# EE 449 Milestone 1 Report

# Automatic Cable Winding for Surgical Robot Arms

Group 5:

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**Introduction**
The goal in this project is to create a closed loop controller that will perform an automatic cable winding for the RAVEN surgical robot. The system should be able to wind the cable on the capstan (a long cylinder metal with thread on it) at the specified velocity and acceleration. The user can also enter the number of turns and direction as inputs. In this report, we include the discussion about our customer and his expectations of the project. We will also explain about our plant, actuator, sensor, and control resources. In addition, we will discuss about our schedule, plan, and personnel use for this project.

**Customer**
Our customer is Professor Blake Hannaford who is the Director of the Biorobotics Laboratory. Biorobotics laboratory is a research lab that focuses on Haptic Devices and Surgical Technology. Haptic Devices are high performance mechantronic (computer and mechanical) devices that allow the physical interaction between humans and computer models. Surgical technology is the idea to create robotic devices that makes the surgeon be able to perform a surgery safely and effectively. In this project, we need to create an automatic cable winding for one of the surgical technology robot called RAVEN. RAVEN is a smart surgical robot that has two portable surgical robotic arms that can be deployed in the operating room or on the harsh environment like underwater and on the desert as shown in figure 1.

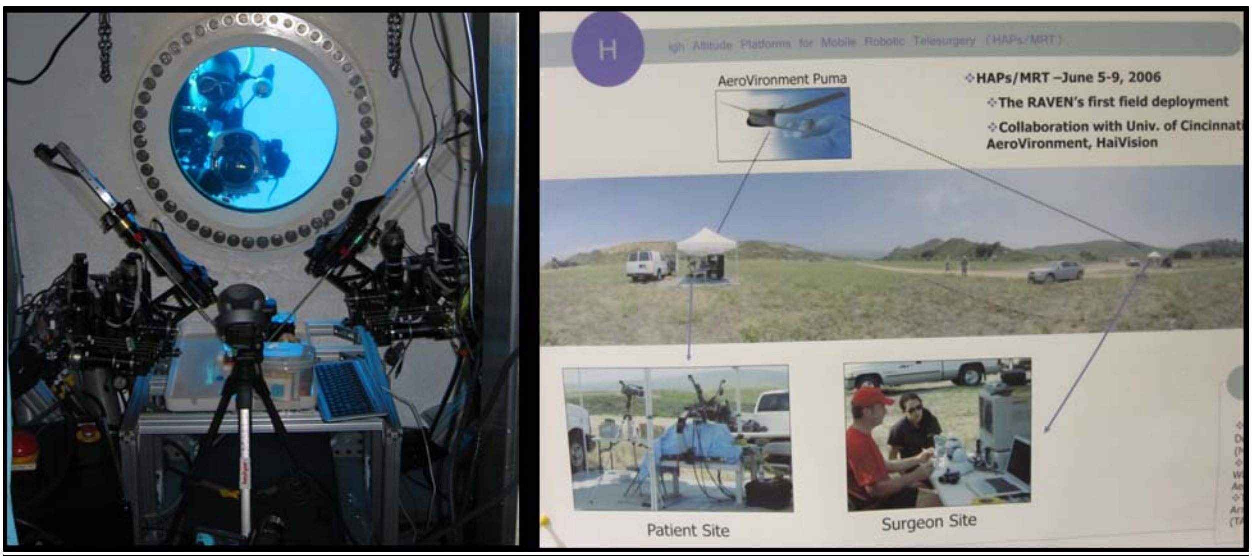



**Figure 1**. Telesurgery - the surgical robot being test on the desert (right) and under-water (left).

**Project Goals**
RAVEN surgical robot has a lot of motors and capstans with cables winding. Some of the capstans are located on the places that are hard to manipulate by hand (see figure 2). Currently, someone needs to replace all the cables on the each capstan manually. Thus, to help the maintenance of the surgical robot, we are required to create a closed loop controller that will perform an automated cable winding for the surgical robot. The customer also wants the system to turn at a certain direction with a specified number of turns. The system also should be able to rotate at a specified speed and acceleration. In summary, below are the performance criteria for our project.

**Performance Criteria**

1. The user only needs to press a computer keyboard and hold the end of the cable to perform automatic cable winding.
2. The system should be able to wind the cable in two different directions.
3. The user should be able to control the number of turns.
4. The user can specify the velocity. (Ranges from ~10-20 rotation per minute).
5. The system should hold the position of the capstan at a reasonable amount of time (~1-5minute) after the cable being wound.

