

# The Use of CCTV Model Analysis for a Smart Environment in Semarang City

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**Abstract.** This study examined the concept of a smart city and the importance of a smart environment in city management. CCTV analytics has been employed to monitor and manage urban environments, especially in Semarang City. Smart city and CCTV analytics challenges facing the Semarang City Government were investigated. Interviews, document analysis, and field observation provided input for this case study, combined with specific cases to gather detailed explanations from various sources or stakeholders. The installation of a CCTV analytics system in Semarang aims to create a smart environment. The city strategically installed CCTV cameras with analytical technology and a data center to process and store CCTV data. This system monitored high-risk areas such as flood plains. The Quick Response Team handled problems immediately after the early warning system was activated. However, funding, analytical CCTV supply, and system integration were issues. Hence, the government must address these challenges to manage the environment and reduce risks. This research discovered that analytical CCTV in Semarang City provided real-time data and visualization of environmental conditions, helping the government make the right decisions and policies. Access to CCTV footage and decision-making benefited the community. Air pollution and flooding must be addressed as the integration continued. This study emphasizes urban environmental management strategies and the pros and cons of technology integration. The potential of smart environments and the challenges of smart city implementation require more research and development.

## 1 Introduction

The global community has found itself in the midst of a transitional phase known as Industry 4.0, marking the fourth stage of the industrial revolution. This phase is distinguished by substantial transformative changes and possesses wide-ranging implications in diverse

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fields. The notable shift is propelled by the utilization of technology that can eradicate obstacles between the tangible and the virtual realms [1]. The concept of Industry 4.0 postulates that various technological advancements, such as increased utilization of robots in manufacturing, integration of embedded technology, collaborative and coordinated machines, autonomous decision-making systems, autonomous problem-solving capabilities, machine learning, and 3D printing, will play a dominant role in production. The primary focus of society will revolve around applications such as wearable internet, big data analysis, sensor-based living, and the implementation of a smart city concept.

This societal shift is expected to prompt the manufacturing sector to enhance the caliber of its products, with the aim of satisfying consumer demands and sustaining a competitive edge. The present understanding indicates that Industry 4.0 represents a paradigmatic shift. The concept of community marriage refers to a type of marital arrangement that involves the active participation and support of the surrounding community. Similar to previous industrial revolutions, major transformations have occurred in society, education, economics, and trade. Taking into consideration the previous perspective, the present article furnishes relevant insights pertaining to the ongoing discourse encompassing Industry 4.0 within the scientific and industrial spheres. This study makes two practical contributions: The initial provision of the definition of Industry 4.0 aids in elucidating the fundamental concept within the realm of practitioners. Furthermore, it can be utilized to bolster the execution of the six design principles for Industry 4.0 scenarios. It aids in delineating prospective scenarios and will serve as a reference for guidance during the execution phase [2].

According to Giffinger, the smart city concept contains six dimensions: smart people, smart economy, smart living, smart governance, smart environment, and smart branding [3] [4]. The course of government must follow the social development of the community to fulfill its need for optimal government services [5]. Various alternative forms of governance procedures to meet the increasing needs of the community have emerged. One of them is to provide optimal services and meet the needs of the urban community, where the smart city concept is increasingly emerging. Hence, cities are required to maximize the use of information and communication technology in managing urban life.

One of the pillars of a smart city is a smart environment, providing comfort, resource sustainability, and environmental protection for the community. A smart environment is an environment-based city management system developed through the extraordinary capabilities of technology. The function of this technology is real-time environmental monitoring 24 hours a day for seven days. The implementation of a smart environment will provide benefits and improve the quality of life for the urban community [6]. Managing and realizing a sustainable environment that maximizes the use of technology is the goal of a smart environment. The ease with which the government can monitor and access environmental conditions in its territory will enable the government to make decisions and policies according to real-life conditions. A smart environment, if managed properly, can help handle a disaster crisis in addition to organize an urban environment [7]. Video analytics technology is a crucial component of Closed-Circuit Television (CCTV) systems. For the purpose of capturing and identifying various phenomena that cameras capture, such as river water levels, river flow rates, and the presence of puddles on roads, the integration of sensor technology is essential. The utilization of video analytics technology can facilitate the government's management of urban road inundation caused by heavy rainfall and mitigate the occurrence of flooding. This phenomenon can be attributed to the fact that this technological advancement facilitates the expeditious and accurate provision of pertinent information to governmental entities, enabling them to promptly and accurately formulate decisions [8].

