Scholars Journal of Engineering and Technology

OPEN ACCESS

Abbreviated Key Title: Sch J Eng Tech
ISSN 2347-9523 (Print) | ISSN 2321-435X (Online)
Journal homepage: https://saspublishers.com/journal/sjet/home

Approaches and Challenges in Development of Smart Cities in Perspective of Big Data and Machine Learning

Hiba Iftikhar*

Department of Computer Science Engineering, Jamia Hamdard University, Delhi, India

***Corresponding author:** Hiba Iftikhar

| **Received:** 17.07.2019 | **Accepted:** 24.07.2019 | **Published:** 30.07.2019

DOI: 10.36347/sjet.2019.v07i07.001

Abstract | **Original Research Article**

There are various requirements posed by smart city projects which include a large number of users and these requirements are very diverse in nature. This paper proposes big data and machine learning as an approach for smart city project development and analyses its impacts and perspectives for the deployment of these projects. Big data is considered as an essential element to tackle most smart city projects. Unfortunately, due to lack of orthodox mechanisms and standards, most of the data generated gets wasted without extracting the potentially useful information and knowledge out of that data. This study reviews the application of big data and machine learning and explores the advantages and disadvantages as well as the opportunities and challenges of applying big data applications to smart city projects. The review suggests that there are several opportunities available for utilizing big data in smart city projects; however, a few challenges and issues are yet to be addressed in order to achieve an optimum utilization of this technology.

Keywords: Internet of Things, Big Data, Machine Learning, Smart City.

INTRODUCTION

`Urban regions cover only 0.2 per cent of the Earth's land surface but contain nearly half of the world's population. This is a data given by the United Nations Population Division.

`This results in extreme pressure on today's cities and hence, generates large quantities of data at exceptional rates. Reports also predicted that the population growth rate in urban areas might hit 68 per cent by 2050.

` `Moreover, 70 per cent of the world's resources are consumed by cities. Therefore, smart city concept can help a government to achieve the required level of sustainability and can also improve the standard of living in their cities which can be achieved through big data applications.

`Smart cities are an approach considered effective in order to support the economic growth, while also controlling the climate changes and adapting innovative technologies to improve the living standards of urban citizens. The distinguished common problems in cities include congested traffic, unplanned urbanization, waste management, and lack of mobility, high rate of increase in population, scarce resources and energy distribution amongst many other problems to be concerned about.

Smart city projects with the advantage of Internet of Things (IoT) and machine learning relieves the pressure on their inefficient infrastructure while creating a more sustainable environment which therefore results in the generation of large quantities of data at exceptional rates. Unfortunately, due to lack of orthodox mechanisms and standards, most of the data generated gets wasted without extracting the potentially useful information and knowledge out of that data.

This paper mainly investigates the application of big data in smart city projects by reviewing the opportunities and challenges that will be faced by implementing this technology in smart cities. Moreover, the paper explores the general requirements to design and implement big data applications for smart city applications and services.

BIG DATA DESCRIPTION

To become a smart city, cities need at least one thing in common. **They all need reliable (sensor) data to base their long-term decisions on.** Data is the lifeblood of a smart city.

Three Layers of Data

- First is the technology base, which includes a critical mass of smartphones and sensors connected by high-speed communication networks.
- The second layer consists of specific applications. Translating raw data into alerts, insight, and action requires the right tools, and this is where technology providers and app developers come in.
- The third layer is usage by cities, companies, and the public. Many applications succeed only if they are widely adopted and manage to change behaviour.

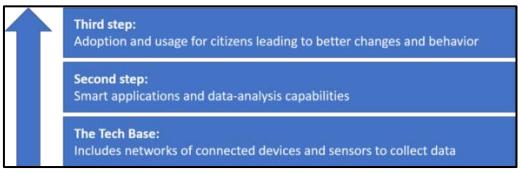

Fig-1: Three layers of Data

Big data can help reduce emissions and bring down pollution. Sensors fitted in the roads will measure the total traffic at different times of a day and the total emissions. The data can be sent to a central unit which will coordinate with the traffic police. Traffic can be managed or diverted along other less congested areas to reduce carbon emissions in a particular area.