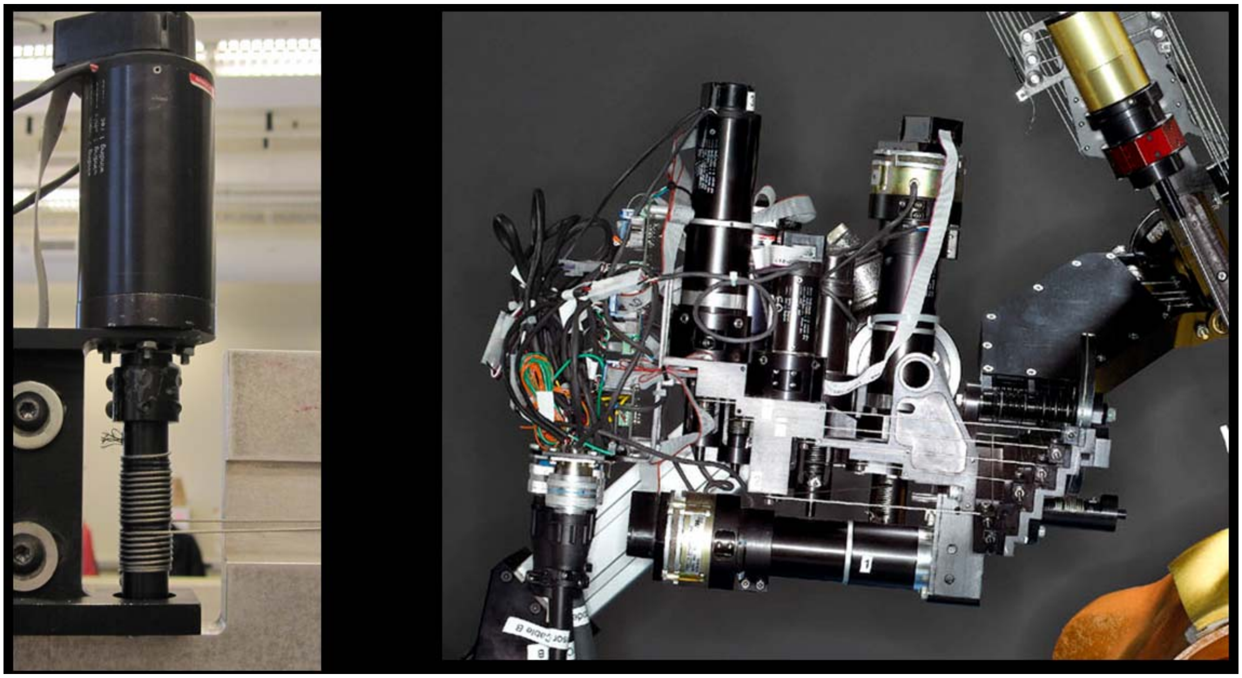


**Figure 2**. Surgery robot has a lot of motors and capstans (right). The cable winding system on the pulley board that acts similar like surgery robot cable winding system (left).

**Description of plant, actuator, sensor, and control resources**

In this project, first, we need to successfully implement our automatic cable winding on the pulley-board (the system that acts similar like the actual surgical robot arms) (see figure 3). Then, we continue to work on the capstans on the actual surgical robot. Thus, the plant is just a capstan on the pulley-board (see in figure 4) and capstans on the surgical robot. A capstan is a long cylinder metal with thread on it. The actuator is a brushless DC motor (see in figure 5). Brushless DC motor is a motor that driven by a direct current and having an electronic commutation system. Furthermore, the sensor is an optical encoder that useful to capture the characteristics of the system (see in figure 6). For the controller resources, this project are using a Linux based PC that connected to the I/O board made by Biorobotics lab (see figure 7).

