CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
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Project Number
S0802

Project Title
The Effect of Nonlinearity on Recalibrating the AQI and Air Pollutant Forecasts for 3 Bay Area Urban Micro-climates

Abstract

Objectives/Goals
The Bay Area Air Quality Management District (BAAQMD) uses ozone (O(3)) and particulate matter (PM(2.5))readings to issue their daily Air Quality Index (AQI), eclipsing the impact of other criteria pollutants in urban microclimates. Current AQI forecasts also use linear and deterministic models that belie the impact of nonlinear pollutant interactions.Thus, my hypotheses are that (1) using nonlinear correlations and the Analytical Hierarchical Process (AHP) will result in an aggregated AQI accuracy of over 50% against the EPA's current AQI; (2) using nonlinear neural networks will produce accurate hourly pollutant forecasts.I obtained 3 years of hourly meteorological and pollutant data from BAAQMD for San Jose, San Francisco, and Oakland.

Methods/Materials
I applied Spearman's Rho to derive monotonic coefficients between the met factors and pollutants, which I used to develop an AHP that derived a weighted AQI scale for each pollutant per microclimate in Excel.This AQI was tested for accuracy of pollutant impact against the control EPA AQI. I applied the coefficients to enrich BAAQMD data to construct pollutant/microclimate-specific LSTM networks in Python to forecast hourly pollutants.The forecast results were tested for accuracy against the control BAAQMD forecasts and against actual pollutant data.

Results
The correlations showed that primary pollutants (CO, NO(2), & SO(2)) had greater impact on pollutant levels than met factors. My AHP-based AQI showed that 58.3% of EPA control AQIs reduce the impact of other pollutants, despite their having higher concentrations. My LSTM models increased the forecast accuracy by 57.3% for winter PM, 10% for summer O(3), and 8% for fall O(3), as compared to BAAQMD's control forecasts. Finally, annual forecasts were 96% accurate as tested against BAAQMD pollutant records.

Conclusions/Discussion
80% of global urban populations live in substandard air environments affected by anthropogenic primary emissions, compounded by topographical factors.My revised AQI provides an accurate pollutant representation for these microclimates that inform health impacts and empirically highlight the true sources of pollution.My nonlinear forecasts prove that dynamic urban environments are unsusceptible to linear and deterministic forecasting models and that using pollutant-centric nonlinear models provide accurate forecasts that allow individuals to plan their daily activities.

Summary Statement
Using nonlinear correlations, I proved that primary air pollutants have a higher impact on urban microclimates than meteorological factors, which accurately represents aggregate air quality and allows for robust pollutant forecasting.

Help Received
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