An Automated Inspection System for Hydraulic Control Unit Hose Assembly Using Deep Learning-based Object Detection

Data **a**nalytics and **i**ntelligent **S**ystems Lab

Changyeong Kim and Hyungun Cho

Advisor: Sudong Lee

Dept. of Industrial Engineering

University of Ulsan, Ulsan, South Korea

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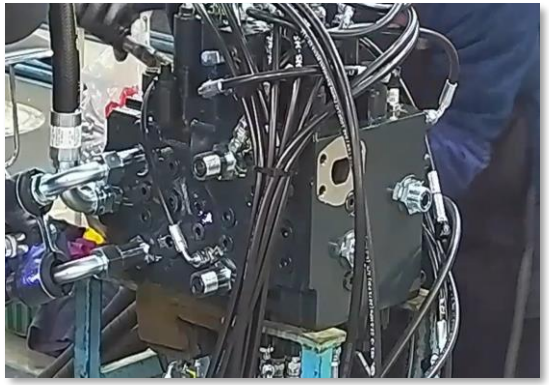
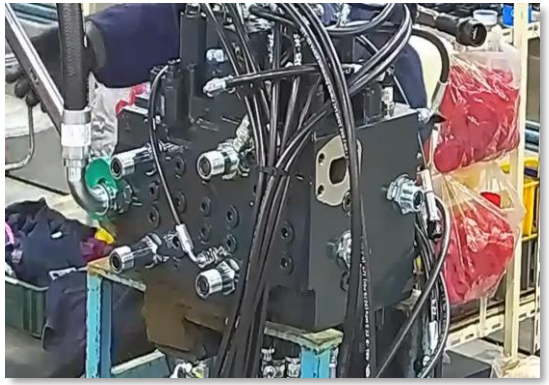
Project Introduction

AS - IS



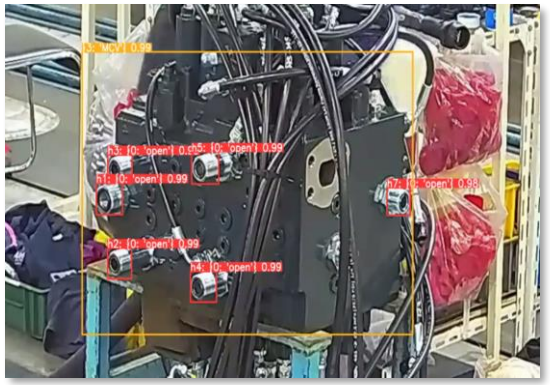
Hose connection



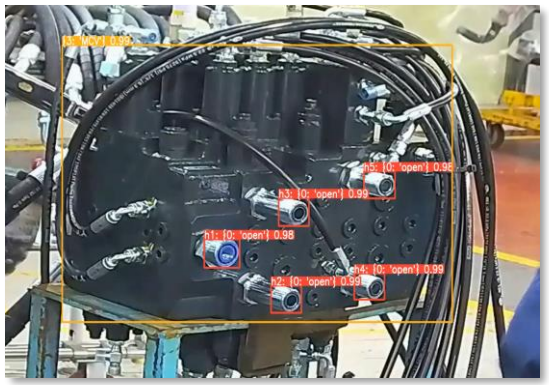
Assembling using a wrench

- Visual inspection by inspectors to assess product and functionality
- Determining task completion by direct marking made by the operator
- Occurrences of task duplication and omissions during operations.

