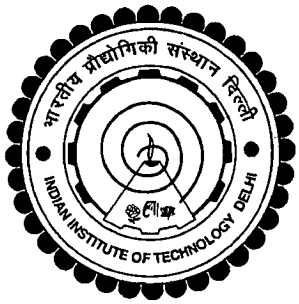
NEURO-FUZZY MODELLING OF VEHICULAR EXHAUST EMISSIONS ON URBAN ROADS

by

SURESH JAIN

Civil l ngineering Department

Submitted
in fulfillment of the requirements of the degree of Doctor of Philosophy
to the



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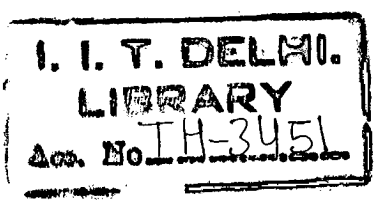
① Emission control – Exhaust gases
⑤ Neuro-Fuzzy models



यत् सांख्यैः प्राप्यते स्थानं तद् योगैर् अपि
गम्यते ।
एकं सांख्यं च योगं च यः पश्यति स पश्यति
॥५॥

yat sānkhyaih prāpyate sthānam
tad yogair api gamyate
ekam sānkhyam ca yogam ca
yah paśyati sa paśyati

One who knows that the position reached by means of analytical study can also be attained by devotional service, and who therefore sees analytical study and devotional service to be on the same level, sees things as they are.

BHAGAVAD-GĪTĀ (V- 5)

Dedicated

To

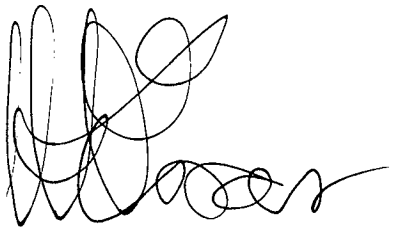
My Parents, wife (Punam)

&

daughter (Samridhi)

CERTIFICATE

This is to certify that the thesis entitled "**Neuro-Fuzzy Modelling of Vehicular Exhaust Emissions on Urban Roads**" being submitted by **Mr. Suresh Jain,** has been prepared under my supervision in conformity with the rules and regulations of the **Indian Institute of Technology Delhi**. I further certify that the thesis has attained a standard required for the award of a degree of **Doctor of Philosophy** of the institute. This work, or any part thereof, has not been submitted elsewhere for the award of any other degree or diploma.



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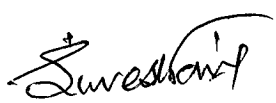

SURESH JAIN
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ABSTRACT

Movement of traffic on urban roads and roughness elements surrounding an air quality control region (AQCR) add more complexities in vehicular exhaust dispersion modelling studies. The conventional modelling approach using deterministic Gaussian based models may not be able to take into account these complex variations in meteorological and traffic parameters and so affecting their prediction efficiency. In addition, stochastic based vehicular exhaust emission models, to some extent, may explain the non-linearity (randomness) present in the meteorological and traffic data in such complex urban corridors. However, the variations in air quality data are so complex and non-linear in nature that it requires prior assumptions concerning their distribution. In contrast, artificial neural networks (ANNs) based models are capable of analyzing such complex non-linear data more accurately than stochastic and deterministic based models. One of the constraints in ANN based air quality models is their inability to converge to global minima even by complex back propagation learning due to their dependence on trial and error method in determining the number of hidden layers and nodes. Additionally, they also may not take into account, analyze and interpret the linguistic information. The fuzzy based air quality models, to some extent, overcome the above shortcomings of ANN based models. They are capable of analyzing linguistic information and efficiently carry out programming/processing with improved knowledge representation and uncertainty reasoning. Further, the Neuro-Fuzzy modelling technique, hybridizing fuzzy inference system and ANNs interpret and analyze more precisely any

kind of information (numeric, linguistic or logical) and possesses self-learning, self-organizing and self-tuning capabilities, thus improving the quality of forecasts.

In the present research, 1-hr average Neuro-Fuzzy based carbon monoxide (CO) and 24-hr average Neuro-Fuzzy based nitrogen dioxide (NO_2) models have been developed at selected AQCRs in the urban district of the Delhi city. These models have been formulated with three meteorological and one traffic characteristic variables. The performance of 1-hr and 24-hr average Neuro-Fuzzy based models has been evaluated on unseen test data. Degree of agreement (d) and other descriptive statistics have been used for evaluating the model performance. The prediction performance of 1-hr average Neuro-Fuzzy based CO models has been found to be satisfactory with predictions accuracy varying from 91% to 98%. The 24-hr average Neuro-Fuzzy based NO_2 model predictions are 89% and 98% error free at $AQCR_2$ and $AQCR_1$, respectively.

Further, 1-hr average Neuro-Fuzzy based CO model prediction performance has been compared with ANN and deterministic based General Finite Line Source (GFLS) and Delhi Finite Line Source (DFLS) models. The Neuro-Fuzzy based CO model shows satisfactory predictions as compared to other models in terms of degree of agreement index (d) and RMSE values.

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