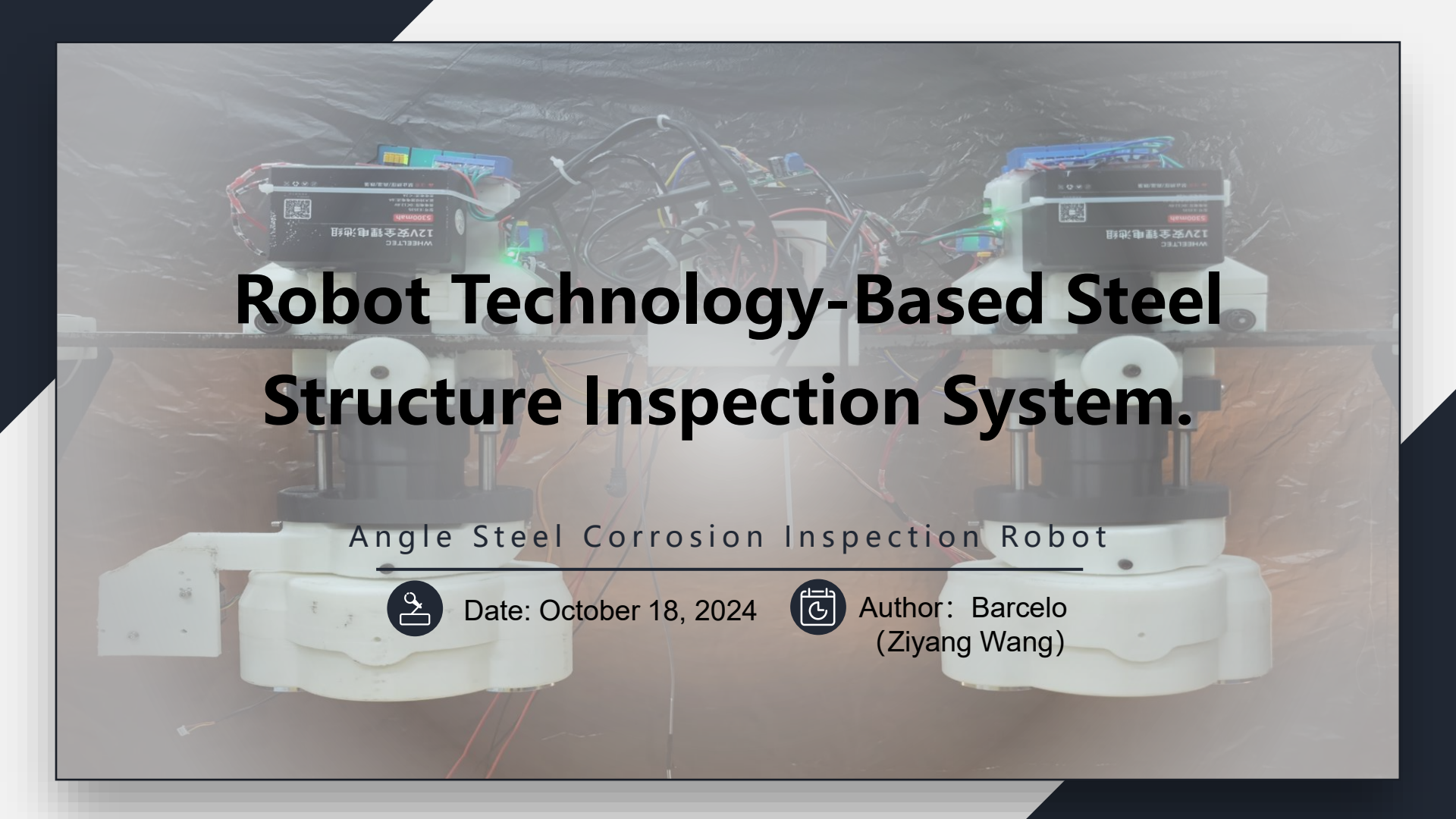




# Robot Technology-Based Steel Structure Inspection System.

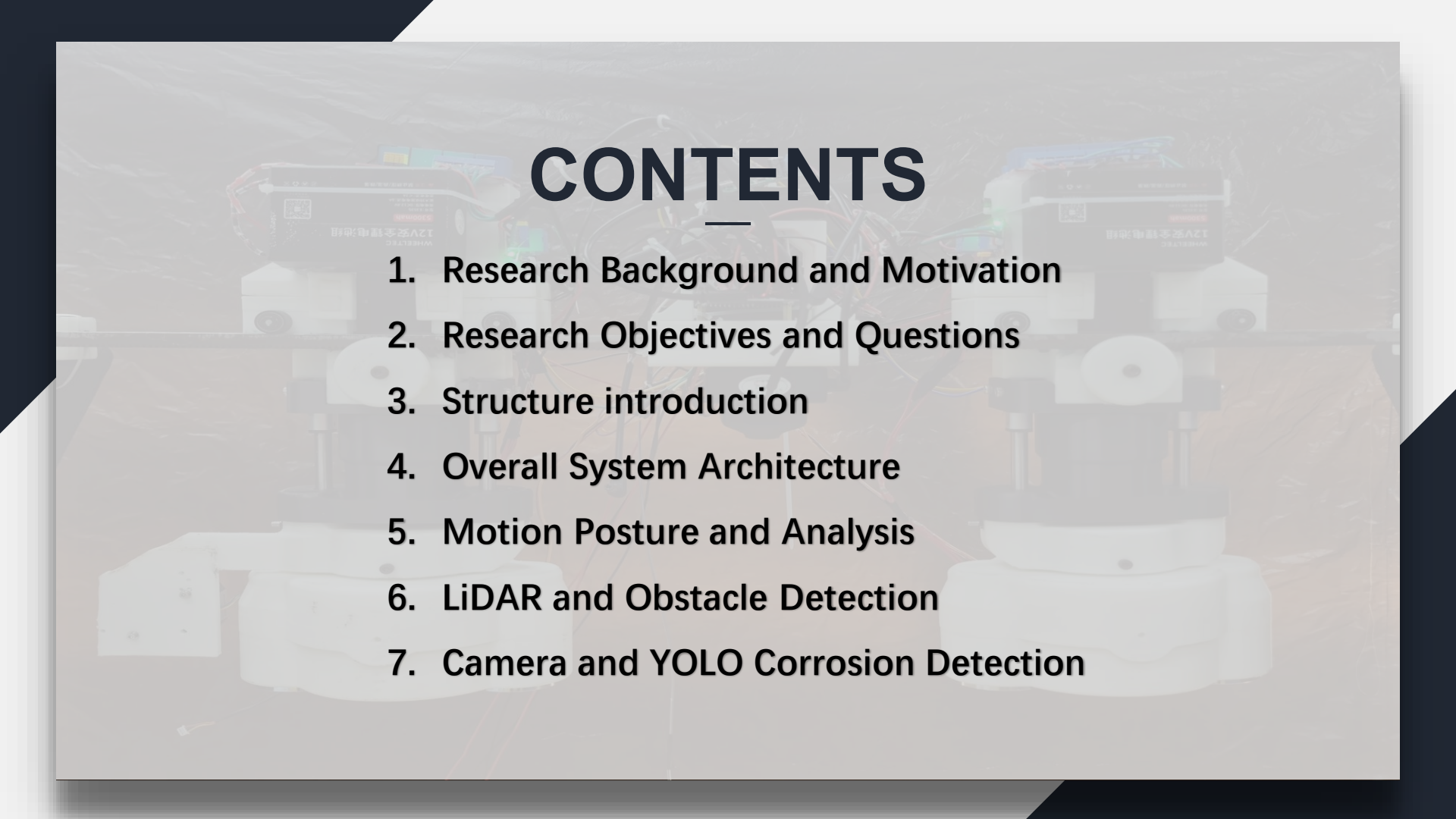
Angle Steel Corrosion Inspection Robot



Date: October 18, 2024



Author: Barcelo  
(Ziyang Wang)



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# **01 - Background and motivation for the study**



# Background for the study

Angle steel frames are widely used in the supporting structures of buildings, bridges, and other industrial facilities. Over time, they are prone to corrosion, deformation, and damage, which can compromise safety. Traditional manual inspections are time-consuming and prone to human error, making it difficult to efficiently and accurately detect potential issues.

With the advancement of industrial automation, using robots for angle steel frame inspections has become an effective solution. Robots equipped with advanced sensors and algorithms can automatically and precisely detect structural problems, reducing human error and improving inspection efficiency.

