ECE 4335: ECE Systems Design

Report Format: ADDIE Design

The second report, both written and oral, concerns the *Design* portion of the ADDIE process. The sections in ADDIE *Design* are listed below, along with a brief explanation of what is to be covered in each section. These are individual reports and will count toward the student’s individual grade. However, the presenting student should consult the team to be sure the report is accurate and up-to-date. Oral presenters would be wise to make a presentation to the team to check for accuracy as well as timing. Both the written and oral reports are to be uploaded to Blackboard.

In all reports, written and oral, the writing and slides must be created by the presenter. Do not reproduce material from any previous reports, except for what we will call “team property”, which consists of the following: Purpose, Problem, Need, Significance; Division of Labor; Deliverables; Target Objective; Overview Diagram; Goal Analysis; Gantt Charts; photographs or videos of projects; project diagrams or flowcharts created by the team.

When you give a report of any type in this class, you should always assume that your audience is not familiar with your project. In the Goal section we will ask for a project description, which should be written based on that assumption. Make sure you are not using terminology or describing things that only someone familiar with the project would understand.

***Written Report Format***

Your report should be spaced at what Microsoft Word calls 1.5 lines. This paragraph is formatted with that spacing. Use a font size no smaller than Times New Roman 12 pt. There is no minimum page requirement, but your report should not be longer than 10 pages, including figures. Use 1” margins all around.

Each of the topics below (1 – 10) should get a separate heading in your report, but specific formatting (beyond that indicated above) is up to you. As always, your writing and your formatting should be clear and concise.

***Oral Report Format***

The contents of the oral report are the same as that for the written report, with the exception that there is no cover letter, and that you do not need to present a detailed test plan. Use PowerPoint or something similar to create your presentation.

Presentations must not exceed 9 minutes in length. The presenter will be cut off after 9 minutes, and points will be deducted for failing to finish the report. Be prepared to answer questions after the presentation.

An oral report should cover all the topics listed below, but it is going to have less “text” and more visuals. Use drawing programs, photographs, movies, or appropriate clip art to illustrate what you are trying to say. Don’t try to explain complicated topics without a picture.

**Report Contents**

***Cover Letter*** (Written Report Only)

Use proper formatting for a formal business letter. The letter should be addressed to your customer (your faculty or industry sponsor). It should include your team members’ names and a brief description of the report contents. Summarize where you are in terms of your progress to date, and assure your customer that you are on target for a successful completion!

***Report Body***

The sections of the report are as follows.

1. **Project Title and Team Members**

You have introduced your team members and their skills in the *ADDIE Analysis* report, so you don’t need to do that here; just list them.

1. **Purpose (overall project)**

Always list your purpose, even though this was discussed in the ADDIE Analysis report. This is a high-level statement about what you are trying to accomplish for the semester.

1. **Overview Diagram**

An overview diagram needs to be descriptive, and it needs to clearly convey the project idea without a lot of text. This diagram will be used as the focal point of your poster presentation at the end of the semester.

1. **Deliverables (both semesters)**

By now you will have a better idea of your deliverables. For this report, list your deliverable for both this semester and next. It may have changed since the ADDIE Analysis report; explain any changes. What will you be presenting at your demonstration? What functions will your project be capable of?

1. **Design Considerations**
2. **Target Objective and Goal Analysis**

Be sure that your goal analysis contents (the boxes) contain things that are measurable and testable; these are your goals. You should therefore have in mind a test or set of conditions that need to be satisfied in order to declare that the goal has been reached: these are your specifications. They will be described as part of you test plan.

A common error in generating a goal analysis is to identify tasks (“design robot”, “research microprocessors”, “build device”) instead of goals (“robot can follow a black line”). Be sure yours contains goals, and not tasks.

1. **Test Plan**

In the test plan section of the report, you will explain how each goal in your goal analysis will be tested: what exactly are you going to do to prove that your goal has been reached?

***Specifications:*** You should include specifications for each goal. These are the technical characteristics of your project (not individual parts) that answer questions such as how much? How many? How often do we need to do sampling? As you complete your testing, you should show in your presentations that you have met the specifications.

