Team 113 Operation Manual

Project Overview

The senior design team is developing a collapsible testing fixture for the Biosense Webster engineering design team. The team's design settled on using plastic to serve as the base for the testing rig. The catheter lies on top of the plastic platform and is rigidly fastened within a mold to hold the handle of the catheter. The catheter spans the length of the acrylic box, dubbed the "heart box" that lies where on the opposite side of the plastic platform. The distal end of the catheter is then inserted within the heart box. The handle of the catheter is controlled by a stepper motor that rests against within the handle. The stepper motor is fastened to a mold that secures onto the knob of the catheter. A camera will rest above the heart box to capture the output of the distal end. The captures from the camera will be processed into MATLAB to validate the output and input angle and ensure they are the same.

The project's completion allowed Biosense Webster to safely advertise to practitioners and surgeons that they can safely navigate within the human heart with a 0.5 degree of freedom precision using their cardiac catheter. This helps enforce a safer standard for those receiving heart procedures.

Component/Module Description

The 113 SD team's design is comprised of multiple separate modules that all come together to form a fully functional device that achieves the team's mission statement. Only one item of the device has been provided by the Biosense Webster team. A few items have been purchased via the Biomedical Engineering order form. The rest of the items that will be mentioned will be 3D printed and incorporated. Tools, machinery, hardware, and a few nuts and bolts have been provided by the Biomedical Engineering department and the Mechanical Engineering department.

The first module of the project is the Catheter, provided by the sponsor company, Biosense Webster. The catheter itself is not to be altered for the project's scope but will act as the vessel or control variable used by the team to test their operations and experiments. The catheter will be tracked and analyzed via image processing software.

Figure #: Catheter

The next module of the project is the Handle Mount. This mount has been designed to hold the handle in place without inhibiting its ability to rotate while also not providing too much freedom to rotate out of place. This mount has been 3D printed.

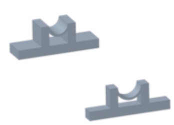


Figure #: Handle Mount

Following the handle mount, the next module of the overall design in the Handle Mold. Not to be confused with the handle mount, the handle mold is only to provide a secure attachment to the stepper motor. This mold has been designed to sit snuggly around the female port of the handle. This mold is 3D printed.

Figure #: Handle Mold

Moving past the handle mold, the next item apart of the 113 SD team’s design is the Sheath Holder. Yet another 3D printed part, however, there are four prints of the sheath holder to support the length of the rubber tube that will connect from proximal to distal end, The sheath holder is at the height of the hole in the box as well as the height of the motor. This is to ensure that there will be as minimal slack throughout the product as possible.

Figure #: Sheath Holder

Following the sheath holders, and onto part of the distal end pieces, the past the handle fasteners, the next item apart of the 113 SD team’s design is the Sheath Holder. Yet another 3D printed part, however, there are four prints of the sheath holder to support the length of the rubber tube that will connect from proximal to distal end, The sheath holder is at the height of the hole in the box as well as the height of the motor. This is to ensure that there will be as minimal slack throughout the product as possible.

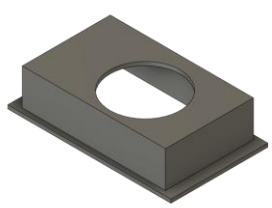


Figure #: Camera Mold

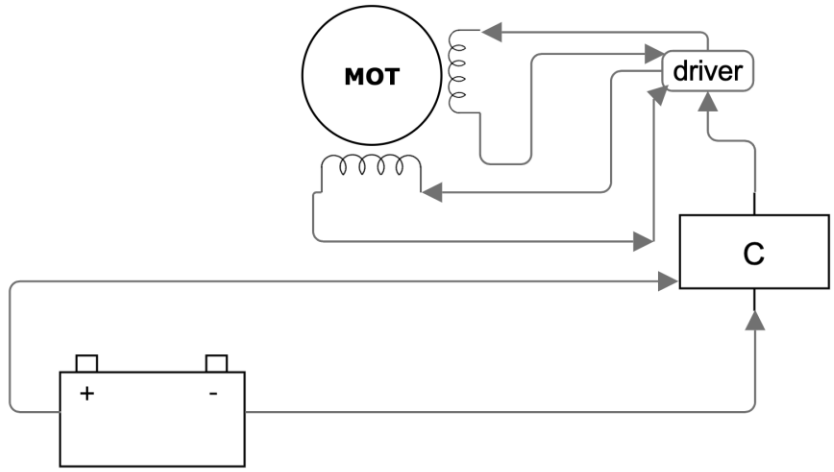
The next 3D printed part of the assembly is the camera mold. This mold will fit within the camera mount. This piece is used to ensure the stability and repeatability of image capturing when using the digital camera provided by the student.

