Role of Machine learning and Internet of Things devices : An explorative study with respect to Smart City

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***Abstract*— This paper is an explorative study to analyze the role of various Machine Learning (ML). Algorithms which can be used for Internet of Things (IoT) devices. Since the growth in use of Internet of Things devices, the ease and quality of living of Human species has touched a different level. Everyday creating a huge amount of data. While. Machine learning on the other hand is ensuring that this Big Data is analyzed optimally and innovatively. Through this paper we are also trying to explore the possibilities of combining these two approaches ML and IoT; to understand its application in the field of Smart cities.**

***Keywords*— Machine learning, Internet of Things, Big Data and Smart city**

I. INTRODUCTION TO MACHINE LEARNING

Machine learning is one of the sub branch of artificial intelligence (AI) which makes system capable of learning and improving their performance through experience. With the presence of Big Data, Machine learning algorithm emphasize on the progress of computer programs that can access Big Data and use it for learning and making smarter decisions. [1]

Some of the applications of machine learning include image analysis, speech recognition, medical diagnosis, applications for fraud detection in a bank. However, with use of IoT devices, the data produced is also getting analyzed through Machine Learning.

Machine learning techniques are generally divided into two parts: Supervised learning and unsupervised learning. Unsupervised learning mainly deals with an unlabeled data and we don't need to supervise the machine. It helps us find all unknown patterns in the data given. It is easier for humans to get unlabeled data than labeled data.

In supervised learning we work on labeled data. We get the output of the given data with the data from the previous experience

II. ALGORITHMS USED IN MACHINE LEARNING

A machine learning algorithm is usually divided into two phases. One is the training phase and other is the testing phase. In the training phase algorithm is trained on the data where we know what the output variable is, whereas in the testing phase the algorithm is tested on a new data and the efficiency of the algorithm is found out. Machine learning Algorithms are broadly divided into Classification, Clustering and Regression Algorithms. Here we are briefly discussing some of the commonly used in machine learning found in other literature reviews for Smart City. They are: Linear regression, logistic regression, Decision tree, K nearest neighbors, Naive Bayes. Prediction algorithm is the most used in Smart homes applications.

A. Linear regression

A relation is established between known and unknown variables by a regression line which is given by Y=a*X+ b
Y is dependent variable
X is dependent variable
Here a, b are the parameters. The values of a, b are changed after every iteration.

B. Logistic regression:

It's used to estimate discrete values from variables. Many functions like relu, tanh are used in this algorithm.

C. Decision Tree:

This algorithm is mainly used for classifying problems. In this algorithm the data is split into two or more sets depending upon the variables involved.

D. KNN:

In KNN it is assumed that similar things exist in the same vicinity. Distance of unknown points is found out from the known points and depending on the value of k, the unknown data is labelled.

III. INTERNET OF THINGS

Today's world population is engaged all sort of connectivity, especially through Information and Communication Technologies (ICT) than ever [2]. Many researchers have claimed that by 2050, more than 70 percent of the global population is expected to be living in cites which are connected smartly [3]. The growth of population in cities and the increased dependency of human race on ICT has led to advancements towards better management of all city resources. This will ensure that major aspects of city life will get addressed appropriately omitting the threats to development and sustainability. Thus, enabling human race can experience a better quality of living.

Internet of Things (IoT) on the other hand is a massive network of connected devices to provide enhanced experiences in day to day life for common people, industries and enterprises. Any IoT device works basically by creating a digital identity of a device, reading and analyzing data from it and its surroundings.. IoT enables easy access and amalgamation

between a variety of smart devices such as home appliances, vehicles, smart phones, wearables, agriculture equipment's etc. in an urban city setting. By merging IoT in the smart city, better resource management for different application domains within in a city can be achieved efficiently [4].

There are some key elements that are responsible for functioning of IoT. Before discussing its role in smart cities, lets analyze these elements:

- Sensors and Actuators: These are the basic component which gather and analyze information from their surroundings continuously. They could be found at various levels such as home appliances, wearables, smartphones, machines, environmental sensors and in a lot of other devices.
- Communication Channel: IoT is a network of devices, to connect these devices and share information between them comes in picture the Communication Channel. This communication channel is responsible to connect the devices and the cloud-based service for frequent processing of information.
- Cloud Storage: Data and information that is gathered from devices are cleansed, combined, stored, transformed and modelled with past existing data. This is where the final processing is done and results are generated for the end user.
- Information Delivery: The last step in this IoT chain is the delivery and consumption of these generated results to the end users or devices, and on the basis of that decisions making takes place.

IV. IOT TECHNOLOGIES FOR SMART CITIES

Like any other network smart devices summing up to be IoT network works on standard communication network protocols. Its convergence point is the Internet. The main concept of the IoT network focuses on data produced through smart devices, which can be measured, inferred, understood. This Big data is further processed using Machine Learning Algorithms to change the environment. Thus, IoT is based on the developments of various smart devices and their connectivity. The impact of the IoT on the life of users can be considered as the major aspect of representing Smart city culture [4]. Some of the IoT-related technologies that could be easily adapted for implementation of smart city are discussed in the following.

A. Radio-Frequency Identification (RFID)

This is the technology where digital data is encoded on RFID Tags and is captured by a reader. These devices are playing a vital role with context to IoT. By applying these technologies to any involved object, it is possible to carry out their automatic identification and assign a unique digital identity to each object, in order to be incorporated in the network and the data provided by them can be further analyzed through Machine Learning. [4].