You do not need to provide a test plan for every goal in your goal analysis all at once. Just provide this information for the goals you are working on when the report is given. Goals that are scheduled for later in the project do not need to be explained in detail yet. However, you should be thinking about a test plan for all goals when you write the goal analysis. If you do not know how you are going to test your goal, it’s not a good goal.

1. **Schedule**

The schedule shows (i) your goals (from the goal analysis), (ii) who is working on each goal, and (iii) the time span over which the goal will be worked on (and by implication the completion date). This can be done in a lot of ways, including a Gantt chart or a simple bulleted list, but be careful about how much detail you include in one figure. If no one can read the font because it is too small, it will not be useful.

1. **Budget (full project)**

Outline expected costs, including both parts (hardware) and labor. Show budget expenditures to date (how much have you spent so far) as well as total projected expenditures. Use a table or pie chart.

1. **Summary/Conclusions**

Provide a concluding paragraph about the project, summarizing what you are going to do, why it’s important, and why yours is the right team for the job.

**Report Submission**

Upload your report (oral and written) to Blackboard. Written reports must be submitted as word processing documents, and oral reports as presentation documents (e.g., PowerPoint). Do not submit a .pdf. Use the following file name format:

*LastName*\_*FirstInitial*\_Team*N\_*ECE4335\_\_Design

Blanchard\_A\_Team16\_ECE4335\_Design

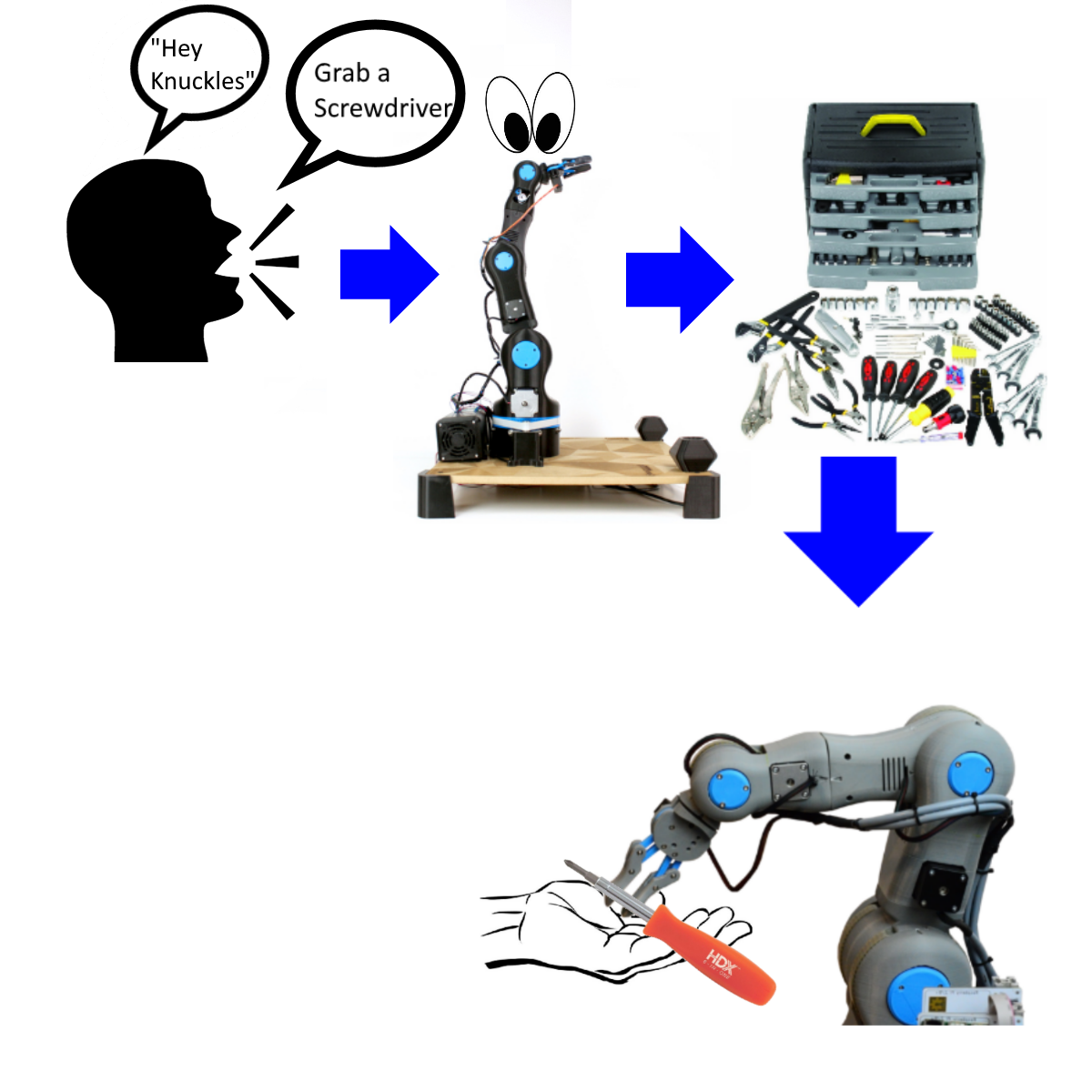
ADDIE Design

By: Andrew Blanchard, Matthew van Zuilekom, Paola Hernandez, Rym Benchaabane

**Purpose (overall project)**

Knuckles is an assistive robotic arm that will hand the user requested objects and tools. It will serve as a convenient assistant that will increase the user’s productivity and decrease the risk of dexterity incidents.

**Overview Diagram**

[ANDREW INSERT THE DIAGRAM U MADE THAT IMPRESSED TROMBETTA HERE]

**Deliverables (both semesters)**

By now you will have a better idea of your deliverables. For this report, list your deliverable for both this semester and next. It may have changed since the ADDIE Analysis report; explain any changes. What will you be presenting at your demonstration? What functions will your project be capable of?

Deliverables this semester: \*include from test procedure\*

At the demonstration, we will be presenting Knuckles capabilities (movement, object detection, voice recognition). We will show Knuckles recognizing a voice command and then picking up the correct object before handing it to the user. We will show the object detection program and what the robot is “seeing”, and the robot converting a voice command into text so it can understand the command.

Original deliverables:

At the end of the Fall semester, our team will provide the hardware part of the project, which will be the physical robotic arm. The user will be able to use a developed simulation on the computer to manually control the robot through text commands. The simulation will be done through Rviz on the Robotic Operating System (ROS). At the end of the Spring semester, our team will provide the software portion of Knuckles, which will include the object detection and voice recognition portion of the project. With the additional help of the software packages, the user will be able to give voice commands to receive requested objects from Knuckles.

**Design Considerations**

The **mechanical properties** of Knuckles are divided into two components, the arm and the gripper. The **arm’s 5-axis movement** and mechanics will be developed using ROS on Linux Ubuntu 16.04 LTS. We are connecting the arm’s joints with a total of **6 stepper motors** (2 for the base). These motors will be processed by **ROS** and controlled by **Arduino**. Programming the ability to move autonomously allows the robot to decide how to move without external input beyond voice commands or manual input on ROS. The gripper is a three-finger design; each finger will have a set of **tactile sensors** to give the robot feedback on the pressure applied to the object it is attempting to grasp. The gripper will be controlled by a **DC motor** with an H-bridge. The gripper can therefore respond accordingly and autonomously adjust its grip with sensors. Once functioning in conjunction with the software components, it will be able to calculate and complete the best path to the item and its return path to the user. The robotic arm and the gripper will be 3D printed using an AutoCAD design. The design is inspired by the open source robotic arm [BCN3D MOVEO](https://www.youtube.com/watch?v=XSY0kieEL8A) (3D printed), with the gripper designed from an [IEEE research paper](https://ieeexplore.ieee.org/document/7109102/?part=1%7Ctable1#).

For this project, we are programming in Python 3.5 and C programming. The two main software applications are visual and voice recognition.

The **visual processing** for Knuckles, including mapping and object recognition will be handled using **OpenCV, Rviz, and TensorFlow**. Knuckles will utilize the Intel RealSense Depth Camera D435 using the mentioned software packages in ROS. **OpenCV** analyzes the video feed to **detect, identify, and log the location of objects** as the room is mapped. The recognition features will be executed through **TensorFlow**. **Rviz** is our 3D visualization application for ROS that will work with the Intel Camera. These libraries will allow us to access and process images, while training with TensorFlow and improving the visual recognition. The user will activate Knuckles with a voice command which will begin the mapping of its surroundings and the execution of the command.

