The Robographer: Progress Review #1

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Team: G (Robographers)
Teammates:
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ILR No.: # 2
Submission Date: Oct 23, 2015

1. Individual Progress

Responsibilities: Project management
Mechanical design & development

Softwares/tools Used: MS-Project, Solidworks, MS-PowerPoint, Google Drive, Google Calendar

Task Description:

Following tasks were completed before the progress review 1:

a. Overall project scheduling & tracking
b. Bi-weekly project scheduling & tracking (Sprint #1)
c. Setting the goals for PR#1
d. Revising the planning and navigation subsystem work plan
e. Conceptual design, CAD modelling and weight analysis of pan-tilt camera unit
f. PR#1 presentation

a. Overall project scheduling & tracking:

After 10 team brainstorming sessions and 4 sponsor meetings, the overall project schedule was derived before the CODR. (Conceptual Design Review) It was revised again before the progress review 1 (PR#1). I was responsible for the overall project scheduling and tracking it. MS project software tool (made available by DreamSpark-CMU collaboration) was used for scheduling the work plan.

To ensure better communication amongst the team and keep everyone on the same page, the project schedules have been put in a single folder shared over Google Drive. Moreover, Task reminders and their corresponding dates have been set over a shared google calendar so that each team member gets automatic notifications of his/her tasks to be accomplished.

b. Bi-weekly project scheduling & tracking (Sprint #1)

With the learnings from the class 16650 (Systems Engineering & Management for robotics), the idea of generating short bi-weekly sprints seemed appealing to me. We decided to implement this practice for better project tracking. The convenience in tracking the projects was evident. The first project sprint was generated (shown in figure 1) and was shared via Google drive with every team member. Also, timely email reminders/notifications were sent to concerned team members by me.

To Do List

Project: Robographer
12 Oct 2015 - 31 Oct 2015

Pending
Complete

Project / Task	Status	Start D	Due Date (11.59 pm)	Owner	Notes	Column 1
Material Procurement						
Parts List for Mechanical Assembly	Done	12-Oct	14-Oct	ROHIT		
Parts List for Detection Module	Done	12-Oct	14-Oct	SIDA, TIFFANY		26th Oct
Parts List for Planning Module	Done	12-Oct	14-Oct	GAURI, ROHIT		
Budget Preparation	Pending	15-Oct	17-Oct	ROHIT		
Purchase Request	Pending	17-Oct	18-Oct	ROHIT		
Mechanical Development						
PT2 unit & Elevation Rod design	Done	12-Oct	13-Oct	ROHIT		
3D CAD model design for single robot system	Done	13-Oct	20-Oct	ROHIT		
Fabrication of Elevation Rod	Pending	21-Oct	31-Oct	ROHIT		
Detection Module						
Familiarize with Intraface, openCV, C++	Done	12-Oct	15-Oct	SIDA, TIFFANY		
Interfacing camera & zoom lense*	Pending	12-Oct	18-Oct	SIDA, TIFFANY		
Interfacing Camera unit & IntraFace*	Pending	12-Oct	25-Oct	SIDA, TIFFANY		
Facial expression recognition with Intraface using single camera (Partial Work)	Pending	26-Oct	08-Nov	SIDA, TIFFANY		
SVARM Collaboration						
Find person of interest collectively	Pending	19-Oct	09-Nov	JIMIT		

Figure 1: Project Sprint #1

c. Setting the goals for PR#1:

We (the team G) set the following goals for PR#1:

- 3D CAD model for Pan Tilt Zoom Unit
- Research and Finalization of 'Planning and Navigation' subsystem development Schedule
- Demo of human face detection using IntraFace software and webcam
- Completion of ROS training (Demo of Task 6)

d. Revising the planning and navigation subsystem work plan:

Though the tentative project was devised on paper before the CODR, the understanding of task elements involved in planning and navigation subsystem development work flow was not clear. To eliminate the ambiguities involved in it, I along with Gauri Gandhi decided to research more on this aspect of the project. Due to inherent similarities in the nature of the project, we decided to refer the project 'Roborn: Search and Rescue' done by Team C from MRSD 2014-15 class.

