AI-Powered IoT in Smart Cities

Miro Abdalian
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Introduction

The increasing population in urban areas and inadequate access to resources make it difficult for public agencies to provide quality services. To address issues associated with the quickly changing social environment, such as hyper-urbanization, and to secure financial and ecological stability, smart cities have become a common phenomenon. The integration of internet of things (IoT) into city transportation applications is key in fostering economic development, modernizing city infrastructure, enhancing climate conditions, streamlining transit systems, and reducing the cost of managing public resources. Combining IoT and AI offers illuminating insights that can aid urban regions in mitigating the impact of contemporary socioeconomic concerns. There is currently no standard of commonly accepted set of definitions that appropriately characterize a “smart city”. However, smart cities make use of artificial intelligence and a network of sensors for collecting data. The utilization of artificial intelligence to automate systems is central to the conceptualization of smart cities. At their core, smart cities encompass the application of technologies and various sorts of information sensors and actuators to enhance municipal frameworks and daily operations.

Over the recent past, the world has witnessed growing trend of integrating computing and communication capabilities into everyday devices. This trend has led to the creation of IoT networks comprising a vast number of interconnected sensors and actuators. These devices also possess information storage and processing capabilities. As a result, an IoT-enabled device is capable of sensing its environment, transmitting, storing, and cycling the information gathered, and responding appropriately. An effective IoT-based system can scale to support the growing needs within the area of application. In addition to scalability, the system must be reliable, which means that it must exhibit consistency. Since such systems are deployed in diverse conditions, their capability to produce the same performance is critical. An effective framework for the Internet of Things ought to include artificial intelligence to support the fundamental goal of automating systems (Inclezan and Pradanos 1). The automation aspect not only reduces the need for personnel but also improves accuracy.

Contemporary State of the Art

Current state of the art IoT-powered intelligent systems leverage machine learning algorithms to automate various aspects of cities. The reliance on artificial intelligence enhances the usage of resources, resulting in energy and cost savings, reduced environmental footprint, and improved quality of life and service delivery. Essentially, a city that integrates and monitors all its key infrastructures can optimize its resources, improve maintenance, and promote security. Smart cities comprise various dimensions, which are categorized into physical and social elements. Specifically, artificial intelligence can be used to foster smart living, environment, mobility, governance, and people. Smart technologies offer the mechanism for connecting the huge the network of people, organizations, and infrastructures found in cities to create synergies. They do so by harnessing data collected from millions of sensors to enable learning, which is essential for supporting decision-making.

Recent AI publications have also focused on how AI can be used in autonomous vehicles (AVs). AVs can be a safer and more strategic alternative to unreliable human drivers and possess the potential to replace private vehicle traffic. However, the reliance on artificial intelligence in smart city applications could present adverse health and social consequences. In particular, when AI is used to make sensitive decisions, the outcomes can be risky. In the case of autonomous cars, the decisions could result in the loss of life. Indeed, using AI could lead to several ethical worries, including loss of autonomy and data security risks. For instance, when facial recognition technology and biometric are used for verification and security, the risk of privacy infringement increases. Within the context of smart cities, the data collected from the large network of sensors could be stolen, especially if the security controls applied are vulnerable.

The smart city architecture comprises three levels that work together. At first, the base technology includes mobile phones and devices with sensors that can access information and connect to fast communication networks. The role of these devices is to collect data and transmit it to diverse destinations. Second, the framework includes computers that look at the data to figure out how to solve the problems in a way that works. Computers possess processing capability that is applied in making data-driven decisions. The final phase involves using the insights derived from the systems.

The Rationale of the Topic of Discussion

The topic of artificial intelligence and its utilization to create intelligent systems is an important one as the trend is gaining popularity. Today, most everyday devices possess computing capabilities. The data collected from these devices can be used in machine learning algorithms to automate a variety of systems. In smart cities, for instance, data obtained from cars, weather stations, and other sources can be used to improve efficiency in terms mobility. Indeed, traffic prediction techniques are improving as technology evolves. However, it is essential to address specific concerns, like how to predict short- and long-haul traffic congestion issues using continuous data sources. It is also important to explore model-driven and data-driven approaches in the use of IoT to power intelligent systems. Most traffic models that have been made in the past are not data-driven. Accordingly, such models fail to take advantage of the insights that can be obtained from data. Still, artificial intelligence possesses the capability to address societal challenges hence the need to prioritize its development and adoption.

Background and Problem Definition

Over the past few decades, the population of people in cities has increased significantly. It is estimated that 4.1 billion people live in cities today and this number is expected to increase significantly in the near future. The ballooning population increases the pressure on social amenities and services such as transportation. As the number of cars increase on the road, the problem of traffic congestion becomes apparent. In most cities, traffic management is a leading critical infrastructure problem. Besides traffic congestion, other challenges associated with traffic management include accidents and pollution. Traffic congestions can be costly from a financial perspective as they lead to the loss of valuable time that could have been spent doing productive activities. Therefore, it is essential to increase urban mobility, especially in the context of traffic congestion by promoting infrastructure development facilitated by technology.

Leveraging Data in AI Systems

Machine learning algorithms consume data to learn or improve their performance. These algorithms are generally divided into unsupervised, supervised, and reinforcement learning methods. Whereas supervised methods are trained first, unsupervised ones are used to identify clusters and, therefore, require no prior training. Reinforcement learning encompasses creating a system that can learn from prior mistakes. Machine learning methods can be applied in transport settings to improve efficiency. Indeed, massive travel infrastructures and structures can benefit from applications that coordinate the rider experience. Passengers on trains, buses, and vehicles can provide real-time information on delays, breakdowns, and less congested routes via their mobile devices. The data obtained from these systems can be used to guide traffic hence averting bottlenecks and improving travel efficiency. Collecting and analyzing data on public transportation usage can also help cities and towns make more informed adjustments to public transportation routes, schedules, and finances.

