Colorado Science and Engineering Fair

2024 Individual Project Abstract Form

Please print 2 copies of the completed form. Sign both copies, keep 1 for your notebook and submit 1 copy to your Regional Fair Director with your other paperwork.

Title of Project: National Ground-Level NO2 Predictions Via Satellite Imagery Driven Hybrid Neural Networks

Finalist's Name: Elton Cao

School and City: Fairview High School, Boulder

Sponsor's Name: Paul Strode

Category: Mathematics & Computer Sciences (MACS)

Division: Senior (9th - 12th grades)

Abstract (250 words or less):

Outdoor air pollution, specifically nitrogen dioxide (NO2), poses a global health risk. Land use regression (LUR) models are widely used to estimate ground-level NO2 concentrations by describing the satellite land use characteristics of a given location using buffer distance averages of variables. However, information may be leaked in this approach. Therefore, in this study, I leverage a convolutional neural network (CNN) architecture to directly pass pixel plots of satellite imagery for the prediction of U.S. national ground-level NO2. I designed CNN architectures of various complexity which inputs both image and numerical based data, testing both high and low resolution pixel plots. My resulting model accurately predicted NO2 concentrations at both daily (R2 = 0.898) and annual (R2 = 0.964) temporal scales, with coarse resolution imagery and simple CNN architectures displaying the best and most efficient performance. Furthermore, the CNN outperforms traditional buffer distance models, including random forest (RF) and neural network approaches. Additionally, with a novel graph neural network (GNN) based approach which leverages network interactions between monitoring sites, I developed a hybrid hierarchical GNN-CNN model which captures both short and long distance associations between monitors. The resulting hybrid model significantly improved prediction against new and unseen monitors. With the success of hybrid neural networks in this approach, satellite land use variables continue to be useful for the prediction of NO2. Using this computationally inexpensive model, I encourage the globalization of advanced LUR models as a low cost alternative to traditional NO2 monitoring.

I hereby certify that the above statements are correct and the information provided in the Abstract is the result of one year's research. I also attest that the above properly reflects my own work.

Finalist's Signature: 

Date: 2/27/2024

In addition, all students must complete the ISEF Student Checklist (1A), Research Plan, Approval Form (1B), and Checklist for Adult Sponsor (1), and any other ISEF forms required for this type of project. See the International Rules and Guidelines for form requirements. Return COPIES o all of these forms to your Regional Fair Director with you Finalist Verification/Permission Form. A signed copy of this form must be included in your notebook.