After 3 insightful meetings with previous year team C members, a good understanding of path planning module was developed. In addition, we (Gauri and me) obtained important information from Team Roborn website regarding localization, world model builder development, global planner and navigation sub modules designed by them. This really emphasized on the importance of website development course requirement for me. On the basis of this understanding, I and Gauri conducted an exercise to identify the relevant mechanisms from the Roborn-search and rescue (for the Robographer project). Eventually, we could come up with a comprehensive work schedule for planning and navigation subsystem (shown in figure 2):

21	**4. Planning & navigation module (Fall)**	**36.19 days**	**Sun 11-10-15**	**Fri 20-11-15**	**Gauri,Rohit**
22	**Localization sub-module development**	**30.63 days**	**Sat 17-10-15**	**Fri 20-11-15**	**Gauri,Rohit**
23	Procurement of repositories, codes from Team ROBORN	3.13 days	Sat 17-10-15	Tue 20-10-15	Gauri
24	ROS assignment tutorial	3 days	Wed 21-10-15	Fri 23-10-15	Gauri,Rohit
25	**Development of Inbuilt localization**	**9.13 days**	**Fri 23-10-15**	**Mon 02-11-1**	**Gauri,Rohit**
26	Turtlebot wheel calibration using ROS	3.63 days	Fri 23-10-15	Sun 25-10-15	Gauri
27	Turtlebot IMU calibration using ROS	3 days	Mon 26-10-15	Wed 28-10-1	Rohit
28	Development of local EKF using ROS	1 day	Thu 29-10-15	Thu 29-10-15	Gauri,Rohit
29	Final calibration check of Turtlebot using ROS	3.63 days	Fri 30-10-15	Sun 01-11-15	Gauri,Rohit
30	**Absolute AprilTag Localization**	**16.25 days**	**Tue 03-11-15**	**Fri 20-11-15**	
31	Procurement of AprilTags	2 days	Tue 03-11-15	Wed 04-11-1	Gauri
32	Single AprilTag calibration with Kinect using ROS	4.13 days	Fri 06-11-15	Tue 10-11-15	Gauri,Rohit
33	Meeting for further schedule development	1 day	Tue 10-11-15	Tue 10-11-15	Gauri,Rohit
34	Developing World Frame using ROS	3 days	Wed 11-11-15	Fri 13-11-15	Gauri,Rohit
35	Identify AprilTag positions in ROS environment	3 days	Wed 11-11-15	Fri 13-11-15	Gauri,Rohit
36	Mount AprilTags in actual environment	2.06 days	Sat 14-11-15	Sat 14-11-15	Gauri,Rohit
37	Mapping tag Ids with Tag locations in world frame using ROS	1.56 days	Sun 15-11-15	Mon 16-11-15	Gauri,Rohit
38	Development of Global EKF in ROS	1 day	Tue 17-11-15	Tue 17-11-15	Gauri,Rohit
39	Obtain state estimate of Kinect (Turtlebot)	3 days	Wed 18-11-15	Fri 20-11-15	Gauri,Rohit
40	**World Model Builder Development**		WBD	WBD	Gauri,Rohit
41	**Global Planner sub-module Development**		WBD	WBD	Gauri,Rohit
42	**Navigation sub-module development**		WBD	WBD	Gauri,Rohit
43	**5. Planning & navigation module (Spring)**		Wed 20-01-16	WBD	**Gauri,Rohit**
44	**Relative AprilTag Localization**	15.25 days	Wed 20-01-16	Fri 05-02-16	Gauri,Rohit
45	**World Model Builder Development**	14.75 days	Sat 06-02-16	Sat 20-02-16	Gauri,Rohit
46	**Global Planner sub-module Development**	14.19 days	Sun 21-02-16	Sat 05-03-16	Gauri,Rohit
47	**Navigation sub-module development**	14.25 days	Sun 06-03-16	Mon 21-03-1	Gauri,Rohit

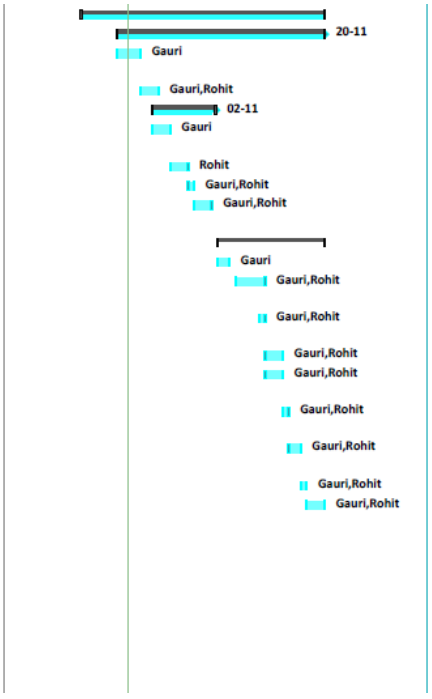

Figure 2: Work Schedule for planning and navigation subsystem

e. Conceptual design, CAD modelling and weight analysis of pan-tilt camera unit:

The core idea behind mounting the pan tilt camera units was to provide the face detection camera with 2 extra axes for better face tracking.

