sustainability

MDPI

Article

Smart City Crime Prevention Services: The Incheon Free Economic Zone Case

Mun-su Park [1] and Hwansoo Lee [2,*]

[1] Business Career Innovation Center, Dankook University, Yongin-si 16890, Korea; amhaeng@dankook.ac.kr
[2] Department of Industrial Security, Dankook University, Yongin-si 16890, Korea
* Correspondence: hanslee992@gmail.com

Received: 21 May 2020; Accepted: 9 July 2020; Published: 14 July 2020

Abstract: This study explores ways to improve the security systems of emerging smart cities by conducting a case study of the smart crime prevention service of the Incheon Free Economic Zone (IFEZ) in South Korea. Data from the IFEZ were collected between January 2017 and December 2018 across the smart system's four functional areas (intelligent video surveillance, suspicious vehicle surveillance, emergency alerts, and abnormal sound sources) and 10 types of situations (emergency, violence, civil complaints, intrusion, kidnapping, loitering, throwing, suspicious vehicle, collision explosion, and sudden event). Descriptive statistics were analyzed to show the limitation of the smart crime prevention service. The results revealed three significant insights into the best practices for smart crime prevention services in smart cities: first, smart crime prevention services are required to verify the accuracy and consistency of collected data; second, the government must establish a consistent process to link all crime prevention services and to secure data linkages; and third, the government must urgently foster and secure experts in specialized institutions to carry out these advised functions. Ultimately, these findings suggest that in-depth discussions of data collection and sharing are required to ensure the optimal development of smart city security services.

Keywords: smart city; IFEZ; smart security service; crime prevention; data sharing

1. Introduction

The world is aggressively pursuing smart city policies to fundamentally solve urban problems connected with urbanization, such as those related to population concentration and energy use [1]. Along these lines, the push for smart cities is being driven by an increase in the size of cities (so-called megacities); associated increases in the operational complexities of cities relating to the environment, crime prevention, disaster prevention, and welfare; and the need to effectively respond to such issues [2]. From the industrial perspective, smart cities are garnering attention because they are more competitive, proactively responsive to the fourth industrial revolution, and are effective engines of new growth [3]. Amid the intensifying trend of stagnating growth worldwide, rapidly developing information computer technology (ICT), and increasing demands for urban development, countries around the world are now competitively racing to develop smart cities [4].

Through the U-City project, Korea has made significant investments (eighty million dollars) in constructing and operating cities as early-stage smart cities. As a result, it is time for a comprehensive review and analysis of the effectiveness of the development of smart cities in Korea to uncover best practices for new development directions. Korea's U-City has been rated as the world's best in its definition and acceptance of technology standards. However, it is often viewed as merely a showcase rather than a living city. Despite various Internet of Things (IoT)-enabled benefits, industry evaluated that Songdo, one of the U-Cities of Korea lacks a diverse economic core, which makes it difficult to get people to actually live there [5]. Although the level of advanced technology based on IoT, such as telemedicine, was sufficiently high, it was limited in practical application due to Korean legal issues [6]. In other words, even if cities have excellent technology, factors outside of technology have a greater effect on their success.

Most existing studies on smart cities have focused on their construction and considered them as a solution for technical issues [7]. Existing studies primarily emphasized using data to solve urban issues related to the environment, transportation, health, energy, and crime [8]. However, there are a lack of empirical studies based on real data, stemming from a lack of actual operating cases. Although smart cities' innovative technologies are attracting attention as potential solutions to urban problems, there is a lack of discussion on urban security systems for crime prevention and safety management. In the analyses of 121 studies published in the last 10 years related to smart cities, security is only discussed in terms of its technological aspects. There has yet to be discussion, based on real data, of the actual performance of the security technology or the social benefits that may arise from it [9].

Responding to this gap, this study used the Incheon Free Economic Zone (IFEZ) as a case study and analyzed the performance and limitations of the security investment in the U-City project. The three new city regions in the IFEZ (Songdo, Cheongra, and Yeongjong) were used as target areas for this study. With analysis of crime prevention data, one of the key areas of smart city security, this study discusses how to design and invest in smart city security systems. This study is meaningful because it is an early study exploring the dynamics of smart crime prevention in Korea. This study offers insights into the current state and limitations of security operations in the smart city, providing practical implications for smart city construction projects.