TO - BE



CAM 1

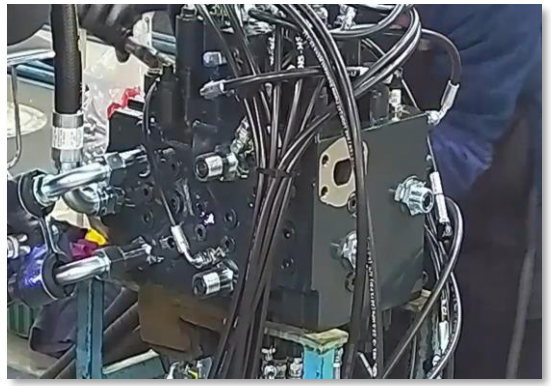


CAM 2

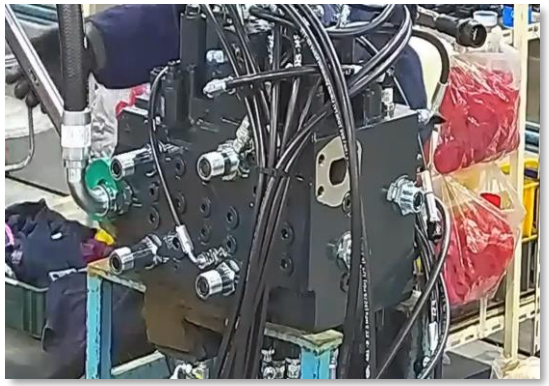
Development of automated inspection technology is necessary to address limitations in the current method of verifying engine hose connections.

Project Introduction

Overview



Hose connection

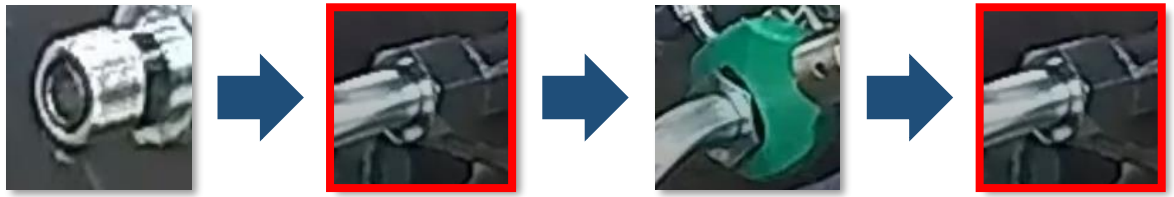


Assembling using a wrench

- Visual inspection by inspectors to assess product and functionality
- Determining task completion by direct marking made by the operator
- Occurrences of task duplication and omissions during operations.

Problem Definition

- Identifying points that have not been properly completed
- object detection model fails to distinguish and detect hose connection and assembly completed



Initial Status | Hose connection | Assembling using a wrench | Assembly completed

- Blind spots occurring due to the worker or other objects.

Automated Inspection System for Hydraulic Control Unit Hose Assembly

ATECH 주식회사 에이테크

Manufacturing site

CAM1 CAM2

Data collection and refinement

Annotation and labeling

Construction of a training dataset

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Automated Inspection System For Engine Hose Assembly

