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PREDICTION ANALYSIS OF AQI FOR MINERAL MINES TO SAVE THE WORKERS LIFE USING INTELLIGENT SYSTEM

Aayush Sharma, JK Lakshmipat University, India (ayushsharma@jklu.edu.in)
Gireesh Kumar, JK Lakshmipat University, India (gireesh8@gmail.com)
Richa Sharma, JK Lakshmipat University, India (aligarh.richa@gmail.com)

ABSTRACT

The proposed system predicts the air quality index (AQI) of harsh mining conditions to reduce the number of heart and pulmonary diseases among the workers. In this study, we analyze the prediction of AQI which has been challenging task in past. A harsh mining environment depends on various parameters like temperature, humidity and pollution. At the same time, monitoring, predicting and modeling is more relevant in mining sectors, due to the severe impact on human health. In this study, we use machine learning (ML) and Internet of Things (IoT) to predict the AQI of the mining area by using a machine learning algorithm. The system predicts AQI by considering various parameters which further help to take the necessary steps by making changes in work patterns. The system directly impacts the working efficiency of the workers, which lead to economic growth without compromising the health of human beings.

Keywords: NodeMCU, Wi-Fi, IoT, ML, AQI.

1. INTRODUCTION

Economic development of the nation leads to increasing the environmental pollution problem. Indian Mining Industry is one of the most important mineral producers around the globe. The export of minerals leads to an increase in the economic growth of India. Major minerals produced by the Indian mining industry are chromite, coal, iron ore, and bauxite. Minerals play as a backbone for the economic growth of any nation (Sahoo et al., 2014). For a long time, continuously getting evidence of illegal mining practices leads to human exploitation and environmental pollution.

Particularly air pollution from mining directly impacts human health (Entwistle et al., 2019). The main causes of air pollution are exhaust gases from mining vehicles, fires, and dusty environments. The nature of Mining Industries loses thousands of human lives and wealth (Pandey et al., 2014). Environmental condition seriously impacts worker's health by increasing the number of cases pulmonary and heart diseases. High temperature (50 Degree Celsius in Summer) causes dehydration and also leads to accidents. Recent studies and surveys has been shown that air pollutions caused by the mining process increase pulmonary disease cases among the Nearby villagers (Aggarwal et al., 2020).

In earlier days, the systems were mainly designed to counter the danger from any disaster and accidents. The Control Management System (CMS) was designed to countermining dangers, but it is not efficient and consumes more power and easily gets frequently damaged due to the worse environmental conditions. After that, device-to-device communication technology is used as a better alternative, and it uses Zigbee protocols for communication. The major limitation with Zigbee is the limitation of communication distance. Later, wireless technologies like nRF24L01 were used for communication between the devices for constructing wearable devices (Maheshwari et al., 2019).

Currently, IoT enabled system used for measuring temperature, humidity, gas, and smoke, during emergency conditioned it will generate alarm (Venkata et al., 2019). Workers' health monitoring system is used for measuring workers' health conditions and tracking mechanism help to track the worker during any industrial accident. Technology generally based on the wireless system and RFID (Deshmukh, 2017). All the currently available solutions are health centric.

In a country like India, major accidents do not happen in the minefields every day but mining conditions harm the worker's health regularly. Workers have to spend more than 5 hours without any break in the mining field. There is a requirement of the system which predicts the air quality by using real-time data to minimize the harsh impact of pollution on human health. Our proposed system is based on IoT and uses a machine-learning algorithm for predicting the AQI. Various applications of IoT already exist in our real world. The IoT system can be scale as per the requirement of the project. Our system uses sensors to collect the data and send it to the cloud (adafruit) with the help of ESP8266. Data will be fetched from the cloud and use for a machine learning approach to predict the air quality. The objective behind the proposed system is to analyze the real-time data and reduce the number of diseases among the mineworkers. The prediction helps to take necessary steps as per the situation to maintain the worker's health and company economic growth.

2. PROPOSED SYSTEM

The proposed system is divided into two parts. one is Data Collection Unit (DCU) and the other is Monitoring Workstation. The Fig. 1 represent the graphical representation of the proposed system. In Fig. 1, the main objective of the DCU is to collect data and upload it on the cloud and the Monitoring Workstation contains different stages for fetching the store data from the cloud, processing the data, and implementation of the prediction of the AQI.

