The Robographer: Progress Review #2

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Teammates:
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ILR No.: # 3
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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 1:

a. Conducting team meeting and deciding goals for PR#2
b. Revising conceptual design and CAD modelling of pan-tilt camera unit for additive manufacturing
c. Fabrication of the pan-tilt unit prototype using additive manufacturing
d. Conceptual CAD modelling of the integrated turtlebot-pan tilt unit system

a. Setting the goals for PR#2:

Conducting team meeting and deciding goals for PR#2

- 3D CAD model for Pan Tilt Zoom Unit and turtlebot assembly
- IMU and Wheel calibration of one Turtlebot
- PTZ unit prototype fabrication with additive manufacturing
- Research & Finalization of Collaboration subsystem development Schedule
- Demo of human face detection using IntraFace software and webcam

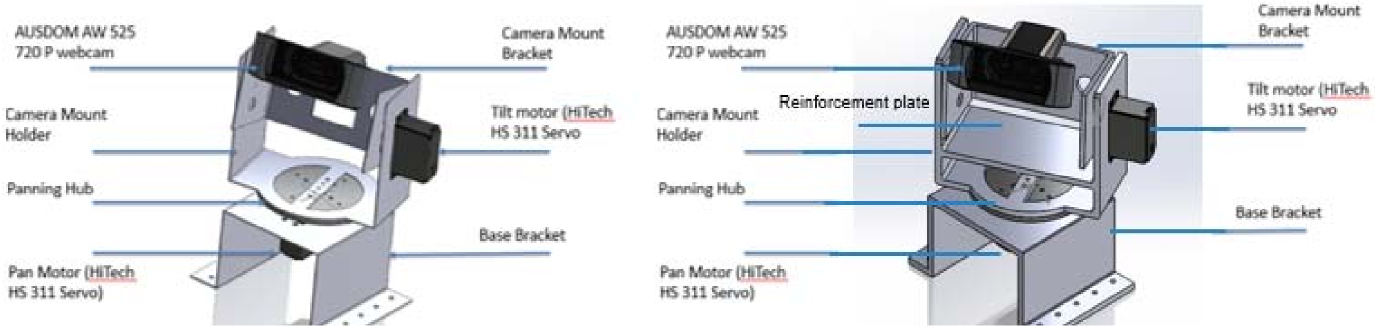
b. Revising conceptual design and CAD modelling of pan-tilt camera unit for additive manufacturing:

We decided to fabricate a working prototype of the pan tilt unit to demonstrate in the PR#2. Given the constrained time limits, we decided to use additive manufacturing method to expedite the fabrication of the PTZ unit. I decided to use the Makerbot 2X Replicator 3D printing machines present in the MRSD laboratory for the same.

As these printers use ABS plastic as the printing material, I had to take care of the overall strength of the PTZ assembly. The thickness of the child parts in the initial design was set to 1.2mm as I had considered mild steel sheet metal as the manufacturing material. For better sustainability of the ABS plastic prototype, I made following changes in the previous CAD model shown in ILR#1:

- Increasing the thickness of the child parts to from 1.2mm to 4.8mm (4 times of the original thickness).
- Adding a reinforcement to camera mount holder to avoid potential bending of vertical columns.

Figure 1 shows the difference between the initial CAD model (for mild steel) and the modified CAD model (for rapid prototyping).



Rev 0: Material used: Mild steel (1.2 mm thickness) Rev 1: Material used: ABS plastic (5 mm thickness)

Figure 1: Pan Tilt Unit CAD model Revision for additive manufacturing

c. **Fabrication of the pan-tilt unit prototype using additive manufacturing:**
After the revising the CAD model and making it suitable for rapid prototyping, I converted the individual child parts to STL (STereoLithography) format using the Solidworks software. Further, I decided to use the SD card mode to feed the input files to the Makerbot 2X duplicator in the MRSD robotics lab. It was observed that the Makerbot machines only accept the .x3g format files while using the SD card mode[1]. Hence, I had to convert the .STL files to .x3g files. After preliminary research over the internet, it was observed that this conversion[2] was done using the stand-alone Makerbot Desktop software. Hence, I downloaded the Makerbot Desktop software on my laptop and used it to convert the .stl model files to .x3g. While conversion, following 3 settings were done to ensure better printing:

- **Setting proper part orientation:**
  The parts were oriented so that no portion of them would be hanging in space to avoid the potential distortions in final print due to gravitational effect. Figure 2 shows the final orientations of the parts done using the Makerbot Desktop software:

