# **Project Title:** Smart Parking

## Predictive maintenance Algorithm:

Designing predictive maintenance algorithms begins with a body of data. Often you must manage and process large sets of data, including data from multiple sensors and multiple machines running at different times and under different operating conditions.

You might have access to one or more of the following types of data:

1) Real data from normal system operation
2) Real data from system operating in a faulty condition
3) Real data from system failures (run-to-failure data)

For instance, you might have sensor data from system operation such as temperature, pressure, and vibration. Such data is typically stored as signal or time series data. You might also have text data, such as data from maintenance records, or data in other forms. This data is stored in files, databases, or distributed file systems such as Hadoop.

In many cases, failure data from machines is not available, or only a limited number of failure datasets exist because of regular maintenance being performed and the relative rarity of such incidents. In this case, failure data can be generated from a Simulink model representing the system operation under different fault conditions.

Predictive Maintenance Toolbox provides functionality for organizing, labeling, and accessing such data stored on disk. It also provides tools to facilitate the generation of data from Simulink models for predictive maintenance algorithm development.

## Example

### Train Detection or Prediction Model:

At the heart of the predictive maintenance algorithm is the detection or prediction model. This model analyzes extracted condition indicators to determine the current condition of the system (fault detection and diagnosis) or predict its future condition (remaining useful life prediction).

### Fault Detection and Diagnosis:

Fault detection and diagnosis relies on using one or more condition indicator values to distinguish between healthy and faulty operation, and between different types of faults. A simple fault-detection model is a threshold value for the condition indicator that is indicative of a fault condition when exceeded. Another model might compare the condition indicator to a statistical distribution of indicator values to determine the likelihood of a particular fault state. A more complex fault-diagnosis approach is to train a classifier that compares the current value of one or more condition indicators to values associated with fault states, and returns the likelihood that one or another fault state is present.

## Usage

When designing your predictive maintenance algorithm, you might test different fault detection and diagnosis models using different condition indicators. Thus, this step in the design process is likely iterative with the step of extraction condition indicators, as you try different indicators, different combinations of indicators, and different decision models. Statistics and Machine Learning Toolbox and other toolboxes include functionality that you can use to train decision models such as classifiers and regression models.

## How IoT sensors detect free parking space

IoT sensors utilise an ultrasonic wave to determine the distance to something. Each sensor is implanted in the parking space surface and finds the distance to the undercarriage of a vehicle if the parking space is full.

### 3 possible detection conditions:

- If space is occupied: The distance determined to an object by the sensor is 10 to 50 centimetres, four to 20 inches.
- If space is free: The distance determined to an object by the sensor is more than 50 centimetres, about 20 inches.
- If space is dirty: The distance determined to an object by the sensor is less than 10 centimetres, that is, four inches.

- If the condition is “dirty,” it means the sensor may be covered by something or blocked, and the device needs prompt maintenance and cleaning.

The application operates on AWS IoT and AWS Lambda and displays a driver the free spaces in green, full/occupied spaces in red and sensor malfunctions in yellow.

## IoT-based smart parking system configuration :

The number of parking spaces available in a parking lot specifies the software and hardware needs for IoT configuration and system architecture. For large parking lots, it is best to use gateways and the LPWAN protocol for the sensors.

Using the LoRaWAN standard is one of the latest IoT trends and the best way to improve the operating hours of an autonomous system by minimising power usage. As per the specifications of the LoRa Alliance, this decreases the demand to substitute the batteries. Battery life is increased to five years before replacement.

## Sensors for IoT-based smart parking:

Smart parking sensor types have ultrasonic, electromagnetic field detection, and infrared.

**Ultrasonic:** The sensing accuracy is improved by using ultrasound to know the measurement. The drawback of this type of sensor is the possibility of blockage by dirt.

**Electromagnetic field detection:** This sensor notices slight changes in the magnetic field whenever metal objects come closer to the sensor.

**Infrared:** This type of sensor measures the changes happening in the surrounding temperature and identifies the motion.

**Parking 4.0:** Future and opportunities in smart cities:

Adopting smart parking systems is expected to grow because the technology is beneficial and brings helpful changes in daily life.

Augmented reality technology is of great help for large-scale parking lots as it can create a mapping function overlay on top of authentic images captured by a smartphone. These ARbased outdoor and indoor navigation systems can direct drivers with a virtual path to their parked cars.

Another innovation utilises visual image processing to capture the license number of a vehicle to identify it with the support of Optical Character Recognition technology. Then, it automatically opens the gate to the parking lot, and the system helps the driver to a suitable parking space.

So, we can conclude that the future of smart parking systems is quite promising. Technologies behind this possible solution are Artificial Intelligence, IoT, Machine Learning, and Augmented Reality. These are also responsible for digital transformation for businesses under the “Industry 4.0” term. By potentially using these innovations, Parking 4.0 will enhance the efficiency of the parking system by solving urbanisation issues.