

# Image Feature Detection & Count Using Computer Vision

MS Data Science & Business Analytics

DSA/DSB/DSE 7500 - Summer 2020

Practicum Project Final Presentation

08 August 2020



WAYNE STATE  
UNIVERSITY



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# Introduction



# Team



**Kamrun Sumi**

MSDSBA Advanced Analytics



**Karim Alhusaini**

MSDSBA Advanced Analytics



**Mathai Paul**

MSDSBA Advanced Analytics



**Matt Seraj**

MSDSBA Data Driven Business



**Rajpal Virk**

MSDSBA Advanced Analytics



# Faculty



**Dr. Yanchao Liu**

Assistant Professor



**Dr. Murat Yildirim**

Assistant Professor



**Dr. Sara Masoud**

Assistant Professor



# Sponsor



**Ben Messick**

Corporate Strategy Deployment Manager



**Stan Patterson**

VP of Operations



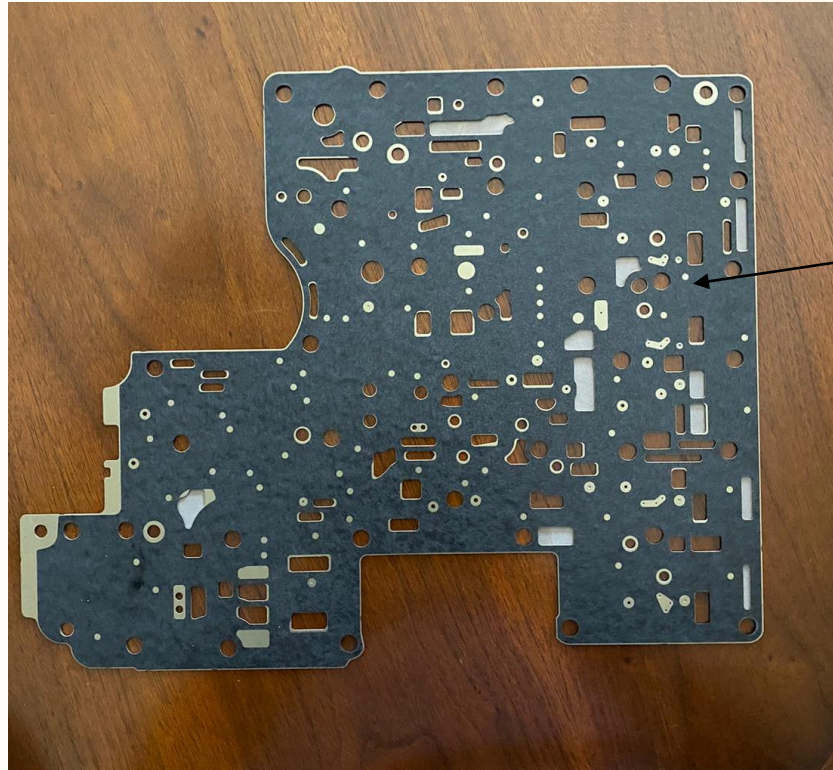
# Project Details



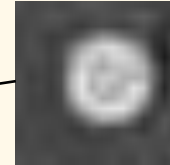


# Project Objective

Use machine learning to identify and count the instance(s) of a certain feature present in the object image



Input Image



Feature



Output Image





# Project Deliverables

- Python script that takes a set of 2 images (source image and feature image) as input and results in the correct count of a certain feature as output
- Literature review and documentation related to Python code application

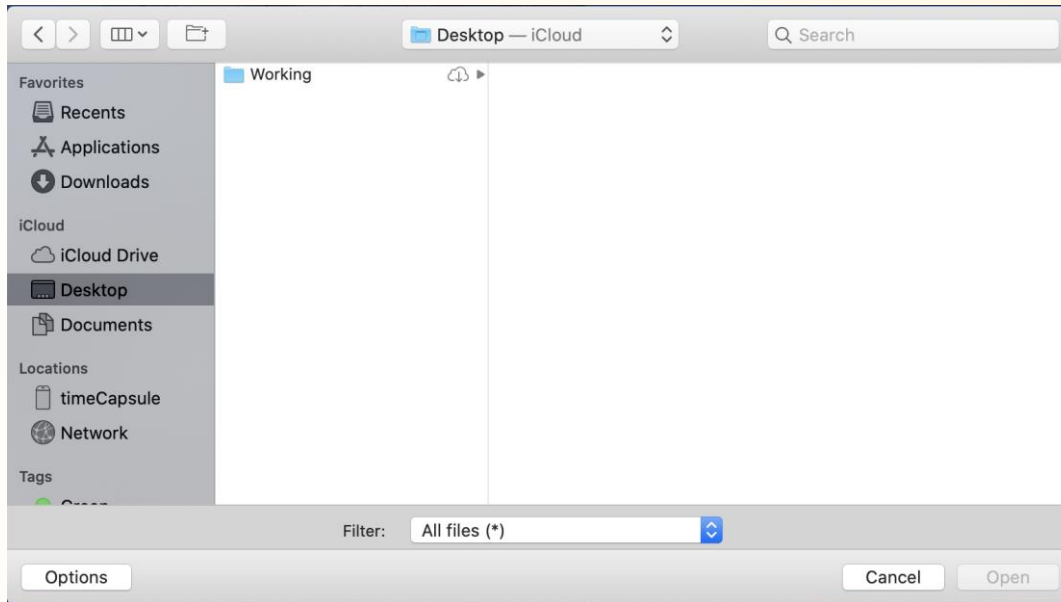
## Deployable Features

- **Based on open-source libraries:**



# Deployable Features (cont'd)

- **Support for GUI:**



- **Highly Dynamic:**

- Works on any given part and detects any selected feature

- **Highly portable:**

- Cross-platform compatibility with different operating systems, primarily Android



