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A MACHINE INTELLIGENT FRAMEWORK FOR DETECTION OF OZONE LAYER DEPLETION ZONE USING INTERNET OF THINGS

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Abstract

Ozone layer depletion is a very serious issue for human life and environment. It is depleting day by day due to the increase of pollution in the atmosphere. The polluted gases in the atmosphere are responsible for reducing the content of ozone (O_3) gas in the atmosphere. Ozone helps the environment in absorbing the ultraviolet rays emitting from sun. Therefore, it is necessary to monitor the ozone depletion to save the environment from ultraviolet rays. A framework is designed in this work to detect the ozone layer depletion at different zones using a machine learning based system architecture and Internet of Things (IoT) platform. Here, at a zone the IoT devices connected with ultraviolet ray detection sensor and other necessary sensors are responsible for sensing. The sensor readings are then forwarded to the cloud through the base station. The cloud uses a machine learning based approach to detect the ozone depletion from the readings received. This machine learning based approach is called as stacking classifier that is build using hybridization of some standard machine learning models. From the results it can be stated that the proposed stacking classifier outperforms other standard machine learning models by showing a classification accuracy (CA) of 94.80% in detecting the ozone depletion zone.

Keywords: Ozone Layer Depletion Monitoring, IoT, Machine Learning, Accuracy

1. INTRODUCTION

Ozone layer depletion is a serious issue nowadays due to increase of air pollution in the environment (Srinivas et al. (2019), Roy et al. (2016), Rekha et al. (2018), Masmoudi et al. (2020), de Paula Correa (2022), Ayele & Mehta (2018), Shaban et al. (2016)). Air pollution is the leading cause for reduction of ozone content in the atmosphere. The ozone layer is mainly below the stratosphere. It helps well in absorbing the ultraviolet rays that are emitted from sun. The zone where the ozone layer content is less is called as the ozone layer hole. From this hole, the ultraviolet rays enter very easily and approach the environment directly that is dangerous for the human life and other organisms. It can cause skin cancer, other skin diseases, etc. So, there should be a framework or design where the ozone depletion should be monitored regularly in the desired zones or locations.

IoT plays important role in monitoring an activity using sensors and sending the activity information to other device or network using Internet for record or processing (Atrozi et al. (2010), Rose et al. (2015), IoT protocols & Standards (2022)). Therefore, IoT will be better solution to this problem where the ultraviolet sensor, and other necessary sensors can be deployed at the desired zones and using the IoT technology this activity information can be monitored. However, IoT devices have limited storage, power, and processing capability therefore these activities can be offloaded or processing can be performed in another device that has high computational capacity, storage, and power supply. Therefore, cloud computing will be a better solution to solve this problem. Cloud is responsible for providing services to user on demand (Sadeeq et al. (2021), Maray & Zebari (2022)). For processing the work very efficiently the cloud now uses AI (artificial intelligence) technology for performing the activities. The AI technology can be machine learning or deep learning strategy to solve classification, prediction, clustering, pattern mining, etc. type of problems. As the problem in this paper is based on classification of ozone depletion layer zone from normal zone, the supervised machine learning models (Bhoi et al. (2021 & 2022), Nayak et al. (2022)) will be a better solution for this.

The contributions to this paper are stated below:

1. A framework is designed to detect the ozone layer depletion at different zones using a machine learning based system architecture and IoT.
2. Here, at a zone the IoT devices connected with ultraviolet ray detector sensor and other necessary sensors are responsible for sensing. The sensor readings are then forwarded to the cloud through the base station. The cloud uses a machine learning based approach to detect the ozone depletion zone from the readings received.
3. That machine learning based approach is called as stacking classifier that is build using hybridization of some standard machine learning models.
4. From the results it can be stated that the proposed stacking classifier outperforms other standard machine learning models by showing a CA of 94.80% in detecting the ozone depletion zone.

The next sections such as Section 2 to Section 5 discusses about related work, methodology, simulation and conclusion respectively.