# Motivation for the study

1. Improve inspection efficiency and accuracy, reducing human error.
2. Enhance facility safety by detecting structural damage in a timely manner.
3. Lower labor costs and risks, especially in hazardous environments.
4. Promote technological innovation by applying robotics and intelligent inspection technologies to improve maintenance processes.



## **02 - Research objectives and issues**

# Research objectives and issues

## Key Issue 1:

How to design a robot that can stably walk on the surface of steel structures, such as high-voltage transmission towers or steel beam bridges, and detect obstacles and rusted areas?



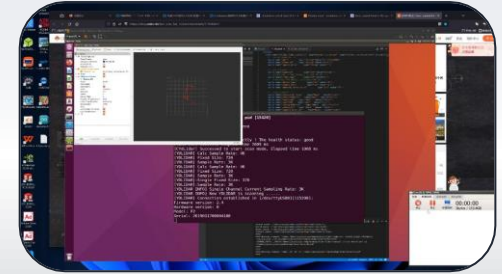
## Objective:

The objective of this study is to develop and apply a robotic-based angle steel frame inspection system aimed at enhancing the automation and accuracy of structural inspections in industrial facilities. By integrating advanced sensors, machine vision, and intelligent algorithms, the robot will be able to efficiently and accurately detect corrosion issues in angle steel frames.



