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Literature Survey on Wireless Sensor Networks in Smart Cities using Machine Learning Techniques

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***Abstract*— Artificial intelligence (AI) and machine learning (ML) methods are very powerful to properly manage the automatic operation of the Internet of Things (IoT) nodes installed smart cities. In smart cities, great IoT applications for smart traffic monitoring, smart waste management, smart structures and patient health monitoring. Small IoT notes based on low power Bluetooth standard and wireless. The standard is usually used to transfer data to a remote location using gates. WSN data IoT-based (WSN-IoT) design problems include network coverage and communication issues, power usage, need bandwidth, maximizing network life, communication protocols and state of the art infrastructure.**

Keywords*— Internet of Things, WSN-IoT, Machine Learning, Smart Cities.

I. INTRODUCTION

The smart city is an urban area that uses remote sensors and the Internet of Things empowering technology to collect data from a variety of sources and applications for improvement quality of life of the people. Low power, wireless sensor networks with low data rate used to monitor and control applications in smart cities. WSN notes are used as a basic technology infrastructure in the Internet of Things. In the Internet of Things, "Things" refers to small hearing devices connected to the Internet make a specific plan. Currently, a new method of change known as artificial intelligence and machine learning emerge as a completely automatic future Internet of Things applications. Given the rapidly growing capabilities of the IoT, it is poised to serve as a central feature of smart cities. In the last few years, there has been a surge of research aimed at exploring the potential of the IoT in the sustainable development of smart cities

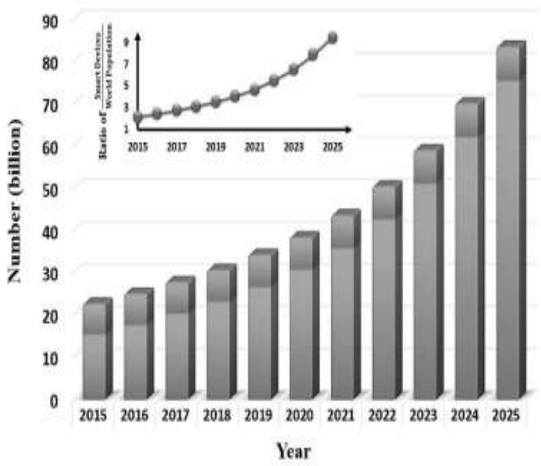

Figure 1. Comparison between the estimated world population and the projected number of smart devices connected to the Internet: 2015–2025 [9].

Machine learning is part of AI, where, computer algorithms learn by themselves the development of previous experiences. Detailed survey of ML algorithms was made until 2013 [1] Like machine learning and Internet of Things, technology is emerging rapidly, therefore, writers are expanding their experimental work. IoT applications to smart cities smart traffic monitoring [2], smart grids, smart waste management, smart agriculture, smart health care, etc.

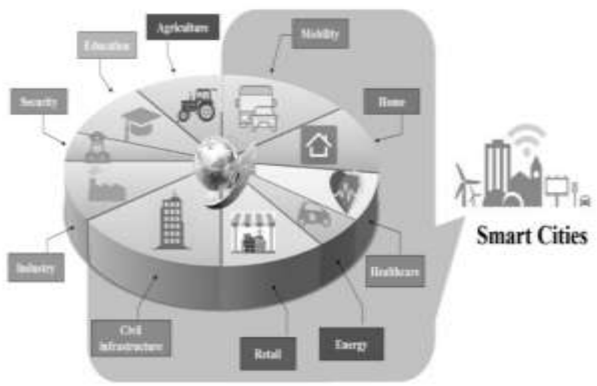

Figure 2. Smart cities in the application domain of IoT.

Machine learning can be used in WSN-IoT to improve route tables in WSNs, localization of nodes in WSN-IoT mobile nodes, identification and segmentation erroneous areas for network development and predicting energy harvesting value in harvesting the power of WSN.

II. WSN-IoT

IoT and WSNs are the prime moving force for technology in the current world. WSNs unfold their capacity day by day in almost every aspect of life. IoT enables to integrate the different devices and makes it possible to communicate with each other.

WSN-IoT technologies for smart cities.

Bluetooth Low Energy (BLE)

Bluetooth Low Energy is a wireless personal area network technology designed and marketed by the Bluetooth Special Interest Group (Bluetooth SIG) aimed at novel applications in the healthcare, fitness, beacons, security, and home entertainment industries.

Radio Frequency Identification (RFID)

Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. An RFID system consists of a tiny radio transponder, a radio receiver and transmitter. When triggered by an electromagnetic interrogation pulse from a nearby RFID reader device.

ZigBee

ZigBee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection.

Wi-Fi

Wi-Fi is the wireless technology used to connect computers, tablets, smartphones and other devices to the internet. Wi-Fi is the radio signal sent from a wireless router to a nearby device, which translates the signal into data.

Long Ranged Wide Area Network (LoRaWAN)

LoRa is a modulation technique for specific wireless spectrum, while LoRaWAN is an open protocol that enables IoT devices to use LoRa for communication.

