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A Survey Paper on Spatial - Temporal Outliers Influencing Air Quality

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Abstract:- *Air quality is estimated using various parameters which vary with space and time i.e., which are spatio-temporal. An object that has at least one spatial and one temporal property can be defined as a spatiotemporal object. The spatial properties are location and geometry of the object. The temporal property is time interval for which the object is valid. The spatio-temporal object usually contains spatial, temporal and thematic or non-spatial attributes. This survey paper focuses on spatio-temporal data influencing air quality of heavily polluted regions called hotspots over a period of time, also identifying the parameters which cause movement of pollutants. Based on dataset, effect of these outliers on air quality at the point of origin and their influence on the surrounding regions because of movement of pollutants which are denoted as outliers throughout the paper leading to the changes in air quality of those regions is summarized.*
Keywords:- *Air Pollution Spatial Mining, Anomaly Detection, Imbalanced Data.*

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I. INTRODUCTION

Increasing in road traffic and industrial areas has adversely affected environmental air quality. Such areas are considered as hotspots throughout this paper. This survey is focused on these hotspots affecting air quality at the point of time and space of outlier emissions based on the spatio-temporal outlier dataset, parameters responsible for pollutants movement and influence of these outliers in surrounding regions. Measurements will be based on month's period of time and resolution of data covers bits of information on one-day scale. On the other hand, outlier detection is a emerging field, which has lot of significance due to increasing amount of spatio-temporal available and the need to interpret it. Spatial properties are location of object and temporal properties are time intervals for which object is valid. Applying spatio-temporal dataset patterns to hotspots' influence on air quality helps to understand the physical phenomenon behind them. This survey progresses by classifying this paper into various sections as follows understanding the air quality estimating parameters, Methods used to detect air quality index, Data collected on some hot spots, case study on AQI of Uttarakhand, spatio-temporal outliers influencing other regions, analysing the air qualities of hotspots and effected regions, some proposed hotspot prevention methods for balance in sustainability of useful air quality.

Understanding air quality estimating parameters:

Hotspots are heavy traffic zones and industrial areas. These heavy traffic zones emit greenhouse gases like CO, CH4, N2O. Also acidifying compounds like NOX emissions and SO2, gases causing photo chemical smog like NOX, VOCs, CH4 and CO, local air pollutants CO, VOCs, SO2, CO2, lead compounds and PM10. It is taken that level of air pollution because of these parameters is proportional to traffic intensity. NO2 and PM10 spread is mainly governed by horizontal/ vertical movement of air and their corresponding speed and direction. The measured parameters and changes of air pollution are closely tied with nature and patterns of air flow. Air quality is easily understood and communicated with parameter called as AQI which is air quality index. It is a single number which weighs all the values of outliers. Eight parameters PM10, PM2.5, NO2, SO2, CO, O3, NH3 and Pb having short-term standards have been considered for near real-time dissemination of AQI. Green Index, Fen Stock Air Quality Index, Ontario API, Oak Ridge Air Quality Index, Greater Vancouver Air Quality Index, Most Undesirable Respirable Contaminants Index are indices used to measure AQI.

1.Methods Used To Detect Air Quality Index

A. Green Index (GI):

One of the earliest air pollution indices to appear in literature was proposed by Green (1966). It included just two-pollutant variables - SO2 and COH (Coefficient of Haze). The equations to calculate the sub indices were:

ISO2 = 84 *X0.431

ICOH = 26.6 *X0.576

Where,

ISO2 = Sulphur dioxide sub-index

ICOH= Coefficient of Haze Sub-index

X = Observed pollutant concentration

The Green Index is computed as the arithmetic mean of the two sub-indices:

GI = 0.5 * (ISO2 + ICOH)

The above equations are obtained from the break point concentration shown

Index	SO2	COH	Descriptors	Remarks
0-25	0.06	0.9	Desired Clean	Safe Air
25-50	0.3	3.0	Alert Potentially	Hazardous
50-100	1.5	10.0	Extreme Curtail	Air Pollution Sources

B. Fenstock Air Quality Index (AQI):

Fenstock (1969) proposed an index to assess the relative severity of air pollution and applied it to assess AQI of 29 U.S cities. This was the first index to estimate air pollutant concentrations from the data on source emissions and meteorological conditions in each city:

AQI = Wi Ii

where, Wi = weightages for CO, TSP and SO2

Ii= estimated sub-indices for CO, TSP and SO2

This index is applicable to square urban area with wind always parallel to one side for uniform meteorological conditions under neutral stability with continuous source distributed uniformly. This AQI is not used for daily air quality reports but for estimating overall air pollution potential for a metropolitan area.

