A

TE Mini Project Report

On

FAILURE DETECTION AND PREDICTIVE MAINTENANCE OF SHAFT USING MACHINE LEARNING

Submitted By

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Under the guidance of

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VIDYAVARDHINI'S COLLEGE OF ENGINEERING AND TECHNOLOGY

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DEPARTMENT OF MECHANICAL ENGINEERING

Certificate

This is to certify that following students: -

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Have submitted their Mini Project entitled

FAILURE DETECTION AND PREDICTIVE MAINTENANCE OF SHAFT USING MACHINE LEARNING

As a part of their Mini Project work in partial fulfilment of requirements for T.E. (Sem. 6), Mechanical Engineering of the Mumbai University during the academic year 2022-2023.

PROF.KAMLESH BACHKAR	Dr. U. V. Aswalekar	Dr. Harish Vankudre
(Project Guide)	(HOD,ME)	(Principal)

Acknowledgement

We are highly indebted to our guide **PROF KAMLESH BACHKAR** for giving us an opportunity to work under his guidance. Like a true mentor, he motivated and inspired us through the entire duration of our work. We express our gratitude towards **Dr.U.V. Aswalekar,** Head of Mechanical Engineering Department for his support throughout the Mini Project work.

We are also grateful to the Mechanical Engineering Department for assisting us and guiding us throughout the Mini Project. We also extend our thanks to the supportive staff of Mechanical Engineering Department for providing us all the necessary facilities to accomplish this Mini Project. Last but not the least, we express our profound gratitude to the Almighty and our parents for them blessings and support without which this task could have never been accomplished.

Declaration

We declare that this written submission represents our ideas in our own words and where others ideas or words have been included. We have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whose proper permission has not been taken when needed.

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Place:

Date:

Approval Sheet

This Mini Project report entitled **"FAILURE DETECTION AND PREDICTIVE MAINTENANCE OF SHAFT USING MACHINE LEARNING"**

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Is approved as a part of Mini Project Term Work for THIRD YEAR (Sem.6) in Mechanical Engineering.

Examiner:

1._____

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Mini Project Guide:

1._____

2._____

CONTENTS

CHAPTER 1
INTRODUCTION

1.1 PROJECT DEFINATION

This project is about designing the system that is capable to sense the fault in the rotating shaft connected to the motor and train it using the data collected previously and using Machine learning algorithm , also lets us help to provide the predictive maintenance to the shaft.

1.2 PROJECT OBJECTIVE

The aim of the project is to study the vibration of the shaft while rotating at high speed and fault arised during rotation. Using the data of vibration, creating the Machine learning algorithm to sense the fault .
The main objective are listed below:

- Timely acknowledged about fault
- Help to provide predictive maintenance
- Increase machine life
- Improved repair time and product quality

