# Advancing AI-Vision-enabled microplastic monitoring through novel YOLO model development and underwater 3-D Imaging

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ASET-REU

## INTRODUCTION

- Microplastics (<5 mm) are a major environmental threat to human health and ecosystems
- The large portion of microplastics is derived from riverine systems, however this area is under-researched
- Furthermore, current microplastic detection methods are asynchronous and laboratory-based while technologies for accurate, real-time detection remain under-researched

Research Context:

Previously, the Imtiaz lab designed a two-dimensional camera system for underwater capture of microplastics, and trained and developed a You Only Look Once (YOLO) v5-based deep learning model to detect the presence and calculate the velocity of underwater microplastics.

## GOALS AND EXPECTED RESULTS

Study Objectives

1) Upgrade software to receive data from 3D camera system to improve size and velocity calculation.
2) Train, implement, and assess YOLOv8-based deep learning model accuracy and precision for underwater microplastic detection.
3) Deploy YOLOv8 model on a small-sized single-board computer for real-time microplastic detection.

We expect improved accuracy in microplastic size and velocity calculations using 3D camera data, and a faster, higher-performing YOLO model for microplastic detection, especially smaller objects. Findings from this research may inform environmental monitoring and protection efforts against microplastic pollution.

## METHODS

### A. Experimental Setup & Data Collection

- Data collection was performed in the 12 by 0.45-meter wide, recirculating open channel flume in Clarkson University's water resources lab (Fig. 1)
- Data was collected at five water velocities: 10cm/s, 20cm/s, 30cm/s, 40cm/s, 50cm/s microplastics of size 1mm, 2.5mm, and 5mm were released at varying distances from 270-400mm away from the camera.

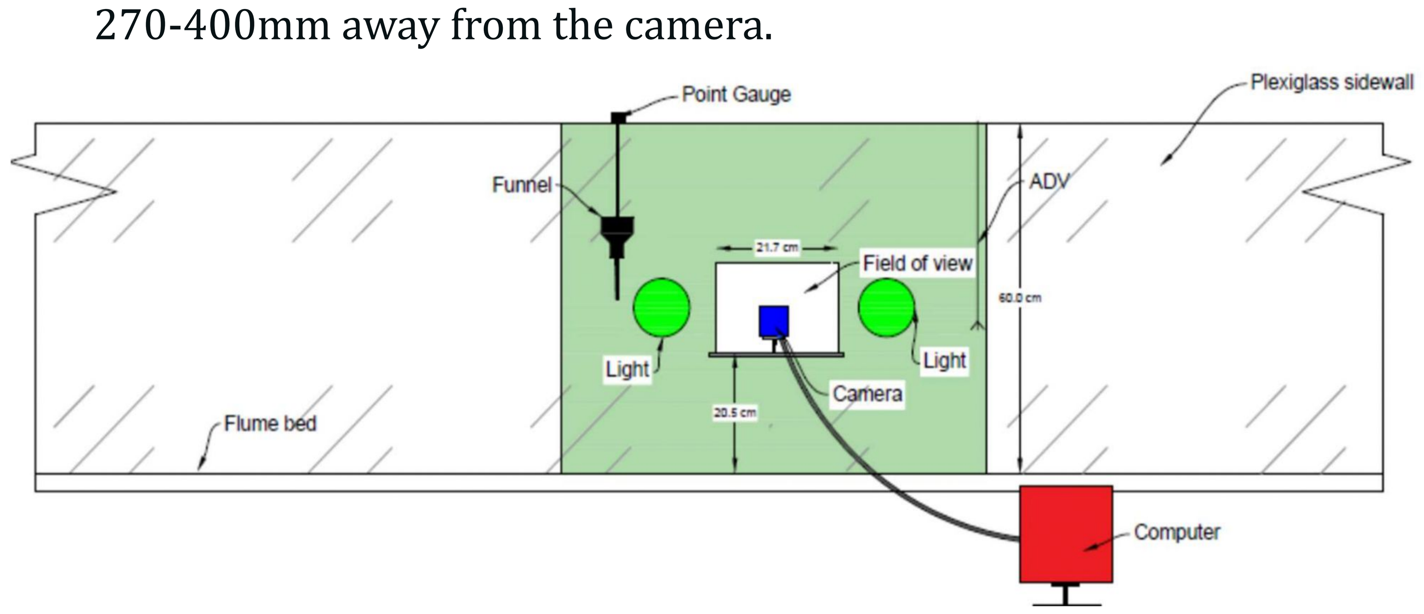


**Fig 1.** Schematic representation of experimental setup for data collection

## METHODS (cont.)

- Image capture was performed by two two-dimensional cameras: the fixed-focus See3CAM_CU135 camera and the auto-focus See3CAM_160 camera (Fig. 2), and one three-dimensional camera: the Intel RealSense Depth Camera D435, which has a stereoscopic depth sensor
- All cameras were housed in a waterproof casing and attached to two LED lights to maximize visibility and quality of image capture

### B. Image Acquisition and Training

- 2000 images were collected using the three-dimensional camera system.
- Next, images were annotated using the open-source software LabelImg, then separated into into train, test, and validation (80%,10%,10%) datasets
- These datasets were used to train the newly implemented YOLOv8-based model with a batch size of 16, learning rate of 0.01, and 200 epochs.