Nanotechnology, robots, artificial intelligence, and the Internet of Things (IoT) are the results of the current phase of Industry 4.0. The technological infrastructure transformed to

become part of the IoT has attracted a lot of attention. One of the technologies becoming part of the IoT is surveillance cameras, or CCTV. CCTV is a camera-video recording tool used to record an event in a certain area to be displayed on a limited monitor with a certain range of publications [9]. Many cities in the world have thousands of CCTV used to monitor urban areas. The challenge is to change these CCTV cameras to be connected to each other by utilizing IoT, requiring technology to analyze an incident from the video captured by CCTV cameras. This CCTV technology can later be employed by cities implementing the smart city concept to manage urban management and establish urban policies [10].

Semarang City is located on the north coast of Java Island, making it one of the coastal cities on the island heavily influenced by the ocean. Accordingly, the community, ecosystems, and socioeconomics are all put at risk by marine dynamics, like floods and tidal waters, deemed vulnerable due to climate change. How susceptible a population is to the effects and fluctuations brought on by climate change depends on the scale of those changes [11], [12]. In Semarang City's coastal areas, where rising sea levels are an indicator of climate change, the average rate of land subsidence is 6-19 cm per year [11]. Some coastal cities and agricultural regions are becoming increasingly vulnerable as their socioeconomic resources become resource-dependent. Vulnerability can be affected by land subsidence [13]. Hence, understanding how coastal cities will be affected by sea level rise requires extensive research on the topic. As a result of climate change, coastal areas are more likely to be flooded due to rising sea levels, upsetting the delicate balance of these regions.

The use of CCTV in monitoring the situation in the smart environment of Semarang City aims to provide real-time data, present visualization data in monitored areas, and display processed data as a basis for policymaking [14]. The community can access the installed CCTV on the website <https://tiliksemar.semarangkota.go.id/>, making it easier for the community to monitor environmental conditions and accurately formulate decisions [15], [16]. The stagnant and flooded roads during the rainy season are the common problems encountered in this city. Puddles and floods caused by rain often result in traffic jams, hampering the lives of the community. Installing CCTV analytics provides information and warning signs for handling disaster crises, in this case, puddles and floods [17]. The CCTV analytics model employed by the Semarang City Government, CCTV, could analyze events recorded by the camera by converting the video data into numerical data [18]. However, the CCTV integration is still in the early stages of development and is only installed in certain areas. Hence, the problems in this city have not been caught maximally. In short, the Semarang City Government has faced several challenges in developing a smart city and a smart environment through the limited installation of CCTV analytics.

## **2 Methods**

This research employed a qualitative method with a case study approach, generating descriptive data by gathering written or spoken words from individuals and observing their behavior. The case study approach entails the researchers engaging in a comprehensive investigation of a specific subject of analysis, scrutinizing it as a singular case. The data could be sourced from a variety of channels, indicating that relevant data could be gathered through interviews, analyzing documentary evidence, and making field observation pertaining to the specific case under investigation to acquire verified data [19]. It was driven by the objective of directing research endeavors toward particular cases, enabling the formulation of comprehensive and profound explanations derived from diverse sources or stakeholders associated with the case under investigation. This study ran qualitative data analysis, encompassing data reduction, data processing, data presentation, and the derivation of conclusions. The research utilized triangulation, involving the verification of data validity

through the comparison and integration of multiple sources of data. This technique enabled the utilization of data in the research process.

### **3 RESULTS AND DISCUSSIONS**

In the contemporary era, effective environmental management within urban areas necessitates a strategic approach. The term “smart” in this context pertains to the urban development strategies employed by a city, prioritizing the consideration of environmental conditions. The city government is obligated to mitigate the consequences of climate change and modifications in individual behaviors, exerting influence on the urban environment [20]. The following three sections unveil the research findings on the use of CCTV analytics to realize a smart environment in Semarang City.

#### **3.1 Infrastructure and resources**

The study incorporated various input variables, including infrastructure, servers, supervision, budgetary allocation, and human resources. A total of more than 10,000 CCTV cameras were strategically installed throughout Semarang City, encompassing a wide range of locations from central areas to the neighborhood (RT and RW) levels. These installations encompassed various components, including infrastructure, server, and surveillance aspects. Within the CCTV network of Semarang City, several CCTV cameras were equipped with analytical technology. Semarang City implemented a system of CCTV analytics, strategically deployed at various locations such as Kota Lama, Simpang Lima, Segitiga Emas, and several pump houses situated within the city. A total of 16 CCTV cameras were equipped with analytics technology. These cameras were strategically deployed in critical locations and pump houses.

