A Hand Gesture Recognition to Control Wheelchair to Help People with Special Needs

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ABSTRACT

In this project, using the Accelerometer sensor to take several different readings to obtain a quantity of information until the machine recognizes the various movements by defining the X, Y, and Z coordinates. Collects information about the location of X, Y, and Z coordinates during the movement. Accelerometer sensors convert motion into electrical signal so, signal be suitable for measure. The sensor makes several movements so, that Edge Impulses can recognize it. The motion must be repeated several times so, Edge Impulse can recognize it. Every two minutes we repeat the movement. The more attempts which do it more exact results we get. All the data which measure by Accelerometer sensor be store it in Edge impulse. In Edge Impulse there are a lot of steps I should go through it. Data acquisition use to collect data. Then create impulse by add processing block choose spectrogram. Next, adding Learning block then choose Neural Network (Keras). It can generate feature by select MFCC. It will show 3D shape with different colour for x, y, and z. NN classifier use to training output. It is showing percentage of accuracy. In Model testing show green colour if identify colour if it is unknown will be shown orang colour. Last one is Deployment. It used to build on device model. The edge impulse can be train and test data till machine recognized. After the machine recognizes several movements, so can build model. Then program it by using a microcontroller to do three different action, so that action can be useful for People with special needs, I hope this project will be helpful for their needs. The importance of this project lies in the use of machine learning to identify hand movement.

LIST OF ABBREVIATIONS

DC: Direct Current

PWM: Pulse-Width Modulate

IDE: Integrated Development Environment

PPE: Personal Protective Equipment

LIST OF SYMBOLS

VIN: Input Voltage.

v: voltage.

I/O: Input/ Output

Gravity vector g^s

1. INTRODUCTION

Through this project, refers to finding a mechanism to help people with special needs, by making a hand gesture that helps them perform some tasks such as use the wheelchair to move forward, backward and turn right. The idea of the project to use Machine learning (ML), training it, building set of data, collecting data, testing the impulse, and then programming to do a specific action.ML is concept of writing computer program. ML lies to convert raw data into important information. In the ML there is process called training, which mean use specific algorithm to identify rules of data. (Jan Jong boom 2020)

1.1 Background of the Project

The importance of the project lies in helping people with special needs to perform some simple. The mainly reason to choose this project to do several action, the most important of which is helping people, and the other reason is to use machine learning, and as we know that machine learning has a large and effective role at the present time to do work that is difficult for a person to do, and the machine learning can solve all complex problems, so it is good to know how Machine Learning Works. Machine Learning has a big role in various industrial, health, agricultural, etc. It is difficult now for the factories to operate without the presence of machine learning. The world

has become an urgent need for machine learning to solve all the needs of people and solve complex problems. Every one of us uses machine learning in our normal affairs. Examples of using machine learning are Google Siri and Alexa. We use it for face and fingerprint to unlock the phone and that is a part of Machine Learning. (Vinayak and Ltd 2020)

Machine learning need Accelerometer to collect data. This sensor identifies the movement and analyses it by knowing the X, Y, and Z coordinates and collects information about the location during the movement. Accelerometers are called MEMS, which is a short of Micro-Electro-Mechanical Systems and the Accelerometer is usually very small. There are two types of acceleration force, the first is the static force, an example is friction and gravity, and the second is the dynamic force, such as vibration. (Danny Jost 2019)

1.2 Proposed Approach

1.2.1 Project Aim

To build a machine learning with a set of data by using Edge Impulse platform to make hand gesture recognition system to control wheelchair.

1.2.2 Project Objectives

1- To control wheelchair using hand gesture motion.

2- To collect data by using Accelerometer sensor.

3- To build a machine Learning model to identify the movement.

4- To identify data which build in machine learning and get at least 80% accuracy.

5- To program data to control wheelchair to move forward, backward and turn right.

6- To design a system which can be able to recognize and detect hand gesture motion, which can be capture three axis of hand motion.

1.3 Applications

Hand Gesture can be used by people with special needs, to move their wheelchair forward backward and turn right.

It used to transport patients in a hospital.

Helps the elderly to complete daily tasks, for example transfer using a wheelchair from one place to another place.

1.4 Project Limitations

Of course like other application, challenge will be there with some restrictions. Which limit my project.

1- Not suitable for long distance, because difficult to people with special needs to move their hands up, down, and right.

2- Wheelchairs bear certain weights and that consider as a limit, hence not all people may be able to use it.

3- Has limit charge, hence need to be charge after some range.

4- Difficulty of using the wheelchair in the warm areas because he is disappearing to a cooling system to avoid combustion.

1.5 Overview of the Project Report

In this project nine Chapters to be completed. Chapter 1 introduces the project, where aim and objective muse explained well. Applications, which verify where we can used in our life. Limitation of using Machine Learning. Chapter 2 related to methodology where methods must be explained well with reason why choosing this method. Examples must be given. A diagram that explains the selected methodology must be drawn up. Chapter 3 about Literature Review four different topics must be chosen and then abbreviate it and write each topic separately. Chapter 4 about budgeting and project management, which include proper tables to show the scheduled clearly. The prices of the parts must be schedule. The management risks to be mentioned. Chapter 5 about Design and Analysis project require to draw a block diagram, flowchart, and circuit diagram. key parameter to be identify. Chapter about simulation and testing. It requires to automatic switching for complete schematic diagram.

2. METHODOLOGY

Methodology helps us to get important and valuable information. To find guidance and considered as guidance to get the desired results, so important for us, before starting any project, to have a specific methodology to follow to get an ideal project. Having a methodology helps to solve all the problems encountered in the project and achieve the desired goals. There are five different models, choose each one that we find it the best and applicable. (Emma 2020)

The five models are:

The first one is Waterfall model. Easy to use and determine. It is simple. Should last stage finish then software can be ready. High risks to use this method. The second type is Iterative model. In some cases, can develop in the beginning. Easy to progress and measurable. cannot choose it if we do simple project, so applicable for difficult project. The third type is Spiral model. Can make change in the beginning even if can reach the last stage. Huge number of stages require especially in the intermediate. It is expensive. The four type is V-shaped model. Suitable for small projects. Can be controlled easily. Can make testing and verification in the beginning. It is not flexible. The last one is Agile model. The project contains short iterations. The risk is low. The only thing where cannot know the cost of the project, Because of the changes that take place. (Anon 2017)

In my project, choosing V-shaped SDLC model is the best choice, because of its features. It is useful for use by engineers due to the requirements required of them. Suitable for small and large projects. Each stage has its own controller. Can be controlled easily. Can make testing and verification in the beginning. It is not possible to move to the second stage until after completing the first stage. Another name for this model is validation and verification model. (Anon 2017)
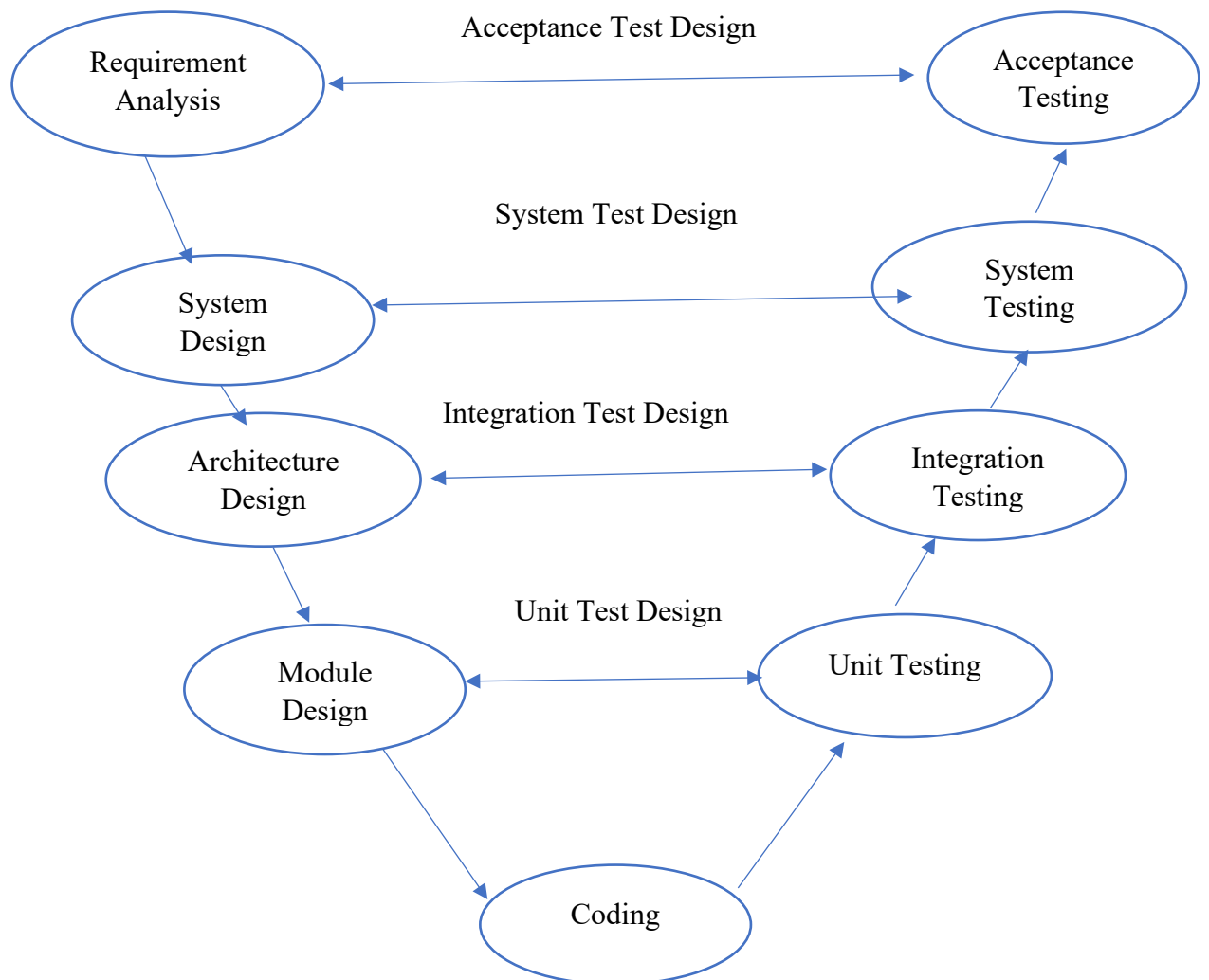
2.1 Applied Methodology

Figure2.1: Various phases of V-shaped SDLC model. (Dharmendra Kumar 2019)

In the figure2.1 shown that, this method is characterized by the ease, so that it is not possible to move to the other step without completing the first step, so it is easy to complete the project easily and smoothly by completing each stage step by step and then moving to the next step.

The main phases involved for this method are:

Requirements Analysis: The main initial requirement in my project is Accelerometer sensor, Arduino Nano 33BLE Sense, computer to download Edge Impulse, micro-USB cable, two motors need it for the output, and it controlled with

motor driver and four batteries. Normal wire required to connect output devices. Need chassis to keep motors on it and need two wheels. Relate to Edge Impulse, should download some software require before connecting any devices to Edge Impulse. Arduino does not have Wi-Fi; hence should download software program. Arduino CLI. Need to be download it to connect Arduino with Edge Impulse. This software needs if devices do not have Wi-Fi or IP connection. Serial Daemon use to upload configuration setting for all devices not connected with Wi-Fi or IP connection.Node.js v12. Need to be download it to connect Arduino with Edge Impulse. Arduino IDE, need this software to program finding result.

System Design: All hardware and software required in this project will mention in detail by help of block diagram, flowchart, and circuit diagram. Where the block diagram will show the work of each functional unit, and how it connects. Accelerometer sensor identifies the movement and analyses it by knowing the X, Y, and Z coordinates and collects information about the location during the movement. Accelerometer connected with Arduino Nano 33BLE Sense by using micro-USB cable. The Arduino detected motion which is generated in the accelerometer. Then all signals will send it to Edge Impulse. Edge Impulse is a program which help engineering to solve complex problem which is difficult to solve it by human. Which collect different information through the availability of a groups of data, its analysis and matching in the similar movement. The program can sort similar movements. We have similar motions that a machine can identify. Edge Impulse can do different process collect data, train data, test data and finally implement data. Flowchart will define all steps require. Data will be sent from Arduino to Edge Impulse. Edge Impulse will do different process and store data, so the first process will be end here. Second process is Implementation the data. First connect Accelerometer with Microcontroller. The system will read the accelerometer in each two seconds, then the model will classify the data, according to the classifications (action 1, or action 2 or action 3). Then Microcontroller can be program by using Arduino programming, where can use the dataset to build a program which can do different action. At the output, the DC motor will be used.