CHAPTER 2
LITERATURE REVIEW

2.1 LITERATURE RELATED TO PROJECT

1. Vibration Analysis of Shaft Misalignment Using Machine Learning Approach under Variable Load Conditions

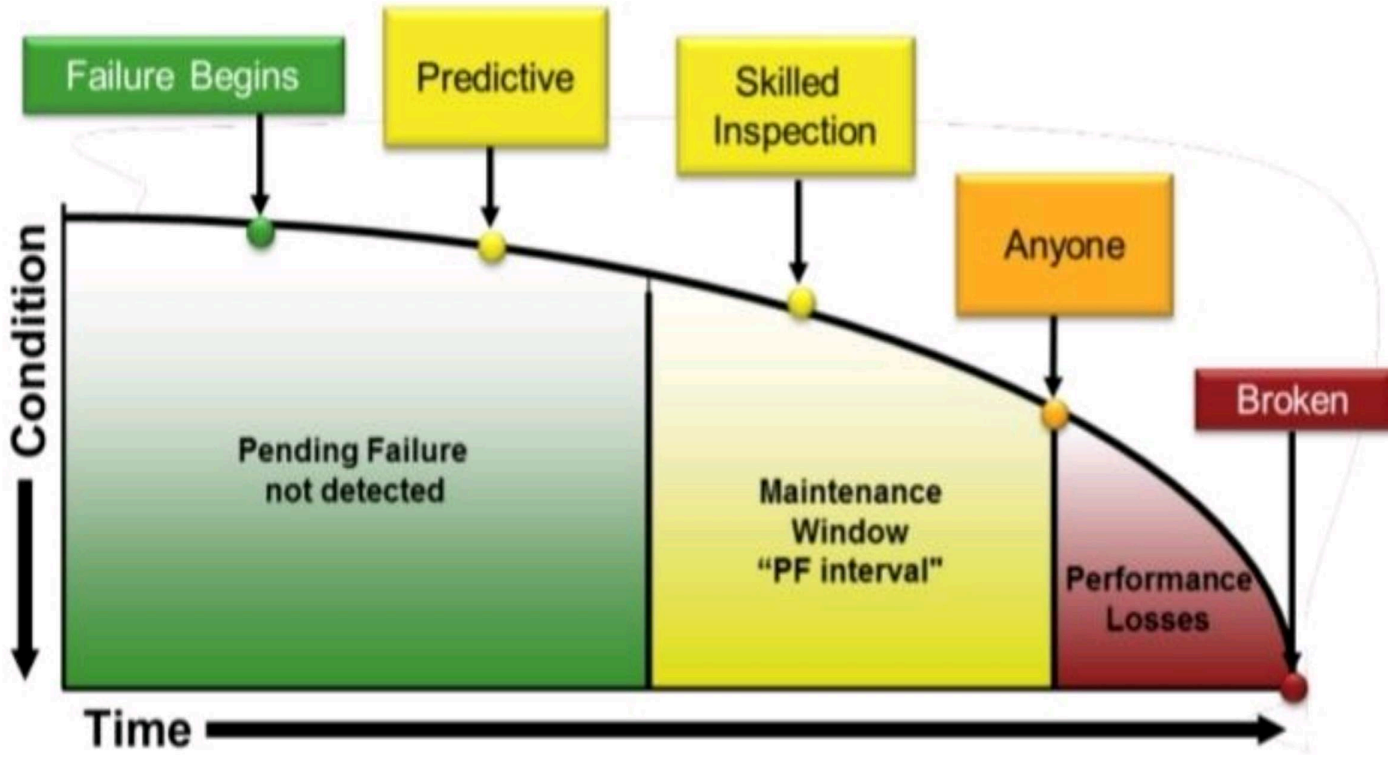
Author: A. M. Umbrajkaar

In this paper, emphasis is given on machine learning-based approach for condition monitoring of shaft misalignment. His work highlights combined approach of artificial neural network and support vector machine for identification and measure of shaft misalignment**.**

2. Creation of a Machine Learning model for the Predictive Maintenance of an engine equipped with a rotating shaft

Author: Prof. Tania Cerquitelli

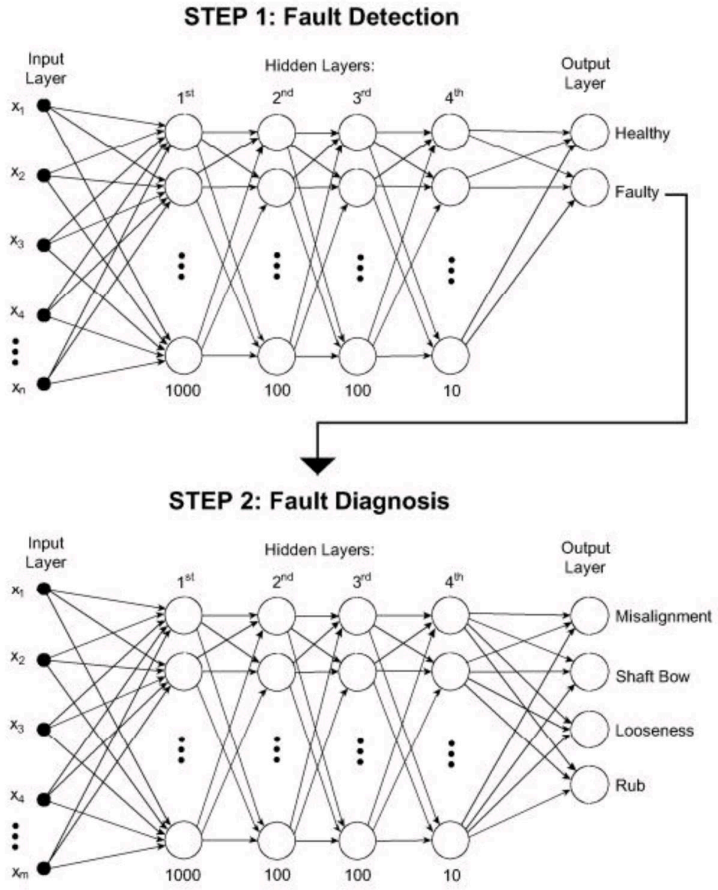
The literature of the paper give us the brief knowledge about the process of detection of failure in various Shaft. It also shows the variation in the condition of shaft over the period of time.



3. **Robust vibration-based faults diagnosis machine learning model for rotating machines to enhance plant reliability**

Author: Natalia F. Espinoza-Sepulveda Jyoti K. Sinha

This paper has proposed 2 step approach for data collection and analysis. In first step both healthy and faulty data were collected and analysed while in second step faulty data was analysed for different types of fault such as shaft misalignment, shaft bow , looseness and rub.