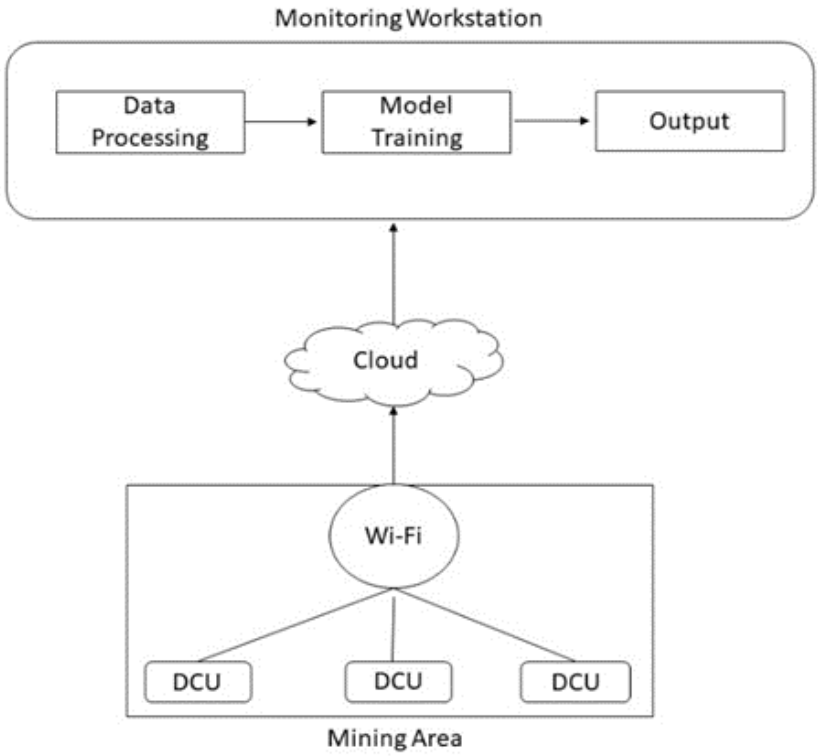

Figure 1: Representation of Proposed system

The proposed system is designed by considering various mining environmental conditions. DCU consists of various sensors for collecting temperature, humidity, and AQI data. Each DCU is powered by batteries or through the grid. Bunch of DCU uploads data on the cloud through Wi-Fi mode of transmission. Due to the physical conditions of mines, Wi-Fi Routers helps to make the system more effective and economically sustainable.

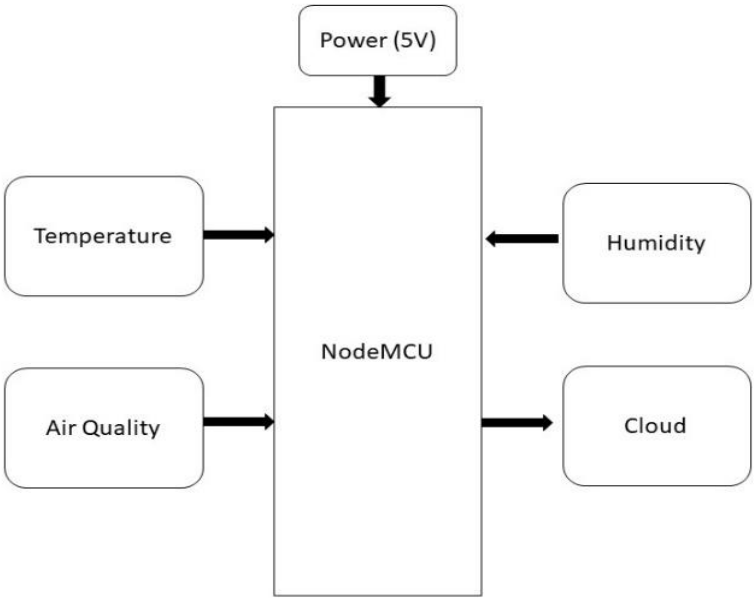

Figure 2: Representation of the DCU

Fig. 2 represents the systematic representation of the DCU. Adfuit.io is used as a cloud platform for storing data. At monitoring workstation, stored data goes from various data processing techniques to increase the model accuracy. Fig. 3 represents the process flow of the proposed system. DCU collect data from the mining areas and upload on the cloud through the private network. Mining areas have irregular landscape patterns and physical barriers. Considering environmental and physical factors help to make the proposed system more reliable. Data processing is a crucial part to remove the noise from the data, which helps the model to predict the result more accurate.