Figure #: CAD Assembly

An acrylic platform is robust and the ideal material for testing due to its strength and stability it gives to allow for consistent testing.

Figure #: Observation Box

Observation “heart” box is made of plastic material. A clear acrylic box is see-through, ideal for testing procedures. This allows for clear observation of the catheter within to allow the camera to easily pick up on the angle at which the cather’s distal end is positioned at.



The wiring displayed represents the circuit board that incorporates the stepper motor, computer, Arduino, and battery. This diagram can be used to help the operator using the design ensure their wiring is proper for testing. It also provides a good visual representation of what the wiring should look like if the operator needs to check the connections.

```
#define EN 8

//Direction pin
#define X_DIR 5

//Step pin
#define X_STP 2

//A498
int delayTime = 3600;
int stps=200;

void step(boolean dir, byte dirPin, byte stepperPin, int steps)
{
  digitalWrite(dirPin, dir);
  delay(100);
  for (int i = 0; i< steps; i++)
  {
    digitalWrite(stepperPin, HIGH);
    delayMicroseconds(delayTime);
    digitalWrite(stepperPin, LOW);
    delayMicroseconds(delayTime);
  }
}

void setup()
{
  pinMode(X_DIR, OUTPUT); pinMode(X_STP,OUTPUT);
  pinMode(EN, OUTPUT);
  digitalWrite(EN,LOW);
}
void loop()
{
  step(false, X_DIR, X_STP, stps);
  delay(2000);

   step(true, X_DIR, X_STP, stps);
  delay(2000);
}
```

This is the stepper motor code. This code executes the stepper motor to rotate the handle of the catheter in two increments, one being a 90-degree rotation and the other being a 180-degree rotation. The stepper motor code will also output the time taken to rotate both those increments. These results are then coupled with the image processing code to develop a correlation between the rotation and deflection.

```
%% Calculations
% Loop through each frame
for i = 1:framePrecision:numFrames
    index = index + 1;
    frame = read(videoReader, i); % Read current frame
    frameArray(index) = i; % Store frame index

    [binaryFrame] = findBlue(frame); % Extract binary frame containing blue regions

    modBF = binaryFrame.*gridPattern; % Apply grid pattern to binary frame
    maxPoints = max(modBF(:)); % Maximum points in the modified binary frame
    point = 1;

    % Iterate through each pixel in the modified binary frame
    for pixel = 1:maxPoints
        % Check if the pixel is present in the modified binary frame
        if ismember(pixel, modBF) && ((round((boxPrecision^2)/8)) <= (sum(modBF(:) == pixel)))
            [centroid(point,1), centroid(point,2)]= calcCentroid(modBF, pixel); % Calculate centroid for the pixel
            point = point + 1;
        end
    end

    imshow(binaryFrame); % Display binary frame
    hold on;
    plot(centroid(:,1), centroid(:,2), 'r*'); % Plot centroids in red
    hold off;

    meanCurvature(index) = calcCurvature(centroid); % Calculate mean curvature
```

The entirety of the current image processing code is not pictured, this is merely a snippet of the current image processing code. This image processing code allows the 113 SD team to track deflection while and handle is motor. This code measures the deflections, or rather change in deflection, against time. These results are then coupled to develop a correlation between deflection and rotation.

<u>Water pump system: parts and flow chart</u>

Figure #: Y-Connector

The Y-connector allows for the catheter to be tightly inserted into one end and the water from the pump on the other end, connecting both into one tube.

Figure #: Inlet and Outlet Valve

The inlet and outlet valve are sealed within the observation box to allow for the pump to have water flow into and out of the box in a consistent manner.