The robot will be able to receive **voice commands** to perform actions such as handing objects including phones, pencils, etc. The microphone will be incorporated with an [Intel® Speech Enabling Developer Kit](https://click.intel.com/intelr-speech-enabling-developer-kit.html). This add-on module is designed to fit the Raspberry Pi3 board. The **Raspberry Pi3+** sends the audio to the [Amazon Alexa Voice Service](https://developer.amazon.com/alexa-voice-service) and receives the text request to be processed using a listening script connected to **ROS**. The command will be translated into the object data detected from the map created via **RViz**. The robot’s arm motors will move and execute the motion command. A voice command will be used to “wake-up” Knuckles from its standby state, which then allows Knuckles to execute commands.

The first constraint we have is time. For example, we want to develop a gripper that’s capable of grabbing a larger group of differently shaped objects differently shaped. The second constraint is the RealSense camera that is not able to create an image on space within a foot of the lens.

**Target Objective and Goal Analysis**

A common error in generating a goal analysis is to identify tasks (“design robot”, “research microprocessors”, “build device”) instead of goals (“robot can follow a black line”). Be sure yours contains goals, and not tasks.

**Test Plan**

The test plan covers the **twelve** phases:

1. Tests the physical mobility of the robot arm.
   1. Verifies the arm and gripper motion with a controller. The motors are going to be tuned accordingly.
2. Test robot connection to ROS.
   1. Request the robot to position itself in straight up, straight out, and in reaching motions.
3. Test the object recognition.
   1. Validate that can recognize multiple objects at the same time.
4. Test the ability of the robot to map the environment.
   1. The mapping should be an accurate representation of the workspace of the robot.
5. Test the combination of visual recognitions.
   1. Measure and compare the accuracy of object object tags in ROS and in real space.
6. Test the search function.
   1. Use text recognition to have the robot point at objects.
7. Test the retrieval function.
   1. Using text recognition to retrieve an object.
8. Test the voice recognition.
   1. We are going to be speak in a microphone and check if the word matches the text in the ROS terminal.
9. Test the user search function.
   1. Upon voice request, have the robot find the user.
10. Test the return function.
    1. Have the robot drop the object as close to the user as possible.
11. Test the gripper with the return.
    1. Have the robot wait until the user is within range and pulls on the object.
12. Test the timing of the entire process: Have the robot time to complete function.

Therefore, the test would the obeissance of the robot, the ability of the robot to recognize, grab and retrieve the object to the right user in a humanly timing. The other testing possibility is to give robot commands through text and through ROS.

