Project Deliverable B - Need Identification and Problem Statement

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January 25th 2022

Problem Statement

John Faurbo and the Royal Canadian Navy need a robotic arm that has the ability to detect, remove and paint over corroded areas to ensure proper maintenance on the Halifax class warships. Cost, ease of use, proportions and safety of product are key to creating the best product for the client's needs.

Information About the Client

Lieutenant Commander John Faurbo worked as a Naval Combat Systems Engineer with the Royal Canadian Navy. Now working with Theo Eastmond at Naval Material Technology Management for the National Defense, they intend to deploy robotic arms aboard the Halifax Class Vessel to aid in the ship's maintenance, mainly with corrosion along steel surfaces.

Implementing robotic arms to perform simple tasks will free up crew members and sailors as well as cut the cost of hiring more crew for simple jobs. The robotic arm and its end-effectors must scan and record the geometry of the corroded regions. The surfaces can vary from simple and flat to curved planes and intricately designed piping in compact areas. Once scanned, the robot can apply corrosion removing spray, clean the surface from the coating, and spray a final layer of paint.

The previous attempt to solve this problem was met with difficulties as the arm is not programmed with inverse kinematics (such as the Thor model), which increases the accuracy of the motion to a certain position. GCODE is used to move each arm individually, but it is less effective without inverse kinematics. In addition, the sensors bought by the Navy did not fit the model of the arm used.

Client Needs

Our client needs a cheaper way to detect, remove, and paint over corrosion on the Halifax Class Vessel. The ideal case for the cost of this project would have it staying within the predetermined 100$ budget, but it is possible to negotiate a slightly higher budget. The robot arm is required to fit into small spaces to scan, analyze, and paint in all areas of the ship. The general use involves:

- Setting the arm in proximity to the problem area,
- Activating the camera to scan and identify problem areas in a point coordinate system, and
- Painting the identified targeted areas.

The robot must be usable in low oxygen areas and have lights or night vision to detect imperfect areas anywhere on the ship in all lighting conditions. It must be deployable to paint the ship's outside on cables or a barge moving around the exterior.

The robot arm should be able to hold up to 1kg of weight (camera, nozzle and paint) and withstand approximately 140-180psi of pressure from the water hose. The robot arm must be powered by 120-volt outlets, the vessel's only energy source. The robot must be sustainable and only require minor repairs every two to three months and significant repairs after six months.

The 3D printed robotic arm will need 3 degrees of freedom to perform actions with precision. Accomplishing this requires inverse kinematic equations to determine the desired coordinate positions of the robot's movement. For efficiency, the robotic arm must reach a minimum speed of 1m2 per hour.

The software used for the robotic arm design is open-source codes, G CODE and GRBL, and a well-known programming language such as C or C++ or Python to program the robot's tasks. A useful asset for the robot would be to capture a visual with the camera and send it over to Royal Canadian Navy offices.

The robot's controls must be simple and easily accessible by any crew member. A handle or carrying system is needed to ensure the user can maintain three contact points when climbing ladders or stairs on the vessel. The ability to switch between different endpoints, catered to clients' demands, quickly and efficiently is essential. If appropriate safety measures are implemented, crew members will be more comfortable working with the arm, such as an automatic pause or shut down the system when a person approaches the robot. Ideally, the robot is small or compactable into smaller pieces that do not exceed 20lbs (including its end-effector, which weighs less than 750g).

Organized groups of needs and priorities

Needs	Priorities (1-10)
Ability to move and complete the 3 tasks with inverse kinematics	10
Safety system	10
Easy switchable end effectors for different tasks	9
Lightweight and compact	9
Simple/familiar code, files and hardware	9
Infrequent repairs/replacement pieces	7
Holds and withstands the end effectors (weight and pressure)	7
Efficiency/speed	5
Light up a dark area to take picture scan	4
Water resistant/ able to work in near water environment	3

Benchmarking (User perceptions of similar products)

6DOF robot used for previous iteration/solution: http://thor.angel-lm.com/ This arm seems to be well liked but the client themselves have stated that it is not exactly what they are looking for as it does not implement inverse kinematics. In addition, the sensors bought by the client did not fit this arm which lowered their opinion on it.
Inverse Kinematics: https://medium.com/@marcin_97686/inverse-kinematics-in-a-robotic-arm-learn-how-to-calculate-it-54156a63b65b
Arduino Programmable Robot Arm: https://create.arduino.cc/projecthub/ryanchan/simple-programmable-robotic-arm-bd28a0 Many people found this arduino project to work properly and effectively for its use, but the arm we were tasked with is on a much larger scale built with different materials which can affect the effectiveness of the arduino programming.
DIY Arduino Robot Arm controlled by hand gestures https://create.arduino.cc/projecthub/eben-kouao/diy-arduino-robot-arm-controlled-by-hand-gestures-6525e7 The comments on this project are mostly positive but a handful of people suggested different parts/hardware to improve the product which indicates it is not at its most improved state and it is more complicated than it could theoretically be. In terms of the given project we are working with files instead of hand movements which is a difference between the 2.

To be continued … (we will find more as we progress in the project)