Object detection

ID Allocation

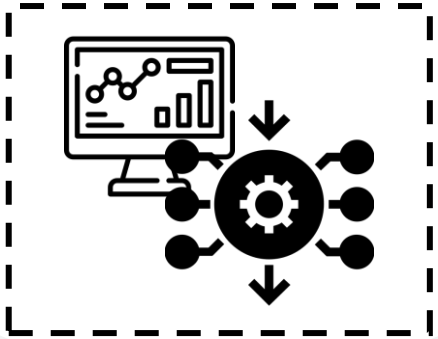
Assembly Status Transition

Multi-Angle

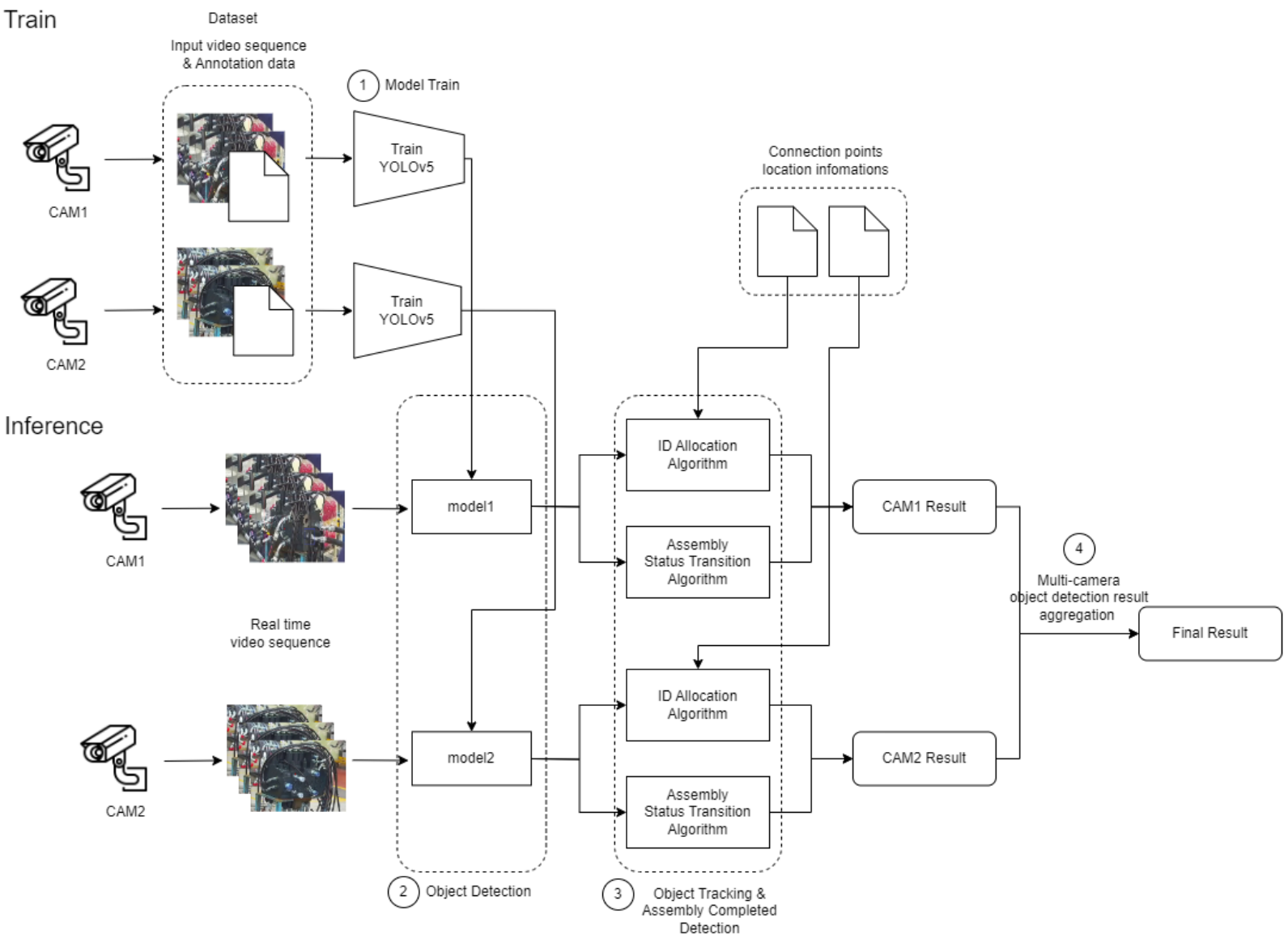
ATECH 주식회사 에이테크

RDBMS

Real-time monitoring



Automated Inspection System for Hydraulic Control Unit Hose Assembly