With the model trained, the next steps were to:

- Perform YOLOv8-based model inference on the 3D images obtained from the Intel RealSense camera.
- Implement software to extract RGB images and depth information from the Intel RealSense camera
- Integrate the YOLOv8-based detection algorithm with the DeepSORT tracking algorithm
- Using complete system, perform microplastic size and velocity calculations

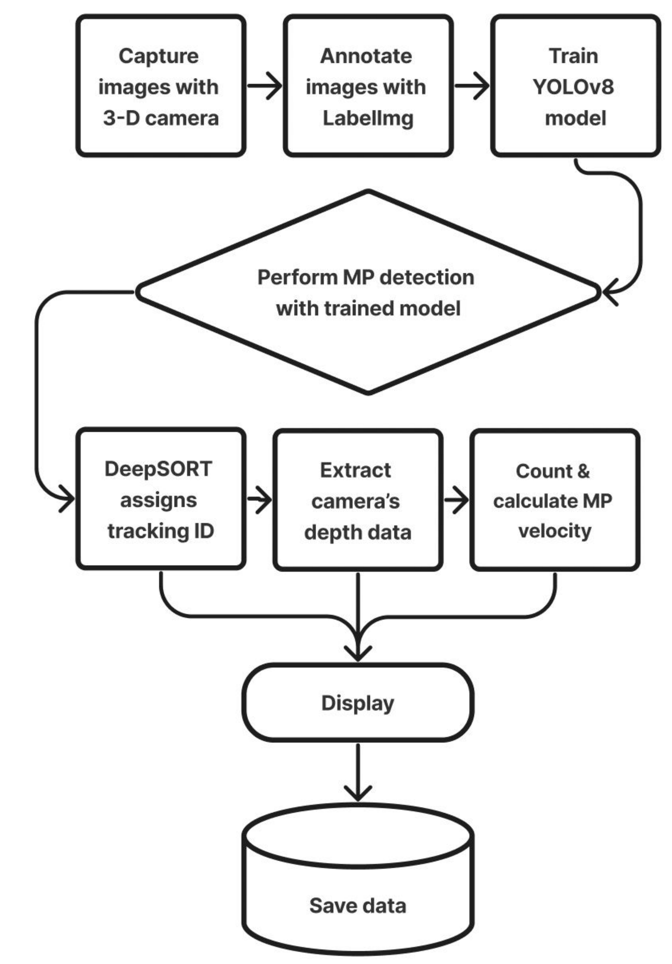


**Fig 4.** Flowchart of developed methodology

## RESULTS & DISCUSSION

Ultimately, the results demonstrate the ability of a YOLOv8-based system to more accurately detect small-sized microplastics, and a need for improved accuracy in microplastic velocity calculations.

- The current 2d-camera based system was inaccurate in its velocity calculations, with all median velocities showing greater values than the water velocities (Fig.5)

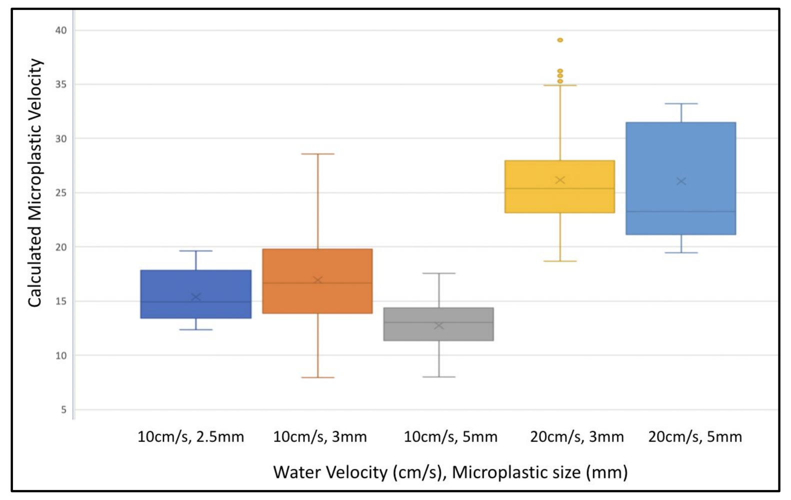


**Fig 5.** Variance in water velocity calculations based on two-dimensional camera system

- As it is not theoretically possible for microplastics to be moving at a greater horizontal velocity than the water flow, this demonstrates error in size and/or velocity calculations
- Hence, this highlights the need for a 3d-camera based system, which can integrate depth and therefore accurate size measurements into microplastic velocity calculations