# Business Value

- Process improvement & proof of concept project

Current Process		Proposed Process
01	Manual feature detection & count process	Automated feature detection & count process
02	Lack of real-time feedback of detection results	Real-time feedback of detection & accuracy results
03	Image data collection is limited to rejected parts only	Complete image data collection of every inspected part



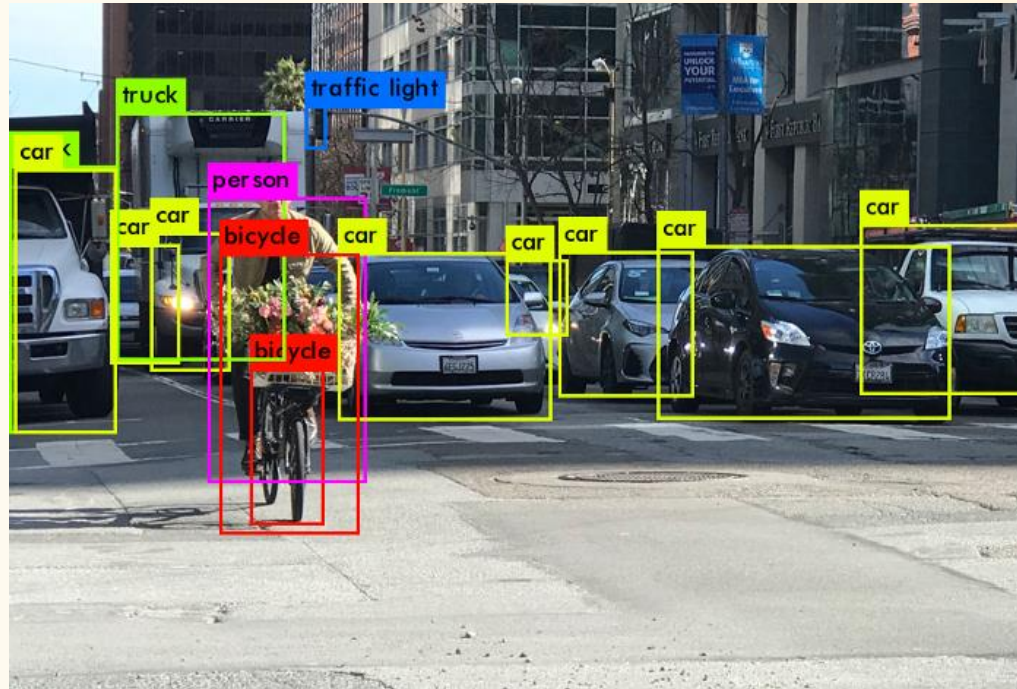
# Technical Details



# Techniques Researched

- **YOLO Object Detection**

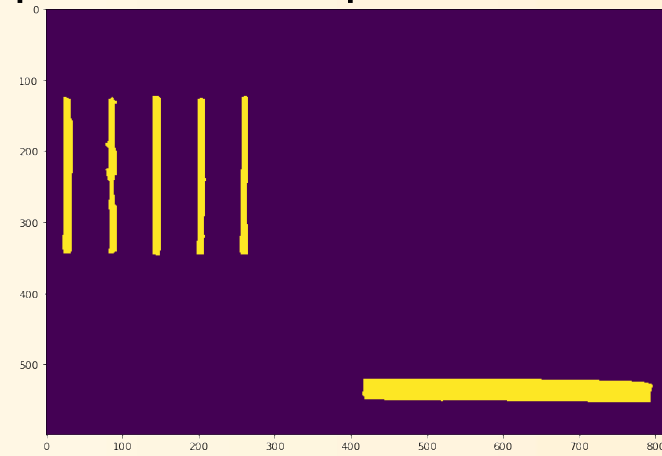
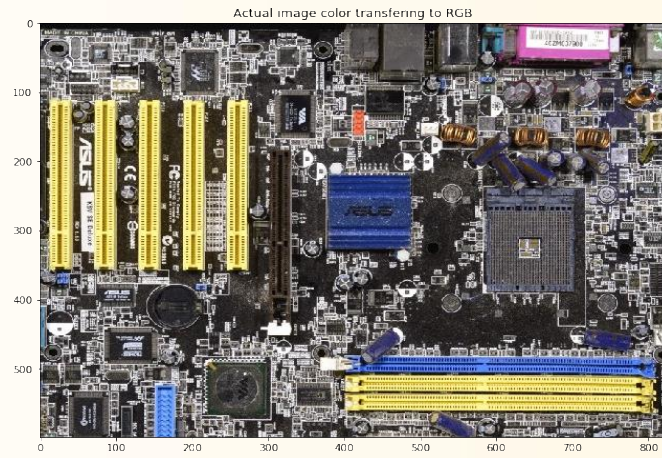
- **Method:** Fast and real-time object detection using pre-trained models
- **Limitation:** Lack of optimized pre-trained models for most industrial parts



# Techniques Researched (cont'd)

- **HSV Color Space & BLOB Detection**

- **Method:** Feature detection and count using HSV color parameters and BLOB detection
- **Limitation:** Sensitive to color variations and requires manual parameter tuning



- **One-shot Learning**

- **Method:** Learns information about object categories with one or a few training images
- **Limitations:** Slow training process and no single model generalizes well on all parts