- Parking problems can be better managed. Cars will have sensors attached which can guide the car to the nearest available parking lots.

- The environment will cooler and greener with less energy being consumed. In Bristol, a program that involves development of a wireless network based on IoT is under way. This network will use less energy and power than the traditional Wi-Fi and mobile networks. So, batteries on mobile devices will last more and there will lesser need to charge the devices frequently.

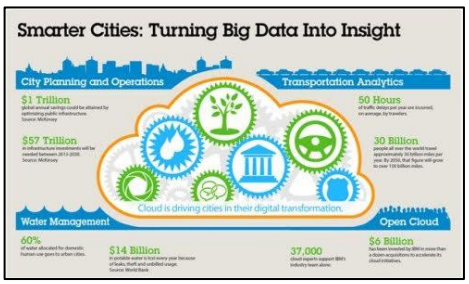

Fig-2: Impact big data can have in building smart cities

THE DATA CHALLENGE AND SOLUTION

Cities and their solution providers cannot extract the full value of data if it is held in disparate systems and databases that limit access and use. There are already huge amounts of data in our cities, however much of it is in silos serving specific needs, rather than contributing to the common good. It includes government statistics, maps, and details on public tenders.

Better parking, efficient lighting, improved traffic flow, smarter security, improved waste management, and disaster planning are all areas where technology can make a difference. However, there's a lot of fragmentation; we need a way to connect all these different standards and bring them all in a common, unified platform.

Creating a smart city depends on how well organizations can share and analyse the vast amount of data being generated. Without the ability to share key information in real time, businesses operating both in the private and public sector can't develop the applications that support automation, nor the software solutions that form the 'smart' capabilities of a city and its infrastructure.

Furthermore, each new sensor type often requires a new database, which is often subject to the city procurement process. These systems frequently do not talk to each other in ways that are useful or intuitive, making it virtually impossible to extract actionable insights from the information.

Big data may be catalogued and stored at various sites, owned by different entities and yet mostly sits unused. Furthermore, there is a variety potential uses of big data to address problems directly from the source as well as analytics for deeper insights through data analytics, data intelligence and data mining. To further facilitate this huge demand for resources to support big data analytics, the Cloud stepped in and offered an elegant and efficient solution. The Cloud is a suitable platform for highly resource intensive applications for active collaboration between different applications. This fits very well with the requirements of smart city applications and could help resolve some of its challenges. Through these technological uses, smart cities have higher possibilities to be smarter than ever and achieve their goals more effectively and efficiently.

The effective management of data is not limited to data capture and storage, but must also include data that is shared and combined so it can be accessed,

analysed and used across departments, between organizations, and even with the community at large.

In every major city in the United States, and beyond, there are millions of sensors producing a staggering amount of data every millisecond, second, minute, hour, and day. That data is captured, stored and more or less forgotten after. Smart cities need to be built on networks that allow for the free communication of data.

COLLECTION AND STORAGE OF DATA

Information and communications technology (ICT)

Information and communications technology (ICT) plays a major role in smart cities by making data that's collected through information technology components available. This technology, also called the Internet of Things (IoT), works by communicating between connected devices while exchanging data that requires internet, wireless connections, and other communication mediums.

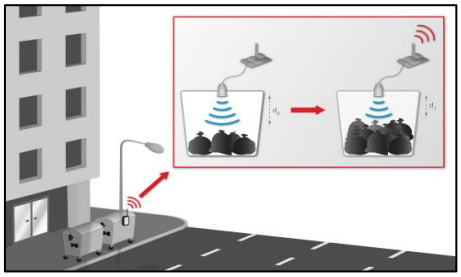

Fig-3: Example of a sensor being used to improve the city management

Mainly, smart cities make use of IoT devices to fetch data and efficiently process it for implementing it in a particular area. Smart city sensors and connected devices collect data from various smart city gateways installed in a city and then analyse it for better decision-making.

By inserting sensors across city infrastructures and creating new data sources—including citizens via their mobile devices—Smart City managers can apply Big Data analysis to monitor and anticipate urban phenomena in new ways.