Study Method Object detection

- YOLOv5 for object detection
- Class abstract

0 : open

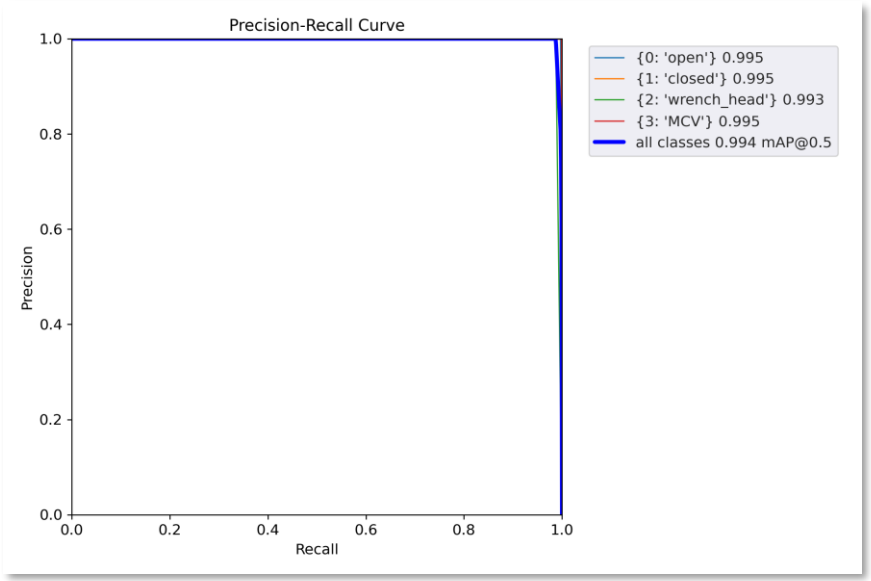
1 : closed

2 : wrench head

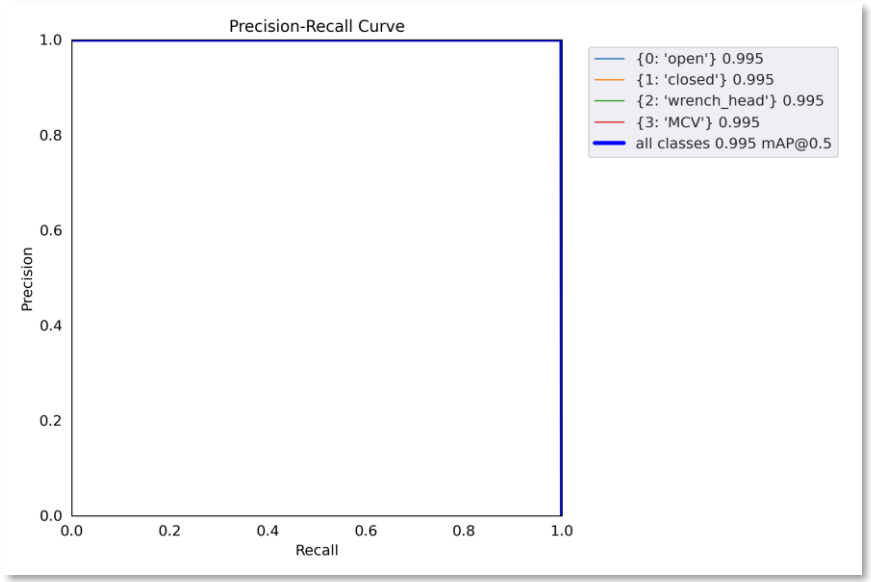
3 : MCV(engine model)