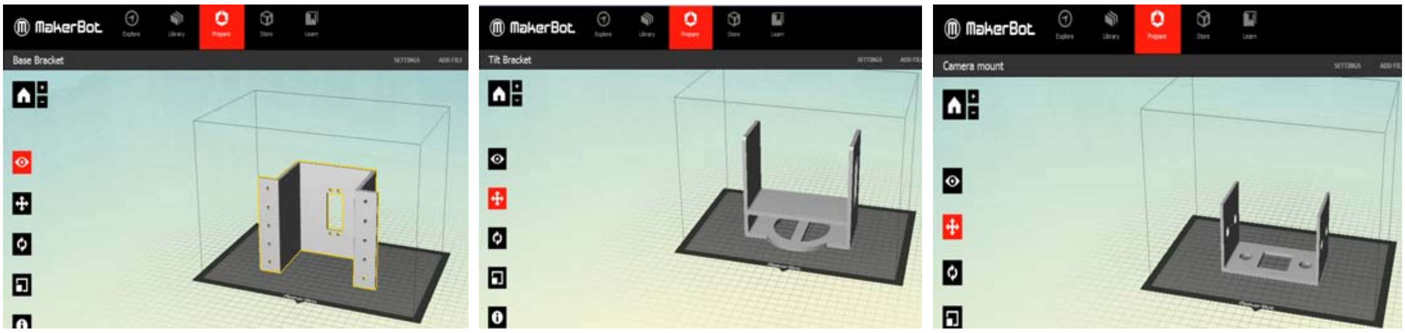


Figure 2: Orienting parts in Makerbot Desktop Software

- **Setting proper temperature:**[3]
  This is a very important configuration while using a 3D printer. With the help of a preliminary research regarding temperature setting for Makerbot 2X, the correct temperature setting was identified and the printing temperature was set to 130 deg C in the Makerbot Desktop software.

- **Setting the desired print quality:**
  The printing quality was set to LOW to save on the print material and the printing time.

The final .x3g files were then transferred to a SD card. The SD card was inserted in the Makerbot machine. Moreover, using the user interface of the Makerbot machine, I selected and printed the .x3g files one by one. Finally, I assembled the parts together using the desired set of fasteners and servo motors. The PTZ assembly was mounted on a turtlebot. Figure 3 shows the PTZ–turtlebot assembly.

Additional work:
To check the performance of the pan tilt unit, I wrote a test code (Appendix A1) was written in Arduino IDE, constraining both the servo motors to rotate within an angular range of 0 deg to 40 deg. It was observed that servos were working correctly, with no signs of any potential/actual deviation or damage in any of the child parts as well as the complete PTZ assembly. Though not promised in the goals of the PR#2, I was successful in demonstrating the working of the Pan Tilt unit with both the pan and tilt operations.

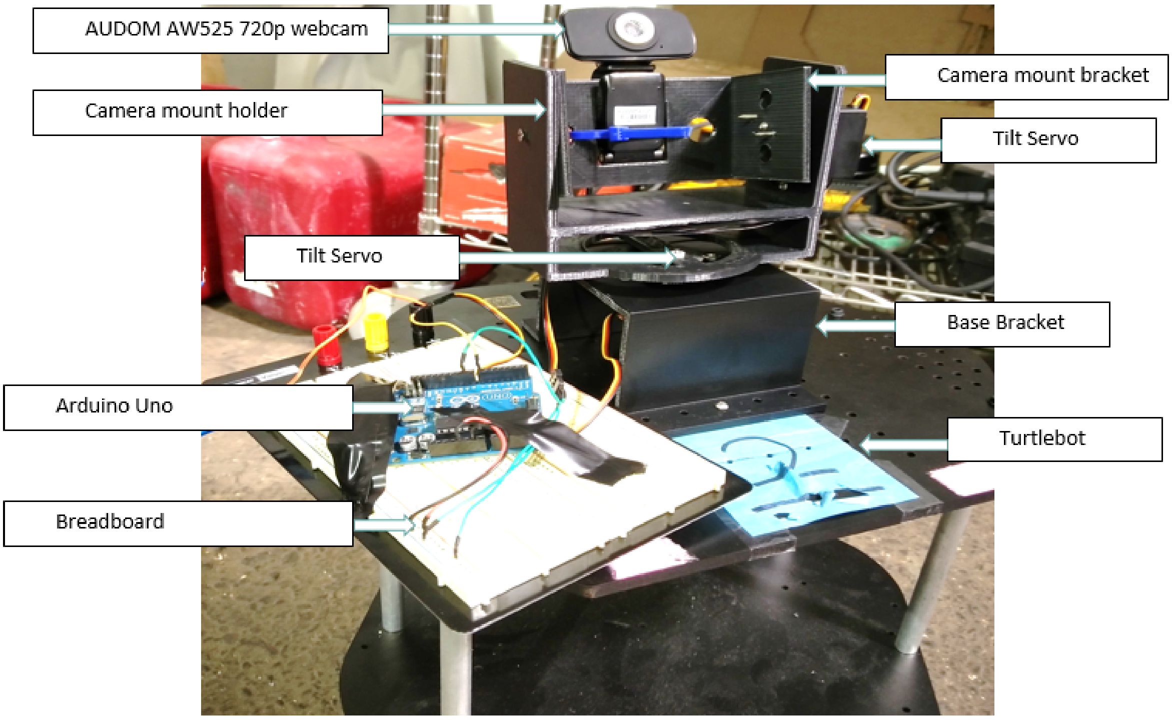


Figure 3 : PTZ unit+ Turtlebot Assembly

d. Conceptual CAD modelling of the integrated turtlebot-pan tilt unit system:

