# SUMMER 2025

## VISION PREPROCESSING

## Objective:

To enhance underwater gate detection by preprocessing the image dataset for better clarity and edge definition before training the object detection model.

## Tools Used:

* **Python 3.**
* **OpenCV:** For image processing
* **NumPy:** For kernel-based sharpening
* **VS Code + virtual environment (venv):** To safely manage dependencies

## Preprocessing Journey:

## 1. Initial Plan: Denoising

* Goal: Remove underwater noise and improve clarity
* Tried OpenCV's built-in: python
* **Result:** Images became **blurry**, especially around the gate edges
* Rejected: Denoising reduced useful details and didn’t help YOLO training

**2. Improved Strategy: CLAHE (Contrast Limited Adaptive Histogram Equalization)**

* Goal: Improve visibility of edges in low-light, underwater conditions
* Applied to the L-channel of LAB color space:

## clahe = cv2.createCLAHE(clipLimit=2.0, tileGridSize=(8, 8))

* **Result:** Significantly better visibility of gate frames; edge features became more defined

**3. Final Enhancement: Image Sharpening**

* Goal: Amplify gate structure and boundary contrast
* Used a simple sharpening kernel with OpenCV: python

## kernel = np.array([[0, -1, 0], [-1, 5, -1], [0, -1, 0]])

## cv2.filter2D(enhanced\_img, -1, kernel)

* Applied this **after** CLAHE
* **Result:** Visibly sharper gates, better candidate for object detection training

## Key Learnings:

* Denoising can **blur useful features** if overapplied, especially in low-contrast underwater data
* CLAHE is a **powerful contrast tool** that enhances gate structure without losing clarity
* Light sharpening **after CLAHE** boosts edge visibility further
* YOLO models benefit more from **enhanced clarity** than smoothed denoised inputs

## RESULTS

RAW IMAGE: AFTER DENOISING:

## A person in a swimming pool AI-generated content may be incorrect.

A person standing under water

AI-generated content may be incorrect.AFTER CONTRASTING: AFTER SHARPENING:

A person standing under water

AI-generated content may be incorrect.

## CONCLUSION:

After experimenting with multiple preprocessing techniques, CLAHE-based contrast enhancement combined with light sharpening provided the most effective results for underwater gate images. Unlike traditional denoising, which blurred critical features, this approach improved edge clarity without loss of detail — significantly aiding visual recognition. These enhanced images form the foundation for robust YOLOv8-based object detection and anomaly filtering in future training phases.