4 : completed

※ Added class 4 for detecting the final assembly status

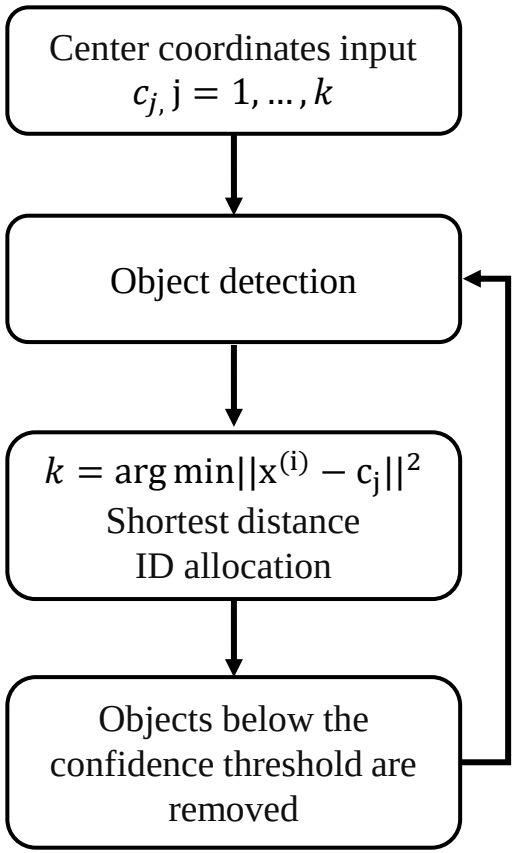


CAM1 PR curve



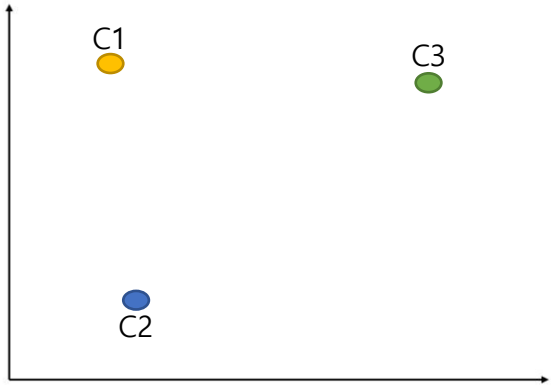
CAM2 PR curve

Study Method Shortest Distance ID Allocation Algorithm

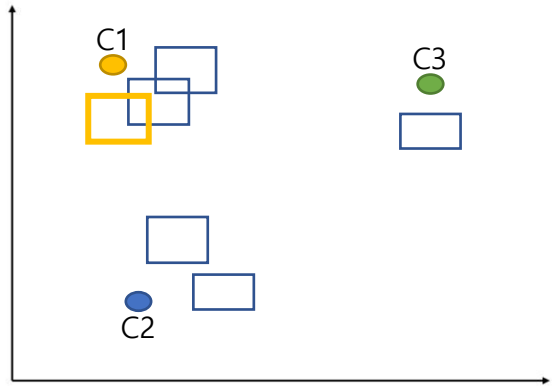


Iterating for each frame

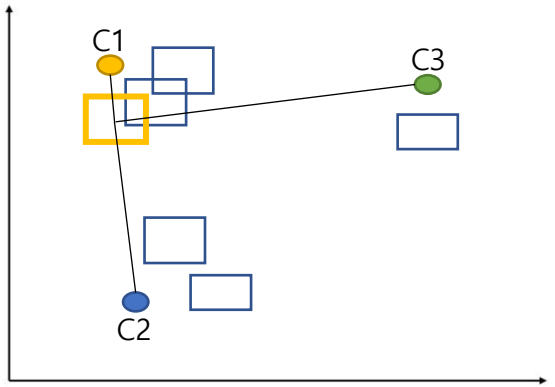
Shortest Distance ID Allocation Algorithm



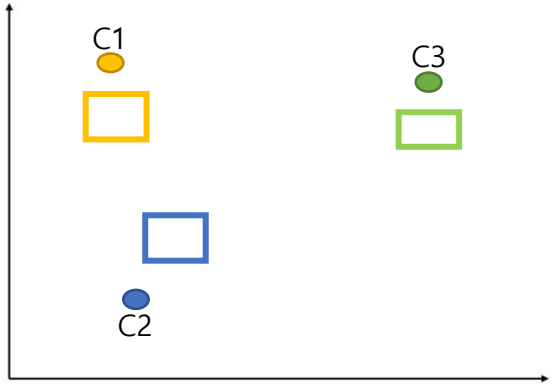
Center coordinates



Object detection



Shortest distance ID allocation



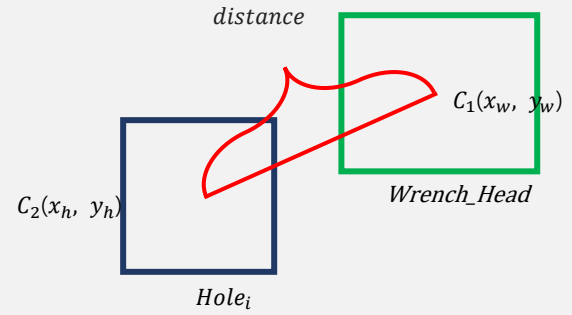
Objects below
the confidence threshold are removed

Study Method Assembly Status Transition Algorithm

Distance-based condition

If the distance between the detected hole and the detected wrench head is less than $epsilon$

