International Journal of Mechanical and Industrial Technology ISSN 2348-7593 (Online)
Vol. 10, Issue 1, pp: (1-9), Month: April 2022 - September 2022, Available at: www.researchpublish.com

Preventive Maintenance using Arduino Uno

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Abstract: **Over the past few years, there have been incidents at factories where lathes are used for precisely machining really hard materials. These incidents include fire breakouts, thefts and illegal entries and damage to machinery and they occur due to inefficient monitoring and unavailability of proper real time data. Hence there is a need of proper software and services for monitoring of environmental conditions of the factories. To fulfil this need, we created this project using IoT based sensors which will be connected to an Arduino Uno, and linking them to lathe machines for detecting their temperature and humidity changes, measuring distance around them and also abnormal vibrations. This data will be transferred to the phone or serial monitor of the concerned authorities thus making it easier for them to detect any unwanted changes in the aforementioned parameters related to the lathe machines and ensuring their smooth functioning in the factories.**

Keywords: **Arduino UNO, Sensors, Internet of Things, Preventive Maintenance.**

I. INTRODUCTION

Due to the current pandemic situation, everyone is looking for ways to automate as much as possible. This gives rise to Industry 4.0 that totally revolutionizes all the existing industries. Be it manufacturing, chemical or medical, today every industry is looking for ways to keep its data as secure and at the same time as accessible as possible to the right authorities. With the testing times technology like Internet of Things has gained enormous fame cause of its ability to provide remote control over wide variety of manually monotonous tasks.

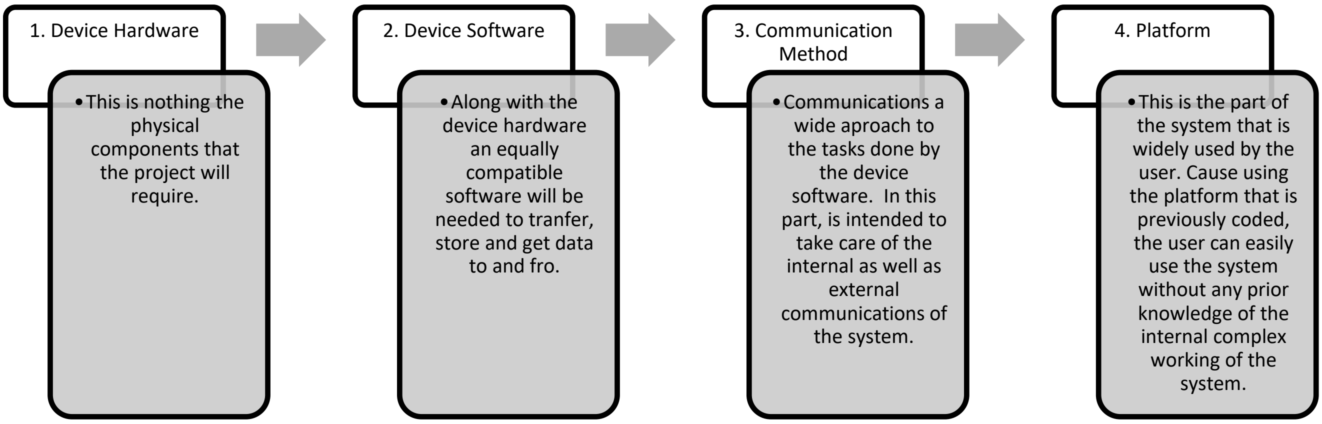
1.1 What is Internet of Things?

Internet of Things also abbreviated as IoT, is a network established between computers, machines, objects or even for that matter animals and people provided with individual identifiers that can communicate internally without the need of any physical or traditional interaction like human-to-human or in some advanced cases human-to-computer [1]. It is a highly persuasive technology that makes tiresome tasks easier by improving communications with devices. The major motive of IoT is to bridge the gap between reel and real world. All the necessary information/data is stored in a guarded cloud that has limited access.

1.2 The Elemental Working of IoT system

The working of an IoT based system is divided into the following components, namely[1]:

1. Device Hardware
2. Device Software
3. Communication Method
4. Platform



II. PROJECT IDEA DISCUSSION

We intent to make a device that can monitor parameters like temperature and vibration. If in case any parameter is not in the appropriate range the assigned facility personnel is immediately notified.

