Hazard Analysis
Mechatronics

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Revision History

Table 1: Revision History

Date	Developer(s)	Change
Oct 19, 2022	Everyone	Initial version
...	...	...

1 Introduction

This document is a hazard analysis of Group 20's ASL Translator. The ASL Translator is a real-time sign language translation device intended to aid individuals who are hard of hearing in day to day communication tasks. This device may also be used for the purpose of facilitating the learning of sign language in an educational setting.

2 Scope and Purpose

The purpose of this document is to identify hazards that may occur when using the ASL Translator specifically in the components, their causes and consequences on user operation, hazard mitigation, and their respective requirements.

3 System Boundaries

The device being referred to in the hazard analysis consists of the following components:
1. A Raspberry Pi
2. A camera
3. A machine learning model for ASL
4. A hand tracking script

The system boundaries include the raspberry pi, its machine learning model and hand tracking script, and the camera. Despite the choice of raspberry pi model and camera model being influenced by the user and out of control of the developers, it is important to include these components as they are core to the system's operation. Therefore, a hazard analysis on these components will still be included.

4 Definition of Hazard

The definition of a hazard is based on the definition from Nancy Leveson's work. A hazard is a property or condition in the system along with a condition in the environment that results in a loss. A hazard is anything that can cause our system to function incorrectly, or not function at all. In the ASL Translator, there exists only hazards that affect the proper and intended operation of the device.

5 Critical Assumptions

At this time, there are no critical assumptions to be made.

6 Failure Modes and Effects Analysis

The hazard analysis tool being used is the Failure Modes and Effects Analysis (FMEA). This will enable hazard identification and analysis such that additional safety requirements can be created and considered in the implementation of the project.

6.1 Hazards Out of Scope

The out of scope hazards for our project is primarily based on the user's decision. This is because we do not have control over the following:

- The camera that is to be used in conjunction with the system
- The Raspberry Pi model and microSD card capacity being used

Both components listed above are essential to the functionality of the system. However, there is no enforcement on these aspects as the user may prefer something less costly or more costly. The user's decision towards these components may vary and can affect the overall performance of the system. Steps will be taken to minimize the impact of the user's choice in these categories such as ensuring backwards compatibility is possible with our implementation of code on the Raspberry Pi and camera calibration methods.

6.2 Failure Modes and Effects Analysis Table

Below is the FMEA table for the project.

Table 2: FMEA Table

Component	Failure Modes	Effects of Failure	Causes of Failure	Recommended Action	Req.	Ref.
Raspberry Pi	Fail to output translated results	The output is not properly displayed	a. Code execution failure due to improper flashing to board	a. Board will not POST and power LED should be on. Reboot the board and ensure that the correct software and dependencies are loaded.	a. SR2	H1-1
	Hardware failure (board)	Raspberry Pi cannot function	a. The board is not powered due to faulty power supply	a. LEDs on the board will not appear to powered indicating power failure. The raspberry pi is equipped with a polyfuse to prevent over-current. If the board does not power on after 24 hours, the fuse should be replaced.	a. HR1, HR3	H1-2
			b. The software is corrupted	b. Refer to H1-1a. The board shall not boot into the OS indicating that the OS installation is corrupt. The board may also return errors when attempting to run programs indicating that a reinstallation of software is needed.	b. HR1	
			c. The board is faulty or defective	c. Refer to H1-1a. The board may not function as intended during operation indicating either loose connections between peripherals and the board or damage to the board.	c. HR1, HR3	
			d. The microSD card cannot be read	d. Same as H1-2b	d. HR1	H1-2

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Component	Failure Modes	Effects of Failure	Causes of Failure	Recommended Action	Req.	Ref.
Camera	Failing to detect motion	Device is unable to detect or translate sign language	a. Poor lighting conditions	a. The system will not recognize hand gestures and relayed video capture will be too dark to differentiate objects.	a. ER1	H2-1
			b. Unclear hand gestures by the user	b. The system will incorrectly classify hand gestures which indicates that there is an issue with the received input.		
	Hardware failure		a. Issues with the lenses	a. The system will not be able to recognize hand/body joints indicating that there is an issue with the lenses or camera itself.	a. HR2	H2-2
			b. Electrical power issues	b. The camera will appear to be unpowered and not relay any video information to the system. The system will also return an error if a VideoCapture object cannot be instantiated.	b. HR2	
The machine learning model for ASL	ML model is not accurate	The device will produce incorrect or unexpected outputs	a. Incorrect data set is being used	a. During training, the model will return an error if the incorrect dataset is used. This may be due to dataset structure or formatting.	a. MLR1	H3-1
			b. ML model is misusing data and turning it into meaningless input	b. The model is recognizing and classifying input that has not been implemented for classification. The model should reject classifications that are not supposed to be recognized	b. MLR1	

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Component	Failure Modes	Effects of Failure	Causes of Failure	Recommended Action	Req.	Ref.
The machine learning model for ASL	ML model is not accurate	The device will produce incorrect or unexpected outputs	c. The training dataset is not randomized enough resulting in the model anticipating specific orders of input	c. The model shall be trained from scratch on each iteration instead of expanding upon prior implementations.	c. MLR1	H3-1
			d. Model is underfit or overfit resulting in poor generalization outside of the training dataset	d. System will return inaccurate classifications indicating that there is underfitting or overfitting occuring. This should be accounted for when training the model by modifying ML parameters.	d. MLR2	
Hand tracking script	Script is not running	The device will not be able to translate sign language	a. Code execution error	a. System script will throw exceptions. The system should have built-in error handling to account for this.	a. SR1	H4-1
			b. Code was not flashed onto the board correctly	b. Same as H1-1a	b. SR2	

7 Requirements

7.1 Hardware Requirement

HR1: The Raspberry Pi board should be checked and tested before using it in the project.
HR2: The camera should be checked before each use to ensure the lenses are clean and working properly.
HR3: The power supply shall be checked before usage to ensure that there is no risk of electric shock

7.2 Environment Requirement

ER1: The camera shall be mounted in a manner that prevents obstructions from hindering its operation.

7.3 Machine Learning Requirement

MLR1: The dataset chosen should be checked and verified for sufficient information before training. Preprocessing should be done on the dataset for standardization and normalization.

MLR2: ML model should be built accordingly for the purposes of classification and tested using a confusion matrix or relevant metrics such as loss and accuracy. Further optimization should be considered such as early stopping or dropout.

7.4 Script Requirement

SR1: Various software testing (Black box testing, White box testing, etc) should be performed on the script before it is flashed onto the board.
SR2: Complete functionality testing should be performed after the code is flashed onto the board.

8 Roadmap

The hazard analysis has resulted in new safety requirements that were not considered in the initial revision of the System Requirements Specification (SRS). Given the current time and budget constraints, while some hazards will be accounted for and removed, some hazards might still remain in the final revision of the project. These hazards that may not be addressed may include model inaccuracy and Raspberry Pi hardware failure/failure to display results. This is primarily due to the intensive training needed for an accurate machine learning model and due to the hardware limitations of a Raspberry Pi as the project develops. In these cases, notices will be provided to the user to ensure safety and proper regulation. Throughout the next steps of the project, the hazard analysis will continuously be consulted to determine risks that have already been considered in the implementation and risks that will be removed in future updates.