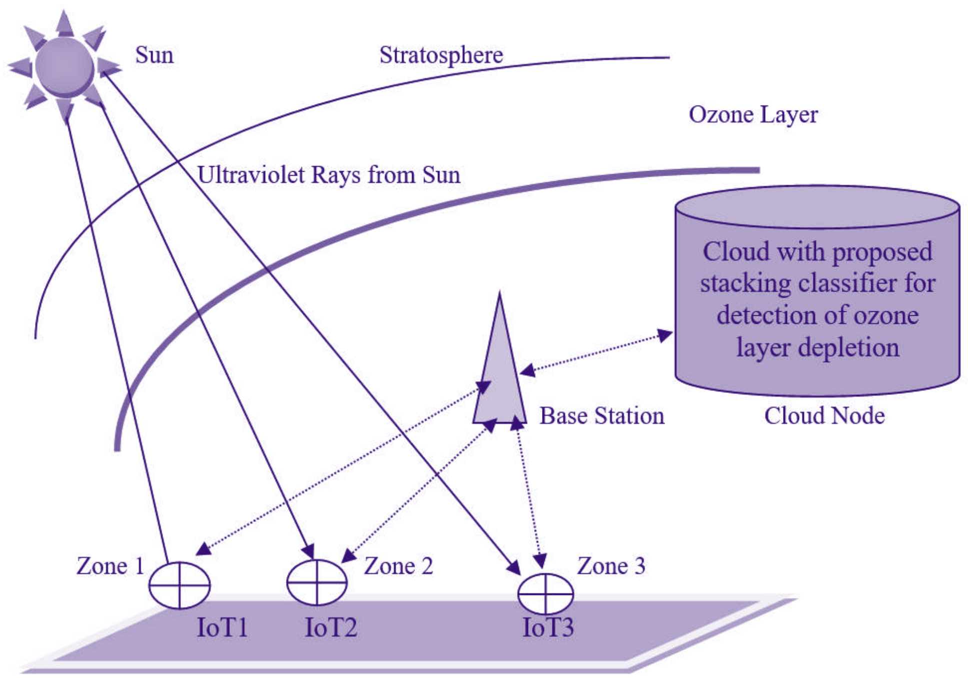
2. RELATED WORK

In this study, it is found that very less works is done related to ozone layer zone detection in machine intelligent cloud based IoT framework. The framework proposed in this work has new solution for detection of ozone layer depletion zone. However, some related works are discussed as follows. In a work, the authors predicted the concentration of ozone using machine learning approach (Srinivas et al. (2019)). In another work, the authors used multivariate regression for prediction of ozone layer concentration (Roy et al. (2016)). In another work, the authors predicted concentration of ozone using machine learning (Rekha et al. (2018)). In two other works, the authors monitored air pollution using machine learning and forecasting models respectively ozone monitoring (Ayele & Mehta (2018), Shaban et al. (2016)). In another work, the authors predicted air pollutants using feature selection and and multivariate regression (Masmoudi et al. (2020)). In another work, the authors estimated the ultraviolet radiation using machine learning approach (de Paula Correa (2022)).

3. METHODOLOGY

The proposed framework as shown in Fig. 1 mainly consists of IoT devices that consist of ultraviolet ray detection sensors. In this framework, there are two types of layers such as device and cloud. Device layer consist of IoT devices I={IoT1, IoT2,…, IoTn} at the zones Z={Z1, Z2,…,Zn} where ultraviolet rays are to be recorded or monitored. An IoT device consist of ultraviolet sensor, and any other sensors as per system requirement. The sensors attached in an IoT device are represented as S={S1, S2,…, Sn}. The IoT device has internet capability to send the data to cloud through base station (BS). The device is assumed to have less memory and less processing capability. The power is also a limitation in this device. Therefore, the highly complex task such as training and testing using machine learning model is performed at the cloud. The cloud layer consists of a cloud node C that is responsible to store the readings of the sensors from the IoT device and process the readings using a machine learning model to detect the ozone layer depletion at a zone. If the ultraviolet ray's intensity is more at a zone, then we can say that the ozone depletion occurs. The cloud node has high processing capability and power is not a limitation. The communication between the devices occurs in two way such as device to cloud (D2C) and cloud to device (C2D). The nodes communicate using wireless technology with any node containing Internet or in ad hoc manner.

Fig. 1: System architecture framework



The main functionality of the proposed framework is represented in step-by-step manner as follows and also represented in Fig. 2:

Step 1: The ultraviolet sensor and other sensors attached with the IoT device at a zone reads the physical environment.