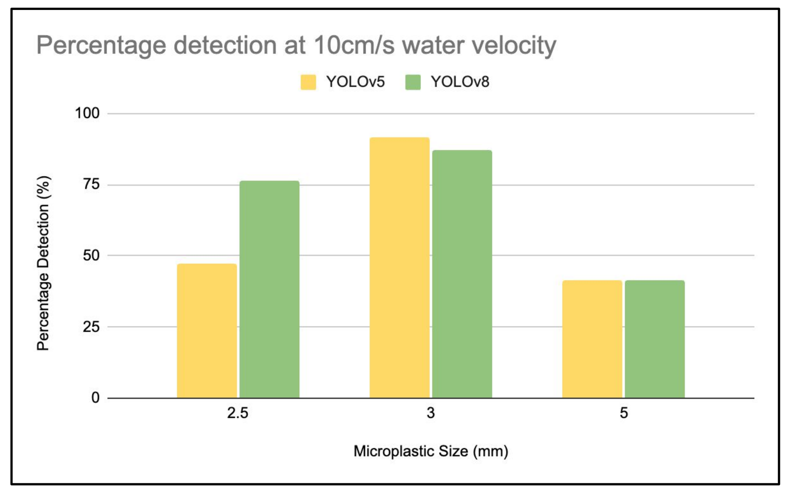


**Fig 6.** Percentage detection by YOLOv5 vs. YOLOv8 models at a water velocity of 10cm/s

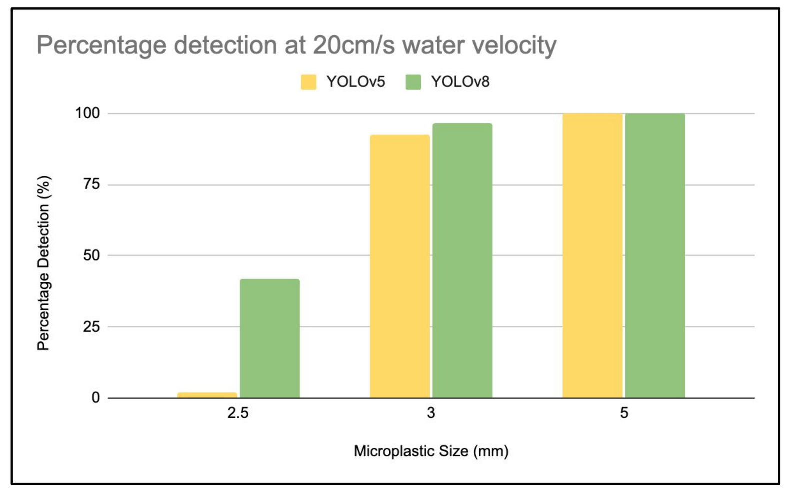


**Fig 7.** Percentage detection by YOLOv5 vs. YOLOv8 models at a water velocity of 20cm/s

- The new YOLOv8-based model detection system was able to produce promising results for detecting small-sized microplastics:
  - At 20 cm/s, the YOLOv8-based model was slightly more accurate (4%) in detecting 3mm size microplastics, however it was 5% less accurate in doing so at 10cm/s
  - Most notably, the YOLOv8-based model was significantly more accurate in detecting the smallest size microplastics (2.5mm), with 60% greater detection accuracy at 10cm/s, and 20x accuracy at 20cm/s.

## CONCLUSION

Overall, our research findings displayed a need for more accurate microplastic velocity algorithms through the potential usage of 3D camera systems, and the potential of a YOLOv8-based deep learning model to detect smaller-sized microplastics with greater accuracy.

<u>Future work and applications</u>

- The newest YOLO model, YOLO-NAS, can be trained and implemented for potentially higher precision and accuracy in detection
- Continued exploration of the camera system design, such as other 3D cameras, lighting sources etc.
- Performing data collection and object detection in real-world riverine environment - addressing issues such as turbidity, complex background etc.
- This camera system and detection algorithm has applications to other areas in ecology, such as fish detection.

## REFERENCES

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2. Nelson, Joseph. "The Yolo Algorithm: A Guide to Yolo Models." Roboflow Blog, 25 May 2023, blog.roboflow.com/guide-to-yolo-models/.

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