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

System Requirements Specification
CSE 4316: Senior Design I
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Ganbare
Duck Hunt

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Revision History

Revision	Date	Author(s)	Description
0.1	3.24.2023	JuG	document creation
0.2	3.31.2023	AO, DN, JaG, JuG, LD	complete draft
1.0	8.08.2023	AO, DN, JaG, JuG, LD	official release

Contents

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1 Product Concept

The project consists of a Mitsubishi robot arm that will be able to play a duck hunt game on its own. Without external input, the robot arm should be able to move and engage with the target. If time allows, the system can be modified to allow a person to control the target while the robot arm tries to engage it.

1.1 Purpose and Use

The project will make use of machine learning to detect and identify the target on the screen. The duck hunt game will run using a WiiU in order to use HDMI inputs that can be used for the machine learning system.

The purpose of the project is to encourage curiosity in the Computer Engineering degree and other technology based degrees at UTA. The project is intended to be able to market and advertise majors related to science, technology, engineering, and math and create interest in careers within these fields. The project could be shown during events such as lab tours and engineering summer camps to reach the target audience.

1.2 Intended Audience

The intended audience will be students in secondary schools that could potentially be interested in pursuing an engineering degree and career. The project could also be used by college professors and recruiters to market engineering as a field. As the system is designed to be used for marketing purposes within UTA, there is no intention for the system to be available commercially.

2 Product Description

The robot arm is 3 feet tall and will have a Wii remote attached to it. The television and the Wii sensor on top of it will be inside the cage. The students will either be outside the lab looking through the glass or inside the lab at a safe distance away from the robot to watch the robot play the game. There will also be a secondary TV using an HDMI splitter to show the people close up what the robot is doing. The users will be able to view the robot in person through the glass.

2.1 Features & Functions

In order to identify and engage the target, data will be gathered from video frames of the game using an HDMI splitter that will be used for a machine learning algorithm. Machine learning will be used to identify the target prior to the robot arm engaging with it. After the target has been identified, the system will use RT Toolbox3 to program the robot arm and GX Works3 to interact with the GPIO. The robot arm has a gripper that will be used to hold onto the Wii remote, which will engage the target while the robot arm is moving. For the purpose of safety, while the robot arm is running inside the cage, spectators should remain outside of the cage.

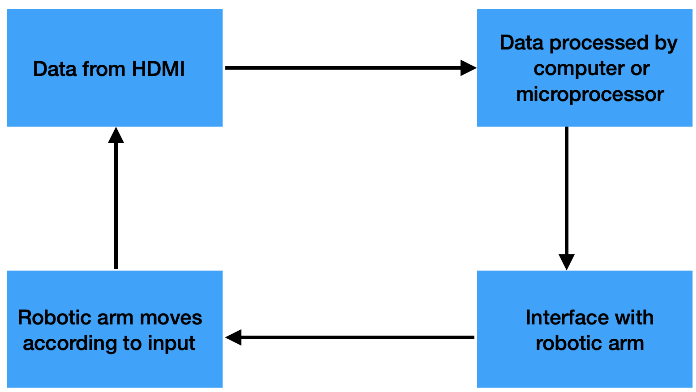

Figure 1: System Overview

2.2 External Inputs & Outputs

From the perspective of the intended audience for the project, there is little input required from the spectator. A person that is familiar with the project can manually turn on any required equipment and run the robot arm through the RT Toolbox3 software. If time allows, modifications can be made to allow spectators to interact directly with the system by adding the ability for a person to control the target. The Raspberry Pi will have software that can communicate to GX works at the desktop automatically configured to run at startup. This will make the customer' job much simpler as all he has to do to configure the Pi, is turn it on and attach it to the GPIOs of the desktop.

2.3 Product Interfaces

To those that are simply watching the robot arm play the duck hunt game, there is not much that the spectator needs to interface with. For a person that is running the system, the robot arm can be used with the RT Toolbox3 software.

3 Customer Requirements

Customer requires system for target identification and acquisition (virtual duck) using a Mitsubishi Robotic arm implementation. Identification implementation should be handled autonomously via Artificial Intelligence(AI) and/or Machine Learning(ML)/Computer Vision(CV). Target acquisition will be done both virtually (using HDMI splitter) and physically (robotic arm will traverse to engage). The customer would also want to know how to use the machine and raspberry pi integration. This can be achieved by giving step-by-step instructions via a video or written.

3.1 Target Identification

3.1.1 Description

System will identify target (virtual duck) without external input. This requires implementation via Artificial Intelligence or Machine Learning/Computer Vision.

3.1.2 Source

CSE Senior Design project specifications.

3.1.3 Constraints

Machine learning implementation response speed (latency) and compatibility with HDMI splitter.

3.1.4 Priority

- Critical

3.2 Target Acquisition

3.2.1 Description

System will engage target (virtual duck) using Mitsubishi Robotic arm after target identification. The system will move towards the target and fire.

3.2.2 Source

CSE Senior Design project specifications.

3.2.3 Constraints

Various constraints exist:

- Robotic arm traversal speed
- Robotic arm angular constraints/velocities
- HDMI splitter/GPIO functionality

3.2.4 Priority

- Critical

3.3 Control of Target

3.3.1 Description

A spectator will be able to control the target (virtual duck) while the robot arm attempts to engage it.

3.3.2 Source

CSE Senior Design project specifications.

3.3.3 Constraints

Time available to implement the feature

3.3.4 Priority

- Low

3.4 Digital Use Tutorial

3.4.1 Description

Customer will be provided with a digital tutorial covering the setup and use of project implementation.