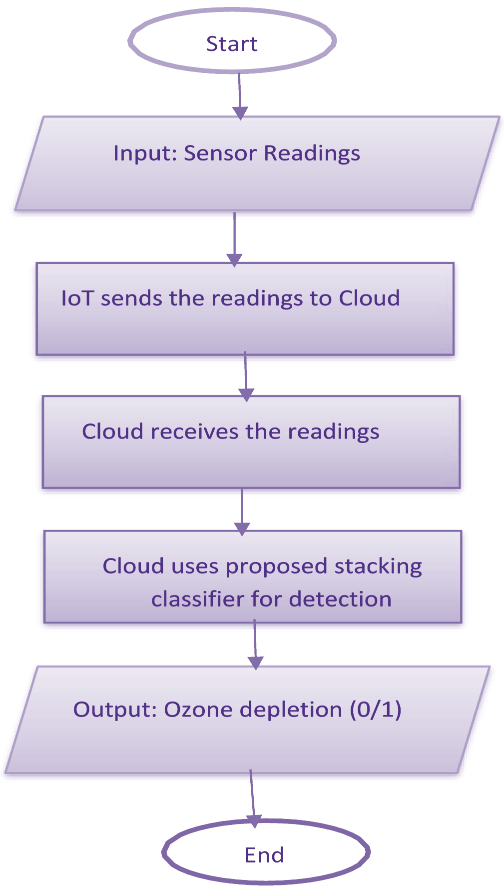
Step 2: The readings are then collected at the IoT device local memory and then send to the cloud through the base station.

Step 3: The cloud node receives the readings from the IoT device at a zone and stores it in a IoT device table. This table data is updated regularly when the same IoT device sends the readings periodically.

Step 4: The cloud node uses the proposed stacking classifier to classify the ozone layer depletion as 0/1.

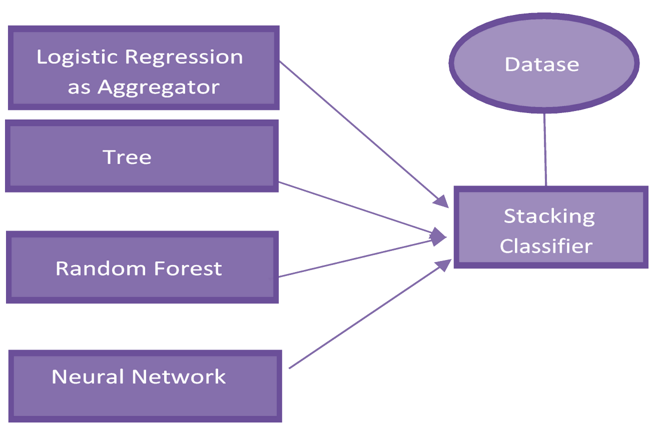
Step 5: After detection, the depletion status is updated at the cloud storage and if the depletion happens (1) then an information from cloud is sent to the pollution control authority for taking required actions in emergency.

Fig. 2: Flowchart of functionality of proposed framework



The proposed stacking classifier used in the cloud node is designed using logistic regression as the aggregator. It aggregates three standard machine learning models for enhancing the CA of the proposed framework. The stacking classifier designed is represented in Fig. 3 as follows.

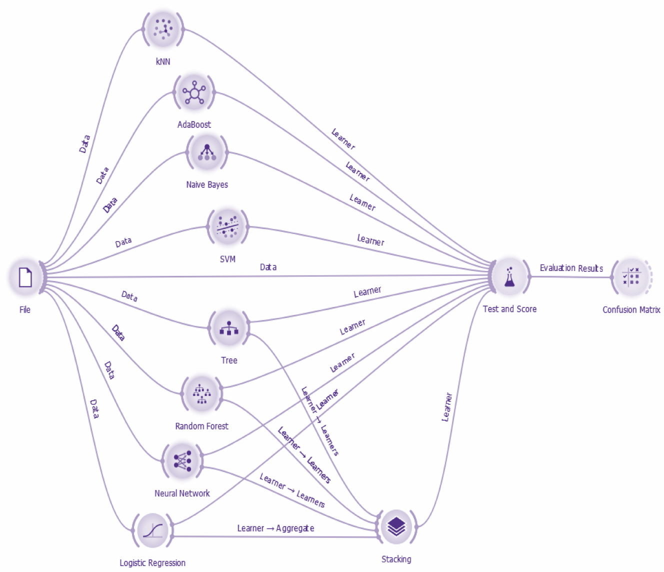
Fig. 3: Proposed stacking classifier for cloud



