McMaster University

Software & Mechatronics Capstone

eBin

Hazard Analysis

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1 Revisions

Date	Revision#	Authors	Comments
Oct.14 2019	Revision 0	Anna Wei Alan Yin Ditong Liu Huajie Zhu Junni Pan Zhihao Yang	Initial draft of Hazard analysis
Feb.23 2020	Revision 1	Anna Wei Alan Yin Ditong Liu Huajie Zhu Junni Pan Zhihao Yang	Delete project purpose and scope. Add hazard Analysis purpose and scope. Add FEMA scale table picture for methods

Table 1: eBin Table of Revision

2 Introduction

2.1 Document Purpose

The purpose of this document is to identify the components in eBin which may potentially cause hazardous consequences. The Failure Modes and Effects Analysis (FMEA) method was used in developing a hazard analysis for eBin. In the following sections, comprehensive considerations were taken for all modules to ensure both software safety and hardware system safety. This document will include various system failure states that may occur during both the development and the implementation of each system.

2.2 Scope

The system being implemented is one that is meant to automate garbage sorting in garbage bins in school and university facilities. Students and staff walking by the eBin will throw whatever garbage they have into the bin, and the eBin will detect and sort the garbage. Passersby will also be able to see the results of the garbage sorting on a screen.

2.3 Naming Conventions and Terminology

Term	Description
eBin	eBin is our garbage sorting machine
sub-bin	sub-bins are the two small bins embedded in the large bin
FMEA	Failure Modes and Effect Analysis
LED	Light Emitting Diode
Core App	Python application that handles the cooperation of each component

Table 2: Terminologies and corresponding descriptions

2.4 Overview

The system design document contains information about the breakdown of the components of the system. The document will include a context diagram relating to how our components behave, a component diagram that shows the detail of the interactions between components, lists of system variables and constants with interpretation and the general overview of system behaviour. Next, each component will be broken down and described in terms of input/out, behaviour, timing constraints/performance requirements and initialization procedures. At the end, this document will detail normal operating states as well as undesired events of our system and how they will be handled.

2.5 Constraints

2.5.1 Development Constraints

The project is developed in two parts. One is software. The other is hardware. In the software, we use python to develop the garbage recognition. In the hardware, we use stepper motor to control the plate.

2.5.2 Operation Constraints

Both garbage recognition and the control of plate are operated by raspberry pi, which is a tiny desktop computer.

2.5.3 Schedule Constraints

The project must be finished before April on 2020, the development of process will follow the schedule of deliverable.

2.5.4 Budget Constraints

The maximum budget of our project is 750 Canadian dollars.

3 Component Overview

The components can be divided into the following five components.

3.1 Camera System

The camera system is a combination of python application and a webcam. It will monitor the plate and take a picture once a garbage on the plate has been detected.

3.2 Core App System

Core App System is a python application that can handle the cooperation of each component. It will ensure the whole system works in a logical sequence. Once eBin has been turned on, the Core App System sends cameraHandler a signal to initialized camera system. ImageData message then can be received from camera module all the time and passed through analytic system. If analytic system returns a signal saying that there is a garbage placed on the plate, Core App System will start the following process to sort the garbage: First, Core App System pass the imageData message received from camera system to interface system and analytic system, waiting for analytic system to return a signal containing the garbage type, then MainController will send a signal to motorHandler corresponding to the garbage type. Upon the motor receiving the signal from Core App system, it will be initialized by its mainHandler.

3.3 Analytic System

A python application that can receive the image data type, resize the image and utilize different trained models to recognize the garbage type.

3.4 Interface System

The interface system is a combination of a python application and a display. It will show the processing steps, the garbage type and the system status.

3.5 Garbage Disposal System

The Garbage disposal system contains a python application, a motor and a plate. It will hold the garbage on plate for processing, then dispose the garbage into corresponding bin according to the instructions returned from Core App.

