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

Project Charter
CSE 4316: Senior Design I
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Robotic Team
Duck Hunting Arm

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Revision History

Revision	Date	Author(s)	Description
0.1	2.28.2023	JuG	document creation
0.2	3.03.2023	AO, DN, JaG, JuG, LD	complete draft
1.0	8.08.2023	AO, DN, JaG, JuG, LD	official release

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1 Problem Statement

The director of senior design, Dr. Christopher McMurrough, is wanting to market the Computer Engineering degree to high schools and encourage them to join this major. With the rapid evolution of technology, multifaceted and interdisciplinary programs are essential to remaining viable in the field. Tech developers are faced with creating solutions fusing Artificial Intelligence, Machine Learning, Computer Vision, and Hardware Applications.

2 Methodology

In order to display the fusion of these technologies, a duck hunt game will be played by a machine. This project is designed to be interesting to watch and encourage curiosity, drawing people to UTA's tech-based majors. This project will employ a Mitsubishi robotic arm that makes use of a toy gun in order to engage a virtual target displayed on the screen.

In order to identify the target, machine learning will be used through OpenCV and implemented in python. The AI device will be able to detect and identify the object on the screen.

When the robot detects the duck on the screen, it will traverse across the screen using the ratio between the distance on the display relative to where it was initially calibrated. Traversal will be handled using ROS in combination with OpenCV. When the game is over it will be re-calibrated to ensure that the robot arm will not drift off the display or miss.

3 Value Proposition

UTA will benefit from gaining new students in engineering if this project is successfully advertised. More importantly, it will display the benefit of applying interdisciplinary approaches to education in a challenging team environment. This will also serve as proof of concept for computerized target identification and acquisition.

4 Development Milestones

- System Requirements Specification - March 2023
- Become comfortable coding the arm movements - March 2023
- Architectural Design Specification - April 2023
- Get the actual game and play - May 2023
- Have display cable splitter and AI machine plugged in - May 2023
- How to read splitter display data - May 2023
- Detailed Design Specification - June 2023
- Final Project Demonstration - August 2023

5 Background

America is losing its competitive advantage in the manufacturing industry. There is a deficiency of skilled STEM workers that can compete in the global economy. There is also a problem in inspiring American high school students to pursue high-tech careers.

More college stem majors could potentially increase the amount of manufacturing accomplished once the engineering majors graduate. In order to create more interest in jobs related to science, technology, engineering, and mathematics, we will use a Mitsubishi robot arm that will be capable of playing a duck hunt game. The goal is to provide a project to successfully engage American high school students to potentially work in high-tech jobs.

6 Related Work

To restate the problem, the director of the senior design class is trying to market to people who are in secondary schools. He is currently in need of good senior design projects that are eye-catching, engaging, and versatile. The project we are designing would allow the watcher to engage in the game and control the duck while the robot arm tries to shoot it. The robot arm moves and points the toy gun at the screen and will be actively involved in the game so it would be very eye-catching. This could be used as digital marketing or direct marketing [1]. The type of attention this project would draw is called focused attention [3].

A simple video demo of this project would be more than enough to take to other schools without showing them in person. This makes the project quite versatile. However, if the robot arm is shown in person, it would be far more engaging, especially with interaction from the audience. Audience interaction is known for increasing their retention of the event [5]. Compared to the other demo projects that would be shown to secondary schools, this one would be far more entertaining and draw in the largest crowd because of how different it is.

Chris McMurrough could also use previous projects designed by other people such as the Rubik's Cube solver. The Rubik's Cube solver was slowed down so that people can enjoy watching it move step by step for entertainment purposes. Of course, it could go way faster. He also could have used the demonstration of the robot that could cook grilled cheese for people. This project, however, would be better because it can interact with the audience by the audience playing against it by being the bird.

Curiosity is an essential factor used to drive the younger generation into the UTA engineering and computer science department. Curiosity about how the project works would be the driving factor that would give UTA the edge over other universities advertising to secondary schools. This project would encourage curiosity in the users by how well it performs and how the robot arm actually moves. This curiosity will also hold their attention [2]. Curiosity is very useful for motivation [4].

7 System Overview

The system will utilize a robot arm to play a point and shoot game on its own. This system will be engaging to the audience and create curiosity for fields in science, technology, engineering, and mathematics.

The solution to the problem entails various scopes: machine learning and the overall programming of the robotic arm. While these scopes may seem difficult, the team believes that they are worthwhile pursuits concerning the project. The pursuit of difficulties will build strength that will be useful in future endeavors, both in career and in life.