B. Wireless sensor network (WSN)

Wireless Sensor Networks (WSN) are used in many industrial applications and they are a key ingredient in the growing Internet of Things (IoT). Wireless sensors can collect useful data through RFID Tags or their operational environment. This data gets captured wirelessly, to omit the cost of wired infrastructure, especially when we focus on long distance sensor, or when network is retrofitted into an already existing operational environment. The data is then moved from the network via a gateway to a software application. The software's intelligence then makes decisions based on the data, either from single data points, or from trends and statistics derived from large data sets.

C. Addressing

Internet changed the way Human interact, remarkably; revolutionizing the ICT. Likewise, IoT can provide an interconnection of objects and things, the way they exchange data. This data can be then analyzed through Algorithms establishing smart environments [5]. The way computer networks provide addressing to uniquely identify a device. Similarly, an effective mechanism needs to implement in addressing IoT devices. This is due to the fact that uniquely addressing the large-scale combination of smart objects is vital for controlling them through the Internet. Apart from uniqueness concept, reliability, scalability as well as persistence represent other key requirements to develop a unique, applicable and robust addressing scheme [5].

D. Middleware

IoT devices result into a heterogeneous network, wherein all the objects have restricted storage and process capability, along with diverse application scope, therefore middleware plays a critical role in the interconnecting these smart devices to the application layer. The key objective of the middleware is, indeed, to concisely integrate the functionalities and communication capabilities of all involved devices.

V. SMART CITY

A smart city is a framework, predominantly composed of Information and Communication Technologies (ICT), to develop, deploy, and promote sustainable development practices to address growing urbanization challenges. [6]

A. Concept and Use

The key technologies that make a smart city work are:

- Smart Energy: the energy consumption in a city should be monitored and then acted upon. Smart streetlights is one of the options. LED's should be used instead of a normal tube light. Smart grids, smart meters should be installed to see how much energy is being wasted.[10]
- Smart transportation: Smart traffic lights that monitor traffic flow can reduce traffic jams. Also, by making parking smarter people can spend less time in parking their cars.
- Smart Environment: Environment refers to healthy living conditions with respect to pollution. A smart must monitor the pollution levels and deliver this information to citizens, especially to those with health care conditions. Other aspect to be considered can be noise pollution [9].
- Smart infrastructure: Planning of the cities will be better if we have large amounts of data being worked on.
- Smart security: From people's point of view safety and security are the major factors of concern. For this purpose we must monitor the smart city continuously,

analysing the data and detecting crimes which are challenging otherwise to detect[9]

- Smart mobility: Smart mobility refers to using modes of transportation like carpooling, public transportation, walking, biking and more. This helps in reducing the congestion problems of the city due to traffic.

Smart cities use the collected data to analyze the situations and problems of the city[7]. Upon the analysis of this data necessary development is made in the city. The key problems that can be solved by this idea are:

- Infrastructure: To collect data and improve the standard of living of the residents of the city. To manage all the pipelines, transportations tunnels, steam pipes of the city.
- Smart Solutions: Smart cities will provide smart solutions like providing basic data to everyone, treating waste water from time to time.
- Promoting Development: Development of schools, buildings, colleges, shopping malls benefit all the people of the society.

B. Algorithms used in smart cities

Prediction algorithms are mostly used for smart cities.

- Naïve Bayes: Naïve Bayes algorithm is based on the Bayes Theorem. Its emphasis on classification of a problem. Different types of Naive Bayes classifiers are Multinomial, Bernoulli, and gaussian. The difference is dependent on the parameters, variables taken. The disadvantage of this algorithm is that the predictors should be independent, whereas in real life predictors are dependent. This is mainly used for smart waste generation
- KNN: KNN is a supervised learning algorithm. It classifies the new case based on how similar it is to the existing points . To find the K nearest neighbours of a given point we use the Euclidean distance, norm, angle, hamming distance. It is used for Node detection and tracking in smart cities.
- Support Vector Machine: Support vector machines are non- probabilistic, binary classifiers. They are formally defined by a hyper plane that divides classes of the training set. The label of the new date point is decided based on which data point it falls into. This algorithm is mainly used in vehicle Localization.
- Support vector regression: SVR is almost the same as SVM but with some restrictions. The model returns a continuous valued output instead of an output from a set. Demand response management in a city is done by this algorithm.
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C. Smart cities around the world

Some of the cities around the world have implement the concept of smart city in few areas. However, they have focused on only one or two aspects [8] like:

- New York: This city has topped the list as one of the smartest cities in the world. New York has deployed a large scale Automated Meter Reading system to understand better the water consumption problems of the city. The city also has smart bins which help in monitoring the waste in the city and ensure that the waste is collected from time to time.
- Amsterdam: This city is implementing data vault, where the transportation related traffic data is shared created mapping apps specifically to only interested users. Thus empowering people to make optimal use city's traffic system.
- Tokyo: This city is using face recognition technology in driverless taxis to improve the security of the tourists.
- Singapore: This city has implemented a parking guidance system which lets people know the parking situation in real time. Smart bins are also introduced in the city. Singapore also has a one monitoring system where people get to know about the traffic in and around the city.[3]

CONCLUSION

Through this paper we have tried to correlate the aspect of ML and IoT. Since IoT comprises of a massive quantity of different smart devices being connected with each other in a heterogenous environment. These devices thus, transmit huge amounts of data. To analyze and use this data we need appropriate ML algorithms. Further, in this paper we have discussed that smart city is one of the major application of IoT, which is getting implemented in major cities around the globe, however this concept is fairly new to Indian cities. To approach an ideal solution for big data generated by smart city application, its analysis must be done using appropriate ML algorithms. Selecting a suitable algorithm considering the application of IoT for smart city is however an important issue.

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