Circuit diagram will show all components with pin connection. In the input connect LSM9DS1 which have 9 axes. 3 axes for Accelerometer. 3 axes for Gyroscope. 3 axes for Magnetometer. It has 16 bits for the data output. VDD connect with 3.3v. SCL with pin9 which digital pin. SDA with pin8 which digital pin. The Arduino connect with 3.3v in pin30 which related to input voltage (VIN). Pin 5,6,7 are digital pins, hence I connect with output. (Store.arduino.cc 2020)

Architecture Design: Where the block diagram will show the work of each functional unit, and how it connects. Accelerometer sensor identifies the movement and analyses it by knowing the X, Y, and Z coordinates and collects information about the location during the movement. Accelerometer connected with Arduino Nano 33BLE Sense by using micro-USB cable. The Arduino detected motion which is generated in the accelerometer. Then all signals will send it to Edge Impulse. Edge Impulse is a program which help engineering to solve complex problem which is difficult to solve it by human. Collect a different information through the availability of a groups of data, its analysis and matching in the similar movement. The program can sort similar movements. We have similar motions that a machine can identify. Edge Impulse can do different process collect data, train data, test data and finally implement data.

Module Design: Flowchart will define all steps require. Circuit diagram will show all components with pin connection. Data will be sent from Arduino to Edge Impulse. Edge Impulse will do different process and store data, so the first process will be end here. Second process is Implementation the data. First connect Accelerometer with Microcontroller. The system will read the accelerometer in each two seconds, then the model will classify the data, according to the classifications (action 1, or action 2 or action 3). Then Microcontroller can be program by using Arduino programming, using the dataset to build a program which can do different action. Using motors as output.

Circuit diagram will show all components with pin connection. In the input connect LSM9DS1 which have 9 axes. 3 axes for Accelerometer. 3 axes for Gyroscope. 3 axes for Magnetometer. It has 16 bits for the data output. VDD connect with 3.3v. SCL with pin9 which digital pin. SDA with pin8 which digital pin. The Arduino connect

with 3.3v in pin30 which related to input voltage (VIN). Pin 5,6,7 are digital pins, hence connect with output.

Coding: A process which let project be coding, need to programming language to convert my project into code. Must be chosen the appropriate language for this project. choose Arduino IDE. Arduino IDE, need this software to program finding result.

Unit Testing: One of the important things that must be known is to know the faults of the sensors, so it is important to do measurements for the input and output for the component. Developers develop a set of codes used to test different and specific function. The machine must be well trained to be able to recognize the movements. Where cannot do a test for machine unless adequately trained. Edge Impulse has been programmed with this approach.

System Testing: Through this phase the project will be test if it is validated, through different tests which are Integration Testing, System Testing and Acceptance Testing. The test results will be tabulated. I should test method. A test must be performed for all components in the project. Check the Arduino if it is working properly. Connect the Arduino to the computer and download some required software to be installed in Edge Impulse. Also make sure the programming software used to be programmed can be used in Edge Impulse.

3. LITERATURE REVIEW/THEORY

In this chapter choose four different article from different sources. Then write the limitation, analysis, approach, and suggestion.

Hand-on Machine Learning with Scikit-Learn Keras & Tensor Flow

(Jupyter 2019)

What is Machine Learning System?

When anyone hears about a machine learning, he imagines that to be a robot that does all the work. Imagination has become reality today and has become widespread. Computers can learn without need to program it, and this is called a machine learning. This is what Arthur Samuel said in the year 1959. When the system learns something,

we call that training, and each training is called a training sample. There are different several type of ML. The first one is Supervised Learning. Spam filter is an example of Supervised Learning. This type of learning does train many times till machine identify. The second type is unsupervised Learning. It is unlabelled training data. The system can learn without need for someone to supervised. The third type is Semi supervised Learning. Label data always needs many times and very expensive, hence in this type they use unlabelled instant with a few label instant. The last type is Reinforcement Learning. Always learn by itself, so it chooses best strategy.

Effective Inertial Hand Gesture Recognition Using Particle Filtering Trajectory
(Tiancheng L 2018)

Hand gestures have become very common today. There are many types of hand gestures, depending on the method used to find the hand's location. One of the most common methods is Proposed Method. This method relies on determining the path of the hand through knowledge of positional estimator. Proposed method can obtain velocity and position evaluated. To obtain the evaluated attitude quaternion dependence to three sensors, which are an accelerometer, a gyroscope, and a magnetometer. This evaluated called a particle filter.

There are two type of hand gesture related to its classification. The first one in inertia sensor based. Getting the movement of the hand gestures through the MEMS. It is not expensive compared to Vision Base. To get more accurate gestures through knowing the user's attitude. A gyroscope can be used because it gives accurate readings. It is possible to use two types of sensors to determine the speed, which helps to recognize hand gestures in real time, so will get accurate result. If we use a single sensor, we may not get satisfactory results.

 The second one is the vision based. It is identified user's motion. It can detect users' hand, to give accurate result. One of the most important advantages of this type is that it is relatively reliable, so it is widely used in the field of artificial intelligence. This type is considered very expensive compared to the other type.

A fusion Recognition Method Based on Multifeature Hidden Markov Model for Dynamic Hand Gesture

(Daniele Bibbo 2020)

A fusion method which recognizes dynamic hand gesture. There are two stages in this method. The first one is separate hand gesture dynamic through evaluate the speed of moving hand to get data. The second stage is chosen four different sorts of hand gesture which are bending angle, palm postures, gesture trajectory and opening angle. Leap motion help to recognize this four sorts through identify hand motion. When comparing a hand gesture static and a dynamic, we note that it is easy to determine the amount of hand acceleration in a hand gesture static. There are two kinds of sensor can be use in hand gesture. The first one wearable sensor and the second is vision-based sensor. They are used to catch movement of fingers and hand. wearable sensor is difficult to control and difficult to use to perform hand gestures. The user may feel unnatural, which making it difficult to use. It is better to use a Vision- based sensor because it is considered less complicated, and it is easy for the user to use it because there is no physical contact with sensor and user.

Chinese Tone Recognition Based on Dynamic Muscle Information
(Jianbiao Zhang 2020)

Initial experiments were based on lip movement in Chinese experiments. But the results were not satisfactory. Other experiments have been established based on the distinctive Mandarin tone. This experiment is based on recognizing the Mandarin tone through vowel pronunciation. The results indicate that the lip tone gave more pronounced results, with a rate of 97.3%. The lip movement experiments did not obtain satisfactory results due to the complexity of the Chinese language and different pronunciation. The method used to know the movement of the lips is pixel-based method use to collect information and identifying the surrounding objects as a feature. This process requires a camera to capture the 3D information to obtain high accuracy. Uses facial depth images to obtain three-dimensional points. Getting the characteristics of the lips is somewhat difficult to find because it may be affected by the light or the colour of the skin.

Table 3.1. Summary of papers reviewed on" A hand gesture recognition to control wheelchair to help People with special needs."

Title, Author and Year	Concepts, Approach, Methods, Analysis adopted	Inconsistencies, Gaps, Contradictions, Differences	Improvements
Hand-on Machine Learning with Scikit-Learn Keras & Tensor Flow (Jupyter 2019)	There are different several type of ML. 1-supervised Learning. 2- unsupervised Learning. 3-Semi supervised Learning. 4-Reinforcement Learning.	Label data always needs many times and very expensive.	Use unsupervised Learning. It is unlabelled training data.
Effective Inertial Hand Gesture Recognition Using Particle Filtering Trajectory (Tiancheng L 2018)	To obtain the evaluated attitude quaternion dependence to three sensors, which are an accelerometer, a gyroscope, and a magnetometer. This evaluated called a particle filter.	This type is considered very expensive compared to the other type.	-

A fusion Recognition Method Based on Multifeature Hidden Markov Model for Dynamic Hand Gesture (Daniele Bibbo 2020)	When comparing a hand gesture static and a dynamic, we note that it is easy to determine the amount of hand acceleration in a hand gesture static.	wearable sensor is difficult to control and difficult to use to perform hand gestures.	It is better to use a Vision- based sensor because it is considered less complicated, and it is easy for the user to use it because there is no physical contact with sensor and user.
	The method used to know the movement of the lips is pixel-based method use to collect information and identifying the surrounding objects as a feature.	Getting the characteristics of the lips is somewhat difficult to find because it may be affected by the light or the colour of the skin.	Better to use the Mandarin tone through vowel pronunciation.

4. BUDGETING AND PROJECT MANAGEMENT

In this chapter, mention that the budget of the components needs to do this project. Also mention all risk that may will face during doing project. Explanation of all parts of PESTEL Analysis.

4.1 Project Budget

Table4.1: Project Budget.

Quantity	Component	Approximate price
1	micro-USB cable	3 OR
2	Arduino Nano 33BLE Sense	20 OR
3	Computer	250 OR (I already have computer)
4	Switch	3 OR
5	2 motors	2 OR
6	Motor driver	2 OR
7	car	5 OR
8	Normal wire	1 OR
Total price	All Components	286-250=36 OR

In the Table 4.1, the components used in this project are listed, along with their price. This schedule aims to develop a well-thought-out plan so that the project does not cost huge amounts of more than 200 Omani riyals.

4.2 Project Schedule

Table 4.2: Gantt Chart

	Week 1&2	Week 3&4	Week 5&6	Week7 &8	Week9 &10	Week11 &12	Wee k13	Wee k14
Check chapter 1,2, ,3,4,and 5.	███							
Write Code		██						
Writing chapter6			██					
Writing chapter7				██				
Writing chapter8					██			
Writing chapter9					██			
Conclusion						███		
Final report submission. missing .							██	

Final report submission							� green bar	
Presentation								▬

I the Table 4.2 shown that, explanation of the plan followed to complete the report. During the first three weeks, I chose the topic on which I will do my project and I read carefully about it, and then I chose the appropriate topic. In the fourth week I wrote down the Proposal and submitted it. In the fifth and sixth weeks, I wrote chapter 1. In the seventh and eighth weeks, I wrote chapter 2. In the ninth week, I wrote chapter 3. In the tenth week, I wrote chapter 4. In week 11 and 12 I wrote Conclusion & check if something missing, and I will also submit the report. Finally, in Week 14, I will present my presentation. In second semester I did chapter 6, 7, 8, and 9. All these chapters need three weeks to do it, so did it in week 9, 10, and 11.

4.3 Risk Management

Table 4.3: Risk Management

Type of risk	Description	How to overcome
Political (p)	The project has no political relationship because it talks about developing machine learning, and this is permissible in all countries.	-
Economic(E)	The project may cost an expensive to a certain extent because it needs a high-quality component for the project to be success, instead of using a poor-quality or ineffective component.	By searching for a high-quality component at an affordable price.
Sociocultural (S)	This project helps the community by facilitating the needs of people with special needs. It is expected that the community will like it because it will facilitate the people with special needs to use it in their daily needs.	-
Technological (T)	One potential problem is that the accelerometer may not be able to obtain	Maybe I need to use another sensor that works with Accelerometer like

	accurate readings unless we train it permanently.	Gyroscope to get accurate results.
Legal (L)	There are no illegal things in my project.	-
Environmental (E)	The project is very safe on the environment and does not contain harmful substances.	-

Table 4.3 shown that, All PESTEL elements are explained. From a political point of view, the project does not talk about any political matters. On the economic side, some of the components may be expensive, so must look for places to sell the components at a reasonable price. From the cultural point of view, the project is considered acceptable. Technology is a big world. If reading and knowing the good qualities of the components, our technological problems will decrease. There is nothing illegal in this project. Finally, the project does not harm the environment at all because it does not contain harmful substances.

5. DESIGN AND ANALYSIS

In this chapter will be discerption of block diagram and flow chart. All components will be identified, and parameters will be mentioned. Schematic diagram will be designed by using software tools which is applicable to design schematic diagram.

