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

Project Charter
CSE 4316: Senior Design I
Spring 2022

Team Kratos
Mitsubishi Robotic Arm

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Revision History

Revision	Date	Author(s)	Description
0.1	3.12.2022	NB	document creation
0.2	3.13.2022	NRB, CJK, AS, YW	complete draft

Contents

1 Problem Statement

Our team decided to do this project because we want to build a human-interactive robotic arm that can play a game based on preset algorithms. We are utilizing the Mitsubishi Robotic Arm model RV8CRL.

2 Methodology

We decided on a few ideas to implement on the robotic arm. We are planning on making our robotic arm be able to play tic-tac-toe or jenga or even follow human passing by and follow hand gestures. It is a hardware-based project which involves implementation of algorithms. At the end, our team is hoping to create a complete human-interactive robotic arm.

3 Value Proposition

This project can be very useful in increasing human-robot interactions. It can be used as an educational tool to teach students about the human-interactive robotic arm. It can be displayed in an interactive space so people can play with it. The algorithms we implement can be used to test the intelligence limits of the robotic arm and how it responds to different scenarios.

4 Development Milestones

List of milestones and completion dates:

- Project Charter first draft - March 2022
- System Requirements Specification - April 2022
- Architectural Design Specification - April 2022
- Demonstration of hardware setup - May 2022
- Detailed Design Specification - June 2022
- CoE Innovation Day poster presentation - August 2022
- Final Project Demonstration - August 2022

5 Background

Today is a world of computers and technology. Robotics may still seem like a futuristic fantasy, but robots have been a part of our daily life for several decades. It has always been in development and today is one of the most dynamic fields present. In the past, robots would be able to perform automotive factory based tasks including assembling car parts and working in conveyor belts picking up items. But robots have come a long way from that time. Today, robots not only participate in different sections of law-enforcement strategies and so on but also substantially help with different healthcare systems. Robots nowadays can even perform tasks like playing complex games. Having robots play games sounds simple but implementing the different algorithms is not always straightforward. With current research and development, machines are able to perform a variety of tasks with intelligence limitations. Our project purpose : Integrate intelligence and problem solving through game algorithms. If we are able to work in its betterment, we can potentially have a robot with little to no errors at all.

6 Related Work

There has been a tremendous amount of research carried out in regards to robots playing games. There are several companies who are working to develop fully functioning game playing robot arms: in 2019, students from MIT trained a robot arm to play Jenga. It turned out to be very complex. They trained a modified ABB IRB 120 to work with a soft gripper and external camera to design a bot that can remove a block without toppling the tower. In the paper published by IEEE, a 3DoF robot manipulator system has been presented. The system utilizes computer vision and a robot arm to perform chess moves on a real chessboard. Game playing is complex and it requires utilization of computer vision and machine learning. It is an important part of computer science research.

7 System Overview

The Mitsubishi Rv-8CRL robot project has three major components that we will be utilizing. Firstly, the program itself. This basically is the code that we will be writing in order for the robot to move: which includes picking and placing various objects related to the game. The program will utilize some parts of Artificial Intelligence in order to decide which move to take next and predict different scenarios that will be possible. For example, the robot must be able to decide which step it is going to perform if the human chooses one of the possible moves. It should be able to give the most optimal solution so as to win against the human. It should be competitive to the human which will be its sole purpose. The second component is the robot itself. The robot we will be using is the Mitsubishi RV-8CRL robot. It is an 8 axis robot with an 8-kg payload. The robot will be equipped with sensors or cameras to determine the moves of the human and position of objects and decide the next move accordingly. The third part will be the human assistance. Human assistance is required if there is any technical difficulty that the robot comes across during work.

8 Roles & Responsibilities

Our stakeholders will be Professor Conly and Professor McMurrough. They will be overseeing our project and will be our point of contact. Our team consists of four undergraduate members out of which three are Computer Engineering majors whereas one of the team members is a Computer Science major at the University of Texas at Arlington. Currently, we are yet to decide which game playing methods we will use for the project and as we are working on document based work, we have decided to divide the work equally for now. The equal splitting of work will be done for all the document-based work. The owner of the project is the UTA senior design department. Professor Conly will make decisions on whether to accept or decline the sprint result. The scrum master for the first sprint is Nabin Raj Bista, and the role will change periodically.

