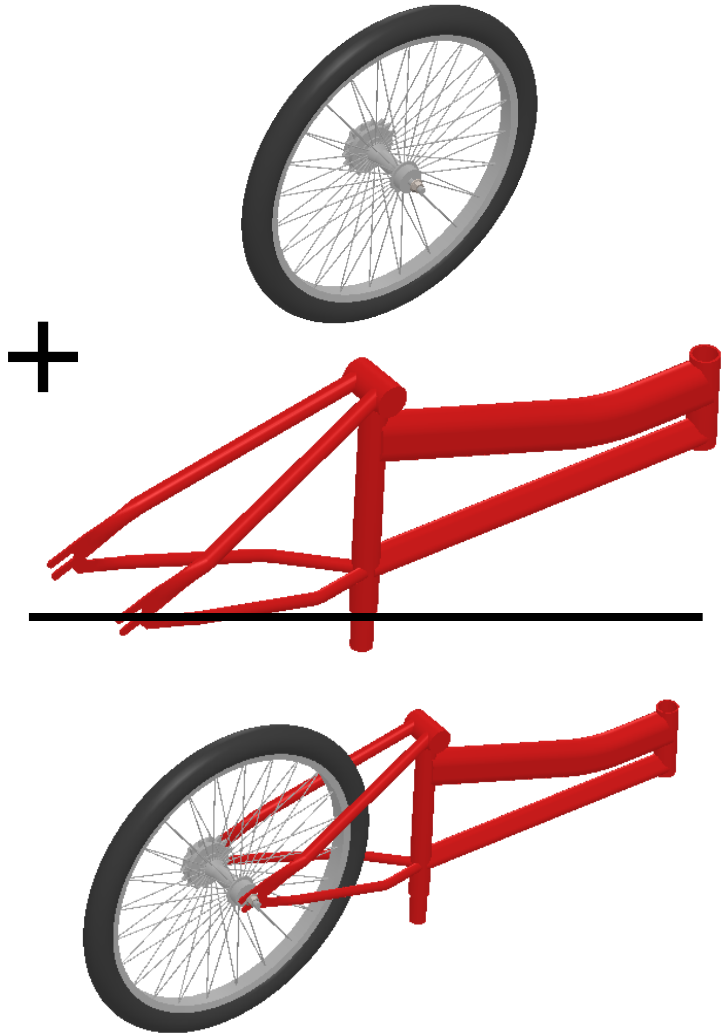
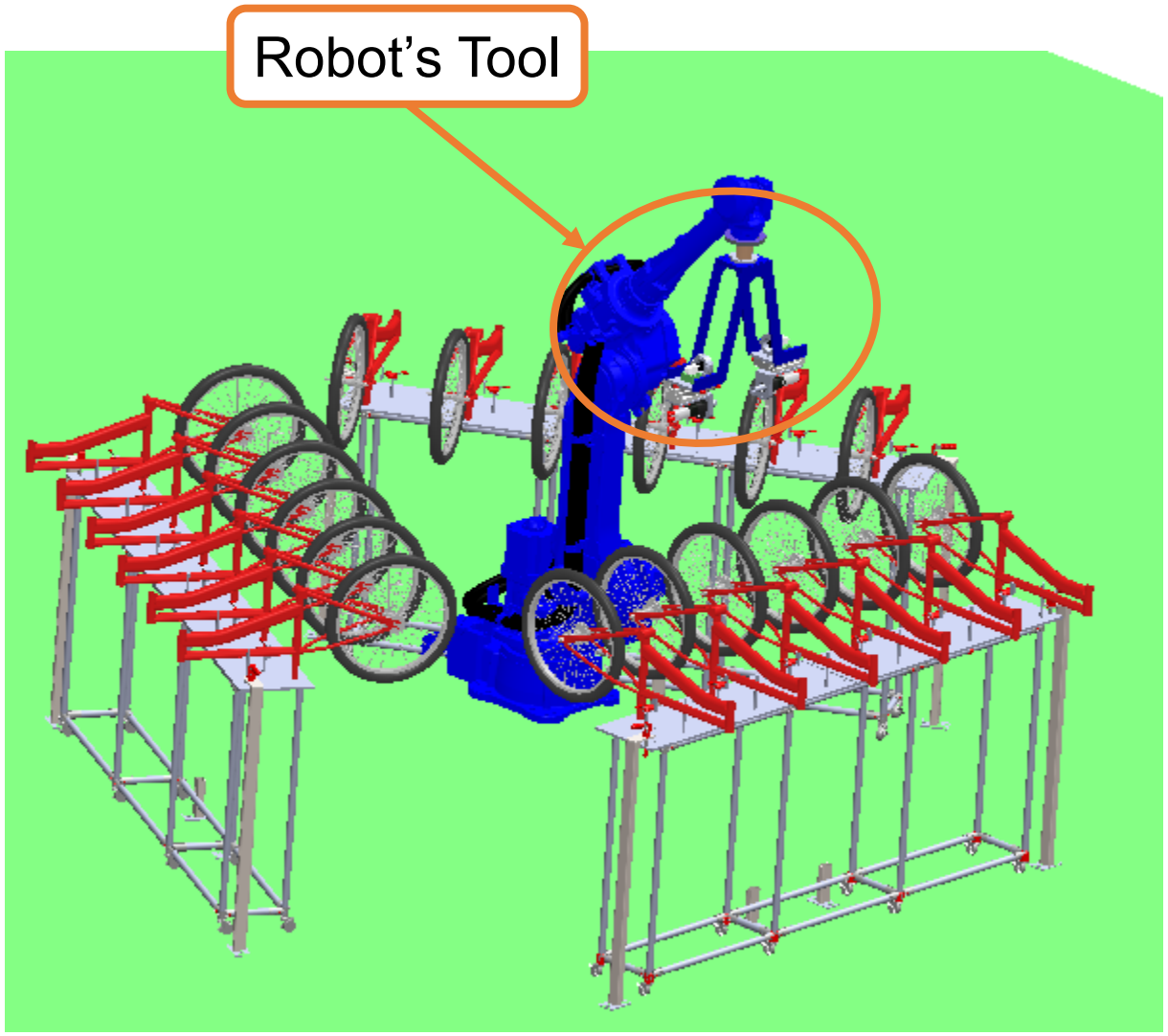
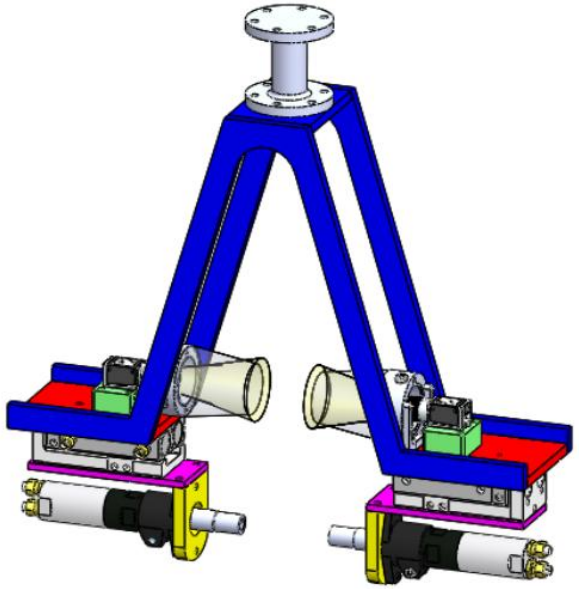
System