5.1 System Analysis

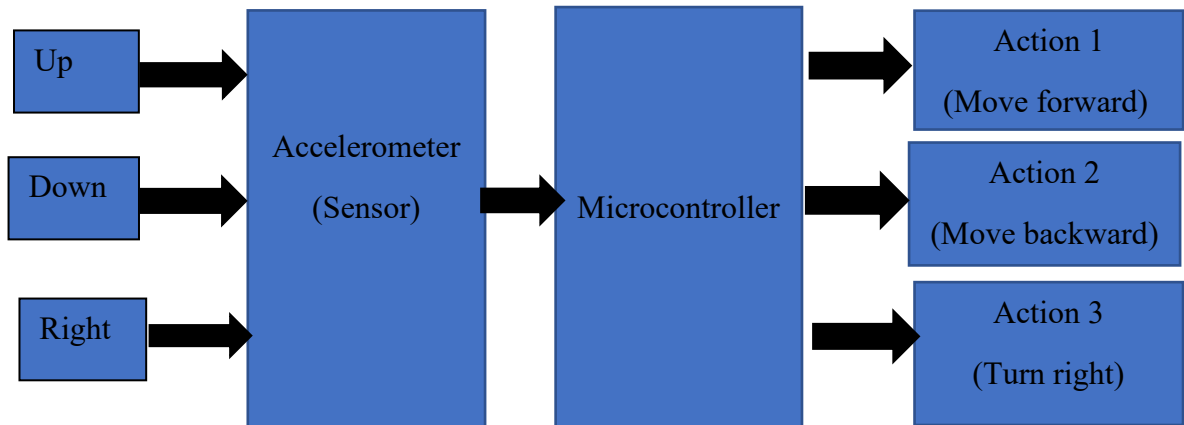### 5.1.1 System Block Diagram

TRAIN &TEST:
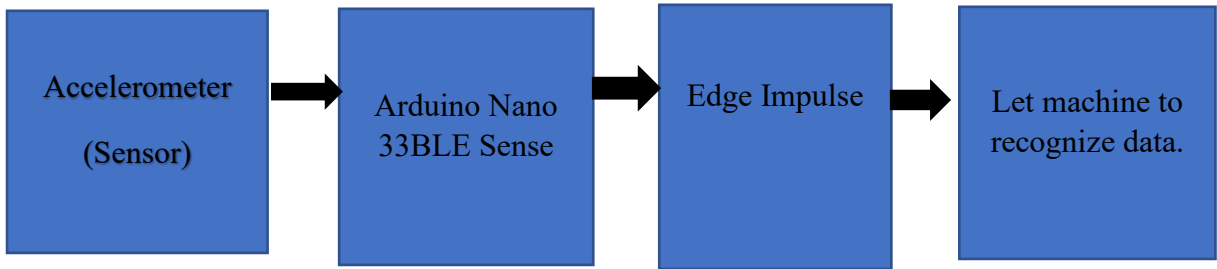
IMPLEMENTATION:

Figure 5.1: Block Diagram

TRAIN &TEST:

In the figure 5.1 the Accelerometer is a tool or device which measures Acceleration. As known that acceleration represented by speed per time (meter/second square). This sensor identifies the movement and analyses it by knowing the X, Y, and Z coordinates and collects information about the location during the movement. Accelerometer connected with Arduino Nano 33BLE Sense by using micro-USB cable. The Arduino detected motion which is generated in the accelerometer. Then all signals will send it to Edge Impulse. Edge Impulse is a program which help engineering to solve complex problem which is difficult to solve it by human. It can collect different information through the availability of a groups of data, its analysis and matching in the similar movement. The program can sort similar movements. Where a machine can identify similar motions. Edge Impulse can do different process

collect data, train data, test data and finally implement data. All this data will be stored in machine. Two seconds is the best to collect data for sample length. When accelerometer collected enough data, the data will be going in different process. The spectral analysis will extract the data features, then the data will be classified by Neural Network. When impulse trained, it is a time to test the data. The data which trained we can get its classification by Neural Network in Live classification, but if applied new data which is not train before, in this case new block must be add. The new block called Anomaly detection, where new data can be classified. When data tested well, so the data is ready to use to build a model by using Arduino Library.

IMPLEMENTATION:

 The Accelerometer take several different readings to obtain a quantity of information until the machine recognizes the various movements by defining the X, Y, and Z. When Accelerometer identify different motion now, hence can program finding motion to do specific action. By using Arduino software to program three different action and at the output will be connect with motors. The motors work as output, when wheelchair move forward that is mean action 1 will work etc. When machine recognize the data, it time to move hand gesture up or down or right, the Accelerometer will sense the motion and depended to that motion wheelchair will move forward or backward or turn right.
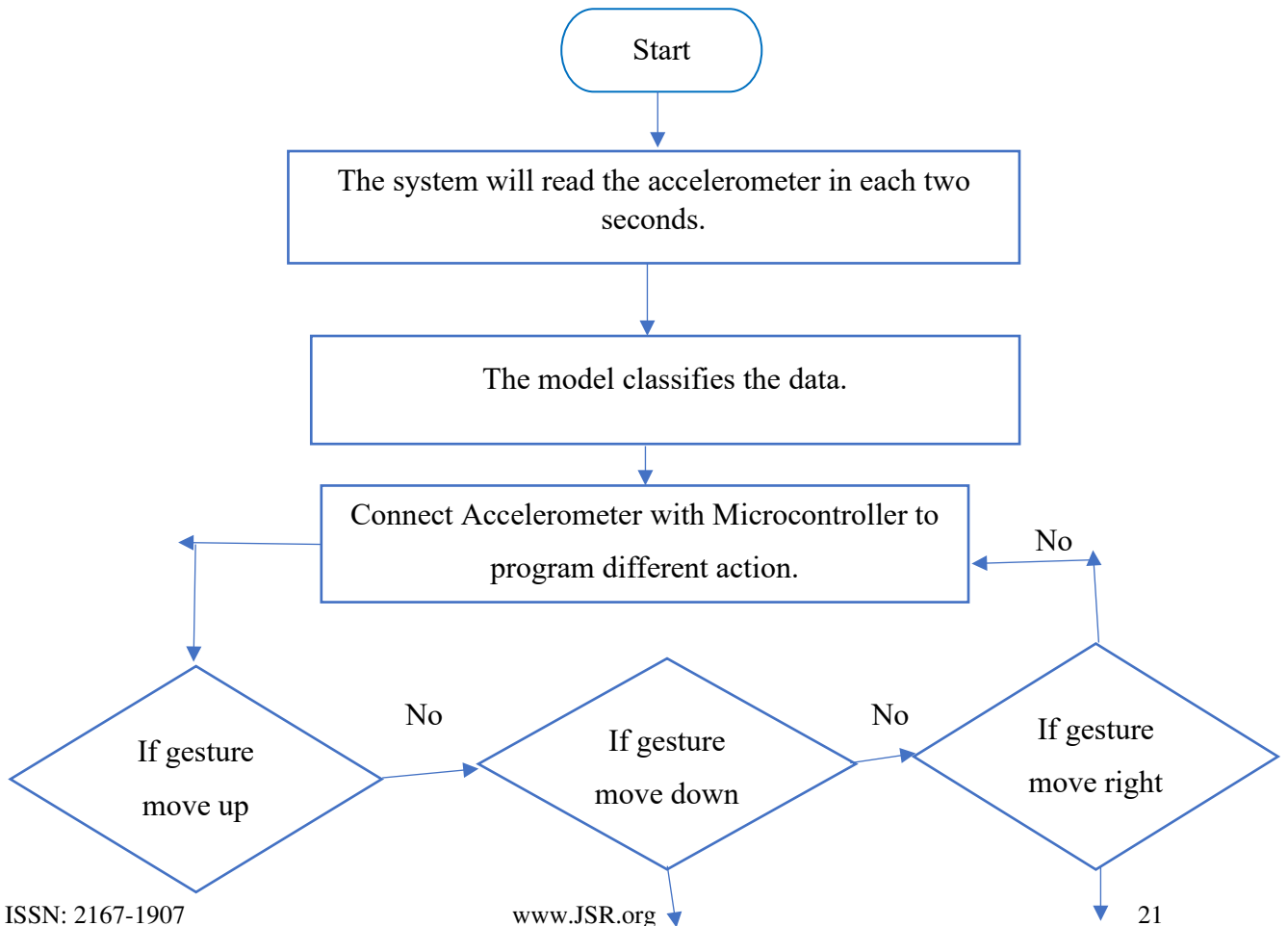
5.1.2 System Flow chart

TRAIN &TEST:

```
┌──────────────────────┐
│  Collect, Train, Test, and │
│     process data.        │
└──────────────────────┘
           │
           ▼
        ◇ If machine
          recognize        ──── No ──►
          different motion
           │
          Yes
           ▼
┌──────────────────────┐
│   Store model data      │
│   in the machine.       │
└──────────────────────┘
           │
           ▼
        ( End )
```
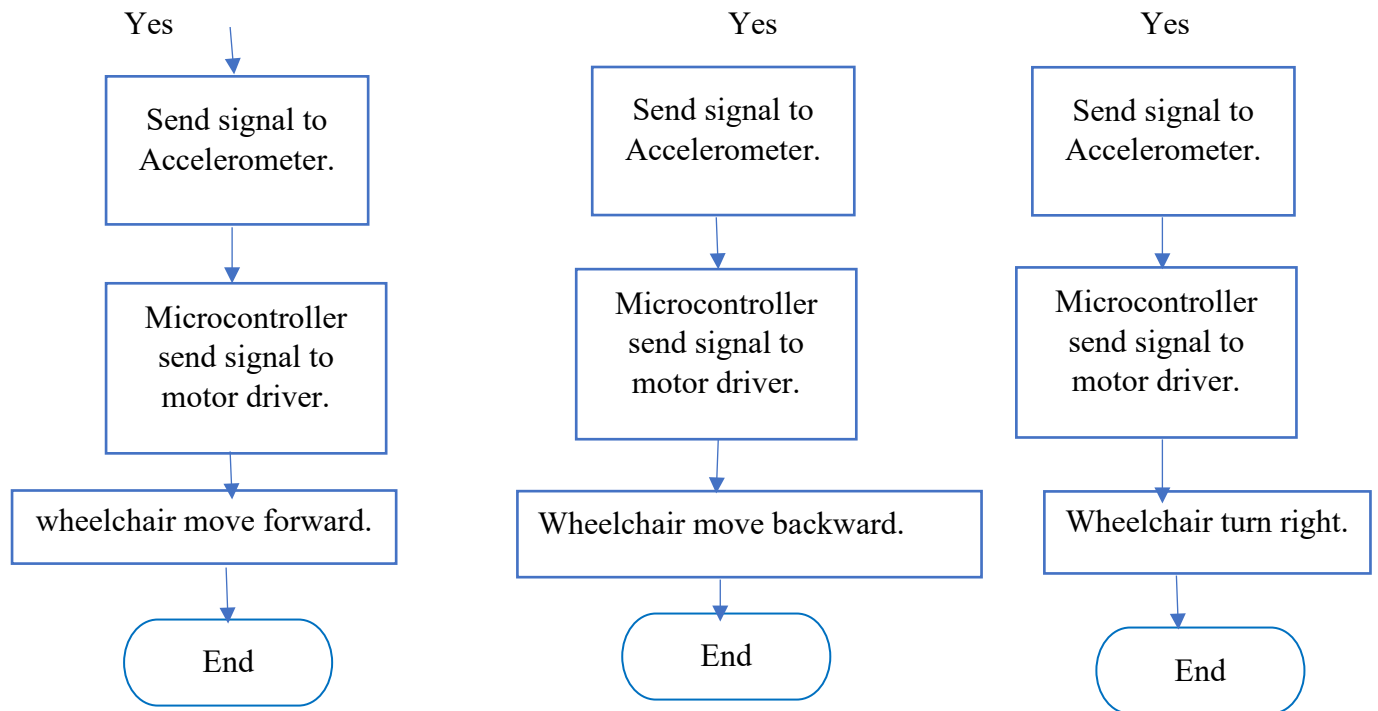
IMPLEMENTATION:

```
        ( Start )
           │
           ▼
┌───────────────────────────────────────┐
│ The system will read the accelerometer in each two │
│                seconds.                 │
└───────────────────────────────────────┘
           │
           ▼
┌───────────────────────────────────────┐
│        The model classifies the data.         │
└───────────────────────────────────────┘
           │
           ▼
┌───────────────────────────────────────┐
│ Connect Accelerometer with Microcontroller to │  ◄── No
│         program different action.          │
└───────────────────────────────────────┘
     │
     ▼
  ◇ If gesture    ── No ──►  ◇ If gesture   ── No ──►  ◇ If gesture
    move up                    move down                  move right
```

Yes

Yes

Yes

| Send signal to Accelerometer. | Send signal to Accelerometer. | Send signal to Accelerometer. |

| Microcontroller send signal to motor driver. | Microcontroller send signal to motor driver. | Microcontroller send signal to motor driver. |

| wheelchair move forward. | Wheelchair move backward. | Wheelchair turn right. |

End

End

End

Figure 5.2: Flow chart

In figure 5.2 shown that the flow chart of my project. It is going into two process, the first one is train & test and second one is implementation. In the beginning, connect Accelerometer with Arduino Nano 33BLE Sense by using micro-USB cable. Data will be collecting by using accelerometer sensor. The data which collected will be trained and testing, hence data can be classify. If the data classify, so it is a time to deploy a data and build a model, so the first process will be end here. Second process is Implementation the data. First connect Accelerometer with Microcontroller. The system will read the accelerometer in each two seconds, then the model will classify the data, according to the classifications (action 1, or action 2 or action 3). Then Microcontroller can be program by using Arduino IDE to control wheelchair, dataset will be used to build a program which can do different action.