4. **Machine Learning in Predictive Maintenance towards Sustainable Smart Manufacturing in Industry 4.0**

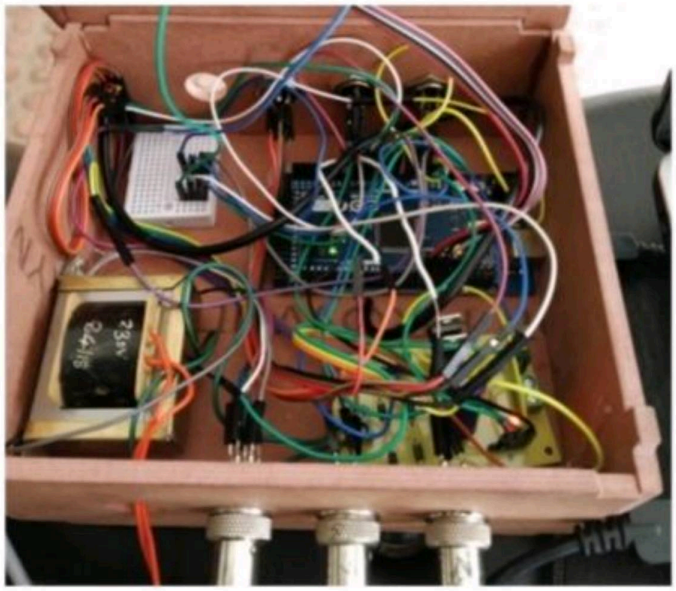
Author: Zeki Murat Cınar,Abubakar Abdussalam Nuhu,Qasim Zeeshan,Orhan Korhan Mohammed Asmael and Babak Safaei

This paper presents a comprehensive review of ML techniques

applied in PDM of industrial components. Several ML algorithms were reviewed and presented.

5. **Tyre Pressure Supervision of Two Wheeler Using Machine Learning Author:** Sujit S. Pardeshi, Abhishek D. Patange, R. Jegadeeshwaran,

   From this paper we have developed knowledge about data acquisition system (DAQ)In house development

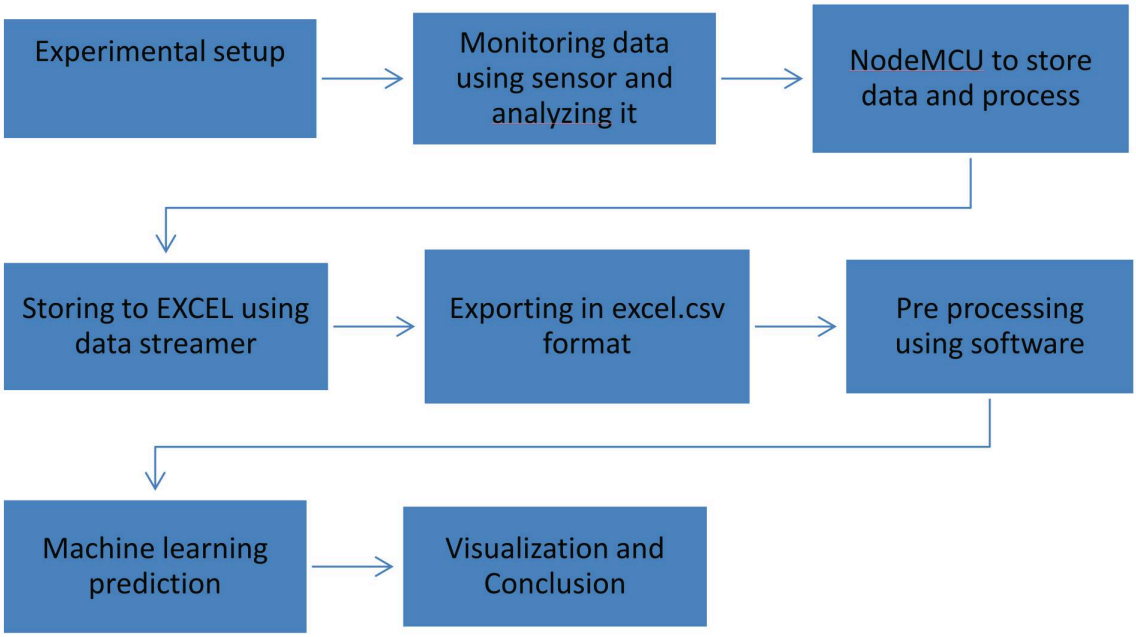


6. **Wind Turbine Fault Diagnosis and Predictive Maintenance Through Statistical Process Control and Machine Learning**

