Machine Learning-Based Modeling of HAP Emissions from Corn Ethanol Fermentation Process

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Introduction

- Fermentation emissions include carbon dioxide (CO_2), ethanol, and regulated (carcinogenic) hazardous air pollutants (HAPs), which vary in concentration throughout the fermentation cycle.

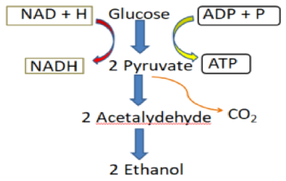

Figure 1. Fermentation Process

- On an industrial scale, HAP production and emission amounts are inconsistent in each batch and fermentation tank.
- Treatment is demanding in natural gas and water (6 to 12% of a plant's overall energy).
- Conventional optimization approaches are limited in considering all involved parameters.
- Machine Learning models can identify the correlations and patterns using high-dimensional and non-linear data from fermentation processes.

Objectives

Utilize machine learning models to:

- Optimize scrubber water and chemical additives usage.
- Optimize operating conditions for emission control systems.
- Develop more accurate and adaptable models of overall plant operations for the fermentation emissions predictions.

Methods

Finishing the 8th month of a 2-year research project focused on HAP emissions from the ethanol fermentation process, the following stages are in progress:

Stage 1: Data Collection

- Collecting time-series data on the fermentation process parameters and emissions that will be used in the next modeling stages.

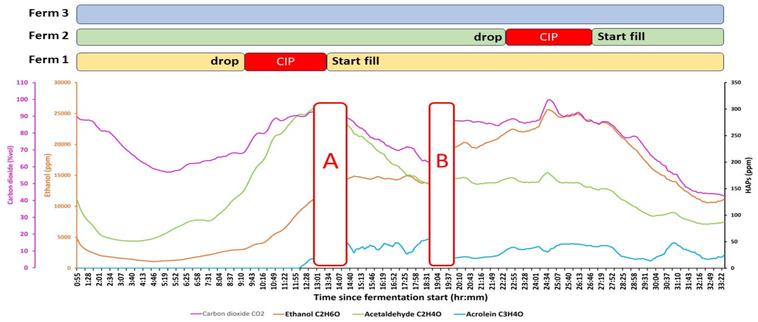

Figure 2. First 30-hour Sampling of One Fermentation Cycle

Stage 2: Machine Learning Modeling

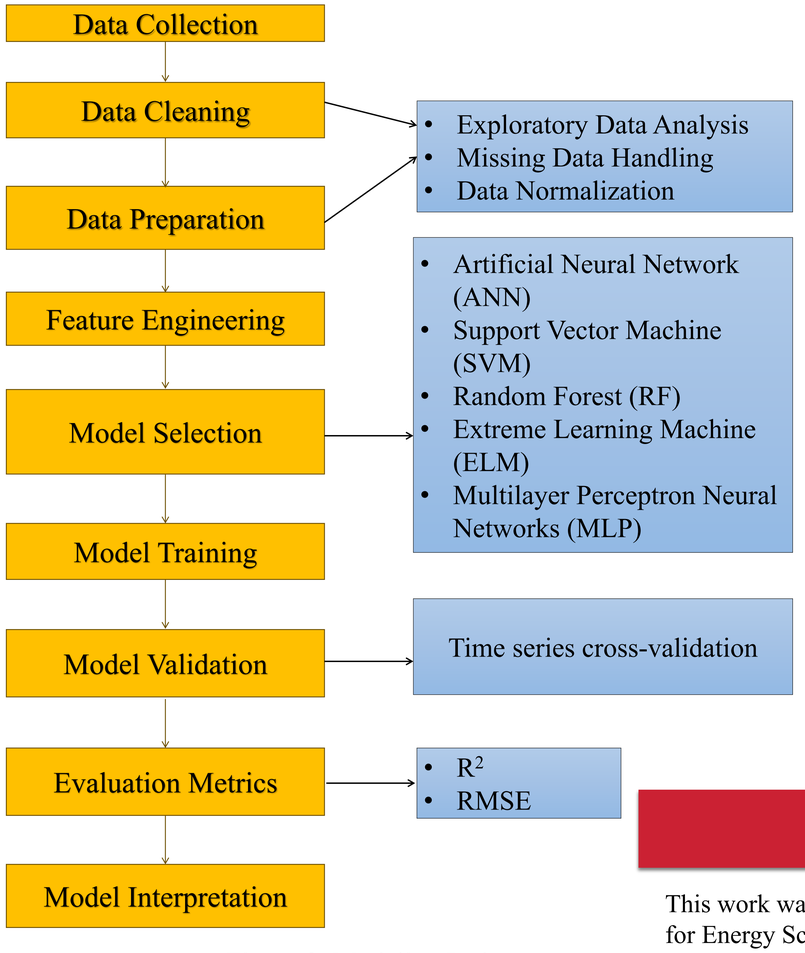

Figure 3. Modeling Pathway

Stage 3: Chemical Process Simulation Model

- Using collected data to develop computer simulation models of fermentation processes and reactions.
- Using the simulations for the effectiveness evaluation of new emission control strategies.
- Identifying energy, water usage, and carbon intensity optimal approaches.

Anticipated Results

- **General Predicting Model:**
  - Approach A: ***Inputs:*** Ethanol Yield, Process Conditions, temperature. ***Outputs:*** Ethanol (gas), CO_2, HAPs ➔Chemical process modeling.
  - Approach B: ***Input:*** Process Conditions, temperature, CO_2, Ethanol(gas). ***Output:*** HAPs, Ethanol Yield ➔ Identifying key correlations.
- **PEMS (Predictive Emission Monitoring Systems)**
  - Model: Modified models for specific fermenters:
  - ***Input:*** Specific Process Conditions. ***Output:*** HAPs
- **Potential Infections Prediction**
  - ***Inputs:*** Liquid stream data, temperature, HAPs, ***Output:*** Ethanol Yield

Potential Benefits

- The predictive models have the potential to improve the emission treatment of ethanol plants and reduce water, chemical, and energy usage.
- These models can reduce the greenhouse gas emissions through energy reduction.

Acknowledgments

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