5.2 Requirements Analysis

5.2.1 Summarizing the key parameters from the datasheet.

Arduino NANO 33 BLE include 9 axes. 3 axes for Accelerometer. 3 axes for Gyroscope. 3 axes for Magnetometer. The Microcontroller has code nRF52840. It is working with 3.3 operating voltage. The limit of Input voltage is 21v. This Arduino

require DC current per I/O pin which is equal to 15mA. It has clock speed of 64MHz. It has 14 digital Input and 14 digitals. Always PWM (pulse-width modulate) all connected with digital pins. It has 32 bits. It has 8 analog Input pins.

(Store.arduino.cc 2020)

LSM9DS1 have 9 axes. 3 axes for Accelerometer. 3 axes for Gyroscope. 3 axes for Magnetometer. It has 16 bits for the data output. Between 1.9v -3.6v analog supply voltage. 1.9 of power mode. (Store.arduino.cc 2020)

Microcontroller (n RF52840) have range of supply voltage between 1.7v -5.5v. For external components voltage between 1.8v-3.3v. (Store.arduino.cc 2020)

Motor Driver(L298N), which have four inputs. Two inputs related to first motor and remain two inputs for second motor. It has two enable PWM, one for motor 1 and other for motor 2. It has four outputs. Two outputs related to first motor and remain two outputs for second motor. It connects with DC power source at the input around 12V. For switching logic need 5V. It can control speed and direction of motors by using motor driver. Inputs pins control direction and enable pins control speed. (Components101 2020)

5.2.2 Initial Conditions

To initialize the Arduino, we first need to connect it with micro-USB cable to the computer. Then it needs certain steps to be activated in Edge Impulse program to be recognized. After the Arduino connected to the program, a green colour will turn on and the program is ready. We define the frequency and sample time and the type of sensor used. In this project, I will use an Accelerometer sensor to take different movements, each movement for 2 seconds. Repeat the movements as many as possible to get an exact answer. The program will take reading of sample each 2 second.

Hardware Requirement:

Arduino NANO 33 BLE include 9 axes. 3 axes for Accelerometer. 3 axes for Gyroscope. 3 axes for Magnetometer. The Microcontroller has code nRF52840. It is working with 3.3 operating voltage. The limit of Input voltage is 21v. This Arduino require DC current per I/O pin which is equal to 15mA. It has clock speed of 64MHz.

It has 14 digital Input and 14 digitals. Always PWM (pulse-width modulate) all connected with digital pins. It has 32 bits. It has 8 analog Input pins.

(Store.arduino.cc 2020)

Micro-USB cable. The length of this cable is 3feet which equal to 1 meter. It is used to connect devices.

Motor Driver(L298N), which have four inputs. Two inputs related to first motor and remain two inputs for second motor. It has two enable PWM, one for motor 1 and other for motor 2. It has four outputs. Two outputs related to first motor and remain two outputs for second motor. It connects with DC power source at the input around 12V. For switching logic need 5V. It can control speed and direction of motors by using motor driver. Inputs pins control direction and enable pins control speed. (Components101 2020)

Computer is a devices which use to download all requirement software.

Software requirements:

Edge Impulse. It is platform use to develop machine learning which help developers to develop aa new things related to artificial intelligence. New module can be built. There are different kind to gathering, so can use camera, accelerometer, and phone data.

Node.js v12. Should be download it to connect Arduino with Edge Impulse.

Arduino CLI. also download it connect Arduino with Edge Impulse. This software needs if devices do not have Wi-Fi or IP connection. Serial Daemon use to upload configuration setting for all devices not connected with Wi-Fi or IP connection.

Arduino IDE. I need this software to program finding result.

Easy EDA. It is a software program use to draw schematic diagram.

5.2.3 Input and output parameters

To initialize the Arduino, first need to connect it with micro-USB cable to the computer. Then it needs certain steps to be activated in Edge Impulse program to be recognized. After the Arduino connected to the program, a green colour will turn on and the program is ready. We define the frequency and sample time and the type of sensor used. In this project, I will use an Accelerometer sensor to take different movements, each movement for two seconds.

The Accelerometer take several different readings to obtain a quantity of information until the machine recognizes the various movements by defining the X, Y, and Z. When Accelerometer identify different motion now, can program finding motion to do specific action. Use Arduino software to program three different action and at the output I will connect motor driver to the microcontroller. The motors work as output, when motors move forward that is mean action 1 will work etc.

Motor Driver (L298N), which have four inputs (IN). Two inputs related to first motor and remain two inputs for second motor. It has two enable PWM, one for motor 1 and other for motor 2. It has four outputs. Two outputs related to first motor and remain two outputs for second motor. It connects with DC power source at the input around 12V. For switching logic need 5V. It can control speed and direction of motors by using motor driver. Inputs pins control direction and enable pins control speed. Motor driver will work as output. (Components101 2020)

5.2.4 Relations

The Accelerometer take several different readings to obtain a quantity of information until the machine recognizes the various movements by defining the X, Y, and Z.

Non gravitational or specific force represented by ($\vec{f}$).

When there is no motion mean at rest the specific force = + local gravity.

Acceleration defines by ($\vec{a}$).

The magnitude of local gravity represented by g_0. The unit of g_0 is m / s^2.

Gravity vector $g^s = g_0 \cdot \gamma^s$ ➜1

Unit vector represented by $\gamma^s = [\gamma x \;\; \gamma y \;\; \gamma z]^T$ ➜2.

$$\gamma^s = [-sin\theta \;\; sin\emptyset.cos\theta \;\; cos\emptyset.cos\theta]^T$$

specific force $(\vec{f})= \vec{a} - \vec{g}$ ➜3

Substituted equation 1 in equation 3.

$f^s(t) = a^s(t) - g_0 \cdot \gamma^s(t)$ ➜4

Instantaneous time represented by t.

Vector of acceleration represented by $a^s(t)$.

Sometimes we need to add filter to remove unwanted signal. Filter keep result clear.

$$f_p(t) = \left[f_{x,}\rho_{(t)} \;\; f_{y,}\rho_{(t)} \;\; f_{z,}\rho_{(t)} \right]^T$$

When I add low pass filter to the equation 4.

$f_p(t) = a_p(t) - g0.\gamma_\rho(t)$ ➜5

$a_p(t) and \; \gamma_\rho(t)$ related to low pass filter. (Manos, Klein and Hazan, 2019)

All reading of x, y and z will be test in Edge Impulse then uploaded in Arduino NANO 33 BLE. Then will program it to do several action.

5.2.5 Constraints

1- Arduino NANO 33 BLE works only with 3.3v.
2- As it is known, using one sensor does not give exact readings compared to if we used 2 sensors. When the Accelerometer works with the Gyroscope it gives high accuracy.
3- The Machine Learning cannot recognize a few movements, so we must make many movements as we can to train the Machine Learning to run on more than 100 times to get more resolution.
4- All devices that do not have Wi-Fi, we need to a lot of setups to connected with Edge Impulse.

5.3 System Design
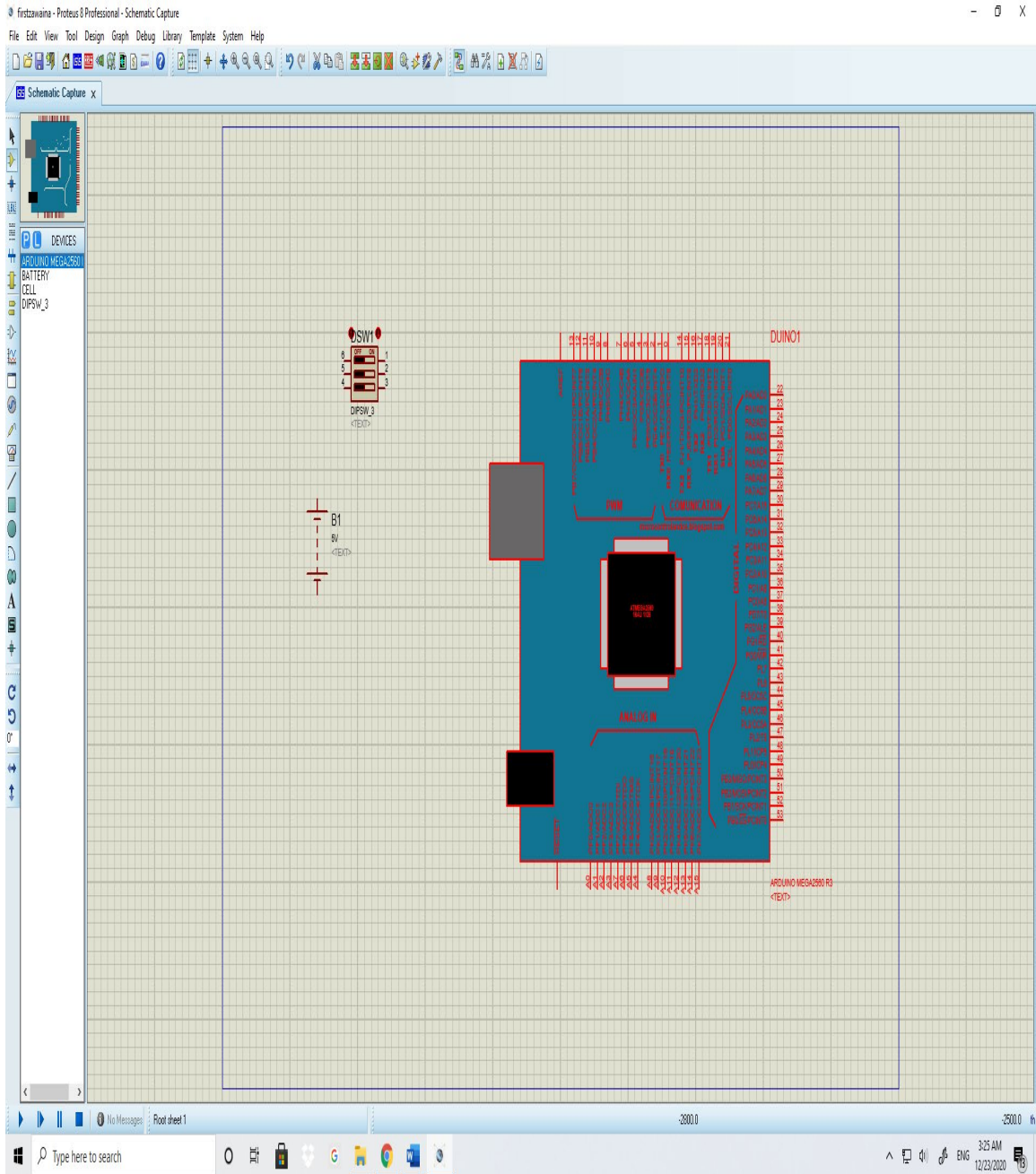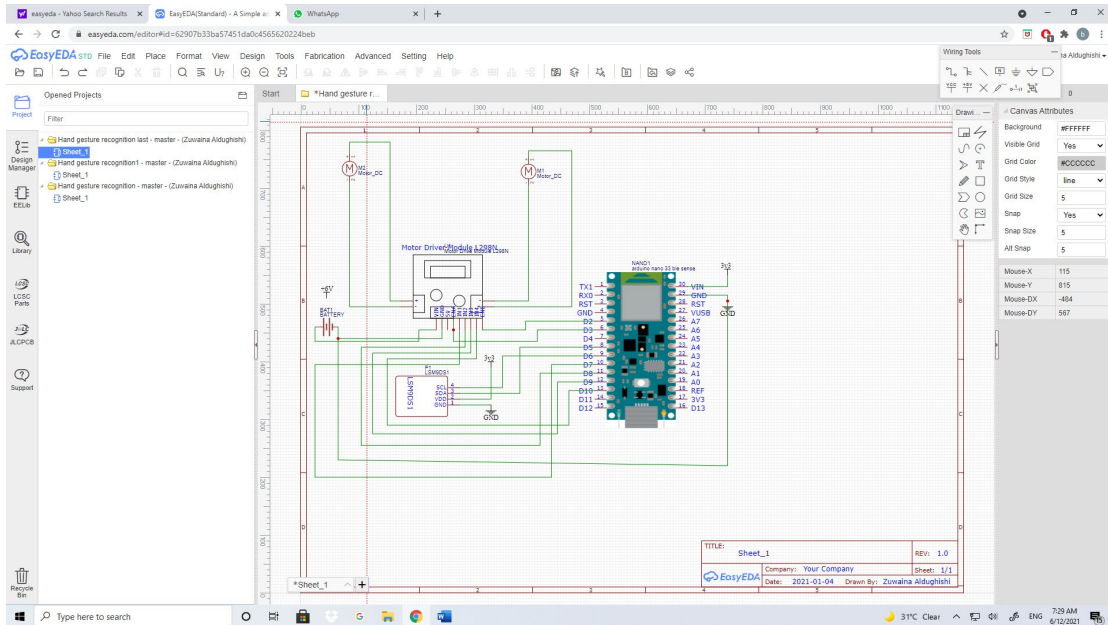
Figure5.3: Circuit diagram. (Arduino Project Hub 2017)