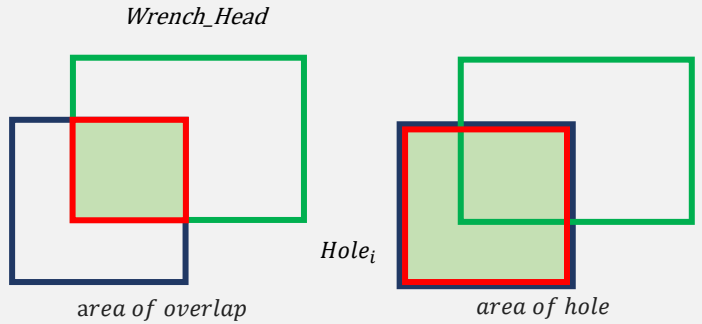
$distance = \sqrt{(x_w - x_h)^2 + (y_w - y_h)^2}$, $epsilon = 100\text{px}$



Area-based condition

If IOU between the detected hole and the detected wrench head is greater than threshold

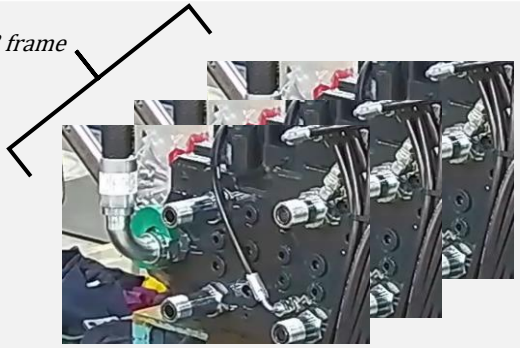
IOH = $\frac{area\ of\ overlap}{area\ of\ hole}$, IOH Threshold = 0.5