The planned single turtlebot+ PTZ assembly system is supposed to have a manual height adjustment as a risk mitigation factor to avoid a potential risk of working failure due to differences in human height. Hence, we have planned to incorporate the elevation mechanism for height adjustment. I found it necessary to have a visualization of the assembled system with height considerations. Figure 4 represents the integrated turtlebot-pan tilt unit system:

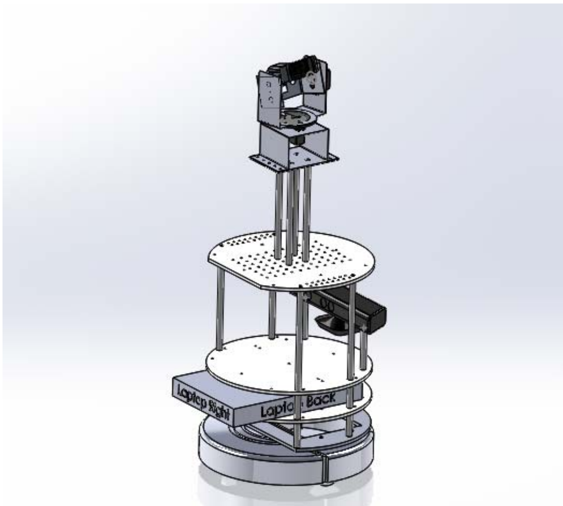


Figure 4: Integrated turtlebot-pan tilt unit system

2. Challenges

I faced following challenges during the preparation for the PR#2:

- **.stl to .x3g conversion for SD card printing mode:**

  After converting the Solidworks files to .stl, I tried feeding them directly to the Makerbot Duplicator 2X using a SD card. However, the printer did not accept .stl files directly. With some research over the internet about this issue, it was figured out that Makerbot only accepts .x3g files in SD card mode. However, due to lack of proper documentation over internet, the methods/tools of conversion were not figured out quickly. With some more research about this issue over internet, I came to know about the Makerbot Desktop software and was successful in converting the .stl files to .x3g format and print the parts.

- **Time taken by the Makerbot 3D printing:**

  The Makerbot duplicators, (or actually any 3D printing machine) have a high lead time of manufacturing. Each part took around 3 hours to get printed while using the Makerbot duplicator. This led to cause a high delay in assembling the PTZ unit components together.

3. Teamwork

To complete the project in time, Team G has chosen to follow a decentralized approach taking the individual skills into consideration. Being designated as a project manager by everyone in the team, I organised a meeting to decide the goals for PR#2. Together, we had a good brainstorming session to fix our goals for the PR#2. Sida and Tiffany worked very hard on the IntraFace software and were successful to achieve human expression detection using the same. They successfully demonstrated this during the progress review. Gauri made it sure to absorb the ROS basics well and succeeded in getting the turtlebots moving while avoiding obstacles. Jimit found the turtlebots parts over the web and completed the turtlebots assembly which was used by me to achieve the goal 1 for the PR#2. Moreover, he also accomplished the PR#2 goal 4 to develop and finalize a work plan for collaboration subsystem development.

4. Future Plans

Individual future plans before 3rd progress review regarding the Robographer Project:

1. Design of elevation (height adjustment) mechanism for PTZ unit
2. Validation and fabrication of elevation mechanism
3. Kinect calibration using the April Tags with ROS environment
4. Additional April Tag based localization of a turtlebot
5. Development of local extended Kalman filter for additional calibration of the turtlebots

References

1. Makerbot SD card printing requirements: https://www.makerbot.com/support/new/06_Replicator_2X/Knowledge_Base/I_Can't_Find_My_File_on_the_SD_Card
2. .stl to .x3g conversion: http://zahncenternyc.wikidot.com/makerbot-replicator-2-overview
3. Temperature for Makerbot 3D printer: https://www.3dhubs.com/talk/thread/best-printing-practices-makerbot-replicator-2-and-2x

Appendix A1

```
#include <Servo.h>

Servo myservo;  // create servo object to control a servo
Servo myservo1;
// twelve servo objects can be created on most boards

int pos = 0;    // variable to store the servo position

void setup() {
  myservo.attach(7);  // attaches the servo on pin 9 to the servo object
  myservo1.attach(9);
}

void loop() {
  for (pos = 0; pos <= 40; pos += 1) { // goes from 0 degrees to 180
degrees
    // in steps of 1 degree
    myservo.write(pos);              // tell servo to go to position in
variable 'pos'
        myservo1.write(pos);
        delay(150);                       // waits 15ms for the servo to
reach the position
  }
  for (pos = 40; pos >= 0; pos -= 1) { // goes from 180 degrees to 0
degrees
    myservo.write(pos);              // tell servo to go to position in
variable 'pos'
    myservo1.write(pos);
        delay(150);                       // waits 15ms for the servo to
reach the position
  }

}
```