Luckey et al. presented a platform for intelligent transportation based on the internet of things approach (2020, 1). The platform was able to acquire data using coordinated devices in linked automobiles and roadside units. In their test, they employed the resistive multi-objective-based data set compelled ideal method calculation, which provides dynamic street protection from the weight of each segment, computes the ideal path from the starting point to the goal, and variably records the data by street (Luckey et al. 1). This study demonstrates the process of collecting data and using it to comprehend the traffic situation of the road network based on the directed framework and then select the optimal route to the destination (Luckey et al. 1). The effectiveness of this framework is based on the ability to collect timely, accurate, and relevant data.

Installing sensors in critical areas of buildings makes it possible to collect social event data on energy use and to predict how people are likely to act. Data from the AI system can enhance consistency and keep track of daily, weekly, and occasional changes. Using traffic signals and data congestion, crisis administrations can reach their objections more quickly and safely. Cities may collect accident data or measure several indicators to help them plan for the future and make more effective safety measures.

Short-, medium-, and long-range communications can be integrated into vehicle communication systems to support intelligent vehicular interchanges. According to Al-Sakran, continuous control and management are possible if the framework includes IoT (37). Still, several security and framework security concerns and risks must be addressed. The combination of artificial intelligence (AI) and internet of things (IoT) is called the AI-controlled internet-of-things (AIoT). This combination can solve the complicated problems that arise from using various devices. By adding artificial intelligence into their IoT-based road infrastructure, cities can make their street networks work better.

Smart urban lighting is the foundation upon which smart cities are developed. Lights play the integral role of directing traffic, which means that they must be intelligent to enhance effectiveness and efficiency. Accordingly, IoT devices can be installed to collect, send, and process data about traffic and pedestrian flows, environmental parameters like air quality, temperature, wind speed, and humidity, and acoustic data like gunfire detection, urban noise. Having a system for collecting diverse types of data is particularly important as the accuracy and effectiveness of machine learning algorithms depend on the quality and quantity of data used.

Experiments and Outcomes

Using remote sensor monitoring and internet of things (IoT) technologies is a practical framework for evaluating traffic volume and vehicle arrangement. Xiao and Wang conducted a study on the integration of artificial intelligence (AI) and internet-of-things (IoT), also known as AI-driven Internet-of-Things (AIoT), into an automated traffic management system (887). Taking into consideration vast volumes of data collected by a large number of devices, their research demonstrated that this combination could solve complex problems. As a result, they devised a system that could utilize this combination to manage traffic lights. The method can increase the effectiveness of the smart city's road system. Using distributed multi-agent Q-learning and many surveillance cameras, they provided real-time data for intelligent traffic signal control systems to monitor motorized and non-motorized traffic scenarios (Xiao and Wang 887). The data-driven approach adopted in this study improved prediction outcomes.

Another experiment is based on the concept of using functional radio-frequency identification (RFID), remote sensor improvements, systems administration, and Internet-based data frameworks to allow labeled traffic objects to be addressed, tracked, and questioned across an organization. Al-Sakran presented an intelligent traffic information system based on internet of things and specific integration of AI intelligence data (37). The study offered a framework for collecting and monitoring real-time traffic data using internet of things and wireless communications. Active radio-frequency identification (RFID), wireless sensor technologies, object ad hoc networking, and Internet-based information systems were utilized to represent, track automatically, and query tagged traffic issues within a network. They presented a solution that ensures the uniqueness of license plates by using an EPC code and an RFID code to receive radio frequency signals from traffic tools. They demonstrated that the RIFD-based monitoring system is not hindered by darkness or adverse weather.

With the help of IoT and an AI-powered data approach, Kong et al. concluded that urban environments can be improved, and some of the most critical transportation problems in cities may be fixed or minimized (97). Smart City environments can make it easier to get to public stopping areas by using sensors that can, for example, indicate to the driver where the closest parking space is. This way, the driver does not have to move around randomly. Kong et al. used data obtained from RFID to reduce the number of stops which eventually helps to minimize traffic and air pollution (97). With the city's data available through the network of IoT, city planners can make informed and valuable decisions. Suppose this information is combined with other pieces of data provided by the city's networked infrastructure, the overall value of the informational assets increases considerably. Smart city amenities may include smart seats, smart traffic lights, and smart road lighting. The idea is to implement systems to collect vast quantities of data to support the artificial intelligence system in automating traffic and other elements of the smart city.

Future Recommendations

Artificial intelligence, which entails making machines with human-like abilities, continues to find applications in many areas of life. At the heart of artificial intelligence is the field of machine leaning that encompasses using statistical approaches to make machines learn without explicit programming. In cities around the world, inhabitants face a myriad of problems, including traffic congestions, accidents, and pollution. Using artificial intelligence, combined with an extensive network of sensors, can help minimize such issues. Rather than focusing on machine leaning models, there is a need to develop data-driven systems as they are likely to produce better outcomes. It is also critical to address challenges associated with intelligent systems such as data security and privacy issues. In particular, mechanisms for protecting the confidentiality of private data collected through sensors is key. More importantly, there is a need to address the issue of the digital divide and algorithmic bias. The data used and the models created should be made deliberately objective to ensure fairness and transparency.

Works Cited

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