2. Related Background

2.1. The Smart City

The word "smart" is widely used across fields to signify new types of innovative services [10]. It has been used as a term for intelligent services in various fields such as those related to smartphones, smart education, smart homes, and smart transportation. Recently, the term has expanded to include tourism and cities, and academic discussions are increasingly focusing on smart tourism and smart cities [11]. "Smart city" refers to a city that can effectively resolve issues arising from people living in the city and engaging in economic activities within it [12,13]. To date, in Korea, many smart cities have been developed based on the U-City project, which began in the early 2000s and sought to improve the lives of urban citizens and encourage urban economic development. Notably, U-City was the first smart city-related project among developed countries. The project, which focused on new cities, was an effective choice that took advantage of Korea's new city constructions to secure resources to apply advanced ICT technologies. Therefore, creating smart urban infrastructure was prioritized over creating services for citizens in new cities that were not yet home to urban industries. While existing cities have separated the management and operations of transportation, crime prevention, disaster prevention, and urban facilities, U-City opted to create a smart-city-integrated platform to comprehensively manage urban infrastructure. Furthermore, it installed a systematic control center to link and integrate mutual data—this advanced decision enabled its smart management. The wide range of data collected in this process is quickly becoming the foundation for city problem-solving and development [14]. Smart cities such as Singapore and Barcelona have constructed data-centric platforms based on public-private partnerships to provide a variety of solutions [15,16], and newly emerging countries in Asia are executing government-led smart city policies to strengthen their competitiveness and resolve issues related to rapid urbanization and economic recovery [3].

2.2. Smart Cities around the World

Today, smart cities are generally being approached from the perspective of how they may best develop the lives of urban citizens and urban economic environments. Toronto, noted for its convergence of innovative firms and smart city features, offers multiple insights on smart city norms [17,18]. In 2001, Waterfront Toronto was established to facilitate urban recycling in the city, and Sidewalk Labs was selected as the final partner. Sidewalk Labs is a research institute that explores how Google's new technologies can resolve urban issues and tasks and enhance quality of life; more specifically, the team brings together science, engineering, and urban problem-solving. The institute's "Sidewalk Toronto" plan presented a typical smart city plan based on such new technology. Ultimately, the plan imagines a city in which vehicle traffic is limited by the installation of self-driving shuttles; heated bicycle roads; and underground tunnels home to transmission lines, water pipes, and passageways for cargo robots. By converging state-of-the-art urban design and new digital innovative technologies, Sidewalk Toronto is working to secure sustainability, mobility, and affordability; furthermore, its innovative recommendations also extend to efforts to resolve issues related to energy and the environment, and new architectural methods to reduce costs associated with constructing housing and consumer retail shops. In particular, Sidewalk Labs focused on practical and sustainable urban growth, with an eye on securing social public spaces where people can enjoy outdoor activities (www.sidewalklabs.com).

In 2015, China announced plans to construct 500 smart cities and invested 7 billion dollars in R&D, making the smart city project a national project. The recently announced smart city plans for Xiongan New Area also have significant implications [18,19]. If the case study of Toronto is indicative of a joint smart city project with a global, innovative firm, then China's plans emerge as an effort to construct a large-scale smart city by involving innovative and state-owned enterprises in energy and communications [20]. Accordingly, China is moving to create a large-scale smart city that encompasses all the features of the future city, responding to the needs associated with environmental and ecological sustainability, smartness, high-tech industries, innovation, public infrastructure and services, effective transportation, and openness. It is important to note here that China's plan is a large-scale national project involving over 100 smart city-related firms, including not only high-growth IT firms such as Huawei and Tencent, but also state-owned enterprises in the energy, construction, and financial sectors. This aggressive push for smart cities can be interpreted as an effort to overcome the slow economic growth that has recently plagued the nation.

2.3. Security Services of Smart Cities

Urban security is an important issue affecting all other elements of urban life, and it is becoming a key issue in smart city development [21]. Rapid urbanization creates problems for traditional safety and security infrastructure; economic and social change in urban areas makes it more complex to effectively ensure public safety [22]. As a solution to this complexity, a smart city that ensures safety for its citizens by using data and ICT has been proposed. Since smart cities control urban infrastructure based on ICT, it is necessary to view smart city security from the CPS (cyber-physical systems) perspective [23]. However, existing studies related to smart city security have mainly discussed information or cyber security technologies.

