Debris in Space Autonomous Removal Mechanism (DISARM)

Project Plan

Team Members

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Structure System Lead: Vincent Panichelli

Structure System Supporting Engineers: Davey Renoid, Ali Lebbar, Daniel Soto

Client	Faculty Advisor
Dr. Markus Wilde (mwilde@fit.edu)	Dr. Marius Silaghi (msilaghi@fit.edu)

Client Meetings	
January 20, 2020	Initial Meeting to discuss plan
January 27, 2020 – December, 2020	Recurring weekly meetings every Wednesday

Motivation and Goal

Space debris is clogging Earth's orbits, posing a threat to future space endeavors. A need exists for a way to safely clean up the debris in space. The biggest challenge delaying the development of a space debris removal system is a viable method for capturing the debris. For this reason, it is imperative that a debris grappling system be designed.

This system should be a self-contained device that is able to capture large pieces of space debris, such as the upper stages of rockets and defunct satellites. The system should also be universal for all debris types. This is done so that any piece of debris can be captured, no matter how irregular. Ideally, this device should be economical, efficient, and fast acting.

With the statement previous in mind, the goal of our project is to provide a tool that improves the safety of all space missions by removing the risk of colliding against space debris. As space technology progresses the necessity of having a safe orbit becomes crucial and multiple companies could benefit from the development of this product. Not only are future space missions at risk, but also all current satellites that are orbiting our atmosphere are in danger against debris.

The computer science goal of this project is to provide the requirements and software needed to automate the actual welding of the system. The software needs can be categorized into a control flow of five stages: groove direction qualification, dislocation calculation, attitude revision, stud welding, and verification of weld completion. Together these stages will ultimately reach the goal of safely capturing debris in space.

Approach

DISARM Autonomy

1. The grappling device can autonomously perform the stud welding process.
   a. DISARM constantly calculates the XYZ position axis of the object, searching for a safe welding point, and once found welds onto the target debris.
2. When objects collied, the device can transfer collision data such as velocity and momentum of the space debris.
   a. DISARM uses both these variables to update the welding points accordingly in case that these cause any displacement.
3. DISARM can continuously transfer real-time distance between orbiting debris and itself.
4. In the case of a welding error, DISARM can automatically restart the control loop until a safe welding location is detected or is shutdown manually.

DISARM Manual Function

5. The device shall be able to provide an accessible interface for power and data transfer.
   a. Users can check status of welding completion with aircraft.
   b. If autonomy fails, users can manually cancel or shut off the welding process.
6. Using the collected data that is transferred to the user-interface, users can adjust the grappling hook to fix the errors that occur during autonomy.

Novel Features

1. Autonomous welding performed by a completely new designed algorithm that supports working inside a vacuum and zero gravity.
2. Utilizing the latest in sensor and software technology to protect and optimize the welding process.

Technical Challenges

- The programing of the microcontrollers such as Arduino or Raspberry Pi to connect the algorithm to DISARM itself.
- The programming of ROS plugins for the implementation and testing of the algorithm.
- 3-D modeling of test cases to be used in the simulation using Gazebo and Solidworks.
- The implementation of converting analog output to digital from the Lidar-Lite sensor.

