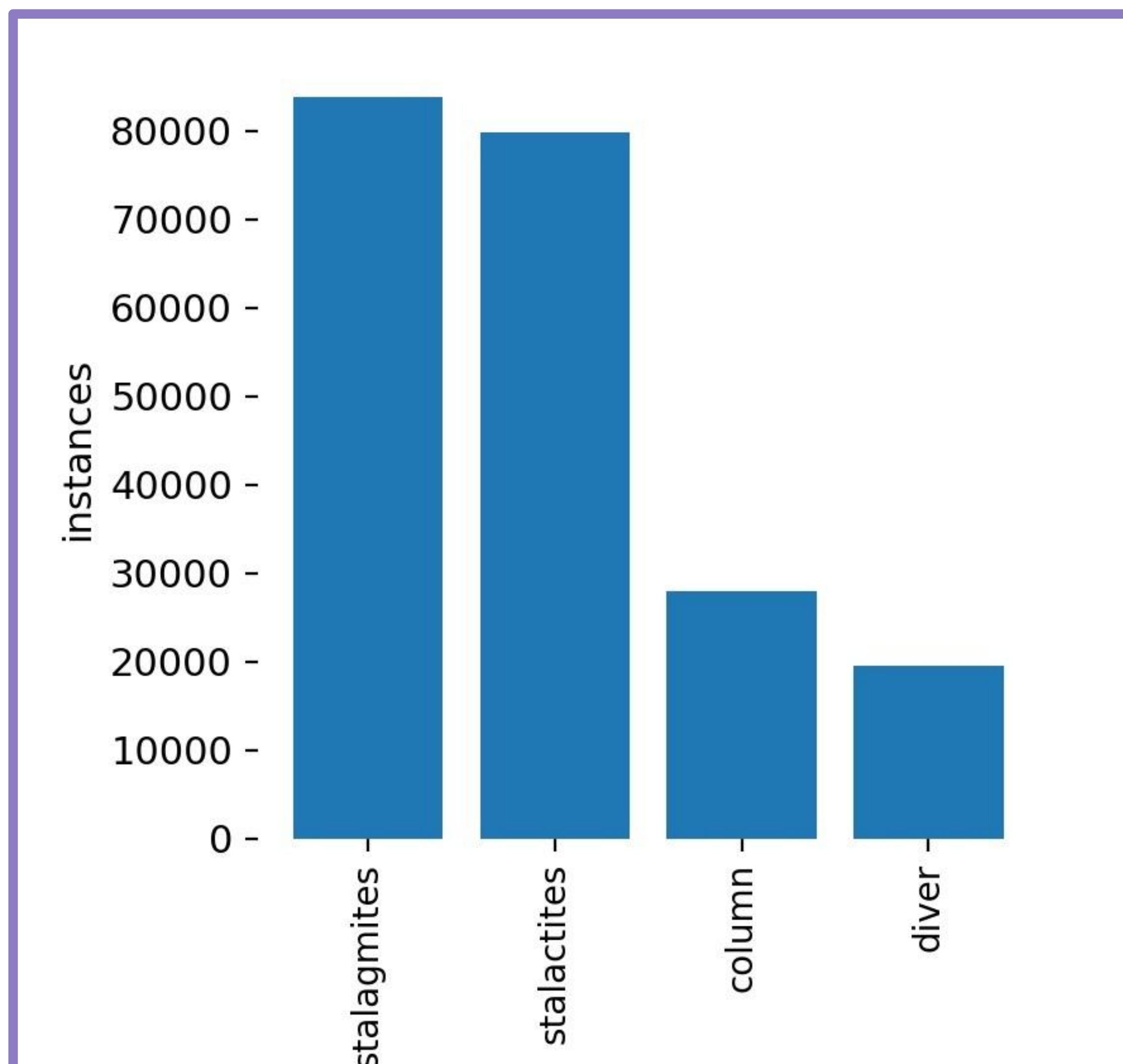


Fig. 5: Distribution of classes in training data.

Conclusion

- A major limitation of this model is the lack of training data quantity and quality.
- In the future when AQUA2 is performing cave diving missions collected data can be used for further training.
- Next step is to modify the network structure to tailor it to the underwater cave environment.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 2050896.

References

[1] M. Xanthidis, N. Karapetyan, H. Damron, S. Rahman, J. Johnson, A. O'Connell, J. O'Kane, and I. Rekleitis, "Navigation in the presence of obstacles for an agile autonomous underwater vehicle," in IEEE International Conference on Robotics and Automation, Paris, France, 2020, pp. 892–899.