Whereas cyber security involves the protection of information and systems, the security of smart cities must include a human safety aspect. Advanced surveillance technology using ICT also contributes to enhancing individual safety in urban life [24]. The improvement of traditional devices, such as smart street lights, can also enhance citizens' safety [25]. Recently, scholars have begun to actively discuss the concept of a safe city that protects the safety of its citizens based on these technologies. A safe city means a city that effectively protects citizens from the threats of crime and terrorism and allows citizens to respond quickly to health problems and emergencies [26]. To develop such a safe city, it is necessary to understand various components such as technology, devices, and services, but it is not easy to design or build an architecture incorporating them due to their interconnection issues. In addition, since these components are closely related to the safety of citizens, their reliability and effectiveness must be verified through sufficient research [27]. Moreover, it is necessary to consider factors other than technology, such as laws, regulations, citizens' awareness, and culture, even after verification. As such, academic discussion needs to be sufficiently developed.

3. Case Study: The IFEZ in South Korea

3.1. Korea's U-City Project

Korea established a smart city public-private partnership with Incheon Smart City Incorporated, which developed the U-City infrastructure project for Songdo Zones 1–4 between 2013 and 2017 [28]. This project established the public-sector software-defined data center (SDDC), which uses cloud technology and has saved ten million dollars and 25% of operating and maintenance costs every year through a comprehensive design that encompasses Songdo, Yeongjong, and Cheongra (See Figure 1). With the basic infrastructure established, a single integrated operations center now manages the smart cities in these three zones of the IFEZ; notably, the center involves a comprehensive video control system that provides security services for transportation, crime prevention, disaster prevention, environmental maintenance, and citizen services.

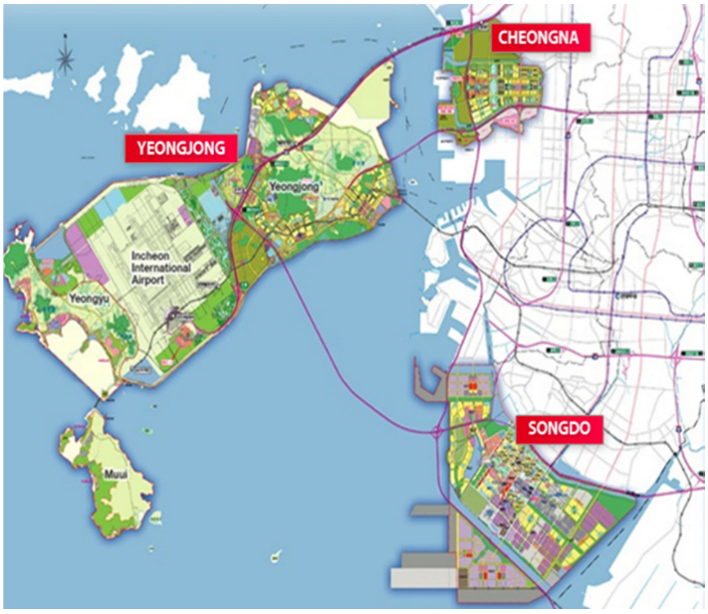


Figure 1. Incheon Free Economic Zone (IFEZ).

The IFEZ Smart City Integrated Operations Center in Songdo is composed of an integrated control room, viewing room, equipment room, and meeting rooms in an area of 1169.5 m^2, connecting all of the Songdo, Cheongra, and Yeongjong districts in one communication network and comprehensively conducting control functions by connecting individual services (e.g., administration, transportation, crime prevention, disaster prevention, environment, facilities, etc.) [18]. The functions of the IFEZ Smart City Integrated Operations Center are divided into monitoring, data management, and situation control. It collects data from facilities, manages the collected data, and processes the situation (event) information to be transferred to authorities in cases of emergencies, supporting swift responses. In total, there are 51 staff members in the IFEZ Smart City Integrated Operations Center, with 28 in charge of CCTV control and monitoring and 4 in charge of controlling emergencies and responses by authorities at the Operations Center. The average number of CCTVs per staff member is around 140 [18]. Since its launch in 2012, Incheon Smart City has been in charge of the design, building, and operation of the smart city. In the area of information collection technology, it is also in charge of building and operating IoT sensors, i.e., facilities such as CCTV and other communication infrastructure. Furthermore, in the area of information processing technology, it has developed its own IFEZ smart city platform, and has built and currently operates the IFEZ Smart City Integrated Operations Center. In the area of information utilization technology, it has developed, and currently operates, smart city services linked with the smart city platform. In other words, in operating the IFEZ smart city services, its activities encompass the majority of management functions including IT; finance, budget, and accounting; human resources; labor relations; and public relations.

