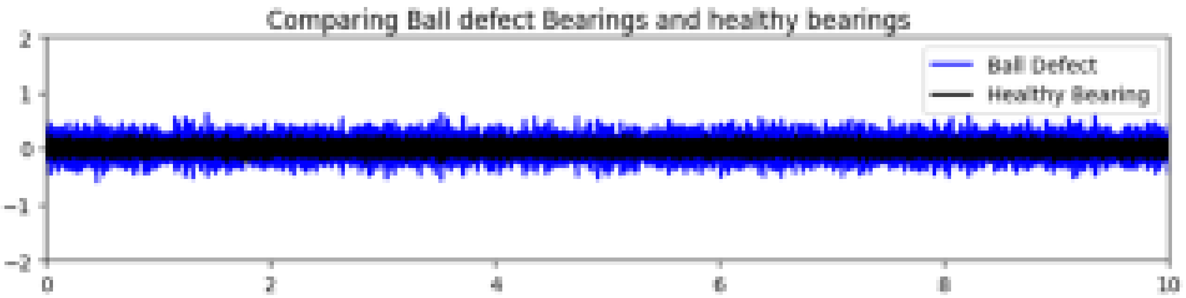
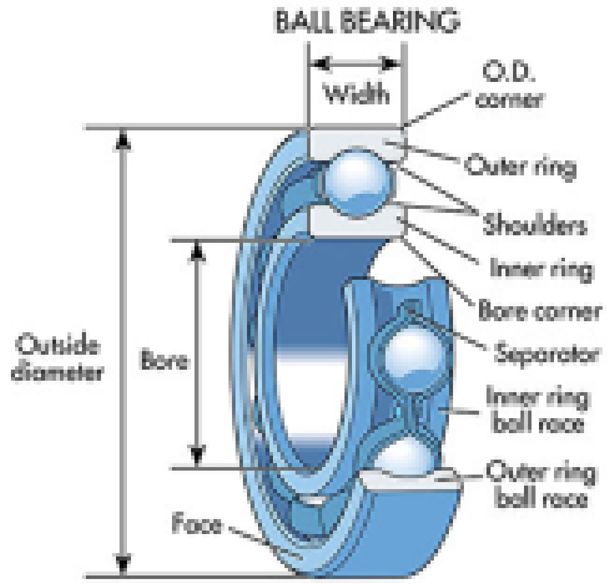
Ball Defect

➢ Ball defect vibrations are normally high-frequency and have a frequency related to the ball pass frequency, while healthy bearing vibrations are low-level and have a consistent amplitude.





Inner Race Defect

➢ In the frequency domain this not only gives rise to a discrete peak at the carrier frequency but also a pair of sidebands spaced either side of the carrier frequency.

Outer Race Defect

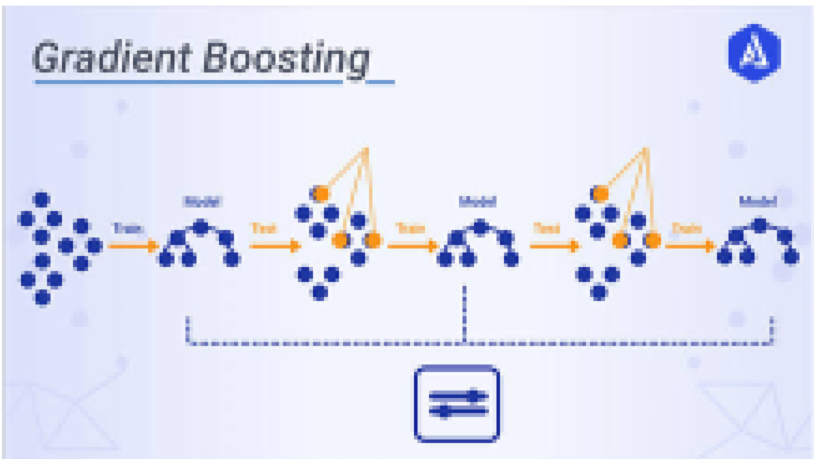
➢ A discrete fault on the outer raceway will generate a series of high energy pulses at a rate equal to the ball pass frequency relative to the outer raceway in this case.

Time domain features

- Time domain features of vibrational data for bearings refer to the characteristics of the signal in the time domain. Features are important because they can provide insights into the condition of the bearing
- The time-domain features we used are Average value, Root-Mean-Square (Rms), Standard deviation, Form Factor,Crest factor, Kurtosis and Skewness
- For example, Changes in the RMS value over time can then be correlated with the presence of a fault, such as an increase in vibration due to bearing wear.

Gradient Boosting

- It is an ensemble method that combines multiple weak predictors to create a strong predictor.
- The model uses gradient descent optimization to minimize the loss function.
- In each iteration of the algorithm, a new decision tree is fit to the negative gradient of the loss function with respect to the predictions made by the previous model.