Not only that this is of utmost use to the facility during the onset of any hazardous event, but also helpful to prevent any major failures or downtimes of departments as a whole. This a segment of preventive and predictive maintenance which is carried out by various facilities to avoid foreseen disasters. A device like this also helps in maintaining safety of the workers working in a dangerous and critical environments. The following are the five types of preventive maintenance that can be carried out [2]:

1. Time – based Maintenance (TBM):

This type of maintenance is already predetermined based on the components' lifetime used in the machine or system. Usually, the component with the shortest lifetime is replaced before it brings the whole system or machine to standstill.

2. Failure – Finding Maintenance

In failure – finding maintenance the most critical components are checked to ensure the smooth working of the mechanism. It helps to identify hidden sources of mishap.

3. Risk – based Maintenance

Risk - based maintenance is essentially Pareto's Law which states that for many outcomes, roughly 80% of consequences come from 20% of causes (the "vital few"). Other names for this principle are the 80/20 rule, the law of the vital few, or the principle of factor sparsity. This means that out of all the problems that can occur 80% of them are from only 20% of the components of the system. Thus the identification of these 20% components is necessary. This method is the most over-looked yet most effective method of preventive maintenance.

4. Condition – based Monitoring (CBM)

CBM is better preventative maintenance strategy than time-based, because it is a dynamic measure intended to individually identify changes in machine performance and head off issues. The parameters that are measured are –

a. Visual – Cracks, corrosion, Wears, Fractures between colliding surfaces

b. Vibrations – Changes in the intensity of the vibrations of compressors, pumps and motors

c. Temperature – Changes in the temperatures of the faulty machinery can cause change in temperature of the whole system

d. Sound – A faulty machinery is bound to make some noises.

III. LITERATURE REVIEW

Kinnera Bharath Kumar Sai et al. [3]worked on setting up air quality monitoring system using Vector Auto Regression (VAR) machine learning model. This system employed Wi-Fi-enabled Arduino Uno (with ESP-01), MQ135 (for detecting ammonia, carbon dioxide, alcohol, and smoke) and MQ7 sensors (for detecting carbon monoxide). The parameters (i.e. air quality in ppm, temperature, humidity, etc.) acquired by the sensors were sent to ThingSpeak for visualization and storage.

In,[3] a system that could observe mines was designed, prototyped, and implemented with Arduino Nano and Uno. This was aimed at ensuring safety of the miners by gathering data on the quality of air in the working environment. An IoT-based wearable device was developed in [4] using Arduino Nano that could observe air quality while detecting obstacles and providing other useful tips. The device made use of wireless temperature, humidity, gas, and collision detection sensors for effectiveness.

Monira Mukta et al. [5] created an IoT-based Smart Water Quality Monitoring (SWQM) system using fast forest binary classifier to classify water samples into potable and unpotable. The system was effective in real-time monitoring of water pH, temperature, turbidity, and electric conductivity. The readings perceived by four different sensors were accessed by the Arduino Uno and sent to a desktop application built on the .NET framework. Likewise, Yong Jie Wong et al. [6] developed and deployed an additively manufactured IoT-based water quality monitoring system (WQMS). WQMS was capable of measuring turbidity and water level every two hours, utilizing only solar energy. It comprised four modules: energy, time, monitoring, and communication. The turbidity sensor provided an accurate measurement of turbidity over 10–1000 FNU. The optimum measurement range of the water level sensor was found to be 2–400 cm.

Sandeep V. Gaikwad et al.[7] built an IoT-based agro-meteorological system to ensure optimal quality crop production in the agricultural industry. The system made it possible to precisely and continuously monitor soil moisture, temperature, air humidity, and temperature at the agro-field level. The system circuit setup included an Arduino kit, four soil moisture sensors (RC-A-4079), soil temperature probe (DS18B20), air temperature and humidity (DHT11) sensor, power source, and Wi-Fi module (ESP8266). Suhas Athani et al. built an IoT system that was prototyped on the Arduino Uno computing platform and designed to observe changes in soil moisture. The system when built proved useful for the targeted region (North Karnataka, India).