   Author: J.-Y. Hsu et al

   The study demonstrates that, by data mining and modeling, the failures of wind turbines can be detected, and the maintenance needs of parts can be predicted. Model results may provide technicians early warnings, improve equipment efficient, and decrease system downtime of wind turbine operation

Chapter 3
Methodology



Steps performed in project:

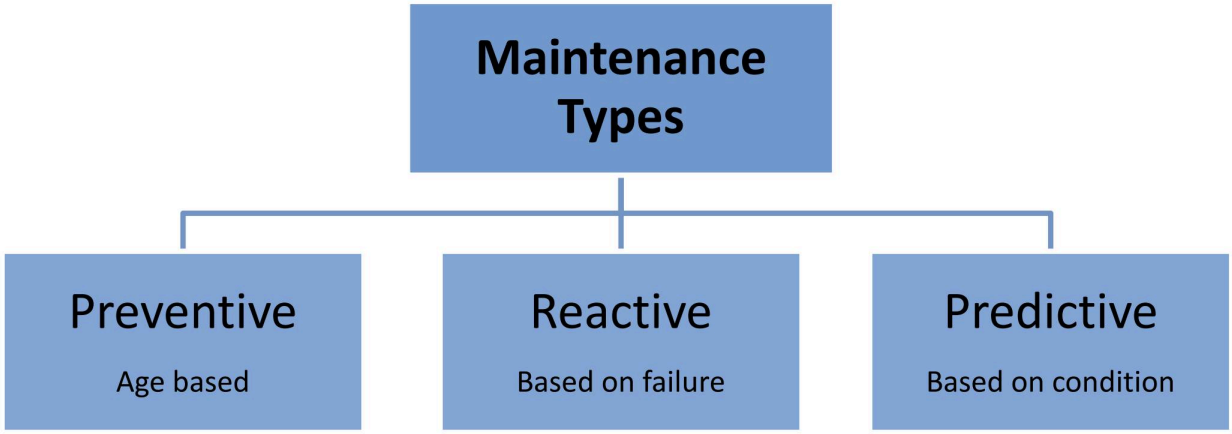
a. As the mechanical machinery related data are not easily available , we have developed experimental setup as per the requirement of the project.
b. Data are collected using the accelerometer sensor which provide information of variation in vibration.
c. Nodemcu microcontroller is used and real time data streamed directly in the Excel sheet .
d. Saved in excel in CSV format
e. Data than preprocessed in Jupyter and python module are used .
f. Machine learning model created based on the data
g. Model are finalized depend on accuracy and predict the failure of shaft.

Chapter 4
Maintenance in industries and Machine learning

4.1 Maintenance:

The cost of maintenance in many industry are much higher than production and operational cost due to untimely failure of the machine components. Hence the profitability of the industry generally depend upon the maintenance process.
In most of the industries maintenance is done when the machine reaches a certain age or stops working .It is also provided with the schedule maintenance but this type of maintenance doesn't provide any information about machine health in future . Different types of maintenance is provided to serve the purpose. The main three type of maintenance used by most of the industries are:

I. Reactive maintenance
II. Preventive maintenance
III. Predictive maintenance



4.1.1 Preventive Maintenance

In preventive maintenance , machine are provided with timely maintenance to prevent machine from failure . The components of the machine which may lead to failure are replaced in advance before it fails.
The drawback of this approach is ,

- Over maintenance is performed
- The machine and the component are not fully utilized
- Skilled labor is needed to maintain the equipment
- Operation cost increases
- Life span of machine is decreased

4.1.2 Reactive Maintenance

In this , maintenance will be performed when machinery and components have a problem or it stop working. In this components is used to its full life span.
Drawback of this :

- Increase in downtime
- Unscheduled maintenance

4.1.3 Predictive maintenance

In this, it help to predicts the fault and perform the maintenance on the machine and equipment before failure or fault. Component can be replaced when it is going to fail soon. It help to extend the life span of the component.
Advantages of predictive maintenance :

- It help to decrease the planned downtime by reducing premature repair and inspection.
- It can reduce the unplanned downtime

It require an IOT based system . The drawback of this process is the initial cost to build such a system is very high.

