**Predictive Maintenance System for Motor Defect Detection**

**Project Overview**

This project was carried out by a student from the University of Swabi, under the supervision of a doctoral student in mechanics and a teacher-researcher in mechanics at the University of Peshawar (UOP). The aim of the project was to study and implement predictive maintenance techniques to identify motor defects using the noise emitted by motors during operation.

**Objective**

The objective of this project was to design a predictive maintenance system capable of identifying defects in motors based on the noise they produce. The approach involves leveraging machine learning to predict the type of defect by analyzing motor sounds. The goal is to determine whether the motor is functioning properly or if there is a specific problem that needs attention.

The system will focus on detecting **three types of motor defects** based on the sound generated by the engine during rotation.

**Predictive Maintenance Overview**

Predictive maintenance is an essential strategy for businesses looking to optimize their maintenance processes, reduce production downtime, and lower repair costs. It involves using data-driven approaches to predict and prevent equipment failures before they occur, resulting in enhanced productivity, increased operational efficiency, and cost savings.

**Maintenance Categories:**

1. **Reactive Maintenance:**  
   Reactive maintenance refers to addressing issues only after a breakdown or malfunction occurs. It is costly and can result in significant downtimes.
2. **Preventive Maintenance:**  
   Preventive maintenance involves regular, scheduled maintenance for each piece of equipment. This type of maintenance aims to reduce the risk of failure by ensuring equipment is maintained at regular intervals. It is more cost-effective than reactive maintenance but can still be improved with data-driven strategies.
3. **Predictive Maintenance:**  
   Predictive maintenance uses real-time data and performance metrics to predict when a machine is likely to fail, enabling repairs to be done just before failure occurs. This approach helps avoid unnecessary downtime and reduces the cost of preventive maintenance.
4. **Proactive Maintenance:**  
   Proactive maintenance combines the benefits of predictive and preventive maintenance by addressing the root causes of failures and using data to monitor equipment performance over time. It is a holistic strategy that proactively addresses issues before they arise.

**Project Methodology**

**Problem Statement:**

The problem addressed by this project is the prediction of motor defects using the noise emitted by the motor. By recording the sound generated by the motor during operation, we can predict if the motor is malfunctioning and, if so, identify the type of problem.

**Proposed Approach:**

This project investigates three different approaches to solve the problem:

1. **Convolutional Neural Network (CNN):**  
   A CNN model will be trained to detect defects from motor sounds. The model will learn patterns in audio data to predict the type of fault.
2. **Feature Extraction-Based Approach:**  
   In this approach, relevant features will be extracted from the motor noise data, such as frequency and amplitude patterns, to predict defects.
3. **Combination of CNN and Feature Extraction:**  
   This approach will combine the CNN model with traditional feature extraction techniques for a more robust and accurate defect prediction system.

**Dataset**

The dataset consists of **4 audio recordings**, each of **12 seconds** duration, collected from different motors. These recordings capture the noise produced by the motors during operation, including both normal functioning and malfunctioning states.

**Defect Types to be Predicted:**

1. **Bearing failure**
2. **Rotor misalignment**
3. **Normal operation (no defect)**

The audio files will be processed to extract relevant features, such as **spectrograms** and **MFCCs (Mel-frequency cepstral coefficients)**, which will serve as input to the machine learning models.

**Project Steps:**

1. **Data Collection and Preprocessing:**  
   Audio files will be cleaned and preprocessed to extract features that represent the motor sounds. Preprocessing steps include noise reduction and normalization of audio files.
2. **Model Development:**  
   Three models will be developed and compared:
   * A **CNN model** to classify the motor defect type based on extracted features.
   * A model using **traditional feature extraction** techniques, such as MFCC, to predict the defect type.
   * A **hybrid model** combining both approaches to improve performance.
3. **Model Evaluation:**  
   The models will be evaluated based on performance metrics like **accuracy**, **precision**, **recall**, and **F1-score**.

**Conclusion**

By the end of the project, the goal is to have developed a reliable predictive maintenance system capable of identifying and classifying motor defects based on the sounds emitted by the motors. This system will help in reducing downtime, minimizing repair costs, and optimizing maintenance schedules for industrial applications.