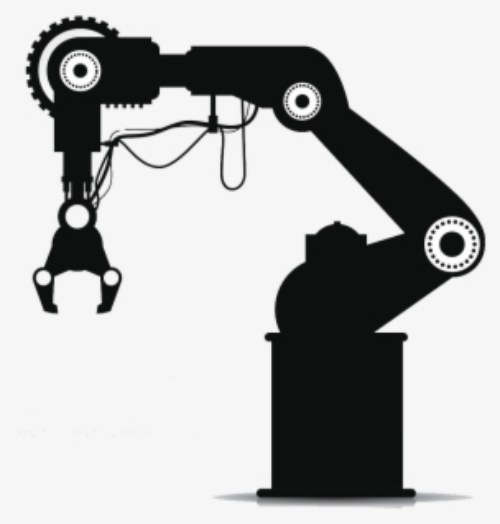
Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Fall 2020



Arm Solutions
UR5 Robotic Parcel Sorting

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Revision History

Revision	Date	Author(s)	Description
0.1	09.27.2020	IR	document creation
0.2	10.09.2020	GF, IR, KP, MZ, DP	Documents update and draft 1 complete

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1 Vision

In the light of corona-virus and recent stresses on the postal system, organizations like USPS, FedEx, and UPS have been overwhelmed with parcels and mail. Workers currently spend all hours of the day picking small parcels from a heap, and placing them onto a conveyor for processing and handling these parcels exposes them to germs on the parcels themselves. Our solution is to not only eliminate the risks to the employees but automate and improve the efficiency of thousands of jobs.

2 Mission

Our objective is to integrate off-the-shelf technologies to create a market-ready system that would work alongside the personnel to pick and place parcels efficiently. Our plan to achieve this will utilize 3D vision and depth perception for identification.Parcels will be moved by using a UR5 robotic arm to pick and place parcels.

3 Success Criteria

Upon completion of the Work-cell (Deliverable 1) for our system, we expect the following milestones to be met:

- A work-cell to accommodate both boxes and flat-ish padded parcels.
- A pneumatic suction cup gripper to pick and place the parcels.

Upon completion of the 3D vision and picking software (Deliverable 2) for our system, we expect the following milestones to be met:

- Ability to identify, segment, and orient the pick and place positions for the robot.
- Ability to scan the work-cell environment and identity the distances between pick and place positions.
- Ability to recognize the parcel and the pick locations.

Upon completion of the supervised automation software (Deliverable 3) for our system, we expect the following milestones to be met:

- A provision to allow a remotely located user to select pick locations on the science.
- A fully functional user interface to allow for direct control by a human operator to assist the system with more complex shapes.

Upon completion of the sorting application (Deliverable 4) for our system, we expect the following milestones to be met:

- Enhance the capabilities of the system using machine learning.

4 BACKGROUND

Technology in our society is increasing at a rapid pace, allowing people to focus less on tedious tasks and improving the overall efficiency and daily work-life for many. However, many areas of our society still lack the technologies to minimize the work-hours employees spend doing mundane tasks. To make matters worse, our global economy grows every day, increasing the demand for resources, challenging companies to expand their capacities and capabilities (not to mention the effects COVID-19). The global postal service is one of the areas this is apparent, where employees are spending all hours of the days sorting parcels. We believe we can improve this sector of our society, and to accomplish this, we intend to automate most of this process, rarely needing human interaction in the process. The goal is not to make human workers obsolete, but to improve their work environment, as automation has done for decades. And while this system is being built for a specific market, the system could easily be adapted to serve other markets as well.

While there have been past iterations of this system, they have only been proof of concepts, testing to see if it was possible to integrate the different technologies necessary to make such a system. Our goal is to build upon the knowledge gained from these past iterations and produce a more market-ready system that can be replicated to be installed in distribution centers where large volumes of unsorted and non-uniform parcels are processed. Our sponsor, FT Designs, has sponsored teams in the past dealing with similar concepts, so they are continuing to invest in us to produce more advanced systems, showing off the capabilities of the system and the potential it has to transform many areas in our society. Like previous teams, they will offer us the resources needed to make their vision a reality.