In Figure5.3 shown that circuit diagram. Used proteus 8, but did not find the Arduino NANO 33 BLE, so impossible to draw the circuit diagram. So, using another program named Easy EDA. It is a software program use to draw schematic diagram. In the input connect LSM9DS1 which have 9 axes. 3 axes for Accelerometer. 3 axes for Gyroscope. 3 axes for Magnetometer. It has 16 bits for the data output. VDD connect with 3.3v. SCL with pin9 which digital pin. SDA with pin8 which digital pin. The Arduino connect with 3.3v in pin30 which related to input voltage (VIN), so I can connect with USB wire. (Store.arduino.cc 2020)

 Pin 10, 9, 8, 7 are digital pins, hence can connect with output. In the output, connected motor driver. Where IN4 with D10. IN3 with D9. IN2 with D8. IN1 with D7. The enable PWM connected with D2 for ENA and D3 for ENB, but that does not mean sense because the mainly propose to control direction, so if enable pins not connected will did not made any change. Vin of motor driver connected with positive voltage (battery), where negative connected with the ground. The ground of motor driver also connected with Arduino at the ground at pin 29. (Arduino Project Hub 2017)

Edge Impulse take reading with sample length of 2s. For each 2s it shows reading.

5.4 System Test Plan

5.4.1 Identifying test points.

TRAIN &TEST:

TP1	TP2	TP3	TP4
Accelerometer (Sensor)	Arduino Nano 33BLE Sense	Edge Impulse	Let machine to recognize data.

IMPLEMENTATION:

TP7

TP5	TP6

Up → Accelerometer (Sensor) → Microcontroller →

Down →

Right →

Action 1 (Move forward)

Action 2 (Move backward)

Action 3 (Turn right)
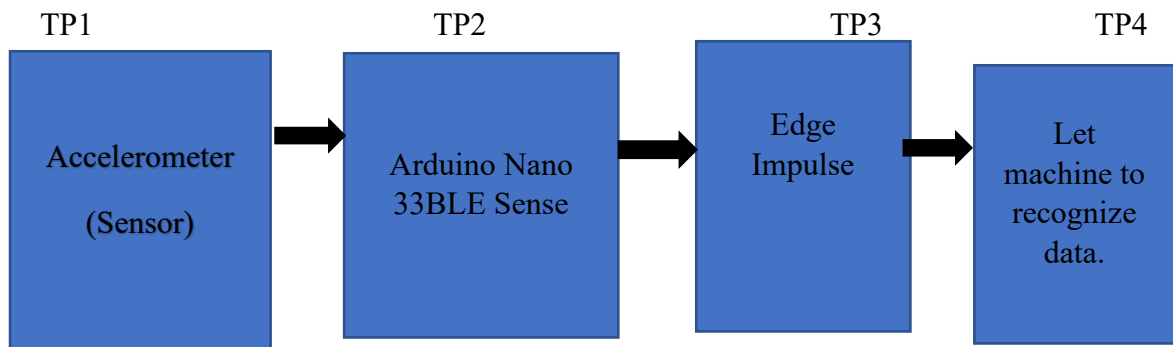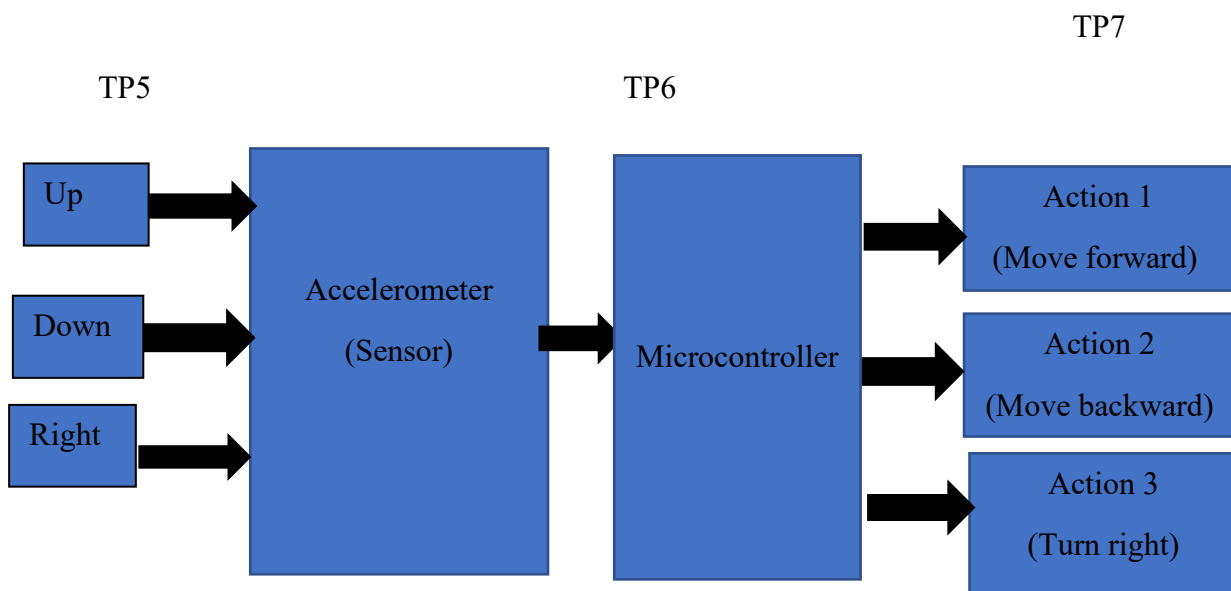
Figure 5.4.1: System Test Plan

Table5.4.1: Testing point.

Test Points	Location	Description
TP1	The accelerometer (LSM9DS1) built in Arduino board.	Accelerometer sensor will send signal to Arduino Nano 33BLE Sense after connected with USB.
TP2	Arduino Nano 33BLE Sense Connect with Edge Impulse	When Arduino connect with the Edge Impulse it will show devices connected and green light illuminate ON. (Login - Edge Impulse 2021)
TP3	Edge Impulse	It shows x, y, and z signals.
TP4	Machine Learning	machine Learning recognized motion.
TP5	Accelerometer	Test if x, y, and z are recognized.
TP6	Microcontroller	Receive data and program it.
TP7	Motors	Test the motor to move forward or backward or turn right.

TP1: Test Accelerometer if it connected in Edge Impulse. As we know that to connect Arduino Nano 33BLE need to download two software or can open Edge Impulse by using google chrome and press connect with USB in Edge Impulse. Testing Accelerometer through taking different motion to check if Edge Impulse can recognize the data which detected.

TP2: I connected output with motor, and it need 6V, so to avoid damage to Arduino Nano 33BLE I used motor driver. Also, connected Arduino Nano 33BLE with USB because the voltage required for this Arduino is 3.3V.

TP3: In Edge Impulse, all the data which collected by Accelerometer it goes through three main procedures. In each procedure the data checked. The first step is training set, where data can be developed. The second step is validation set, where data be improved. Finally, data tested, and it show accuracy of detected data. The data which do not recognize can filter it. Also, test deployment part if zip file can be built.

TP4: All procedures which I did in TP3, it is going to build machine learning. If all procedures are testing in proper way that make machine learning easy to build.

TP5: Tested the reading of x, y, and z when uploaded one raw feature from live classification to Arduino Editor. Then run the program, so the output which got seems like which got it in live classification, So, the signal reached to Arduino Nano 33BLE the LED light flash for a few seconds.

TP6: Tested the codes many time because any single mistake in the code will never get the output. As you know that we did not studied Arduino IDE so, it is difficult to write a code from one time. Each change in the code must be verify and tested till get the correct output.

TP7: The most important testing where be sure the motor driver is connecting wire in proper way. In motor driver there are pins used to control speed which connect to PWM pins. Other pins connected with digital pins to control direction. Testing the codes to connect Arduino Nano 33BLE with output using motor driver.

5.4.2 Developing test Plan

TP1: LSM9DS1 have between 1.9v -3.6v analog supply voltage. 1.9 of power mode.

TP2: The Arduino connect with 3.3v in pin30 which related to input voltage (VIN). The limit of Input voltage is 21v. This Arduino require DC current per I/O pin which is equal to 15mA.

TP6: Microcontroller (n RF52840) have range of supply voltage between 1.7v -5.5v. For external components voltage between 1.8v-3.3v. (Store.arduino.cc. 2020)

TP7: Motor driver can be work with +5V and +12V.

6. SIMULATION, TESTING, AND IMPLEMENTATION

In this chapter, discuss the simulation of whole project and testing software and hardware in detail. Each test I mention in chapter5 will be discussed here with screenshot evidence.

6.1 Test Cases (Hardware and Software)

The main components' that used in this project are Edge Impulse platform for developing and Arduino Nano 33BLE sense (Accelerometer sensor).

The implementation steps which need to build in the board.

1- Sampling.

For sampling Arduino Nano 33BLE must be connected to the edge impulse platform. From data acquisition I collected three different labels.

Figure 6.1: Collecting three labels.