Design

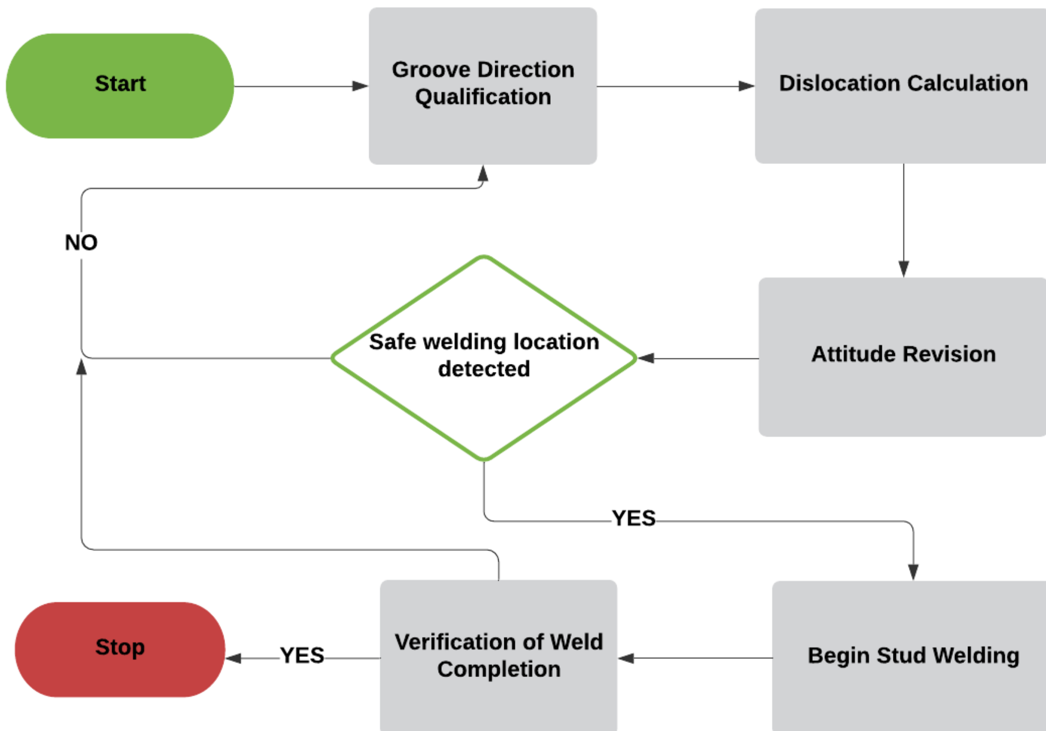

Figure 1: Autonomous Control Flow

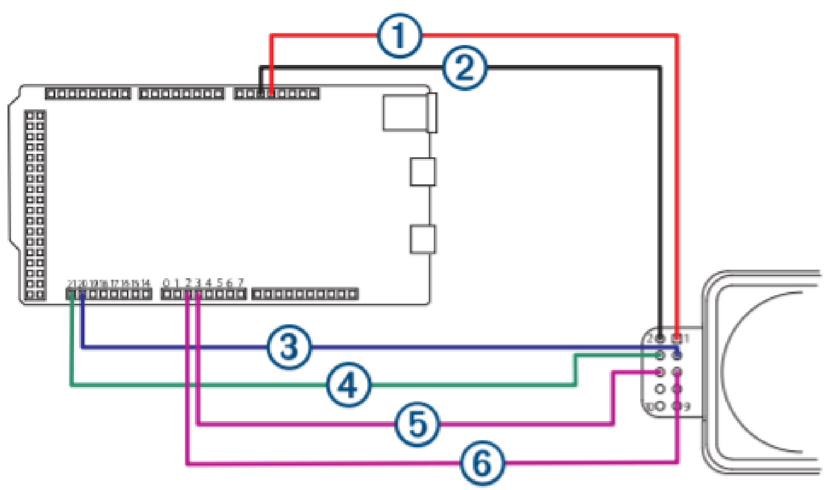

Figure 2: Pin Table Connection between Arduino Due and Lidar-V4 Sensor

Evaluation

- Length of time taken to perform and complete stud welding.
- Reliability of DISARM to safely capture each individual test case. For example, out of ten times, how many times is DISARM able to locate welding points and capture a 1U debris.

Progress Summary

Task	Progress	To do
Design CubeSat test cases	100%	none
Program sensor plugin	50%	Add Lidar-Lite LED V4 features to plugin
Design and implement autonomous algorithm	50%	Finish the previous step to continue algorithm
Develop demo video of simulation	0%	Record video demonstrating capture of debris
Implement DISARM control to work with Arduino	10%	Properly wire sensor and linear actuator

Fourth Milestone – Feb. 17

- Complete simulation requirements
    - Finish developing distance sensor to test the three different space debris test cases.
    - Create DISARM plugin in ROS for tracking debris using sensor information.
    - Implement algorithm for locating welding points.
- Develop a demo where we test the algorithm through the simulation and observe as data is collected.
    - Once simulation requirements are completed test simulation using the 1U, 6U, and 27U CubeSat models.

Fifth Milestone – Mar. 23

- Correctly wire Arduino to Lidar-Lite LED V4 Sensor
  - Implement code to ensure correct communication between sensor and Arduino for collecting data.
  - Test sensor to its distance limit of 10m to make sure sensor is working properly beforehand and that the connection to the Arduino does not fry the device.
  - Convert Lidar-Lite analog output to digital output.
- Transfer designed algorithm code to work in conjunction with Arduino, debugging errors along the way.
- Create poster for senior design show case.

Sixth Milestone – Apr. 20th

- Wire linear actuator motor to the control flow system.
  - Implement code of linear actuator to work with Arduino and sensor.
- Test/demo of the entire wired system working together.
- Evaluation results
- Create user/developer manual
- Create finalized demo video

Signature of CSE Student(s):

Signature: _Mintriago_____________________ Date: _ 1/19/2020______

Approval from Faculty Sponsor:

"I have discussed with the team and approved this project plan. I will evaluate the progress and assign a grade for each of the three milestones."

Signature: _________________________________ Date: ________