5 RELATED WORK

Our team researched on any current implementation of robotic sorting system that exist in industry. Our main intent was to see if the robotic arm that exist have the same vision as our client's or they are used for other purposes. The research indicated a major consequence of Coronavirus-19 pandemic was to automate the current working conditions with the use of robots. The robots not only bring efficiency but also help users follow CDC guidelines for social distancing. In the light of pandemic, two companies installed and automated their parcel sorting when the country was struck its major shutdown and employments layoff's.

Honeywell [1] and FedEx [5] are the two companies who have a upper hand in using robotics in sorting their parcels. Honeywell Robotics is a warehouse for robotics design that delivers speed, accuracy, and efficiency. They introduced their Automated Sorter Induction in March 2020. Which is able to handle most common packages sizes, ranging from boxes to envelops. The purpose of this sorter was to replace or supplement manual labor induction in warehouses, freeing up monotonous and repetitive tasks. This product is used in big commercial companies and mostly for huge warehouses that have complex organization. It improves the distribution productivity and capacity. The system is easily able to integrate in existing workflow, minimizing the cost and technical risk.

FedEx installed quartet of robotic arms from Yaskawa [2] and Plus One [4] partnership in their Memphis facility in March 2020. Their purpose was similar as Honeywell. They wanted to bring automation in sorting massive number of parcels in their biggest facility [3]. Both companies have the commercial automation mindset. Clients cannot use these already produced robots because they want to build something on a smaller scale which will be marketed. They want to also commercialize the product as their own product in UPS stores. Therefore our goal as a team is to start the project from scratch, by building a working cell, software which can detect the type of parcel, install grippers that can suction the object and sort them into sizes.

6 System Overview

The implementation of UR5 robot sorting parcel will make use of multiple technologies. Combination of hardware and software technology will be used in this project. Below is a state diagram showing the flow of high level technologies that will be implemented.