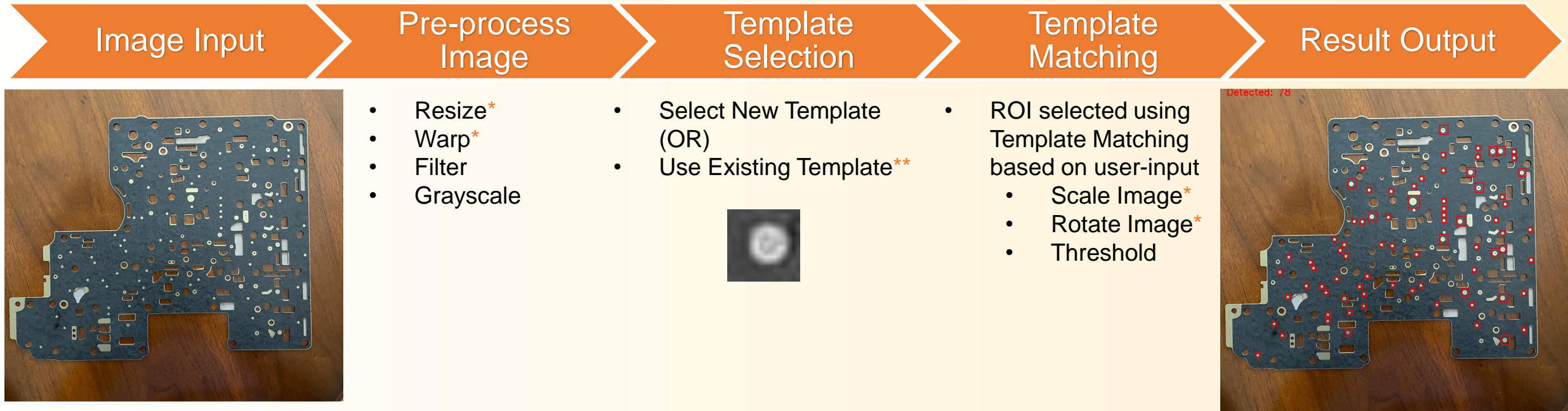
# Technique Implemented

## Template Matching

- Pixel to pixel match between a template image (feature) and a source image (part)
  - ✓ **Dynamic** – No time-consuming model training required for different parts. Instead, a single algorithm generalizes well
  - ✓ **Batch Processing** – Single feature template can be used to process a large batch of part images
  - ✓ **Minimum Operator Input** – Key input requirement is feature template image to detect and count features in image data
  - ✓ **Real-time Result Output** – Images can be processed in as little as a few seconds
  - ✓ **Integration** – Integrates well as an extension to last year's practicum project



# Template Matching - Process Flow



\* Optional Input parameters

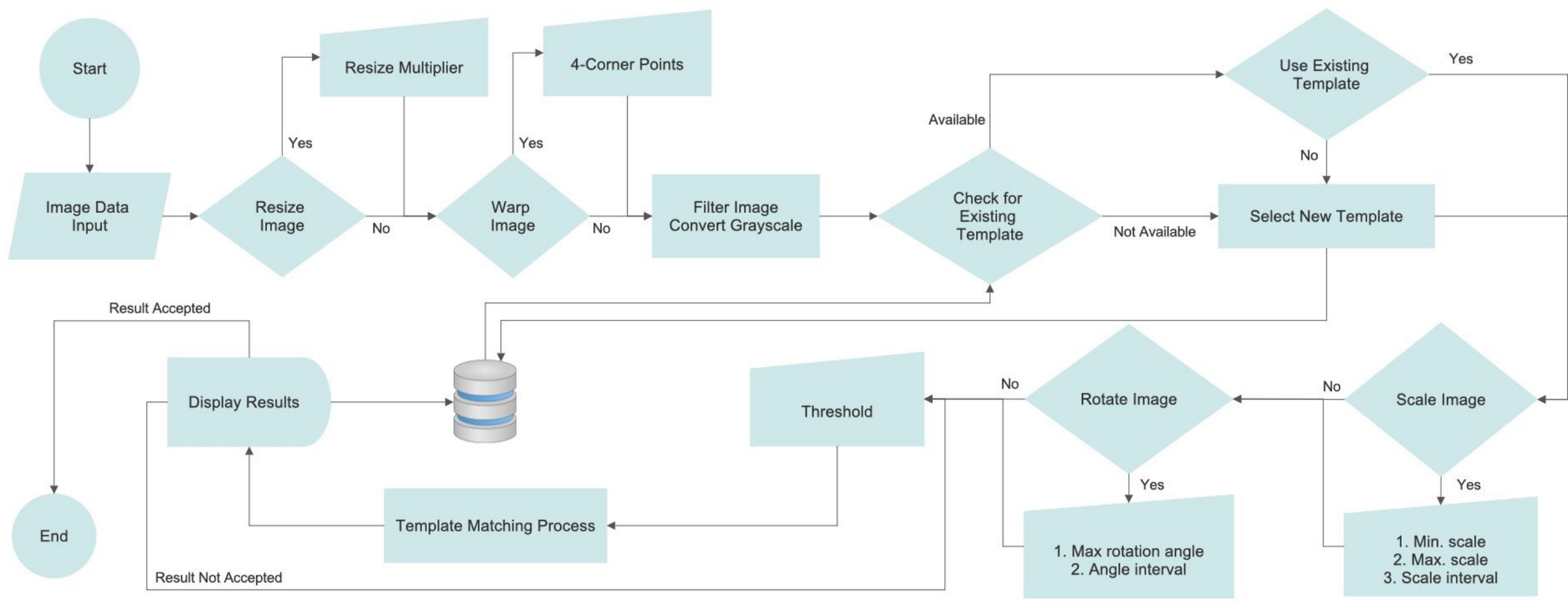
\*\* Use existing template for batch processing



