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Fog SC: Combining Intelligence with Fog Computing to Analyze Large Data in Smart Cities

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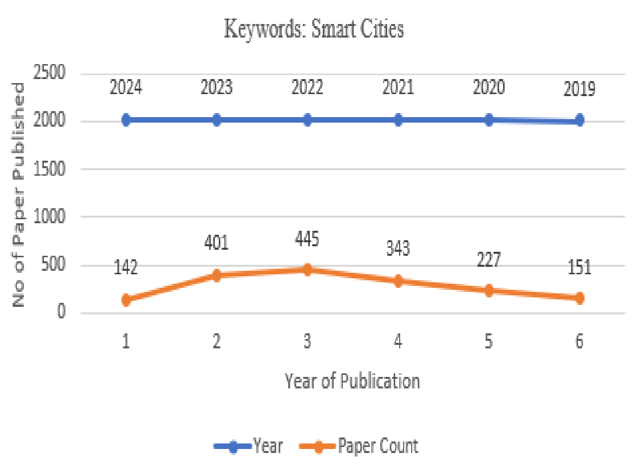
Abstract: The research endeavors to perform big data analysis on the extensive data produced by the Internet of Things (IoT) in smart cities. Its objective is to steer smart cities toward effective governance and secure data processing. To address the diverse data sources within smart cities, the research develops a multi domain data based smart city enhancement model through two level learning model-based cloud layer. The data is processed through a fog-based network, stored in a cloud layer, and trained using a two-level learning based distributed CNN model for predicting the data from different sensors. The two-level learning helps to improve big data prediction performance and the distributed learning mechanism enhances the classifier through feature extraction. The method's performance will be evaluated against existing state-of-the-art techniques to show its efficiency.

Keywords: Smart cities, Fog computing, Big Data, Distributed learning, and CNN.

I. INTRODUCTION

The domains of fog computing and cloud computing have garnered considerable attention from experts and academics. However, because of the significant reaction time lag, cloud computing is undoubtedly not a good choice for applications that require a constant feedback situation. For healthcare applications, fog computing might thus be the most effective solution when low latency and quick response times are needed. Fog computing, which is based on the Internet of Things, operates similarly to a cloud in that it is situated at the edge of a network, allowing it to offer real-time, extremely near support to a device. technological progress, encompassing massive data management via the Internet of Things (IoT). IoT sensors and file input data are the two main forms of healthcare data gathering techniques that are used by heart patients utilizing different devices. Cloud Data Centers (CDC) handle huge data processing, whereas fog nodes handle modest data processing. The network receives the patient data at high rates (250 MB per minute or more). Ali and Ghazal suggested an Internet of Things (IoT) e-health service based on an application that uses Software Defined Network (SDN). The system uses a smartphone to gather data in the form of voice control and determines the patients' health state.



The total number of research paper published during the 2019 to May 2024 as per the PubMed Dataset. Where in the 2022 largest no of paper paper published that is the 445. As per the PubMed Dataset based on Smart cities related paper 1709 paper published.

II. LITERATURE REVIEW

Moghadas, Ehsan, et al. [2019] This research study offered an efficient approach for patient health monitoring. Fog computing and data mining are the foundations of this arrhythmia patient system. By using fog technology, patient data is sent to the cloud less often, which minimizes data transmission delays. The recommended method enabled real-time ECG and patient heart rate monitoring by launching a web service from a Raspberry Pi (a common

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IoT device) using an Arduino Uno and an AD8232 sensor module. Data analysis is therefore carried out at the Fog site. Due to limited access to a large number of ECGs in the implementation region, 452 heart rate samples from different age groups and genders that have been evaluated by the data mining industry are included in the UCI site database. The KNN algorithm was used in this study to analyse whether arrhythmias were present or absent, and the results were split into 16 categories of cardiac arrhythmias. High accuracy was attained in each class of cardiac arrhythmias following a series of tests [1].