Cloud Computing

Smart city is defined a kind of new lifestyle and social management mode, which can obtain massive information and filtrate the information intelligently by integrating information platform of the urban and constructing unified information sharing mechanism with the help of information technology such as internet of things and cloud computing and the information infrastructure. As a kind of new urban from, smart city changes the ways of communication among citizen enterprises and governments, and quickly responses to all kinds of requirements including people's livelihood, public safety, city services and business activities, and then make cities run more efficiently[3].

Smart city means to collect all information resources from all information system supporting city operation and make them a bigger information sharing system under the support of the internet of things and cloud computing. At present, the main problem lies in city information resources integration is isolated information island. Due to lack of the common database construction standards, it is so hard to integrate the information dispersed in different departments and impossible to ensure internet and inter-communicating, resources-sharing. During the process of city development, the massive data accumulated in different departments cannot be shared because of lack of sharing mechanism, and lead to information delay and information deficiency. This phenomenon will be adverse to the integration of information resources and the construction of smart city. So other than the unified standards of information construction, the data integration for different urban departments is also important for the smart city construction. Only when the above two points are satisfied, the object of massive data sharing will be achieved, and then all the citizen, enterprises and city participants can get the intelligent service, we can have a smart city[4].

The key factor for the construction of smart city is to make the communication and information infrastructure more perfectly, construct information sharing platform, and make all the city activities participants receive higher efficiently and more intelligent convenience services from the construction of smart city and the relative intelligent system. A successful smart city system should have city information cloud, in which all the relative city services should operate in the unified cloud platform and all the resources can be shared among different parts of the system, and provide the clients with intelligent service by construction of virtualization technology. So a smart city system based on cloud computing should have a platform which can integrate all resources and make the resources shared among the system, and then accomplish the interoperation among clouds. A smart city system should be comprised of infrastructure cloud, platform cloud and application cloud, correspond to infrastructure as a service, platform as a service and software as a service respectively. As the lowest resources layer, the infrastructure cloud provides the necessary basic physical resources including server, network, storage devices to meet the information demand. The infrastructure cloud is the foundation for all services and the information sources.

The resource pool of infrastructure cloud is constructed by virtualization platform, and drew up by all the regulatory agencies of private cloud. In the end,

we get the goal for standardization and collaboration. Lied between infrastructure cloud and application cloud, the platform cloud is the core layer and the key factors for information sharing. The function of platform layer is to manage regional cloud resources and integrate data resources from infrastructure cloud by the ways of data collection and data switching. After being integrated, the resources need to be reprocessed, numerous application tasks need to be dispatched, and then the resources can be used efficiently and safely. Application cloud lies in the top-level of the whole cloud framework, and is the implementation layer for information sharing. The main function of application cloud is to provide implementation platform. In this layer, we can develop all kinds of government affairs clouds to meet the requirements from city activities participants [5].

BENEFITS AND OPPORTUNITIES

The high dynamical nature of smart cities calls for new generation of machine learning approaches that are flexible and adaptable to cope with the dynamicity of data to perform analytics and learn from real-time data. There are many examples of big data and machine learning applications serving smart cities such as:

Smart Lighting

Problems: High energy use, utility costs, and maintenance needs. Solution: Smart lighting that reduces maintenance needs, decreases energy consumption, and lowers utility bills.

Smart lighting projects typically take place on city streets and public land. Old infrastructure and incandescent lighting is replaced with connected infrastructure and energy-efficient LED bulbs. The more efficient bulbs lower carbon emissions to improve sustainability and use less energy, which decreases costs for cities. Connected infrastructure then monitors performance so maintenance is only deployed when there's a problem so they can quickly resolve it [6]. Added Benefits of Lightning include longer lifespans for streetlights and improvements in public safety that come from having more spaces adequately lit.

Smart Parking

Problems: Traffic congestion and legacy city road and parking infrastructure. Solution: IoT monitoring that locates empty parking spaces and quickly directs drivers to open spots. Up to 30 per cent of traffic congestion is caused by drivers looking for places to park [7].

CHALLENGES

Data Sources and Characteristics: Data is generated from many different sources in many different formats. There are a lot of new data formats many of which are unstructured (e.g. images, audio, tweets, video, server logs, etc.). This data need to be managed and classified into a structured format using some form of advanced database systems [8].