# Demo Videos



# Template Matching - Process Flow



# Testing & Results

- Code tested on multiple images with different parameters
- Parameters tested:
  - Image resolution
  - Camera distance
  - Camera angle
  - Lighting & visual obstructions



Iphone+Template(IPhone)+Different_distance_NO_Scaling_Rotation							
Image Name	Angle	Interval	Threshold	Total Count	Template	Scaling	Rotation
r1.jpeg	360	5	0.82	5	picked from this	No	Yes
r2.jpeg	360	5	0.82	5	Same	No	Yes
r3.jpeg	360	5	0.82	0	Same	No	Yes
r5.jpeg	360	5	0.82	0	Same	No	Yes

Iphone+Scaling+Rotation+Template(Iphone)+Different_Distance							
Image Name	Angle	Interval	Threshold	Total Count	Time	Scaling	Template
r1.jpeg	360	5	0.82	5		0.2, 1.5, 20	Picked from it
r2.jpeg	360	5	0.82	5	Duration in minutes: 4.52	0.2, 1.5, 20	Same
r3.jpeg	360	5	0.82	5	Duration in minutes: 6.37	0.2, 1.5, 20	Same
r4.jpeg	360	5	0.82	1	Duration in minutes: 4.1	0.2, 1.5, 20	Same

Iphone_Rotation_No_Scaling+Template+Each_Image							
Image Name	Angle	Interval	Threshold	Total Count	Time	Resized	Template
r1.jpeg	360	5	0.8	5	Duration in minutes: 1.24	0.4	Itself
r2.jpeg	360	5	0.8	5	Duration in minutes: 1.5	0.4	Itself
r3.jpeg	360	5	0.8	5	Duration in minutes: 0.97	0.4	Itself
r4.jpeg	360	5	0.8	5	Duration in minutes: 2.1	0.4	Itself

Panasonic_Different_Device_Template_Rotation							
Image Name	Angle	Threshold	Threshold	Total Count	Template	Time	Resize
D1.jpg	360,5	(5)0.82	0.7	5	Iphone(r1)	Duration in minutes: 0.95	0.4
D2.jpg	360,6	(0)0.82	0.7	3	Iphone(r1)	Duration in minutes: 1.48	0.4
D3.jpg	360,7	(0)0.82	0.7	5	Iphone(r1)	Duration in minutes: 1.2	0.4
D4.jpg	360,8	(0)0.82	0.7	5	Iphone(r1)	Duration in minutes: 0.87	0.4

Panasonic_Rotation_Template_Panasonic							
Image Name	Angle	Threshold	Total Count	Template	Time	Resize	
D1.jpg	360,5	0.8	4	Picked from Panasonic	Duration in minutes: 1.12	0.4	
D2.jpg	360,6	0.8	1	Same	Duration in minutes: 1.34	0.4	
D3.jpg	360,7	0.8	4	Same	Duration in minutes: 0.87	0.4	
D4.jpg	360,8	0.8	5	Same	Duration in minutes: 1.04	0.4	

Panasonic_Rotation_Template_Each_Image							
Image Name	Angle	Threshold	Total Count	Template	Time	Resize	
D1.jpg	360	0.82	4	Itself	Duration in minutes: 1.12	0.4	
D2.jpg	360	0.8	5	itself	Duration in minutes: 0.9	0.4	
D3.jpg	360	0.8	4	itself	Duration in minutes: 1.77	0.4	
D4.jpg	360	0.8	5	itself	Duration in minutes: 2.4	0.4	

# Limitations & Recommendations





# Image Resolution Variations

## Limitation

- In batch processing, using a high-resolution template image to process low resolution input data (or vice-versa) can decrease the detection accuracy



Low Resolution Input Image  
Accuracy > 90%



Low Resolution Template  
Image



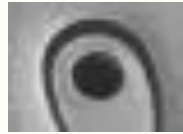
High Resolution Input Image  
Accuracy < 30%



# Image Resolution Variations

## Recommendations

- Select distinct new templates for both low-resolution and high-resolution batch image data



Low Resolution  
Template Image



Low Resolution Input Image  
Accuracy > 90%



High Resolution  
Template Image



High Resolution Input Image  
Accuracy > 90%

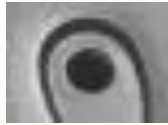


- Alternatively, the user can adjust the **threshold** parameter to increase accuracy

# Camera Angle Variations

## Limitation

- Processing Images captured at different angles using a template taken from a certain fixed angle can decrease the detection accuracy



Template Selected  
from Straight Image



Straight Image  
Accuracy > 90%



Angled-Image @ 15 degrees  
Accuracy > 85%



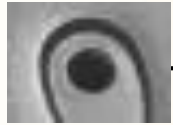
Angled-Image @ 30 degrees  
Accuracy < 50%



# Camera Angle Variations

## Recommendation

- Use new templates for images rotated more than  $\pm 8^\circ$



Template Selected  
from Straight Image



Straight Image  
Accuracy > 90%



Template Selected  
from Image @ 30°



Angled-Image @ 30°  
Accuracy >90%

- Alternatively, the user can adjust the **rotation**, **warping** and **threshold** parameters to increase accuracy





