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IoT-Based Smart Systems for Enhancing Urban Services and Emergency Response in Smart Cities

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Abstract

In developing smart cities and smart homes, the Internet of Things (IoT) has played an especially key role. IoT has already been considered by many countries, including India; this is why smart cities are going to make our lives easier. "The scope of smart cities varies from country to country, and which areas are critical to the country." For example, in recent years the Smart Cities Mission (SCM) has been established in India, picking cities like Pune, Bhopal, and Ahmedabad to be phased in with financial support, though in a smart city's mode for easier for people. "In every country, the scope of smart cities is different and depends on which areas are most important to the country." In India, cities like Pune, Bhopal, and Ahmedabad have been chosen in recent years to receive phased financial support through the SCM, which focuses on transforming them into smart cities. Building on traditional urban infrastructure (office buildings, homes, hospitals, schools, transportation, police services, etc.), this initiative extends these cities into what could be characterized as 'smart' cities, incorporating more advanced technologies that actually transform these cities. They allow services to improve, promote better sustainability, and make cities more efficient. Countries, including India, are focusing on building smart cities using IoT to show how smart cities make life easier for people. "In every country, the scope of smart cities is different and depends on which areas are most important to the country. This argument initiative expands on standard urban infrastructure-including office buildings, homes, hospitals, schools, transportation, and police services- by incorporating advanced technologies that genuinely transform these cities into "smart" ones. These technologies help improve services, promote enhanced sustainability, and make cities more efficient. This paper explains the advancement, i.e., IoT, now.

Keywords: Internet of things, Smart cities, Emergency response, Urban sustainability, Data aggregation, Rapid medical response plan.

1 | Introduction

Ever-growing urban populations increase cities' burden for resource management, public safety, and disaster response. In response to these issues, the idea of smart cities is here as a solution that leverages the benefits

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of advanced technologies to build smarter, more efficient, sustainable, and responsive urban ecosystems. To build smart cities, the Internet of Things (IoT) is key for interconnecting the devices and systems that aggregate, process, and share data in real time. Such connectivity can make all the difference in emergency response systems, where fast action can significantly reduce damage and save lives.

Environmental or health-related disasters need quick and effective ways of responding. Data analysis systems to address environmental emergencies, floods, earthquakes, or fires, and public health crises, such as epidemics, are neededton quickly analyze data and coordinate resources. Since these traditional methods of response often suffer from lag time in communication or lack of live sensing, there exists a need for a system in which the response to a threat can be immediate. In the context of modern urban environments, it is impossible for human intervention to run all the time; therefore, automated systems are crucial in order to help manage disasters.

The problem of continuously monitoring the key parameters, including environmental conditions and individual health metrics, is addressed by IoT-based systems, which enable this feature. Early warning signs of disasters, fires, or elevated heart rates, for example, can be detected by these systems. With the use of IoT networks composed of connected sensors and devices, real-time data can be transmitted to response teams, allowing emergency services to be dispatched immediately and together. This technology has been applied to various departments including health care, agriculture, security, and traffic management, which proves its versatility and seriousness in making urban areas resilient.

We propose in this paper an IoT-based Rapid Medical Response Plan (RM-IoT) to assist in emergency response in smart cities. Using health risk categories to categorize households and drawing from wearable devices and cloud-based sensors as input, the system monitors physiological parameters within a community. Then, based on this information, healthcare providers and emergency services are alerted when critical conditions are present. We model the framework using Cup Carbon, a wireless sensor network simulation tool for smart cities, to improve both the efficiency and effectiveness of emergency response in urban environments.

1.1 | Background

As populations in cities keep growing, cities are facing increasing pressure to effectively manage resources that few can afford to lose, to ensure public safety and react quickly to emergencies. As a potential solution to this problem, the concept of smart cities emerged by capitalizing on the power of progressive technologies to build sustainable and responsive urban ecosystems. The central aspect of this transformation is the IoT, which facilitates the exchange of real-time data from devices, enabling connected objects to aggregate, process, and share data.

This global movement is exemplified in India by the Smart Cities Mission (SCM), which awards phased financial support to cities like Pune, Bhopal, and Ahmedabad to improve their respective infrastructure. This work aims to incorporate IoT technologies into existing urban environments and turn them into intelligent systems that offer enhanced services and optimize sustainability. Continuous monitoring of environmental and health parameters with IoT makes it possible to detect potential disasters and health crises early. Nevertheless, the expansion of smart cities and IoT integration creates enormous security and privacy issues, as potential cyberattacks and data breaches are widespread. The work outlined in this paper proposes an IoT-based RM-IoT that has the potential to improve the efficiency of emergency response in smart cities for urban resilience and sustainability.

1.2 | Purpose and Scope

This paper explores the potential of the IoT to transform smart cities by leveraging efficient emergency response systems. The focus is on various applications of IoT technologies and the impact of IoT technologies on urban infrastructure, public safety, and the lives of residents. This work formulates an RM-IoT goal to improve emergency response efficiency. It proposes an IoT-based RM-IoT response plan that uses real-time data from wearable devices and cloud-based sensors. This paper contributes to understanding how IoT may advance resilience and sustainable development in smart cities by addressing the challenges presented by urbanization and the messiness of contemporary urban environments.

