DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

PROJECT CHARTER
CSE 4317: SENIOR DESIGN II
SPRING 2022

H.I.L ROBOT TEAM
H.A.F.R.A

RESHA ADHIKARI
KATIA LOPEZ
NISHAN PATHAK
CESAR REA
RICHARD TRAN

Revision History

Revision	Date	Author(s)	Description
0.1	09.22.2021	RT	document creation
0.2	09.28.2021	RA, KL, NP, CR, RT	complete draft
1.0	10.04.2021	RA, KL, NP, CR, RT	official release
2.0	05.10.2022	RA, KL, NP, CR, RT	final release

Contents

List of Figures

1 Problem Statement

The problem of inefficient machinery affects overall production and causes substantial error. The solution will increase and optimize production of the machinery.

2 Methodology

The solution is to develop an envelope-picking application that will work with a Universal Robot, also known as the UR5. The project will include human assistance that will oversee and fix any mistakes the robot has made remotely. Once implemented, the solution will increase overall productivity and ultimately reduce any errors or mistakes.

3 Value Proposition

Creating a robot that can mimic and perform human tasks efficiently and correctly and can be a great benefit to industries. The UR5 robot increases performance and reduces error to nearly 100% through human assistance. Will get rid of potential risks while still having a consistent worker. It is a profitable idea by replacing the cost of paying a human worker constantly to only a one-time investment.

4 Development Milestones

The following is the list of core project milestones which includes all major documents, demonstration of major project features, and associated deadlines.

- Project Charter first draft - October 2021
- Project Charter first draft - October 2021
- System Requirements Specification - October 2021
- Architectural Design Specification - November 2021
- Demonstration of Basic UR5 functionality - November 2021
- Detailed Design Specification - May 2022
- CoE Innovation Day poster presentation - April 2022
- Final Project Demonstration - May 2022

5 Background

Currently, robots and machines are being implemented into the workforce to perform regular tasks that humans do. Whether it's picking from a bin, picking from a conveyor belt, or organizing boxes on a pallet. Replacing a human with a machine that will have much less risk and higher performance seems like the perfect idea at first, but reaching that point of perfection proves difficult. With current research and development, machines are able to reach approximately 99% performance with the <1% being mistakes and risks. However, being able to cover that small percentage is where the problem comes in. This is where the purpose of this project comes in, to make up for the small percentage of mistakes we want to utilize the idea of human assistance. Essentially, once the robot reaches a block of some sort, the robot will communicate with the human remotely and a user will be able to help the robot with the problem it has encountered. If done correctly, we could potentially have a robot that could perform with a success rate of 100%.

6 Related Work

There is a tremendous amount of research done in bin picking robots. There are many universities, and companies who are working to develop fully functioning random bin picking robots

- Through research and development with breakthroughs in computer vision and motion control, software has enabled robots to make basic distinctions between objects. However, robots still struggle with accuracy and understanding the shape of objects. The National Institute of Standards and Technology of USA is carrying Agile Robotics for Industrial Automation Competition since 2017, aiming to solve these domain challenges [3].
- In a paper published by IEEE, a universal software framework with the focus on virtual bin-picking was presented, where using the framework enabled the integration of various algorithms for recognition, motion planning, different types of robots, grippers, and vision systems [4].
- The International Conference on Intelligent Robots and Systems held in 2010 approached the bin-picking issue by applying the latest state-of-the-art hardware components, incorporating an environment model, and allowing for the physical human-robot interaction during the entire process [2].
- In another robotics conference held in Karlsruhe, Germany, presented an applicable solution for the bin-picking problem which was based on a standard 3D-sensor and was able to handle arbitrary objects [1].
- Bin picking is so complex, specialists have attempted to apply deep-learning techniques but the results have been disappointing, at least for industrial use [5].

7 System Overview

The Human Assistance For Robot Arm (H.A.F.R.A) project has three major components which are the UR5 robot, the movement program, and the vision program. The movement program will send instructions to the robot to perform its task, which will be picking up envelopes with an AruCo tag label off of a table and placing them into a bin. The vision program will use an Intel RealSense camera to detect the AruCo tags. In addition, the vision program will have human assistance so that if the robot detects something unique or a problem it does not have a solution to, it will send an image to a human. The human will then be able to access the robot remotely, will assist the robot, and ultimately fix the problem.