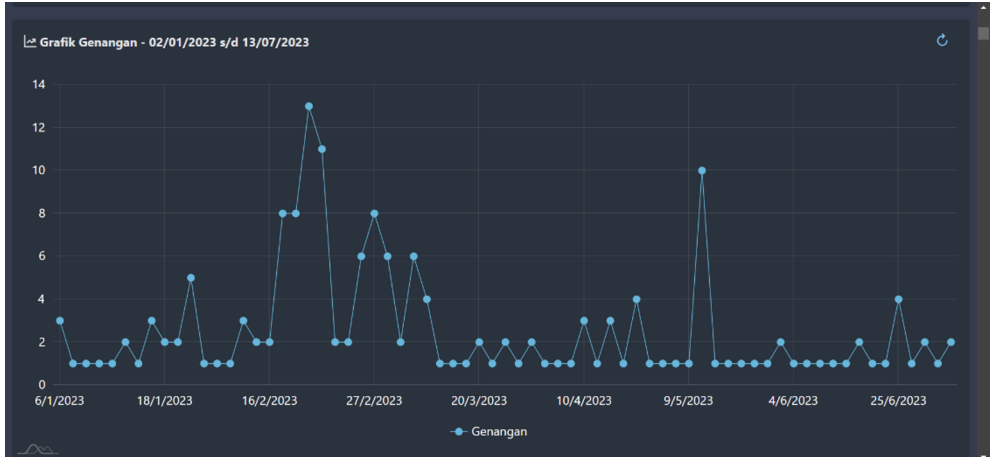
The management of server capacity for processing large volumes of data was overseen by the Communication and Information Department (Diskominfo) of Semarang City through the utilization of a data center or network center. This facility was utilized to examine recorded CCTV analytics data. The data center utilized for the storage of extensive data media exhibited a significant and appropriate capacity, complemented by a backup system that efficiently mitigated the potential for disruptions, minimizing the potential loss of CCTV data. The management team within Diskominfo was tasked with the supervision and management of CCTV utilization by the Human Resources Department. The facilitation of infrastructure procurement and management was achieved through the allocation of funds from the Semarang City Regional Revenue and Expenditure Budget, distributed annually. The allocated budget was spent to support the implementation of a smart city initiative in Semarang, with an estimated annual expenditure of 20 billion Rupiah. However, this situation, in terms of the provided funding, still encountered difficulties, specifically that it did not cover several crucial areas, such as Tambak Lorok and Marina Beach.

Other problems included the fact that the funding did not cover the entire area. In an effort to take preventative measures by collecting data, providing integration as an input basis for equipment procurement activities had been performed. There was still an extremely limited supply of analytical CCTV in Semarang City. It was not integrated with any applications used by the community, in spite of the fact that the early warning system had been transmitted to the government in the integrated data center system.

#### **3.2 Monitors of high-threat or dangerous locations and data-driven**

An early warning system indicates the provision of information to be prepared to be alert in facing danger [21]. An early warning system with CCTV and CCTV analytics in several

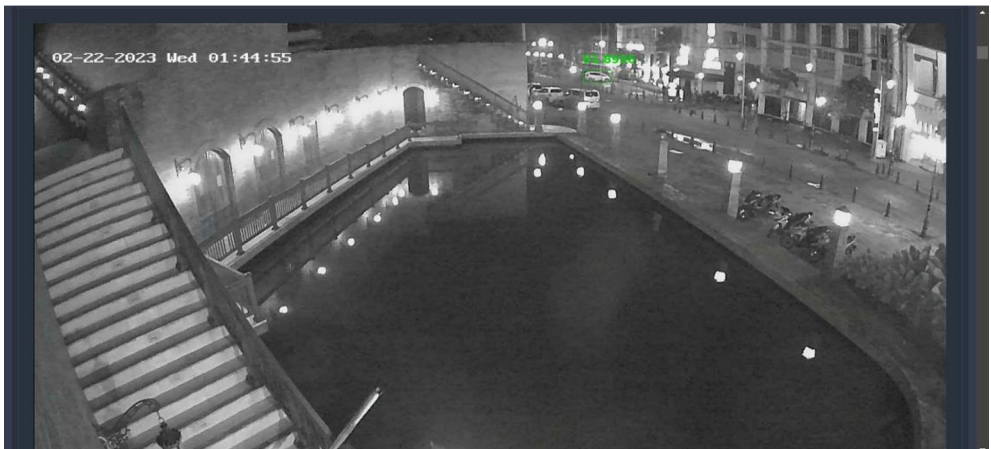
areas was monitored 24 hours a day through a situation room owned by the government and a public website. Fig. 1 displays the movement of increasing water as monitored on CCTV. Subsequently, the data were sent by the control room to the relevant department in charge of overcoming the inundation.



**Fig. 1.** A graph of the movement of puddles

Source: <https://tiliksemar.semarangkota.go.id/dashboard>, (2023)

CCTV provided a picture of the real situation when the graphs of the number of puddles were monitored, one of which was in the water feeder in the Kota Lama area, which had a pump house; if the water discharge rises and even a flood occurs, it is immediately operated. It was the response made when the early detection alarm provided a warning.



