Chapter 56
Smart Pollution Alert System Using Machine Learning

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ABSTRACT

This chapter proposes a novel mobile-based pollution alert system. The level of the pollutants is available in the air quality repository. This data is updated periodically by collecting the information from the sensors placed at the monitoring stations of different regions. A model using artificial neural network (ANN) is proposed to predict the AQI values based on the present and previous values of the pollutants. The ANN model processes the normalized data and predicts whether the region is hazardous or not. A novel mobile application which could be used by the user to know about the present and future pollution level could be developed using a progressive web application development environment. This mobile application uses the location information of the user and helps the user to predict the hazardous level of the pollutants in that particular location.

INTRODUCTION

The introduction of particulates, harmful gases and other biological molecules into the Earth's atmosphere causes air pollution, which leads to disease, death and damage to humans, damage and other living organisms such as food crops. These particles and gases that pollute the atmosphere are known as air pollutant. The air pollutant causes adverse effects on human beings and their ecosystem. Sources of air pollutants are generally either anthropogenic or natural.

Air pollutants are classified as primary or secondary. A primary pollutant is emitted directly from a source, e.g. Sulfur Dioxide (SO2), Carbon Monoxide (CO), Nitrogen Oxides (NOX), and particulate matter (PM). A secondary pollutant is not directly emitted as such, but forms when other pollutants

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(primary pollutants) react in the atmosphere. An example of a secondary pollutant is Ozone. When hydrocarbons are emitted and they react with NO_x in presence of sunlight, they form ozone.

The secondary pollutant Ozone has critical effects on human health such as permanent lung damage, aggravated asthma, or other respiratory illnesses. Above certain limits they also cause damage to plants, reduce the crop yield, and also increase of vegetation vulnerability to diseases.

Particulate matter (PM) is the mixture of all solid and liquid particles suspended in air, many of which are hazardous. Both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets are present in this mixture. Some of them such as dust, dirt, soot, or smoke, are large enough to be seen with the naked eye while the rest are so small that they can only be detected only using an electron microscope. Fine particulate matter ($PM_{2.5}$) consisting of particles with diameter 2.5 mm or smaller, is an important pollutant among others as they are capable of penetrating deeply into the lungs and cause health problems, including the decrease of lung function, development of chronic bronchitis and nonfatal heart attacks (EPA, 2005).

Sulphur dioxide is another eminent air pollutant whose source is from fossil combustion of industries and locomotives. Its effects on human beings include damage of respiratory system, particularly lung function, and can irritate the eyes. It mainly causes respiratory tract inflammations along with coughing, mucus secretion and also aggravates conditions such as asthma and chronic bronchitis. Also, wet deposition of it is acidic and causes acid rain that contains sulfuric acid. This badly affects the ecosystem by changing the nutrient balance in water and soil (EPA, 2005).

Nitrogen dioxide, another important air pollutant is part of a group of gaseous air pollutants produced as a result of road traffic and other fossil fuel combustion processes. Globally, it contributes to global warming and is the third most important greenhouse gas in the UK. Nitric Oxide (NO_x) gases react to form acid rain and smog and also contribute to the formation of fine particles (PM) and ground level ozone. All these, in turn affect human beings with their associated adverse health effects (EPA, 2005).

Periodic air quality evaluation could be the best way to monitor and control air pollution. The suitability of air for lives on earth depends upon its characteristics. The Air Quality Health Index (AQHI) is a health protection tool designed in Canada that helps to understand the impact of air quality on human health. As shown in Figure 1 it provides a number from 1 to 10+ to indicate the level of health risk associated with local air quality. As the number increases it indicates greater the health risk and suggests the needed precautions to be taken. The index describes the level of health risk associated with this number as ‘low’, ‘moderate’, ‘high’ or ‘very high’, and suggests steps that can be taken to reduce exposure. Building a forecast system to predict hourly average concentrations of the pollutants and thereby its AQHI would be an efficient system to protect the people especially the vulnerable groups on a daily basis from the negative shades of air pollution.

The three main factors that mainly influence the concentration of air pollution at a particular location are meteorological factors, the source of pollutants and the local topography of that location. Many air quality forecasting uses straightforward approaches like box models, Gaussian models and linear statistical models. Though, these models are easy to implement and allow for the fast calculation of forecasts, they fail to describe the interactions and non-linear relationship that handle the transportation and behavior of pollutants in the atmosphere.

The knowledge discovery and their interpretations from the huge amount of past air pollutant concentrations data and meteorological data seemed vital in the process of forecasting air quality. Machine learning that originated from the field of artificial intelligence has become popular in solving it. A large number of neural networks are used for forecasting air quality and are also found to be more advanta-