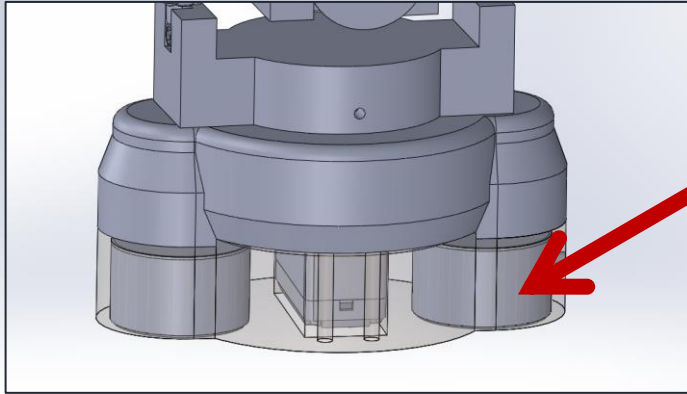
## Key Issue 2:

How to achieve automated rust detection on steel surfaces using a robot, and coordinate the operation of multiple sensors and actuators through ROS?



## **03 - Structure introduction**

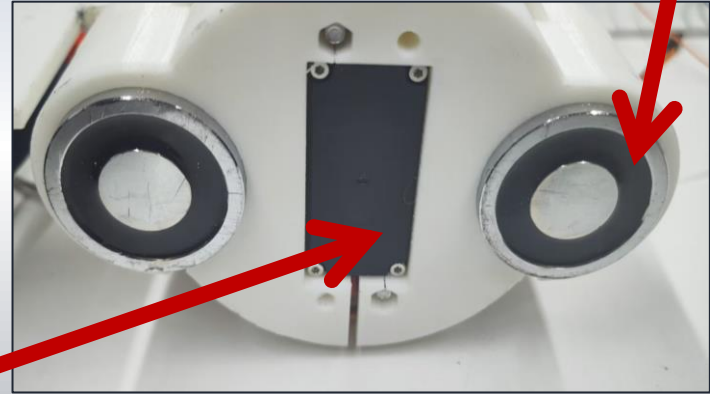
# Strongly gripping foot adhesion device



Mechanism modeling diagram

Turning is achieved using a servo motor that provides 80 kg·cm of torque.

Using two 60 kg electromagnets to securely attach the device to the steel tower structure

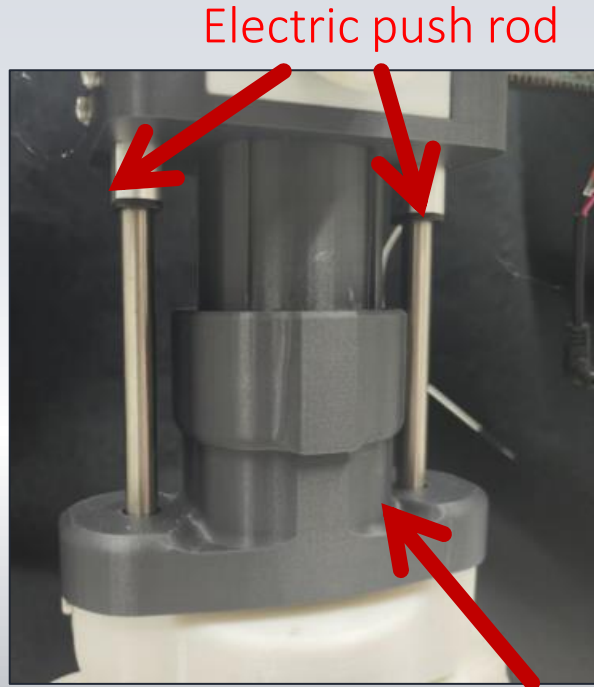


Physical diagram of the mechanism

# Hall signal lifting mechanism

Two sets of electric push rods, controlled precisely by Hall signals, are used to accurately regulate the extension length.

Calculations ensure that the device can 'overcome obstacles' in full load conditions, in conjunction with LiDAR (The silver part in the image represents the electric push rod)

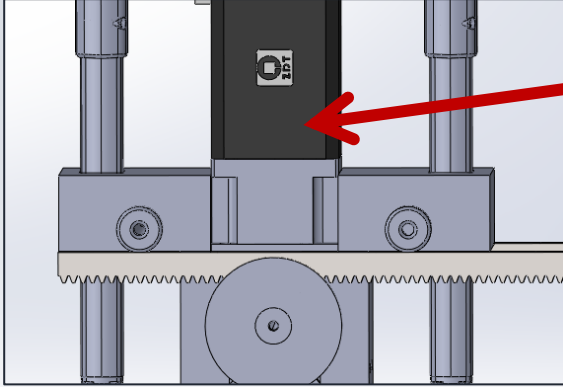


Electric push rod

To resist excessive loads generated in the rod during rotation, a torque-resistant sleeve has been added (shown as the black parts in the image) to ensure operational stability

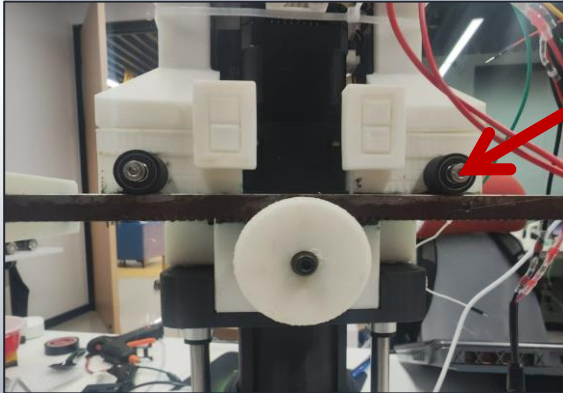
Torque-resistant sleeve

# Transverse movement



## · Movement power device

To accurately control the forward step distance, a 57-step stepper motor combined with a driver is used for power in this section. The connecting components are made from high-strength PLA material using 3D printing, and the motor drives the gear to move along the rack.