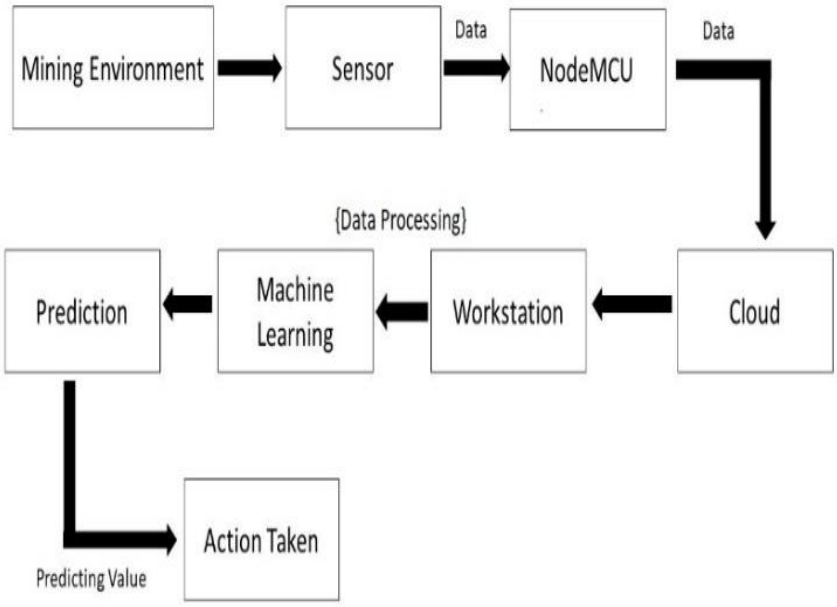

Figure 3: Proposed System Block Diagram

A. Hardware Description

For the development of hardware, different sensors were used to generate the data. Fig. 4 shows 2 sensors used for the construction of the DCU. Both the sensors play the important role for capturing the data. Detail description and the usage of the hardware component mentioned below:

- DHT11

The DHT11 is a digital temperature and humidity measuring sensor. It is basic and low-cost temperature sensor. For measuring humidity, it uses capacitive humidity sensor and thermistor to measure the air divide the signal on the data pin. It easily interfaces with other microcontrollers. The sensor measures temperature from 0°C to 50°C and humidity from 20% to 90%. Fig. 4 shows the picture of DHT11.

- MQ135

The MQ135 sensor is a air quality sensor for detection of different gases. Different gases that can be detected from the sensors are NH3, NOx, alcohol, benzene and carbon dioxide. This sensor is highly sensitivity to smoke and many harmful gases. Fig. 4 represents the image of MQ135.

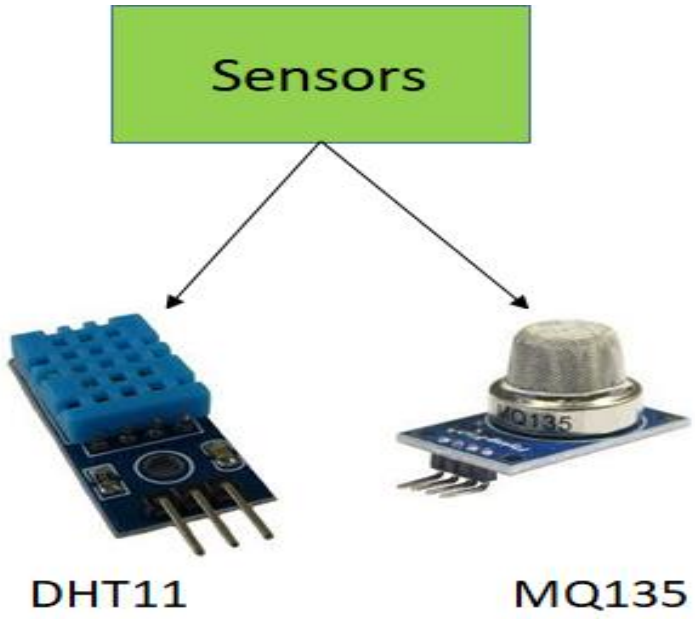

Figure 4: Types of sensors used

- NodeMCU

NodeMCU is a open source platform for IoT. It contains ESP8266 Module. It support with the Arduino IDE for uploading the code. The C or C++ language can be used for writing the code.

- Circuit Diagram

DCU is electronic device which designed according to the physical environment of the mining area and the need. Fig. 5 represents the circuit diagram of the DCU. All the wire connections of the sensors with the NodeMCU were highlighted by the suitable colors. In a Fig. 5, color lines represent the wires.

