The Robographer: Progress Review #3

Name: Rohit Dashrathi
Team: G (Robographers)
Teammates:
Jimit Gandhi
Gauri Gandhi
Rohit Dashrathi
Sida Wang
Tiffany May
ILR No.: # 4
Submission Date: Nov 13, 2015

1. Individual Progress

Responsibilities: Project management
Mechanical design & development
Prototype fabrication

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

Task Description:

Following tasks were assigned to me and completed before the progress review 3:

a. Conducting team meeting and deciding goals for PR#3
b. Conceptual design and CAD modelling of pan-tilt camera elevation (height adjustment) unit
c. Conceptual CAD modelling of the integrated turtlebot-pan tilt elevate unit system
d. Revising the cyber-physical architecture

a. Setting the goals for PR#3:

Conducting team meeting and deciding goals for PR#2

1. Design and 3D CAD model for elevation (height adjustment) Unit and turtlebot assembly
2. Turtlebot calibration for better IMU and wheel odometry results
3. Operator AprilTag detection using Kinect
4. Setup FVE environment
5. Face detection using webcam-PTZ unit
6. Obtain clicked image on workstation

b. Conceptual design, 3D CAD model and weight analysis for elevation (height adjustment) Unit:

I was assigned to design and develop a manual height adjustment elevation mechanism for the pan tilt camera unit. The core idea behind designing it was to provide a vertical elevation axis to the pan tilt camera so that its height can be adjusted according to the height of the person to be photographed.

Following requirements were listed out for the pan tilt camera unit design:

- Manual elevation (to avoid complexity)
- Height adjustment flexibility up to a span of 3 Feet.
- Holes at every 6 Inches for locking
- Able to recognise face of person 5 Ft. to 6.5 Ft. height
- Holding support of $1/3^{rd}$ the total elevation rod height to avoid vibrations in the system.

Figure 1 shows the CAD model of the elevation mechanism assembled with the pan tilt camera unit developed in Solidworks:

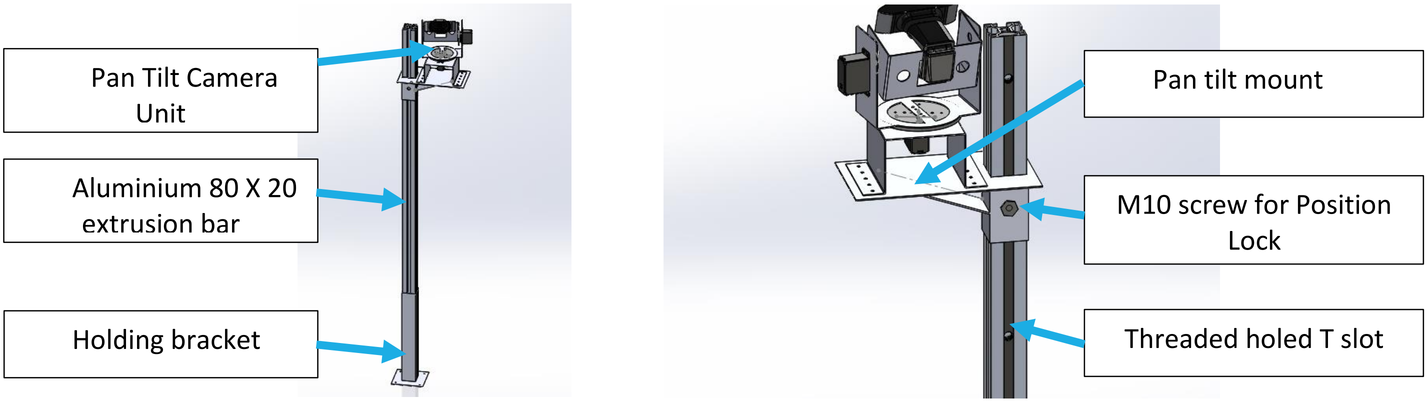

Figure 1 : Elevation mechanism CAD model (Figure to the right indicates the Zoomed version)