9 Cost Proposal

A major portion of our budget will be spent on purchasing the different servos and sensor to create the robotic arm. We want the arm pieces to be purchased metal, but if not, consider making them acrylic and shape them with a laser cutter. The most basic servo system will be our baseline, but according to our plan, we think that this robotic arm may need some servo system that can handle heavy objects, and we set a maximum weight standard of eight kilograms, so that the robot arm may be used in the future by improving it functions to perform a wider range of tasks. Depending on the amount of money invested in a project is directly related to its potential and future use.

9.1 Preliminary Budget

Components	Estimated price
Logic circuit	100
Microcontroller	50
Rotating sensor	120
Operating units	100
Locating sensor	50
Positioning sensor	50
Functional units	100
Fixture	150
Total	720

Table 1: Budget Table

9.2 Current & Pending Support

All current funding is from the CSE department at the University of Texas at Arlington, with an estimated amount of 800 dollars. There is currently no possibility of any other investment intentions appearing.

Funding Support	Amount in USD
UTA CSE Department	800
Total	800

Table 2: Financial Support

10 Facilities & Equipment

Currently predictable required equipment, including required hardware servo motors, linear potentiometers, Arduino Uno development boards, breadboards, etc. Robotic arms rely on a combination of electronic and mechanical design. The robotic arm is expected to function by using servo motors controlled by PWM signals. Other aspects of the robotic arm may need to be considered. The first thing to consider is the material of construction of the robotic arm. Metal-like materials are ideal for prototyping but require more difficult machining. Plastics like acrylic offer better strength and can be bolted into place but doing so still requires some level of mechanical fabrication and processing equipment, although it is not clear what those are. While 3D printed parts are also on the list, K'NEX is a versatile and robust material that allows for rapid prototyping. But 3D printers are also expensive and require project members to learn the use of CAD software tools. The above ideas are based on brainstorm-level assumptions and simple investigations, and do not fully represent the real needs for equipment, lab space, testing grounds, makerspaces to complete the final design.

11 Assumptions

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

- We will use a high-level language such as python or java to program the functions of the robotic arm, and hope to find open-source programs for reference on GitHub.
- We will use the Raspberry Pi as the main control system because it is inexpensive, highly playable, and more importantly, it is familiar to those of us in computer engineering.
- We expect to design the robot operating system will be Ubuntu or Android. Ubuntu and Android are similar in function, and both can support multiple languages.
- In addition to relying on the control system, we will add rich API interfaces, equipped with powerful expansion boards and electronic modules, etc. to realize more gameplay.
- Before the 2nd development cycle, the team members will have sufficient knowledge of CAD design to carry out the design of the robot arm.
- We now have very limited knowledge of servo servos, and it is expected that there will be team members who can learn and provide technical support during the 2nd sprint cycle.
- In the 4th sprint cycle, team members can implement the logic needs of the robotic arm in terms of artificial intelligence programming.

12 Constraints

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

- Total development cost must not exceed 800 (in principle).
- The design of the product should not exceed the capacity of the large equipment provided by the current departmental Lab.
- Final prototype demo must be completed by August 7th, 2022.
- All data obtained from customer site must be reviewed and approved for release by the Information Security Office prior to being copied to any internet connected storage medium.
- Product must follow robot safety standard which is a collection of guidelines for robot specifications and safe operations in which all involved in the manufacture, sales and use of robots.

13 Risks

This section contains a list of five of the most critical risks related to our project. Additionally, the probability of occurrence, size of loss, and risk exposure have been listed. 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)
Personal Safety during robot operation	0.47	30	110
Equipment malfunction	0.29	10	110
Robot misuse out of limitations	0.09	20	110
Shipping delays for new parts	0.11	14	5
Cost of robot accessories	0.65	11	29

Table 3: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The project charter will be worked on through overleaf in different parts by different team members and then compiled when all sections are complete. It will be updated every month after the date of initial submission to go in line with any changes or decisions we implement. The initial version will be delivered March 13,2022. The final document will be delivered on the project submission day.