Victor Chang and Craig Martin [8] used the Arduino-sensor system and WPF application to track the temperatures and the position of ladle vessels for metallurgical applications. K-Type thermocouple, Global-Positioning System (GPS) shield, real-time clock, and Bluetooth module were among the modules coupled to the Arduino microcontroller. In addition, their system showed the capability of reading temperatures as low as –200℃ and as high as 1250℃. This study can assist in developing new and enhancing existing industrial IoT-based smart sensing devices for extreme temperature measurements, e.g. ovens used in manufacturing industry, liquid nitrogen used in chemical industry, etc.

Abhishek Kumar et al. [9] focused on constructing a greenhouse control system using the Arduino Uno, different sensors, and GSM (Global System for Mobile communication) module. The sensors incorporated in this system are soil moisture sensing probe, DHT11 (temperature + humidity) sensor, and LDR (Light-Dependent Resistor) sensor. It is important to note that the application of this system is ubiquitous as it purely runs on solar energy. It could regulate soil moisture, temperature, water and lighting conditions for optimal crop growth in accordance with the sensor data. For example, when soil moisture is sensed to be below the required level, the Arduino will switch the water pump ON. Likewise, when temperature and/or humidity level is sensed to have been changed, the Arduino will switch the fan ON/OFF to increase or decrease the cooling action. When light intensity is sensed to be below the threshold, the Arduino will switch the light bulb ON. In any of the aforementioned scenarios, the farmer receives an SMS alert as and when the GSM module updates the status.

The Arduino-based drive systems have been used to clean the drainage pipes [10] to prevent clogging and for human welfare. The water level was detected by an ultrasonic sensor, the clog in the drainage pipe was detected by an LDR sensor, and the waste level in the collecting bin was detected by an IR sensor. When a clog is detected, the microcontroller sends a signal to the servo motors in order to pick up solid wastes and collect them in the bin. This microcontroller was run by a 12V solar-powered battery. Thus, IoT enables progress towards a green and sustainable smart city without much need for human intervention.

Hamza Zahid et al. [11] proposed an approach for integrating BIM (Building Information and Modeling) and IoT sensors to assist Heat Ventilation and Air Conditioning (HVAC) systems in achieving thermal comfort optimization. They developed a prototype with the Arduino Uno (compatible with Firefly BIM-IoT integration module) and DHT11 sensor. A real-time 3D dynamic visualization of thermal comfort was presented along with the calculation of optimal temperature to ensure ideal indoor thermal comfort.

Gaikar Vilas Bhau et al. [12] aimed to maximize the output power from solar energy, thus making renewable energy resources a viable alternative to the present conventional fossil fuels for electricity generation. Here, lithium battery was used as an energy storage device for solar photovoltaic (PV) panel. Also, a voltage sensor was used to detect electrical or optical signals. They presented a comparative profile of current, voltage and temperature with respect to time. If any deviation is seen from the expected profile, the defects may be rectified on time. The PV panel's capacity could then be calculated from the data monitored by the sensors. Chang-Sic et al. [13] developed, prototyped with Arduino Mega, and implemented a system for monitoring renewable energy. The system monitored the quantity of energy generated from renewable energy sources such as solar energy, wind, and nuclear energy. It aimed to know the quantity that is effectively utilized.

Mustafa A. Omran et al. [12] configured the server automation framework of their smart home automatic system (SHAS) with the Raspberry Pi 3 Model B+ and the Arduino Mega 2560. In addition, Blynk app was used to send notifications to the house owners over WiFi. The various sensors connected to the Arduino Mega controller kept track of current, voltage, power, frequency, humidity, temperature, smoke/flame, gas leakage, etc. Thus, this kind of technology enables users to keep an eye on electricity consumption and save on energy costs by switching OFF the appliances when not in use.

Digital twins for smart manufacturing [14] are currently being designed and implemented based on open-source technologies made accessible on platforms like Arduino. The design and implementation of a sonde, which is otherwise very costly, can be made cost-effective with the help of Arduino[15]. This system was created using Arduino Mega and Arduino Uno boards and was proven to work well. Arduino may also be used to deploy a system that manages the laboratory sterilizing process autonomously[16]. B. Mondal et al. [17] have built a quantitative recognition of combustible and hazardous gases using an embedded platform like Arduino and artificial neural network (ANN).

IV. ANDROID APP

Using Android Studio, we built an app that can communicate with Arduino, get the readings and display them on the app. The Bluetooth module, HC-05, is used to communicate and transfer data from Arduino to the app or vice-versa.

