Computer Vision Enabled Dropwise Condensation Heat Transfer Measurement

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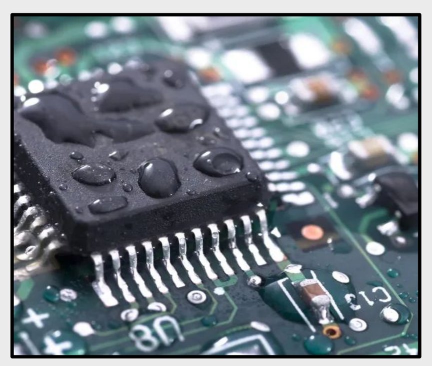
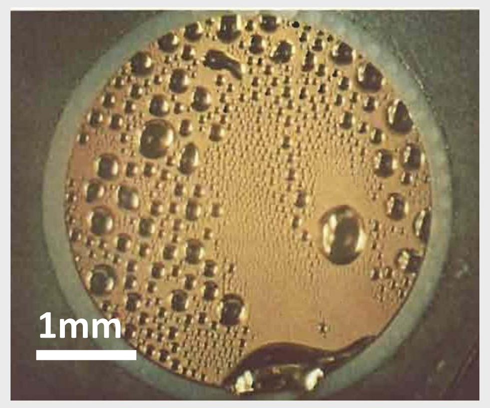
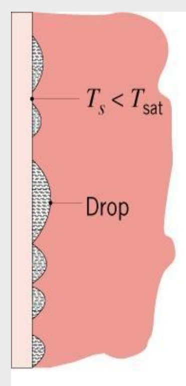
Abstract and introduction

- Condensation is a widely observed phenomena over a range of industries from electronic industries to desalination plants.
- Condensation occurs mainly through two methods - filmwise and dropwise.
- Dropwise condensation - Surface covered by droplets which coalesce, grow to a certain size and then slip away from the surface.
- Heat transfer rate for dropwise condensation (water) is 5-7x higher than that of filmwise condensation
- For complex surfaces, difficult to fit data to the conventional models, hence the use of computer vision and ML.







Expected learning outcomes

- Understanding of concepts related to heat transfer, such as condensation - specifically dropwise condensation.
- How surface characteristics impact the heat transfer coefficients and droplet size.
- Learning new computer vision techniques, machine learning algorithms.
- Use of the Ultralytics Yolov8 model and many of its functions.

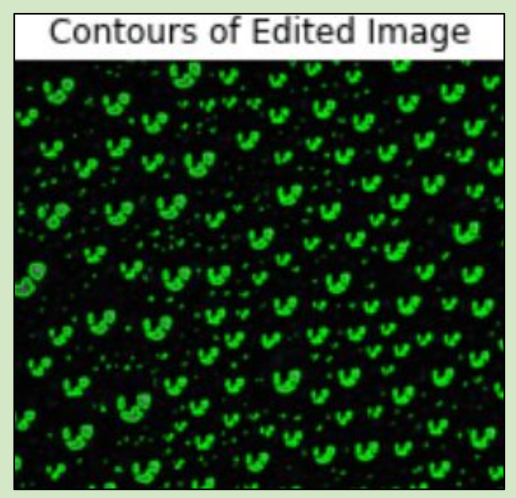
Objectives

Our main objective is to estimate the condensation heat transfer performance of droplets on various types of surfaces.
To achieve this, we need to:

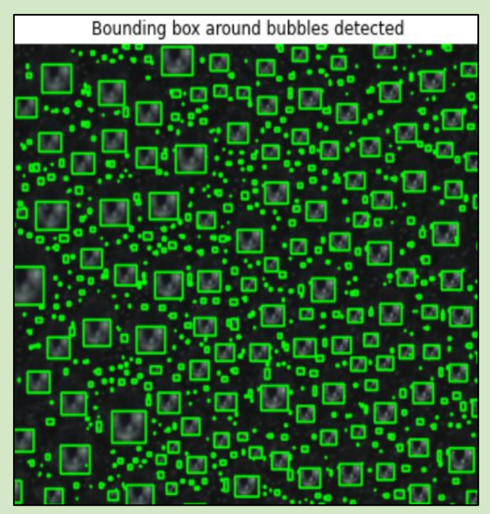
- Detect the presence of droplets on surface
- Track the movements and change in radius for each droplet
- Determine the radii and its growth rate for each droplet
- Calculate individual droplet's heat transfer to eventually get the total heat flux for that surface.

