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Internet of Things (IoT) in GIS

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Abstract

Our world is transforming and rapidly becoming digital. Today, people are on the cusp of an IoT-driven technological revolution, affecting most sectors including energy industry. With billions of connected sensors deployed on assets and networks and in products around the world, companies are collecting and processing data at a higher frequency and velocity with the help of 6G (the sixth generation of wireless technology). GIS and IoT are interrelated and nested technologies. The challenge that continues to plague many organizations is how to make effective decisions with the help of 6G network technology. Organizations are facing many new challenges and looking toward technology to improve situational awareness, create operational efficiencies, and optimize all aspects of work. As IoT and GIS adoption increases and their applications mature, the future is becoming increasingly intelligent and automated. As IoT connects the data, and the GIS adds context around the asset, connecting the information model to other models and to its surroundings. GIS creates digital twins of the natural and built environment, and it can also be used to integrate many different digital representations of the real world.

Introduction

In the Digital era, evolution in technologies motivates and inspires us to live a better quality of life. Digitization has made once the impossible visions come true. Internet of Things (IoT) and Geographical Information System (GIS) are one of those technologies people witness today.

IoT is offering boundless opportunities for consumers and businesses. The connectivity between the objects and able to collect a considerable amount of real-time data has made it efficient. On the other hand, GIS has a foundation of data collected through IoT devices and digital maps.

With the help of 6G network technology, the data transfer will be faster. 6G will use higher frequency bands and agile, cloud-based networking technology to deliver record-breaking speeds and microsecond latency.

Internet of Things (IoT)

Internet of Things is a system that interconnects with a network of physical objects like sensors, computing devices, and software for transferring data over to other systems without any interference of human to human or human to computer interaction, i.e., smart homes. Growth of the Telecommunication Industry offers us new connectivity offerings like 6G service going to be connected soon.

The devices can connect with IoT range from ordinary household appliances to large industrial equipment. It is used for computing, and to minimize human intervention, with IoT, people automatically collect and share the data to align with your daily process with machinery or lifestyle.

Internet of Things can be defined as a network that allows things around us to interconnect and talk to each other. Things around us are smart, smartwatch, smart T.V, smart mobile and more. The future of IoT is vast and future will be based on IoT technologies.

6G Wireless Technology

6G is the sixth generation of wireless technology. 6G network follows up on 4G and 5G; 4G has the speed of approx. 33,88 Mbps, 5G has the speed of approx. 40-1,100 Mbps. 6G has the speed of upto 1 Tbps (1,000,000 Mbps). 6G is using higher frequency bands and agile, cloud-based networking technology to deliver record-breaking speeds and microsecond latency. The internet connectivity will become like air and this will come to true with the help of 6G technology.

6G will not only support mobile phones, but also it will be used for technology like automated cars and smart-home networks, helping create a seamless connectivity between the internet and everyday life.

Fusion of IoT and GIS

GIS is a technology used to keep tracks on the location of an object or user and store, manipulate the data for more digitized solutions. GPS on smartphones, traffic conditions on maps, Uber rides, food delivery exact locations are some of the famous examples of GIS technology. GIS and IoT are interrelated and nested technologies. Combining both gives a bigger picture with the range of objects, individual buildings and locations, and as well as large areas like smart cities, transit development, and disaster management. When GIS and IoT work together, it offers benefits such as an increase in flow efficiency, cost efficiency, and, most importantly, can get real-time information from the sensors without the need for human intervention.

Architecture of IoT and GIS

Flow chart in Figure 1 presents the system architecture of pairing IoT and GIS. IoT sensors are conventional sensors used to collect data from the environment, traffic conditions, and locations like individual buildings, roads, and smart cities.

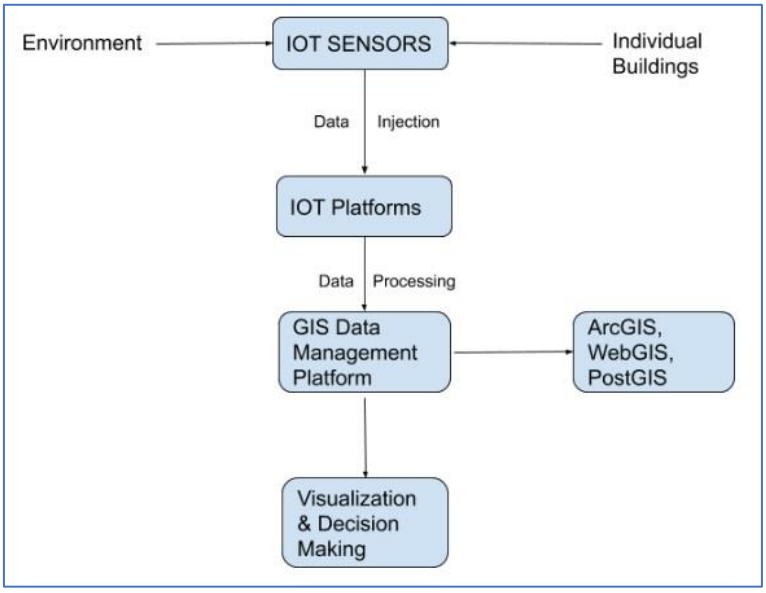

Figure 1. System architecture of pairing IoT and GIS Flow chart

Data Injection is storing the gathered information into the IoT platforms like technologies that manage, provision and connect with the IoT World. The next step is Data Processing, where the data gathered from the IoT are used in GIS platforms. The collected data is for manipulating, storing, and analyzing by WebGIS, PostGIS, and ArcGIS applications. Visualization and Decision making is to use all data into the mapping layers. From the Identified data, people can visualize the environment and locations. This process is providing solutions to the digital world.