Cellular Mobile Communication (4G/5G)

A cellular network or mobile network is a communication network where the link to and from end nodes is wireless.

Higher-level communication protocols in WSN-IoT.

- Message Query Telemetry Transport (MQTT) protocol : It is a lightweight open messaging protocol that provides resource-constrained network clients with a simple way to distribute telemetry information in low-bandwidth environments.
- Advanced Message Queuing Protocol (AMQP):It is an open standard application layer protocol for message-oriented middleware. The defining features of AMQP are message orientation, queuing, routing (including point-to-point and publish-and-subscribe), reliability and security.
- Constrained Application Protocol (CoAP) : It is a specialized Internet application protocol for constrained devices, as defined in RFC 7252. It enables those constrained devices called "nodes" to communicate with the wider Internet using similar protocols.
- Data Distribution Service (DDS) protocol :It is a middleware protocol and API standard that provides data connectivity, extreme reliability and a scalable architecture to meet real-time system requirements.
- Smart Transducer Interface protocol: It is IEEE P21451 It provides protocols for interoperability interfaces Sensor Connectivity, interoperable communication.

III. Literature Survey

The major challenges of a smart city are as follows: smart education, smart classrooms, smart traffic monitoring, rain water harvesting, smart grids in smart buildings smart healthcare in hospitals, smart agriculture, industrial IoT, smart waste management, smart governance, smart environment monitoring, etc.

The supervised learning algorithms are used in WSN for target tracking, localization of Nodes, event monitoring, data security, fault detection, etc. There are two types of supervisor learning as regression and classification. The objective of unsupervised ML is to know the probability distribution model of input data. In the reinforcement learning algorithm, there are two main components called the agent and the environment. The agent refers to the WSN-IoT node and the environment refers to the type of application deployment, e.g., temperature monitoring, pollution monitoring, smart agriculture monitoring, etc.

The solution provided by machine learning algorithms in WSN-IoT for problem of smart cities. The WSN node localization problem is considered as a classification or multivariate regression task in the ML domain. Therefore, SVM classification [3] or SVM regression model [4] algorithms are applied as a solution for the node localization problems in WSN-IoT. The security issues are tackled by correlation techniques and handled by using the Bayesian learning technique. Cluster head selection tasks in WSN-IoT are considered clustering tasks in the ML domain.

The k-NN [5], PCA and ANN [6] have been used for clustering. WSN node energy management is considered a prediction problem in the ML domain. The Q-Learning [7] has been applied to predict the energy issues. Similarly, in energy harvesting based WSN (EH-WSN) predicts future energy availability using reinforcement learning algorithms like Q-Learning, SARSA and deep Q-learning have been applied. Event monitoring and fault detection problems are considered as classification models. The routing of data packets in WSN-IoT is considered a classification problem in the domain of machine learning. The routing optimization algorithms such as genetic algorithms [8] and classification algorithms such as Markov decision process (MDP) in decision tree, random forest and Q-learning (QELAR) have been used. The QoS (latency, bandwidth and coverage) in

IoT is considered a prediction problem in IoT. Therefore, Q-Learning, ANN and SVM have been used as the solution.

The authors [10] conducted an experimental study of ZigBee and its potential application in an outdoor irrigation system. However, the testing environment did not consider different types of obstacles such as trees and walls, which is normally found in such an environment. The authors in [11] conducted an experimental performance evaluation and measurement of ZigBee PRO wireless technology. Despite the fact that the used hardware is compliant with the ZigBee standard, the results showed a huge performance gap between the practical and theoretical results. Thus, the attained results provide WSN developers and designers with a realistic expectation of the available hardware and help them in having an efficient network design that is close to reality. However, the indoor experimental environments used in this study does not reflect the realistic outdoor environment where WSNs are expected to be deployed. Furthermore, WSN nodes are deployed closed to each other without taking the effect of various types of obstacles that normally exist in the Area of Interests.

The ML and WSN-IoT pair can act as a boon for the medical healthcare sector in smart hospitals in smart cities. In [12] smart hospitals, the advanced ML techniques with efficiently deployed WSN-IoT can be applied for the treatment of infected patients placed in quarantine. The sensors attached to biomedical instruments can send patient's data over the internet to the doctors for medical diagnosis. Thus, doctors need not go near to the patients and hence avoid/reduce the virus spread in the smart cities and society.

IV. Conclusion

In this paper, a detailed survey of ML techniques for the smart city challenges. From this survey, it was concluded that supervised learning algorithms were used at a much higher rate compared to Reinforcement Learning and unsupervised. ML algorithms are so diverse and powerful that a single type of ML algorithm can be used in many applications in WSN-IoT intelligently. cities. For example, a powerful SVM algorithm can be used for partitions and retrofit operations on WSN-IoT. In the future, a more powerful and sophisticated algorithm will be emergence, which limits human intervention. The futuristic IoT-based solution for smart cities will include machine learning techniques.

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