# Camera Distance Variations

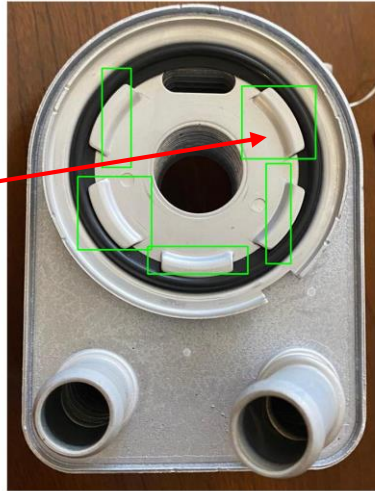
## Limitation

- Processing images captured at different distances using a template taken from a fixed distance can reduce detection accuracy



Template

Detected: 5



Original source image: 1 ft  
away  
>90% Accuracy

Detected: 5



2ft away  
>90% Accuracy

Detected: 1



3ft away  
<20% Accuracy



# Camera Distance Variations

## Recommendation

- Select new templates for images at distances more than 1.25 times of original distance
- Alternatively, the user can adjust the **scaling** and **threshold** parameters to increase accuracy



Template selected from  
image at 2ft distance



Image at 2ft distance  
Accuracy > 90%



Template selected from  
image at 3ft distance



Image at 3ft distance  
Accuracy > 90%





# Lighting & Visual Obstructions

## Limitation

- Strong light reflections / illuminations and obstructions can result in poor accuracy



Light reflection ceased  
detection of objects

Labels hid features that  
match with template



**Recommendation** - Retake images without light reflection and obstructions

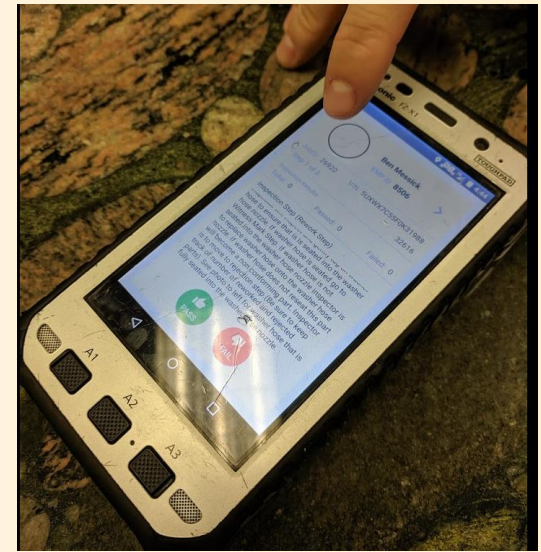
# Future Scope



# Future Scope

- **Android Application**

- Deploy python script to a production environment to be installed on an Android device, such as the Panasonic FZ-X1



- **ATCO 2019 Project Integration**

- Merge scripts from both projects to ensure captured images meet acceptable standards before applying the template matching algorithm

- **Image Database**

- Create an image database of inspected parts to be used for future Computer Vision projects that include supervised learning models



# Lessons Learned



# Lessons Learned

- Importance of identifying project deliverables and reaching an agreement among all project stakeholders
- Sensible & skill-based division of work
- Project management & planning
- Touch base multiple times a week
- Extensive literature review & research