Preliminary weight analysis of the pan tilt unit was performed using Solidworks (figure 2) to estimate if the assembly is sustainable by the turtlebots or not.

```
Mass properties of HEIGHT ADJUSTMENT ASSEMBLY
     Configuration: Default
     Coordinate system: -- default --

Mass = 2242.62 grams

Volume = 945128.19  cubic millimeters

Surface area = 815621.53  square millimeters

Center of mass: ( millimeters )
        X = 159.22
        Y = 629.14
        Z = 278.33

Principal axes of inertia and principal moments of inertia: ( grams *  squ
Taken at the center of mass.
         Ix = (0.01, 1.00, -0.00)        Px = 1858594.51
         Iy = (-1.00, 0.01, -0.02)       Py = 312175061.60
         Iz = (-0.02, 0.00, 1.00)        Pz = 313032239.08

Moments of inertia: ( grams *  square millimeters )
Taken at the center of mass and aligned with the output coordinate system.
        Lxx = 312118476.39      Lxy = 4201083.64        Lxz = 10497.58
        Lyx = 4201083.64        Lyy = 1916015.36        Lyz = -408516.73
        Lzx = 10497.58  Lzy = -408516.73        Lzz = 313031403.45
```

```
Mass properties of Pan Tilt Assembly
     Configuration: Default
     Coordinate system: -- default --

Mass = 353.19 grams

Volume = 236419.98  cubic millimeters

Surface area = 161191.01  square millimeters

Center of mass: ( millimeters )
        X = 72.54
        Y = 106.32
        Z = -56.56

Principal axes of inertia and principal moments of inertia: ( grams *  squ
Taken at the center of mass.
         Ix = (0.02, 1.00, -0.07)        Px = 811407.53
         Iy = (-0.99, 0.03, 0.16)        Py = 1339662.15
         Iz = (0.16, 0.06, 0.99)         Pz = 1749187.97

Moments of inertia: ( grams *  square millimeters )
Taken at the center of mass and aligned with the output coordinate system.
        Lxx = 1349431.39        Lxy = 8925.61   Lxz = -64214.08
        Lyx = 8925.61   Lyy = 815661.91 Lyz = -60267.83
        Lzx = -64214.08 Lzy = -60267.83 Lzz = 1735164.35
```

Figure 2: Weight analysis for Pan Tilt unit assembly and Height adjustment assembly

The analysis was done by considering the Aluminium (density[1] 0.0027 gm/cubic mm) as the manufacturing material. Thickness of each Aluminium child part was assumed to be 1.5mm. However, only the frame weights of the pan tilt unit and the height adjustment assembly were considered for this analysis. Hence, the weights of the camera and the servo motors were also added to them to estimate the total weight of pan tilt camera unit + the height adjustment assembly. Table 1 summarizes this calculation along with the material considerations:

Table 1: Weight sustainability analysis for the pan tilt unit + elevation mechanism design

Material Assumed	**Aluminium**
Density:	0.0027 gm/mm^3
Pan tilt frame assembly wt. from Solidworks	353.19 gms
Height adjustment assembly wt. from Solidworks	2242.62 gms
AUSDOM webcam wt.[2]	93 gms
Hitech HS 311 Servo wt.[3] (2 QTY)	2*43gms
Total Assembly weight	2773.81 gms
Turtlebot Payload[4]	5 kg

As seen from table 1, if Aluminium (density 0.0027 gm/mm^3) is used as a manufacturing material for the pan tilt assembly as well as the height adjustment assembly, the total assembly weight calculated using Solidworks is 2.73 kg. This is well within the turtlebot payload of 5kg. This indicates that the preliminary weight analysis signifies the design as safe.

c. Conceptual CAD modelling of integrated turtlebots-pan tilt elevate unit system:

Using Solidworks assembly module, the pan tilt elevate unit was mounted on the turtlebots CAD assembly as shown in figure 3:

Figure 3: Complete single robot system assembly

d. Revising the cyber-physical architecture:

After the team presentation for the assignment 2 of the system engineering for robotics, we were given a feedback suggesting us to revise the cyber-physical architecture of our project. I took on the responsibility to identify the lags, improvement areas and make the necessary changes in it. I observed that our cyber-physical architecture was not in sync with our functional architecture. Also, there was not enough clarity about the softwares and equipments to be used for the in project which reflected badly in the architecture. I tried to correct these pain points and communicated to the team before the preliminary design review. Gauri had taken the responsibility to document it in the soft format for the PDR presentation and did a good job. However, we received some immediate feedbacks about the same regarding the colour scheme used by us which caused difficulties to understand it properly. Hence, I made additional formatting changes and revised the cyber physical architecture once again. I also conveyed to the team members this while conducting another team meeting. Figure shows the final revised version of the cyber physical chart.