4 Safety Considerations

4.1 Camera System

Software Issues:

- Taking multiple pictures of the same item repeatedly thus slows the whole image processing speed
- Time for capturing a picture is too long to meet the system requirement
- Camera does not capture pictures due to incorrect signals taken

Hardware Issues:

- Pictures cannot be taken due to broken or blocked camera
- Camera lost power due to poor connections to the processor (broken or loosen wires)
- Camera lost function due to high temperature of the integrated circuit board
- Pictures cannot be taken properly due to poor focus, lighting or wrong positioning of the camera

4.2 Core App System

Software Issues:

- Core App system cannot send initialization signals to other systems on time
- MainController cannot pass signals through other systems
- Time for processing signals is too long to meet the system requirements, or software algorithm is not efficient to handle complex situations

Hardware Issues:

- Microcomputer cannot process power signal due to electrical issue or environmental noise
- Microcomputer cannot process data signal due to electrical issue or environmental noise
- The connection between micro-controller and other systems are lost(broken or loosen wires)

4.3 Analytic System

Software Issues:

- The analytic handler may fail to fetch the processed image data from the main controller, or it may fail to pass the function calls with image data to the analytic controller
- The analytic handler may fail to resize the input image to 300*300
- The analytic controller may fail to pass the calculated garbage type to the main handler

Hardware Issues:

- The analytic handler may stop running and thus fail to continuously receive function calls
- The image recognition mechanism in the analytic controller that translates raw json output into the final calculated garbage type may fail

4.4 Interface System

Software Issues:

- The user view handler may fail to receive the inputs from the main controller, or it may fail to output message to the user view component
- The user view handler may not properly receive updateUserView from main controller component, or it may be unable to send the appropriate update instructions to the user view component
- The user view component may fail to display the garbage data as output

Hardware Issues:

- Hardware delays may cause user view component to have a delay greater than 2000ms when displaying the object type and garbage type
- The user view handler component may have hardware connection issues to the main controller.

4.5 Garbage Disposal System

Software Issues:

- The garbage disposal system may fail to communicate to the other components of the device due to software failure.
- Software response times may cause too high of a delay for the time it takes the garbage disposal system to actually move.

Hardware Issues:

- The sub-bins that are embedded at the bottom of the eBin frame may cause interference to the camera system..
- The flipping plate that temporarily holds the garbage for the camera to take pictures with may stop rotating.

5 FMEA Work Sheet

5.1 Failure Modes and Effect Analysis Table

The following is a breakdown of the failure modes and effects analysis, or FMEA table. A hazard function will be presented with the possible failures, the unacceptable events that could occur should said failure occur, the severity of the failure, the possible cause of said failure, the likelihood of the failure, recommended action and the likelihood of failure detection. The numbers of severity of failure and likelihood of occurrence for each section are based on the experiments and experiences when use garbage bin in campus, along with the FMEA Scales for severity, occurrence and detection(see reference 6.1).

Function	Failures	Unacceptable Events	Severity of Failure (0 - 10)	Cause of Faliure	Likelihood of Occurrence (0 - 10)	Recommended Action	Likelihood of failure detection (0 - 10)
Garbage Holding	Plate is not able to hold the garbage	Garbage and plate drop into one of sub-bin	9	Unexpected overweight garbage	1	Prompt user the maximum weight on the garbage can	1
Object Detection	System is not able to detect the object	System can not proceed to next step	9	Insufficient lighting condition in the garbage bin	8	Include LED lighting and light sensor in the garbage bin	3
Image Capture	No response when user put the garbage on the plate	No image for the system to analyze	8	Camera sensor is not connected to the raspberry pi correctly	2	MainController is used to report error when components are disconnected	5
	Camera can not capture clear and full images	Wrong images for the system to analyze	6	The garbage is put in the wrong place	8	Prompt user to place the garbage where the camera can take a clear picture	5
Object Analysis	The object is identified as a wrong object	Wrong object is displayed to the customer	7	The trained model does not work well	2	Retrain the model after with the new data	8
Garbage Type Analysis	The garbage is identified as a wrong type	Wrong garbage type is displayed to the customer	7	The trained model does not work well	2	Retrain the model after with the new data	8
	Wrong garbage type is sent to the core app	The garbage will be disposed into the wrong bin	9	The trained model does not work well	1	Retrain the model after with the new data	8
Result Display	Processing information is not showing properly	The user will feel confused about the processing steps	4	Wrong data is sent to the display / Display configuration is not correct	1	Change the configuration of userView	9
	The display is not clear enough to view	The user experience will be affcted	2	The screen size is too small / The screen brightness is too low	3	Upgrade to a high quality screen with big size and high brightness	6
Garbage Disposal	Error in motor rotation	Dispose garbage into wrong bin	8	Wire connection issue on motor	1	MainController is used to report error when components are disconnected	1
	Garbage remains on the plate	Garbage not disposed into garbage bin	3	Garbage stuck on plate	3	Analytic controller keeps track on continuously repeatitive results	7
	Not able to power motor	Motor rotation inconsistent	7	Battery is malfunctioning	2	Main controller to monitor battery information	6
Initial State Reset	Not able to rotate to initial position	Incomming garbage droped into bin without going through classification process	8	Plate being blocked during initialization process	2	Motor controller is used to report error if motor position is not initialized	7
	Incomming garbage during intialization process	Incomming garbage droped into bin without going through classification process	8	Initialization process took too long Unexpected user input	4	Add reminder to inform user the correct operation process Optimize motor controller	7
Hide wires and functional equipments	Liquid in garbage poured onto exposed wire and components	Hardware damage and risk of fire	9	Wire and electronic components not properly insulated from outer shell	1	Check hardware connection and enclosure during maintenance	9
	Unexpected user access to core components	Hardware damage and risk of electric shock	9	Wire and electronic components not properly insulated from outer shell	1	Use of insulating material in wire connections and core components	8

