GEO-IOT: A DATA-DRIVEN DISRUPTING TECHNOLOGY FOR SMART CITIES

IOT is defined as the system of interconnected devices that has the capability to exchange data over wired or wireless communication.

by Damandeep Singh

Integrating LI with GIS results in Geo-IOT. With Geo-IOT, not only the position of the asset is recorded but also its attributes which further contributes to spatial analysis.

One of the main goals of UNDP (United Nation Development Program) is working towards sustainable development across the globe. To achieve this task, UNDP, a United Nation agency have broadly classified the goals in two main categories:

- Millennium development goals (MDG)
- Sustainable development goals (SDG)

It is evident from the Figures 1 and 2, that MDG and SDG are further classified into sub-categories. These categories are heavily dependent on data. Data is one of the prerequisite to establish sustainability worldwide.

Embracing the disrupting technologies of the modern-day such as GIS, Remote Sensing, IOT (Internet of Things), etc, helps in easy capture of the data. With the advancements in technology both in hardware and software, data accessibility is like shooting a fish in a barrel i.e. within the reach of the masses. GIS and remote sensing use satellite data to perform the spatial analysis. Satellite not only helps in acquiring the data of the areas that are inaccessible but also aid in change detection and time series analysis of various classes that

About Author

Damandeep Singh

Adjunct Faculty - GIS (Coordinator)
Shri Vishwakarma Skill University
Gurugram, India
Email: *er.daman.ece@gmail.com*

the image is classified into such as built-up, barren land, etc.

At the micro-level, the numerical data such as PM (particulate matter) values, noise values, rain, temperature, humidity can be integrated into GIS. Heat maps or density maps are easily prepared using numerical data.

The numerical data is easily acquired using sensors. Sensors are basically an electronic circuit, that sense the changes in the nearby environment by varying the electric and the voltage signals. The technological breakthrough has enabled the sensors to use them in numerous IOT projects. IOT is defined as the system of interconnected devices that has the capability to exchange data over wired or wireless communication. For example, Kulkarni & Sathe (2014) have discussed, how IOT is used to monitor the various health parameters such as heartbeat, diabetes and other parameters in real-time. In another example, IOT is used in agriculture for monitoring diversified parameters such as salinity, temperature, soil moisture, humidity that are essential for monitoring the growth of crop (Elijah, Member, & Rahman, 2018).

IOT not only enables the easy capture of data but it also has the ability to arrest the location of the sensor. Location analytics is one of the crucial components of GIS. Location plays an integral part of doing business. Deriving insights from the data captured from a particular location result in locational intelligence (LI). LI or spatial intelligence (SI) is often interchangeably used terms. Spatial analytics allows binding the tremendous amount of data by establishing its relationship with the whereabouts.

Integrating LI with GIS results in Geo-IOT. With Geo-IOT, not only the position of the asset is recorded but also its attributes which further contributes to spatial analysis. Geo-IOT is considered an important driving factor for Smart Cities. The concept of

Figure 1: Millennium Development Goals.

Figure 2: Sustainable Development Goals.

Smart cities varies from place to place and is not universally defined. The Indian Government launched "Smart Cities Mission" in June 2015. To fulfill the conception of "Smart Cities" various technologies mentioned above such as IoT, Big Data are exploited. With the help of emerging technologies, information from every possible dimension is captured and processed to meaningful insights. Leveraging the potential of low-cost sensors, Geo-IOT helps in creating a sustainable environment and providing a decent quality of life to citizens, hence working towards the goal of achieving the concept of "Smart Cities".

Data, the vital requirement for Smart Cities is gathered using IOT via Smart City Applications in various domains such as energy, waste management, health, etc. For example, a research conducted by Santos *et al.* (2018) in the city of Portugal, wherein environmental parameters such as temperature, humidity, air quality were monitored using sensors deployed at certain locations. The data from the sensors were then analyzed for any temporal or spatial granularity and then visualized onto the map.

This article presents one such application areas of Smart City i.e. "Smart Bins". Smart Bins stands for the smart dustbins, wherein the status of the bins is known using IOT and the data impending from the sensors, can then be used for creating maps such as heat maps.