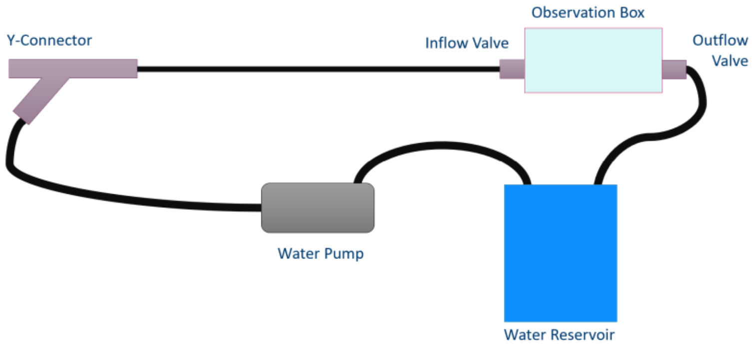


Figure #: Diagram of Water Pump System

Integration

The product will be assembled by first attaching all hinges to the platform. The platform is split into three separate sections, two being 20x10 inches, lengthxwidth, and the third being 30x10 inches. Between the two 20x10 inches sections, hinges will be fastened on the top of the top sections, connecting the two sections. Past the further 20x10-inch section, the 30x10-inch section will be connected similarly, however, with the hinges on the underside of the two sections this time. This will allow the platform to fold up in a simple manner.

Following the hinges the handle mount will be attached to the edge of the first 20x10-inch platform. This handle mount is to be secured against the exterior 10-inch side of the platform and centered on the section. The handle mount will be secured down using buckles; however, screws are a worthy substitute at this point in the assembly.

For the next assembly, a stepper motor will be secured into the motor mount via the stepper motor mount with screws. The stepper motor will then be fastened with the handle mold. This mold will secure onto the handle of the catheter to allot for turning of the device. This motor mount will then be attached to the platform using L-brackets, like the handle mount, centered in the middle of the platform.

The catheter itself will be placed on the handle mount, having the handle sit in between the two catheter handle mounts and snuggly into the handle mold. The catheter will then be connected to a y-connector, allowing for both the sheath and water to be connected to the two other holes of the y-connector. The water pump will be attached to the side closest to the catheter, whereas the sheath will attach to the hole of the y-connector in-line with the catheter itself.

Next, the catheter and sheath will be lengthened along the platform length to the opposite end, secured along the platform via the sheath holders. The catheter will be supported via four of the sheath holders, evenly spaced down the platform's length.

Once the catheter is at the end of the platform, the catheter and sheath will be funneled into an inlet valve which is spaced directly in the middle of the heart box. The heart box, of which, will be secured down on the far end of the platform’s edge via brackets. The box will also have an outlet valve on the bottom corner of the heart box’s back side. Above the heart box rests the camera mount, which is centered on the top side of the heart box, both length and width wise, and is connected/secured to the platform by using L-brackets. Within the camera mount a camera mold will be fitted in, and a camera will rest within that mold.

The water pump will then be funneled to a water reservoir, held beneath the platform, that will then circulate water through the water pump and back to the y-connector. The water is connected from outlet valve to reservoir to pump to y-connector via tube fit for the water pump.

Lastly, all electronics and power sources will be organized behind the stepper motor and behind the motor mount, all wires from the stepper motor going above and beyond the mount. Behind the mount will rest the Arduino, power source, and computer that is executing the code.

Figure #: CAD Assembly of Product

Troubleshooting

One of the earliest issues that may arise when operating this device comes first with the assembling of the product itself. There may be a few items that are misplaced when trying to assemble the product. If the separate pieces of the assembly don't seem intuitive enough to assemble, sufficient instructions will be provided to aid in any assembly issues. The instructions provided will have parts labeled in alphabetical order with their corresponding spots labeled on the platform with the corresponding alphabetical letter.

Another issue that may arise when operating this device could stem from wiring/Arduino connections. If this issue occurs, the team suggests that the user operating the device confirms that they are using the same hardware as the 113 Senior Design team used in their product. If issues continue, the team suggests the user operating the device reviews the provided electronic and wiring diagram to negate extra questions. However, if operation of the electronics still proves to be inadequate, the next step would be to search an online Arduino database for help. There are many online, but the team suggests that the operator looks at the one published by the Arduino website themselves.

A third problem area the team has identified is image processing. The image processing has been executed in MATLAB with specific set metrics in accordance with the camera that will be used. The camera used by the team may not be the same as the one used by the Johnson and Johnson Engineering team, so adjustments to the image processing code may be required. The main manipulations will more than likely be in resolution and frame rate.