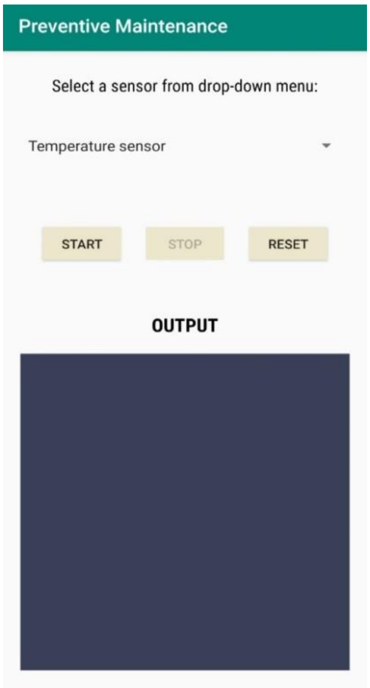


Figure 1: UI design of our app with component tree

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Working of the application

1. Once the app is installed on Android device, it is to be ensured that Bluetooth is switched on and HC-05 is paired.

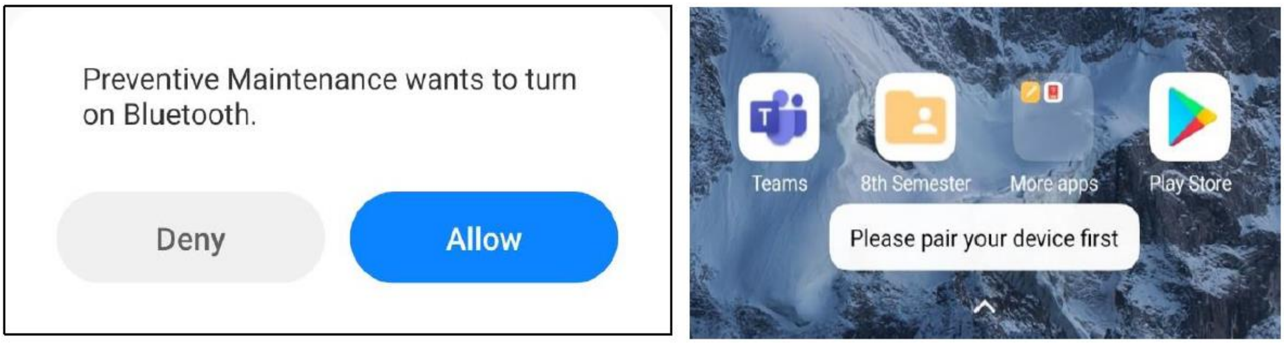

Figure 2: Android device needs to be paired to the Bluetooth module

2. In order to pair a device with HC-05, a pin needs to be entered. The pin is usually 0000 or 1234.

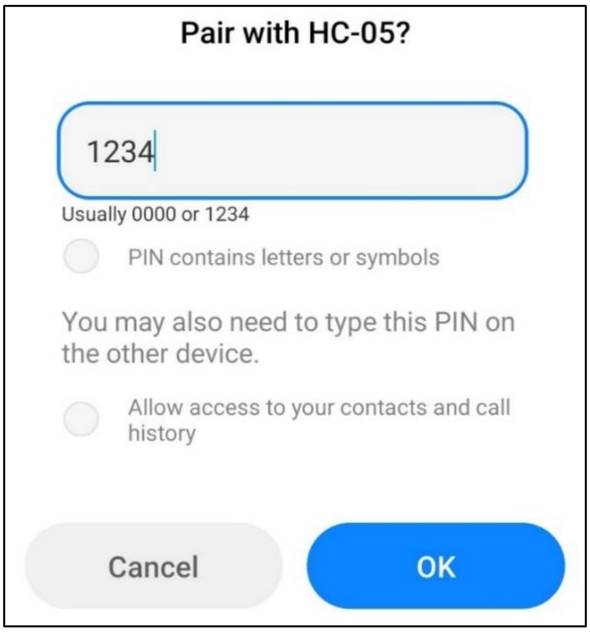

Figure 3: The screen that is shown on the device while pairing HC-05.