2. Indian Air Quality Index (IND-AQI): Proposed System

Air quality standards are the basic foundation that provides a legal framework for air pollution control. An air quality standard is a description of a level of air quality that is adopted by a regulatory authority as enforceable. The basis of development of standards is to provide a rational for protecting public health from adverse effects of air pollutants, to eliminate or reduce exposure to hazardous air pollutants, and to guide National / local authorities for pollution control decisions. With these objectives, CPCB notified (http://www.cpcb.nic.in) a new set of Indian National Air Quality Standards (INAQS) for 12 parameters [carbon monoxide (CO) nitrogen dioxide (NO2), sulphur dioxide (SO2), particulate matter (PM) of less than 2.5 microns size (PM2.5), PM of less than 10 microns size (PM10), Ozone (O3), Lead (Pb), Ammonia (NH3), Benzo(a)Pyrene (BaP), Benzene (C6H6), Arsenic (As), and Nickel (Ni)] . The first eight parameters have short-term (1/8/24 hrs) and annual standards (except for CO and O3) and rest four parameters have only annual standards.

Pollutant	SO2	NO2	PM2.5	PM10	O3	CO(mg/m3)		Pb	NH3
Averaging time	24	24	24	24	1	1	24	24	
Standard	80	80	60	100	80	4	1	400	

Indian National Air Quality Standards (units: µg/m3 unless mentioned otherwise

IND-AQI Category and Range:

AQI category	AQI range
Good	0-50
Satisfactory	51-100
Severe	101-200
Poor	201-300
Very-poor	301-400
Severe	401-500

3. Data collected on some hot spots: Air Quality Index is a tool for effective communication of air quality status to people in terms, which are easy to understand. It transforms complex air quality data of various outliers into a single number (index value), colour. There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. Each of these categories is decided based on ambient concentration values of air outliers and their likely health impacts. Based on the measured ambient concentrations of a pollutant, sub-index is calculated, which is a linear function of concentration (e.g. the sub-index for PM2.5 will be 51 at concentration 31 µg/m3, 100 at concentration 60 µg/m3 and 75 at concentration of 45 µg/m3). The worst sub-index determines the overall AQI.

Of the total 56 cities covered for calculation of AQI during March 2016, 22 cities revealed good air quality, 38 cities revealed satisfactory air quality, 37 cities revealed moderate air quality, 14 cities indicate poor air quality, 5 cities showed very poor air quality and 2 cities indicate severe air quality. At present, continuous air quality monitoring stations are connected to the web-based system from 23 cities. Central Pollution Control Board has initiated National Air Quality Monitoring Programme (NAMP; manual monitoring system) in the year 1984. Under NAMP, three air pollutants viz., Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2) and Particulate Matter size equal to or less than 10 micron (PM10), have been identified for regular monitoring at all the locations. The NAMP network presently comprises 614 operating monitoring stations located in 254 cities/towns in 29 states and 5 union territories across the country. National AQI bulletin was calculated for the month of March 2016 for 13 states covering 56 cities at 128 locations / ambient air quality monitoring stations with 1131 AQI values.

II.CASE STUDY ON AQI

A. Uttarakhand:

No of cities: 2 (Rishikesh, Dehradun)

No of locations : 4 (Nagarpalika Parishad, B.S.N.L Bldg, Clock Tower, Rajpur Road, Himalayan Drug(ISBT))

Total no of observations: 26

The analysis of AQI values in Uttrakhand during March 2016 indicates that 65% AQI values are falling in Moderate category, 31%are in poor and 4%are in very-poor category. This indicates that the people in these areas have breathing discomfort for the sensitive people, people with lung, heart disease, children and older adults.