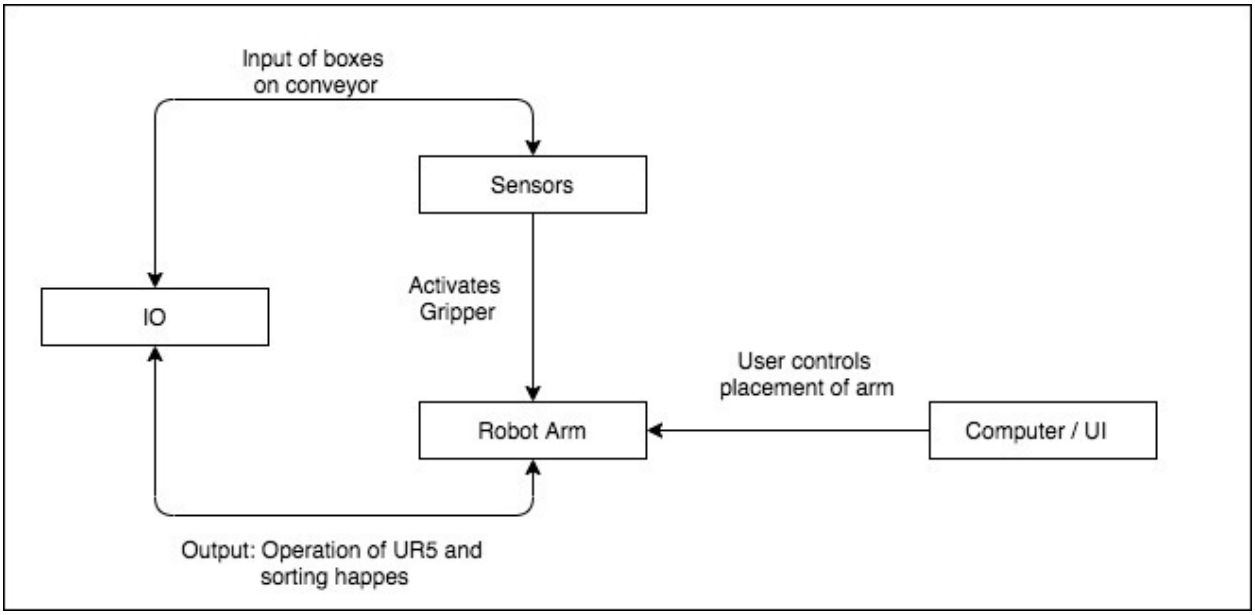

Figure 1: System Overview

As seen in this picture, the main components of our project is making use of a UR5 robotic arm. It is surrounded by other factors that will trigger it's movements. We will make use of sensors like 3D camera that can detect the size of object and signals the robot. This action triggers the robot arm movements making it activate it's suction grippers to pick up the object. The computer have a User Interface installed that will allow user to monotonically change drop off location of objects. The robots wont be pre-programmed with their drop off location. This feature will enable the user to pick the location when the robotic arms are installed or let them divert the parcel drop off to the location of their preference.

7 Roles & Responsibilities

The stakeholders for this project is our sponsor "James Staud - FT Designs" as it's his idea to develop a small scale working cell of robotic arm that will aid the sorting process at UPS facility. This product could be a standalone products or also placed in conjunction with a small group of workers. Therefore, the UPS facility will also be our stakeholder. The reason is that we will be marketing this product to them to be used at local warehouses and they will be our primary testers after a working product prototype is developed. At higher level, The University of Texas at Arlington also have a stake in this project, as the success of robotic parcel sorting determines the preparedness of the students at the department of Computer Science and Engineering (CSE).

The point of contact will be with Dr. Conly as the course professor and James Staud who is our sponsor. The roles for the agile development and responsibilities of each member are given below depends on one's experience and may change throughout the course.

Agile Roles

1. **Product Owner:** Krishna Patel
2. **Scrum Master:** Inara Rupani

Responsibilities

1. **Krishna Patel:** Hardware technologies
2. **Mathew Zinke:** GUI and Computer Vision
3. **Gregory Ferguson:** Hardware Technologies, Robotics
4. **Donny Pham:** Robotics and GUI
5. **Inara Rupani:** GUI and Computer vision

8 Cost Proposal

The two major expenses we will be requiring aside from the UR5 robot are it's components: Suction Cup and camera. The justification of these two components are given below.

- **Suction Cup:** This is the major component for our UR5 Structure and our primal deliverable. Suction Cup is what going to grip the boxes or envelopes from the conveyor belt and sort them in position based on their size.
- **Camera:** Another major component for our UR5 Structure and our primal deliverable. Camera will be mounted on the top of UR5 and will make use of sensors to detect the size of object. Which will actually trigger the sort process would work.

8.1 Preliminary Budget

Category	Item	Quantity	Budget
Robot	UR5	1	$ 46000
Sensors	Intel Realsense	1	$ 200
WorkCell Parts	Metal Fab	1	$ 500

Table 1: Perliminary Budget

8.2 Current & Pending Support

1. CSE Department: 800 - This is the default funding my CSE department for Senior Design Project
2. Sponsor - FT Designs: $ TBD This amount is yet not given or decided if we will be receiving extra amount from the sponsor.