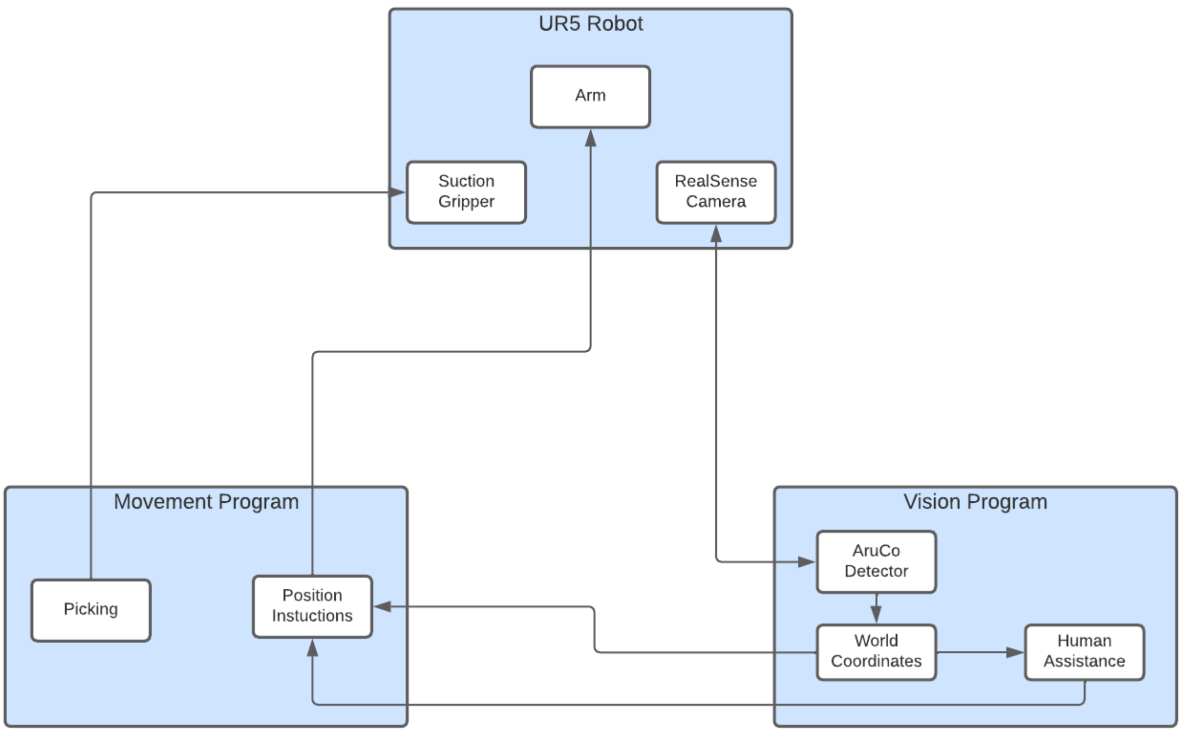

Figure 1: System Overview Diagram

8 Roles & Responsibilities

Our stakeholder will be Professor McMurrough, he will be overseeing our project each sprint and will be our point of contact for any questions we may require from customers. We have five members in our team. Four of us are doing undergraduate degrees in computer science at the University of Texas at Arlington. One of us is doing an undergraduate degree in software engineering at the University of Texas at Arlington. For the assignments that are document based, we will divide the sections and distribute them evenly between each other. The product owner of this project will also be Professor McMcurrough as he makes decisions on accepting or declining sprint results. The scrum master role will change periodically.

9 Cost Proposal

The approximate budget for the project is eight hundred dollars. This amount will come from the Computer Science and Engineering (CSE) department. If any additional funding is required, the sponsor will be contacted. Then, the inadequate budget will be discussed and decided accordingly. This will require effective communication between the team, the CSE department, and the sponsor.

9.1 Preliminary Budget

Potential Items	Cost	Why we need it
Envelopes	$10	The robot will need to pick up envelopes
Bin	$20	To drop-off the envelopes
USB-C Cable	$20	To connect RealSense camera to PC

9.2 Current & Pending Support

Our team will be receiving eight hundred dollars from the CSE department. However, if the budget is insufficient, the sponsor will be able to help us with the budget shortage. We will communicate with Professor McMurrough if we need to exceed the default funding amount. This will be done by effective communication with the team and the sponsor.

10 Facilities & Equipment

Our team will need to use Lab 335 in the Engineering and Research Building to complete our project. We will also need access to the UR5 robot and the teach pendant that is used to control it. The robot and its corresponding equipment is present in Lab 335. We will need to purchase the necessary equipment to test the functionality of the robot. We will need to purchase a bin and the envelopes.

11 Assumptions

The following list contains critical assumptions related to the implementation and testing of the project.

- Lab 335 in ERB will be available by the second sprint cycle.
- The computers in Lab 335 will be available and functioning when beginning to program
- The ERB will provide network connectivity.
- When ordering materials for our project, it will arrive in no later than three weeks.