3. Once the device is successfully paired, the application is ready to receive data from Arduino over Bluetooth.

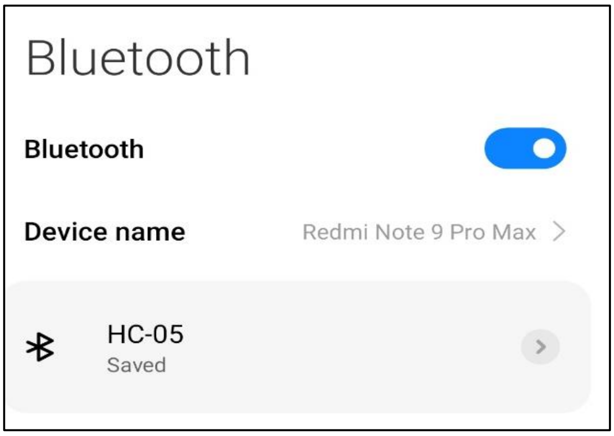

Figure 4: Android device paired with HC-05

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4. You need to select one of the four sensors from the drop-down menu to read temperature, humidity, distance to target (ultrasonic) or vibration.

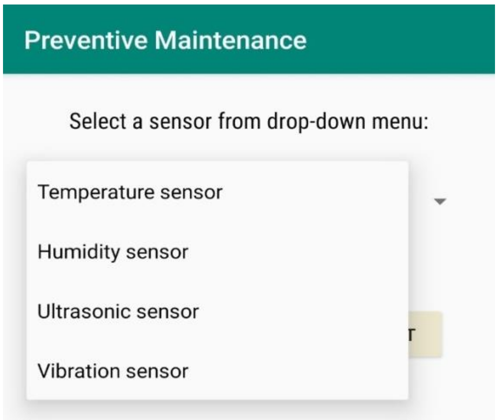

Figure 5: A spinner displaying the available choices from array

5. Once a sensor is selected, you need to click on START button to send that choice to the Arduino and receive the corresponding readings from the sensor serially.

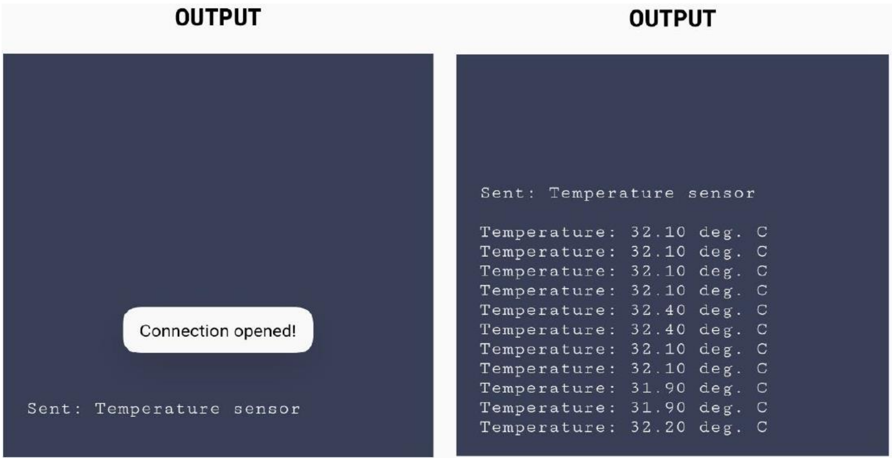

Figure 6: Temperature readings (from DHT11 sensor) being printed on output window

6. As the data is continuously received, the TextView will automatically scroll down for you to keep track of the latest readings. If you want to stop receiving the data, simply click on STOP button.