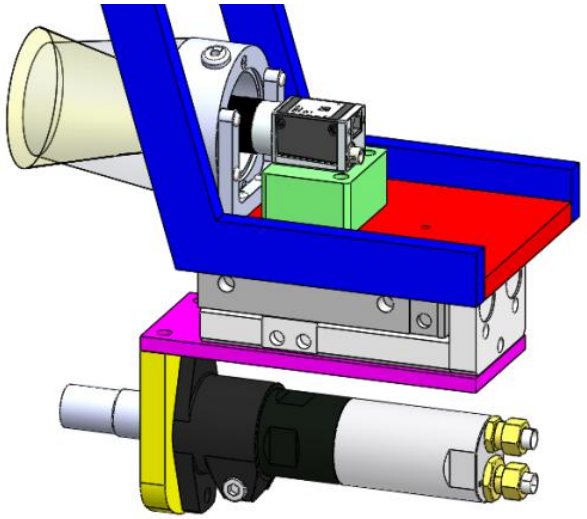


Assembling and tightening the bicycle bolts

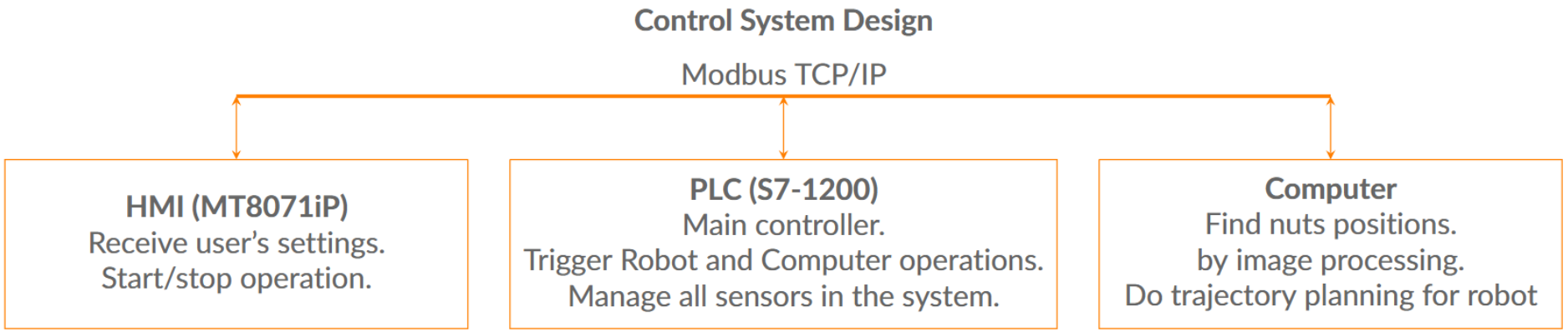
Workspace

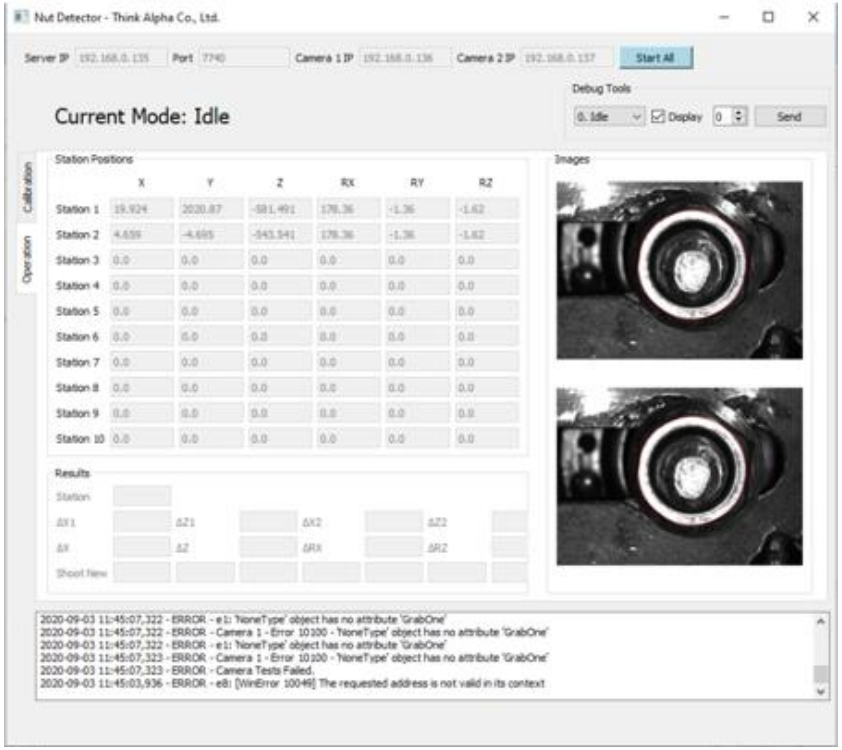






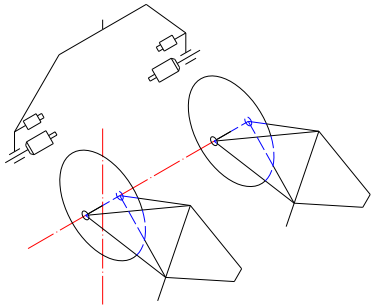
Control System Design



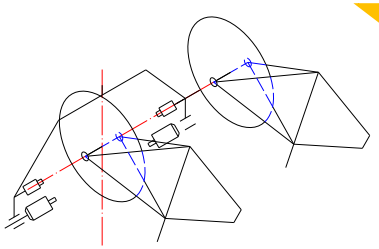


The Workflow

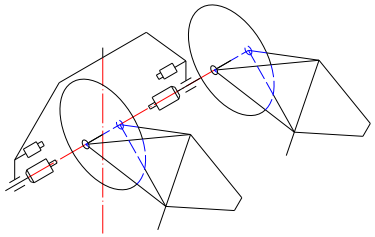
My golden star !!!



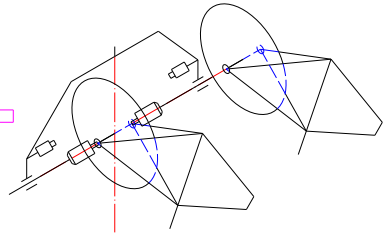
Move to $P_{prepare-i}$
Defined when the bike type is chosen.



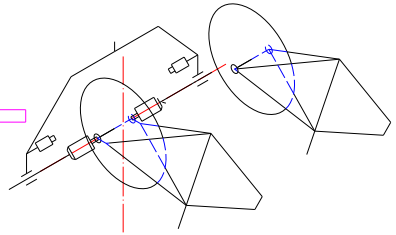
Move to $P_{capture-i}$
Defined when the bike type is chosen.
Cameras are requested to capture and the img processing started.



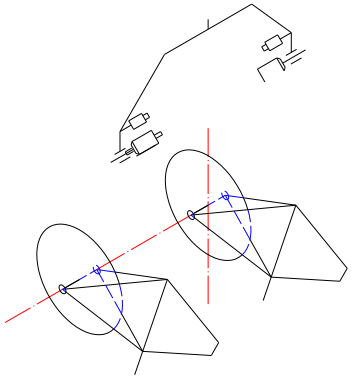
Move to P_{hold-i}
Calculated by Image Processing Algorithm
At this time, the sockets and the shaft are co-axial.



Still at P_{hold-i}
The cylinders extract to hold the nuts



Move to P_{run-i}
Defined when the bike type is chosen.
At this position, the motors run to tighten the nuts.