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

- Universal camera mount (for limited number of camera types)
- No zooming axis
- 2 axis rotations: (1 Pan axis, 1 Tilt axis)
- Manual elevation (to avoid complexity)
- Low self-weight
- Sustainable to 2 kg camera weight (with 1.3 FOS)*
- Height from surface 5.5 Ft. (Avg Human Height)
- Able to recognise face of person 5 Ft. to 6.5 Ft. height
- Range of operation: -90 to +90 deg [Pan motion]

  $-\tan^{-1}(1/(2R))$ to $\tan^{-1}(1/R)$ Tilt motion, in deg]

  'R' – Distance between the pan tilt camera and the human face

Figure 3 shows the CAD model of pan-tilt camera unit developed in Solidworks:

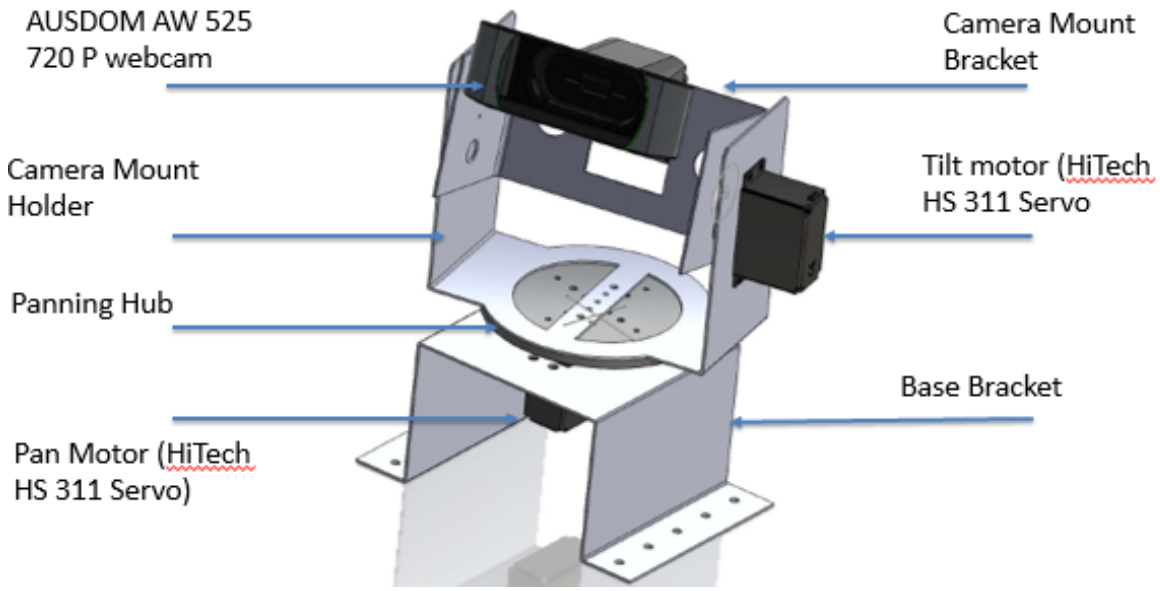

Figure 3: 3D CAD model-Pan tilt camera unit

Preliminary weight analysis of the pan tilt unit was performed using Solidworks (figure 5) to estimate if the assembly is sustainable by the turtlebots or not.