Current status

Processed raw images - contrast and colour effects, thresholding.
2 methods to detect droplets -

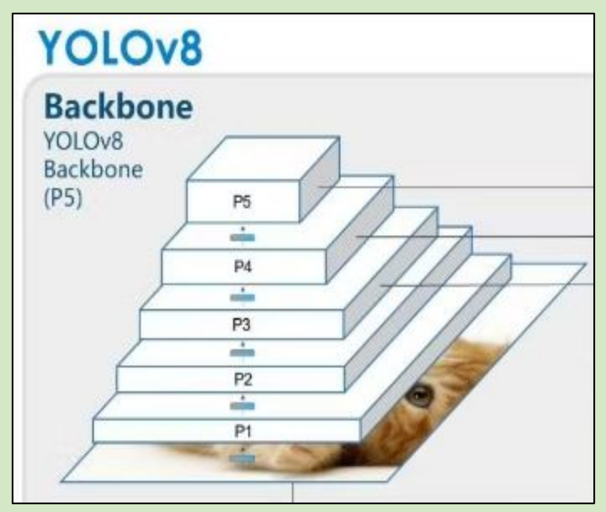


- **Using contour area method**:- The points having significant difference in intensity of colouration are identified. Contours are collection of such points. The contours detected from this method were U-shaped (from raw images). To neglect noise, contours with area < 5 units were neglected.

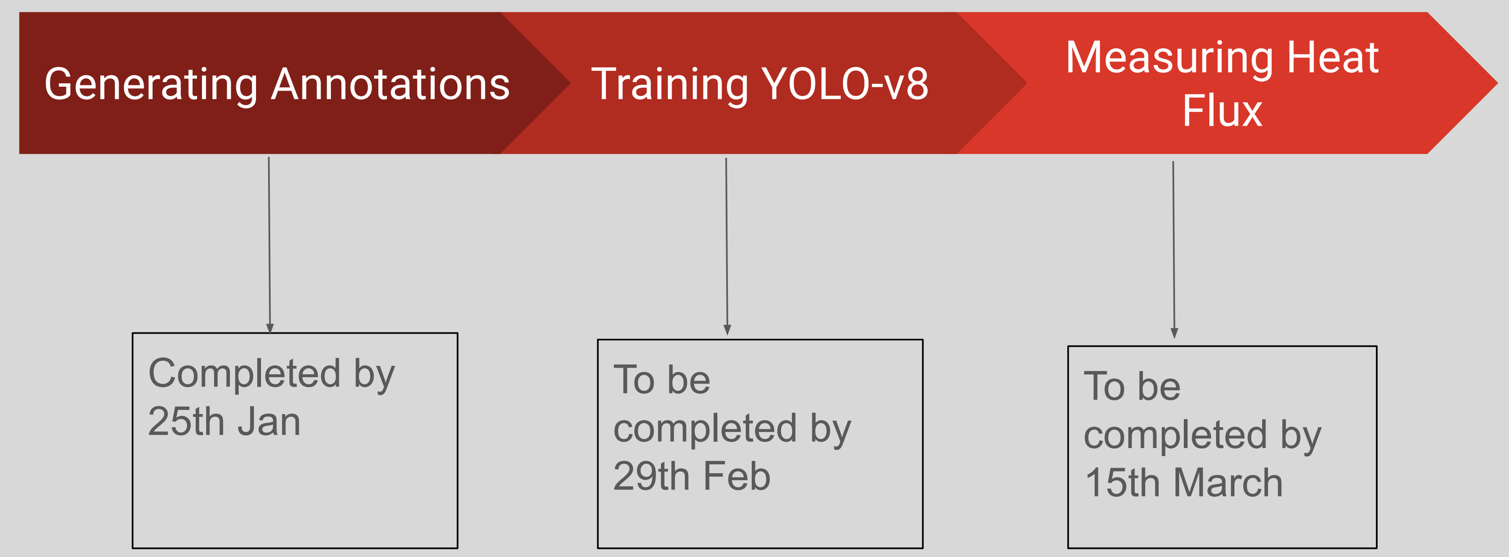


- **Using bounding box method**:- This method involves enclosing contours within the smallest possible rectangle that entirely contains them. This rectangle, known as the bounding box. For each box params like x_centre, y_centre, width, height are returned and stored as annotations for that image. The width of box is considered as radius of the bubble.