Smart Bins

Waste Management is one of the areas of Smart Cities that needs serious attention. A trash bin, powered by IOT device that monitors the status of the bin i.e. whether the bin is empty, half-filled, fulfilled and so on. This status can then be updated to the municipal corporation of the

concerned areas so that a garbage van is arranged to pick up the garbage.

Components of IOT Device Required for Smart Bin

1) Arduino Uno: An electronic board that consists of a single chip microcontroller i.e ATmega328P. The various pins of board act as input/output that are programmed using the integrated development environment (IDE) of Arduino via USB cable of type B.

2) Ultrasonic Sensor: For measuring the depth or the height of the bin, an ultrasonic sensor i.e. HC-SR04 is used. Its range varies from 2cm to 400cm. The sensor consists of a transmitter and receiver that aids in computing the distance or height, which is based on a simple mathematical formula

Distance = speed x time

3) Jumper wires: The wires are used as a passage for the current to flow easily. Solid strip jumper wire such as male to male, male to female, female to female are used.

4) USB/ Battery: To power, the electronic board and ultrasonic sensor, either a battery of 5V is connected or a USB cable is used. A USB cable is also used for programming the electronic board.

Integration of Arduino Uno with Ultrasonic Sensor

The above-mentioned components of the IOT device are integrated as shown in Figure 4. This complete setup is now capable to capture the height or the depth from the sensor to the surface or ground. The output from the device is viewed onto the monitor of the PC as shown in Figure 5. The status of the bin is visualized and is saved onto the system using various methods which then is further used for analysis.

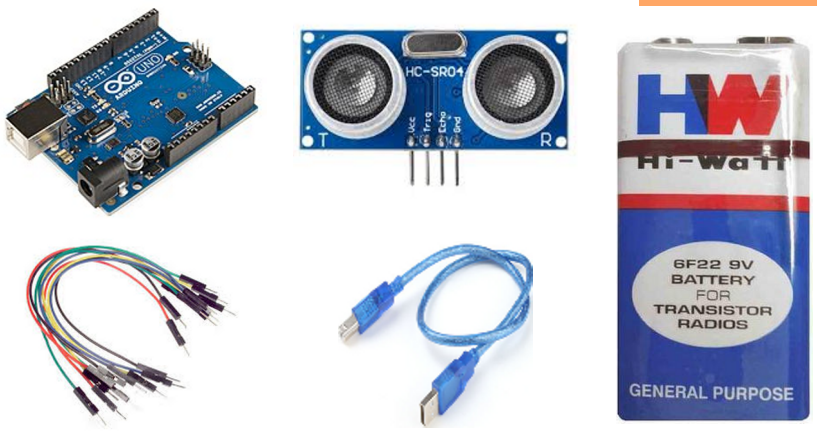

Figure 3: Arduino Uno, Ultrasonic Sensor (HC-SR04), Jumper Wires, USB Cable, 5V Battery (Top to Bottom - Left to Right).

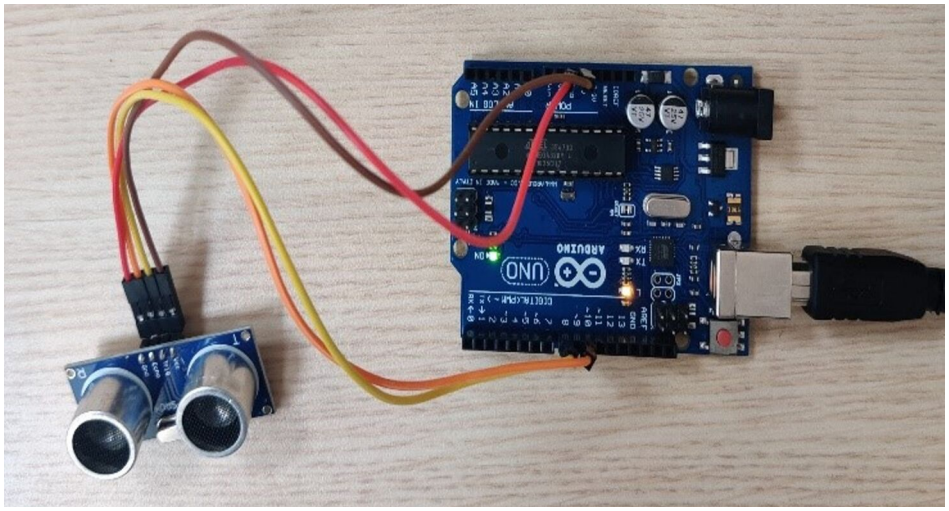

Figure 4: Integration of Arduino Uno with Ultrasonic Sensor.