Figure 1: FMEA Table

6 Reference

6.1 FMEA Scale

Severity Scale for Failure Modes & Effects *(scale of 1 [least severe] to 10 [most severe] for each effect)*

Minor *(Rank 1)*	**Low** *(Rank 2 - 3)*	**Moderate** *(Rank 4 - 6)*	**High** *(Rank 7 - 8)*	**Very High** *(Rank 9 - 10)*
Unreasonable to expect that the minor nature of this failure will have any noticable effect on item or system performance or subsequent process or assembly operation. Customer will most likely not be able to detect the failure.	Due to the nature of this failure, the customer experiences only slight annoyance. Customer will probably notice slight deterioration of the item or system performance or a slight inconvenience with a subsequent process or assembly operation, i.e. minor rework.	Failure causes some customer dissatisfaction which may include discomfort or annoyance. Customer will notice item or system performance deterioration. This may result in unscheduled rework/repair and/or damage to equipment.	High degree of customer dissatisfaction due to the nature of the failure, such as inoperable item or system. Failure does not involve safety or government regulation. May result in serious disruption to subsequent processing or assembly operations and/or require major rework.	Failure affects safety or involves noncompliance to government regulations. May endanger machine or assembly operator (9 with warning, 10 without warning)

Occurrence Scale for Potential Root Causes *(scale of 1 [least frequent] to 10 [most frequent] for each root cause)*

Remote *(Rank 1)*	**Very Low** *(Rank 2)*	**Low** *(Rank 3 - 5)*	**Moderate** *(Rank 6 - 7)*	**High** *(Rank 8 - 9)*	**Very High** *(Rank 10)*
Failure unlikely. No failures ever assocaited with this process or almost identical processes (1=1:1.5M)	Only isolated failures associated with this process or almost identical processes (2=1:150K)	Isolated failures associated with similar processes (3= 1:30K; 4=1:4500; 5=1:800)	This process has occasional failures, but not in major proportions (6=1:150: 7=1:50)	This process or similar processes have often failed (8=1:9; 9=1:6)	Failure is almost inevitable (10=>1:3)

Detection Scale for Failure Occurrence *(scale of 1 [always detected] to 10 [never detected] for each occurrence)*

Very High *(Rank 1 - 2)*	**High** *(Rank 3 - 4)*	**Moderate** *(Rank 5 - 6)*	**Low** *(Rank 7 - 8)*	**Very low** *(Rank 9)*	**Absolutely No Detection** *(Rank 10)*
Current controls almost certain to detect the failure mode. Reliable detection controls are known with similar processes. Process automatically prevents further processing.	Controls have a good chance of detecting failure mode, process automatically detects failure mode.	Controls may detect the existence of a failure mode.	Controls have a poor chance of detecting the existence of failure mode	Controls probably will not detect the existence of failure mode	Controls will not or can not detect the existence of a failure. No known controls available to detect failure mode.

Figure 2: FMEA scale Table