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Air Quality Monitoring System: Predict Concentrations of Pollutants

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Abstract:
In this work, the system provides clear visualizations of air pollutants details (NO_2, PM_{25}, P M_{10}, SO_2, CO and O_3) in our environment and list outs the diseases that may affect living beings by considering the concentration levels of each pollutant. In addition to that our system also recommends some overcome measures to reduce levels of poisonous air pollutants which are gradually increasing. So that Government can monitor pollutants concentrations over a period of time and take control measures to make the world pollution-free. It also prognosticates hourly concentrations of air-pollutants by training the model with historical data and calculate AQI values by using respective concentration levels. We prognosticate air-pollutant concentrations by using some machine learning concepts, which yields an efficient model to predict the values by training the model with a large amount of historical data. There are many models proposed by many others to predict air-quality by applying simple standard Regression models using both linear and non-linear. Here we consider it to be multi-task learning and applied various regularization routines to list out the efficient model which can forecast concentration levels of pollutants.

Keywords: *Air pollutants, AQI, prediction, Regression model, Multi task learning and Regularization*

I. INTRODUCTION

Environmental pollution causes many issues that people are suffering now. It includes pollutions like air, water, noise and soil. Among those, air pollution has direct impact on human well-being [1]. Atmospheric pollution is typically caused by excess gases such as carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter (PM_{25}, PM_{10}) and ozone (O_3), etc. Human health is primary concern due to atmospheric pollution, predominantly in non-rural areas. Leading originators of air pollution are vehicles, firms, power plants, Metallurgic ores, volcanic eruptions, industrial emissions etc. O_3 ratio increases beyond 10 ppb which might cause to demise [2,3]. If the CO ranges are between 150 to 200 parts per million which is hazardous to lives, it may cause disorientation, unconsciousness and deaths are possible [4]. For each pollutant, if it crosses its normal range of concentrations then it definitely results in a major issue to human health.

Since human health is a major concern, the public should have proper awareness about what are the problems that people may suffer due to air pollution.

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So, prognostication may help to turn down consequences of atmospheric pollution on surroundings by taking some precautions.

Previously proposed systems prognosticate air quality using straightforward approaches like box models [5], Gaussian models [6] and linear statistical models [7,8].

Implementation and prognosis can be conveniently done in these models. Typically, however, they do not define the interactions and nonlinear relationships that govern pollutant transport and behaviour in the atmosphere [9].

With these challenges, machine learning methods originating from the field of artificial intelligence have become popular in air quality forecasting and other atmospheric problems [10].

In our system, we prognosticate hourly levels of pollutants and list out diseases that public may suffer.

It also suggests some overcome methods to reduce the hazardous concentration levels of air pollutants. We mainly focus on 6 major air pollutants such as NO_2, PM_{25}, P M_{10}, SO_2, CO and O3 which are a dangerous threat to human health.

II. System to Measure and Recover Concentration Level of Pollutants

We collect air quality data from Breezo meter API and meteorological data from websites [11].

A. Procedure followed to measure the concentration levels of pollutants

- Obtain historical air pollutant concentrations data from each zone from the Breezo meter API that will deliver information in JSON format. Isolate relevant content from JSON response.

Request the Breezo meter API [12] by providing longitude, latitude of area and date for which you need historical data.

- Calculating AQI (Air Quality Index) values for each pollutant.

AQI of p = $\frac{I_{max} - I_{min}}{C_{max} - C_{min}} * \left(C_p - C_{min}\right) + I_{min}$

where p : pollutant

C_p : pollutant (p) concentration
C_{min} : concentration break point <= C_p
C_{max} : concentration break point >= C_p
I_{min} :index breakpoint related to C_{min}
I_{max} : index breakpoint related to C_{max}

For concentration and index breakpoints, consider the Table-I.

- Consider the pollutant which is having less AQI value as dominant pollutant of the day of that particular area.

Table-I: Break point values [13]

CATEGORY (RANGE)	PM_{10} ($\mu g/m^3$) (24-hr)	$PM_{2.5}$ ($\mu g/m^3$) (24-hr)	NO_2 ($\mu g/m^3$) (24-hr)	O_3 ($\mu g/m^3$) (24-hr)	CO ($\mu g/m^3$) (24-hr)	SO_2 ($\mu g/m^3$) (24-hr)
GOOD (0-50)	0-50	0-30	0-40	0-50	0-1	0-40
SATISFACTORY (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80
MODERATE (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380
POOR (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800
VERY POOR (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600
SEVERE (401-500)	430+	250+	400+	748+*	34+	1600+

B. Air Pollutants ranges and their effects on human health

By using the following ranges charts, we can provide health issues that people may suffer due to respective concentration levels of air pollutants in the air. We collect this data from [14].

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Table-II: Concentration ranges and effects of pollutants

CO		
Range	**Category**	**Effects**
0.2ppm	Normal	People with heart problems are likely to suffer from more frequent and longer angina attacks, and they would be at greater risk of heart attack. Children and unborn babies are particularly at risk because they are smaller and their bodies are still growing and developing.
1 to 70 ppm	Moderate	People are uncertain, but most people will not experience any symptoms. Some heart patients might experience an increase in chest pain.
> 70 ppm	Unhealthy	Symptoms may become more noticeable (headache, fatigue, nausea).
150 to 200 ppm	Hazardous	disorientation, unconsciousness, and death are possible.