12 Constraints

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by May 1st, 2022
- Team will only be able to work on the project in person since the robot is located in the Engineering and Research Building.
- Keep budget under $800
- Have one semester to do the implementation, since another senior design team used the UR5 robot during the first semester of Senior Design.

13 Risks

Risk description	Probability	Loss (days)	Exposure (days)
Lack of experience	.85	14	11.9
Team member getting ill	.15	14	2.1
Misunderstanding the customer needs	0.10	7	0.7
Team member is not able to attend meetings or finish their part	.30	3	0.9
Delay in shipping from overseas vendor	.10	20	2.0

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The document will be maintained in the Overleaf LaTex editor, and will be updated for new ideas in development. Each member of the development team will keep a copy of the Project Charter. The initial version will be delivered on October 4th, 2021. The final version will be delivered in May 2022.

14.1.2 System Requirements Specification

The document will be maintained in the Overleaf LaTex editor,and will be updated for new ideas in development. Each member of the development team will keep a copy of the System Requirement Specification. The initial version will be delivered on October 25th, 2021. The final version will be delivered in May 2022.

14.1.3 Architectural Design Specification

The document will be maintained in the Overleaf LaTex editor, and will be updated for new ideas in development. Each member of the development team will keep a copy of the Architectural Design Specification The initial version will be delivered on November 15th, 2021. The final version will be delivered in May 2022.

14.1.4 Detailed Design Specification

The document will be maintained in the Overleaf LaTex editor, and will be updated for new ideas in development. Each member of the development team will keep a copy of the Detailed Design Specification. The initial version will be delivered in early 2022. The final version will be delivered in May 2022.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

From the SRS, we decide which of the tools are really important, and then we decide to order it after adding it to the product backlog. The items will be prioritized on the basis of importance of order, and the decision to add items to the product backlog will be made by the team members, with sponsor's approval. To maintain and share the product backlog with the team members, we will share a common Google doc file that everyone can see and edit.

14.2.2 Sprint Planning

Each sprint cycle we will have as many team meetings as required, either online or in-person. During these meeting, we will make plans for the project and divide the work for the next sprint as well. There are a total of eight sprints to divide the project into parts.

14.2.3 Sprint Goal

The sprint goal will be decided by the team members and discussed with the sponsor as well. Since we need to present the work done after each sprint, it will be clearly stated our customer/sponsor, and we will make changes if necessary.

14.2.4 Sprint Backlog

The team members will decide in unison which part of the product backlog gets included in the sprint backlog. The team members will share their view, and express their ideas on this matter. The backlog will be maintained through a Google doc file that is shared with all team members.

14.2.5 Task Breakdown

The tasks from the sprint backlog will be divided into five parts. We will be using a website to randomly assign each part to each team member. Each member will be responsible for tracking and documenting how much time they spent in completing their tasks.

14.2.6 Sprint Burn Down Charts

Each sprint, a team member will be chosen to generate the burn down chart for that sprint. Each member will track their total amount of effort, and this information will be combined with the rest of the team member's effort to produce the team's burn down chart. The burn down chart will use the format of the figure below.

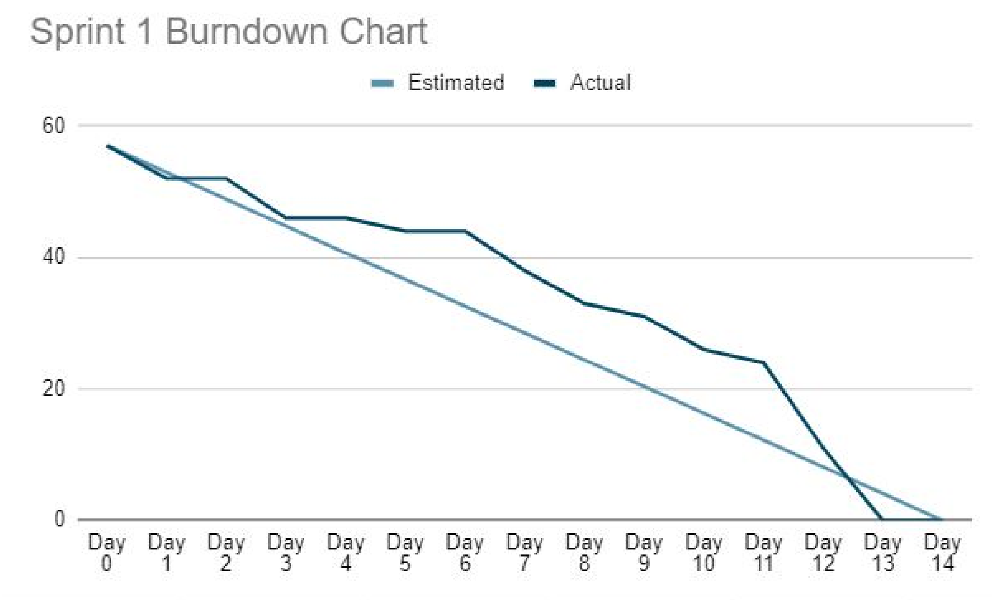

Figure 2: Example sprint burn down chart

14.2.7 Sprint Retrospective

We will have a sprint retrospective at the end of each sprint. If our sprint ends on a Monday, then the sprint retrospective will be the following Wednesday. As a group we will discuss what went well and what can be improved for the next sprint. The sprint burn down chart and a summary of the sprint will be documented as a team. This will be due no later than a week from the end of the sprint.