For the programming of the arm, we will be using Robot Operating System (ROS). ROS is open-source software used in the development of robotic software. Contrary to its name, it is not an operating system, but rather it is a set of software frameworks for robot software development. Even though reactivity is important in robotics development, ROS is also not a real-time operating system. ROS will be scripted on a terminal computer issuing the track and engage commands. The velocity and rotation of the arm will be computed and issued by the terminal computer after receiving validation from the machine learning system. The data that will go to the machine learning system will come from the HDMI splitter. The machine learning system will either be a microcontroller or a computer. The first input of the HDMI splitter will go into the flatscreen television, while the other two inputs will go into the terminal computer and the WiiU itself. Using the WiiU rather than a NES will likely be easier as an NES does not have an HDMI input, but rather RCA inputs.

Machine learning will be implemented using OpenCV due to its vast libraries and the nature of open-source. Machine learning is a subset of OpenCV that provides easy-to-access classes. When it comes to training, OpenCV has the ability to take input images to learn what the target image is and output a certain confidence interval. A majority of algorithms require all or a high amount of training samples to be valid, but OpenCV's algorithms can tackle this issue. The terminal computer will then translate the positions of the targets into movements and rotations of the robot arm to aim the Wii U remote. Latency may be an issue, however, but that will have to be addressed in further development. The robot arm did however have a quick velocity due to a cursory glance at the datasheet.

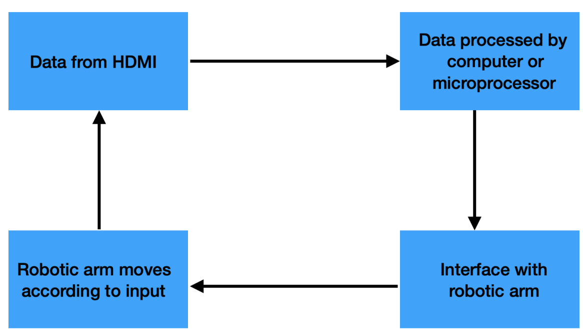

Figure 1: System Overview

8 Roles & Responsibilities

The stakeholders include the design team, UTA, and the director of senior design. The design team is a stakeholder because they lost all the time they spent on the project. UTA is a stakeholder in the project because they could lose all the money they invested in the project.

The design team intends to work in a collaborative manner without formally assigning team roles to individual team members. This allows each member to be actively involved in every fundamental part of the project. If the design team feels that work is not being done productively, formal team roles can be assigned to increase productivity.

9 Cost Proposal

9.1 Preliminary Budget

- Wii U Console (required to play the video game) $90-100
- Wii U Controller with the console(required to play the video game)
- Wii Controller x2 (required to play the video game and backup in case the first one breaks from the robot) $30
- SMB or PC (required to interface with robot) $50-100
- HDMI Splitter (required to know where the duck is on the screen) $10
- (Optional) TV (required to interface with robot) $100-200
- (Optional) Wii gun casing for controller(aesthetics to make it more flashy)

9.2 Current & Pending Support

Currently, we have the allotted senior design budget of $800.

10 Facilities & Equipment

- We will require the use of the RV-8CRL Mitsubishi robot arm as it is the machine that will be used to play the duck hunt game. The robot arm is currently located in the Engineering Research Building (ERB) room 335A, so is already available for us to work with.
- 1 Wii U console
- 1 Wii U controller
- 2 Wii controllers
- TV/Monitor
- HDMI splitter
- 3D printer
- PLA material
- AutoDesk
- PC or SMB system
- Wii Controller Gun Attachment/Casing (optional if there is enough time)
- Camera and stand for videoing the demonstration

11 Assumptions

- The robot will not be used by the senior design 2 team during the first semester while we are using it
- The robot will not be used by a senior design 1 team during the second semester while we are using it
- We can get information about the robot arm and previous code and documentation from the previous senior design team who worked on the robot arm
- Assuming that the computer vision software will support reading from an HDMI display rather than a camera, because Dr. McMurrough mentioned it
- We can interface with the robot arm in under a tenth of a second either through GPIO or re-uploading a program to the arm

12 Constraints

- This project has to be completed by August 2023
- Total development costs must not exceed $800
- The Mitsubishi robot arm has to be used in the project

13 Risks

Critical risks related to the project contribute to unplanned work hours. They are tracked below in order to mitigate unforeseeable issues. The risks are related to the implementation of machine learning software in combination with the Mitsubishi arm.