## · Auxiliary wheels

Interestingly, when the distance between the two feet is too great, the supporting force generated by the long-distance lever can lead to rapid wear of the gears. Therefore, two auxiliary wheels were added at the rear end of the rack to help distribute this load.

# **04 - Overall System Architecture**

# Major electronic components



## Lidar:

Obstacle detection, real-time distance measurement



## Camera:

Corrosion detection, image recognition



## NUC&ROS:

System coordination and data processing

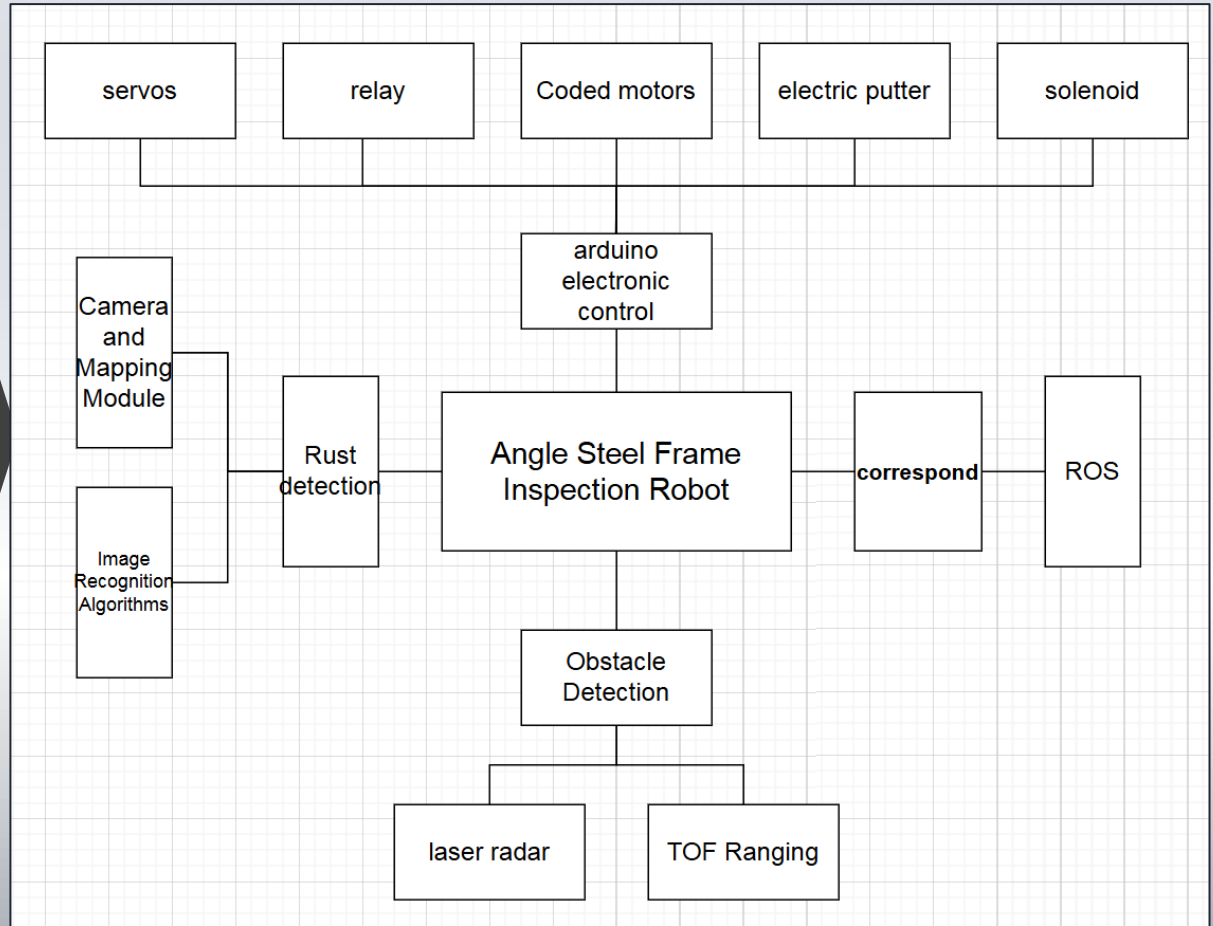


## Arduino:

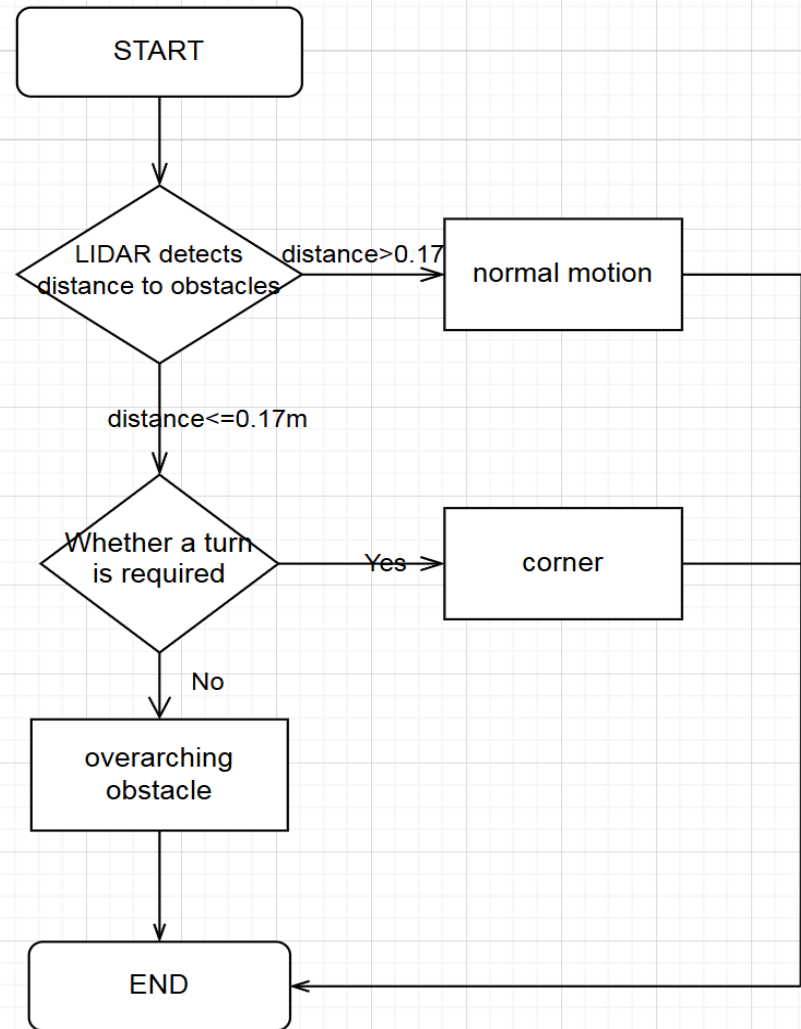
Controlling Robot Motion



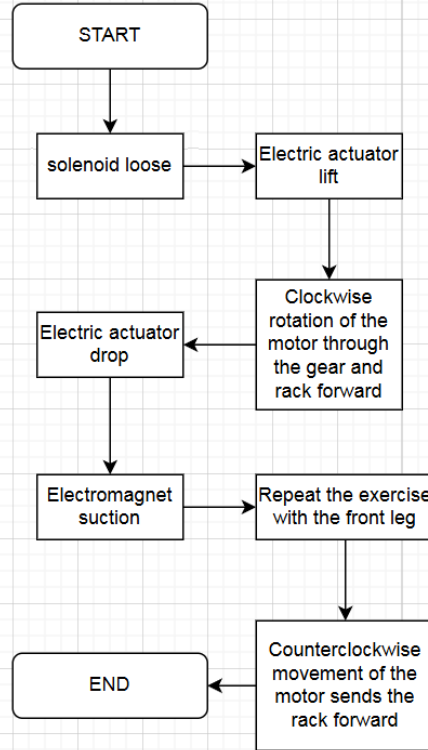
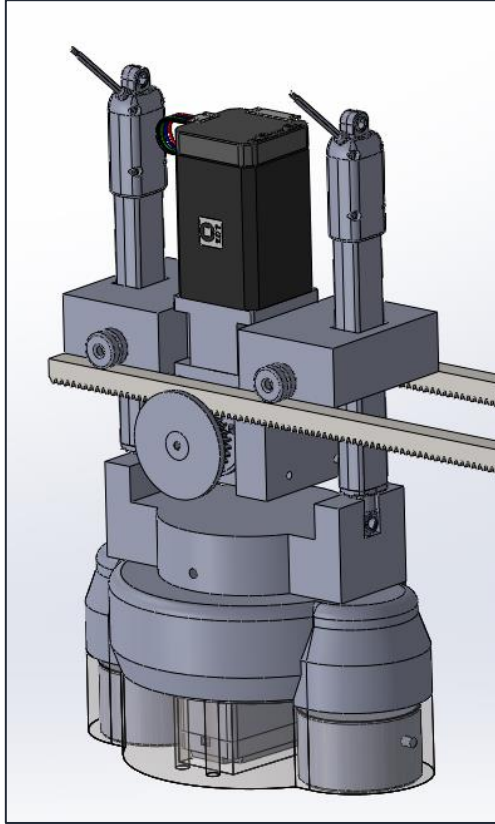
# System Architecture Diagram