Digital Security: Data Security is another threat cities face when they try to implement smart city projects. As personal data gets uploaded into the cloud, it is often shared with digital devices, which, in turn, share the information among multiple users. It is therefore vital to safeguard this information from unwanted use. Applying appropriate digital security measures safeguards the private and proprietary information of citizens, governments, research partners, universities and digital infrastructure.

Data Quality: Looking at more fundamental aspects of big data, there are a number of challenges that are associated with the quality of the data. Data captured by different people under special regimes and stored in distinctive databases is rarely stored in any standard formats [9].

Government Policies: Due to the ever-increasing volume of sensors and their data, robust connectivity technology is a requirement for success. It is also often limited by a city's budget.

CONCLUSION

Big data and machine learning are two modern and important concepts since building smart cities; therefore, many started integrating them to develop smart city applications that will help reach sustainability, better resilience, effective governance, enhanced quality of life, and intelligent management of smart city resources. Our study explored both concepts and their different definitions and we came to identify some common attributes for each. Despite the varying definitions each concept has a number of characteristics that uniquely defines it. We were able to identify the general benefits of using big data and machine learning to design and support smart city applications. Building smart city applications will require addressing the challenges and having well trained human resources, utilizing simulation models and being all prepared and well supported by the governing entities.

We also discussed about the development of technological platform which could dramatically improve the ability of internet to provide services. The services mode and the new network platform constructed by cloud computing advanced a kind of new information resource management platform. The application of cloud computing in smart city can integrate effectively city information resources, and resolve the problem of information isolated island existed chronically in urban information resource management. The application of cloud computing in the fields of intelligent medical, intelligent transportation and intelligent logistics will enhance the information utilization efficiency of all kinds of city activities and provide convenience life for the people.

With all success factors in place and better understanding of the concepts, making a city smart will be possible and further enhancing it for smarter models and services will be an attainable and sustainable goal.

REFERENCES

1. WU X, YANG Z. The Concept of Smart City and Future City Development [J]. Urban Studies. 2010;11(011).
2. Gu S, Yang J, Liu J. Problems in the development of smart city in China and their solution. China Soft Sci. 2013;1:6-12.
3. BI CQ, CAO J, WU WH, WANG YH. Tangshan information sharing mode design based on cloud computing [J]. Journal of Hebei University (Natural Science Edition). 2012;1.
4. Marsh O, Maurovich-Horvat L, Stevenson O. Big Data and Education: What's the Big Idea; 2014.
5. Reid AR, Pérez CR, Rodríguez DM. Inference of vehicular traffic in smart cities using machine learning with the internet of things. International Journal on Interactive Design and Manufacturing (IJIDeM). 2018 May 1;12(2):459-72.
6. Michalik P, Štofa J, Zolotova I. Concept definition for Big Data architecture in the education system. In2014 IEEE 12th International Symposium on Applied Machine Intelligence and Informatics (SAMI) 2014 Jan 23 (pp. 331-334). IEEE.
7. Lee CH, Birch D, Wu C, Silva D, Tsinalis O, Li Y, Yan S, Ghanem M, Guo Y. Building a generic platform for big sensor data application. In2013 IEEE International Conference on Big Data Oct 6. IEEE. 2013; 94-102.
8. Chourabi H, Nam T, Walker S, Gil-Garcia JR, Mellouli S, Nahon K, Pardo TA, Scholl HJ. Understanding smart cities: An integrative framework. In2012 45th Hawaii international conference on system sciences. *IEEE*. 2012; 2289-2297.
9. Bertot JC, Choi H. Big data and e-government: issues, policies, and recommendations. In Proceedings of the 14th Annual International Conference on Digital Government Research 2013 Jun 17. ACM. 1-10.
10. Alexander Gonfalonieri Big Data & Smart Cities. 2018. How Can we prepare for them *https://medium.com/dataseries/big-data-and-smart-cities-why-we-need-them-now-a194b2498fb1* Dec 13, 2018
11. Kaushik Pal Smarter Cities : Turning Big Data Into Insight *https://www.kdnuggets.com/2015/10/big-data-smart-cities.htm.*