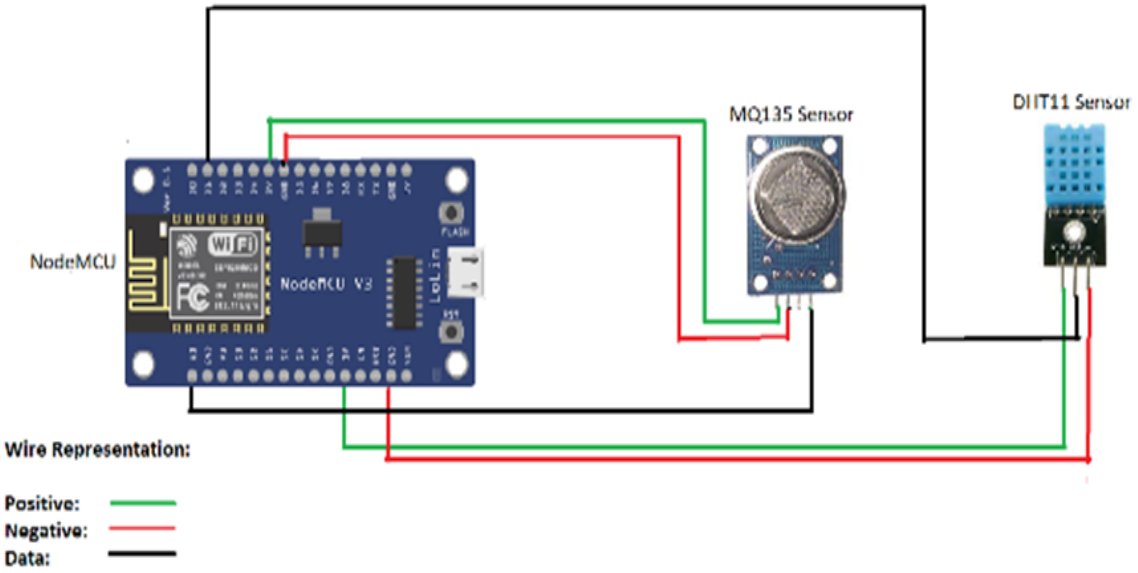

Figure 5: Circuit Diagram for DC

4. ANALYSIS

Analyzing the data help to understand more about the parameters and find out the meaning full outcome. For the further process, Data collected by DCU goes through data processing before model training.

A. Dataset and Preprocessing

The dataset contains various parameters; each parameter plays an important role in the analysis. A prototype of DCU is used for collecting real-time data. Further, a document "Action plan for maintaining the AQI of Raukela" consists of the in-depth analysis of the impact of AQI on local life used as a reference to enhance the quality of the dataset (https://cpcb.nic.in/Actionplan/Bhubaneswar.pdf).

Table 1: Dataset

Date	Time (HH:MM)	Temperature	Humidity	AQI
12/6/2021	00:15	285	40	45
12/6/2021	00:30	28.5	40	47
12/6/2021	00:45	28.5	40	45
12/6/2021	01:00	28.5	40	44

In Table 1, the Column covers or represent all the basic parameters required for prediction. Measured parameters are Temperature, Humidity, and Air Quality Index. The time difference between each row is 15 min. Quality data and its representation play an important role in building a model. Data processing procedures impact the generalization ability of a machine learning algorithm. Data processing procedures generally consist of steps like missing values interpretation, modifying outliers, data transformation, and feature engineering.

B. Model Training

In the previous step, data is collected from DCU for training purpose. In this dataset, different parameters are time, humidity, temperature and AQI. Before applying the data, processing steps on data, unwanted columns has been removed from the dataset like “Date” and “Adafruit.io ID”.

In next step, test the dataset on different Machine Learning models for three different parameters: Temperature, Humidity and Air Quality Index. This will help to understand the behaviors of the data. While training a dataset, algorithm will give the Root Mean Square Error or RMSE value. Lowest value shows the most accurate model for that particular dataset.

Table 2: RMSE value of different models	
Algorithm	RMSE Value
Linear Regression	0.9
Support Vector Machine	11.55
Decision Tree	6.26
Logistic Regression	49.99

Table 2 shows the RMSE value of the different models. Linear regression having the lowest RMSE value as compared to the other models. It means linear regression is the fit for dataset.