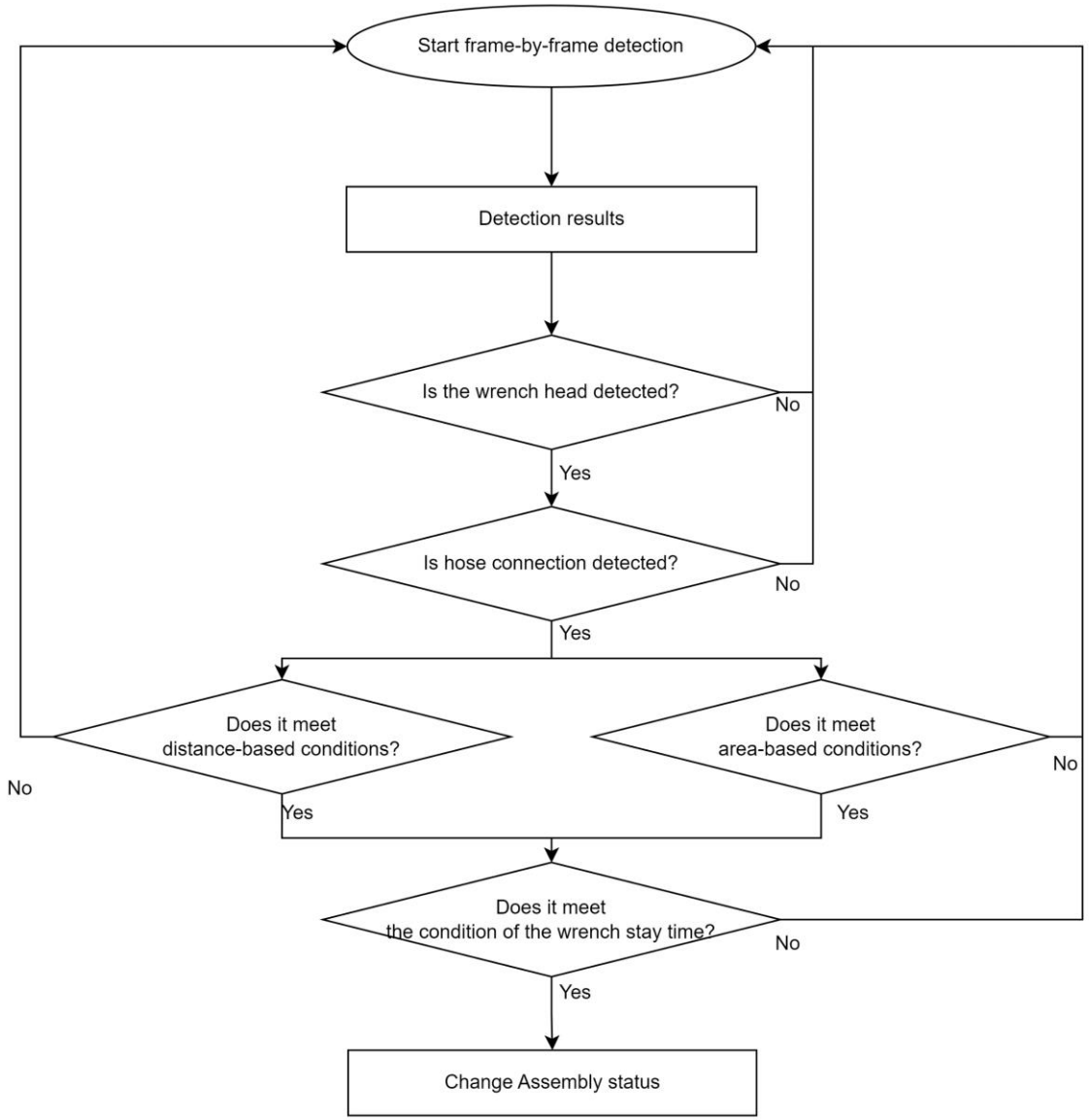
Wrench stay time condition

If the consecutive number of frames exceeds the Wrench Stay Time (wst)