**Schedule**

The schedule shows (i) your goals (from the goal analysis), (ii) who is working on each goal, and (iii) the time span over which the goal will be worked on (and by implication the completion date). This can be done in a lot of ways, including a Gantt chart or a simple bulleted list, but be careful about how much detail you include in one figure. If no one can read the font because it is too small, it will not be useful.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| **Date** | **Progress** | **Entire Group** | **Matthew van Zuilekom** | **Andrew Blanchard** | **Rym Benchaabane** | **Paola Hernandez** |
| *October 10th* |  |  |  | Pick up cleaning tools from Home Depot |  |  |
| **October 12th** |  | Get parts from Regina (or at least dates for parts arrival) | Have robot arm track object in simulation | Submit written report by 5PM (ADDIE Design). Ensure Macbook is enough for Rviz/Gazebo robot arm simulation. Clean all components. | Get RealSense camera working on laptop with 2D object detection | 2D object recognition using RealSense Camera |
| **October 19th** |  | Build robot. | Pick up parts (fasteners) from Home Depot. | Pick up parts (fasteners) from Home Depot. In SWE conference (October 18th) | 2D object detection reliable and working. Get 2D working well before moving to 3D | 2D object detection reliable and working. Get 2D working well before moving to 3D |
| **October 22nd (Milestone 1)** |  | Arm and gripper are fully constructed and functional. All parts printed and parts acquired |  | *Buffer* |  |  |
| *October 23rd* |  |  | *Presenting in senior design lecture* |  |  |  |
| **October 26th** |  |  | Gripper and arm in Rviz/Gazebo simulation (finish final CAD of gripper and arm design, convert to URDF, put in Rviz). Recognize shortcomings of Moveo gripper and implement solutions on final gripper | Gripper and arm in Rviz/Gazebo simulation (finish final CAD of gripper and arm design, convert to URDF, put in Rviz). Recognize shortcomings of Moveo gripper and implement solutions on final gripper | Get 3D pointcloud video input showing in Rviz | *Submit Progress 1 written report by 5PM.* Get 3D pointcloud video input showing in Rviz. |
| **November 2nd** |  |  | Print out and assemble final gripper and mount onto arm. Print out camera mount & mount camera on arm | Print out and assemble final gripper and mount onto arm. Print out camera mount & mount camera on arm | 3D object detection | 3D object detection |
| *November 6th* |  | *Ethics assignment due November 6th at 5PM. Group assignment* |  | *Buffer* | *Presenting in senior design lecture* |  |
| **November 9th (Maker Showcase)** |  | Arm is fully constructed and moveable/controllable | Find and mount tactile pads | *Display built arm at Makers' Showcase* | Train object detection, can recognize every object will most likely encounter | Train object detection, can recognize every object will most likely encounter |
| **November 16th** |  | Tactile pads respond as expected and recognize when an object has been sufficiently grasped | *Submit Progess 2 written report by 5PM.* | Order voice kit and microphone. | Fully functional object detection simulation with RealSense working on Rviz. Saves 3D position of the object | Fully functional object detection simulation with RealSense working on Rviz. Saves 3D position of the object |
| **November 20th (Milestone 2)** |  | Simulate the final arm/gripper design in Rviz. Arm has all hardware attachments (excluding mic).  Camera is working properly in Rviz and providing the saved locations of objects. Tactile pads responding properly and recognize when an object has been grasped. |  | *Presenting in senior design lecture* |  |  |
| *November 21 - 25* |  | *Thanksgiving holiday* | *Buffer* | *Buffer* | *Buffer* | *Buffer* |
| *November 27th and 29th* |  | *Facilitator meetings* |  |  |  |  |
| **November 30th** |  |  | Physical arm fully follows simulation seen in Rviz | Physical arm fully follows simulation seen in Rviz | Arm properly responds to text commands | Arm properly responds to text commands |
| *December 1 - 12* |  | *Final exams, no classes* |  |  |  |  |
| **December 7th** |  |  | Manual control of robotic arm using a controller | Manual control of robotic arm using a controller |  |  |
| **December 14th** |  | Microphone is able to take audio input and convert to text for voice commands |  |  |  | *Out of town* |
| **December 21st** |  | Arm can remember path made when controlled and duplicate the motion when given the proper text/voice command |  | *Out of town* |  |  |
| **December 28th** |  |  | *Buffer* | *Buffer* | *Buffer* | *Buffer* |
| *December 23 - 30* |  |  | *Out of town* | *Out of town* |  |  |
| **January 4th** |  | Arm can create 3D map of its environment |  |  |  |  |
| **January 11th** |  | Arm can properly locate requested object (via voice command), pick it up and present requested object to user | Redesign base of arm to consolodate and accomodate microphone | Redesign base of arm to consolodate and accomodate microphone |  |  |
| *January 14th* |  | *First day of spring semester* | Mount microphone on arm. | Mount microphone on arm. |  |  |
| **January 18th** |  | Arm can be given an object, and place that object in an empty spot on the table |  |  |  |  |
| **January 20th (Milestone 3)** |  | Implement 3D mapping using RealSense. Simulate object detection and implement on the physical robot. Robot will be able to locate and pick up objects in its environment |  |  | Fully trained object detection, can recognize every object will most likely encounter. Responds to voice commands | Fully trained object detection, can recognize every object will most likely encounter. Responds to voice commands |
| **February 15th (Milestone 4)** |  | Improved object recognition and user position recognition. Implement voice recognition software to accept voice commands |  |  |  |  |
| **March 8th (Milestone 6, IEEE Chili Cook off)** |  | Implement final voice commands reference library. Robot arm needs to be 100% done! | Eat chilli | Eat chili | Eat chili | Eat chili |
| *March 11th - 17th* |  | *Spring Break.* Prep Robot for travel |  | Birthday Buffer |  |  |
| ***March 26th (ECEDHA Conference)*** |  | Demonstrate arm at ECEDHA Conference |  |  |  |  |
| **April 15th (Milestone 7)** |  | Fine tuning based on feedback from IEEE National Conference |  |  |  |  |
| **Capstone conference date?** |  |  |  |  |  |  |