Testing

- We are getting an accuracy of 84%.
- Final Test : Healthy Bearings , Bearings with Inner rays defect

Future Plan

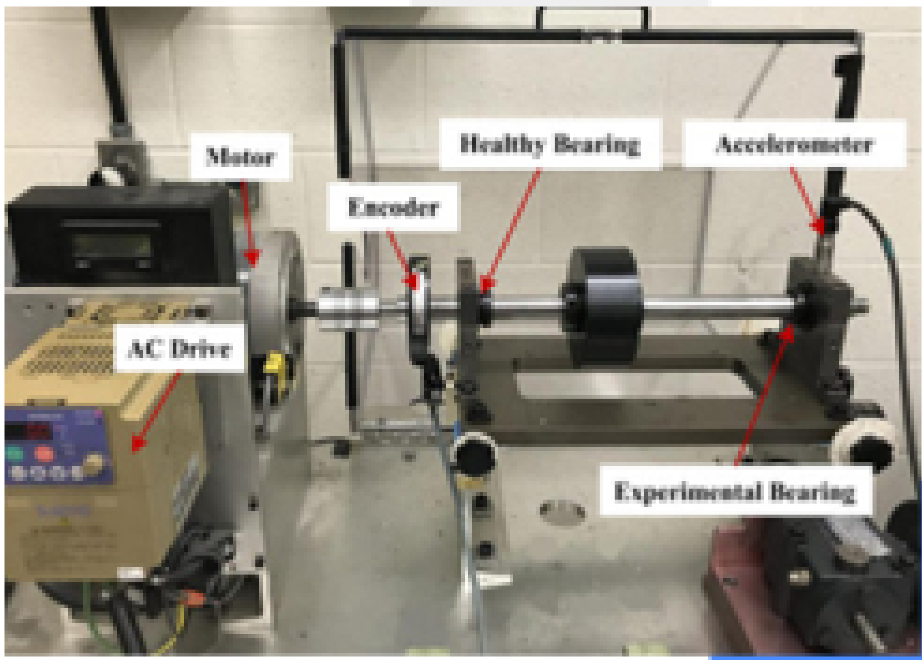
- We are also planning to include cage defect and optimise our model to find out all 4 types of faults.
- Adding more attributes and train our model with a larger set of data to detect faulty bearing of any bearing type and dimensions.
- Deploy our model using app or web interface where vibrational data can be fed or recorded directly.

Prototype

Flow Chart

Project Understanding → Data Collection & Understanding → Data Cleaning & Preparation → Modelling → Evaluation

Experiment Setup



- **Accelerometer** is placed on the housing of the experimental bearing to measure the **vibrational data.**
- **Encoder** is installed near the shaft to measure the shaft **rotational speed** data.

Collecting Bearing Data

- Data is collected from bearings of different health conditions and varying rotational speed conditions.
- Health conditions include
  - healthy
  - faulty with an inner race defect
  - faulty with an outer race defect and
  - faulty with a ball defect
- Operating rotational speed conditions are
  - increasing speed
  - decreasing speed

Bearing Characteristic Frequencies

- Unique frequencies generated by a bearing due to its design and operation.
- Different type of Bearing frequencies:

$BPFI = nfr\ 2\ (1 + d\ D\ cos\alpha)$ [inner-race ball pass frequency]
$BPFO = nfr\ 2\ (1 - d\ D\ cos\alpha)$ [outer-race ball pass frequency]
$FTF = fr\ 2\ (1 - d\ D\ cos\alpha)$ [FTF is fundamental train frequency]
$BSF = Dfr\ 2d\ (1 - [\ d\ D\ cos\alpha]\ 2)$ [ball (roller) spin frequency]

Ball Dimensions:

Type of bearing: **ER16K Deep Groove Ball Bearings**					
Ball Diameter	Pitch Diameter	Number of Bearings	Inner Diameter	Outer Diameter	Width
7.94mm	38.72mm	9	25.4mm	50.8mm	25.4mm

Empathy Map

Says

- Testing a bearing's functionality can be rigorous and a complex task.
- Repeated testing decreases the efficiency of the machine.

Thinks

- I wish there is an easy alternative to check for defective parts.
- There should be a process wherein we don't have to follow up on so many dependent variables.

Does

- Constantly keeping track of various parameters of bearings while testing everytime is an important but unavoidable task.
- Speeding up the process of testing, speeds up the manufacturing process.

Feels

- Exhausting - checking is very tiring
- Annoyed - consumes a lot of time

Define

Problem Statement: Our project involves developing a ML algorithm that can detect the defective bearings using noise and vibration data. Thus, making it economical and time saving.

Ideate

Possible Solutions

Friction & Temperature	Using ML	Visual Inspection
• Friction and temperature testing, calculate power losses.	• Studying vibrations of a proper bearings and using ml algorithm.	• Visual examination possible damage or other abnormalities in bearings.

Concept Evaluation Matrix

Criteria	Friction & Temperature	Using ML	Inspection
Different or Better	3	5	1
Delivery value	3	3	3
Doable	5	1	3
Cost	5	5	1
Fits with Team skills	3	5	1
Have an existing solution	1(YES)	5(NO)	3(YES)
Passion Factor	3	5	1
Total Score	23	29	13