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A Review on Big Data Analytics and Deep Learning for Smart City Development

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ABSTRACT

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The concept of smart cities came into reality because of the advancement in Computer and Communication Technologies. Internet of things (IoT) play a vital role in smart city development in which multiple IoT sensors are deployed across different locations for data collection about mobility of people, garbage, traffic etc. Deep Learning models has been applied on the data collected through IoT sensors in a smart city. This article reviews the use of data analytics and deep learning in the development of smart city. At the end, different research challenges are identified.

Keywords : Internet of Things, Deep Learning, Smart city, Big data analytics.

I. INTRODUCTION

A smart city is sustainable, prosperous, livable and a city that puts its people first. The smartness of a city depends on smart transportation smart crime detection prevention providing safety to citizens etc. The Smart City[1] always aims to provide smart services to the citizens through IoT and Data Analytics .The concept of data analytics and deep learning made Smart City into reality .Deep learning[2] is a machine learning technique which can be used effectively to gain insights from data understand the patterns from the data and classify/predict the data. Smart City uses the concept of IoT which uses sensors and connected devices to collect and analyse data. The collected data is used to manage resources and improve the quality of life of citizens. Smart City Development focus on improving the public transportation, manage traffic, reduce crimes, optimise water and power supply, smart healthcare, smart education and more.

IoT connects billions of devices such as smart sensors, lights and meters that can communicate and interact with each other over the internet and they can be remotely monitored and controlled .Data collected through IoT sensors[3] help to manage traffic, control pollution, make better use of resources and keep people safe and clean. Smart cities can process data from IoT devices and sensors to recognize patterns.

II. THE CONCEPT OF BIG DATA AND BIG DATA ANALYTICS

Big Data refers to a large and complex data sets with size vary from multiples of terabytes to exabytes. Traditional database management systems such as RDBMS are not suitable to manipulate this huge and complex data sets[4]. Large data sets from IoT sensors of smart cities are easily managed by big data. Big Data can be applied to Un-structured, Structured and Semi-structured data sets based on requirements and needs. Whereas Big Data is mainly focused on Un-structured data sets. Nowadays Big Data Analytics[5] has been applied on various smart city applications such as smart healthcare, smart transportation, smart waste management and many more.

2.1 Key Characteristics of Big Data Analytics

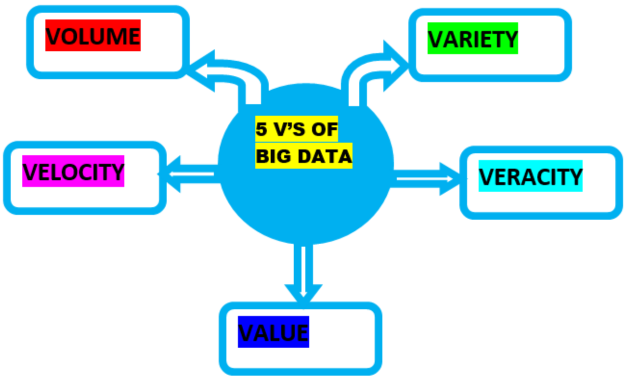

Figure 1. Characteristics of Big Data Analytics

The different Key Characteristics of Big Data Analytics are listed below:

- **Volume:** Volume represents the data size that actually stored and generated. Depends on the data size it has been determined the data set is big data or not.
- **Variety:** Variety represents the nature, structure, and type of data which is being used.
- **Velocity:** Velocity represents the speed of data that has been stored and generated in a particular development process flow.
- **Veracity:** Veracity indicates the quality of data that has been collected and also helps data analysis to reach the proposed target.
- **Value:**Value is the worth of the data being collected. Some Big Data that a business stores may have little or no value in decision making or improving operations. A company may be required for compliance reasons to capture and store large.

2.2 Types of Big Data Analytics

The four types of Big Data Analytics [5] are explained as follows:

2.2.1. Predictive Analytics

These analytics is basically prediction-based analytics. Predictive Analytics works on a data set and determines what can be happened. It basically analyses past data sets or records to provide a future prediction.

2.2.2. Prescriptive Analytics

Prescriptive Analytics works on a data set and determines what actions needs to be taken. This is a valuable analysis but not used widely. Many of the health care sectors used this analysis on the top of various activities to manage their business activities.

2.2.3. Descriptive Analytics

Descriptive Analytics actually analyze the past and determines what actually happens and why. It also helps to visualize this analysis in the dashboard may be in the form of graphical representation or in some other format.

2.2.4. Diagnostic Analytics

Diagnostic Analytics executes on current data sets. It is used to do analysis based on incoming real-time data sets. Many of the systems like business intelligence tools use this analysis to create real-time dashboards and reports.

Therefore, data analytics[6] refers to the set of quantitative and qualitative approaches for deriving valuable insights from data. It involves many processes that include extracting data and categorizing it in order to derive various patterns, relations, connections, and other such valuable insights from it. It act as a key to delivering smart cities.The role of data analytics in smart city development focus on making zero-carbon cities, enhance urban movement, and manage urban infrastructure in a supporable, secure and efficient manner.