Pollutants Movement And Causes Of Spatio-Temporal Outliers Influencing Air Quality At Other Regions:

Pollutants travel thousands of miles from point of origin, whether they are dissolved in water, sorbs to particles and gases. It is known that the PBDE’s, flame retardants used in many industrial products, are transported for long distances through the atmosphere and can arrive to very remote places. Living organisms accumulate these pollutants which can have negative effects on their endocrine system.

The physical processes which transport outliers away from the source are advection, diffusion and dispersion. Advection is movement of outliers along with atmospheric air or water, they move with velocity of the medium until they change their phase otherwise their direction is altered. Time required to move a particle from one point at time t1 to other point at time t2 is $t2 - t1= L/V$. where L is length of movement and V is velocity of movement. Diffusion is the process through which pollutant molecules move through air or water. As the molecules move they strike molecules, mostly pollutant molecules strike air or a water molecule which alters the direction of pollutant molecules. Diffusion reduces the concentration of pollutants by spreading them out, wind current contributes to spreading. A pollutant sorbs on to soil is slowed down with respect to velocity of soil or air phase, this applies to PM10 which is called as retardation. This process helps to contain extent of contamination.

Tracking the movement of these chemicals through environment is a challenge. Depending on the parameter of interest different satellite and ground sensors would be used to monitoring the influx of outliers to a certain region. Geo stationary (geo synchronous) satellites often measure a large region several times an hour, while some polar arbiters measure a region twice daily. Highly visible regional plumes of dust, smoke, and urban haze can be seen with satellite sensors, while ground-based monitoring of air pollutants such as fine particulates, SO2, and toxics occurs at the local level. Integration of these two kinds of measurements allows the user to remotely observe large environmental effects in many areas of the world, while obtaining more detailed information from ground-based monitors. Hence, the combination of satellite-based sensor data and ground-based monitoring data promotes greater understanding of the movement of outliers than either data set alone. Using integrated datasets can increase our ability to understand both the local and the long-distance influences and consequences of environmental events.

This kind of study helps to understand the areas which are getting affected because of hotspots and the study of air quality at the effected zones is carried out. Analysing the air qualities of hotspots and effected regions with the help of monitoring stations air quality at hot spots over a period of time is measured and by using above mentioned geo sensors and satellite data, affected regions because of hotspot pollution are identified and air quality is estimated for the same period of time. With this, the influence of outliers on surroundings is estimated and preventive methods for maintaining sustainable air quality at effected zones are taken.

Mainly, based on the direction of wind currents and geo graphical sites for the presence of river or lakes hotspots has to be selected in future. Places with heavy winds and water bodies must not be given to hotspots as they promote movement of pollutants to good air quality zones.

B. Case study on Punjab-Delhi incident:

In this incident punjab forest fires is considered as hot spot and movement of pollutants towards delhi shown in satellite image from punjab to delhi. Here delhi's pollution statestics are registerd on nov 3, 2016. Because of pollutants movement AQI of delhi is vastly effected and touched danger levels. Punjab has two growing seasons with two main crops. Rice is planted in May and grown through September; wheat is planted in November and grown through April. Since rice leaves behind a significant amount of plant debris after harvest, many farmers burn the leftover debris in October and November to quickly prepare their fields for the wheat crop. Due to burning of debris, the particle size matter travelled towards delhi along wind movement.

NASA's Suomi NPP satellite image taken on 23 October 2016 shows agricultural fires (marked in red) in the Punjab region of India [image by NASA] In early October 2016, Earth-observing satellites began to detect small fires in Punjab, and the number of fires increased rapidly in the following weeks. By November, thousands of fires burned across the state, and a thick pall of smoke hovered over India. The Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite captured a natural color image on November 2, 2016. The map shows the locations of the fires VIIRS also detected.

II. CONCLUSION

By understanding the air quality at hotspots and their intensity levels, using the spatio temporal outlier patterns the influence of parameters on other regions are estimated. By shifting hotspots to less wind, lesser water body zones, movement of outliers to wide spread on other regions' atmosphere is reduced. Thus air quality at sustainable, non polluted regions can be maintained at sustainable levels.

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