Reconstructing Pollutant Dispersion Information by Defining Exhaust Source Parameters with an Inverse Model

Patrick E. O'Brien[1] and Arkadiy Dantsker[2]

1 O'Brien and Associates, WA, USA
2 Detex, WA, USA

The pollutant dispersion from industrial sources is often unknown. Even when information exists, it is usually underreported. Evaluation and reporting of all pollutant dispersion patternare desired thus avoiding dependencies on business and government that own the sources of pollutant emissions (Macdonald, 2003). This is very important.

In order to find such information using the dispersion model, it should be known what the parameters are in different weather patterns paired with the pollutant's emission rate. Then solve the other related questions. What is the height of the pollutant's source? What is the gas exhaust velocity when overlaid with the known wind values and direction? The emission's rate and gas exhaust velocity identification requires continuous monitoring data that for the most cases is not available. That restriction is changing with improved collection methods and modeling.

The approaches to resolve this problem reveal that building inverse models that allows re-engineer pollutant dispersion is possible. The linear inverse models were created to identify emissions rates from multiple sources (Seiber et al, 1997; Lushi and Stockie, 2010). Authors concluded that model of approach should be extended in order to improve accuracy. The accuracy of the inverse model depends on direct model parameters estimation. The estimated parameters that our subject of the concern are:

a) Standard deviations of concentration in the y and z directions. The empirical expressions covered in dispersion models publications (Awastithi, 2006), (Macdonald, 2003) requires some assumption that per invalid selection can result a big error.
b) Effective height of the point emissions source stack. The effective height depends on pollutant release from the stack velocity that can be defined by continuous monitoring. Such monitoring is not in common practice.
c) Emissions rate from the stack

The proposed model reveals to solving Least Square Operator for experimental and analytical expression pollutant concentrations, defining emission rate, effective source height and standard deviation of the concentration as unknown parameters. It allows to find effective height of the source that depends on unknown emissions release velocity from the point source stack.

The new model definition requires to solve complex non-linear system of the equations. The solution such system is defined with theory of Hypernumber (Burgin, 2010), (Burgin and Dantzler, 1995, 2014, 2015).

Cadman's asphalt plant in Kenmore,Washington was selected for testing inverse emissions dispersion model. The particulate data acquisition uses Adafruit PM 2.5 sensor. The analog data from the sensor are read byanalog-digital converter. The output from the converter is plugged to Raspberry Pi 4 Bminicomputer to process data. The model evaluation reveals to such steps:

- Measuring particles concentrations at multiple locations around the plant with PM 2.5 sensor and storing data at Raspberry Pi.
- Computing emissions rate, effective emissions source stack height and standard deviations of concentration with model using collected in previous step concentrations.
- Calculating concentrations around the plant with direct emissions dispersion model.
- Testing the model accuracy by comparing concentrations defined at previous step with dispersion model and experimental data at the same points different from defined at first step.

1. Awastthi, S., Khare, M. and Gargawa, P. (2006) General Plume Dispersion Model (GPDM) for Point Source Emissions. Environmental Modeling and Assessment. Vol. 11, pp. 267-276
2. Burgin, M. (2010) Nonlinear partial differential equations in extrafunctions, *Integration*: *Mathematical Theory and Applications*, v. 2, pp. 17-50
3. Burgin, M., Dantsker, A.M. (2014) Lithium Battery Temperature Prediction. *Integration*: *Mathematical Theory and Applications*, v. 3(4).
4. Burgin, M., Dantsker, A. (2015) Real-Time Inverse Modeling of Control Systems in Hypernumbers, Nova Science Publishers, New York.
5. Burgin, M. and Dantsker, A.M. (1995) A Method of Solving of Operator Equations of Mechanics by means of the Theory of Hypernumbers, Notices of the Academy of Sciences of Ukraine, 1995, 8, pp. 27-30.
6. Lushi, E., and Stockie, J. (2010) An inverse Gaussian Plume Approach for Estimating Atmospheric Pollutant Emissions from Multiple Point Sources. Atmospheric Environment
7. Macdonald, R. (2003) Theory and Objectives of Air Dispersion Modelling.
8. Seibert, P., (1997), Inverse dispersion modelling based on trajectory-derived source-receptor relationships, in: Air Pollution Modeling and its Application XII, S.E. Gryning, N. Chaumerliac, eds., Plenum, New York.