**Budget (full project)**

**TABLE \_ : List of parts for MOVEO BCN3D Robotic Arm with price/unit and current status**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **BOM ID** | **Part** | **Quantity** | **Single Price** | **Status** |
| **1** | **Stepper Motor SM42HT47** | **1** | **23.22** | **Ordered** |
| **2** | **ARDUINO MEGA 2560** | **1** | **14.86** | **Ordered** |
| **3** | **Stepper Driver TB6560** | **6** | **43.99** | **Ordered** |
| **4** | **Power Supply 24 [V], 320[W]** | **1** | **72.89** | **Ordered** |
| **5** | **RAMPS V1.4** | **1** | **12.50** | **Ordered** |
| **6** | **Power Converter 24[V] to 12[V]** | **1** | **41.94** | **Ordered** |
| **7** | **Servo Motor 180 55G** | **1** | **29.00** | **Ordered** |
| **8** | **Gear Ratio 5:1 Planetary Gearbox**  **Nema 17 Stepper** | **1** | **42.00** | **Ordered** |
| **9** | **Nema 23 flat shaft** | **2** | **45.50** | **Ordered** |
| **10** | **Nema 14 36 [mm]** | **1** | **19.99** | **Ordered** |
| **11** | **Nema 17** | **1** | **12.99** | **Ordered** |
| **12** | **Chrome steel smooth bar-134[mm]** | **3** | **4.29** | **Verified** |
| **13** | **Chrome steel smooth bar-114[mm]** | **1** | **0.00** | **Verified** |
| **14** | **Chrome steel smooth bar-80[mm]** | **1** | **0.00** | **Verified** |
| **15** | **Ball Bearing 608ZZ**  **8[mm] x 22[mm] x 7[mm]** | **1** | **9.99** | **Ordered** |
| **16** | **Ball Bearing 625ZZ**  **5[mm] x 16[mm] x 5[mm]** | **1** | **14.72** | **Ordered** |
| **17** | **Ball Bearing 624ZZ**  **4[mm] x 13[mm] x 5[mm]** | **1** | **8.45** | **Ordered** |
| **18** | **Ball Bearing 623ZZ**  **3[mm] x 10[mm] x 4[mm]** | **1** | **7.38** | **Ordered** |
| **19** | **Brass insert M4** | **1** | **18.00** | **Ordered** |
| **20** | **Brass insert M3** | **9** | **0.00** | **Verified** |
| **23** | **Rod Bar M8 [mm]** | **1** | **6.90** | **Ordered** |
| **24** | **Coupling Steel 5 to 8[mm] rigid** | **1** | **6.84** | **Ordered** |
| **25** | **Axial Fan DC 24[V] 80[mm] x 80[mm]** | **1** | **4.95** | **Ordered** |
| **26** | **Axial Fan DC 24V 50x50[mm]** | **1** | **4.93** | **Ordered** |
| **27** | **Power Supply cable IEC 1.8[m]** | **1** | **15.95** | **Ordered** |
| **28** | **Cable USB 2.0 AM/BM 1.8[m]** | **1** | **10.92** | **Ordered** |
| **29** | **Zip ties** | **1** | **5.95** | **Ordered** |
| **32** | **Wood Base** | **1** | **0.00** | **Verified** |
| **33** | **Breco Belt T5** | **7** | **1.88** | **Verified** |