4. SIMULATION RESULTS

The proposed framework performance is analyzed using the python based Orange tool (Orange, (2022)). This tool mainly simulates the classification part where the cloud node detects the ozone depletion as 0/1. The simulation is mainly performed using the above tool that is installed in a core i3 processor machine with 8 GB RAM and windows 64-bit operating system.

Fig. 4: Orange workflow setup diagram



The workflow of the model is mainly represented in Fig. 4. This workflow is designed in Orange tool by considering all default settings of the supervised machine learning models. The test and score here show the CA of the models and the confusion matrix here shows the number of actuals predicted in correct manner to the number of actuals present. The stacking is performed as shown in above figure as per our proposed model.

The dataset used in this for training and testing is downloaded from Kaggle (Ozone Level detection Dataset (2022)). It mainly consist of 74 attributes where the last attribute is the target (0/1). The first attribute is the date and the rest attributes except the last attribute is assumed to be the sensor readings those are used to detect the ozone depletion as (0/1). It also consists of 2535 samples. The dataset is preprocessed using the by default settings of Orange tool. The training and testing size is kept in 80:20 ratio respectively. Random sampling technique is set in the tool for performing the training and testing.

The simulation result shown in Table 1 and Fig. 5 states that, proposed stacking classifier shows an accuracy of 94.8% in detection of ozone depletion at a zone, whereas other supervised machine learning model shows CA of 93.5%, 93.1%, 89.2%, 94.1%, 94%, 70.2%, 93.7%, 90.8%, and 90.8% respectively. Fig. 6-Fig.15 show the confusion matrix (CM) which represents the number of actuals correctly predicted.

Table 1: Comparison of CA of different ML models

Sl. No.	Method	CA (0-1)
1	kNN	0.935
2	Tree	0.931
3	SVM	0.892
4	Random Forest	0.941
	Neural Network	0.940
5	Naïve Bayes	0.702
6	Logistic Regression	0.937
7	AdaBoost	0.908
8	Proposed stacking classfier	0.948