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

Mass = 684.20 grams

Volume = 236419.98  cubic millimeters

Surface area = 161191.01  square millimeters

Center of mass: ( millimeters )
        X = 69.98
        Y = 95.68
        Z = -56.06

Principal axes of inertia and principal moments of inertia: ( grams *  square millimeters
Taken at the center of mass.
         Ix = (-0.01, 0.99, -0.11)      Px = 1781617.98
         Iy = (-0.99, 0.01, 0.14)       Py = 2568776.29
         Iz = (0.14, 0.11, 0.98)        Pz = 3537372.68

Moments of inertia: ( grams *  square millimeters )
Taken at the center of mass and aligned with the output coordinate system.
        Lxx = 2588514.36        Lxy = -18761.81 Lxz = -135709.32
        Lyx = -18761.81 Lyy = 1801058.34        Lyz = -182566.34
        Lzx = -135709.32        Lzy = -182566.34        Lzz = 3498194.25

Moments of inertia: ( grams *  square millimeters )
Taken at the output coordinate system.
        Ixx = 11002273.63       Ixy = 4562620.80        Ixz = -2820196.22
        Iyx = 4562620.80        Iyy = 7302645.26        Iyz = -3852579.07
        Izx = -2820196.22       Izy = -3852579.07       Izz = 13112611.24
```

Figure 4: Preliminary weight analysis of the pan tilt unit assembly (in Solidworks)

The analysis was done by considering the mild steel (density 7.85 gm/cc) as the manufacturing material. Thickness of each mild steel child part was assumed to be 1.2mm. However, only the frame weight was considered for this analysis. Hence, the weights of the camera and the servo motors were also added to the frame assembly to estimate the total weight of pan tilt camera units. Table 1 summarizes this calculation along with the material considerations:

Material Assumed	Plain Carbon Steel (M.S.)
Density:	7.85 gm/cc[1]
Frame Assembly wt. from Solidworks	684.20 gms
AUSDOM webcam wt.[2]	93 gm
Hitech HS 311 Servo wt.[3] (2 QTY)	2*43gms
Total Assembly weight	863.2 gms
Turtlebot Payload[4]	5 kg

Table 1: Pan tilt unit-preliminary weight analysis summary

f. PR #1 presentation:

I took the opportunity of presenting for the progress review 1. A PowerPoint presentation was prepared by me which summarized the planned goals for PR#1 (as mentioned on page 1) and the team efforts to accomplish them.
During the presentation, following points were summarized:

- Planned vs accomplished goals
- Pan tilt unit design considerations
- Pan tilt unit 3D CAD model
- Planning and navigation: Preliminary research
- Planning and navigation subsystem development schedule
- Human detection algorithm

2. Challenges

The primary challenges during the preparation for the PR#1 were:

- **Unavailability of the 64 bit version, lack of previous training and user non-friendliness of the IntraFace face detection software**

  The detection module development for the Robographer is being taken care by Sida Wang and Tiffany May. As per them, a 64 bit version of IntraFace is needed for the project which they were able to get only after a constant follow-up. This resulted in a delayed procurement of the software and allowed less time to work on it. In addition, due to lack of any previous training or experience of working on the IntraFace software. Moreover, IntraFace does not have a graphical user interface and is a command based operation software. Due to these factors, we were eventually unable to deliver our PR#1 goal 3 (Demo of human face detection using IntraFace software and webcam).

- **Lack of training and user non-friendliness of IntraFace and ROS:**

  Alike IntraFace, None of the team members have had any previous training in or experience of working on ROS. Moreover, even ROS has no graphic user interface and supports only command based operations which is not a user friendly phenomenon. This resulted in inability to deliver the planned goal 4 for PR#1 (Completion and demo of Task 6).

3. Teamwork

To complete the project in time, Team G has chosen to follow a decentralized approach taking the individual skills into consideration. I have taken the responsibility to work out the overall planning and scheduling of the project. Also, being a mechanical engineer, I am handling the mechanical designing and fabrication aspect as well. Sida with a good solid programming background and Tiffany with electronic engineering background, are working together on the detection module of the project. For the progress review, both of them tried their best to cope up with unavailability of the required IntraFace software and tried to prepare a face detection demo using MATLAB. Gauri, being another excellent electronic engineer is working on planning and navigation module and is accompanied by me. She has been very proactive to accomplish the PR#1 goal 2 (Planning and Navigation scheduling) and has been interacting with the team Roborn. Jimit Gandhi, with a knack of doing a patient and focused research and SWARM robotics being his area of interest, is handling the collaboration part.

4. Future Plans

Individual future plans before 2st progress review regarding the Robographer Project:

1. Completion of complete single robot system CAD assembly (PTZ (Pan tilt zoom) unit with camera mounted on turtlebots)
2. PTZ unit prototype fabrication using additive manufacturing of child parts
3. IMU + wheel calibration of a Turtlebot
4. Finalization of the list of mechanical parts to borrow
5. Design of the elevation mechanism for PTZ units

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/