# Questions?

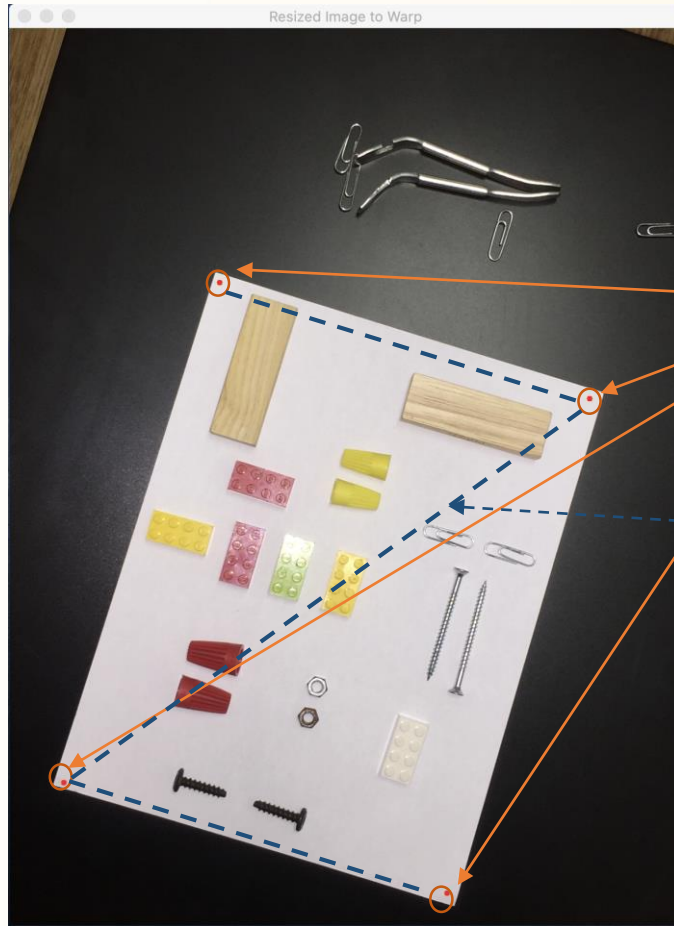




# Appendix



# Image Warping



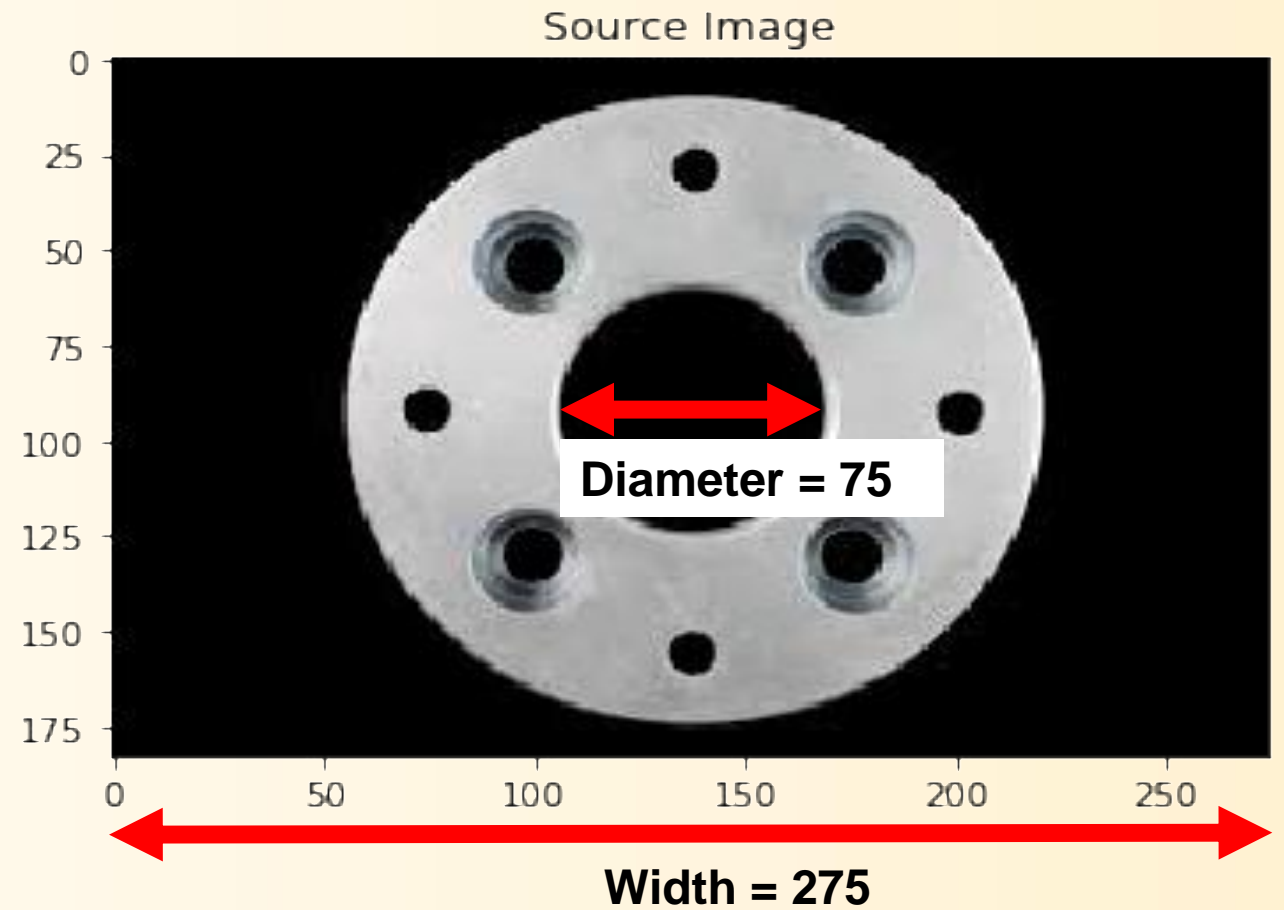
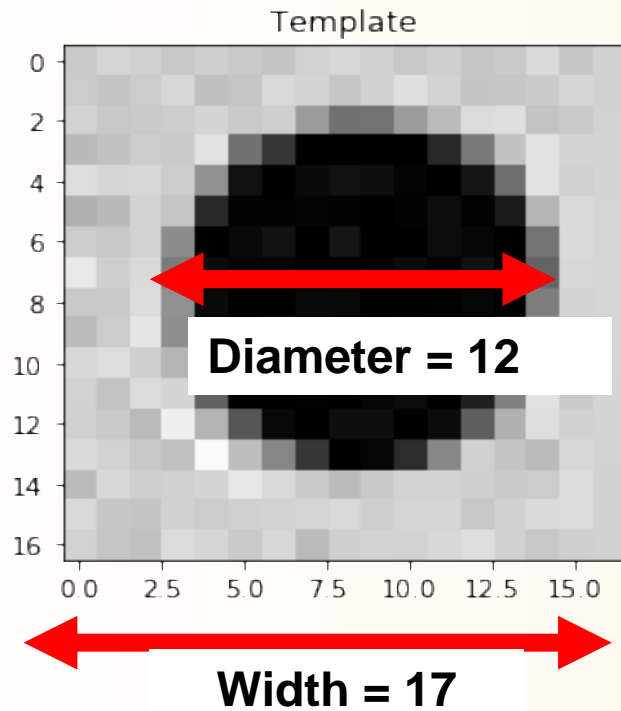
User selects 4 corner points to warp Image