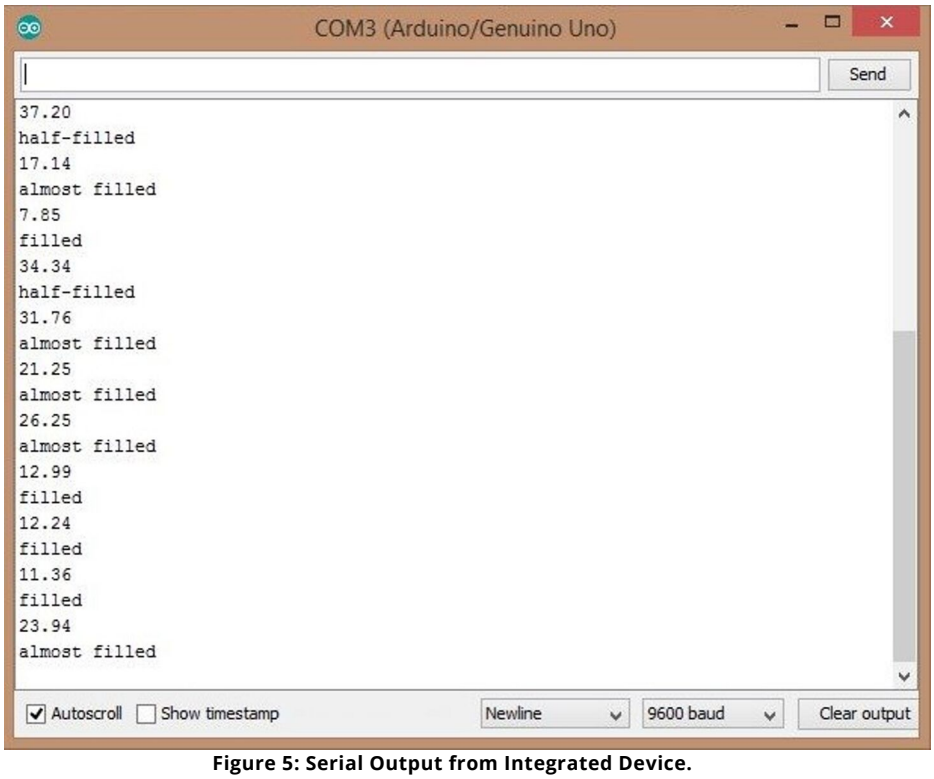

Figure 5: Serial Output from Integrated Device.

Techniques for Saving Captured Data from Sensor:

1) Third-party software/ applications: Numerous open source software are available via which the data from the sensors is saved on to the system in different formats according to the need of the user. One such software is "Tera Term". This software saves the output from the sensors in .csv format. Tera Term also provides an option of saving the data, including the date and time stamp.

2) Data/Web server: Feeds from the sensors can be saved in data servers via different techniques:

a) Using IP address: Addition of wifi module i.e ESP8266 generates an IP address for the setup shown in Figure 4. ESP8266, if configured and installed properly can be pinged and used for getting the feeds on webpage. The IP address generated is used for pushing the feeds into the server. Due to the instability of the ESP8266, the module is not recommended. Instead of adding a separate module, an electronic board should be used that has inbuilt Wi-Fi module such as raspberry pi. With the improvements in technologies, numerous servers for storing the data are available that are broadly classified into two categories open source and proprietary versions.

b) Manually saving the sensor feeds: The feeds from the sensor are saved in a .csv file using open source software mentioned above in point 1, this .csv file is further accelerated to the server manually. On the other hand, Arduino Uno can be programmed using IDE to save the output from the sensor to the desired location in the system, in required format.

