ISSN 2277-2685
IJESR/June. 2025/ Vol-15/Issue-3s/82-87
T.Keerthana *et. al.,* / International Journal of Engineering & Science Research

# Autoencoder Based Gas Detection

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***ABSTRACT***
*The detection of gas emission levels is a crucial problem for ecology and human health. Hyperspectral image analysis offers many advantages over traditional gas detection systems with its detection capability from safe distances. The existing hyperspectral gas detection methods in the thermal range neglect the fact that the captured radiance in the longwave infrared (LWIR) spectrum is better modeled as a mixture of the radiance of background and target gases, we propose a deep learning based hyperspectral gas detection method which combines unmixing and classification.*
*The proposed method first converts the radiance data to luminance-temperature data. Then, a 3-D convolutional neural network (CNN) and autoencoder-based network, which is specially designed for unmixing, is applied to the resulting data to acquire abundances and endmembers for each pixel. Finally, the detection is achieved by a three-layer fully connected network to detect the target gases at each pixel based on the extracted endmember spectra and abundance values. Furthermore, extension we introduce an Ensemble model that combines three different algorithms: CNN, Bi-directional, and Gated Recurrent Unit (GRU) to improve prediction accuracy*.

## 1-INTRODUCTION

Imaging spectroscopy has been used by physicists and chemists for more than three decades to identify materials and their compositions. The concept of hyperspectral remote sensing started in the mid-80s and has been widely used by geologists for mapping minerals to this day. The gas leaks in particular in developed countries in the last decade were one of the crucial environmental problems. Some gases are harmful to the environment and contribute to global warming. They present both short-term risks such as explosions and long-term risks such as cancer to workers or people living close to the leaking facility. To minimize these effects, environmental authorities need to monitor chemical and industrial plants to control gas emission levels. Infrared remote sensing technology, which offers many advantages over traditional gas detection systems, is one of the proposed solutions for this aim as such solutions allow monitoring the scene from a safe distance.

## 2-REQUIREMENTS ANALYSIS

Functional Requirements

**2.1.1 Modules:**

User:

Input Test Data: Users can input their test values

View Result: It predicts the Gas based on the given test values.

**Non - Functional Requirements**

Security : Implement robust security measures to protect applicant data.

Scalability : Ability to handle a growing number of applicants.

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Usability : User-friendly interface that is easy to navigate.

Performance: It works efficiently and Fastly.

Availability : it is available for 24/7 hours.

Portability: it can be used on different operating systems

Computational Resource Requirements

For execution of the project there are some software and hardware requirements.

**Hardware Resources**

| | | |
|---|---|---|
| Operating System | : | Windows 10 |
| Processor | : | Intel i5 and above |
| RAM | : | 4GB |
| Hard Disk | : | 500GB |

**Software Resources**

| | | |
|---|---|---|
| Applicaation | : | Anaconda |
| Programming Language | : | Python 3.12.3 |
| Front End Frame Work | : | Flask |
| Back end Frame Work | : | Jupyter Notebook |
| DataBase | : | Sqlite3 |
| Front end technologies | : | HTML,CSS, JavaScript and BootStrap4 |

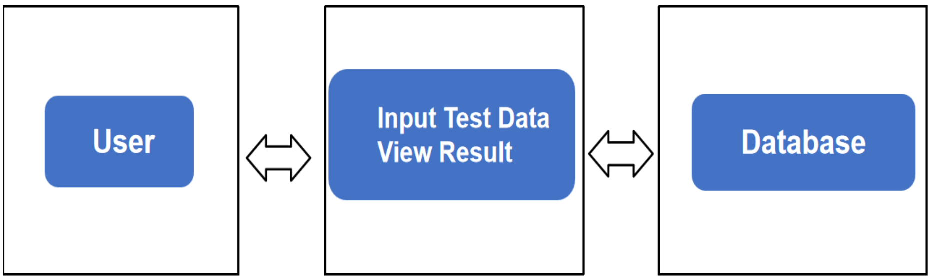
## 3-DESIGN

The architecture of this project is designed to ensure seamless interaction between the user interface, data processing, and predictive algorithms. It incorporates modular components for better scalability, maintainability, and performance. Architecture is of two types. They are