The cylinders retract.
Move to $P_{prepare-i+1}$

Capture, Run and Ref. Positions

The capture position at station i is given by

$$\mathbf{P_{capture-i}} = \mathbf{P_{ref-i}} + \mathbf{\Delta P_{capture-X}}$$

The nut running position at station i is given by

$$\mathbf{P_{run-i}} = \mathbf{P_{ref-i}} + \mathbf{\Delta P_{run-X}}$$

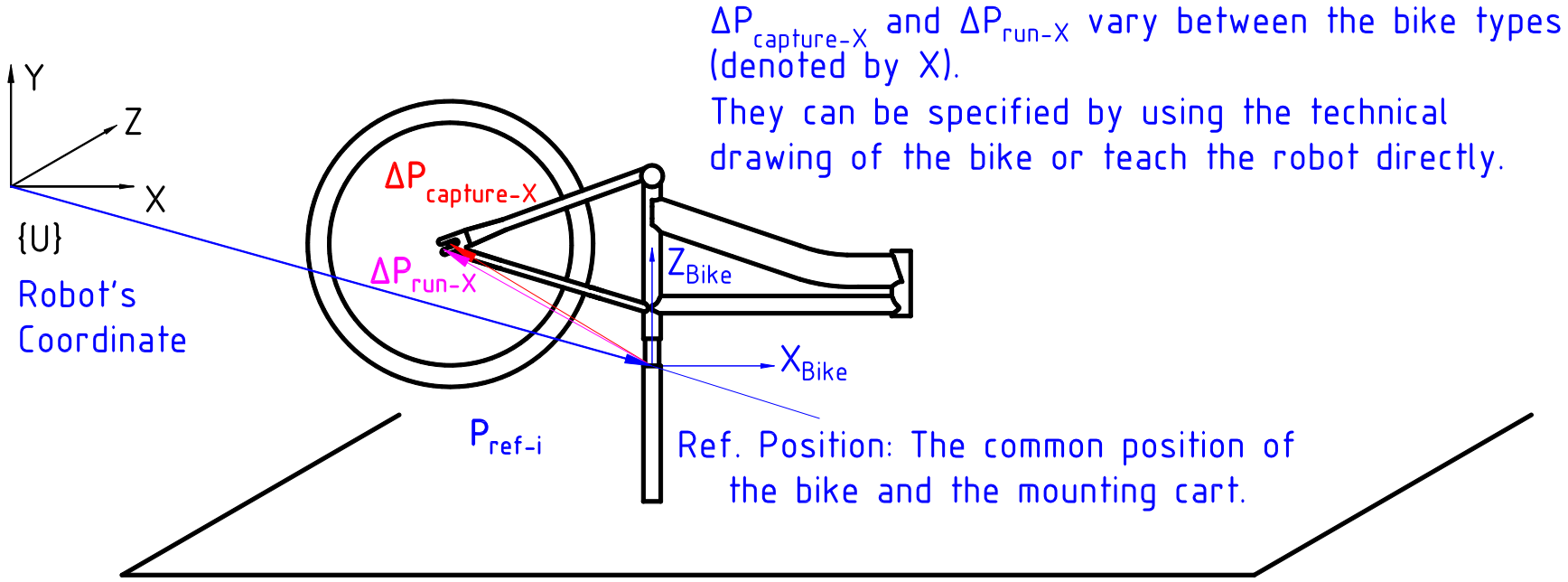
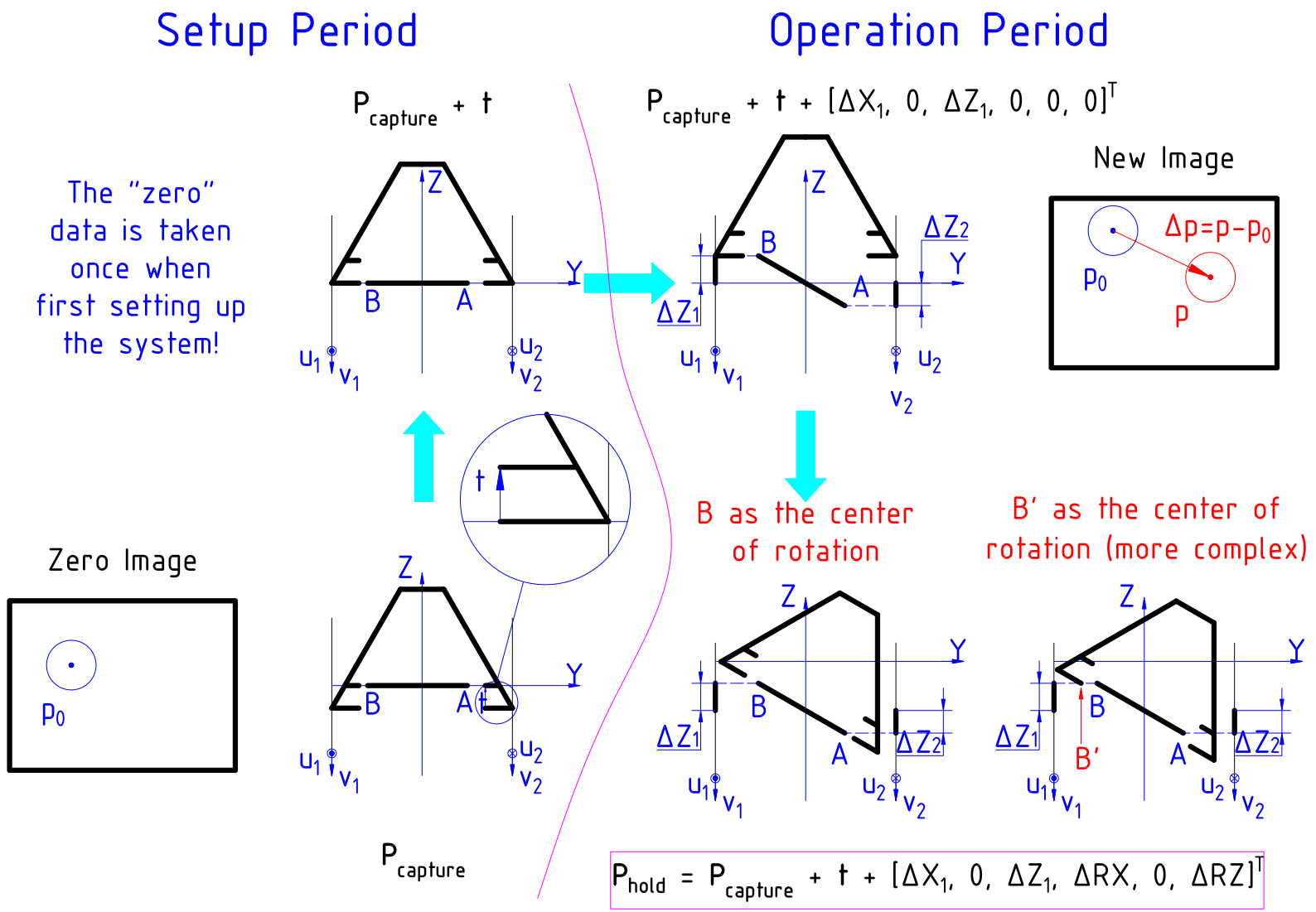
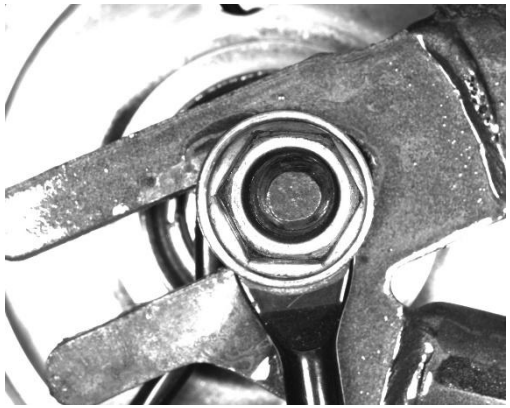