Risk description	Probability	Loss (days)	Exposure (days)
Machine learning implementation (robot)	0.01	10	0.1
GPIO interface with robotic arm	0.10	14	1.4
Robotic implementation (ROS compatibility)	0.30	9	2.7
Robotic implementation (frame and Euler transforms)	0.1	10	1
Splitter implementation not viable	0.30	30	9

Table 1: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

This document will be maintained and updated as necessary when the team agrees to changes related to the project. The initial version will be delivered on Friday, March 3rd, 2023. The final version will be delivered on August 2023.

14.1.2 System Requirements Specification

This document will be maintained and updated as necessary when the team agrees to changes related to the project. The initial version will be delivered on Tuesday, March 21st, 2023. The final version will be delivered on August 2023.

14.1.3 Architectural Design Specification

This document will be maintained and updated as necessary when the team agrees to changes related to the project. The initial version will be delivered on Tuesday, April 11th, 2023. The final version will be delivered on August 2023.

14.1.4 Detailed Design Specification

This document will be maintained and updated as necessary when the team agrees to changes related to the project. The initial version will be delivered on June 2023. The final version will be delivered on August 2023.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

The team will add tasks to the product backlog from the system requirements specification (SRS) using collaboration software. The team can re-prioritize tasks as necessary in the product backlog.

14.2.2 Sprint Planning

Prepare the next sprint upon completion of the previous sprint. We will plan the sprint's criteria based on the results of the previous sprint.

14.2.3 Sprint Goal

We all decide on the sprint goals as a group after discussion. We will discuss the direction of the project with the customer every two or three sprints. Our customer is Chris McMurrough.

14.2.4 Sprint Backlog

As a group, the team will decide which tasks from the product backlog will be added to the sprint backlog for each sprint. As is the case for the product backlog, the sprint backlog will be maintained using collaboration software.

14.2.5 Task Breakdown

Each team member can voluntarily claim tasks from the sprint backlog. Many tasks will be likely to take multiple people to complete.

14.2.6 Sprint Burn Down Charts

We all will be in charge of sprint burn down charts.

14.2.7 Sprint Retrospective

The team will meet as soon as possible after each sprint to discuss what worked and did not work from the previous sprint. This meeting will also be used to discuss the upcoming sprint.

14.2.8 Individual Status Reports

Each team member will complete individual status reports after each sprint. The individual status reports will contain what each individual worked on in the previous sprint as well as feedback on the quality of each other member's work for the project.

14.2.9 Engineering Notebooks

It will be updated as often as the team sees fit and with the approval of the professor. Our professor would sign as a witness if necessary.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype will be demonstrated during the final project demonstration date which is expected to be on August 2023. The prototype will include the Mitsubishi robot arm and the controllers for the duck hunt game.

14.3.2 Project Poster

The poster size will be decided upon completion of the project so that we know the best arrangement of the photos and details.

14.3.3 Web Page

The web page will include a link to the git repository. Most likely, it will be available to the public. Most likely, it will be created at the end of the project once most details are ironed out.

14.3.4 Demo Video

An approximately ten minute demo video will be provided. The video will entail an overview of the machine learning employed through the product and the robotic implementation.

14.3.5 Source Code

Source code will be maintained using GitHub. Only source code binaries will be provided to the customer and will not be publicly available. License terms will be listed in the source file as well as in a readme file.

14.3.6 Source Code Documentation

Source Code documentation will be generated using Doxygen. Final Documentation will be provided in PDF format.

14.3.7 CAD files

Solid Works will be used to produce product CAD files (arm extension, toy gun holder). Closeout materials will be provided in STL format.

14.3.8 Installation Scripts

Installation scripts will be included for the currently employed software packages.

14.3.9 User Manual

Customer will be provided with a digital user manual. Video instructional will be included to accompany the user manual.

REFERENCES

[1] Cyberclick, “What is Marketing? Definition and how it works Cyberclick,” www.cyberclick.net, Apr. 2021. https://www.cyberclick.net/marketing

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[4] “Why Curiosity Is Essential to Motivation,” InformED, Nov. 17, 2017. https://www.opencolleges.edu.au/informed/fe essential-motivation/ (accessed Mar. 03, 2023).

[5] N. Morgan, “Is Audience Interaction A Good Idea?,” Forbes. https://www.forbes.com/sites/nickmorgan/2016/10/27 audience-interaction-a-good-idea/?sh=616f25071291 (accessed Mar. 03, 2023).