9 Facilities & Equipment

This project completion requires access to a multitude of resources. However, the list below is not a complete list due to the complexity of the project. There will be additional resources that will be needed in the future. The following list of items is stated below:

- UR5 Robotic Arm: Currently Available for prototype use at College of Engineering at the University of Texas at Arlington.
- Robot Operating Software [ROS]: Open source software found ROS.org
- Soldering Equipment: Available at CSE Engineering Labs in UTA, MakerSpace
- 3D printers: Located at UT Arlington FabLab and Senior Design MakerSpace
- Laser Cutter and CNC: Available at UTA FabLab

10 Assumptions

- 24/7 Access to UR5 Robotic Arm and Sensors
- UR5 Robotic Arm will be seen by Oct 12 [sprint cycle 2] for initial Review and design implementations for deliverable one.
- Draft designs for Deliverable One will be complete between sprint cycle 3.
- Simple ROS interfacing with UR5 for simple motion will be complete by sprint cycle 3
- Vision Sensors will work in non-ideal lighting conditions.
- Interfacing of sensors with ROS software will be complete by spring cycle 4
- Interfacing of Sensors with UR5 Robotic Arm will be complete by sprint cycle 5

11 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, 2021.
- Total development costs must not exceed 800 dollars.
- Sensors will need to work in environments where lighting is not the best.
- Customer is only available during a normal workday hour.
- The work cell needs to be mobile and sturdy when locked in place.

12 Risks

This section should contain a list of at least 5 of the most critical risks related to your project. Additionally, the probability of occurrence, size of loss, and risk exposure should be listed. For size of loss, express units as the number of days by which the project schedule would be delayed. For risk exposure, multiply the size of loss by the probability of occurrence to obtain the exposure in days. For example:

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	**Probability**	**Loss (days)**	**Exposure (days)**
COVID-19 meeting and working disruptions	0.50	5	2.5
Equipment failure or incompatibilities	0.10	2	.2
Microsoft Teams or other utility failure	0.80	1	.8
Team scheduling issues	0.40	.5	0.20
Lack of subject matter expertise	0.9	4	3.6

Table 2: Overview of highest exposure project risks

13 Documentation & Reporting

13.1 Major Documentation Deliverables

13.1.1 Project Charter

This document will be published then updated an estimated four times. Once for creation and once for each deliverable. If the optional, final deliverable is not completed, this document will make note of it and why the decision to not complete it was chosen. Following this it will be updated on a situational basis. As relevant information is come across, it will be added. Its initial publishing is October 9, 2020. Its final publishing is upon completion of the project.

13.1.2 System Requirements Specification

The System Requirements Specification will be published then updated with each sprint. The understanding of requirements for each part is expected to cause small feedback changes in requirements as a deliverable is made. Furthermore, it will be amended as clarifications/realizations are made. Its initial publishing is the week of October 18, 2020. Its final publishing is upon completion of the project.

13.1.3 Architectural Design Specification

The primary Architectural Design Specification is expected to be mostly consistent throughout the project process. Upon creation of the process, the client has already specified a generalized desired project design. With the increase of understanding of better design options, the ADS will be updated. Its initial publishing is the week of October 18, 2020. Its final publishing is upon completion of the project.

13.1.4 Detailed Design Specification

The Detailed Design Specification will primarily be maintained as needed. Much like the ADS, as understanding of technology and changes of design are realized, updated implementations will be noted. Any minor changes discussed during team meeting will be put into effect. Its initial publishing is the week of October 18, 2020. Its final publishing is upon completion of the project.

13.2 Recurring Sprint Items

13.2.1 Product Backlog

The initial product backlog will be filled by the requirements from the SRS by order of feasibility and customer's priority. An experienced member or the product owner will determine the priorities and expand upon the requirements when the items are near the top. Then the group as a whole will review and give feedback for the backlog. The group will use Trello for maintaining and sharing the product backlog.

13.2.2 Sprint Planning

Each sprint plan will begin with making sure the product backlog is up to date. Determine the number of hours members can commit in the two-week time frame. When determining the set of tasks or main features to accomplish, account for additional hours in case of setbacks, research, and prototyping. The sprint shall end on a Thursday to allow review. There will approximately be fifteen sprints available for the project.

13.2.3 Sprint Goal

An experienced member will propose the sprint goal based on the product backlog. Team members and customer will review, give feedback and accept sprint goal.