Image Processing Technique

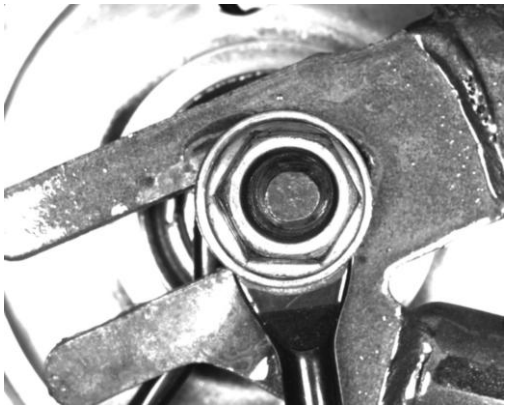


Detect the Nut in the Image (1/2)

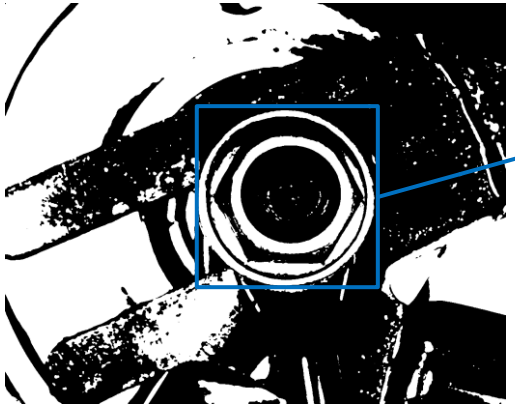


(a) Origin Image

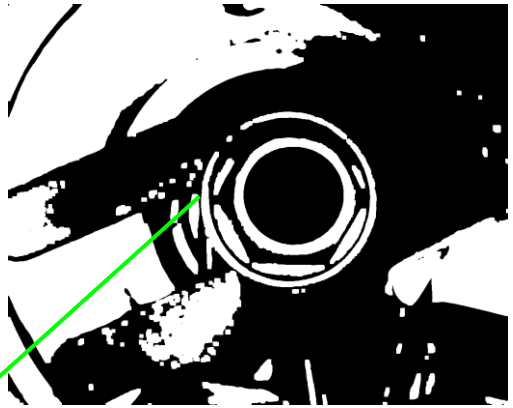
(b) Undistorted



(c) Gaussian blurred

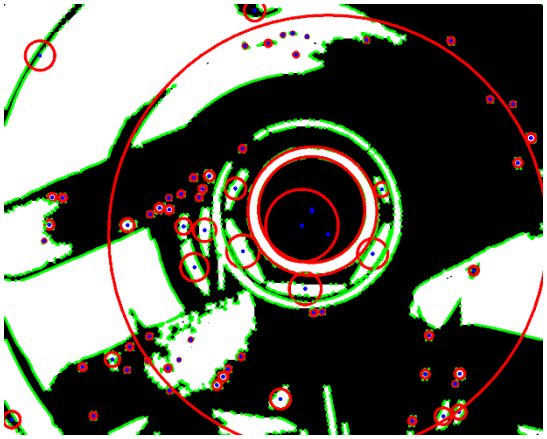


(d) Otsu Thresholed

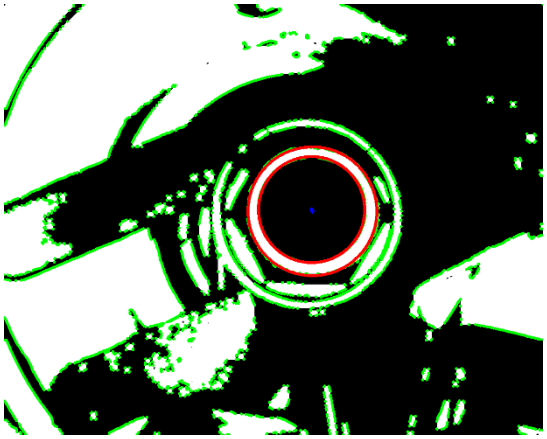


(e) Closing Transformed
(Inverted Image)
(Dilation followed by Erosion)

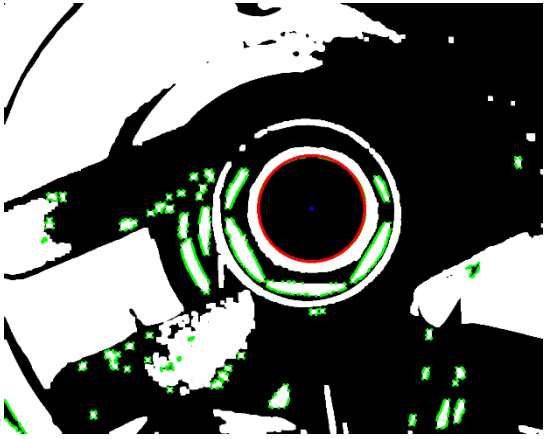
Detect the Nut in the Image (2/2)



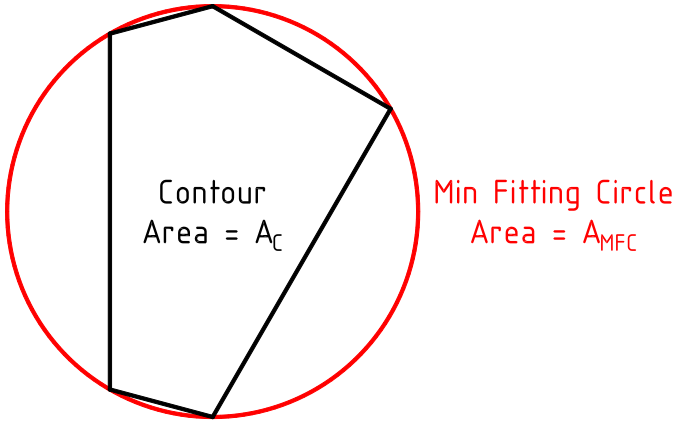
(a) All contours and their min-fitting-circles



(b) Filter out the "not round" contours.



(c) Final contour (using dimensional comparision)



Min Fitting Circle

The "round criterion"

$$\frac{A_C}{A_{MFC}} \in [0.9, 1.1]$$