Smart Mobility Solutions

Transportation plays a crucial role in our lifestyle. Earlier it wasn't easy, but people are traveling faster than time. IoT and GIS give solutions like GPS enabled vehicles and information about the route people need to travel, and people can also get applications for finding hotels, rest stops, filling stations on the go. By using IoT on Vehicles, people can connect to the LAN and connect with others. This tech takes control of the vehicle to avoid accidents. Also, it can report live data back to the relevant control room.

Smart Cities

An extensive range of data of whole cities can be collected by GIS and IoT sensors. From how many buildings, cars, and even lamp posts and reports of traffic, air, noise, GHG and more. This can help the government track the pollution and improve the pollution levels.

For this process, people need to collect large amounts of data, and IoT sensors are installed on cars, highways, roads, and buildings. In this way, people can track if any floods, forest fire, pollution or disease occurrence that are likely to happen on a full range scale. Also, this collaboration can be used to make city planners create routes for cycling and biking. Even for water and drainage routes for better control.

Disaster Management

The government can utilize GIS and IoT data to simulate the impact of natural disasters such as fire, earthquake and flooding. The government also takes preliminary decisions to determine the higher risks by analyzing the simulations of fire, flooding and earthquake. This will help the city planners to design better cities to eradicate these type disasters in advance by the help of the collected data via GIS and IoT.

Geospatial Information System (GIS) is a powerful set of tools that deal with capturing geospatial data, managing that data in a database, analyzing and pattern recognition, and finally visualizing information. IoT, as an emerging technology along with GIS, can result in advanced and user-friendly features in Smart Cities.

The connection between IoT and GIS is geographic location. Most devices combine their physical location from a GPS receiver giving real-time sensor information and positioning.

GIS and IoT-based systems are not only at developers' center of attention but also at officials' and organizations. With the wide range of applications provided by these integrated systems, they are being used in many aspects including urban and rural developments. These studies were categorized into seven groups of sectors and presented in Table 1.

Table 1. Industry share of GIS and IoT integrated applications

Industry/Sectors	GIS and IoT integrated applications
Urban Infrastructure	28
Environmental Monitoring	16
Utilities	16
Disaster Management	14
Agriculture	12
Transportation	9
Healthcare	5

Results

In literature Fuzzy Multi Criteria Decision Making Methods (FMCDM) are used in different fields by many researchers [1-25] by using MATLAB program.

As it is presented in Table 1, the percentages are: Urban Infrastructure 28%, Environmental Monitoring 16%, Transportation 9%, Agriculture 12%, Disaster Management 14%, Utilities 16%, Healthcare 5%. Urban Infrastructure mostly including smart city-related studies has been the most frequent domain of applications. Environmental Monitoring and Utilities shared the same frequency of 16%. On the other hand, less attention was paid to the Healthcare industry in GIS and IoT integrated point of view. These industry shares can be compared with the estimated market share of IoT applications by 2025 in which Healthcare is projected to have the most economic influence. Therefore, it would be a great opportunity to focus on the Healthcare industry to use the great functionality of GIS simultaneously with IoT.

Conclusion

GIS and IoT, this fusion has some confronting challenges ahead of them. To name a few, they are Data Integration, Data Security, Data Storage, and hardware ruggedization. Storage and integration of the data is the biggest challenge. The data are collected in different formats, such as images and videos, and more. Securing information is the most significant challenge as it includes the whole data of the real world of cities, which is now used for better business, improving decisions, and enhanced quality of life. The two technologies will lead the ways for a better world.

While large-scale deployments of IoT have improved the availability and timeliness of data, it can be difficult to connect these sometimes discrete and unstructured datasets. Every sensor, asset, or network has one thing in

common: it is located somewhere. Location provides a common reference system to create relationships. GIS location technology interconnects GIS information via IoT.

Industry and government organizations are facing challenges in every area of their business. They work hard to adapt to and leverage digital technology. Yet they often face today's challenges with yesterday's methods. In the struggle to remain relevant and thrive, they are looking to update to modern advanced information technology (IT) and operational technology (OT) solutions. To achieve these transformation objectives, they need to reinvent the way they do business and change many legacy operating models and processes. To affect the desired change, organizations need scalable solutions that not only meet today's challenges but also align to their strategic future vision. As IoT and GIS adoption increases and their applications mature, the future is becoming increasingly intelligent and automated. GIS and IoT technologies are connecting systems and data in new ways, which is enabling the transformation of many organizational workflows. The innovation and integration of these technologies are creating the nervous system and enabling real-time integrated digital twins.

Digital twins are used to represent accurate historical views, observe and monitor current performance, and predict future states. A digital twin of a fixed asset or real-world system benefits directly from the inclusion of GIS and IoT data about the asset. The IoT connects the data, and the GIS adds context around the asset, connecting the information model to other models and to its surroundings. GIS creates digital twins of the natural and built environment, and it can also be used to integrate many different digital representations of the real world.

In the last several years, the convergence of GIS technology; IoT; and, more recently, building information modeling (BIM) has created interactive 3D visualizations, which are redefining what a digital twin is and the value it brings to organizations. A digital twin is not a single product or solution; it is a complex network of technology and systems. It must work in harmony to achieve the desired transformational outcomes and return on investments that organizations desire. ArcGIS location technology is a proven way to create a framework to bring data together using location and to deploy big data accurately and intelligently against real-world problems and bring IoT data to life in spatial context.

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