The Robographer: Progress Review #9

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Team: G (The Robographers)
Teammates:
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ILR No.: # 8
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1. Individual Progress

Responsibilities: Project management
Mechanical Design and Development

Softwares/tools Used: Google Drive, Google Calendar, Microsoft Excel, Solidworks

Task Description:

Following tasks were assigned to me and completed before the progress review 9:

a. Conducting team meeting and deciding goals for PR#9
b. Identify the design issues in the existing pan tilt elevate unit
c. Redesign the pan tilt elevate unit to overcome the existing design issues

a. Setting the goals for PR#9:

1. Pan Tilt Elevate unit redesign
2. Global camera setup
3. Intrinsic & Extrinsic Calibration of 4 global camera
4. Single robot system validation with new hardware
5. Multi-robot IntraFace communication on single computer

b. Identifying the design issues in the existing pan tilt elevate unit:

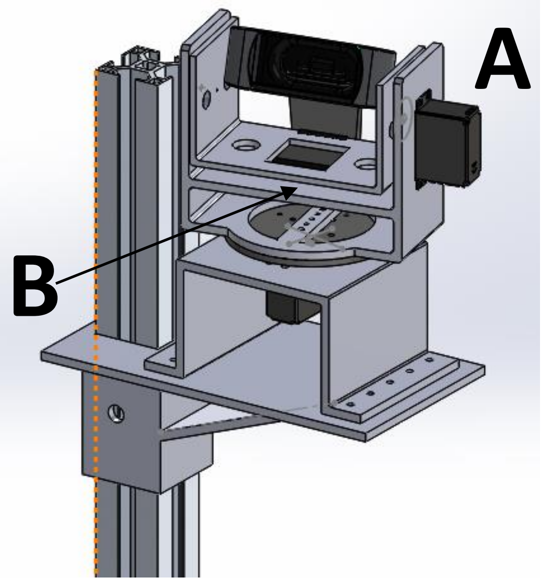

Figure 1 : Existing Pan tilt unit (rev 1.0)

Following design issues were identified in the existing pan tilt elevate unit:

1. **Mechanical restriction over the pan motion:**
The Tilt servo **A** in the existing model is mounted on the outer side of the pan tilt unit. Hence, the motion of the panning servo was often obstructed by the elevation rod, causing the incomplete utilization of the servo range. This was considered while redesigning the pan tilt unit and was fixed by allowing the motor mounting on the inner side of the camera mounting bracket as shown in figure 2.

2. **Mechanical restriction over the tilt motion:**
   As the existing pan tilt unit is fabricated using additive manufacturing, a reinforcement plate was added between the tilt bracket to avoid the bending in its edges due to any load. However, this reinforcement plate acted as an obstruction for the tilt servo motion. Hence, it was not possible to track the human beyond a certain range in the vertical axis. This issue has been solved in the new design of the pan tilt unit as there is no external mechanical restriction to the tilt motor as shown in figure 2.

3. **Bigger overall dimensions and high self-weight:**
   The current pan tilt unit has somewhat huge dimensions (18.5 cm height, 9.525 cm width, 14 cm length). Also, it weighs around 500 gms which is 10% of the turtlebot payload capacity of 5kgs. As the other components mounted on it such as the servo motors and the camera have very small sizes with low weights, it is unnecessary to have such a bulky structure. Besides, it is always better to have compact things regardless of any of the flaws in its predecessor. This has been taken care of in the new design of the pan tilt unit. The overall dimensions of the new pan tilt unit are very small as compared to the existing on (13.7cm height, 7.8 cm length, 7 cm width). The height is reduced by 26%, length by 44% while the breadth is reduced by 27%. In addition, its weight is 300 gms, which is just 60% of the existing pan tilt unit.

4. **Heavy load on the pan motor:**
   As it is evident from the figure 1, the tilt bracket + camera mount assembly is assembled with directly with the pan motor axle. Hence, their weight along with the camera acts directly on the pan motor. This involves a very high chance of motor failure as a large torque, subsequently demanding a large current is required by the motor to move the overhead structure mounted over it. The large current passed through the motor overheats it and causes it to fail which turned out as a reality for us as well. The new design now involves only 2 small brackets with low weight. Also, there is no direct mounted over the pan motor. In fact, the axle of the motor is constrained in the base bracket in such a way that instead of the axle movement (shown in figure 2), the motor itself is rotated when powered.

5. **High system inertia:**
   The existing pan tilt elevation mechanism uses a 4 cm X 4 cm cross section, 2’8” Ft long 80x80 Aluminium extrusion bar for Elevation. This bar itself weighs 1.6 kgs which imposes high inertia on the turtlebot. This high inertia results in the high amplitude vibrations when the system starts/stops. These vibrations make the system unstable and also affect the quality of human detection, expression detection and the photo capture. Also, it was noted during FVE and subsequent testing session that the height of the elevation bar was often under-utilized. Hence, the new design uses a 3cm x 3cm, 2’5” Ft long 80x80 Al extrusion bar, weighing just 600 gms. This reduction in the overall dimensions by 25% and the reduction in weight by 60% of the elevation bar is supposed to lower the effect of inertia and subsequently the vibrations.

c. Redesigning the pan tilt elevate unit to overcome the existing design issues:

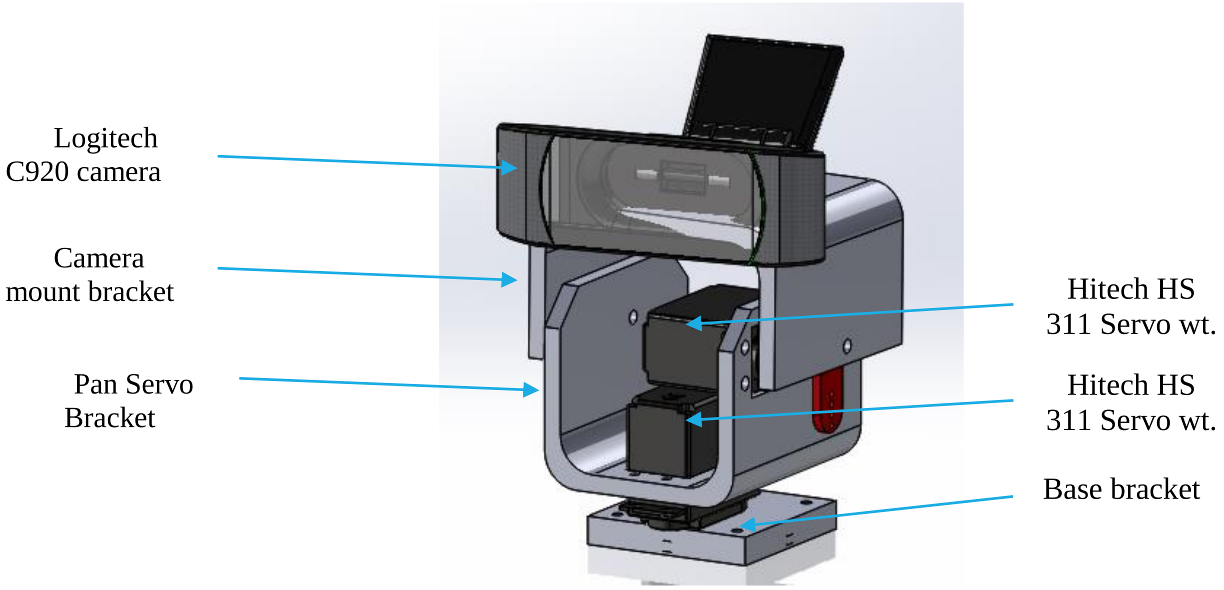

Figure 2 2: Revised pan tilt unit design (rev 2.0)

Figure 2 shows the redesigned pan tilt unit which depicts the following design achievements:

1. Full utilization of the pan and tilt servo limits
2. 26%, 44%, 27% reductions in the height, length and width of the pan tilt unit respectively.
3. 60% reduction in the pan tilt elevate assembly weight
4. Better design to overcome inherent vibrations due to inertia.

2. Challenges

Surprisingly, there were no major challenges involved or faced during the work for this PR. Having done the design and fabrication for the mechanical subsystem in Fall semester, I had a better sense of the necessary modifications to be made. The only challenge I faced was the conceptualization of this next version design of the pan tilt. It took a good amount of time to develop the conceptual rough sketch for this exercise.

3. Teamwork

Since the start of the project, I have taken the responsibility for the completion of the mechanical work subsystem. I, Tiffany worked on developing the environment for the single robot system in Gazebo environment. She also tried to import the AprilTags in Gazebo and code them. We intend to work this out successfully as soon as possible. Jimit and Gauri worked on setting up the global cameras and doing their intrinsic and extrinsic calibrations. Gauri and Sida both worked together on setting up new Chromebook and the camera in the system. Gauri also spent some sleepless nights in establishing the multi-master communication on the single computer and demonstrated it successfully in the PR#9. Jimit did well as a presenter for this PR.

4. Future Plans

My individual plans for the PR#10 for the Robographer Project:

1. **Order remaining 2 quantities of the hardware (cameras and Chromebooks):**
   I had ordered one set of Logitech C920 camera and Acer C720 Chromebook. Then I verified their compatibility with the system successfully. Hence, I plan to order 2 more sets of them for the swarm aspect of our project.

2. **Fabrication of the new pan tilt unit:**
   I had fabricated the pan tilt unit using additive manufacturing process. The resulting components were used successfully for the FVE and showed no signs of damage or performance reduction. Also, additive manufacturing is comparatively a very fast method when compared to the traditional metal fabrication processes when there is no requirement of a huge mass production. Hence, I intend to 3D print a single quantity of the new pan tilt unit design.

3. **Fabricate 3 sets of the pan tilt elevate unit:**
   After fabricating a single quantity of the newly designed pan tilt elevation unit, I have planned to test it by mounting it on a turtlebot and identify the errors/areas of improvement (if any). This will be followed by fabricating 2 more quantities of the pan tilt elevate units and integrating them with 2 other turtlebots that will be used in the SVE. This will complete the mechanical subsystem of the project.

4. **Vibration testing and analysing the methods to reduce them:**
   There are two types of possible vibrations present in the system: (a) Vibration due to the inertia of the pan tilt elevate unit and (b) Inherent vibrations in the turtlebot due to the Kobuki base and floor interaction. During this PR, I have worked to create a design to overcome the vibrations mentioned in the first case. I plan to analyse the type (b) vibrations and come up with a method to greatly reduce or eliminate their effect over the system.