Report #3 - Mechanical Design and Fabrication

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1 An Overview

The assembled robot consists of two motors (one for panning and one for tilting), a camera, and two L-brackets that were 3D printed. The assembled system is shown below in Figure 1.

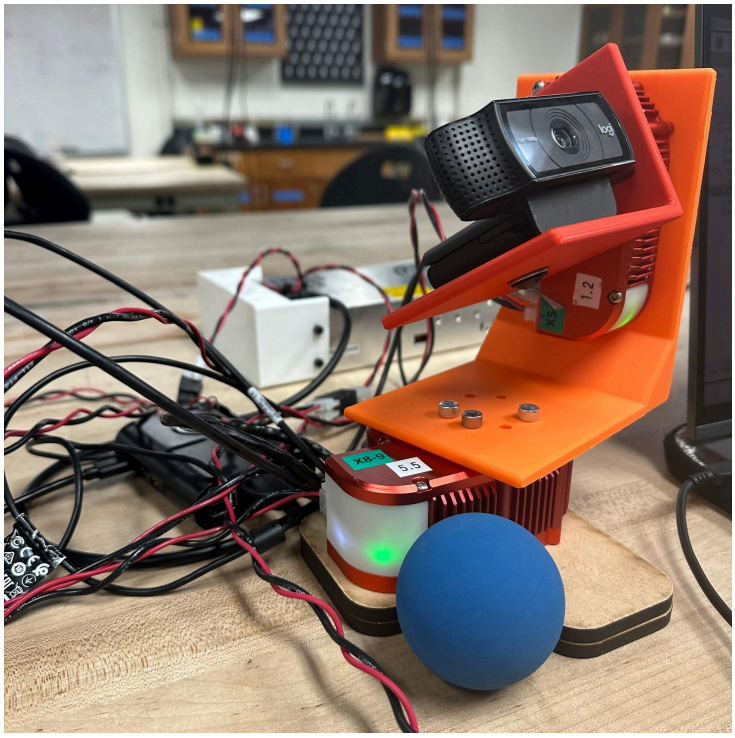

Figure 1: The Assembled Robot

The motors are capable of panning/tilting at least 360 degrees in either direction, however, due to the wiring it is not advisable to pan and tilt the camera further than this as the wires may get got up in the moving brackets or tangled with each other, which could damage the robot under strenuous conditions. Therefore, the pan/tilt angles are reasonable between 0 and 180 degrees.

2 Details of the Parts - Drawings

Figures 2 and 3 below display the CAD drawings of the motor bracket and the camera bracket. The dimensions are also specified in the drawings.