| **34** | **High Torque Geared Motor DC 12[V]** | **1** | **13.99** | **Ordered** |
| **BOM ID** | **Part** | **Quantity** | **Single Price** | **Status** |
| **101** | **Dimension A: M-3 Dimension B: 10 mm** | **10** | **0.48** | **Verified** |
| **102** | **Dimension A: M-3 Dimension B: 12 mm** | **6** | **0.00** | **Ordered** |
| **103** | **Dimension A: M-3 Dimension B: 16 mm** | **13** | **0.00** | **Ordered** |
| **104** | **Dimension A: M-3 Dimension B: 20 mm** | **1** | **10.98** | **Ordered** |
| **105** | **Dimension A: M-3 Dimension B: 25 mm** | **5** | **0.00** | **Ordered** |
| **106** | **Dimension A: M-3 Dimension B: 30 mm** | **2** | **0.00** | **Ordered** |
| **107** | **Dimension A: M-3 Dimension B: 40 mm** | **7** | **0.00** | **Ordered** |
| **108** | **Dimension A: M-4 Dimension B: 12 mm** | **2** | **9.99** | **Ordered** |
| **109** | **Dimension A: M-4 Dimension B: 10 mm** | **2** | **0.00** | **Ordered** |
| **110** | **Dimension A: M-4 Dimension B: 16 mm** | **8** | **0.00** | **Ordered** |
| **111** | **Dimension A: M-4 Dimension B: 40 mm** | **4** | **2.23** | **Ordered** |
| **112** | **Dimension A: M-4 Dimension B: 45 mm** | **6** | **0.00** | **Verified** |
| **113** | **Dimension A: M-4 Dimension B: 60 mm** | **4** | **0.00** | **Verified** |
| **114** | **Dimension A: M-5 Dimension B: 14 mm** | **8** | **0.00** | **Verified** |
| **115** | **Dimension A: M-5 Dimension B: 20 mm** | **8** | **0.00** | **Verified** |
| **116** | **Dimension A: M-8 Dimension B: 65 mm** | **1** | **0.00** | **Verified** |
| **117** | **Dimension A: M-4 Dimension B: 25 mm** | **4** | **0.00** | **Ordered** |
| **118** | **Dimension A: M-3 Nut** | **30** | **0.00** | **Verified** |
| **119** | **Dimension A: M-4 Nut** | **4** | **0.00** | **Verified** |
| **120** | **Dimension A: M-4 Locknut** | **18** | **0.00** | **Verified** |
| **121** | **Dimension A: M-5 Locknut** | **16** | **0.00** | **Verified** |
| **122** | **Dimension A: M-8 Locknut** | **2** | **0.00** | **Verified** |
| **123** | **Dimension A: M-4 Dimension B: 20 mm** | **3** | **0.00** | **Ordered** |
| **124** | **Dimension A: M-3 Dimension B: 8 mm** | **4** | **0.00** | **Verified** |
| **125** | **Dimension A: M-4 Dimension B: 30 mm** | **8** | **0.00** | **Ordered** |
| **126** | **Dimension A: M-3 Dimension B: 35 mm** | **4** | **0.00** | **Ordered** |
| **127** | **Washer M-3** | **10** | **0.00** | **Verified** |