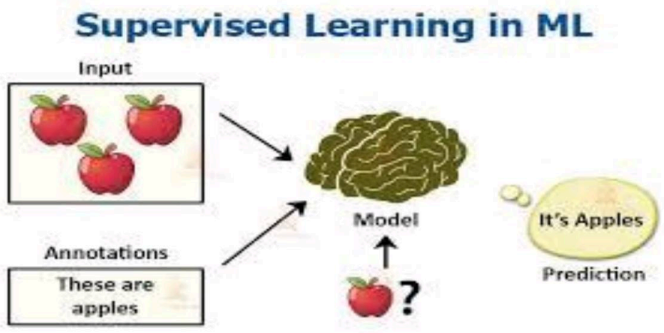
4.2 Machine Learning(ML)

Cloud computing and IOT makes machine learning possible in production and manufacturing industries. Data from the machine are collected easily using the Iot based devices. Data collected from industrial equipment help to build the ML model to predict the faults.
Types of machine learning :

- Supervised
- Unsupervised
- Reinforcement learning

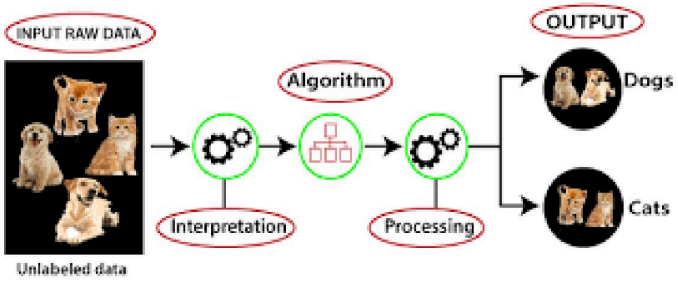
4.2.1 Supervised learning

In supervised learning ,labeled data is provided. It is easy to understand and implement. Both validation and training data are labeled. Input and target output are included in supervised learning which help the model to learn and improve over time. New and unseen data can be predicted after the completion of the training of the model with good label . It is used in classification and regression problems. It include algorithm such as support vector machine(SVM), random forest, naïve baye, logistic regression, linear regression.



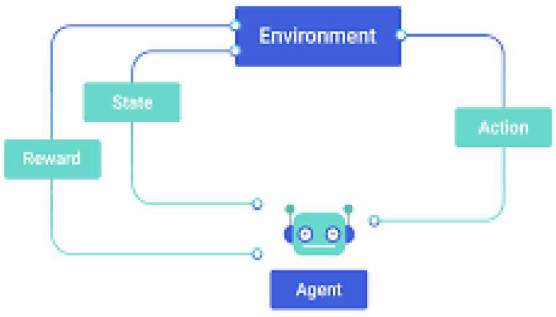
4.2.2 Unsupervised learning

In this approach unlabeled data is provided to the model, it works on the unlabeled data. It help to determine pattern and does the classification based on the data that is provided .Clustering, k-Nearest Neighbour (KNN), anomaly detection, principal component analysis (PCA) are the algorithm in unsupervised learning.



4.2.3 Reinforcement Learning

Reinforcement learning is the type machine learning which does not require a lot of training data . It is not provided with the environment but the agent learn from it environment by the process of trial and error to achieve goals and get rewards.



Chapter5
Working

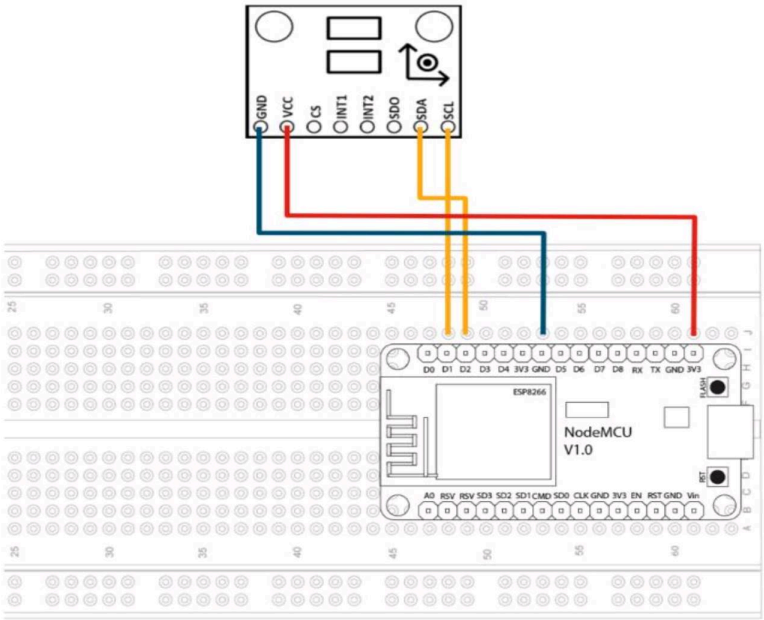
4.1 Circuit connection and data collection

a) Vibration sensor ADXL 345 is used to detect the vibration of the rotating shaft.

b) An ADXL345 is an digital accelerometer that gives the values of acceleration in three axes – X, Y and Z. It has high resolution (13-bit) measurement at up to ±16 g. Digital output data are formatted as 16-bit two complement.

c) It has several special sensing function. Inactivity and activity sensing detect the presence or lack of motion and if the acceleration on any axis exceeds a user-set level.

d) An ADXL 345 is connected to the microcontroller ESP8266(nodeMCU) according to the pin mode connection given in the figure.



