INF2004 - Embedded Systems Programming

Project Testing

Team 34

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Integration Testing

Integration Testing is conducted where software modules are integrated logically and tested as a functional group. This allows us to see if the individual components are integrating properly as a functional group. It lets us detect if there are any problems within each component as a result of not integrating properly. Within each functional group, we perform black box testing using various methods. The list of functional groups are as shown below:

1) Ultrasonic Sensor + DC Motor
2) IR Sensor + DC Motor + Magnetometer
3) Barcode Sensor + Wifi Module
4) Wheel Encoder + DC Motor

Group 1: Ultrasonic Sensor + DC Motor

Functionality: The ultrasonic sensor sets a threshold value to detect an obstacle and once the threshold value is met, it instructs the DC motors through the motor controller to do a reverse manoeuvre for a short distance before detecting again. For this functional group, boundary value analysis is adopted, which is one of black box testing methods.

Table 1: Boundary Value Analysis for sensing distance

Invalid	Valid		Invalid
0	> 0	< = 15	> 15

Table 1 outlines the boundary values analysis for integration testing based on sensing distance in centimetres picked up by the ultrasonic sensors. A distance of 0 cm indicates that the sensing distance is out of range, signalling the absence of obstacles and the car should continue moving forward. When the distance is greater than 0 cm and less than or equal to 15 cm, the ultrasonic sensor detects a close obstacle, prompting the car to stop moving and reverse backwards to avoid a collision. If the distance exceeds 15 cm, indicating a distant obstacle, the car should continue moving forward.

Table 2: Test value and its corresponding test result for the Boundary Value Analysis

Test Value	Test Result	Integration Pass/Fail
0cm	The car continues to move forward.	Pass
1cm	The car stops moving forward, reverses backward for 3 seconds and attempts to move forward again.	Pass
2cm	The car stops moving forward, reverses backward for 3 seconds and attempts to move forward again.	Pass
14cm	The car stops moving forward, reverses backward for 3 seconds and attempts to move forward again.	Pass
15cm	The car stops moving forward, reverses backward for 3 seconds and attempts to move forward again.	Pass
16cm	The car continues to move forward.	Pass

Table 2 provides the outcomes of the Boundary Value Analysis conducted based on the specified distance the ultrasonic is sensing between itself and the obstacle in front of it. The results indicate successful integration between the ultrasonic sensor and DC motor.

Group 2: IR Sensor (Line Tracking) + Magnetometer + Motor

Functionality: There are 2 IR sensors attached to the car that determines if the car is moving straight or should make a left or right turn depending on whether they sense black or white. The different conditions cause the car to manoeuvre differently.

The magnetometer allows the car to turn to a certain degree indicated by the developer, e.g. (90 degrees turn). The car should be able to turn until the magnetometer determines that it has reached 90 degrees to ensure an accurate turning angle of the car. The magnetometer first determines the current heading angle and as it calls the function to turn, it calculates a target angle by adding 90 or subtracting 90. The motor then turns the car until that angle is met. These 3 components should work together to ensure smooth navigation across the maze. For this functional group, cause-effect analysis using a decision table is adopted, which is one of black box testing methods.

Table 3: Decision table for car manoeuvres

No.	**Cause**	Value	1	2	3	4
C1	Left IR sensor detects black	Y/N	Y	Y	N	N
C2	Right IR sensor detects black	Y/N	Y	N	Y	N
	Effects					
E1	Car turns 90 degrees left				X	
E2	Car turns 90 degrees right			X		
E3	Car maintains current trajectory		X			
E4	Car stops moving					X

Table 4: Test cases for car manoeuvres

Test Case	Precondition	Steps	Expected Result	Actual Result	Integration Pass / Fail
1. Car moves straight	Both line on either side of the car is black	1. Align car with both IR sensors over the black lines	Car will continue to move straight	Car goes straight	Pass
2. Car turns 90 degrees to the left on left sensor detecting white	Line on the left of the car is white and line of the right is black	1. Place the car on a left turning junction	Car will turn 90 degrees to the left	Car turns 90 degrees towards the left	Pass
3. Car turns 90 degrees to the right on right sensor detecting white	Line on the right of the car is black and line of the left is white	1. Place car on a right turning junction	Car will turn 90 degrees to the right	Car turns 90 degrees towards the right	Pass