**Table \_ : List of additional systems and technologies to produce the required functionality of Knuckles**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **BOM ID** | **Part** | **Quantity** | **Single Price** | **Status** |
| **35** | **Intel RealSense D435** | **1** | **160.00** | **Received** |
| **36** | **Intel Speech Enabling Development Kit** | **1** | **499.00** | **Verified** |
| **37** | **Raspberry Pi 3B+** | **1** | **34.99** | **Verified** |
| **38** | **Raspberry Pi 3B+ USB 3.0 Expansion Shield** | **1** | **29.59** | **Verified** |
| **39** | **Mini PC** | **1** | **~800.00** | **Pending** |
| **40** | **PS3 Controller** | **1** | **59.99** | **Verified** |
|  | |  | | |
| **Current Expenditures** | | **$953.18** | | |
| **Total Expenditures** | | **$2407.58** | | |

**TABLE \_ : List of 3D-printed parts for Moveo BCN3D Robotic Arm**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **BOM ID** | **Parts** | **Name** | **Quantity** | **Status** | **Print Location** |
| **202** | **Articulation 1** | **1M1** | **1** | **Printed** | **Robotics Lab** |
| **203** | **1M2** | **1** | **Printed** | **Robotics Lab** |
| **204** | **1M3** | **1** | **Printed** | **Robotics Lab** |
| **205** | **Articulation 2** | **2M1** | **1** | **Printed** | **Robotics Lab** |
| **206** | **2M2M** | **1** | **Ordered** | **Robotics Lab** |
| **207** | **2M2H** | **1** | **Ordered** | **Robotics Lab** |
| **208** | **T2M1BD** | **1** | **Printed** | **IEEE Makerspace** |
| **209** | **T2M1BI** | **1** | **Printed** | **IEEE Makerspace** |
| **210** | **Articulation 3** | **3M1** | **1** | **Ordered** | **Robotics Lab** |
| **210A** | **3M2C** | **1** | **Ordered** | **Robotics Lab** |
| **211** | **3M2** | **1** | **Ordered** | **Robotics Lab** |
| **212** | **T3M1C** | **1** | **Printed** | **IEEE Makerspace** |
| **213** | **Articulation 4** | **4M1** | **1** | **Ordered** | **Robotics Lab** |
| **214** | **4M2** | **1** | **Printed** | **Robotics Lab** |
| **215** | **4M2C** | **1** | **Printed** | **Robotics Lab** |
| **216** | **T4M1** | **1** | **Printed** | **IEEE Makerspace** |
| **217** | **Machine - tool** | **Top plate** | **1** | **Printed** | **IEEE Makerspace** |
| **218** | **Bottom Plate** | **1** | **Printed** | **IEEE Makerspace** |
| **219** | **Cylinder** | **2** | **Printed** | **IEEE Makerspace** |
| **220** | **Pivot Arm** | **2** | **Printed** | **IEEE Makerspace** |
| **221** | **Gripper Left** | **1** | **Printed** | **IEEE Makerspace** |
| **222** | **Gripper Right** | **1** | **Printed** | **IEEE Makerspace** |
| **223** | **Idol gear** | **1** | **Printed** | **IEEE Makerspace** |
| **224** | **Servo gear** | **1** | **Printed** | **IEEE Makerspace** |
| **228** | **Base** | **Stand** | **4** | **Ordered** | **IEEE Makerspace** |
| **229** | **Cover** | **Tapa 2M1** | **2** | **Printed** | **IEEE Makerspace** |
| **230** | **Tapa 3M1** | **2** | **Ordered** | **IEEE Makerspace** |
| **231** | **Tapa 4M1** | **2** | **Ordered** | **IEEE Makerspace** |
| **232** | **Tapa TBB** | **1** | **Ordered** | **IEEE Makerspace** |
| **21** | **Other** | **Pulley T5, bore** | **3** | **Ordered** | **IEEE Makerspace** |
| **22** | **Pulley T5, bore** | **2** | **Ordered** | **IEEE Makerspace** |
| **30** | **Specialty Bearing** | **8** | **Printed** | **IEEE Makerspace** |

We are sponsored by the EE department and Makerspace. We already have the Arduino, Raspberry Pi, RealSense Camera and most of our bolts and fasteners. We basically have over 67% of our budget. The total budget is 1,597$.

Outline expected costs, including both parts (hardware) and labor. Show budget expenditures to date (how much have you spent so far) as well as total projected expenditures. Use a table or pie chart.

**Summary/Conclusions**

Provide a concluding paragraph about the project, summarizing what you are going to do, why it’s important, and why yours is the right team for the job.

By the end of the Fall semester, the physical robot arm will be constructed, and the user can use a simulation in Rviz to control the robot through text commands. By the end of the Spring semester, the object detection and voice recognition of the project will be completed, and the user will be able to give voice commands to request objects from Knuckles. We will accomplish our Target Objective by following a modular test plan, allowing us to develop the hardware and software in tandem. We have ordered all the necessary components to build the robot arm, and will pick up the remaining fasteners from Home Depot. Through the IEEE Makerspace and the Robotics Lab, we have almost completed printing out the parts of the robot arm and prototype gripper. We are on track to complete our project by the end of the Spring semester.