Software Architecture

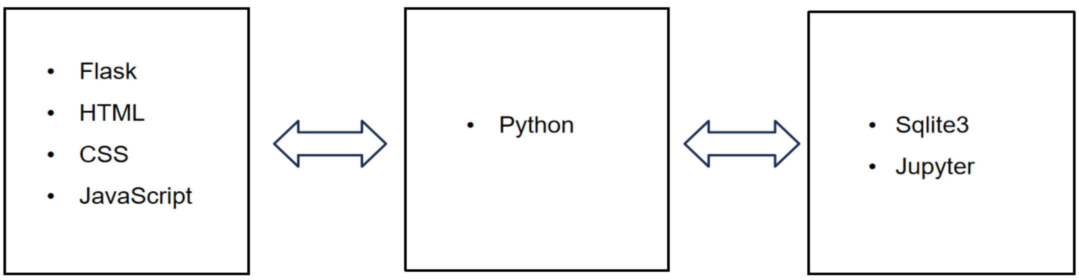
Technical Architecture

**Software Architecture**




Software Architecture

**Technical Architecture**



**Data Flow Diagram**

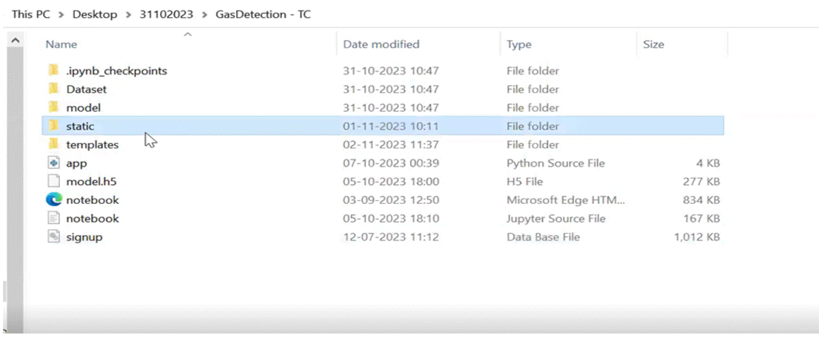
Data Flow Diagram (DFD) represents the flow of data within information systems. It provides a graphical representation of the data flow of a system that can be understood by both technical and non-technical users. The models enable software engineers, customers, and users to work together effectively during the analysis and specification of requirements.