ADXL345	NodeMCU
VCC	3V3
GND	GND
SDA	D2
SCL	D1

Interfacing an ADXL345 accelerometer

e) After the connection the code for collecting data is written in Arduino ide

As we were using nodeMCU and ADXL 345 we require to install the libraries for running our code.

f) ESP 8266 has inbuilt wifi module which help direct transfer of data to the cloud. The stored on the cloud can be used further processing process.

g) After running the code we start to get the data of vibration of the shaft . As we require data for further processing process ,we used Microsoft excel data streamer to get real time data directly in the excel.

h) Pre-processing steps such as exploration, cleaning and transformation of dataset will be done using Python.

i) Machine learning prediction models can be used for predictive maintenance of motor and to predict failures in motor. Visualization of the data can be done using Python Modules

- **Code for collecting ADXL345 data from ESP 8266 using Arduino ide**

```
#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_ADXL345_U.h>
Adafruit_ADXL345_Unified accel =
    Adafruit_ADXL345_Unified(12345);
void setup()
{
 Serial.begin(115200);
 if(!accel.begin())
 {
  Serial.println( ADXL345 is not  detected ... Check your
  connection!");
  while(1);
 }
 accel.setRange(ADXL345_RANGE_8_G);
}
 void loop()
{
 sensors_event_t event;
 accel.getEvent(&event);
 Serial.print(event.acceleration.x); Serial.print(",");
 Serial.print(event.acceleration.y); Serial.print(",");
 Serial.println(event.acceleration.z);
 delay(1000);
   }
```

➢ Data output in Excel Data streamer:

Data In (From Silicon Labs CP210x USB to UART Bridge (COM3))

Data coming from the current data source will appear below as it is received.