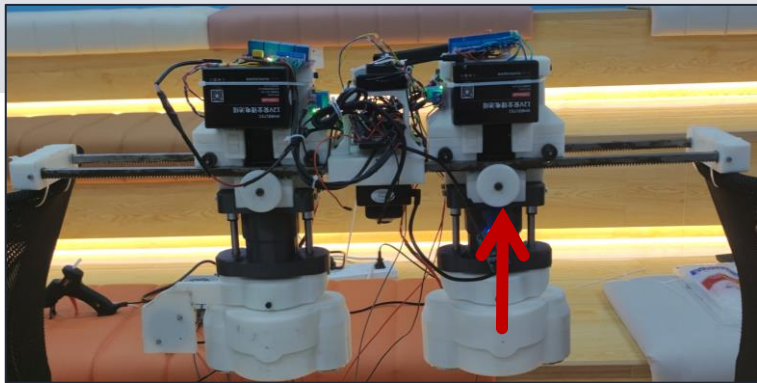
# System operation flow chart



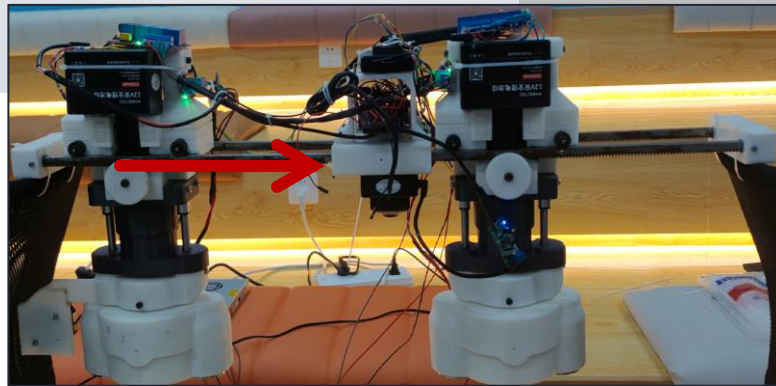
# **05 - Motion Posture and Analysis**



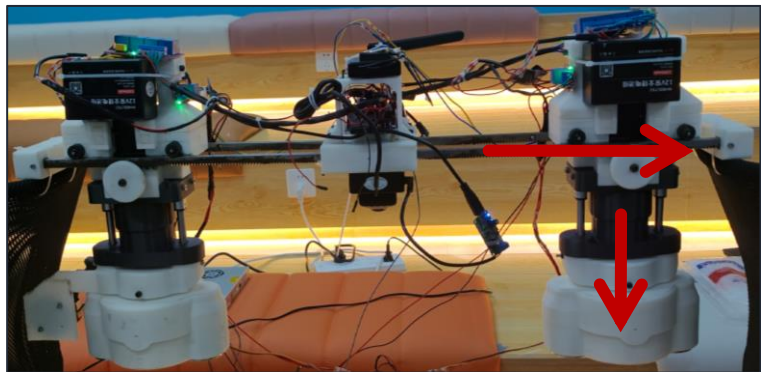
# Flowchart of a common campaign



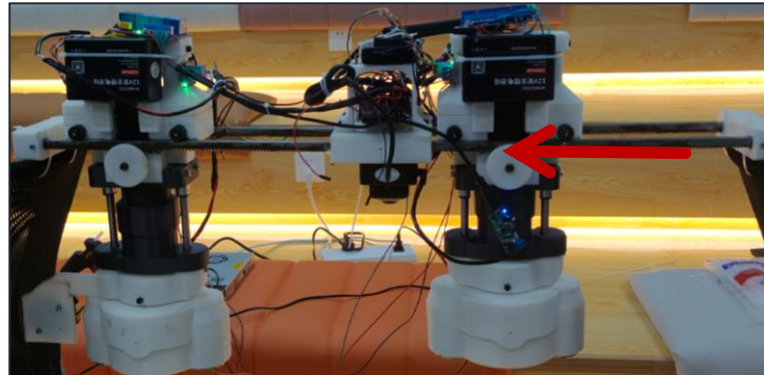
Initial stance with feet together in the center