14.1.2 System Requirements Specification

The project charter will be worked on through overleaf in different parts by different team members and then compiled when all sections are complete. It will be updated every month after the date of initial submission to go in line with any changes or decisions we implement. The initial version will be delivered March 22,2022. The final document will be delivered on the project submission day.

14.1.3 Architectural Design Specification

The project charter will be worked on through overleaf in different parts by different team members and then compiled when all sections are complete. It will be updated every month after the date of initial submission to go in line with any changes or decisions we implement. The initial version will be delivered April 12,2022. The final document will be delivered on the project submission day.

14.1.4 Detailed Design Specification

The project charter will be worked on through overleaf in different parts by different team members and then compiled when all sections are complete. It will be updated every month after the date of initial submission to go in line with any changes or decisions we implement. The initial version will be delivered June 27,2022. The final document will be delivered on the project submission day.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Items will be added from the SRS according to the preplanned chronological order. The highest priority will be given to items that are overdue from a previous sprint and critical items that stop overall project progress. Decisions on product backlog will be determined during the weekly Monday meeting by group vote. The product backlog will be implemented through spreadsheets in excel on teams so that any authorized stakeholders, team members and project associates may access it from their personal devices.

14.2.2 Sprint Planning

Each sprint will be planned through the weekly Monday meeting to ensure consistency and continuous communication and feedback. The estimated sprint length is a fortnight and the project is projected for a 6 month period. 12 sprints would be adequate.

14.2.3 Sprint Goal

The team decides the sprint goal and we plan on having continuous presentations to keep our class and professors updated with our process.

14.2.4 Sprint Backlog

Items will be added from the SRS according to the preplanned chronological order. The highest priority will be given to items that are overdue from a previous sprint and critical items that stop overall project progress. Decisions on the sprint backlog will be determined during the weekly Monday meeting by group vote. The sprint backlog will be implemented through spreadsheets in excel on teams so that any authorized stakeholders, team members and project associates may access it from their personal devices.

14.2.5 Task Breakdown

Individual tasks will be assigned based on ability, availability and preferability. So each team member will provide how much time they will be available during a sprint and their preferred task. The team will then decide allocation based on ability and the other two metrics. Time will be entered alongside the task in the sprint chart.

14.2.6 Sprint Burn Down Charts

We do not intend to initially implement burn down charts but will reassess if we feel the need to boost productivity.

14.2.7 Sprint Retrospective

Sprint retrospectives will be handled monthly and each member will submit their experience and it will be documented alongside the corresponding sprints. All pending tasks will be moved forward to the next sprint.

14.2.8 Individual Status Reports

Individual status reports will be left up to personal responsibility and in correlation with the due dates as set by the professor.

14.3 Closeout Materials

The following materials, in addition to major documentation deliverables, will be provided to the customer upon project closeout.

14.3.1 System Prototype

The robot and algorithms will be presented in the final prototype. The final prototype will be demonstrated at project end, estimated for August 1. All demonstrations will be planned for the on-campus site.

14.3.2 Project Poster

A picture of the robot and a short description on its capabilities will be included on A4 paper and it will be delivered at project end.

14.3.3 Web Page

We do not currently plan to make a web page for the product at this moment but will reconsider if there is an abundance of time at project completion.

14.3.4 Demo Video

The robot and its new capabilities will be demonstrated in the demo video. The video will be approximately five to ten minutes to adequately demonstrate the algorithms implemented.

14.3.5 Source Code

Source code will be maintained through GitHub in a single repository to maintain consistency between teammates. During development, the source code will only be available to the team but released for the final version of the code. Any applicable software licenses will be included in the readme of the repository.

14.3.6 Source Code Documentation

We will look to implement the Microsoft coding standard for C sharp to create a consistent look to the code and make changes easy. We will manually implement the coding style personally so we each learn a standard throughout this project. The documentation will be provided alongside the source code in Github.

14.3.7 Hardware Schematics

We plan to utilize a raspberry pi and other hardware materials if we intend to add any external PCB functionalities for the robot.

14.3.8 CAD files

The team plans on learning CAD to design new aspects of the robot and account for different scenarios.

14.3.9 Installation Scripts

We currently do not plan on any installation scripts aside from directions in the manual.

14.3.10 User Manual

We will provide the customer with a digital user manual that will include a setup video and advice on operation.