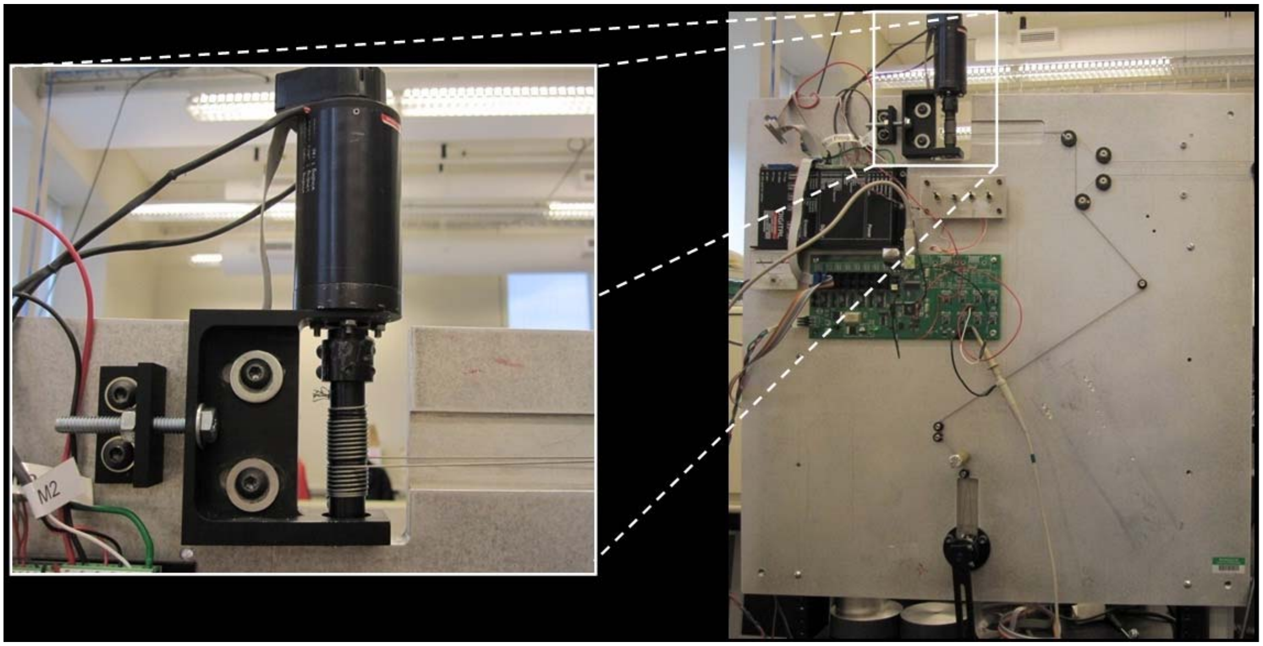



**Figure 3**. Pulley-board for test controller (right). The zoom-in image of encoder, DC motor, capstan, and cables wound in two different directions (left).