In figure 6.1 show the three labels which I collected by using accelerometer sensor. From Record new data, chose the label (up, down, right), chose accelerometer sensor, Keeping length sample up to two second, and the frequency 62.5Hz. Then start
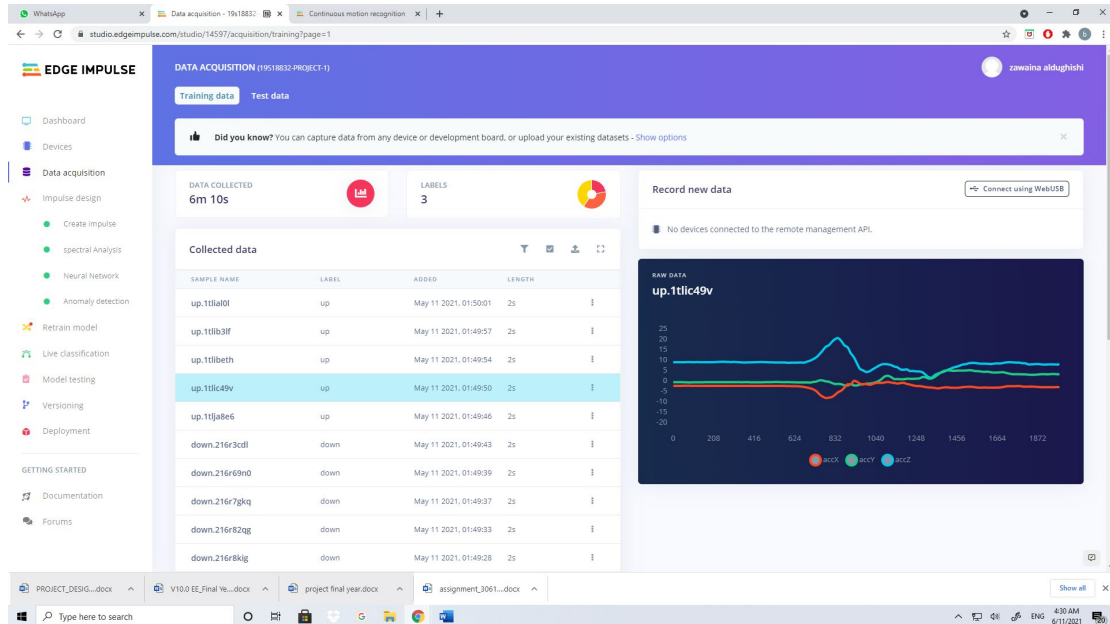
Figure 6.2: Raw data.

2- Design and train the model.

The set of data which collected from data acquisition going to be used in signal processing block to verify the features of the data, which is easy to make a raw data. And Learning block to be used to classify the new data, which is train it and learn from previous experience. From signal processing block use spectral Analysis where filter apply here. The frequency extracted. Where Neural Network is apart from Learning block, which learn from spectral features, so data can be recognize.
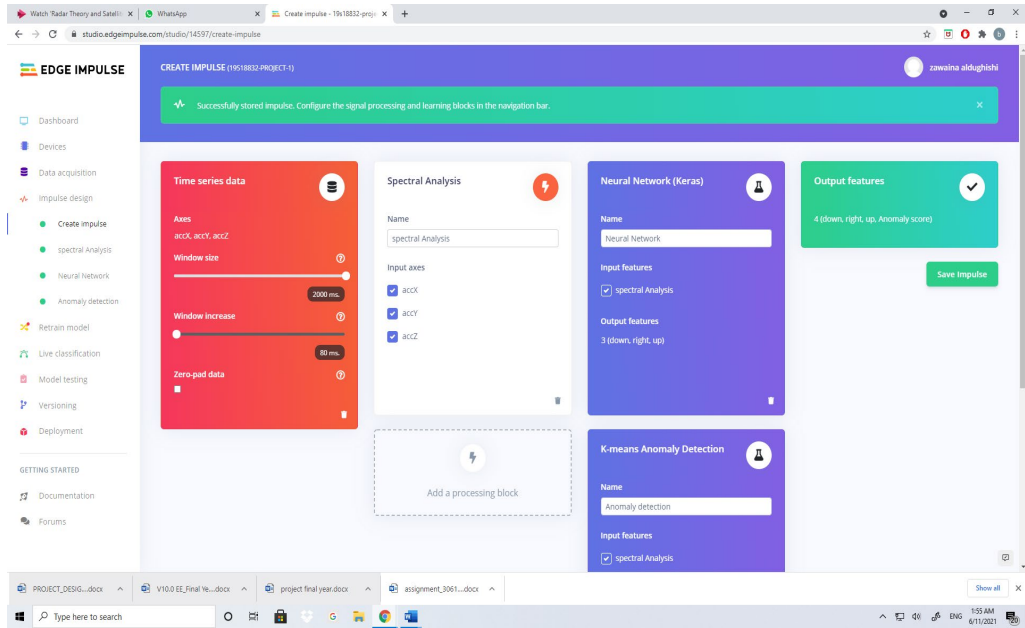
Figure 6.3: Pipeline model.

Figure 6.2 show four steps of pipeline model which contain Time series data,
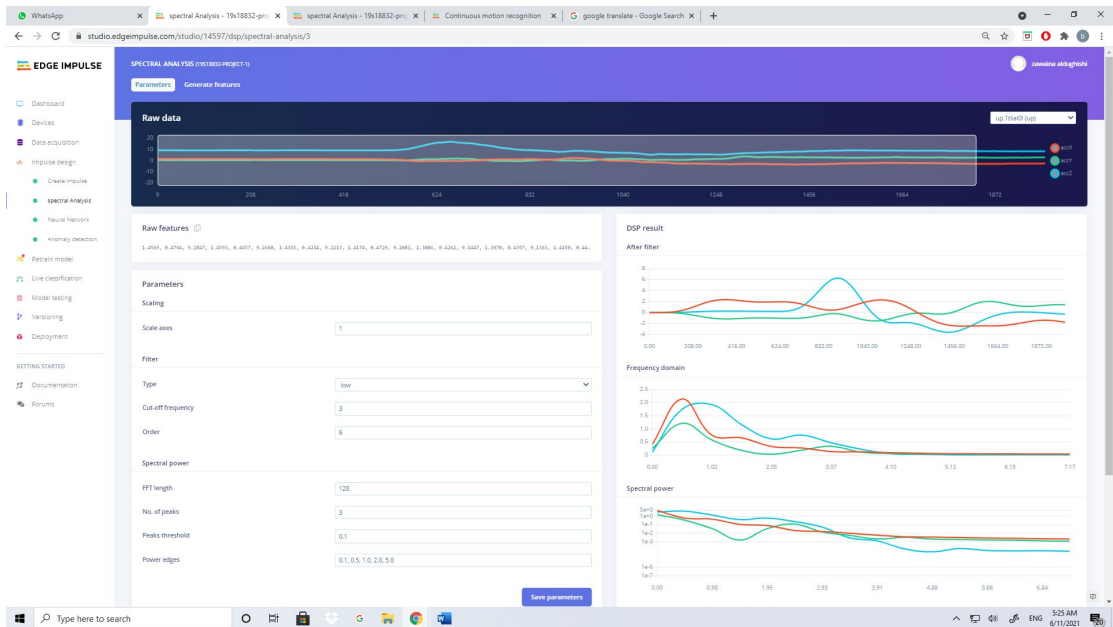
Figure 6.4: Spectral Analysis.
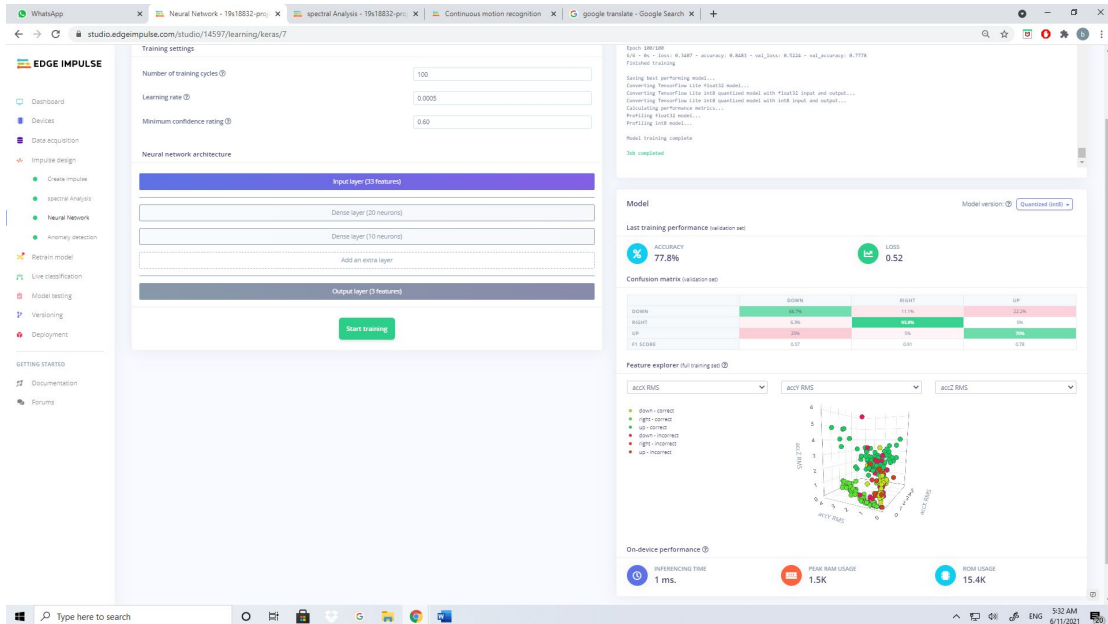
Figure 6.5: Neural Network.
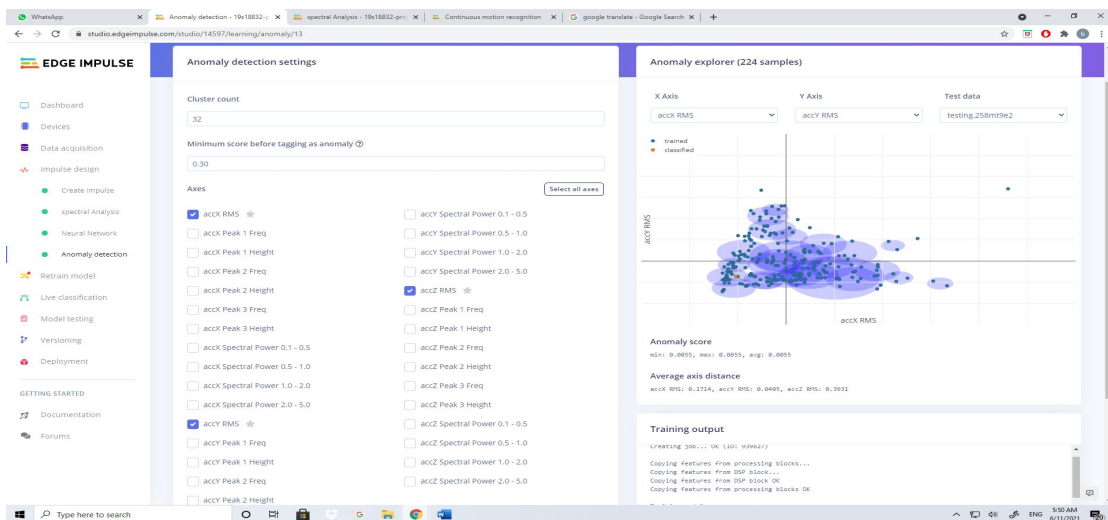
Figure 6.6: Anomaly detection.

In the figure 6.6, add new second network to separate the classified data from misclassified data. If the average between maximum and minimum anomaly sector is less than one, that is mean it is good. Known cluster represented by blue colour. Unknown cluster represented by orange colour.

3- Testing the model.