4. Car stops when both sensors detect white	Both line on either side of the car is white	1. Place car at the end point or at a white spot	Car will stop moving	Car stops moving	Pass

Group 3: IR Sensor (Barcode) + Wifi Module

Functionality: There is an IR sensor that is attached below the car that retrieves ADC readings to determine its barcode value. Upon detection of a valid barcode, it will be sent to the web server hosted on the Pico W. For this functional group, cause-effect analysis using a decision table is adopted, which is one of black box testing methods.

Table 5: Reduced decision table for barcode readings

No.	**Cause**	Value	1	2	3	4	5	6
C1	First Value Of Barcode	*/P/Others	*	P	Others	*	P	-
C2	Last Value Of Barcode	*/P/Others	*	*	-	P	P	Others
	Effects							
E1	Barcode Value is sent to web server		X				X	
E2	Barcode Value is not sent to web server			X	X	X		X

Table 6: Test cases for barcode reading

Test Case	Precondition	Steps	Expected Result	Actual Result	Integration Pass/Fail
Scanned first value and last value is “*” and “*”	Barcode provided is of barcode 39 format.	1. Let the car move forward and glide the Barcode sensor from start of barcode to the end of it 2. View web server for any readings	Character sent to web server	Character sent to web server	Pass
Scanned first value and last value is “P” and “*”	Barcode provided is of barcode 39 format.	1. Let the car move forward and glide the Barcode sensor from start of barcode to the end of it 2. View web server for any readings	-	No data sent to web server	Pass
Scanned first value is not * or P	Barcode provided is of barcode 39 format.	1. Let the car move forward and glide the Barcode sensor from start of barcode to the end of it 2. View web server for any readings	-	No data sent to web server	Pass

Scanned first value and last value is “*” and “P”	Barcode provided is of barcode 39 format.	1. Let the car move forward and glide the Barcode sensor from start of barcode to the end of it 2. View web server for any readings	-	No data sent to web server	Pass
Scanned first value and last value is “P” and “P”	Barcode provided is of barcode 39 format.	1. Let the car move forward and glide the Barcode sensor from start of barcode to the end of it 2. View web server for any readings	Character sent to web server	Character sent to web server	Pass
Scanned last value is not “*” or ‘P”	Barcode provided is of barcode 39 format.	1. Let the car move forward and glide the Barcode sensor from start of barcode to the end of it 2. View web server for any readings	-	No data sent to web server	Pass

Group 4: Wheel Encoder + DC Motor

Functionality: The wheel encoder uses the pulse between the edge rise and edge fall caused by the wheel encoder disc to determine the rotational speed of the motor. Hence, while the DC motor moves the wheel, the encoder will be able to pass the speed and total distance onto the serial monitor for monitoring.

Table 7: Test cases for wheel encoder and DC motor

Test Case	Precondition	Steps	Expected Result	Actual Result	Integration Pass/Fail
Detect car speed when moving	1. Encoder is enabled 2. Car function to move is set	1. Start the car 2. Turn on Serial Monitor to observe speed	Serial monitor should display the moving speed of the car	Serial monitor manage to display the current moving speed of the car	Pass
Detect car speed when stopping	1. Encoder is enabled 2. Car function to stop moving is set	1. Start the car 2. Turn on Serial Monitor to observe speed	Serial Monitor should display 0 speed	Serial monitor manage to display 0 speed when car has stopped moving	Pass
Detect total distance when car is moving	1. Encoder is enabled 2. Car function to move is set	1. Start the car 2. Turn on Serial Monitor to observe total distance	Serial Monitor should display the total distance increasing as it moves	Serial monitor managed to display the total distance and it is increasing	Pass