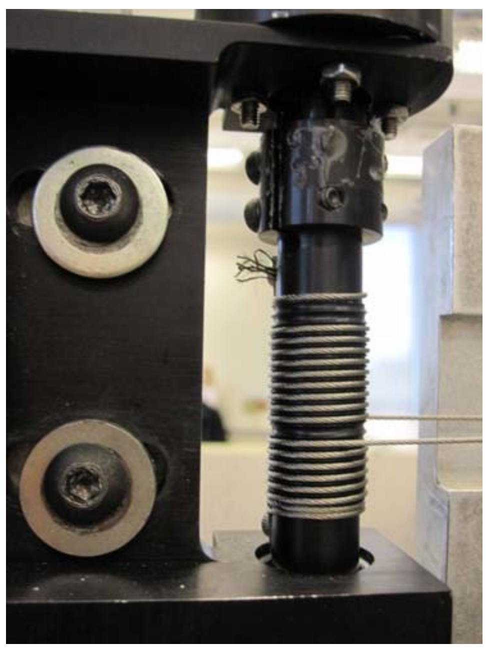


**Figure 4**. Plant – Capstan (a long cylinder metal).

**Figure 5**. Actuator **–** Brushless DC Motor.

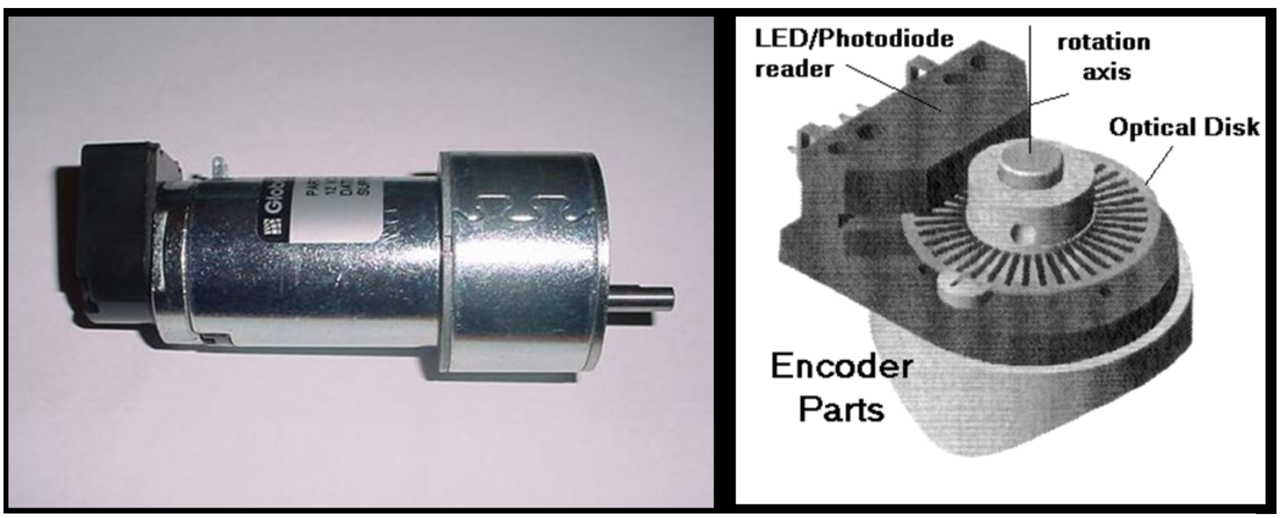



**Figure 6**. Sensor- Optical Encoder.

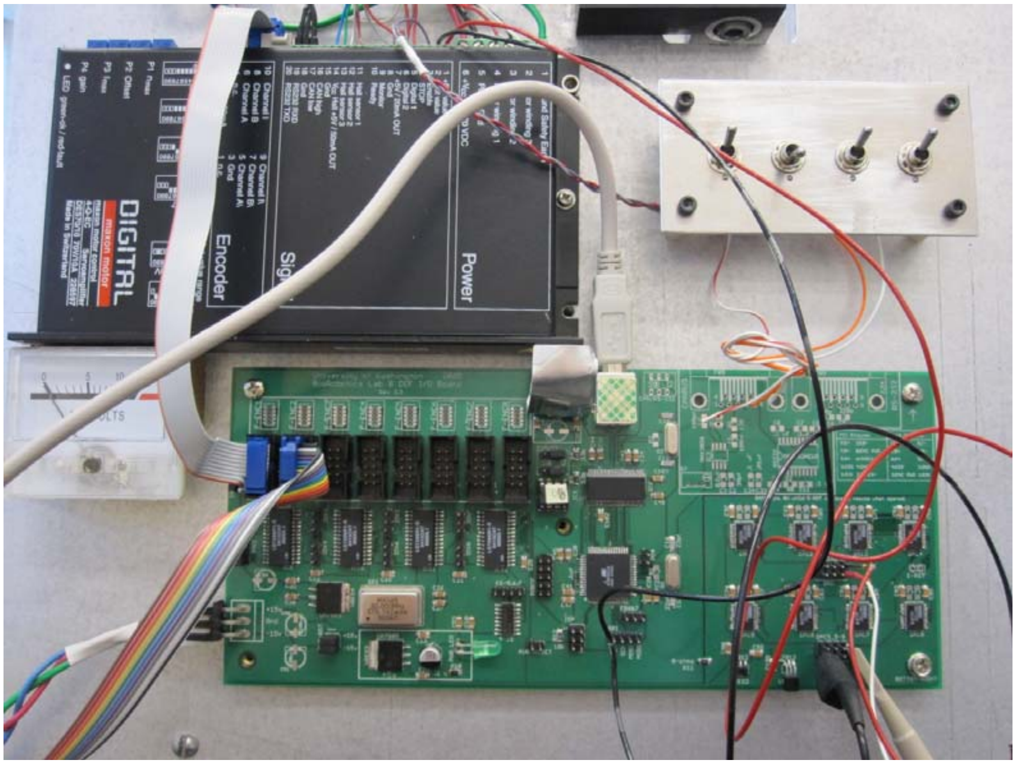



**Figure 7**. Controller – Linux Based PC (not shown) and I/O board made by Bio-robotics lab.

**System Input and Interfaces**

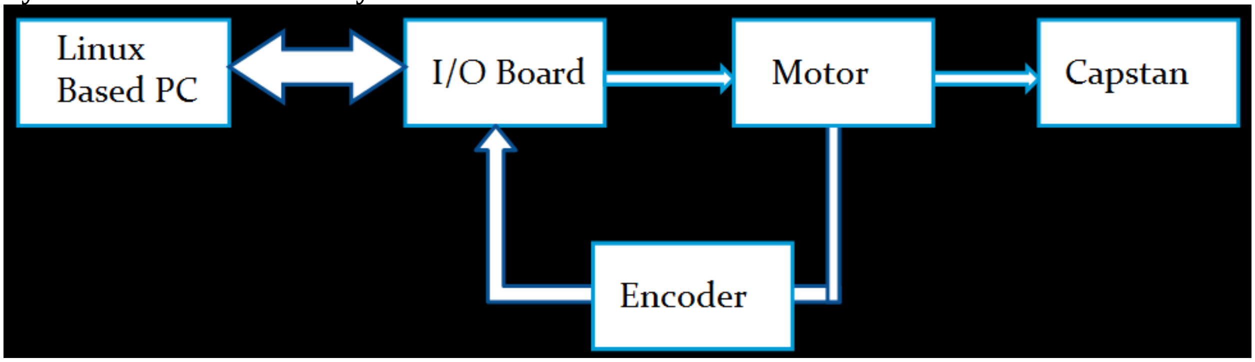
- System input:
  The input for this project is computer keyboard.

- System Interfaces:
  There are two categories in the system interfaces: software and hardware.

  - Software: 1. C program: a program to make the system be able to turns at certain direction and number of turns with specified velocity and acceleration.
    2. Simulink: a program inside MATLAB to do feedback control design of the system.

  - Hardware: 1. Optical Encoder
    2. Brushless DC Motor
    3. Capstan
    4. Cables
    5. Linux Based PC
    6. I/O board
    7. Surgical robot arms.

**System Schematic of the system:**




**Project Cost**

In this project, we can just use the existing equipments from the Biorobotics lab. However, if there is broken equipment, it needs to be replaces by a new one.

**Project Schedule and Plan**

| Task | Week |
|---|---|
| Get familiar with the interfaces. Studying the existing code for the pulley board. | 1-2 |
| Writing a C code to be able to winding the cable at specified turns and direction. | 3 |
| Creates the system modeling for the pulley board cable winding. | 4 |
| Continue the C code to be able to winding the cable at specified velocity and acceleration. Hold the capstan position at the end. | 5 |
| Design a feedback controller for the system. | 6 |