14.2.8 Individual Status Reports

Each individual member will report the status of each task they were responsible for and any issues they may have encountered. They will be reported at the end of each week. Key items that will be contained are the progress of the tasks, questions regarding the tasks or the project, and the availability of each member for the next meeting.

14.2.9 Engineering Notebooks

We will all be updating our engineering notebooks during each of our meetings, testing with our robot, as well as coding our program. We will be recording in more detail each of our meetings and will dedicate at least 5 pages for each sprint interval as well. For each ending of a sprint, we will review each other's engineering notebooks to hold each other accountable. Everybody in the development team has the ability to sign off on another teammate's page as a "witness".

14.3 Closeout Materials

14.3.1 System Prototype

In the final system prototype, there will not be any requirement of a test because our robot is meant to perform at a high success rate and will reach higher success rates with the help of human assistance. With the final deliverable, our robot will be able to operate and function correctly, as well as perform its task with at least an 80% success rate. For the remaining errors and mistakes, it is our job to help the robot avoid these problems and successfully reach even higher rates of success. Nothing will be demonstrated off-site, we will be demonstrating our final product in front of our sponsor.

14.3.2 Project Poster

The poster will include an executive summary, background information, the experimental setup and plan, the experimental results, and conclusions. The dimensions of the poster will be average sized 36" x 48". The poster will be delivered before April 2022, as that is when the next CoE Innovation Day will be hosted.

14.3.3 Web Page

We will be creating an HTML website. The website will be accessible to the public and will contain information pertaining to the project. Information such as summary of our project, goals, demo videos, and development team contact information. The website will be created and delivered at closeout.

14.3.4 Demo Video

For each sprint after we start our development, we will be recording a video of our robot functioning. With each increment we hope to show the progress of our robot slowly filling the role of becoming a useful worker in the workforce. Videos will only consist of the upgraded functionality of our robot with each increment, along with an explanation of what we developed and what has changed since the last sprint. Each video should only be a couple of minutes, by the end we should have a final video of our robot performing its task along with us assisting the robot.

14.3.5 Source Code

We will maintain our source code through the version control system, most probably GitHub. We will use some online platform to share our project to the general public. The license terms will be GNU and will be listed in each source file.

14.3.6 Source Code Documentation

We will use Google Docs to generate the documentation. Final documentation will be provided in PDF or browsable HTML

14.3.7 Hardware Schematics

Our team will not be creating any circuit boards or wiring components as they are not required for the project.

14.3.8 CAD files

We will not be creating any CAD files.

14.3.9 Installation Scripts

We will add the information regarding installation in our website and our GitHub repository. They can also refer to the Universal Robot ROS GitHub and the ArUco's GitHub repository for marker detection functionality.

14.3.10 User Manual

Customer does not require a digital user manual.

References

[1] Dirk Buchholz, Marcus Futterlieb, Simon Winkelbach, and Friedrich M Wahl. Efficient bin-picking and grasp planning based on depth data. In *2013 IEEE International Conference on Robotics and Automation*, pages 3245–3250. IEEE, 2013.

[2] Stefan Fuchs, Sami Haddadin, Maik Keller, Sven Parusel, Andreas Kolb, and Michael Suppa. Cooperative bin-picking with time-of-flight camera and impedance controlled dlr lightweight robot iii. In *2010 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 4862–4867. IEEE, 2010.

[3] Masahiro Fujita, Yukiyasu Domae, Akio Noda, GA Garcia Ricardez, Tatsuya Nagatani, Andy Zeng, Shuran Song, Alberto Rodriguez, A Causo, I-Ming Chen, et al. What are the important technologies for bin picking? technology analysis of robots in competitions based on a set of performance metrics. *Advanced Robotics*, 34(7-8):560–574, 2020.

[4] Adrian Schyja, Alfred Hypki, and Bernd Kuhlenkötter. A modular and extensible framework for real and virtual bin-picking environments. In *2012 IEEE International Conference on Robotics and Automation*, pages 5246–5251. IEEE, 2012.

[5] E Truebenbach. Is fully automated bin picking finally here?, 2019.