3.4.2 Source

CSE Senior Design project specifications.

3.4.3 Constraints

- Camera Availability
- Video Editing Capabilities/Software
- Time available to film the video

3.4.4 Priority

- Low

4 Packaging Requirements

Mitsubishi Robotic arm will be located at operating facility. Software will be pre-loaded on a windows based computer (Windows 10). Hardware external to the Mitsubishi robot arm (Wii-U, Duck Hunt Video-Game, HDMI Cables/Splitter, Video-Game Controller), will be delivered together to be assembled by the user. Two HDTV's will be provided for the customer (one for the operation of the Robot Arm and one for user display).

4.1 Mitsubishi ARM Software

4.1.1 Description

MELSOFT GX Works3 (GPIO interface software) and RT Toolbox3 (CAD and controller for arm) software

4.1.2 Source

Mitsubishi

4.1.3 Constraints

GPIO compatibility with supplied software provides operational constraints.

4.1.4 Standards

Compliant with European Machinery Directives (CE) standard

4.1.5 Priority

Priority: Medium

4.2 Nintendo Wii-U

4.2.1 Description

Wii-U video game console with remote (toy gun or standard gaming controller), HDMI cable and splitter

4.2.2 Source

Project development CSE

4.2.3 Constraints

GPIO and Mitsubishi robotic arm compatibility (splitter implementation).

4.2.4 Standards

Compliant with European Machinery Directives (CE) standard

4.2.5 Priority

Priority: Medium

4.3 Computer (Windows Operating System)

4.3.1 Description

Computer running Windows OS 10 for Machine Learning software implementation and Mitsubishi required software.

4.3.2 Source

Project development CSE

4.3.3 Constraints

Machine learning/vision latency/feedback speeds place a target identification constraint. This constraint further constrains the robotic arm movement/reactionary speed.

4.3.4 Standards

Compliant with European Machinery Directives (CE) standard

4.3.5 Priority

Priority: Medium

4.4 Television

4.4.1 Description

HDTV for displaying video-game and target identification/acquisition demonstration.

4.4.2 Source

Project development CSE

4.4.3 Constraints

CSE Department Budget Constraint

4.4.4 Priority

Priority: Medium

4.5 Nintendo Duck Hunt Video-Game

4.5.1 Description

Nintendo Wii-U Duck Hunt Video-Game

4.5.2 Source

Project Development CSE

4.5.3 Constraints

Budgeting Constraints

4.5.4 Priority

Priority: Medium

5 Performance Requirements

The performance requirements are quite strict. The sensors must be able to sense, send the data to the robot arm, then the robot arm must be able to point and shoot the duck swiftly before the duck flies away which will need to be within a fifth of second. Either that, or we could predict the trajectory and align the shot in advance assuming that the duck flies in a straight line. However, the trajectory could change if a user manually controls the duck.

5.1 Latency

5.1.1 Description

The robot arm will move towards the target and fire within a fifth of a second.

5.1.2 Constraints

The constraints of the Mitsubshi robot arm are that it has six degrees of freedom, and the robot arm can move 2000 times back and forth before it loses its place by a significant amount in regards to the television screen. The maximum resultant velocity is 10,500 mm/sec, which is very quick.

5.1.3 Priority

Priority: High

6 Safety Requirements

When the robot arm is moving, no one should be inside the cage, for both the safety of the arm and of the human.

6.1 Operation of Robot Arm

6.1.1 Description

While the system is running, no one should be inside the cage along with the robot arm. All spectators should remain outside of the cage. The system will not operate if spectators are inside the cage.

6.1.2 Source

Project development CSE

6.1.3 Constraints

The system should only be running within the presence of an operator who is familiar with the system.

6.1.4 Priority

Priority: Critical

7 Maintenance & Support Requirements

Software will not be maintained after development is complete. Therefore, it is the user's responsibility to maintain the code. This code will be created for a certain version of Toolbox and GX Works. It will work for a specific version of both and not be maintained for any future versions. If a group of people would like to maintain the software, make sure to list what versions of Toolbox and GX works are compatible with it. Create troubleshooting guides. The Operating Software that will be running is Windows 10.

7.1 Maintenance

7.1.1 Description

This product will not be maintained after development. A guide will be provided if a user wishes to use the product.

7.1.2 Constraints

The Mitsubishi Toolbox and GX Works could break. The Wii software could also break and maintenance would be quite difficult because Wii is reaching its End-Of-Life.

7.1.3 Standards

There are no standards set.

7.1.4 Priority

Priority: Low

8 Other Requirements

The software tooling for configuration of the industrial robot and Window's operating system would be proprietary to the manufacturer of the system or operating system. For customer setup, the television, Wii console and computer must be turned on with the appropriate attachment to the tooling. The program would have to be manually executed by the operator of the Mitsubishi Arm. For modularity, the console remote module could be exchangeable to replaced with other modules. For extensibility, the difficulty on the robot arm could be changed by increasing latency.

8.1 Presenter

8.1.1 Description

There would need to be a presenter/operator, who would know the software, for the robotic arm to turn on the television.

8.1.2 Standards

All observers must be outside the cage when program for robotic arm is running.

8.1.3 Priority

Priority: Low

9 Future Items

9.1 Secondary Display

9.1.1 Description

There would be a secondary display that would allow spectators to view the Mitsubishi robot arm from a different perspective.

9.1.2 Constraints

This part requires more time and money.

9.1.3 Priority

Priority: Future

REFERENCES