Design Criteria and Target Specifications

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Abstract

This document is meant to act as a design criteria for the production of a 3-DOF end-effector for a pre-existing robotic arm to scan, scrape off, water blast and repaint rusted areas on the Halifax Class Frigate. It intends to specify requirements and specifications of the product according to the client's needs.

Introduction

This document defines the design criteria to be followed for the upcoming deliverables, conforming to the specific requirements and constraints provided by the client. It intends to serve the purpose of guidance to provide a solution for a 3 DOF end-effector, an attachment to THOR, a robot arm, to scan, scrape off, water-blast and repaint rusted areas on the hull of the Halifax class frigate.

Priority Requirements

Functional Requirements	Non-functional Requirements
Weight supported (lbs)	Decent Aesthetics
Quick set-up time	Long Product life (years)
Stability	Corrosion and UV resistance
Electrical safety	Safety: minimal pinch points
Usage of inverse kinematics	Safety: obstruction recognition
	Reliability

Design Criteria

Physical Criteria	***Technical Criteria***
Good battery life, (should last over night), (at least 24hs)	Coding on G code
Minor repairs every 3 months Major repairs every 6-12 months	Open source code
Arm should be able to lift 750g	Pivot mechanism
Attachment based parts	Vacuum turns on with motor
Each part has a maximum of 20 lb	Operable by anyone with a high-school diploma
Each part should be able to fit through a M^2 gap	Low processing power required
Able to work in all conditions	Aware when the arm touches the wall
15000 RPM motor	Aware when sanding done it should start sparing paint
Vacuum cleaner mini	
3 degrees-of-freedom	

Benchmarking

Technical Benchmarking

Against different types of end effectors used in robots

Robotiq 2F-85/140 Grippers

- Stroke:85mm-140mm
- Grip Force: 10N-235N
- Payload: 2.5kg-5kg

Robotiq 3-Finger Gripper

- Stroke: 155mm
- Grip Force: 30N-70N
- Payload: 2.5kg-10kg

Robotiq Hand-E Gripper

- Stroke: 50mm
- Grip Force: 20N-130N
- Payload: 3kg-5kg

Robotiq Vacuum Grippers

- Energy: Electricity or Compressed Air
- Vacuum level: 80%-85%
- Gripper Mass: 332g-710g

Robotiq Sanding Kit

- Pad Diameter: 5 inches
- Max speed: 12000 rpm
- Grits: 60-400

Against pressure washers

K mini from Kärcher

- Weighs in under 5 kilograms
- 1600 psi (not strong enough to strip rust)
- Expels 360 litres of water per hour

AR Blue clean AR 383

- 1900 psi
- Fairly cheap at $150 USD
- Has handle for easy transportation

Ryobi 2000psi 1.2GMP electric pressure washer

- 2000 psi (strong enough to clean rust)
- 1.2 litres per minute
- Weight 32lbs (can be cut down with the removal of the wheel carriage)
- Adjustable pressure

User Benchmarking

Against industrial robotic arms in the automation industry

- The links of the manipulator(robotic arm) are connected by means of joints for translational motion or rotational motion. The links are considered to form a kinematic chain.

- The design of the robotic arm is done by the use of a system design platform called LabView whose graphical language is named “G” not to be mistaken with G CODE.

- Based on research done on this robotic arm, it was discovered that;
    - Three parameters were defined for the performance of a robotic arm: multiple axis (that determined the mass of the arm), DOF that increased space by adding joints, and kinematics that improved the movement of the arm.
    - The many degrees of freedom(DOF) and use of a kinematic chain was found to improve the movement of the robot.

Against pressure washers

K mini from Kärcher

- Water pressure is very weak
- Unable to clean most stains

AR Blue clean AR 383

- Not as powerful as advertised
- Prone to leaking
- Parts are prone to cracking and breaking

Ryobi 2000psi 1.2GMP electric pressure washer

- Prone to breaking and malfunctions
- Parts wear faster than other brands
- Heavy

Target Specifications of Robotic Arm End Effectors

- End effector should be able to do the act repeatedly and efficiently
- Should be able to be removed from the mainbody
- Arm should have easy to repair and replace parts
- Arm should have a holding system to allow the easy installation and removal of the hose.
- The heads of the end effector should be easy to remove
- The end effector needs to be strong to add pressure to the rusted wall

Constraints and Metrics

- Range of time needed for user to become familiar with robotic arm – ideally 5-10 mins after reading the User and Product Manual for a “layman” (someone with no prior technical or robotic experience)
- Number of people needed to operate robot arm – 1 person
- Plotted weight range for all components combined – 30-50lbs
- Budget for project – $100
- Maximum weight of a component – 20 lbs
- Number of components – 3 end effectors for the robot arm
- Intended pressure for PWS – 2,600 to 3,000 psi
- Operating Conditions – Stationary, damp conditions on the hull of the ship
- Product lifetime – 1-2 years with regular servicing
- Intended algorithmic time complexity – Linear complexity
- Time to completion – Benchmarked $4m^2$ under 4 hours, depends on area required

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Wrike Snapshot:
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