## 4-IMPLEMENTATION

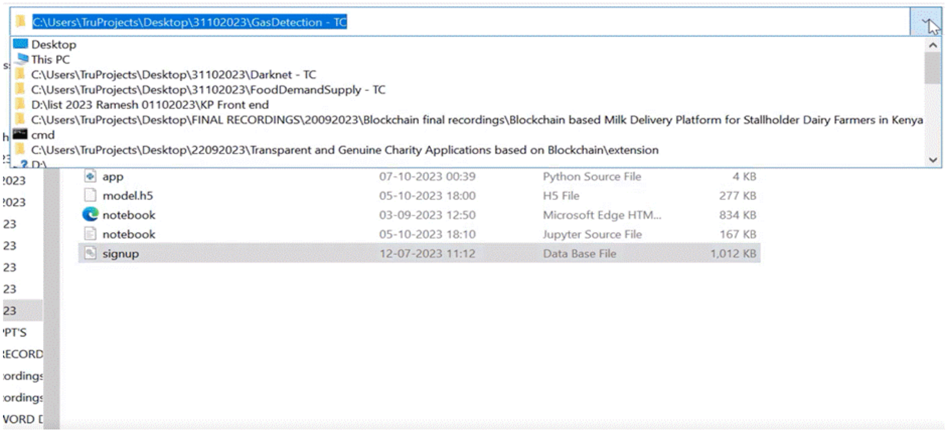
**Python**

Python is one of the most popular programming languages today, known for its simplicity and extensive features. It was created by Guido van Rossum, and released in 1991. Its clean and straightforward syntax makes it beginner-friendly, while its powerful libraries and frameworks makes it perfect for developers. It can be used on a server to create web applications. It can be used to handle big data and perform complex mathematics. Python runs on an interpreter system, meaning that code can be executed as soon as it is written. This means that prototyping can be very quick. Python can be treated in a procedural way, an object-oriented way or a functional way. Python relies on indentation, using whitespace, to define scope; such as the scope of loops, functions and classes. Other programming languages often use curly-brackets for this purpose. Python is a versatile, high-level programming language that emphasizes simplicity and readability. It is widely used in various fields, including web development, data science, artificial intelligence, and machine learning, making it ideal for projects.