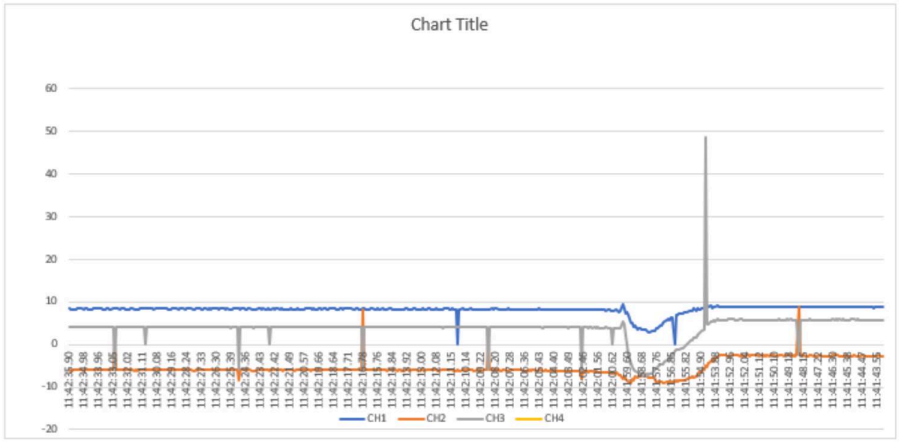
Current Data

TIME	CH1	CH2	CH3	CH4
11:42:35.90	8.51	-5.84	4.04	

Historical Data

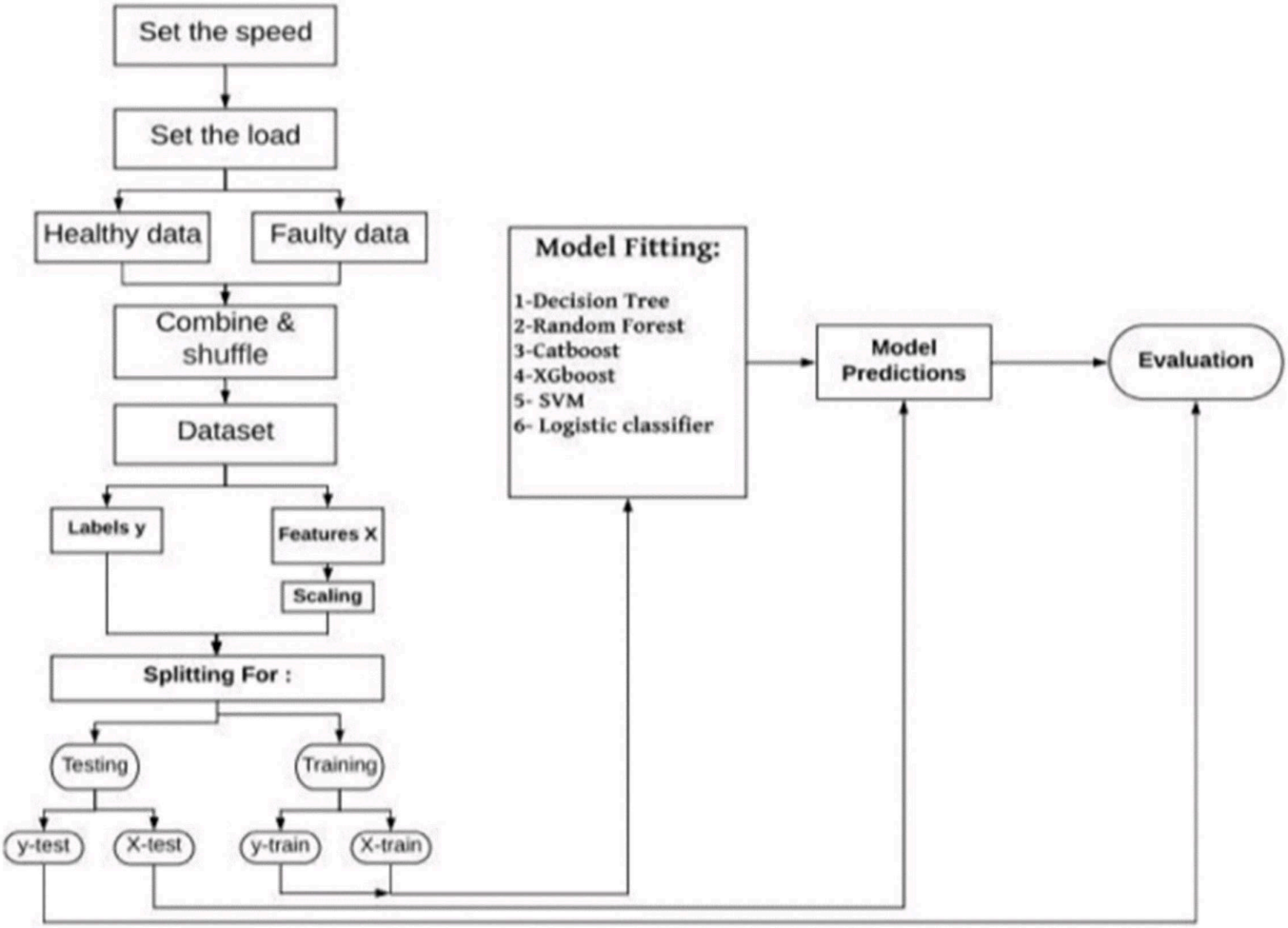
TIME	CH1	CH2	CH3	CH4
11:42:35.90	8.51	-5.84	4.04	
11:42:35.81	8.32	-6.12	4.12	
11:42:35.70	8.24	-6.12	4.04	
11:42:35.60	8.36	-5.92	4.12	
11:42:35.51	8.32	-5.96	4.08	
11:42:35.40	8.39	-6	4.08	
11:42:35.29	8.39	-6	4.08	
11:42:35.20	8.39	-5.92	4.08	
11:42:35.09	8.39	-5.96	4	
11:42:34.98	8.16	-6.12	4	
11:42:34.77	8.59	-5.77	4.12	
11:42:34.68	8.47	-5.84	4.12	
11:42:34.59	8.36	-5.96	4.04	
11:42:34.48	8.32	-5.96	4.08	
11:42:34.37	8.36	-6.04	4	
11:42:34.27	8.43	-6	4.16	
11:42:34.16	8.39	-5.96	4.08	
11:42:34.07	8.39	-5.96	4.08	
11:42:33.96	8.39	-5.92	4.12	
11:42:33.85	8.39	-5.96	4.08	
11:42:33.76	8.43	-5.92	4.08	
11:42:33.65	8.36	-5.96	4	
11:42:33.55	8.36	-6.04	4.04	
11:42:33.46	8.39	-5.88	4.08	
11:42:33.35	8.51	-5.84	4.16	

◀ Newest



Sheet1 | Data In | Data Out | Settings | Manifest

5.2 Conceptual flowchart



This is the conceptual flow chart of the post process which will be carried out after the data has been collected from the sensor . Firstly the motor will be operated at different speed and respective vibration data has been collected. Than we will apply some load to the shaft and collect data generated at that time period . We will develop the data set from the collected data which will be used in the testing and training phase of the model.