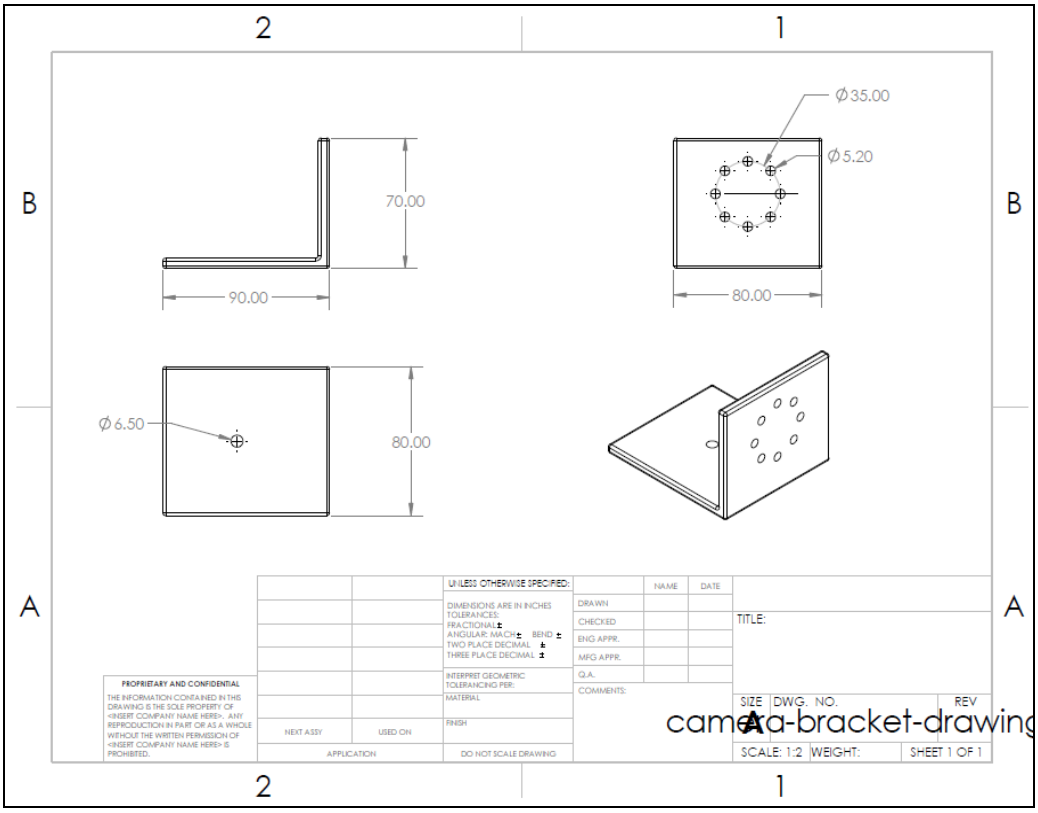

Figure 2: Camera Bracket Drawing

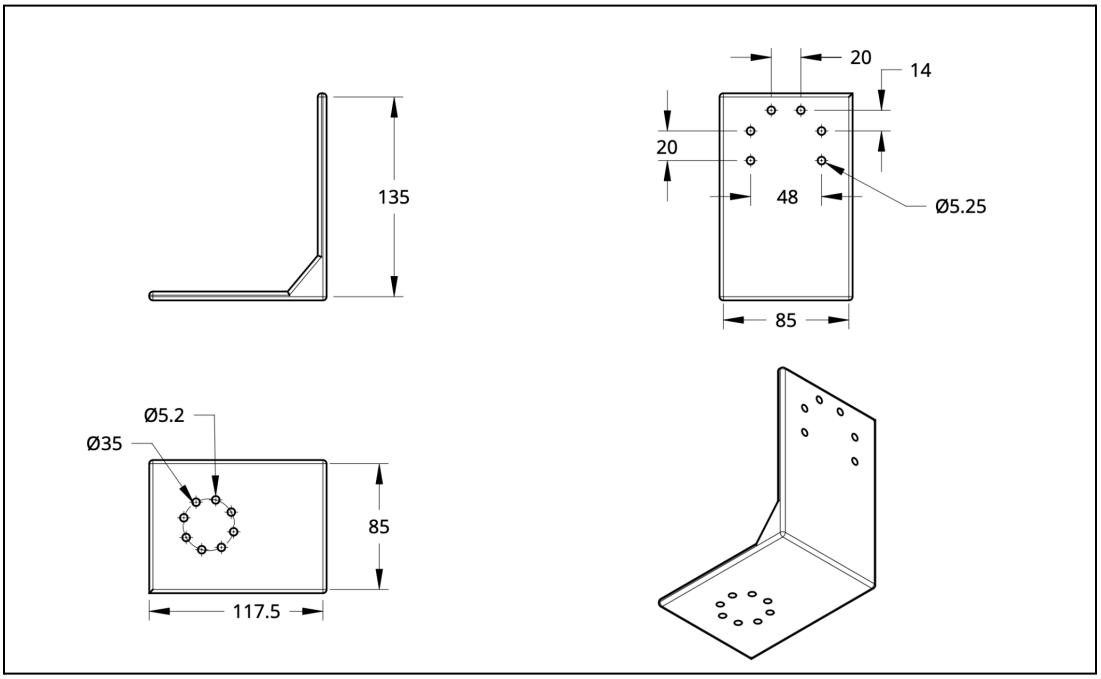

Figure 3: Motor Bracket Drawing

3 Fabrication and Evaluation of the Print

Our parts were 3D printed using default 3D printer settings using the Bambu Carbon X1 3D Printer at the Caltech TechLab. We used Generic PLA plastic and a 0.20 mm layer height, amongst other preset values.

To integrate the motors and camera with the 3D printed parts, we chose the correct tolerances since the screws were able to fit through the holes correctly (see Table 1).

Table 1: Dimensions of the holes in the 3D printed brackets

Critical Part (Hole)	**Measurement from caliper**	**CAD-specified dimension**	**Ideal Tolerance**
Pan Motor Hole	5.17 mm	5.20 mm	0.20 mm
Tilt Motor Back Hole	5.21 mm	5.25 mm	0.25 mm
Tilt Motor Front Hole	5.17 mm	5.20 mm	0.20 mm
Camera hole	6.45 mm	6.50 mm	0.15 mm

We measured the print dimensions using a caliper and noted that they were within the ideal tolerances that we defined, which suggests that our CAD-specified dimensions were reasonable. We did notice that all of the print dimensions were on the lower end of the CAD-specified dimensions, which means that in the future we could specify slightly lower values in the CAD designs.

For the motor bracket, we designed the holes with an incorrect circular pattern. Therefore, they did not align with the back of the motor, so we had to redesign the holes and reprint.
When reprinting, we also increased the height of the motor bracket to have enough space to fit the tilt motor vertically. The holes were printed in a way that required a pi/8 offset for both the pan and tilt motors. The next team can avoid this by checking the dimensions before printing and ensuring the dimensions for the hole patterns are correct.

We printed our parts sideways (the L-shape face down) in order to keep the layers balanced, whereas printing one side face down would have been an imbalanced print.

4 Design and Self-Evaluation.

In order to address structural stiffness, we had added supports to our perpendicular brackets for structural strength in our pan motor print. Additionally, we chose a thickness of 6 mm for the brackets to have enough structural stiffness to hold the motors and still not be too heavy to move.

To design the two brackets, we selected the overall dimensions based on the sizes of the motors and camera. The orientation of the tilt motor was chosen so it is vertical, so the zero position is on the positive y axis. Therefore, the height of our motor bracket was increased to accommodate for the height of the motor. We also filleted the edges of the brackets for a smoother and less sharp finish. For the holes, we did not choose to create countersink holes for simplicity; instead, the screws simply sit on top of the piece.

Our design turned out well since the brackets integrate with the motors and camera without any issue. Our camera also has full degree of freedom in being able to see most of its 3D surroundings and up and down (except for under the pan motor bracket). We could use a different choice of colors so that we have a wider range of colors to detect. Since we chose orange/red (warm-colored parts), we had to confine ourselves to detecting a blue ball.

For our CAD Design, it would make sense to tilt/offset the hole pattern to avoid having to program an offset in the software, which would make the software side cleaner and more understandable.