13.2.4 Sprint Backlog

An experienced member will be responsible for the sprint backlog. The backlog will be maintained with Trello.

13.2.5 Task Breakdown

Individual tasks be voluntarily claimed which will be individually track the time spent on the tasks.

13.2.6 Sprint Burn Down Charts

A member who is not the scrum master or product owner will be responsible for generating the burn down charts for each sprint. Each individual team member will inform the member responsible for the burn down charts of their completed tasks.

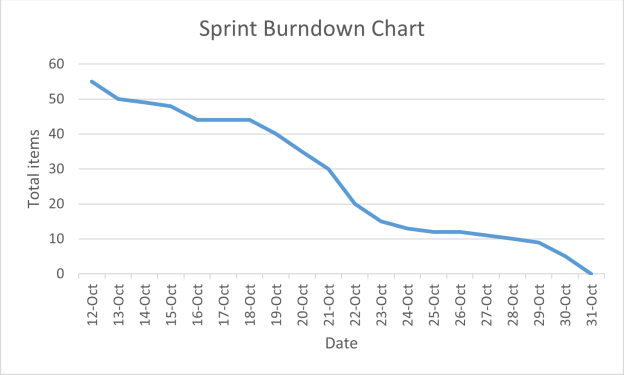

Figure 2: Example sprint burn down chart

13.2.7 Sprint Retrospective

The group will come together to solve any issues regarding the sprints on the Friday. A Member, except the author, will review a piece of work for about two hours for feedback. Feedback, software and electrical documentation, and bugs will be recorded and shall be done before the Tuesday of the next week.

13.2.8 Individual Status Reports

Individuals will report the tasks they worked on, the amount of time spent on them, difficulty of the task from one to five, and grade on the planning from one to five. The status reports will be used to improve planning for future sprints.

13.2.9 Engineering Notebooks

The engineering notebook will be updated each week at a minimum be each team member. Two pages needs to be completed for each of the two-weeks interval. Team members will review each other's notebooks to learn and give feedback to each other. One of the members besides the author will sign as a "witness" for each engineering notebook pages.

13.3 Closeout Materials

13.3.1 System Prototype

Software to interface UR5 and to monitor sensors.

13.3.2 Project Poster

The poster will include the team members, robotic arm and main features. The poster will be 22 inches by 28 inches The poster will be delivered in the beginning of April.

13.3.3 Web Page

The project web page will include the vision, team members, sponsors, the product and its features. The project web page will be accessible to the public and will be updated throughout the project.

13.3.4 Demo Video

The demo video will show the UR5 performing key features like picking up parcels and putting them on a conveyor. The video will approximately be 20 minutes and will cover what the arm is capable of.

13.3.5 Source Code

The source code will be maintained with git using the cloud resource GitHub. The code will be provided to the customer and will be under the Apache License 2.0 license and be in a single file named LICENSE.

13.3.6 Source Code Documentation

When a component is completed, a document of the component will be made using draw.io or any other modeling program. The final documentation will be in PDF form.

13.3.7 Hardware Schematics

TBD

13.3.8 CAD files

TBD

13.3.9 Installation Scripts

Installation scripts are not planned for now but will look into it in the future. For now they will be replaced with instruction on how to build from the GitHub repository in the ReadMe file.

13.3.10 User Manual

The customer will be provided a digital user manual which will contain specific instructions on how to set the project up. The manual will also include various documentation and notes of the project.

REFERENCES

[1] Honeywell robotics, March 2020.

[2] Hc20xp, n.d. Accessed Oct. 9, 2020.

[3] The largest fedex sorting facilities, n.d. Accessed Oc. 09, 2020.

[4] D. Emily C. Lindsey, C. Lindsey and R. Samantha. Plus one robotics, yaskawa america announce partnership with fedex, Jul 2020.

[5] A. Steffen. Robotic arms are now sorting parcels for fedex, Oct 2020.