Rincon, Jaime A. et al. [2020] All forms of monitoring systems and telemedicine have shown to be an effective, affordable tool with broad use in cardiology. Presenting an Internet of Things-based cardiovascular patient monitoring system is the aim of this effort. The system uses the LoRa communication protocol to transfer the ECG signal to a Fog layer service. Additionally, it has a deep learning-based AI system for the identification of various cardiac rhythms, such as atrial fibrillation. In order to improve clinical vision and therapeutic decision making, automated arrhythmia detection can serve as a supplement to a doctor's diagnosis. The suggested system's effectiveness is assessed using two merging Mobile Net networks that identify data for atrial fibrillation with 90% accuracy on a dataset of 8.528 brief single-lead ECG recordings [2].

Shreshth Tuli et al. [2019] Healthcare is a huge endeavour as a service. In this work, we present the novel HealthFog deep learning and Internet of Things based Fog based Smart Healthcare System for Automatic Diagnosis of Heart Diseases, which only addresses the medical demands of heart patients. HealthFog provides healthcare as a fog service and efficiently organizes cardiac patient data coming from several IoT devices. HealthFog evaluates heart disease in the real world by utilizing deep learning on Edge computing devices. Their prediction accuracy was so low since deep learning was not applied in the previous studies for this kind of heart patient study that they could not be employed in practical settings. Extremely accurate deep learning-based models require a considerable amount of computing resources (CPU and GPU) for both training and prediction. This study achieved high accuracy at very low latencies by integrating massive deep learning networks into Edge computing paradigms using state-of-the-art model distribution and communication techniques such as ensembling.

Additionally, by using well-known datasets to train neural networks and implementing a functional system that delivers prediction results instantly, this was verified for use in analyzing real-world cardiac patient data. Using the Fog Bus framework to validate Health Fog in a fog computing environment, we assessed the efficacy of the proposed system in terms of power consumption, network bandwidth, latency, jitter, training accuracy, testing accuracy, and execution time [3].

Verma Parag et al. [2022] As an assistant, providing medical care is a large and delicate undertaking. Our primary goal in the current research project is to concentrate on the healthcare system for patients with heart disease. We propose a smart healthcare system enabled by fog computing, which incorporates the most recent technology, such as deep learning ensemble technique, to provide an automated diagnosis of heart disease by utilizing the FETCH system for IoT enabled resources. FETCH efficiently organizes a cardiac patient's data from many IoT-enabled devices and provides medical treatment in the form of fog computing services. FETCH deploys these edge computing enabled devices in the actual world for the purpose of checking for heart disease using deep learning techniques. Because the deep learning approach was not used in the previous art for this type of cardiac patient assessment, the prediction power accuracy rate was abnormally low, making the results obsolete in real-world scenarios. For both model training and model prediction, the AI-based deep learning model with high accuracy demands very high computing resources (that is, CPUs or GPUs). Through the application of correspondence and model dispersion techniques, this study enabled the network with a complicated deep learning model to establish standards for edge computing, including the ability to meet high latency with low latency. It was authorized to analyses real-world cardiac patient data by building neural networks on popular datasets and delivering a functional framework with the capacity to make predictions in real time. We have approved the FETCH in a fog computing environment using the Fog Bus structure, and we have tested the efficacy of the suggested framework in terms of power consumption, network bandwidth, latency, jitter, training model accuracy, testing precision, and execution time [4].

Bo Tang and others [2017] For huge data analysis in smart cities, we provide a hierarchical Fog Computing architecture in this work. Fog computing, as opposed to cloud computing, parallelizes data processing at the network's edge, meeting location awareness and low latency criteria. In future smart cities, the multi-layer Fog computing architecture will provide high computing performance and intelligence by enabling fast reaction at the neighborhood, community, and city levels. The "smartness" of municipal infrastructure is further improved by utilizing cutting-edge machine learning techniques at every system tier. In order to confirm the efficacy of this design, we have put in place a standard smart pipeline monitoring system. Pipeline safety was effectively monitored by the use of a hidden Markov model, a sequential learning technique, for hazardous event identification. Based on its observed performance, the

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hierarchical Fog Computing architecture has tremendous potential for usage in the future for managing and monitoring smart cities [5].