3.2. IFEZ's Smart Crime Prevention Service

Smart city services are a series of services that mutually integrate the data collected from the city through basic infrastructures, such as sensors in the urban space, with technologies, such as those related to communications [29,30]. IFEZ's Smart Crime Prevention Service provides real-time surveillance of the Songdo, Cheongra, and Yeongjong districts to strengthen security and crime prevention and alert police and fire-fighting agencies of emergencies so they can respond quickly. IFEZ Smart Crime Prevention Service differs from traditional U-City crime prevention services as it improves the efficiency of crime prevention management through data sharing and task linking with other authorities in the city and emphasizes the role of the citizens as service participants.

The IFEZ Smart Crime Prevention Service takes place across three stages of a situation (event): occurrence, registration, and post-event response. The database is set up so that the number of cases for each of the four event types is collected. As shown in Figure 2, the service is executed in the following order: event occurrence, confirmation, situation registration, workflow, and follow-up response.

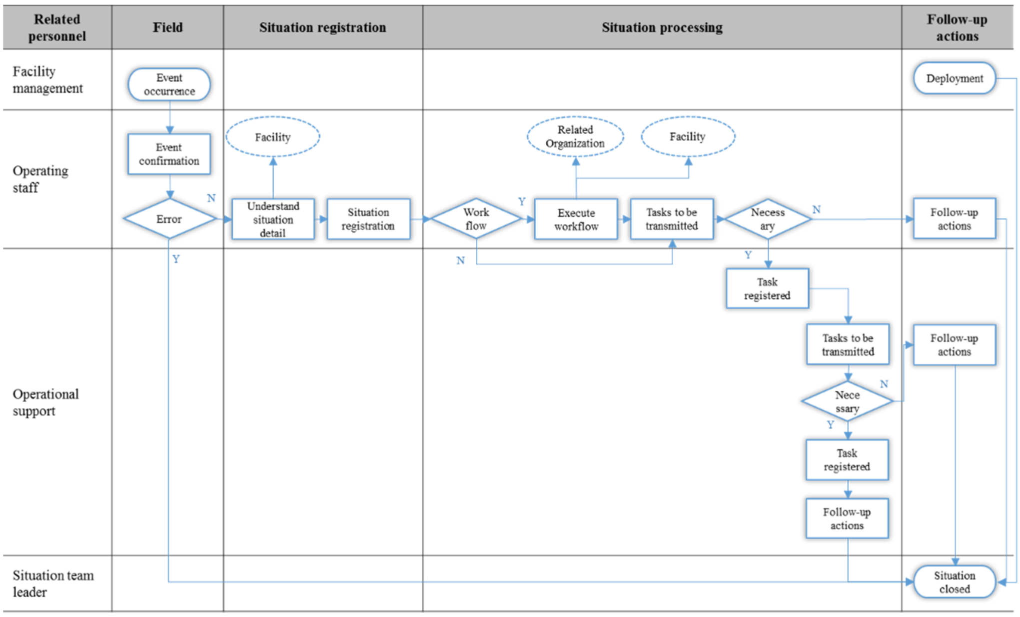


Figure 2. Workflow diagram of the IFEZ smart crime prevention service.

The services dealt with by the IFEZ Smart Crime Prevention Service can be largely divided into everyday crime prevention and vehicle crime prevention, according to the targets of crime prevention. The everyday crime prevention component is made up of intelligent video surveillance; emergency alarms and abnormal sound source detection services; and the vehicle crime prevention components include services that monitor suspicious vehicles such as those used in crimes or registered to delinquent taxpayers.

The intelligent video surveillance service analyzes the video information collected through CCTVs in real-time and initiates an alert when a pre-defined situation arises, notifying the control agent in the IFEZ Smart City Integrated Operations Center who can then immediately determine and respond to the situation. The intelligent video analytics technology was operated as a pilot in the IFEZ Songdo District during Phase 2 of the Ubiquitous Pilot City Project (2010–2011), with CCTV locations selected in reference to theories on Crime Prevention Through Environmental Design (CPTED), such as natural monitoring, access control, strengthened domains, and maintenance.

