College of Engineering
LAMAR UNIVERSITY

Predictive Pioneers

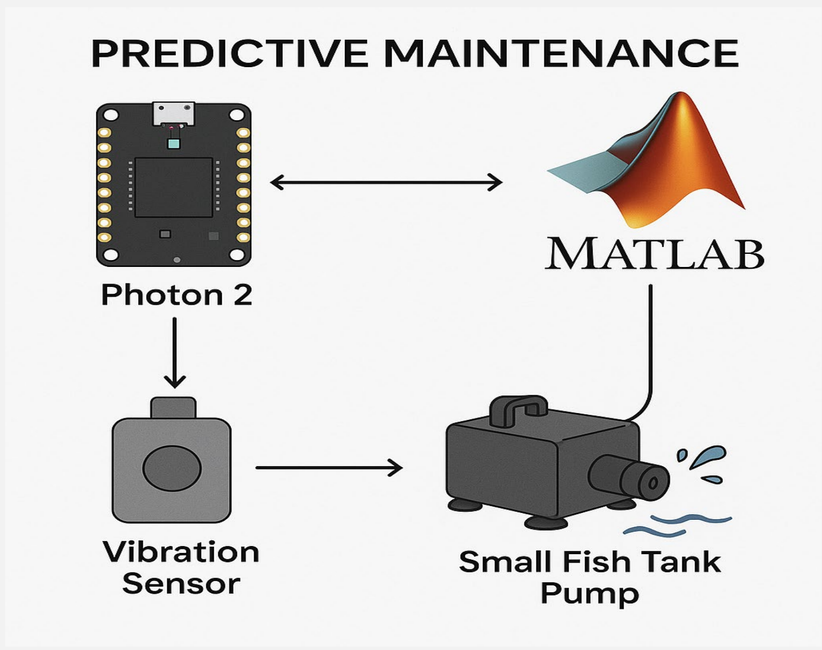
What is Predictive Maintenance?

Predictive maintenance is an approach to maintaining equipment by monitoring the condition in real-time. The cause is to predict potential failures and schedule maintenance before it occurs. There are three main factors to predictive maintenance which are: data collection, data analysis, and failure prediction.

Data Collection: Gathering real-time data about equipment performance using sensors (temperature, vibration, pressure, etc).
Data Analysis: Analyzing patterns, anomalies, or trends that indicate issues.
Failure Prediction: Based on the data analysis, the predictive maintenance system shows when maintenance needs to be done such as repairs or replacement.

Predictive Maintenance Design for Centrifugal Pump

This design consists of a microcontroller known as the Photon 2, a centrifugal pump, piezo vibration sensor, and MATLAB software. With the use of a free programming platform provided by Lamar University (MATLAB), predictive maintenance can be done using these components. The sensor outputs voltage data to the Photon 2 which is then received via serial communication between MATLAB and the microcontroller. Raw data is being collected that is comparative to the threshold set on the MATLAB algorithm. As the raw data is inputted, MATLAB uses signal features of the predictive maintenance toolbox to detect faulty in the pump's propeller. The signal features used are RMS, skewness, crest factor, and kurtosis.



Predictive Maintenance and Sustainability

Predictive maintenance of centrifugal pumps plays a crucial role in promoting sustainability by minimizing unnecessary repairs, extending equipment life, and reducing energy consumption. By using real-time monitoring tools such as vibration sensors, maintenance teams can detect early signs of wear or inefficiency before major failures occur. This proactive approach reduces the need for frequent part replacements, conserves raw materials, and lowers the environmental footprint associated with manufacturing and transportation of spare parts. Well-maintained pumps operate more efficiently, consuming less energy and thereby contributing to lower greenhouse gas emissions. Overall, predictive maintenance not only enhances the reliability and performance of centrifugal pumps but also supports broader goals of environmental stewardship and resource conservation.