Chapter 6
Components:

5.1 Components used in experimental setup

1. Motor
2. Shaft of different material such as mild steel , aluminium etc and different diameter
3. Bearing (to rotate the shaft connected to the motor)
4. Various types of sensor is used to collect the data and monitor the parameters
5. Wooden base plate to keep the experimental setup
6. Variable connected to the motor to control RPM of the motor
7. ESP8266 used for data collection

5.2 Component specification

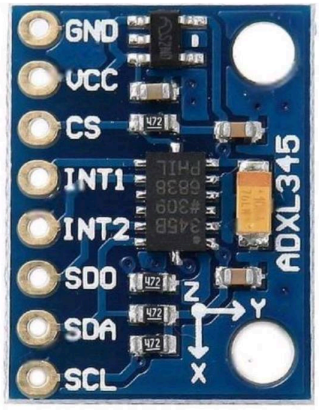
1) Motor
Specifications: - Rpm: - 2500
Voltage: - 220-230
Hp: -1/12
Power: - 50 watt
Dimension: - 23.6*23.4*16.7 cm
Weight: – 2.75 kg

2) Shaft
Specifications: - Material: - Mild Steel/Aluminium
Diameter: - 10-20 mm
Length: - 1 m
Shape: -Circular

3) Vibration sensor

Specification: - Model: - ADXL345

Operating Voltage: - 3.3-5V



4) NodeMCU

WIFI module: ESP-12E

CP2102 Chip

Processor: ESP8266

Built-in Flash: 32Mbit

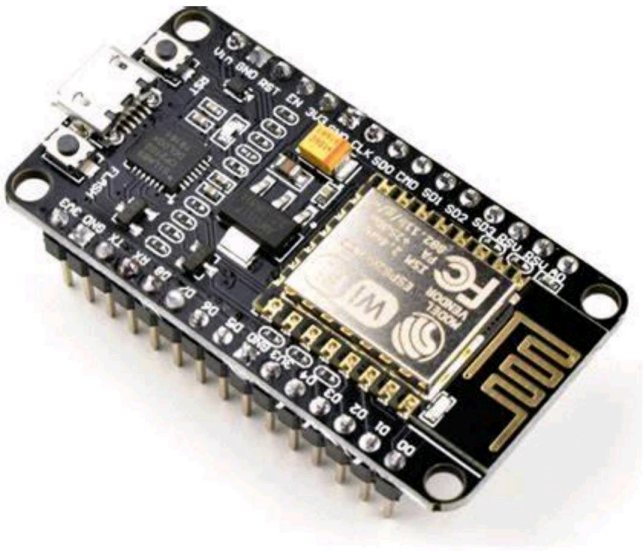
WiFi protocol: IEEE 802.11 b/g/n

Peripheral interface: UART/SPI/I2C/SDIO/GPIO/ADC/PWM

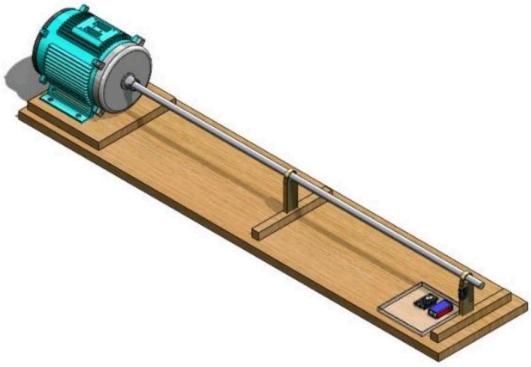
Frequency range: 2.4G ~ 2.5G (2400M ~ 2483.5M)

Power supply: 5V

Logic level: 3.3V



Chapter 7
Modal and Assembly



Solidworks model of setup

Actual setup of the project

Advantages

1. Failure and type of failure of rotating shaft get detected before actual breakdown
2. Maintenance required can be planned properly
3. Less down time in the production process
4. Good quality of product
5. Cost effective maintenance

References

1) D. E. Bently; C. T. Hatch, and B. Grissom. “Fundamentals of Rotating Machinery Diagnostics”. Minden, Nev.: Bently Pressurized Bearing Press, 2002.

2) B. Luo, H. Wang, H. Liu, B. Li, F.Peng. “Early Fault Detection of Machine Tools Based on Deep Learning and Dynamic Identification. IEEE Transactions on Industrial Electronics, V. 66, Issue 1, p.509- 518, 2018.

3)Ayhan, M. Y. Chow and M. H.Song, “Multiple Discriminant Analysis and Neural Network-Based Monolith and Partition Fault-Detection Schemes for Broken RotorBar in Induction Motors”, IEEE Transactions on Industrial Electronic