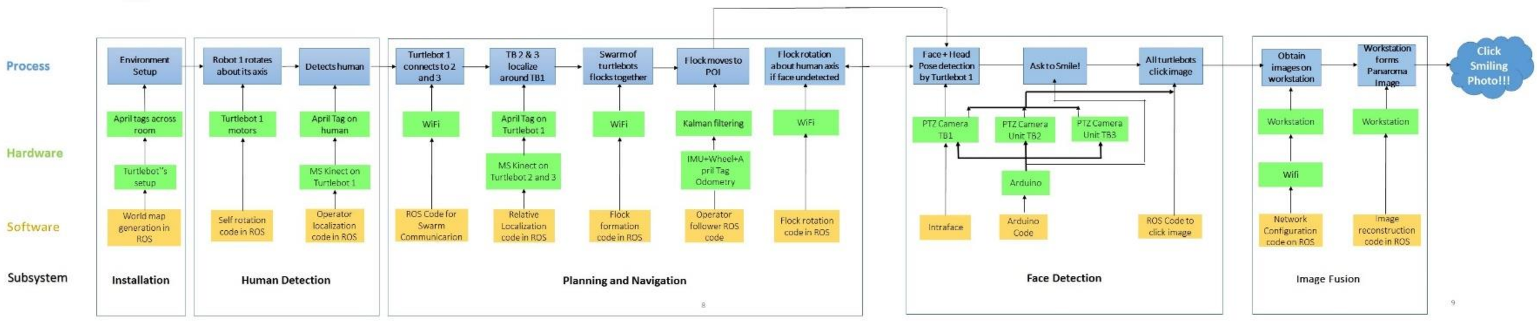

Figure 4: The Robographer-Cyber physical Architecture (Revision 3)

2. Challenges

I faced the following challenges during the preparation for the PR#3:

- **Absence of clarity in the height adjustment unit for the pan tilt camera unit:**
  Before making the conceptual design for the height adjustment unit for the pan tilt assembly, I was not able to picture its mechanism clearly. Hence, I decided to first initiate its actual fabrication to get a better picture of a potential mechanism in mind. Figure shows this initiated assembly work.
  Though this effort took ample time which was not considered in the project schedule, it helped me a lot to immediately acquire a clearer picture of an easy and feasible height adjustment mechanism for the pan tilt camera assembly which is shown in the figure 5.

Figure 5: Initial Height adjustment+ Turtlebot assembly

- **Absence of the user permit for the RI machine shop:**
  To start the fabrication work mentioned above, I used the available resources and inventory in the MRSD lab as I do not have the access to the RI machine shop yet. I took out a 4 cm x 4 cm, 4 feet tall 80x20 Aluminium extrusion bar from the lab inventory, and put threads in its bottom surface using the tapping tools available in the MRSD lab. Using a M6 threaded nut-bolt fastener set, I tied the extrusion bar with a turtlebot over its top plate. Further, I used the Aluminium brackets and fasteners in the MRSD lab to provide a stable support to the vertical extrusion bar and avoid falling down.

3. Teamwork

As mentioned before, I had taken the responsibility to identify the gaps in our cyber physical architecture and improve it further. After this individual exercise on cyber physical architecture, I conducted a team meeting and explained the revised version while asking for their suggestions. The team was very receptive of the changes made and also suggested further improvements. Especially, Gauri and Jimit contributed a lot in this meeting while bringing in the idea of relative localization of swarm robots using April Tags. Gauri and Jimit also made it sure to complete the PR#3 goal 2: Turtlebot Calibration for better IMU and wheel odometry. They also recorded a video of the same to show it during the PR#3. Gauri also did her best to complete the PR2#3 goal 3: Operator April tag detection using Kinect. She showed a great presence of mind to use a webcam instead of the non-working Kinect to complete this task. All the team members did a good job to accomplish the PR#3 goal 4: Setting up FVE environment while cleaning up the allotted room in advanced agent laboratory on NSH 1st floor and making the necessary arrangements. Moreover, Tiffany took over the responsibility of accomplishing the PR#3 goal 5: face detection using webcam and PTZ unit and she tried her best to complete the task.

4. Future Plans

Individual future plans before the 4th progress review for the Robographer Project:

1. Fabrication of elevation (height adjustment) mechanism for PTZ unit
2. Completing the mechanical assembly of the PTZ + height adjustment + turtlebot single robot system.

An insight:

As the design of the CAD assemblies mentioned above is done while considering Aluminium as the manufacturing material, I find it very tedious and time consuming to practically manufacture every single child part using Aluminium sheets. Also, the project requires us to manufacture 3 such pan tilt elevate units. Given the limited time availability for the project, it will consume a great amount of time out of the limited available time to manufacture 3 of such Pan-tilt units and height adjustment mechanisms. Hence, I have decided to fabricate most of the parts using the available inventory as well as additive manufacturing with some necessary modifications in their design making them more robust.

References

1 Density of manufacturing grade Mild Steel:
http://www.allmeasures.com/Formulae/static/materials/31/density.htm

2 Weight of AUSDOM HD 720p webcam:
http://www.amazon.com/AUSDOM-AW310-Definition-Security-Widescreen/dp/B010LP6H0A

3 Hitech HS 311 servo weight:
http://www.amazon.com/s/ref=nb_sb_noss/185-0520746-2914669?url=search-alias%3Dcomputers&field-keywords=hitech+servo+hs+311

4 Turtlebot payload:
http://www.clearpathrobotics.com/turtlebot-2/