**Fig. 2.** Field condition monitoring through CCTV feeder in Kota Lama, Semarang

Source: <https://tiliksemar.semarangkota.go.id/dashboard> (2023)

The Quick Response Team was responsible for promptly conducting assessments pertaining to a given incident. Furthermore, this team was assigned the responsibility of effectively resolving or managing an emergency incident [22]. In the specific urban setting

of Semarang, this research examined the management of stagnant water in Simpang Lima. During the middle of February 2023, a rise in the daily occurrence of puddles was observed through CCTV analytics. Consequently, the warning system within the situation room of Semarang City was activated. Subsequently, the responsible operator initiated communication with the Public Works Department of Semarang City in relation to this issue. The Public Works Department promptly deployed the Quick Response Team to address the issue of standing water in the Simpang Lima area, resulting in a swift resolution of the problem.

The quick response to mitigating a disaster, particularly the inundation of main thoroughfares in Semarang City, exhibited commendable swiftness. The prompt action was taken by the operator in response to a warning issued by the situation room regarding a surge in the quantity of pre-existing puddles involved, promptly contacting the Public Works Department of Semarang City, the pertinent agency responsible for mitigating the issue of inundation. Subsequently, upon observing a rise in the accumulation of stagnant water within a particular vicinity, the Public Works Department expeditiously dispatched the Quick Response Team to rectify the issue by removing the obstructive debris impeding the flow of water in the drainage system. The resolution of this issue required a time frame of two hours, during which the water level gradually decreased, enabling the residents of Semarang City in the affected regions to relocate more easily. As indicated in sub-chapter 3.1 of the monitoring, various obstacles were encountered. The areas requiring monitoring encompassed sea coasts, water pump gates, protocol roads, and other regions susceptible to flooding. The previous scenario entailed a delay in the dissemination of early detection warnings from signal transmission to the data center, resulting in a longer timeframe for the community to receive such alerts. The presence of a CCTV analytics system, unaided by integration with other systems and reliant solely on manual monitoring, posed a hindrance to the data collection. In addition, it is essential to note that the system integration exhibited imperfections, leading to a shortage of corroborative data disseminated to the community.

### **3.3. Lack of integrated system**

The implementation of CCTV analytics for establishing a smart environment in Semarang City encountered several challenges. The installation of the CCTV system outside the designated protocol area of Semarang City and water pumps remained limited. However, implementing CCTV analytics was necessary to visually represent data pertaining to the accumulation of waste from urban waste disposal sites to landfills. The accumulation of waste in urban areas during the high rainy season, despite the installation of CCTV analytics by the Semarang City Government to monitor waterlogging, was a contributing factor to flooding occurrences.

The integration of the findings pertaining to other issues within the smart environment of Semarang City was not incorporated into the flood control procedures implemented at water pumps. The conventional CCTV system, devoid of analytical capabilities, was employed for the continuous surveillance of river surface levels over 24 hours. Upon observing that the water level in the river had reached the alert threshold, the CCTV operator proceeded to activate the water pump through manual intervention. If the pump house in Semarang City is equipped with analytical CCTV incorporating river water level detection technology and establishing automatic connectivity with the water pump, the implementation of flood control measures through the water pump can be both effective and efficient. The implementation of water level monitoring resulted in a shift from manual operation to an automated system for activating the water pump.

The constraints associated with supporting infrastructure, as previously discussed, necessitated a heightened level of commitment from the Semarang City Government to develop a smart environment. It is crucial to note that Semarang City is characterized by its susceptibility to flooding, primarily due to its geographical proximity to the Java Sea. If the situation is not addressed with due seriousness, it will inevitably have repercussions on both short-term and long-term residents. The potential occurrence of a flood disaster, coupled with inadequate management of waste, poses significant risks to various sectors [23].

## 4 CONCLUSIONS

The research discovered several crucial findings. To begin with, the application of CCTV analytics in Semarang City provided real-time data and visualization of environmental conditions in the monitoring area, allowing the government to make decisions and policies based on processed data. The community could also access CCTV footage on the website, allowing them to understand environmental conditions and contribute to decision-making. Moreover, this research highlighted the challenges faced by the Semarang City Government in developing a smart city through the installation of CCTV analytics. The CCTV integration was still in the initial stages, and the analytical system had only been installed in certain areas. It measured the effectiveness of monitoring and addressed problems such as air collection and flooding during the rainy season.

This study also emphasizes the importance of environmental management strategies in urban areas. The concept of a smart environment involves leveraging technology, such as CCTV analytics, to integrate and manage environmental conditions. It could improve the quality of life of the urban community and the ability to handle disaster crises. Overall, the findings of this research contribute to the ongoing discourse around Industry 4.0 and smart city implementation. The use of CCTV analytics in Semarang City unveiled the potential benefits and challenges of integrating technology into urban management. Further research and development are required to fully realize the potential of smart environments and overcome the challenges facing cities in this transition.

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