AN IOT BASED APPROCH FOR MEASURING AIR POLLUTION LEVEL

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ABSTRACT

Traditional air pollution monitoring systems are bulky and expensive resulting in a very sparse deployment. In addition, the data from the monitoring stations may not be easily accessible. With the advent of Internet of things(IoT) technology, millions of smart devices will be connected to each other as well as to the internet enabling easier air pollution monitoring. Low cost portable sensors along with IoT can overcome the above two issues of traditional monitoring systems.

This thesis focuses mainly on three aspects. Firstly, research, development and deployment of IoT-based dense air pollution monitoring using network low cost sensor nodes in an Indian urban setting which is first of kind in India in terms of dense deployment and spatial coverage. Second, it deals with improving the energy consumption of these sensor nodes developed and finally, reducing the redundancy of the nodes. More specifically, an adaptive sensing algorithm and hierarchical clustering based spatial sampling paradigm have been introduced. The results of the proposed implementations have been evaluated upon real-time deployment of the nodes. In total, ten low-cost IoT nodes monitoring particulate matter(PM), which is one of the most dominant pollutants, are developed and deployed in a small educational campus in Indian city of Hyderabad. New data sets were created in the process which is thoroughly investigated by applying various preprocessing, signal processing and clustering techniques. Different analyses such as correlation and spatial interpolation are done on the data to understand efficacy of dense deployment in better understanding the spatial variability and time-dependent changes to the local pollution indicators.

1. INTRODUCTION

They are for general purpose use and usually have huge resources, and are expensive. Whereas, the main job of devices in IoT is not computing, and they have a specific application. They typically have limited resources and are cheaper IoT is a multidisciplinary area with a very broad scope. It is a combination of multiple domains like wireless sensor networks(WSN), sensor technologies, ubiquitous distributed computing, cyber-physical systems, information and communication technologies(ICT), networking, bigdata, data analysis and processing, data security and privacy, machine learning, Artificial Intelligence(AI), etc. As the IoT progresses from an abstract idea towards realization, various stakeholders have made multiple attempts to define IoT formally.

2. PROPOSED METHODOLOGY

6.1 SpatialSamplingTechniques

Previous works on determining the number of optimal nodes in a sensor network vary from using analytical approaches to simulation-based, and geometric-based approaches [1, 2, 3, 4]. Mathematically,

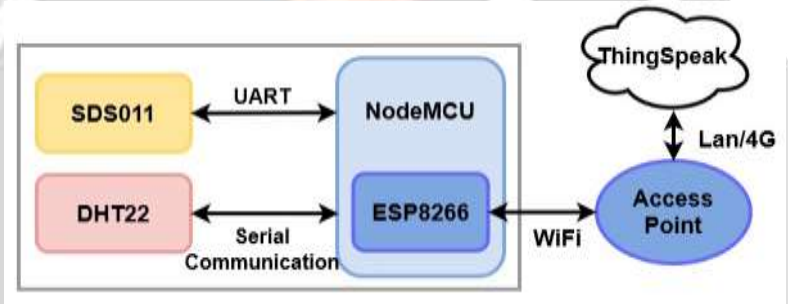
environmental phenomena in a space can be modeled as a spatio-temporal random field. Now the problem becomes sampling the assumed random field. In [1] and [2], the random field is modeled as a Gaussian process, and the sampling strategies are discussed accordingly. Within a spatial setting, we use geometrical arrangements like Voronoitessellation [3] for deciding the optimal location of nodes. In [4], the Monte-Carlo simulation-based approach is used to decide these sensor nodes. However, there are issues with these approaches. None of the approach erase data-centric and do not use an already existing sensor network. In [1] and [2], the main issue is how the approaches

Depend on the nature of the process. The issue with the approach in [4] is that the environmental parameters are not always same.

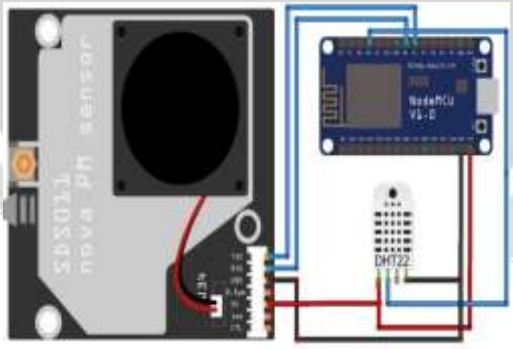
3. DESIGN AND IMPLEMENTATION

This chapter introduces the development and deployment of PM monitoring sensor nodes at the IIIT-H campus. A description of the sensor nodes and their physical deployments for collecting the data set is presented, along with the insights gained from applying various preprocessing, correlation, and spatial techniques on the dataset.