YOLO-v8 is Convolutional Neural Network (CNN) architecture with k = 3*3. It has 53 layers of convolutions, followed by fully connected layers. These layers are responsible for predicting bounding boxes, objectness scores, and class probabilities for the objects detected in an image.
Annotations and images are fed as training data. As final output, we get annotations for test image dataset.

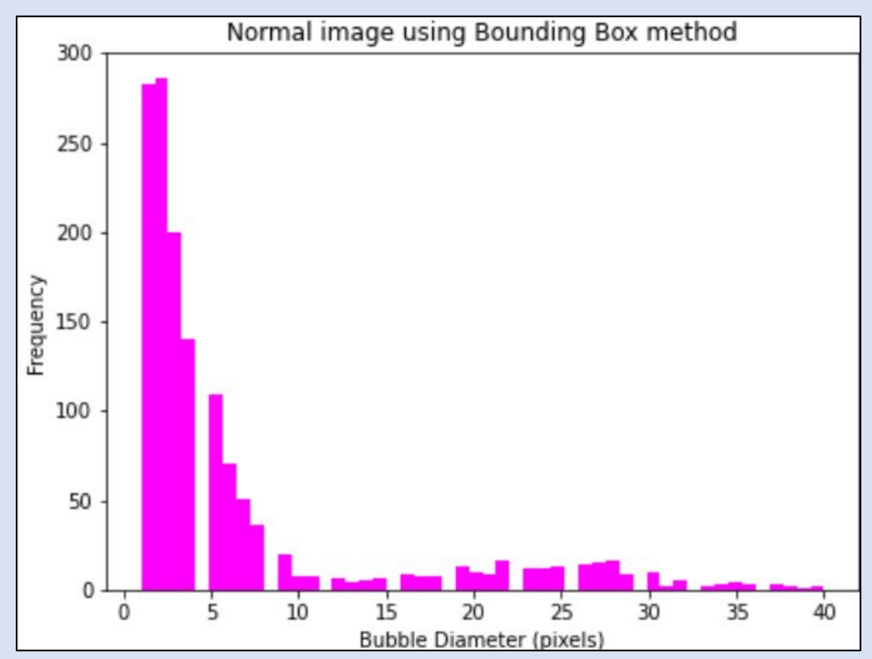


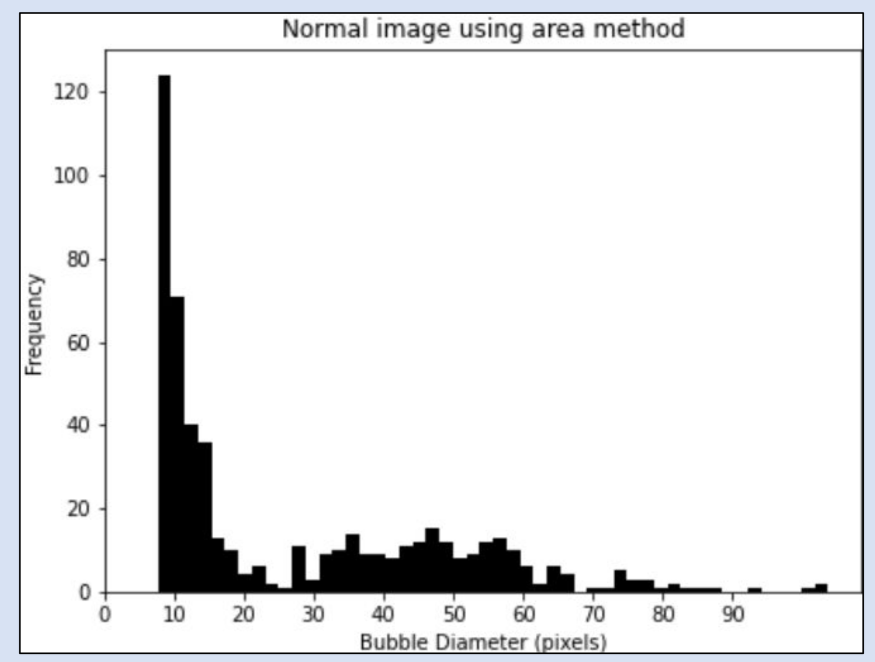
Workflow and Timelines



Results and discussions

It turns out that bounding box method works better than contour area method to detect bubbles and their sizes.





Acknowledgement & References

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