NO2		
0-50 ppb	Normal	No health impacts are expected when air quality is in this range.
51-100	Moderate	Individuals who are unusually sensitive to nitrogen dioxide should consider limiting prolonged outdoor exertion.
101-150	Unhealthy for Sensitive Groups	The following groups should limit prolonged outdoor exertion: • People with lung disease, such as asthma • Children and older adults
151-200	Unhealthy	The following groups should avoid prolonged outdoor exertion: • People with lung disease, such as asthma • Children and older adults Everyone else should limit prolonged outdoor exertion
201-300	Very Unhealthy	The following groups should avoid all outdoor exertion: • People with lung disease, such as asthma • Children and older adults Everyone else should limit outdoor exertion.

SO2		
0 - 0.1 ppm	Normal	
0.1 - 0.2 ppm	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.
0.2 - 1	Unhealthy for Sensitive Groups	Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.
1.0 - 3.0	Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.
3.0 - 5.0	Very Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.
> 5.0	Hazardous	It irritates the nose, throat, and airways to cause coughing, wheezing, shortness of breath, or a tight feeling around the chest. The effects of sulfur dioxide are felt very quickly and most people would feel the worst symptoms in 10 or 15 minutes after breathing it in.

C. Overcome methods to reduce concentration levels of each and every pollutant [15,16,17]

1. Carbon monoxide:
   - Maintain correctly calibrated gas appliances.
   - Increasing horticulture.
   - Drive Less - Drive Smart.
   - Buy products that are fuel efficient.

2. Sulphur dioxide:
   - Transfer fossil fuel plants to lower sulphur fuels.
   - Increased productivity in changing fuel to electricity which will decrease outpouring per unit output.
   - eradicate sulphur from coal prior to combustion.

3. Nitrogen dioxide
   - Transport mode shift (bicycle and pedestrian infrastructure expansion included)
   - Have less nitrogen fertilizers and pesticides
   - Enrich mass transit especially in non-rural area

To forecast the quality of air, we contemplate this as multi task learning problem [18] and apply various regularization methods [19]and identify appropriate one that will result efficient model and give accurate results.

Advantages

- It prognosticates future air-quality and list outs health issues that people may suffer due to high concentrations of air pollutants.
- Government can monitor concentration levels over a period to protect the environment.

1. It suggests few overcome methods for limiting pollutant density to make environment pollution free.

III. Results

We get raw data such as hourly concentrations of each pollutant. Here we calculate AQI valuesusing concentrations with the help of breaking point table[19]. After calculation of AQI values for each pollutant, list out the dominant pollutant by using above methods.

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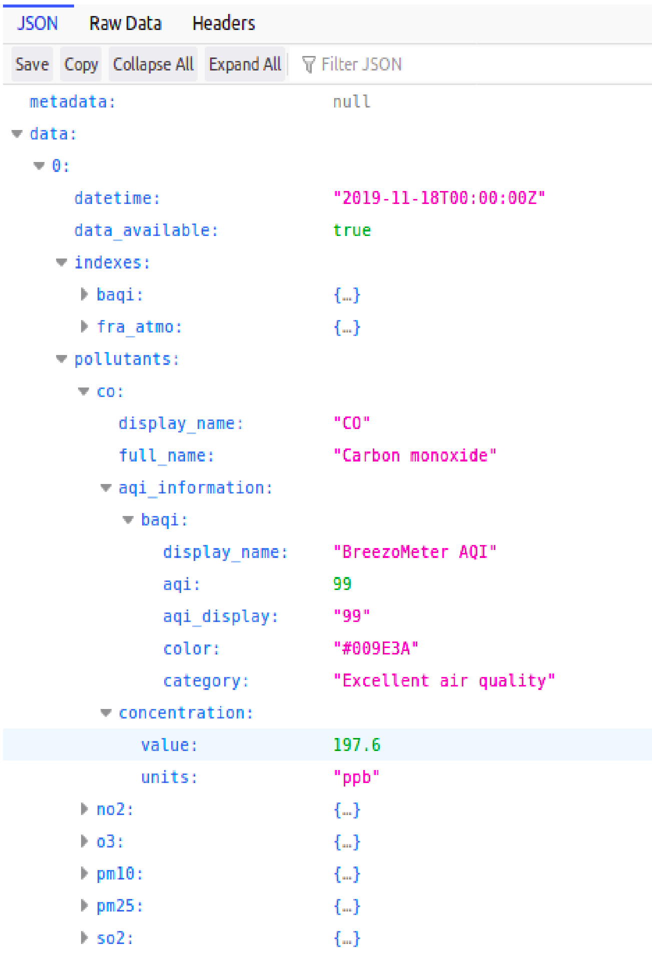

Fig. 2. Dominant Pollutants

IV. Conclusion

This work gives clear envision of air contaminator details in our environment and list outs diseases that people may suffer based on concentration levels of air pollutants. This system provides some overcome methods to reduce concentration levels of toxic pollutants which are rapidly increasing day by day. It also forecast future hourly concentration of air pollutants by using machine learning model which was developed using multi task learning and regularization method by training with historical data**.**

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