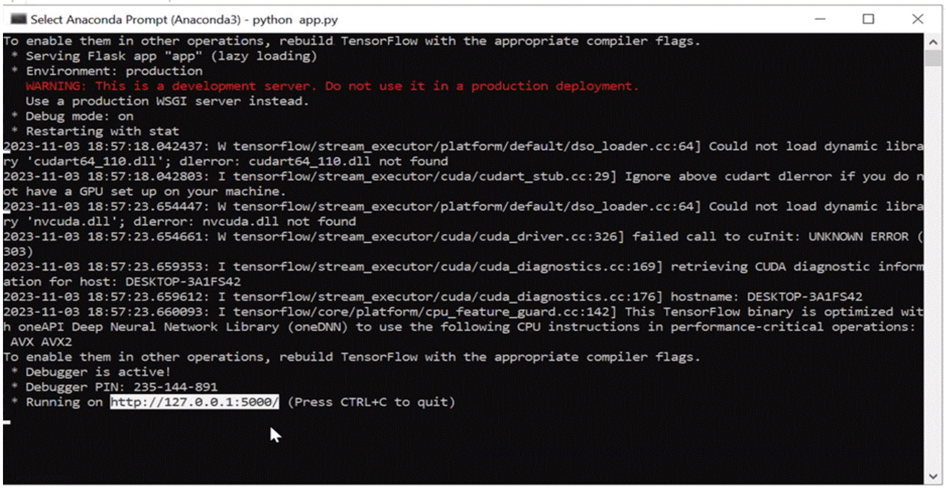
## 5-SCREENSHOTS



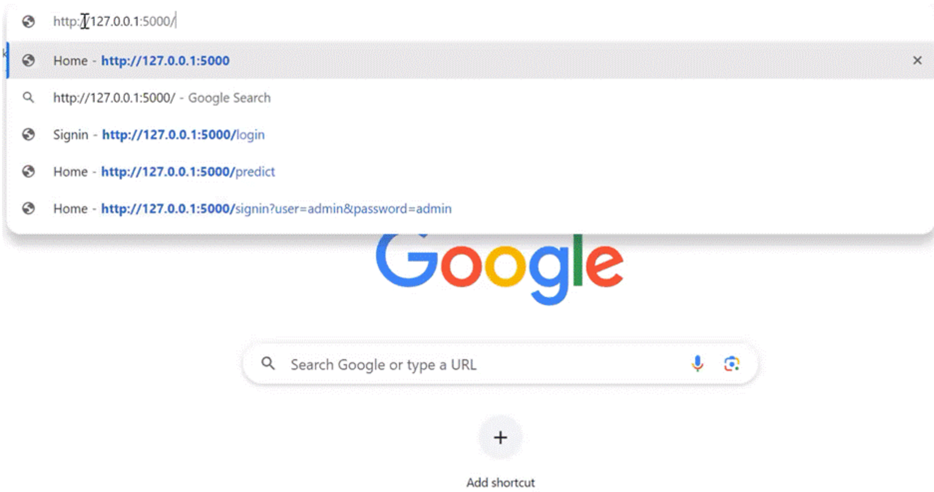

Screenshot 1 Selecting folder



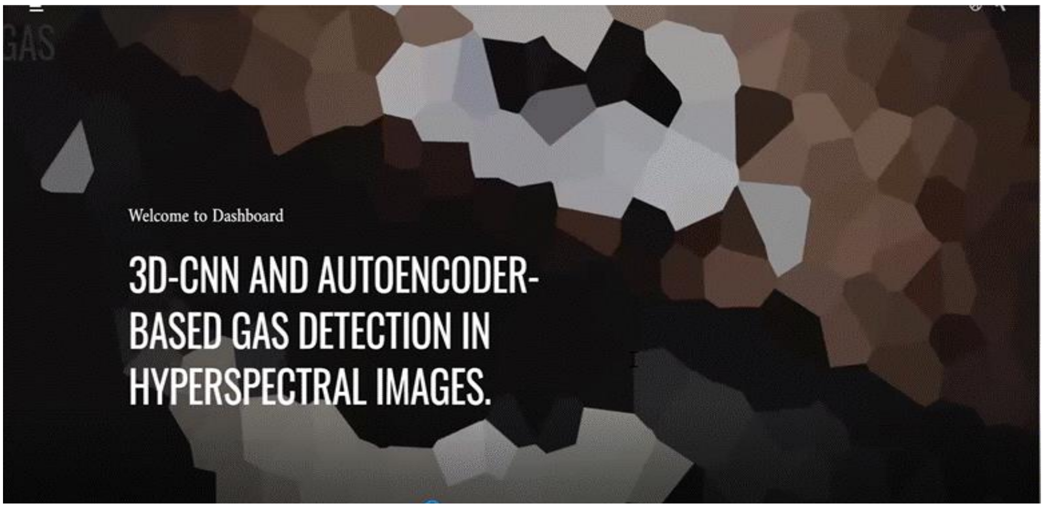

Screenshot 2 Copying folder path




Screenshot 3 Link Generated for webpage

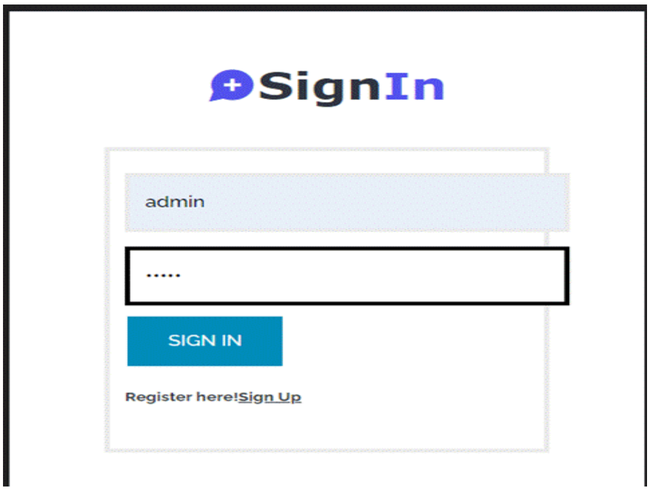



Screenshot 4 Pasting URL in browser




Screenshot 5 Image showing home page of user interface


Screenshot 6 Image showing sign in page




Screenshot 7 Image showing sign up of user

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IJESR/June. 2025/ Vol-15/Issue-3s/82-87
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Screenshot 8 Image showing Parameters to be entered by user

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Screenshot 9 Image showing entered values by user


Screenshot 10 Results 1


Screenshot 11 Results2

## 6-CONCLUSION

We have proposed a deep learning-based gas detection method which combines 3D-CNN and autoencoder-based hyperspectral unmixing with neural network-based classification. An ablation study with respect to the possible different combinations for such a system, such as using direct classification methods or using the same structure with other unmixing methods are also performed. In addition, the 3D-CNN and autoencoder-based unmixing has indicated better results than the conventional unmixing for the proposed gas detection framework. The performed study does not require thresholding, unlike the conventional gas detection methods. Finally, the proposed gas detection method achieves better results than state of the art gas detection methods in LWIR range due to its high learning capacity with 3-D convolutional layers. In propose 3DCNN got 88% accuracy, extension model by combining 3 different algorithms such as CNN + Bidirectional and GRU got 93% accuracy

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