The emergency alarm service comprises emergency alarms that citizens can use to quickly report emergencies and was designed to respond in step with authorities to situations such as disasters, emergencies, and crimes. Pressing the emergency alarm automatically shares the location of the emergency alert with the situation map of the IFEZ Smart City Integrated Operations Center, and the CCTVs at the site of the emergency are automatically controlled to provide video surveillance of the situation occurring near the emergency alarm. Furthermore, it allows for two-way voice communication between the reporter and the control staff and is capable of sounding an emergency siren.

Abnormal sound source detection is a service that provides automatic, real-time surveillance of abnormal sound sources and can alert control staff at the IFEZ Smart City Integrated Operations Center. This can be viewed as a surveillance method that supplements the limitations of video surveillance, especially considering that the Privacy Act deems the use of CCTVs for voice recordings to be illegal. The abnormal sound source detection device detects sounds such as screams, horns, collisions, and explosions, analyzing the waveform information and determining whether it is classified as abnormal. It then automatically controls the nearby CCTVs to point at the source of the abnormal sound and creates an alert for the monitoring agent of the IFEZ Smart City Integrated Operations Center. The IFEZ Smart City Integrated Operations Center then determines the situation and takes action.

Meanwhile, suspicious vehicle surveillance involves the automatic recognition of vehicle numbers through vehicle number recognition cameras—notably, it enables the searching of vehicles used in crimes or belonging to delinquent taxpayers. More specifically, it is composed of a surveillance system that can track down the movement of a vehicle, supporting the activities of the authorities. Today, vehicle number recognition cameras have been installed and are operating on the entrances and exits of each IFEZ district; these cameras save information including the vehicle number, vehicle model, location, and time derived from the camera on a database, allowing authorities to search for suspicious vehicles as needed.

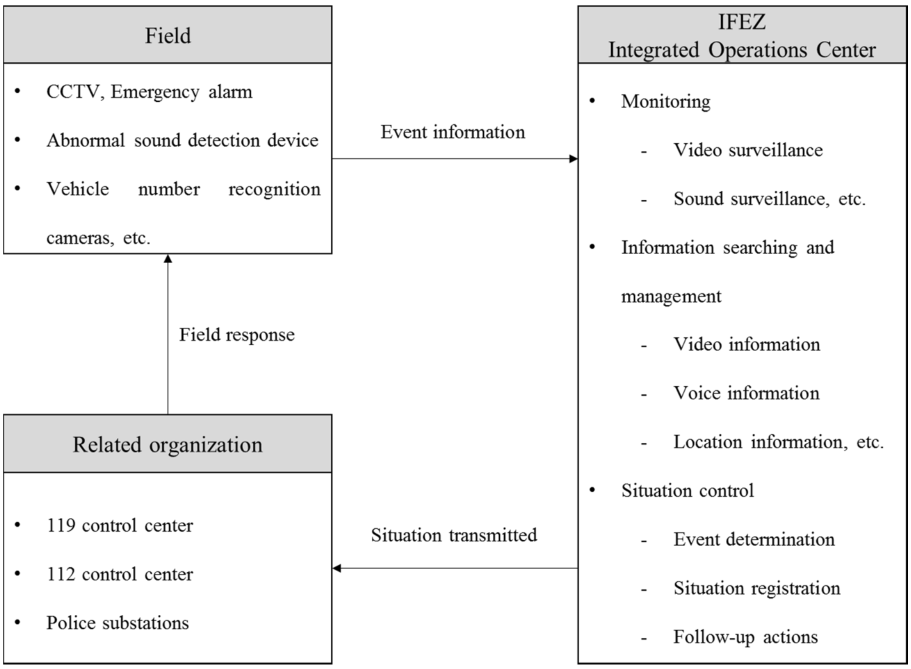


Figure 3. Smart crime prevention service diagram.