To extract the features must be used signal processing. To classify data which trained must be used Neural Network. Anomaly detection used in clustering algorithm where can classify new data which not trained.
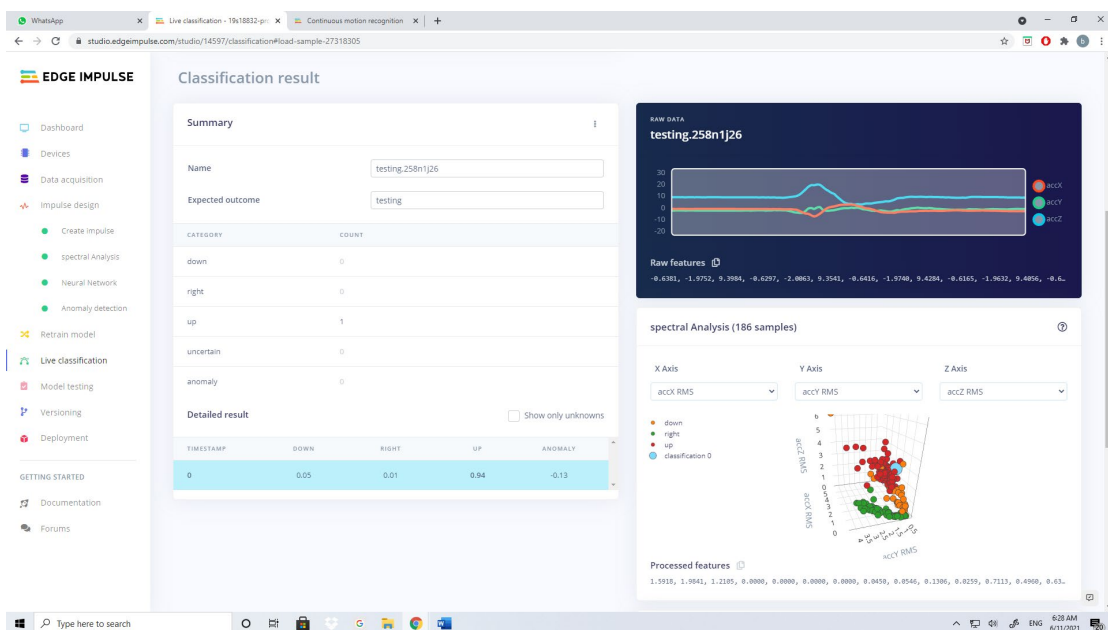
Figure 6.7: Live classification.

In figure 6.7, now can test new data. From live classification can take new sample to be tested to find out if it is recognized. From summary the motion is up. In spectral Analysis the up motion represented by red colour.

4- Deployment.

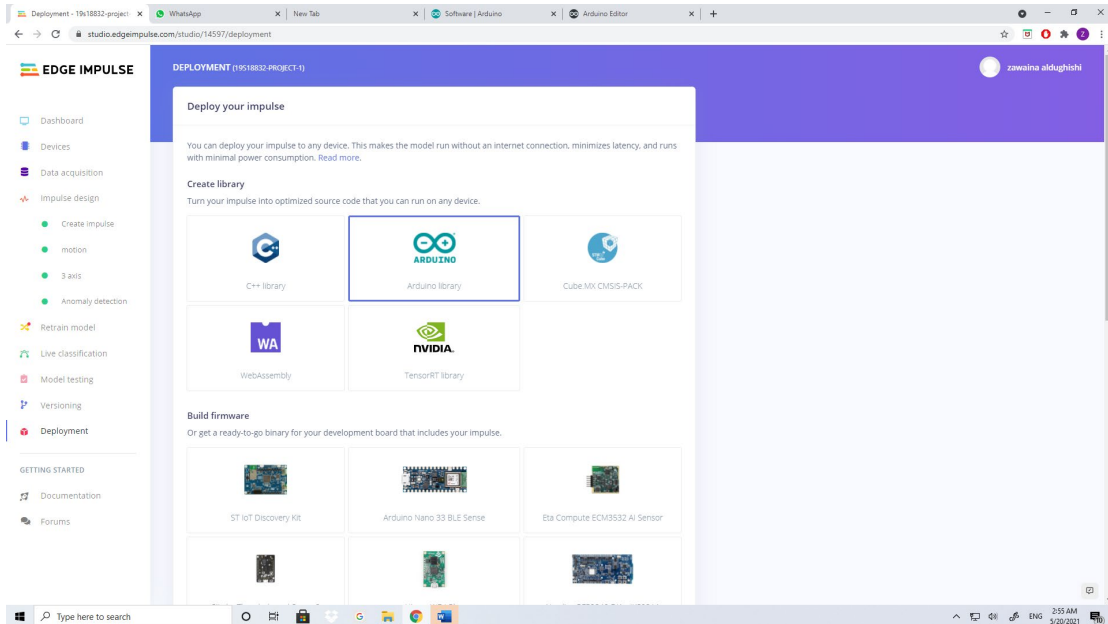After design, train, and testing the impulse, it is a time to build module.

Figure 6.8: Deployment.

In figure 6.8 show deployment part used to export model, so need to create library which used Arduino library in this project. A zip file created, saved, and extract in the desktop.
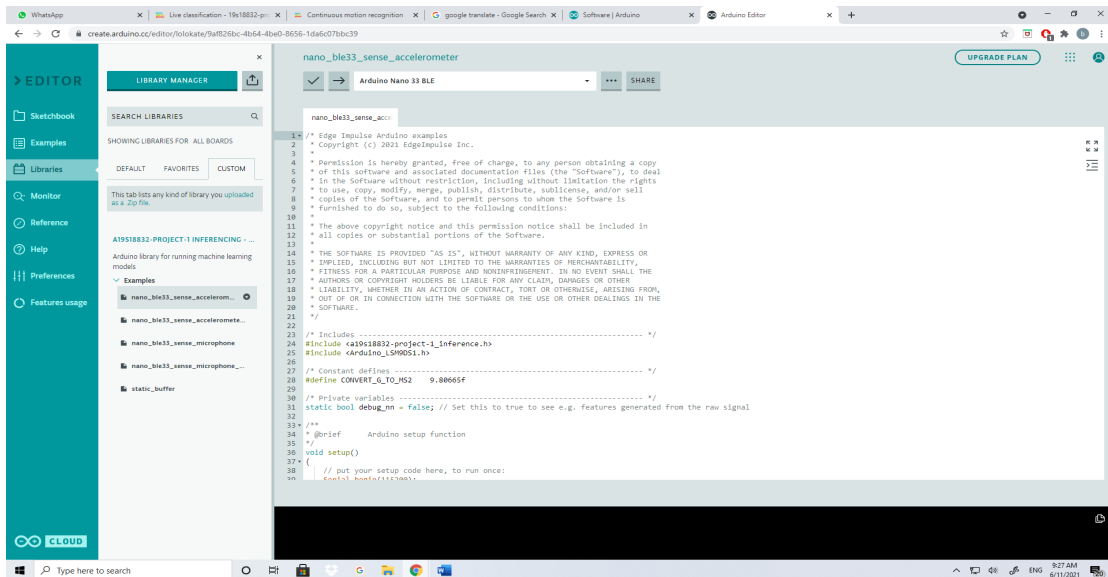

Figure 6.9: Arduino IDE.

Figure 6.10: Arduino IDE to upload and verify the code.

In the figure 6.10, compile the code and upload it to the board, so the Arduino Nano 33 BLE light flash for a few seconds, when stop flashing that is mean the code upload it successful. Then select the monitor using baud rate at 115,200 to show the motion, so signal processing pipeline will be run it to show the output. Now the Arduino nano 33 BLE ready to control wheelchair.

6.1.1 Code

Project name must be adding at the beginning of the program <include>. Also, for the Arduino Nano BLE, LSM9DS1 sensor to be include to the project. Depended to the Arduino, library need to be defined. Where the LSM9DS1 sensor capture three axis of raw data, so the reading of raw will be shown at the serial output.

#include <a19s18832-project-1_inference.h> //include (header file) the project name.
#include <Arduino_LSM9DS1.h> // include the Accelerometer sensor.

==Convert the reading from (g) unit into meter per second square. Where g is gravity.==

```
#define CONVERT_G_TO_MS2   9.80665f
```

==The threshold required is 0.7.==

```
#define CMD_THRESHOLD 0.7
```

==To define the output pins, where the wheelchair controlled by motor driver. The motor driver has four pins to control direction of DC motor.==

```
#define IN1  7   //control the motor driver direction.

#define IN2  8     // control the motor driver direction.

#define IN3  9    // control the motor driver direction.

#define IN4  10   // control the motor driver direction.
```

==features generated==

```
static bool debug_nn = false; // to get features generated from the raw signal
```

==//Arduino setup function In void setup, the output will be appearing in serial monitor by using 115200 baud rate. Over baud rate data came from the device, which be presented by one line per reading and single sensor data.==

```
void setup()
{
    // setup code , to run once:
    Serial.begin(115200); // use serial monitor to show the output in to monitor.
    Serial.println("Edge Impulse Inferencing Demo");
```

==IMU having three sensors with nine axis, where Accelerometer is one of them which having three axis.==

```
    if (!IMU.begin()) { //if statement starting.
        ei_printf("Failed to initialize IMU!\r\n");
    }
```

```
  else {

    ei_printf("IMU initialized\r\n");

  }
```

The sample contains of three axis.

```
  if (EI_CLASSIFIER_RAW_SAMPLES_PER_FRAME != 3) {

    ei_printf("ERR: EI_CLASSIFIER_RAW_SAMPLES_PER_FRAME should be
equal to 3 (the 3 sensor axes)\n");

    return;

  }

}
```

Variable argument

```
void ei_printf(const char *format, ...) {

  static char print_buf[1024] = { 0 };


  va_list args;

  va_start(args, format);

  int r = vsnprintf(print_buf, sizeof(print_buf), format, args);

  va_end(args);


  if (r > 0) {

    Serial.write(print_buf);

  }
```

Declare the output.

```
  pinMode(IN1, OUTPUT); // declear the output

  pinMode(IN2, OUTPUT); // declear the output

  pinMode(IN3, OUTPUT); // declear the output

  pinMode(IN4, OUTPUT); // declear the output

  }
```

In void loop, collect the data and inferencing will be run.

debug Get debug info if true.

```
void loop()

{

    ei_printf("\nStarting inferencing in 2 seconds...\n");

    delay(2000);

    ei_printf("Sampling...\n");

    // reading from IMU

    float buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE] = { 0 };
```

Raw features which extract from Accelerometer and saved into buffer.

```
    for (size_t ix = 0; ix < EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE; ix += 3) {
// size of raw features which show in live classification.

        // Determine the next tick (and then sleep later)

        uint64_t next_tick = micros() + (EI_CLASSIFIER_INTERVAL_MS * 1000);

        IMU.readAcceleration(buffer[ix], buffer[ix + 1], buffer[ix + 2]);

        buffer[ix + 0] *= CONVERT_G_TO_MS2; // Convert the reading from (g) unit
into meter per second square. Where g is gravity.

        buffer[ix + 1] *= CONVERT_G_TO_MS2;

        buffer[ix + 2] *= CONVERT_G_TO_MS2;

        delayMicroseconds(next_tick - micros());

    }
```

```
//  raw buffer converted to a signal where goes to classify

signal_t signal; // because I have data in RAM ,so here I used signal from buffer
function to construct signal.

int err = numpy::signal_from_buffer(buffer,
EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE, &signal);

if (err != 0) {

    ei_printf("Failed to create signal from buffer (%d)\n", err);

    return;

}



//  classifier will be run here

ei_impulse_result_t result = { 0 };



err = run_classifier(&signal, &result, debug_nn);

if (err != EI_IMPULSE_OK) {

    ei_printf("ERR: Failed to run classifier (%d)\n", err);

    return;

}



Let the wheelchair move backward.

if(result.classification[0].value>CMD_THRESHOLD){

    ei_printf("Down detected \n");

    digitalWrite(IN1, HIGH);   //  to move the car backward.

    digitalWrite(IN2, LOW);   //  to move the car backward.

    digitalWrite(IN3, LOW);  //  to move the car backward.

    digitalWrite(IN4, HIGH); //  to move the car backward.
```

```
        }


Let the wheelchair move turn right.
    if(result.classification[1].value>CMD_THRESHOLD){

        ei_printf("Right detected \n");

        digitalWrite(IN1, HIGH);  //  to move the car to the right.

        digitalWrite(IN2, LOW);  //  to move the car to the right.

        digitalWrite(IN3, HIGH);  //  to move the car to the right.

        digitalWrite(IN4,LOW);  //  to move the car to the right.

    }


Let the wheelchair move forward.
    if(result.classification[2].value>CMD_THRESHOLD){

         ei_printf("Up detected \n");

        digitalWrite(IN1, LOW);  // to move the car forward.

        digitalWrite(IN2, HIGH);  //  to move the car forward.

        digitalWrite(IN3, HIGH);  //  to move the car forward.

        digitalWrite(IN4, LOW); //  to move the car forward.

    }


// predictions printed here where predict unseen data. Anomaly used to classify new
data which not trained before.

    ei_printf("Predictions ");

    ei_printf("(DSP: %d ms., Classification: %d ms., Anomaly: %d ms.)",

        result.timing.dsp, result.timing.classification, result.timing.anomaly);

    ei_printf(": \n");

    for (size_t ix = 0; ix < EI_CLASSIFIER_LABEL_COUNT; ix++) {

        ei_printf("    %s: %.5f\n", result.classification[ix].label,
result.classification[ix].value);

    }
```