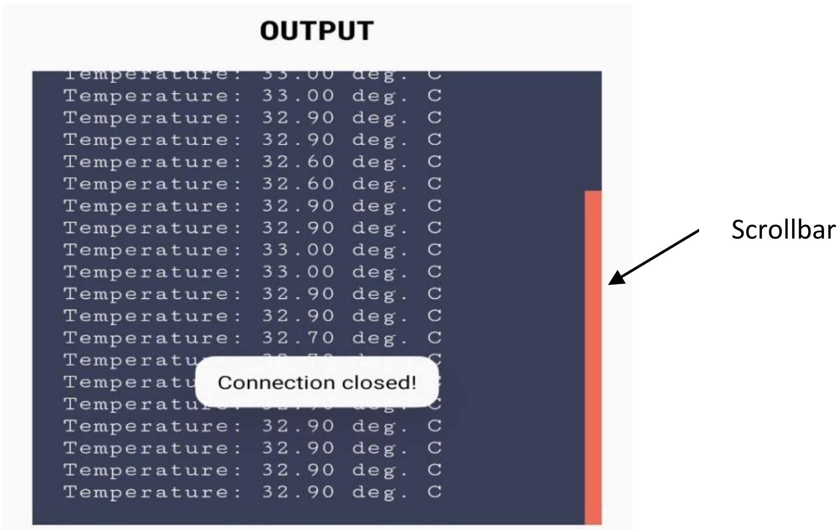

Figure 7: I/O stream closed and app stops receiving data from Arduino

7. We have also added a functionality of push notification to our app which will alert the user to take appropriate action whenever a parameter value exceeds its predefined threshold.

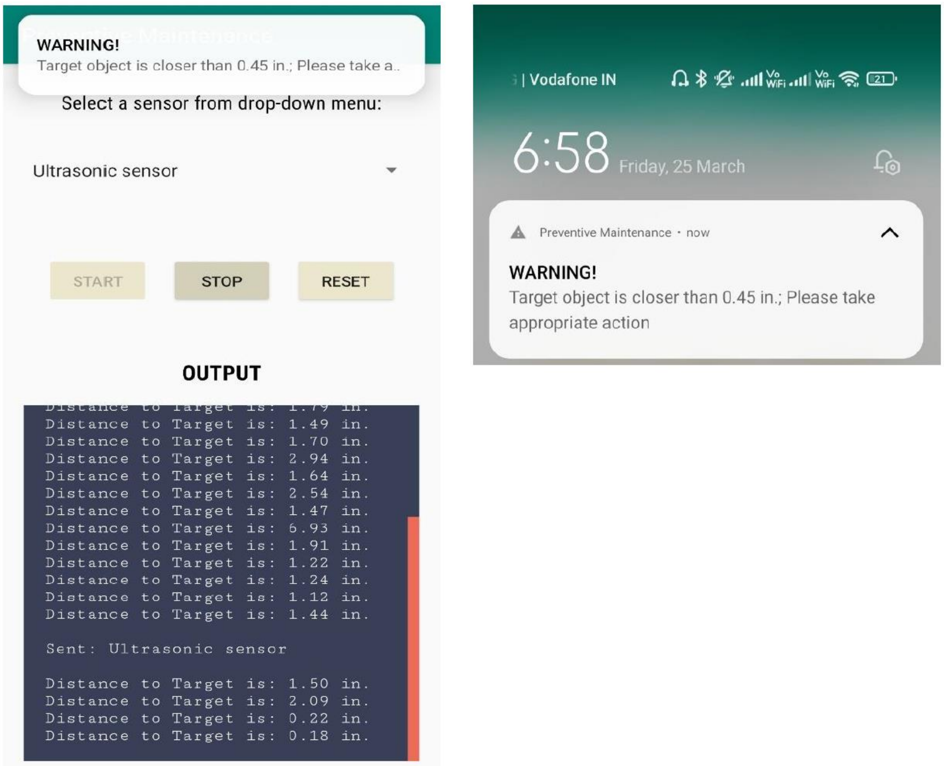

Figure 8: Notification as seen in case of ultrasonic sensor when distance to target becomes less than 0.45 inches