2 | Literature Review

The notion of a smart city implies the use of IoT to optimise the quality of life in cities, the efficiency of resource usage, and other parameters for sustainable development. Much research focuses on the key changes IoT brings to urban systems and infrastructure through real-time monitoring. In the case of health emergencies, IoT systems enable quick response because the environment and health characteristics are constantly being monitored. These systems have been integrated into public health crises and disaster management because they allow instant connectivity between devices and emergency authorities.

However, the subject of incorporating IoT in smart cities also has considerable drawbacks, especially when it comes to security issues as well as privacy. Smart devices' integration raises vulnerability levels of urban ecosystems to cyber dangers such as data theft and penetration. Multi-tenancy raises the Risk of IoT devices and exposes users' information, putting the credibility of identity control and privacy at risk. In the same respect, the devices of IoT systems are heterogeneous, thus making the interoperability of diverse hardware and software difficult to achieve.

The literature also shows how techniques such as machine learning and Deep Learning (DL) help reduce these security risks. They can also improve IoT systems' capability in detecting potential threats and securing IoT systems against threats. These problems are to be solved by the proposed RM-IoT, which uses data from wearable devices and cloud-based sensors employed in smart cities to increase the efficiency of Emergency Medical Response (EMR) while ensuring security and privacy considerations.

3 | Smart City Infrastructure: A Human Analogy in Urban Systems

A smart city is an urban system that integrates different advanced technologies to improve the infrastructure, allowing it to be highly interactive, effective, and highly accessible. Some of the factors driving the emergence of smart cities are the rapid increase in the urban population around the world and the depletion of natural resources such as coal. Environmental changes also present numerous problems.

Such scenarios emphasize the need for smart cities built with novel technologies. A fitting analogy can be made between a human and a smart city: Just as a human has a skeleton, skin, organs, a brain, nerves, and sensory functions, a smart city contains its critical components in the form of buildings, industries, transportation systems, hospitals, law enforcement, banks, and educational institutions. If a human has these physical attributes but no cognitive function, then they do not live. Similarly, as embedded intelligent communication networks, sensors, and software become part of the smart city's infrastructure, existing cities lack vibrancy unless they are embedded with them. IoT technologies are necessary to revitalize cities with existing structures such as buildings and industries. By integrating with this system, cities receive an improved emergency response mechanism with real-time communication, data sharing, and coordinated action capabilities between various city services. Intelligent systems have always existed, and by embedding these intelligent systems into the urban environment, we can build a more dynamic and responsive infrastructure that increases the quality of life for citizens [1].

3.1 | Smart Home

If a water tap in a smart home forgets to shut off after use, it could automatically shut off when not in use, preventing waste if the tap is left on accidentally. This principle of automation also applies to fuel conservation. Security and safety are also important aspects of a smart home, helping one avoid breaking into homes and keeping the house from being broken into. Overall, a smart home is a good thing because you get more convenience for a lot less effort, as well as better management of resources.

3.2 | Smart Cities with IoT Challenges

One of the key issues for smart cities that relate to IoT is the security and privacy issues. However, this accessibility of infrastructure is available to a wide population, which can lead to cyberattacks on citizens of diverse types. Additionally, the vulnerabilities of smart city development put critical government documents at risk of breaches and privacy leaks, creating a need to address these vulnerabilities together in parallel. Multi-tenancy also presents some risk because multiple users share the same devices, thus increasing the risk of data leakage and security breaches affecting data privacy and security. The heterogeneity of IoT systems is another incredibly significant challenge, and that includes the integration of different hardware platforms and hardware specifications. Interoperability issues exist due to the need to consolidate disparate radio technologies, software platforms, and manage a variety of user needs. Device failures must be dealt with, as well as mobility, to allow reliable communication. Furthermore, large-scale deployments bring with them a large set of challenges such as delays due to the sheer size of the deployment and because the devices are mobile, which can affect monitoring and operational tasks.

4.1 | IoT and Machine Learning

The development of applications has been revolutionized by the IoT since applications can be embedded in countless aspects of day-to-day urban life thanks to the presence of connected devices [2]. The applications' intelligence and functionality are improved through machine learning techniques with the increasing volume of collected data [3]. The smart capabilities of the IoT devices and network are carried out with Machine Learning (ML) strategies to mitigate security challenges [4].

4.1.1 | Health disease prediction

Around the world, heart disease is still the number one killer. Liu et al. [5] present an approach to improve the accuracy of cardiovascular disease predictions using machine learning techniques, including identifying critical variables. Using both random forest and linear models, their method comes close to the impressive accuracy rate of 88.7 percent. Forecasting possible health disorders is done in this data using various DL models. Combinations between deep reinforcement learning and Big Data (BD) in the medical IoT, as in Dourado et al. [6], towards integration with computer-aided diagnosis and treatment have the potential to be beneficial. For example, if used in an IoT framework, Convolutional Neural Networks (CNN) are used to classify strokes from Computed Tomography (CT) scans to dissociate healthy brain tissue from ischaemic or haemorrhagic strokes [7]. For example, because of its high incidence, deep reinforcement learning is being investigated for its potential to enable early diagnosis of lung cancer [8].