4 points selected making z-pattern

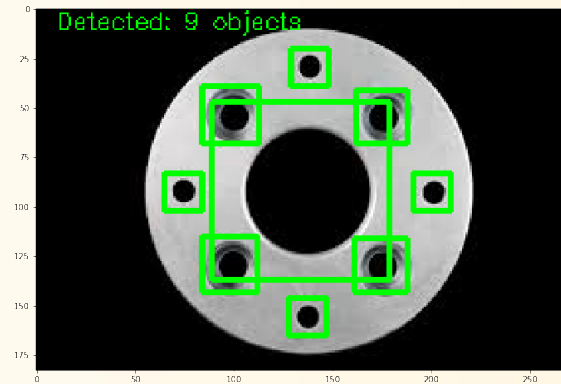
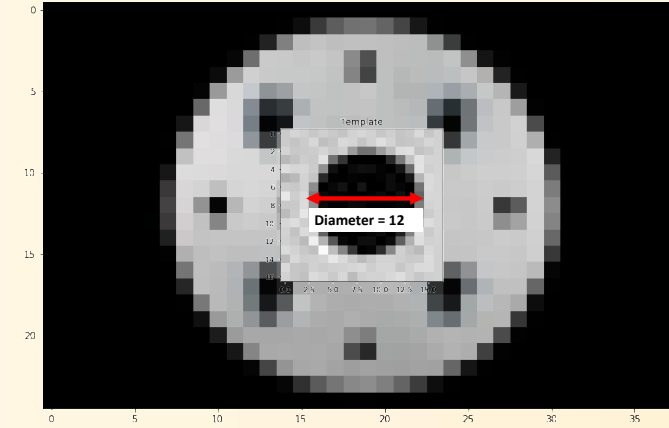
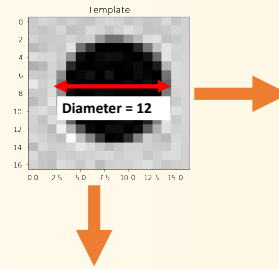
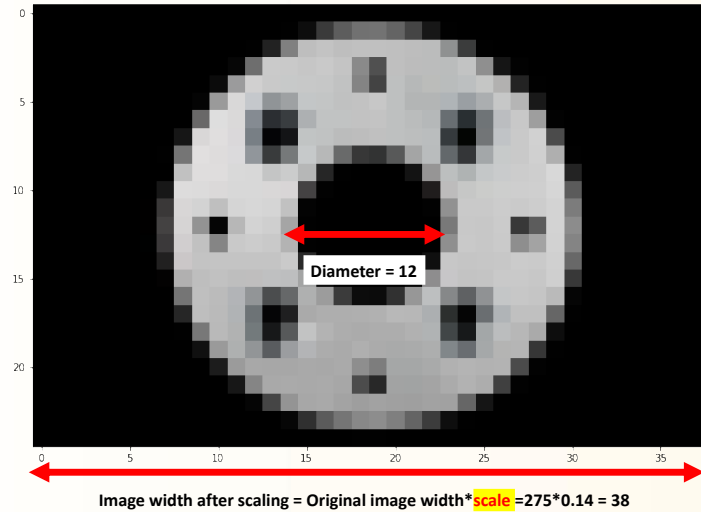
Selected 4 corner points on warped Image