8. Clicking on RESET button will take the app back to its initial state.

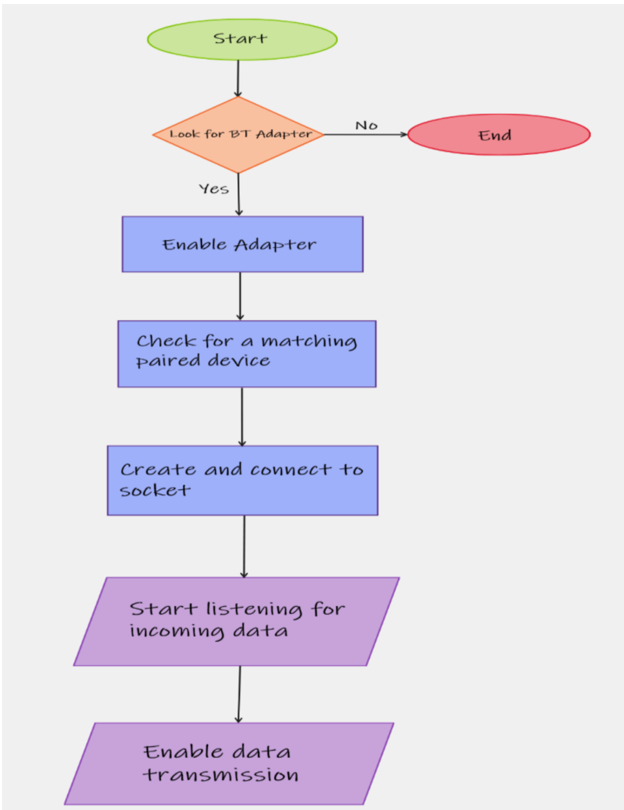

Figure 9: Block diagram/description of modules of the app

V. CIRCUIT DIAGRAM

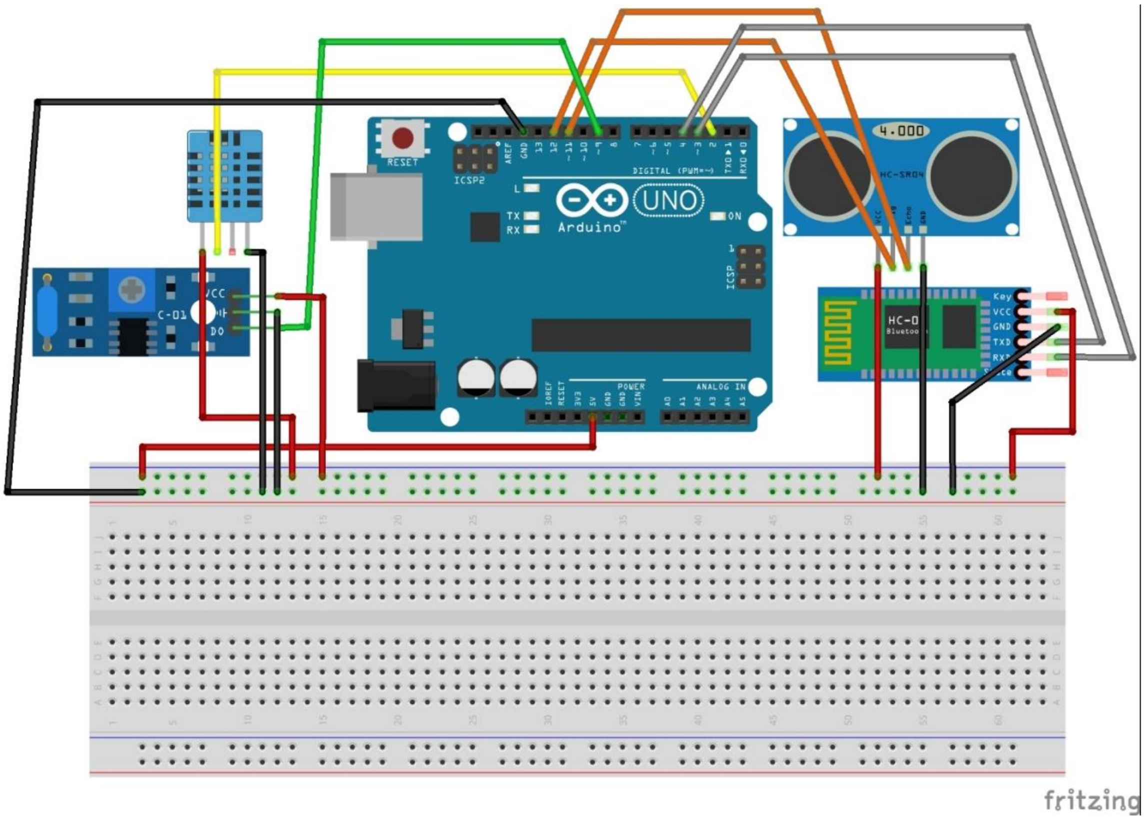

Figure 10: The circuit diagram above shows all the connections and devices used for this project.

VI. CONCLUSION

This is the start of the big project to develop a machine monitoring system. The approach towards preventive maintenance is smaller compared to the problem. However, it's just the beginning. Once the health of the machine is closely monitored, unexpected downtimes can be tremendously reduced. This could not only increase machine efficiency but also aid to save billions of dollars used to fix machines and experience bottleneck situations in production lines.

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