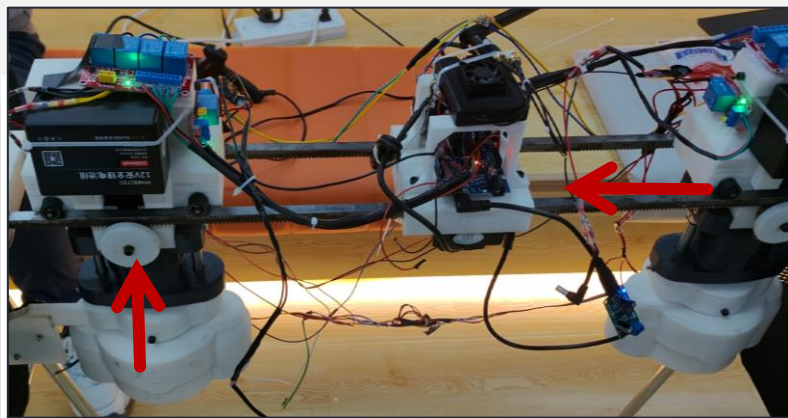
Forward movement of the front legs



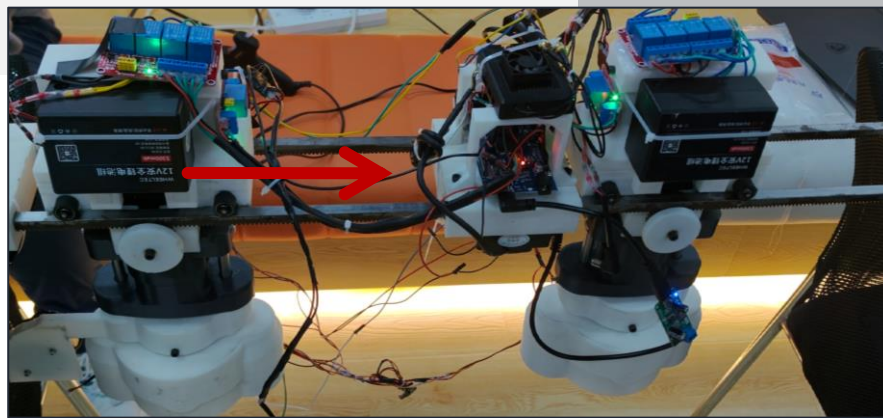
Back leg motors rotate to convey the front leg forward so that the front leg crosses the obstacle



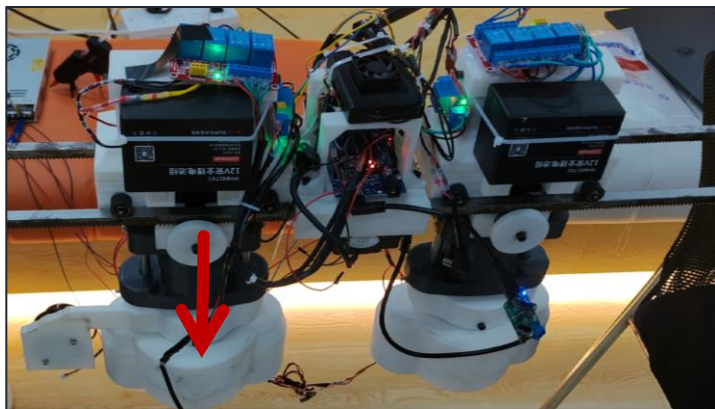
Back legs move forward



**Back leg and then forward**



**Back leg moves forward**



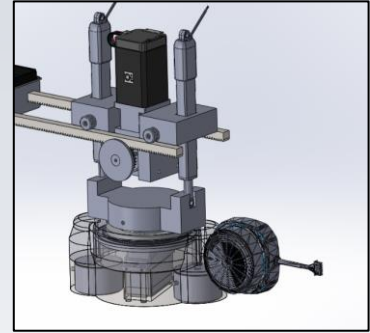
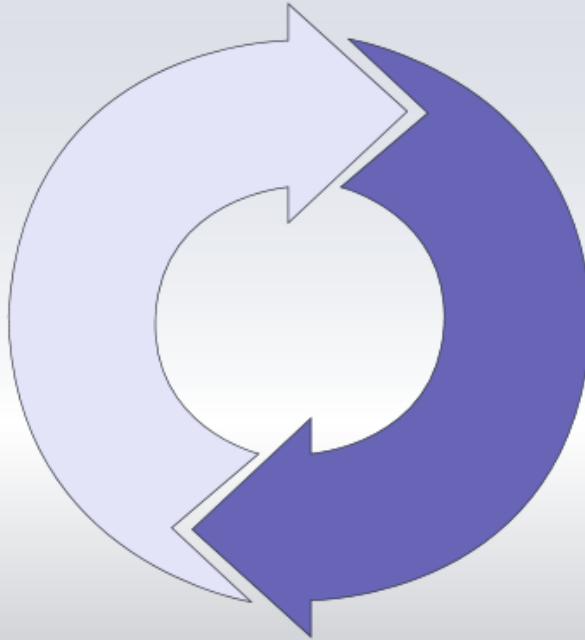
The front leg motors rotate to convey the back leg forward so that the rear leg crosses the obstacle and returns to the initial stance