Linear regression helps to understand the impact of the change in the dependent variable when the variation comes in the value of the independent variable, while other variables remain fixed. Linear regression is based on supervised learning and performs regression tasks.

Linear regression predicts the dependent variable value (y) based in the independent variable (x). Hypothesis function for the linear function can be written as below:

$$y = \theta_1 + \theta_2 . x$$

Where,
x: Represents input training data
y: Represents labels to data (supervised learning)
θ_1: intercept
θ_2: coefficient of x

The model fits the best line to predict the value of y for a given value of x. best regression fit line by finding the best θ_1 and θ_1 values. In the regression analysis, the AQI is set as the (Y) dependent variable, and Time is assigned as the independent variable (X).
Considering the obtain results from the model for the parameters. Predict values will be categorized from the AQI table defined by Environment Protection Agency (EPA). Table 3 represents the 6 AQI categories defined by EPA.

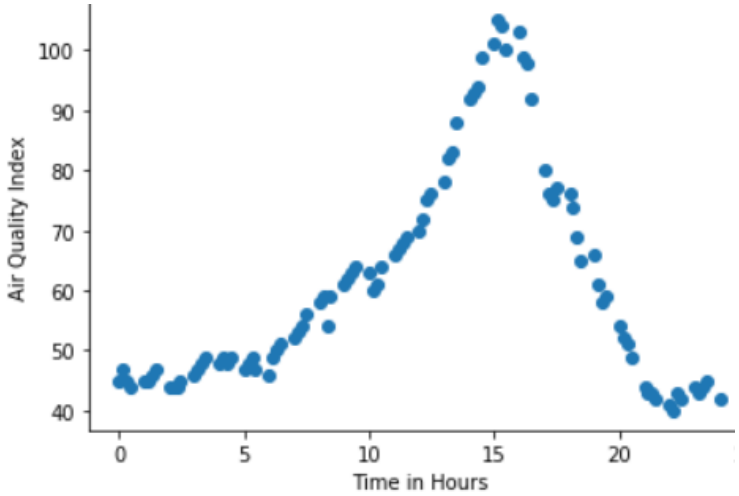

Figure 6: Predicted Air Quality Index

Table 3: AQI defined by EPA

Air quality index value range	Levels of health concern
0 to 50	Good
51 to 100	Moderate
101 to 150	Unhealthy for sensitive groups
151 to 200	Unhealthy
201 to 300	Very unhealthy
301 to 500	Hazardous

5. RESULTS AND DISCUSSIONS

This section describes detail analysis of the considered model. For analyzing the data, python and Jupyter notebook has been used. Heat map and scatter graph are plotted for presenting the data in the effective manner. Table 4 represents the predicted AQI. As we can be observed from table that AQI is 64, and predicted AQI is 60.09 at 10:00 AM. Fig. 7 shows the relation between the AQI and Humidity values. As per the Fig. 7, increasing in humidity leads to lower down the value of the AQI. Low values of the AQI shows the healthy air. Fig. 8 shows the relation between the AQI and Temperature. As per the Fig. 8, increment in temperature leads to increase the value of AQI. Exhaust from mining vehicles, improper ventilation system and bad mining practices are the main causes of bad air quality in high temperature.

Table 4: Predicted AQI

	Time	Air Quality Index	Predicted Air Quality Index
0	17.00	80.0	63.914424
1	10.45	64.0	60.092618
2	2.45	45.0	55.424764
3	20.15	52.0	65.752392
4	19.00	66.0	65.081388
5	4.45	49.0	56.591727
6	19.30	58.0	65.256433
7	1.00	45.0	54.578715
8	19.15	61.0	65.168910
9	18.30	69.0	64.672951
10	17.45	77.0	64.176991