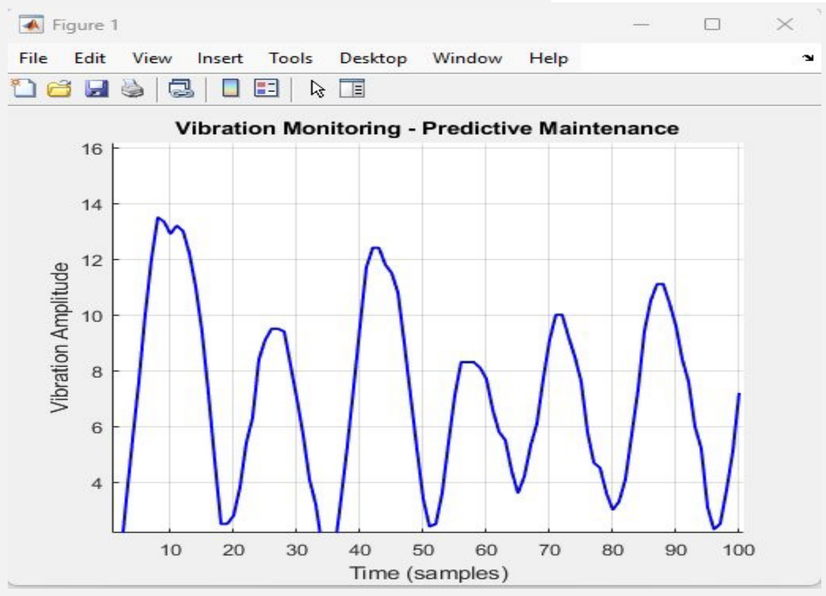
Data Collection of Threshold and Real-Time Monitoring

By using the predictive maintenance toolbox signal features of RMS, skewness, crest factor, and kurtosis, data collection was made in the timeframe of 60 seconds with 10 samples each second. Each data collection ran required removal of the propeller inside and replacement of the other propeller. During real-time monitoring, data is compared to the collections previously made which is the threshold limit. When the vibration is not within the standards of the threshold, abnormal vibration is detected and will indicate the need of maintenance.

```
Command Window

DataCollection =

  struct with fields:

      faultLabel: 'Normal'
      timestamps: [0.0760 0.1864 0.2973 0.4070 0.5181 0.6269 0.7368 0.8484 0.9600 1.0712 1.1833 1.2949 1.4060 … ] (1×539 double)
   vibrationData: [9 0 2 8 0 16 21 27 0 12 0 0 0 0 0 0 16 35 0 19 0 35 12 26 0 3 0 0 0 0 0 6 1 7 12 14 0 13 … ] (1×539 double)

>> DataCollection = load('vibration_Imperfect_20250425_134953.mat')

DataCollection =

  struct with fields:

      faultLabel: 'Imperfect'
      timestamps: [0.0746 0.1861 0.2941 0.4051 0.5282 0.6406 0.7508 0.8625 0.9749 1.0866 1.1971 1.3085 1.4198 … ] (1×539 double)
   vibrationData: [0 0 0 33 39 45 19 0 0 0 0 0 37 32 33 27 0 0 0 4 19 45 37 19 0 0 0 0 12 42 29 27 6 0 0 0 4 … ] (1×539 double)

fx >>
```

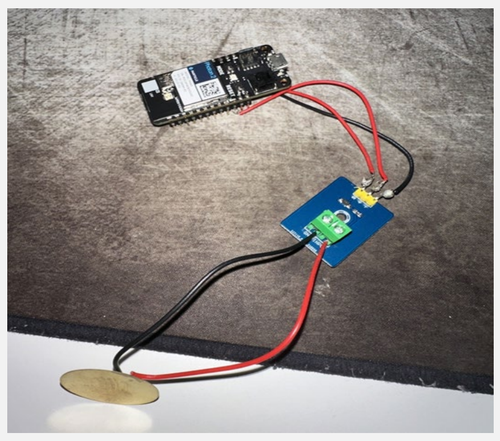
$$x_{kurt} = \frac{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^4}{\left[\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2\right]^2}$$

$$x_{skew} = \frac{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^3}{\left[\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2\right]^{3/2}}$$



Photon 2 Microcontroller

The Photon 2 is a microcontroller used in this design to give signal from the vibration sensor to the MATLAB algorithm. It connects via micro-USB, yet it has capabilities of Bluetooth or wi-fi. This microcontroller processes real-time data received from the sensor and outputs it as voltage reading into MATLAB. This is done by using the signal output pin on the sensor that connects to the analog input pin on the Photon 2. The firmware used is 5.9.0 which requires a flash code to be able to use on MATLAB through serial communication. Serial communication is used due to the Photon 2 not showing up as a compatible Arduino board.



Students & Faculty Advisors
Juan Macias, Dylan Pham, John Melancon
Dr. Bradley

Industrial and Systems Engineering