Biodetection & Evaluation of Sensor Placement Using Computational Fluid Dynamics & Machine Learning

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INTRODUCTION

The tracking and detection of pathogen containing biological aerosols and contaminants is of great interest for public safety (bioterrorism) and health (pharmaceutical manufacturing. With improvements in computational power, we were able to simulate airflow and contamination levels with an open-source computational fluid dynamics (CFD) program known as CONTAM. Using Python, we built machine learning models to determine the best placement of contaminant sensors in 2D and 3D simulated spaces with virtual biological aerosol sensors with different responses to detect biological threat release (e.g bacteria, fungi, spores).

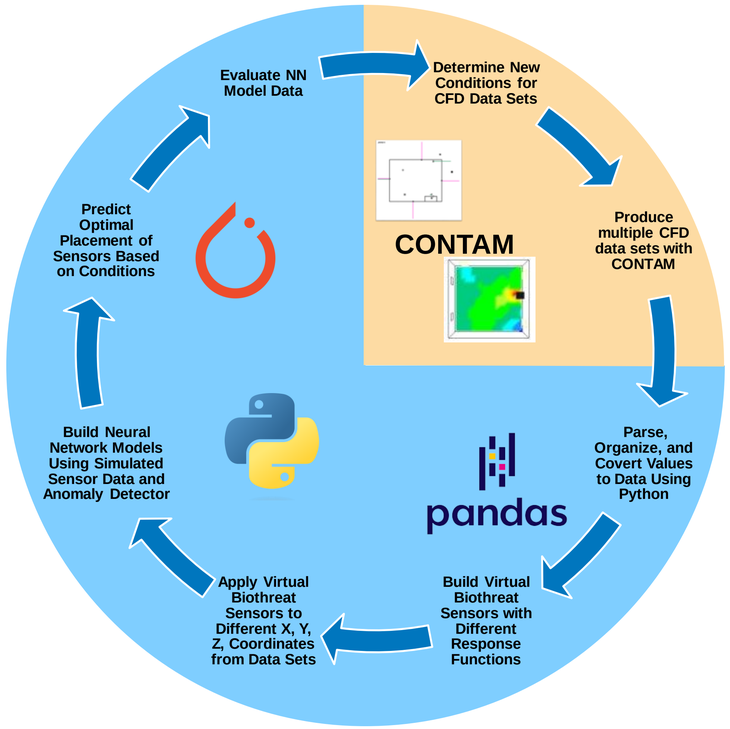

Fig 1. Diagram of modeling approach and optimization of sensor placement

RESEARCH METHODOLOGY

Our team used CONTAM to simulate and demonstrate the effects of contaminant releases and gain detailed data from the simulated sensors. CFD0 Editor, a complimentary software to CONTAM, was used to visualize the spatial distribution of the aerosol contaminants.

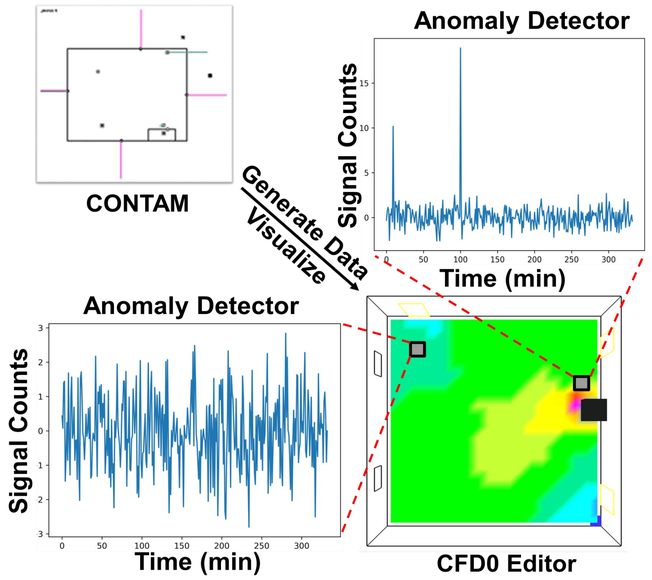

Fig 2. Diagram of CFD modeling and biodetection event

We then parsed the data from the simulation into .csv files using Python. The data was then used in conjunction with sensor response functions to simulate the signal of a detected aerosol particulate. Additionally, to determine whether an anomalous event occurred, or spike in aerosol concentration, a sliding average z-score "detector" was scripted and used to detect if an event with a z-score greater than or equal to 10 occurred.

CONCLUSION

The Battelle biodetection team developed a python parser that rapidly parses and exports simulation data as a .csv file. Virtual biological aerosol detectors using from the simulated data was also written in python. The tools and workflow developed by this team provide the necessary foundation for the later stages of this project which include building a deep learning model to evaluate sensor placements.

FUTURE GOALS

- Generate simulation data which include simulation of aerosols with virtual occupants and pressure changes over time
- Building a deep learning model to predict to predict the optimal placement of multiple sensors in a given space or building
- Write a .NET software package with all the tools that have been described for ease of use

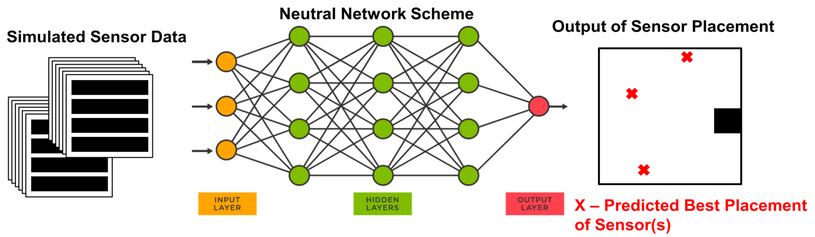

Fig 3. Scheme of general neural network architecture

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