Rahmani, Amir M. et al. [6] This study established the ideas of fog computing and Smart e-Health Gateways within the framework of Internet of Things-based healthcare systems. Mobility, energy economy, scalability, interoperability, and reliability are just a few of the issues that IoT-based health systems must face. Smart gateways positioned strategically in close proximity to sensor nodes can assist. We have investigated in detail a broad range of high-level services, such as local processing, storage, notification, firewall, standardization, web services, compression, etc. that smart gateways may offer to sensors and end users in a geo-distributed manner at the network's edge. We demonstrated our proof-of-concept for an Internet of Things (IoT)-based remote health monitoring system, which comprises the UT-GATE Smart e-Health Gateway. We created an intermediary processing layer using several UT-GATEs to illustrate the fog computing idea for Internet of Things-based healthcare applications. We used our fog-assisted technique to the medical case study Early Warning Scores, where we monitored critically sick individuals. In our thorough system presentation, we go over every stage of the data flow process—from data collection at sensor nodes to the cloud and end users.

Bahar, Farahani, and others [7] Our lives may be made easier and better by the seamless platform that the Internet of Things (IoT) provides to connect objects and people. This vision might move us away from centralized, compute-based systems and towards a more distributed, multipurpose world with smart wearables, smart homes, smart cities, and smart transportation. In this work, we explore possible applications of IoT in healthcare and medicine and provide a comprehensive design of the IoT eHealth ecosystem. The management of healthcare is getting increasingly challenging due to inadequate and subpar services that do not meet the growing demands of an ageing population with chronic illnesses. In order to achieve this, we suggest that healthcare should shift from being clinic-centric to patient-centric, with seamless connections between each agent (a hospital, a patient, and services).

In order to facilitate the speed, diversity, and latency-free processing of complex data, this three-layered architecture—device, 2) fog computing, and 3) cloud—is essential for the patient-centric IoT eHealth ecosystem. A variety of case studies of services and applications that are implemented on those tiers adhere to this fog-driven IoT architecture. These include of population monitoring in smart cities, implants, e-medicine, assisted living, early warning systems, and mobile health. The final section discusses the difficulties of IoT eHealth, including interoperability, data management, scalability, privacy, security, and legal issues.

Research Gap

After Literature review, we find out some research gap that is mention as below.

- The deep learning neural network method the DNN method does not cooperate with the fog computing, so it is not fit for some complex situation and the test accuracy is less due to sample limitation [2].
- The K-nearest neighbor method is not suitable for complex situation, because this method has less capacity for implementing the entire data in the dataset [1].
- The hidden Markov method with sequential learning model use sensor for sensing the data, which is related to the smart cities but such data are not be able to collect easily and should be frequently maintain the battery of a sensor [5].
- Challenges faced by the ML technique include data management, scalability, interoperability, device-network-human interfaces, security, and privacy [7].
- The artificial intelligence based deep learning method leads to more power usage, it is inactive, and this approach does not provide the accurate result [4].

Challenges:

- The security of fog computing is compromised by the large number of devices linked to fog nodes at various gateways.
- Because fog computing reduces the amount of back-and-forth communication between sensors and the cloud and the needed bandwidth, it can negatively affect Internet of Things performance.
- Sensitive data analysis on a local gateway or fog node can significantly enhance data privacy. Hardware design flaws, firmware update constraints, and processing capacity limitations in IoT devices are the sources of vulnerabilities.
- Since the apps for smart cities will produce vast amounts of data, developers must keep track of reliable and pertinent information. Maintaining such data would not be beneficial since some of the created data would be redundant or unnecessary.

III. Result and Discussion

Performance Analysis based on MAE Using Air Quality Dataset:

The performance analysis based on MAE on the Air Quality using the proposed model on training percentage 80

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to achieve the 2.527, 2.475, 2.105, 2.054, and 2.028 with the epoch value 20, 40,60, 80, 100.