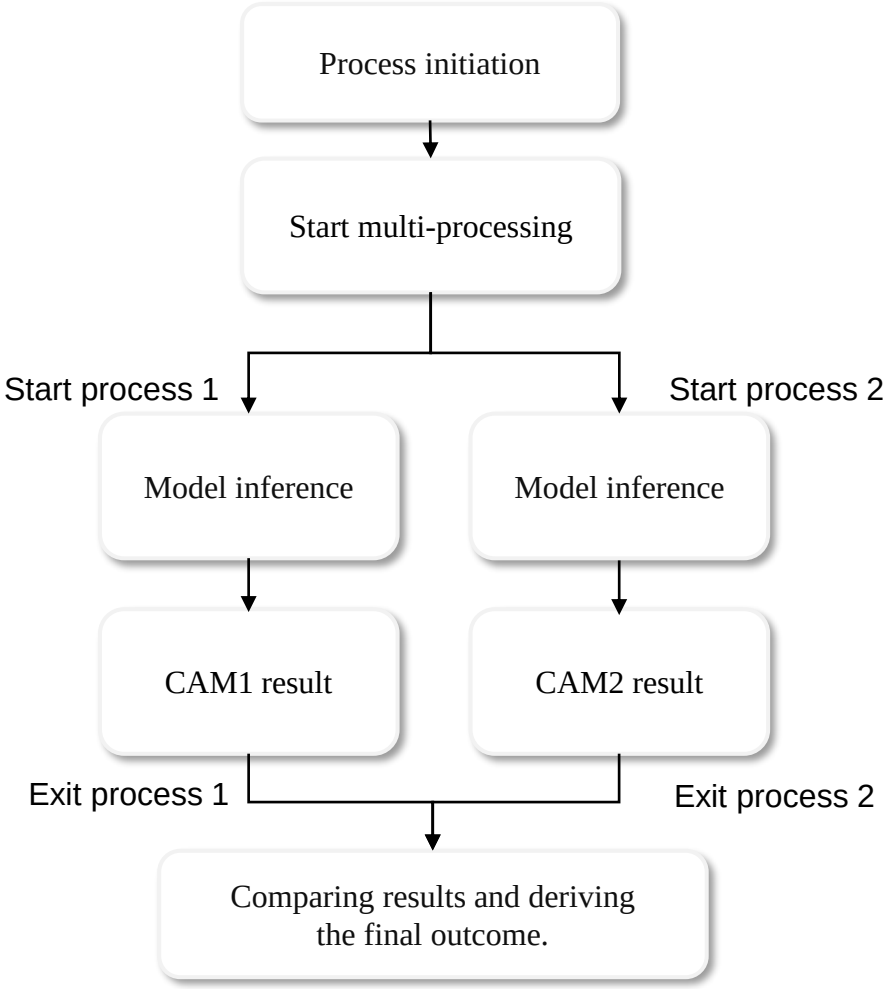
$wst = 3\ frame$



Study Method Assembly Status Transition Algorithm



Study Method Multi Angle



Multi Angle Algorithm

CAM 1

ID	Class (status)
H1	4
H2	1
H3	1
H4	4
H5	1
H6	4
H7	4

CAM 2

ID	Class (status)
H1	4
H2	0
H3	4
H4	0
H5	4
H6	0
H7	0

Merge result
CAM1 & CAM2

Multi-Angle result

ID	Class (status)
H1	4
H2	1
H3	4
H4	4
H5	4
H6	4
H7	4

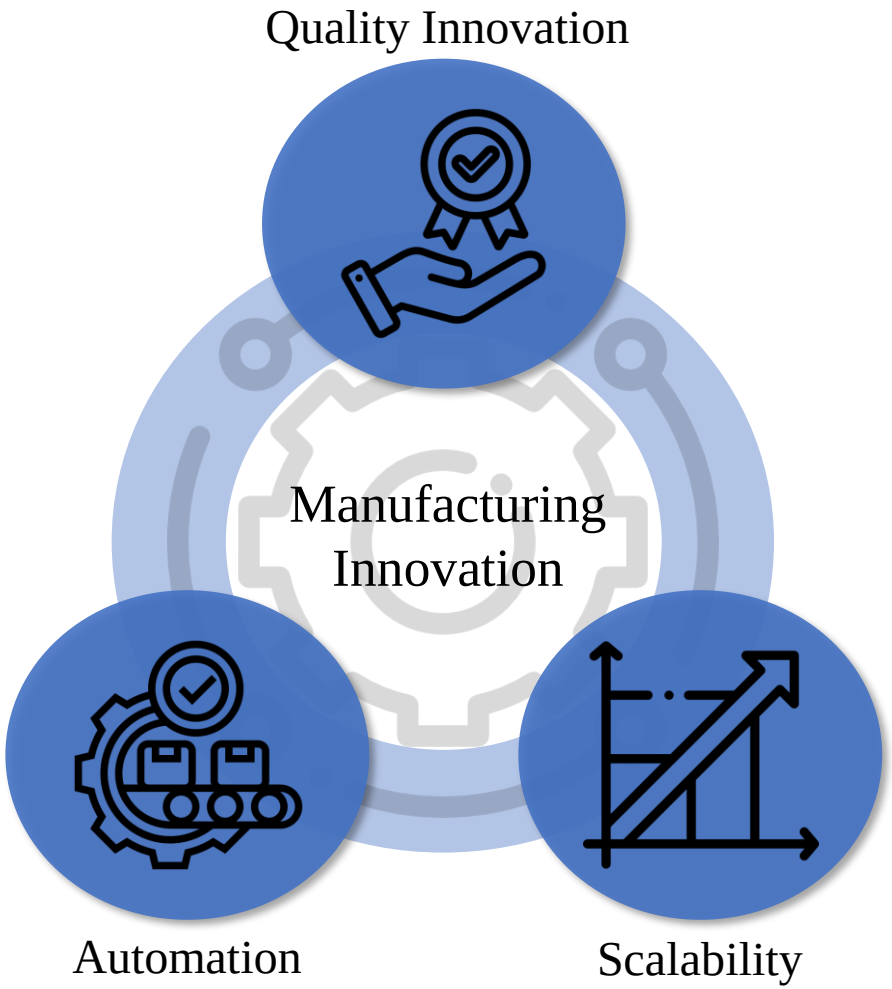
Class name

0 : open

1 : closed

4 : completed

Expect effectiveness



Automation: Automating Inspection Using AI Technology

Quality Innovation: Improving Quality with Accurate Detection

Scalability: Introducing similar processes

Thank you