III. SMART CITY IOT TECHNOLOGY ARCHITECTURE

Smart cities using IoT are using big data analytics to design better public services and mete out better standards of living and cost-effective public services. With the growth in population in cities, civic administrators using **IoT applications in smart cities**[7] that will help them resolve the challenges of smart cities efficiently and effectively. There are many **applications of IoT in smart cities**, but these are dependent on collecting the necessary data from sensors, IoT and other available technologies. After collecting data, there needs to be the necessary infrastructure in place to process it, store it and manage it. The components that make up the data infrastructure for **IoT in smart cities** are - sensors (which collect data and send it to the cloud), actuators - which control the movement of the component or device, cloud gateways to ensure secure data flow and access, data lakes, data warehouses to store the data and ensure that it can be accessed speedily. The technology uses data gathered via sensors, actuators, smartphones and smart applications, which is then collected and analysed. Data analytics task helps the cities monitor in real-time, implement evidence-based actions and track their progress. In the Netherlands, for example, homes are being equipped with smart energy meters and automobiles embedded with smart usage tracking and routing technologies.

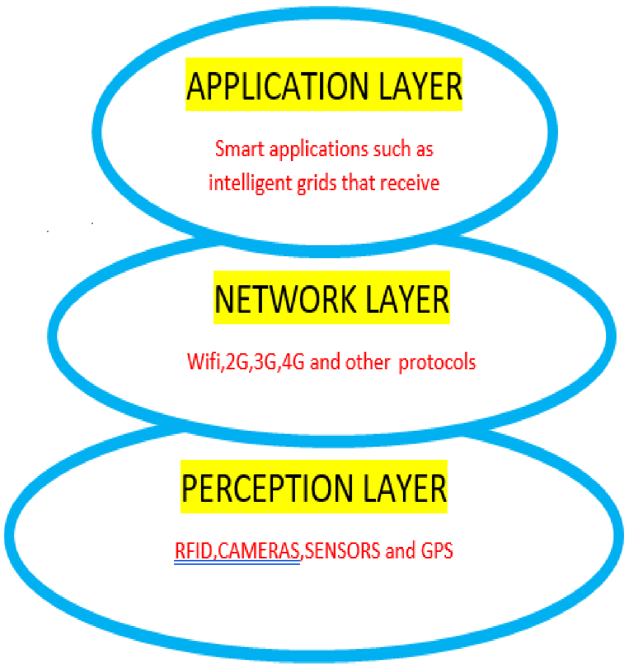

Figure 2. Layers of smart city

Some examples where IoT solutions and data analytics technologies[8] are helping the cities reduce their environmental trail and helping to create a more sustainable and eco-friendly city for a healthier and happier planet includes Waste Management, Reducing Plastic Consumption, Reducing Plastic Consumption, Smarter Resource Usage and many more.

IV. DEEP LEARNING FOR SMART CITIES

Artificial Intelligence is the computers' ability to perform tasks that typically require human intelligence, such as image recognition, transcribing speech to text, and translation between languages. The capacities of AI have grown substantially over the past few years and ML, a subset of AI, provides computer programs with the capacity to learn and improve behaviours by training the program with a given dataset. The trained program then gains the ability to make decisions without being explicitly programmed.DL techniques [9] are typically categorized into supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning.

(a) Supervised learning: refers to learning from labeled training data in order to predict outcomes for unforeseen data []. The two most common applications of supervised learning are classification and regression.

(b) Unsupervised learning: refers to a type of learning that uses descriptive statistics to examine the patterns and relationships that occur naturally within the data [10]. Unsupervised learning is used to find the hidden, interesting structure in data.

(c) Semi-supervised learning: refers to the circumstances in which training data contain a few labeled data with a large amount of unlabeled data [10].

(d) Reinforcement learning: occurs between supervised and unsupervised learning [11]. Reinforcement learning gives an "agent" the ability to learn from its environment, enabling that agent to act and behave smartly. This learner agent then interacts directly with its environment via "actions" and receives "rewards" from surroundings to inspire and create a perfect behavior policy. Q-learning is the most popular reinforcement learning technique [12].

In recent years, Deep Learning has been used extensively on the data generated by **IoT sensors** in a smart city by several researchers. These techniques perform analysis of different kinds of data such as images, speech, text, videos, and so on. The advantage of Deep Learning is that it can perform sequential data analysis. Time series data is a particular form of sequential data.

V. CHALLENGES

It is obvious that Deep learning is rapidly altering the way cities function, provision and sustain all possible facilities such as conveyance, energy, healthcare, connectivity and various others. But selection of the proper technology that provide efficient services to the smart city remains to be a prominent challenge. The time-sensitive applications in the smart city environment deals with real-time and also non real-time streaming of data. Development of frameworks that incorporate big data analytics and fast data analytics also acts as a challenge. The necessity for light-weight ML algorithms for resource constrained devices ensuring security, privacy is another challenge to work on. The datasets used for deep learning applications are also sometimes not available readily and, in enough size, to confirm results through simulations.

VI. FUTURE DIRECTIONS

Transfer learning is a upcoming way of research wherein the distribution of training and testing is altered or transferred from one platform to another. Researchers should also focus on integration of semantic technologies in smart city applications to empower better collaboration of smart devices with the users of the same. Lastly, usability of the smart devices play a significant role. The technologies and devices used in smart cities are often mobile and wearable which allows minimal spaces for users to touch screens which the old aged people often find it challenging. Integration of speech recognition technologies allowing natural language understanding in smart devices is also a potential area of research.

VII. CONCLUSION

In this article a review on IoT based Big Data Analytics and Deep learning for Smart City Development is presented. Several challenges of using deep learning on smart city data are also emphasized. In the end future research directions on usage of deep learning on smart city applications are recommended.

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