4.1.2 | Industry maintenance

In the industrial arena, maintenance is a set of operational and procedural measures implemented to support the availability of a machine and prevent downtime. A significant challenge is the design and development of embedded intelligent systems for the monitoring and prediction of machine health, as reported in [9]. The current industrial transformation, named 'Industry 4.0,' involves improving the productivity of industrial operations while enabling a more resilient, flexible, and capable environment. Past efforts to maximize conventional industrial systems involved primarily scheduling techniques. Brik et al. [9] introduced a tracking tool that aimed to localize resources for disruptions in Industry 4.0 systems. Therefore, actual task scheduling data is used to develop predictive models through machine learning techniques for resource localization.

Fakehri et al. [10] introduced a tool aimed at IoT-based river water quality monitoring [10].

4.1.3 | Smart agriculture

The agriculture sector is increasingly adopting these methods of machine learning and IoT data analytics to tune both the quantity and quality of crop yields. By integrating wireless sensor networks and machine learning, these advanced agricultural computing technologies provide farmers with the tools to improve the way they do things. This was suggested by Akter and Sofi [11]that data analytics and machine learning, as an embedded component of an IoT framework, can predict diseases in apple orchards in the Kashmir Valley. Both Maduranga and Abeysekera [12] have also emphasized the increased interest of researchers in IoT-driven smart agricultural practice through the application of IoT and ML technology for novel research. Overall, the intermediate-level IoT in agriculture's primary purpose is to automate functions of farming so that, upon meeting the ends, farmers can maximize their productivity. The connection enables smart city residents to access their daily lifestyles via smartphones and other such devices integrated natively with the IoT. But this connectivity involves fundamental questions of information security, user privacy, and unauthorized access to databases. For modern smart cities, great progress has been made in information and communication technologies. Not only do these high-tech devices offer many advantages for residents, but they also raise the potential for security vulnerabilities. These security DL and related technologies have been proven to be promising in mitigating these security challenges in scenarios of Ber BD and IoT technology [13]. In fact, these technologies have been proven to be effective in preventing security threats related to BD and IoT applications [13]. A main danger is malware insertion [14]. We propose an approach that uses deep Eigenspace learning to detect IoT Botnet (IoBT) malware from the Operational Device Code (OpCode). Since they are more prone to attacks than traditional desktop computers, this paper demonstrates how one can detect strange network activity arising from contaminated IoT devices using Deep Autoencoders (DAE) [15].

5 | Challenges and Limitations

Several challenges and limitations exist in deploying IoT technologies in smart cities for the implementation of IoT technologies in smart cities.

I. Security and privacy concerns: As IoT devices are fundamentally interconnected and there is an identity gap, they are extremely vulnerable to cyber-attacks. Risk exists, however, when we provide unauthorized access to personal data and critical government information.

II. Interoperability issues: In an IoT environment, we find that the distributed nature of many IoT devices and platforms often lacks standardization for integration, communication, and interoperability of devices. However, this heterogeneity can obstruct smart city applications.

III. Data management and analysis: IoT devices generate vast amounts of data that must be handled and analysed efficiently. The effectiveness of decision-making hinges upon ensuring data accuracy, integrity, and real-time processing.

IV. Infrastructure costs: Upgrading existing urban infrastructure to serve IoT technologies is too costly and consumes too many resources. However, completion of these initiatives remains a barrier in developing regions for securing funding and resources.

V. Public acceptance: There may be concerns about data privacy and that smart technologies are surveillance. For successful implementation, public trust and community engagement are required.

VI. Scalability: IoT solutions must scale as cities do. It is a complex challenge to design systems that can accommodate large populations of devices while maintaining system performance.

Solving these challenges will allow fully leveraging IoT for smart city use cases.

6 | Conclusion

The IoT has further expanded the concept of smart city planning, providing better resources, better security for its inhabitants, and fast responses to emergencies. This argument is particularly true as cities such as Pune, Bhopal, and Ahmedabad, among others, seek to upgrade their status to smart cities; IoT will be able to turn conventional urban structures into a system of systems with sustainable efficiency.

However, the advantages as highlighted are quite significant, and the main barriers include security risks, privacy issues, and compatibility problems in order to optimally adopt smart cities. The suggested idea of the RM-IoT is an up-to-date approach to conflict management, which makes it possible to avoid an unfavourable outcome and react instantly, taking into consideration real-time data coming from wearable devices as well as sensors in the cloud. By emphasizing such innovations along with implementing sufficient security measures, cities create a strong and elastic base for the improvement of the quality of life of the city residents, while constantly maintaining the safety and security of the urban environment in the context of advanced digitalization. In the future, further study and engagement with all key players will be needed to eliminate current barriers and fully actualize IoT for smart cities.

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Data Availability

The data used in this study are available from the corresponding author upon reasonable request.

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