# **06 - LiDAR and Obstacle Detection**

# LIDAR & Camera

## LIDAR function:

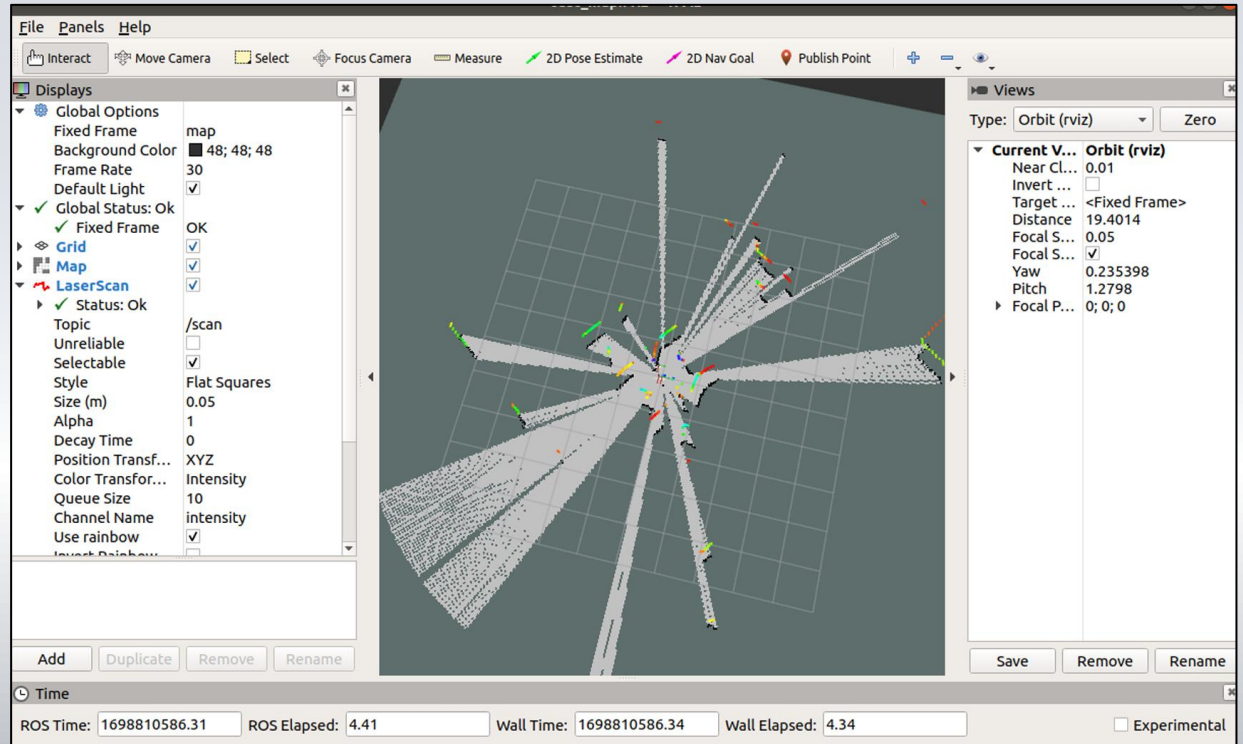
Real-time obstacle detection  
and distance measurement



## Barrier Avoidance Logic:

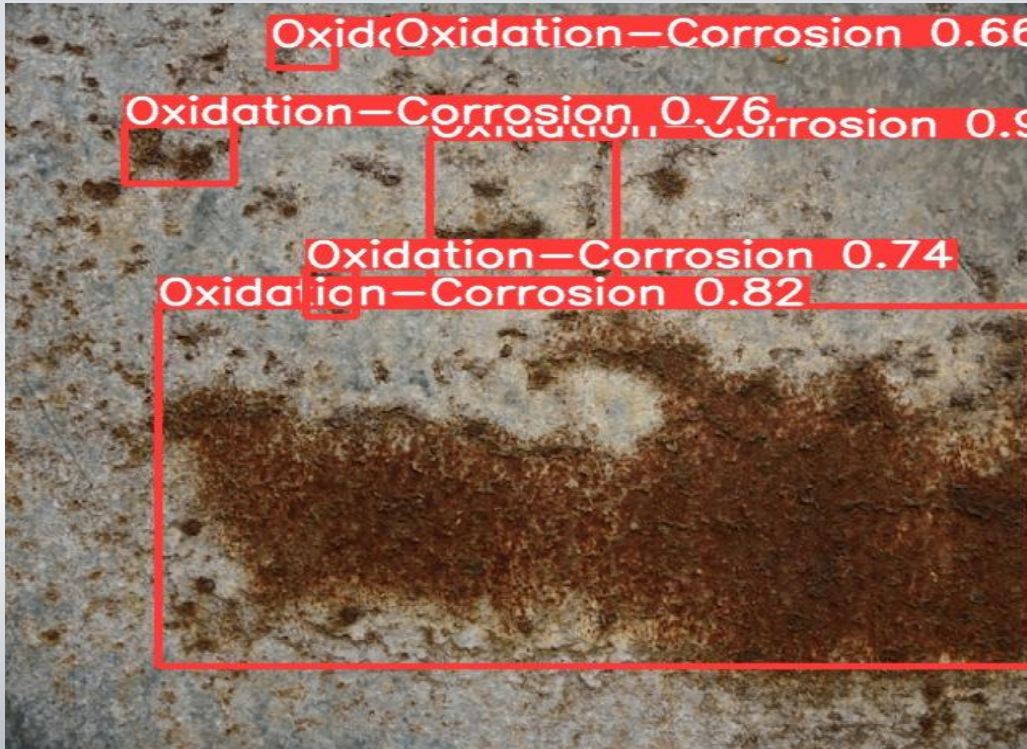
ROS schedules motors and  
servos by sending signals to  
arduino

## Schematic of LiDAR scanning



# **07 - Camera and YOLO Corrosion Detection**

# YOLO Rust Inspection



## YOLO:

The visual detection data is transmitted to the upper computer for image analysis, and the rust spots are analyzed based on each frame of the image. The ground station can observe the rust spot location in real time on the image transmission panel.

Inspection schematic of YOLO identifying corroded areas



# THE END THANKS

Angle Steel Corrosion Inspection Robot

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