For the Smart-Bins use case to be considered in Geo-IOT, coordinates of the device is a must. There are various ways of adding the coordinate information along with the other attributes captured by the device:

a) Using a GPS module: Incorporating the latitude and longitude information to the device outputs, require a GPS Global Positioning System) module to accurately determine the position on earth. Neo-6M one of the GPS modules available in the market can be used for capturing the coordinates

b) Manually feeding the device: The coordinates of the location can be manually added to the .csv output file from the device. This .csv file is pushed into the server. In this article, coordinates are added manually while programming the Arduino Uno with ultrasonic sensor. This aids in depicting a location of the device onto the map. The coordinates added to the device is taken from google, marks the location of Shri Vishwakarma Skill University (SVSU), established by government of Haryana, based in Gurugram. The output from the device with the coordinates is shown in Figure 6.

The IP address and the coordinates of the device generated along with the other attributes output from the device can be further pushed to Geo-Event server via GET or POST method. Geo-Event server is a proprietary product of ESRI, that has the capability to retrieve the live data from the sensors in different formats such as csv, json, geo-json and so on. With the help of Geo-Event server, spatial analysis is performed on the numerical data obtained from the ultrasonic sensor depicting the status of the bin, thereby creating heat maps. A heat map is a data visualization technique that represents numerical data in the spectrum or gradient of colors.

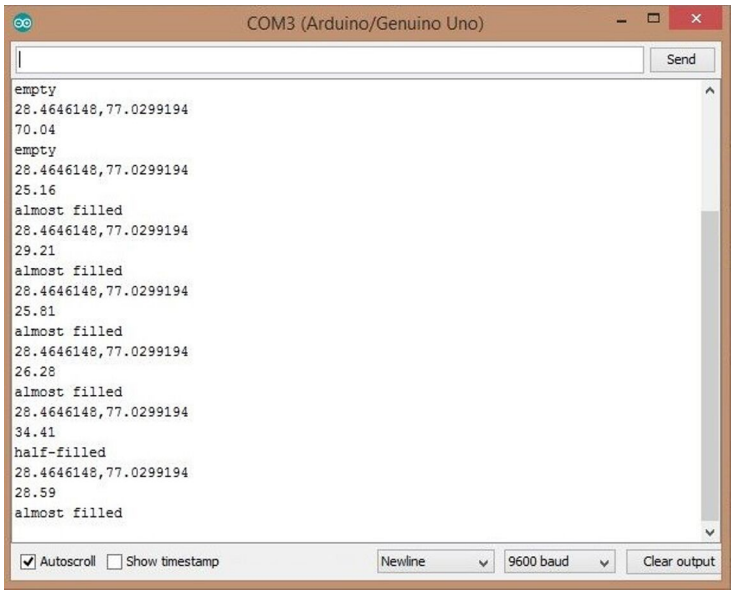

Figure 6: Status of the Bin with the Coordinates of the Location (SVSU).

The numerical data depicting the status of the bin can be used for creating the heat maps. The status of the bins is visualized using heat maps.

Depending upon the status of the bins, a vehicle is arranged from the municipal corporation, to empty the bin. Further application of the GIS can be the implication of network optimization algorithm that can be applied for routing the vehicle to the desired location. Using network optimization algorithm, the shortest path to the required location is known, alternative path in case of any barrier in the path is computed, etc.

References:

Elijah, O.,Member, S., & Rahman, T. A. (2018). An Overview of Internet of Things (IoT) and Data Analytics in Agriculture : Benefits and Challenges. IEEE Internet of Things Journal, 5(5), 3758–3773. https://doi.org/10.1109/JIOT.2018.2844296

Kulkarni, A., & Sathe, S. (2014). Healthcare applications of the Internet of Things : A Review. 5(5), 6229–6232.

Santos, P. M., Rodrigues, G. P., Cruz, S. B., Lourenc, T., Orey, P. M., Luis, Y., … Queir, C. (2018). PortoLivingLab : an IoT-based Sensing Platform for Smart Cities. 4662(c), 1–9. https://doi.org/10.1109/JIOT.2018.2791522