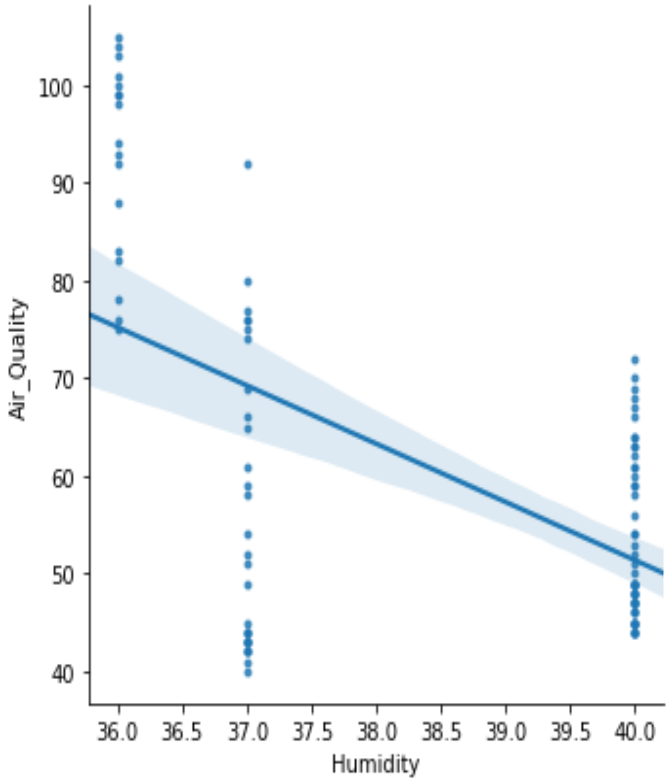

Figure 7: Scatter Plot between Air_Quality and Humidity

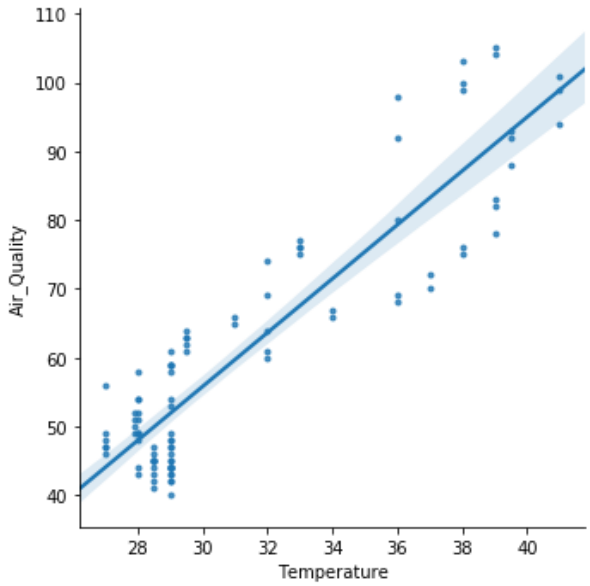

Figure 8: Scatter Plot between Air Quality and Temperature

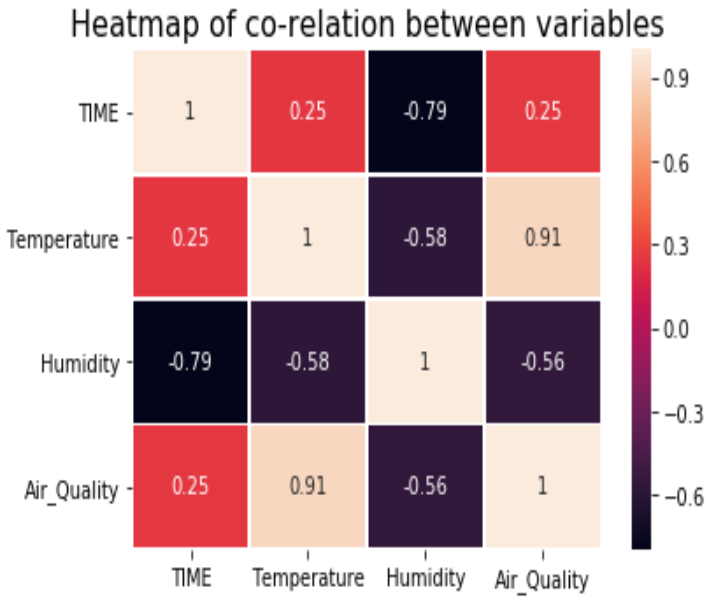

Figure 9: Co-Relation Heat Map

Fig. 9 depicts the relation between the values dependent on the independent values using heat map. According to the result in Fig. 9, the operator can adjust the work pattern to minimize the exposure of workers in the harsh mining conditions. As per Table 3 if the AQI is more than 100, then necessary action will be taken to reduce the number of diseases among workers.

6. CONCLUSIONS

The present mining environment conditions getting worse every day. Workers are playing an important role for running the mining industry. Making mining environment healthy through latest technology by predicting various parameters like air, temperature and many more is necessary. These parameters directly impact the workers' health.

This study uses the real-time approach for predicting the AQI. The regression model can be used by the operator at the Monitoring Workstation to predict the AQI for reducing the worker's exposure in harsh conditions. This will increase the mining capacity and economic growth.

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