#if EI_CLASSIFIER_HAS_ANOMALY == 1 // used if statement.

   ei_printf("   anomaly score: %.3f\n", result.anomaly);

#endif

}

#if !defined(EI_CLASSIFIER_SENSOR) || EI_CLASSIFIER_SENSOR !=
EI_CLASSIFIER_SENSOR_ACCELEROMETER

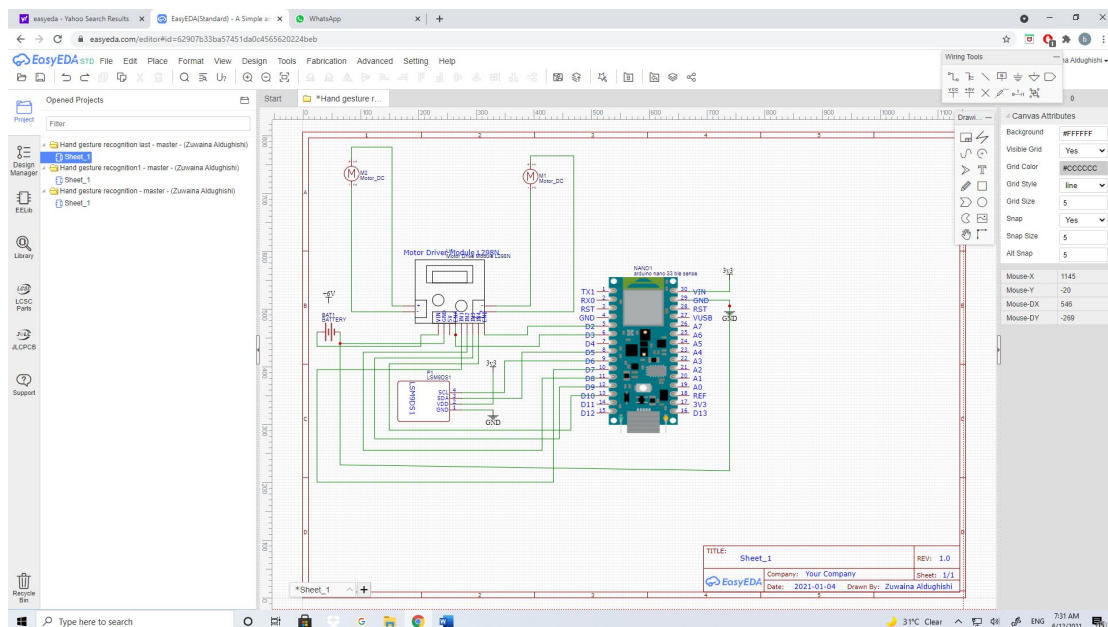#error "Invalid model for current sensor"

Figure 6.11: Schematic diagram of A hand gesture recognition system to control wheelchair.

In figure 6.11 it shown that circuit diagram of A hand gesture recognition system to control wheelchair. Some component can be shown in circuit diagram but there is some component which is not mention here like computer which used it to collect data through Edge Impulse.

6.2 System validation

Table 6.1: Testing user requirement.

Item or element	Observation	Updates or response
LSM9DS1 have between 1.9v -3.6v analog supply voltage	Using two sensor rather than use one sensor will give more resolution. With Accelerometer sensor can also use gyroscope sensor to get more efficiency.	It is not possible to used two sensors in Edge Impulse. To do any updated should change the Edge Impulse by other platform. In this project enough to use one sensor.
The Arduino Nano 33BLE connect with 3.3v	The advantages of this Arduino where Accelerometer located inside it, rather than use another Arduino, it is needed to use Accelerometer separately which need place when design it.	Easy to wear it in the hand rather than used Arduino with Accelerometer which leads to be uncomfortable.
Motor driver can be work with +5V and +12V.	Used motor driver to control two DC motor rather than connect DC motor to Arduino Nano 33BLE, which lead to damage, because Arduino need 3.3 Voltage at the input.	To avoid damage to the component, connect Arduino with motor driver.

Depended on change voltage in power supply especially if used battery. The changed which happened in simulation and implementation are nearly close with designing value. Hence the error very less which around 5%, so it has good accuracy which reach 95%.

7. CRITICAL EVALUATION

System performs error will be discussed here.

We can improve the system of the project by using Bluetooth rather than using wire to connect output. Arduino NANO 33 BLE works only with 3.3v to avoid damage to the Arduino we should connect it with USB rather than battery.

As known that, using one sensor does not give exact readings compared to if we used 2 sensors. When the Accelerometer works with the Gyroscope it gives high accuracy, but in each impulse can be used only 1 sensor and that to give accurate result if taken enough motion.

The Machine Learning cannot recognize a few movements, so we must make many movements as we can to train the Machine Learning to run on more than 100 times to get more resolution. The mainly blocks that used are spectral analysis which is used to extract features. The second thing is Neural Network which is used for classification but in Neural Network the data should be trained before, so it can classify the data. The big issues if apply new data which is not train before, in this case need to add new block which is called it a normally detection where can classify new data which is note train before.

All devices that do not have Wi-Fi, we need to a lot of setups to connected with Edge Impulse in this case to avoid all steps we can log in Edge Impulse from Google Chrome.

8. HSE, SOCIAL, LEGAL, ETHICAL AND SUSTAINABILITY ASPECTS RELATED TO THE PROJECT

8.1 HSE

It is a tool of collection and process to keep health, stay save and save the environments. For each component there is a safety purpose we should follow it to be save and save our environment. In my project, Arduino Nano 33BLE sense need 3.3 voltage at input to avoid damage to the component must connected by USB rather than battery. PPE (Personal protective Equipment) must be wearing during soldering the pin headers board. While soldering hold the board with proper stand. Must be take

care while using electricity. Read the data set to be familiar with exact current and voltage required. When connecting wire better to connect power with red wire, and ground with blue wire. All components which used are save. The project is very safe on the environment and does not contain harmful substances. There is no Effects to the environment. All components are allowed to be used. (Bielefeldt 2021)

8.2 Social Aspects

During do improve our life technologies playa huge rule which make our life became easy. Using wheelchair by people with special needs that is the good things to help them to do many different tasks where use Arduino Nano 33 BLE sense which work as hand gesture to move wheelchair forward, backward and turn right. This kind of project is very helpful to the society where help important people from the society. This project helps the community by facilitating the needs of people with special needs. It is expected that the community will like it because it will facilitate the people with special needs to use it in their daily needs. It helps to move from one place to another without the need for a person to push the wheelchair .Any project that serves groups of society, of course, will have a great turnout by the community. This project does not conflict with the customs and traditions of the community. The community will certainly accept it and rejoice in this achievement.

8.3 Legal and Ethical Aspects

To get all the components, I ordered them online, and because they are licensed in my country and do not conflict with the regulations and laws, so able to receive them from the post office. The explanatory data on the packaging of the parts is written as authorized and does not require a permit to obtain it. The components used do not conflict with our dealings and ethics, so this type of project is considered audible, and there is no conflict with the laws of the state.

8.4 Sustainability Aspects

The project is considered safe and does not affect the environment at all. The project works to preserve the environment, through the voltage used is considered low. The Arduino which requires a little power at the input, which save the power from draining.

The components used do not lead to emissions and do not produce any dangerous chemicals. Therefore, it is considered one of the environmentally friendly projects.

This project has been designed professionally, as it is possible to use 2 ICs instead of using 1 IC. The problem lies in the latter, as it is difficult for people with special needs to use 2 IC to be worn in the hand, which makes it uncomfortable to wear. Therefore, using one ICs that contain an accelerometer sensor is a good feature to reduce the use of other materials in the project, which reduces the need for voltage and current.

There are no negative effects on the health of the consumer if using this project. It is a good helper in that it facilitates pushing the wheelchair without making any trouble and fatigue. Therefore, this project is completely safe. It is known that pushing wheelchairs requires great effort, which leads to back pain, so it is good to use this project to maintain human health and safety.

9. CONCLUSIONS AND RECOMMANDATIONS

The world is now using machine learning in our daily life in a large and wide way. It is important to learn about machine learning. ML is concept of writing computer program. ML lies to convert raw data into important information. In the ML there is process called training, which mean use specific algorithm to identify rules of data. Using Edge Impulse makes it easy for engineers to use machine learning to do their projects. Machine learning need Accelerometer to collect data. This sensor identifies the movement and analyses it by knowing the X, Y, and Z coordinates and collects information about the location during the movement. In this project, using Accelerometer sensor to gathering data. Also, need to Microcontroller to program data which identify by machine learning to use it to do different activities, so can people with special needs use it in real life. As mentioned in the objective enough data should be collected. The data which collected is reach more than 200 samples, hence easy to tarin the impulse, where the data trained in two process which are Spectral Analysist to excrete features of the data. The second things, using Neural Network to classify the data which trained it. If there are any new data which not recognized, hence need to add new block, which called Anomaly Detection. When the data trained, so data going to be tested in the live classification. When data tested, Machine Learning will be built by using Arduino IDE. When zip file imported in the Arduino

IDE, so need to upload in the board. Finally, wheelchair move depended to gesture motion. If gesture moved up, the wheelchair move forward. If gesture moved down, the wheelchair move backword. If gesture move right, the wheelchair turn right, hence the aim of this project reached.

The recommendation to improve this project, which can connect Arduino Nano 33 BLE with Bluetooth to control wheelchair rather than using wires, but the time not enough to do this steps. Another thing, better to collect samples more than 500 to get more accuracy.

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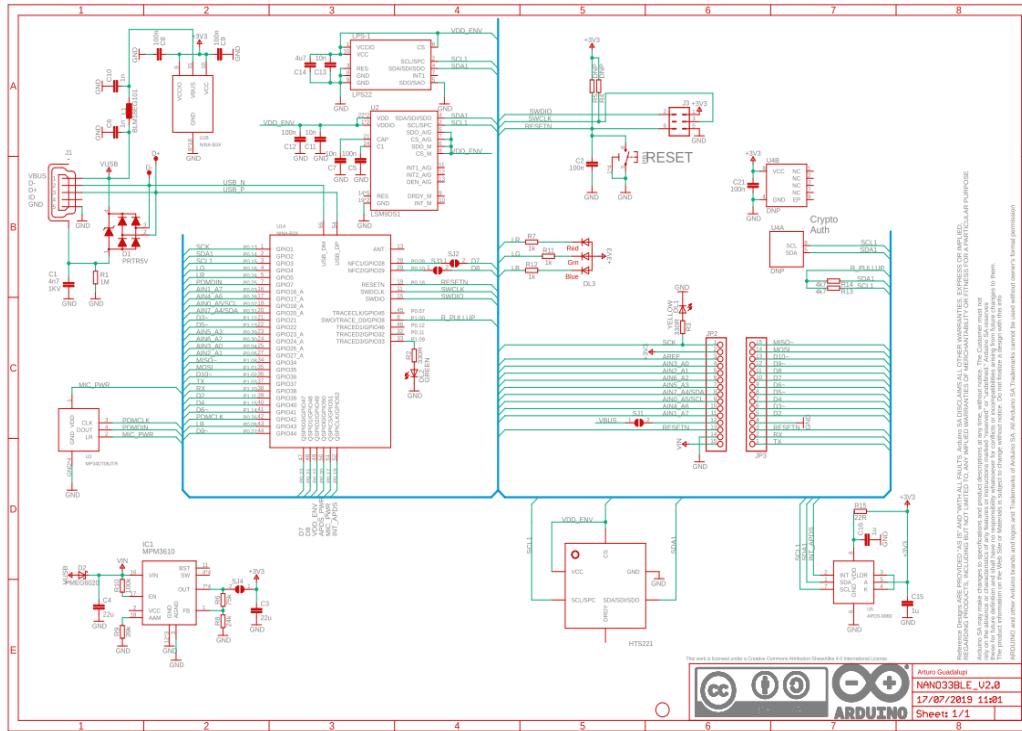installation of the chassis and motors « osoyoo.com*. [online] Available at:
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Appendix A

(Store.arduino.cc 2020)