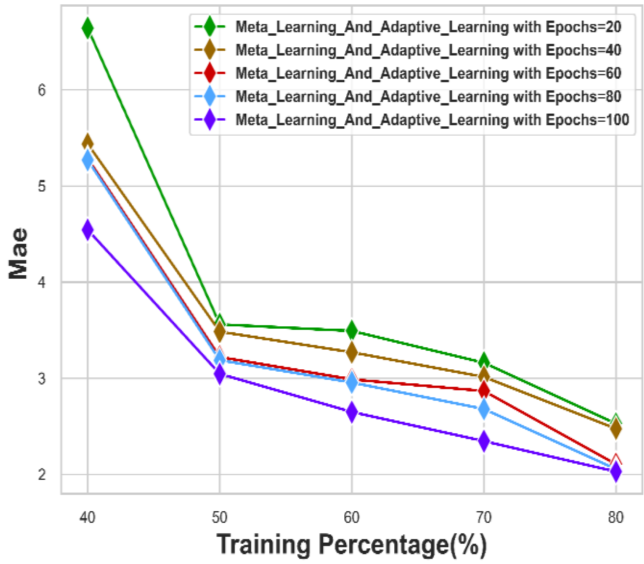

Fig1: MAE Using Air Quality Dataset

Performance Analysis based on MSE Using Air Quality Dataset:

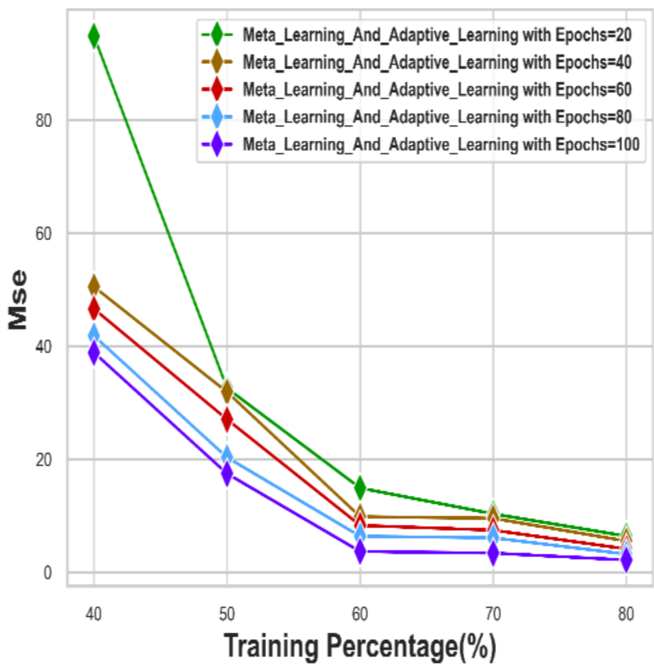

Fig2: MSE Using Air Quality Dataset.

Performance Analysis based on RMSE Using Air Quality Dataset:

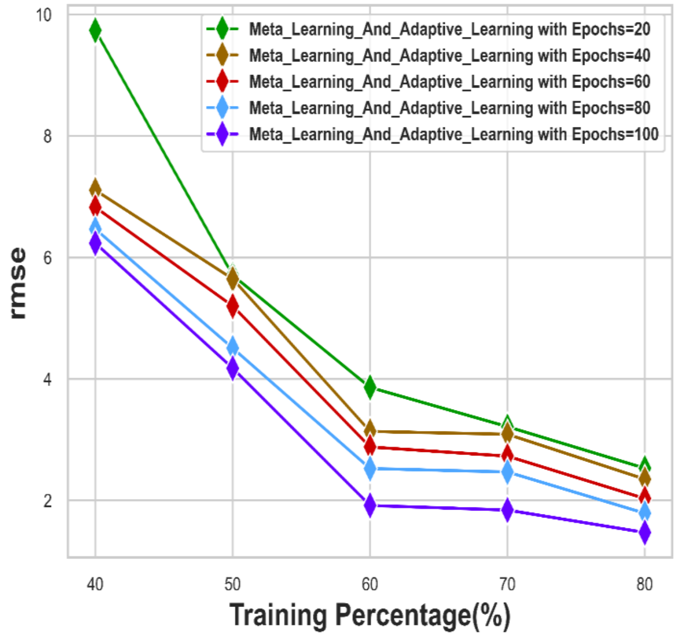

fig 3: RMSE Using Air Quality Dataset

Comparative Analysis based on MAE based on Air Quality:

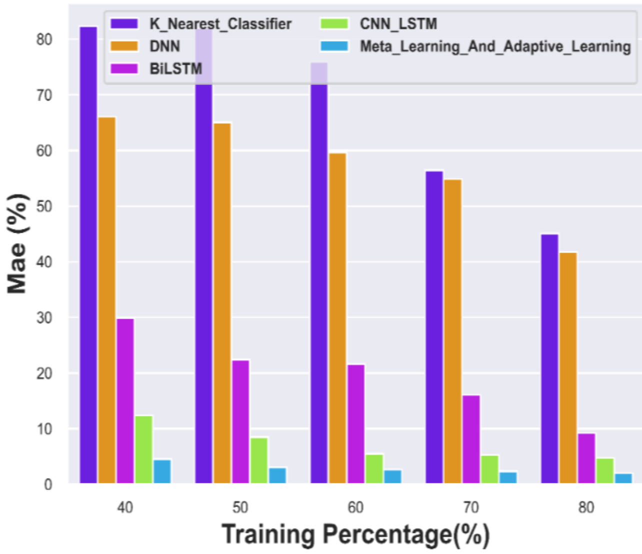

Fig 4: Comparative Analysis based on MAE.

Comparative Analysis based on MSE:

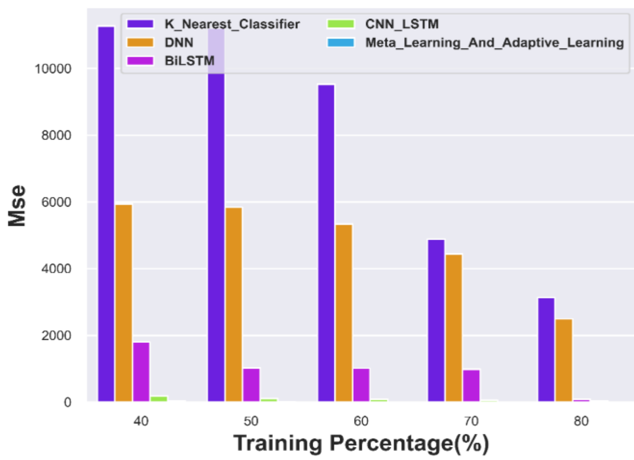

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Fig 5: Comparative Analysis based on MSE

Comparative Analysis based on MAE using Health Data:

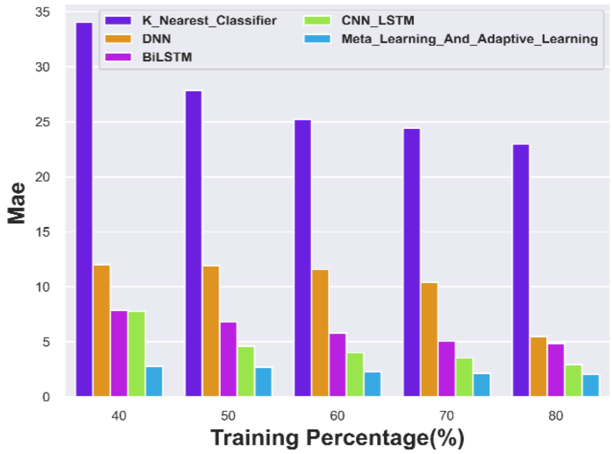

Fig 6: MAE using Health Dataset

Conclusion

In conclusion, a multi domain data based smart city enhancement model is proposed in this research using a deep learning method named two level learning based distributed CNN for big data analysis. Here**,** the two-level learning will improve the performance of the big data prediction model through enhanced learning mechanism and the distributed learning mechanism can enhance the classifier through improved feature extraction process**.** The research outcome will be validated through comprehensive comparative analyses against established big data analysis methods and this validation will prove the superiority of the proposed model. The research is implemented in python and exhibits the enhanced performance in terms of indicating its effectiveness in enhancing the prediction of big data.

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