| Test the performance of the controller. Re-design the system until it meets the performance criteria. Creates a rigid hardware to hold the end of the cable. | 7 |
| Start collecting data parameters from the actual surgical robot. | 8 |
| Implement the controller to the actual surgical robot. | 9 |
| Testing the controller on the actual surgical robot. Re-design until it meets the performance criteria. | 10 |
| Write the final report and prepare for final presentation. | 11 |

**Group Personnel**

| Task | Imam Tjung | Kiran Thomas |
|---|---|---|
| C programming | X | - |
| System Modeling | - | X |
| Feedback Controller Design | - | X |
| Controller Performance | X | - |
| Data Parameters Collection | X | X |
| Implement the Controller into actual surgical robot | X | X |

Note: The person with 'X' means that the person is responsible for the specific task.

**Technical Obstacles**

The most challenging problem is to make the cable wind perfectly on the right position even if the person holding the end of the cable too tight or too loose. If the problem occurs, we are planning to build a mechanical hardware that can hold the end of the cable at a certain force. Thus, the tension on the cable will be always the same.

**Team management**

We are able to communicate and share the tasks equally. Two of us used to work together in other class and it works well. We know each other character and ability. We are pretty helpful against each other. Thus, the communication will not be a problem.

**Resources:**


- BioRobotics Lab Website. [http://brl.ee.washington.edu/laboratory/node/1].
- “Robotic surgeon to team up with doctors, astronauts on NASA mission**”**, 2010. [http://uwnews.org/article.asp?articleid=32163]
- “Mobile Surgical Robot”, 2010. [http://www.washington.edu/mediarel/galleries/robot/]
- Various Posters outside the BioRobotics Lab (EE 455 and EE 461).