SensorNodeImplementation



(A) Block architecture



(B) Circuitdiagram

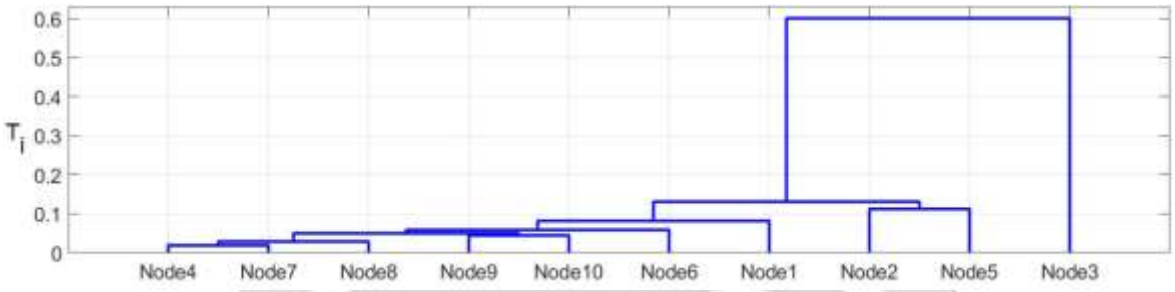
Figure.1 Block and circuit diagrams of sensor node developed at IIIT.

Fig. 1(a) and 1(b) show the block architecture and circuit diagram, respectively, of the PM monitoring sensor node developed at IIIT.

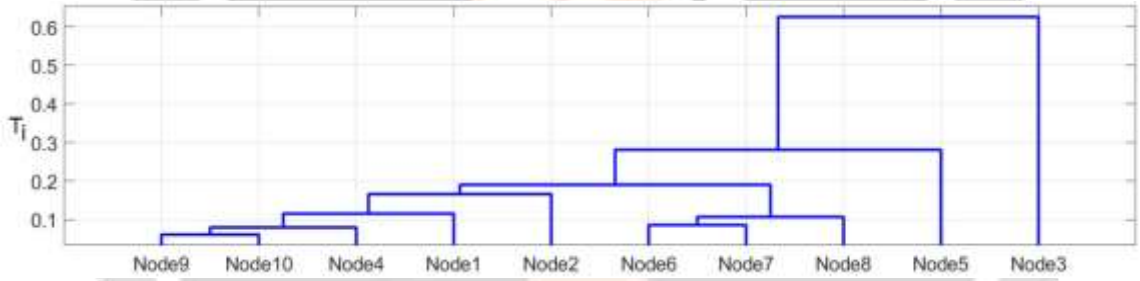
RESULT ANALYSIS

The framework mentioned is applied to clean and pre-processed datasets. The results sectionis organized as follows, 6.4.1 explains the dendrogram obtained for the data and quality of the solution using the cophenetic correlation values. 6.4.2 deals with the geographical distance-based priority order and the clustering of nodes based on heights in the corresponding dendrogram. Fig. 6.4.3 present the results for spatial interpolation and reconstruction errors.

6.4.1 Dendrogram and Cophenetic Correlation



(a) PM2.5



(b) PM10

Figure 6.3 Dendrogram representation of hierarchical agglomerative clustering with complete linkage and correlation based dissimilarity

5. CONCLUSIONS

The work presented in this thesis can be broken down into three parts: spatio-temporal analysis of deployed air pollution monitoring network, maximum frequency based adaptive sensing approach for improving the energy consumption in particulate matter nodes, and hierarchical agglomerative clustering based spatial sampling to remove the redundant node in a deployed IoT monitoring network. The following three paragraphs conclude the work presented on these three topics.

In chapter 4,the dense deployment of IoT nodes has been evaluated for monitoring PM values in the urban Indian setting. A description of these sensor node designs and the two WSN deployments for data set collection was presented. The data preprocessing andanalysis tools applied to the datasets were discussed. The measurements that have been done over more than five months clearly show a significant increase in PM values during Diwali and a noticeable reduction in PM values during national lockdown during COVID-19. It has been shown that the correlation coefficient between some nodes in the same campus has low values demonstrating that the PM values across a small region may be significantly different.Moreover, the IDW-based spatial interpolation results on the day of Diwali show significant spatial variation in PM values in the campus just a few hundred meters apart for PM2.5andPM10.The results also

Show notable temporal variations with PM values rising to 25 times at the same spot in few hours, thus motivating to use of the dense deployment of IoT nodes for improved spatio-temporal monitoring of PM values.

In chapter 5, a maximum frequency based approach has been proposed for adapting the sensing interval for sensor nodes in an IoT network. The algorithm has been employed on the data collected from seven PM monitoring sensor nodes over the year. It has been tested and compared against the

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