# Image Scaling



# Image Scaling (cont'd)



# Image Rotation – Padding Effect

Source Image



Rotation W/O Padding



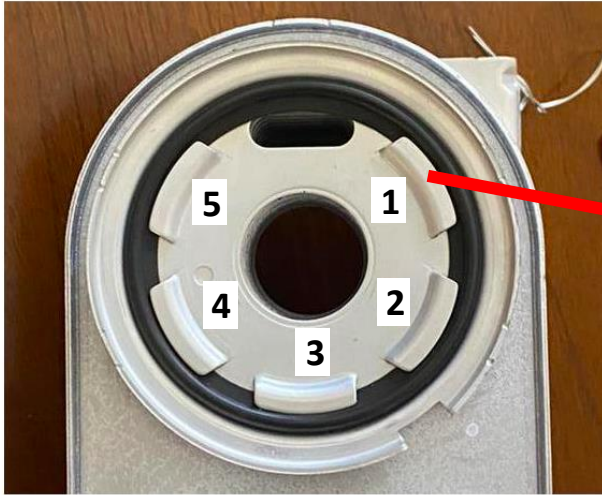
Rotation With Padding





# Image Rotation

Padded Source Image



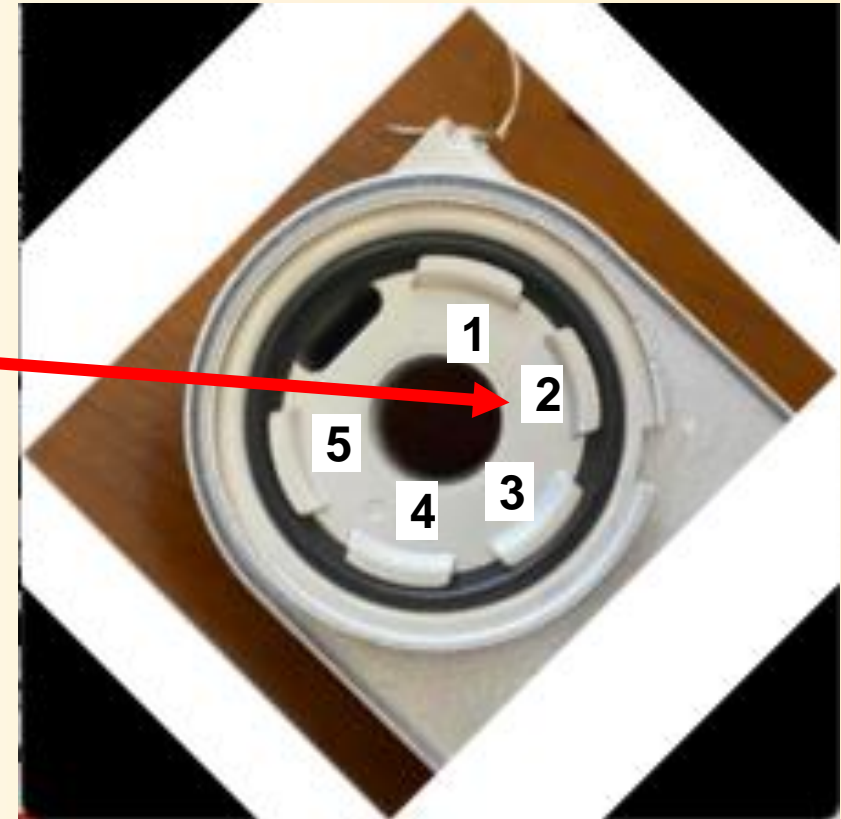
Template

$(x_0, y_0)$



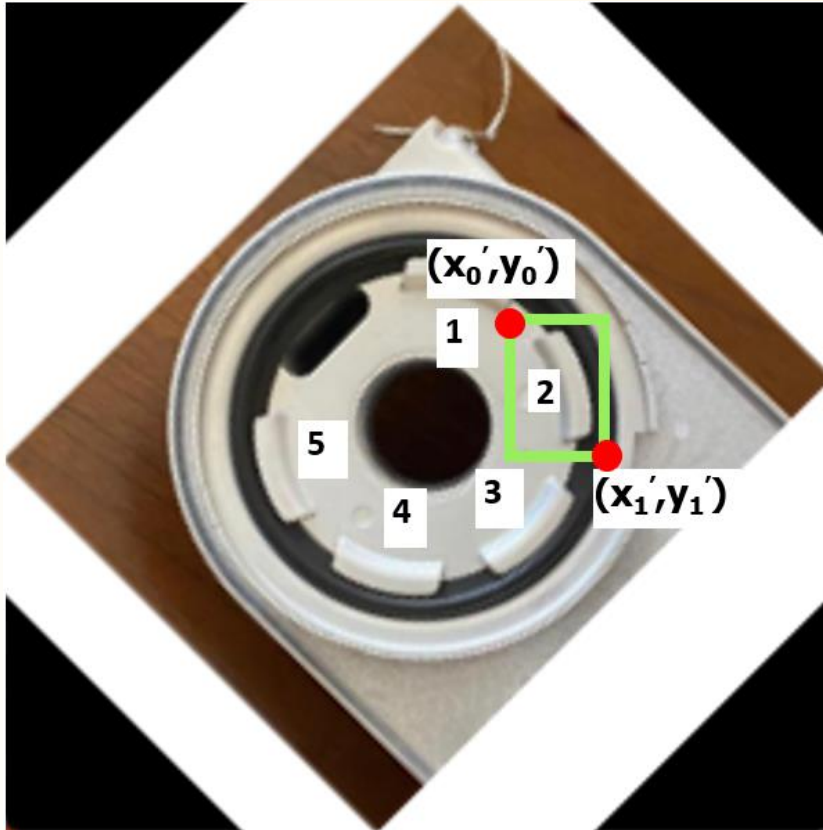
$(x_1, y_1)$

Rotate 45° CCW

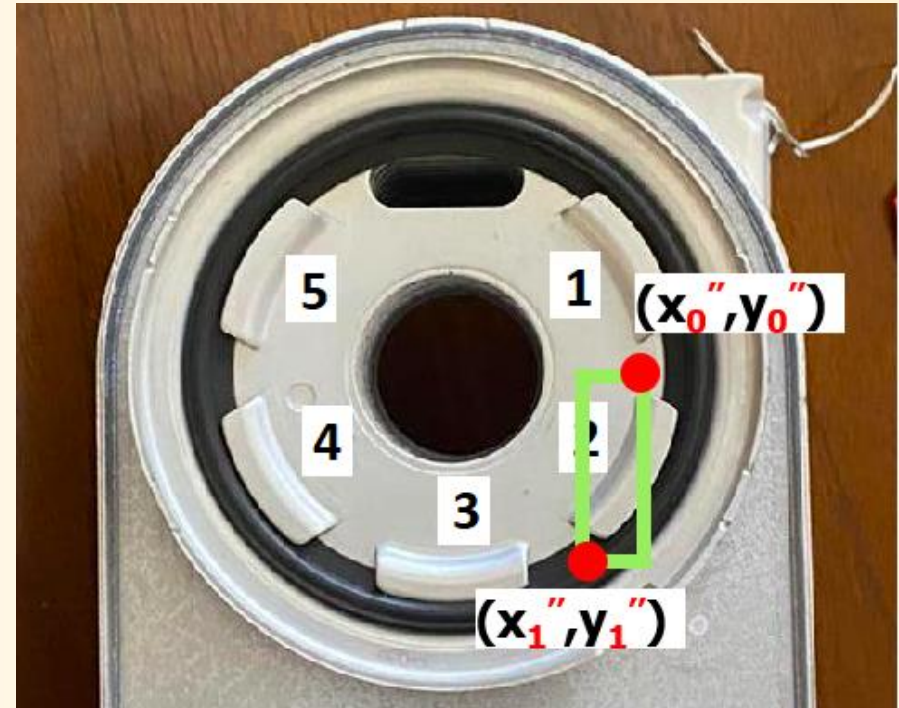


# Image Rotation (cont'd)

Rotate  $+45^\circ$  CCW



Rotate  $-45^\circ$  CW





# Image Rotation (cont'd)