Fig. 5: Comparison of CA of all models

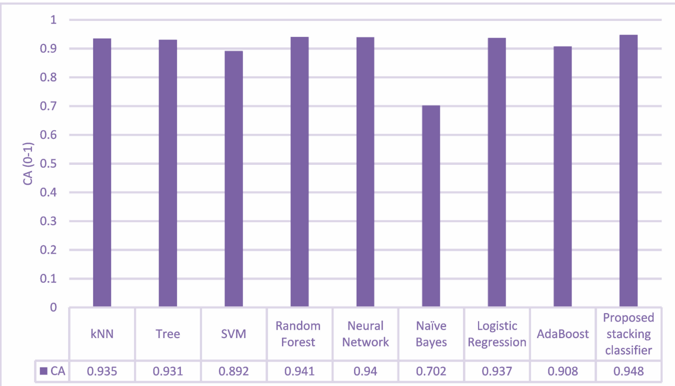


Fig. 6: CM for kNN

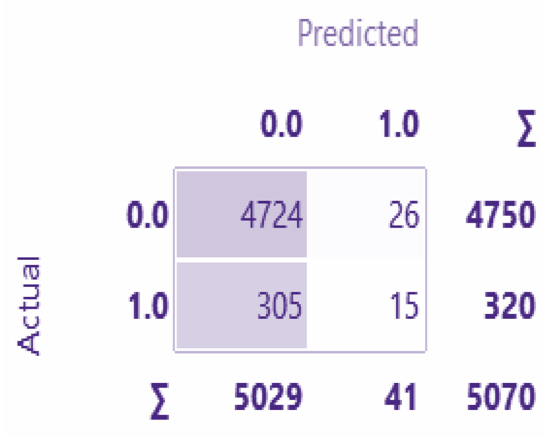


Fig. 7: CM for Tree

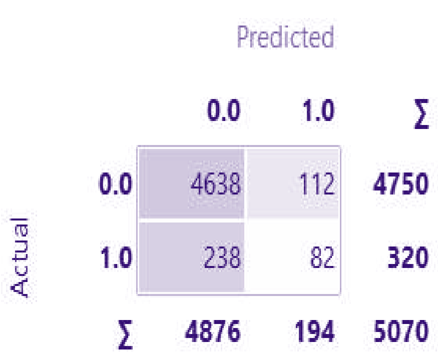


Fig. 8: CM for SVM

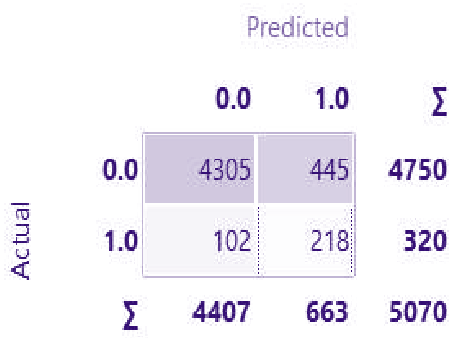


Fig. 9: CM for Random Forest

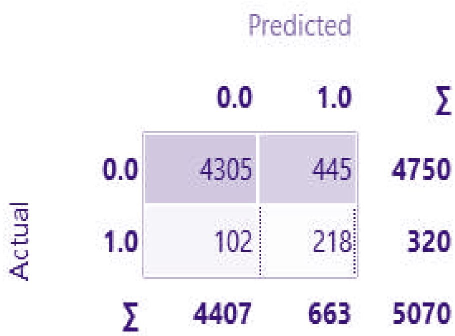


Fig. 10: CM for Neural Network

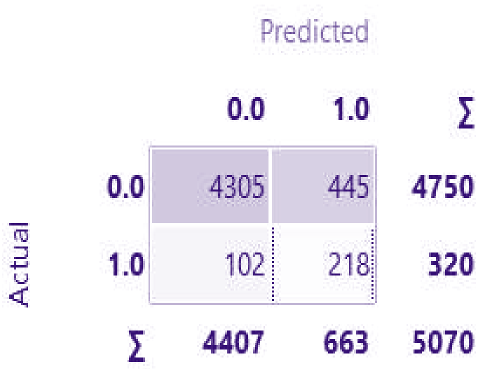


Fig. 11: CM for Naïve Bayes

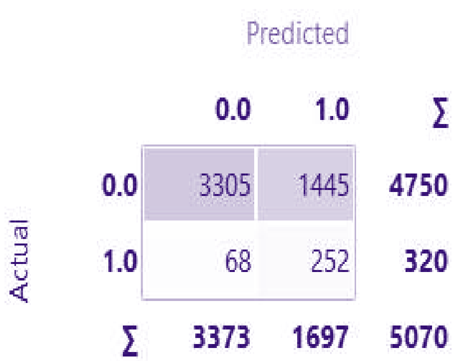


Fig. 12: CM for Logistic Regression

Actual \ Predicted	0.0	1.0	∑
0.0	4706	44	4750
1.0	277	43	320
∑	4983	87	5070

Fig. 13: CM for AdaBoost

Actual \ Predicted	0.0	1.0	∑
0.0	4615	135	4750
1.0	168	152	320
∑	4783	287	5070

Fig. 14: CM for proposed stacking classifier

Actual \ Predicted	0.0	1.0	∑
0.0	4702	48	4750
1.0	216	104	320
∑	4918	152	5070

5. CONCLUSION

In this work, a framework is designed to detect the ozone layer depletion at different zones using a machine learning based system architecture and IoT. Here, at a zone the IoT devices connected with ultraviolet radiation detection sensor and other necessary sensors are responsible for sensing. The sensor readings are then forwarded to the cloud through the base station. The cloud uses a stacking classifier to detect the ozone depletion from the readings received. From the results it can be stated that the proposed stacking classifier outperforms other standard machine learning models by showing a CA of 94.80% in detecting the ozone depletion zone. In future, new hybrid models will be developed to enhance the classification accuracy and also dataset size will be increased to study the impact of it in the increase of classification accuracy.

DECLARATIONS

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Conflicts of Interest: There is no conflict of interest.

Availability of Data and Material: Data is available on request.

Authors Contribution: All authors contributed equally.

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