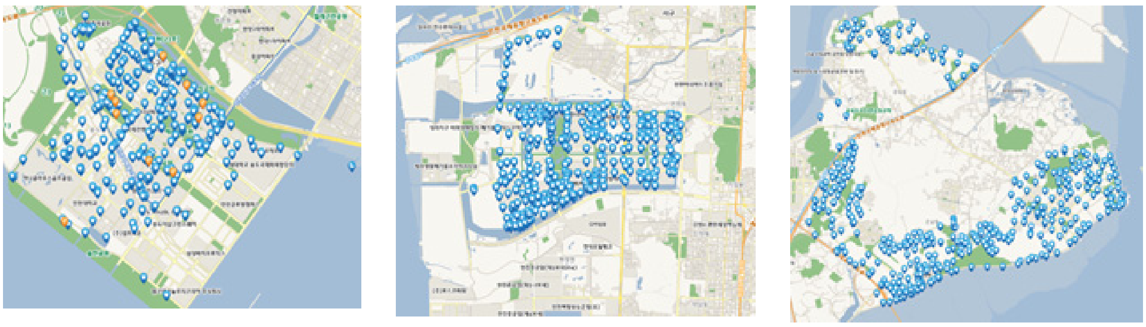
Various situational (i.e., event-related) data occurring across the facilities and CCTVs installed across the IFEZ are collected and classified based on the pre-defined set of rules for the IFEZ Smart City platform. For example, if an emergency event involving a crime or rescue emergency occurs, then the IFEZ Smart City Integrated Operations Center receives and controls the situation, transmits the situation to the authorities such as the fire or police departments, and instructs these departments to respond to the scene. Notably, one police officer is permanently stationed at the IFEZ Smart City Integrated Operations Center, providing initial responses relating to crime (see Figure 3). Situational (event) information relating to crime prevention are classified into 13 situations and assigned an emergency grade from the following list: high priority, priority, warning, and average. The following are classified as high priority emergences: emergency/assault, trespassing, kidnapping, and collision/explosions. Meanwhile, civil petitions and suspicious vehicles are classified as priority emergencies. Abnormal sound sources, loitering, motion recognition, number recognition, and emergency alerts have warning emergency ratings. Finally, throwing has an average emergency rating. This grading system is especially useful when situations occur simultaneously, allowing for priority-based processing.

4. Analysis of the Status of the Smart Security Service

4.1. Service Facilities

For this research, a joint study was conducted with Incheon Smart City, which operates and manages the smart cities in the IFEZ. Basic information on crime data, collected between January 2017 and December 2018 from the smart city platform built and operated by Incheon Smart City, were subjected to data analysis. Based on the data collected, this study analyzed the status of service facilities, everyday crime prevention, and vehicle crime prevention.

Crime prevention facilities in this study include CCTVs, emergency alerts, abnormal sound source detection devices, and vehicle number recognition cameras, each of which has its own internet protocol (IP) address and is managed in real-time through the Integrated Operations Center. Figure 4 presents the distribution of crime prevention facilities for each IFEZ district. Overall, 2151 facilities are used for crime prevention, with 552 in Songdo, 713 in Cheongra, and 886 in Yeongjong.



Songdo Cheongra Yeongjong

Figure 4. CCTV Facilities for public security.

Overall, 1084 CCTVs are used for intelligent video surveillance, with 308 in Songdo, 318 in Cheongra, and 458 in Yeongjong. There are 203 emergency alarms in Songdo, 317 in Cheongra, and 370 in Yeongjong, totaling 890. Furthermore, there are a total of 31 vehicle number recognition cameras used in monitoring suspicious vehicles in Songdo, 78 in Cheongra, and 58 in Yeongjong, totaling 167. However, there are only 10 abnormal sound detection devices, and they are only installed in Songdo. In the case of Songdo, the current population is approximately 50.3% of its total planned population and crime prevention facilities are expected to increase with population growth.

4.2. Everyday Crime Prevention

The statistics on everyday crime prevention were calculated in terms of situation collection and situation occurrence. Situation (event) occurrence information refers to information that is collected through crime prevention facilities and sent to control staff at the IFEZ Smart City Integrated Operations Center, which determines whether the information should be sent to the authorities. The data collected for each of the situation collection types are shown in Table 1. According to Table 1, among 127,936 total collected situations in 2017, there were a total of 8230 cases of security services, including monitoring, emergency alarms, abnormal sound sources, and motion recognition, representing 6.43% of the total.

Table 1. Situation information.

Year	Monitoring	Emergency Alarm	Abnormal Sound Source	Motion Recognition	Cases not Relating to Crime Prevention	Total
2017	28	5773	1106	1323	119,696	127,926
2018	51	2043	-	-	61,596	63,390
Total	79	7816	1106	1323	180,992	191,316

The total number of collected situations in 2017 and 2018 was 191,316, among which there were 79 cases of monitoring and 7816 cases of emergency alarms, indicating that there was a comparatively higher number of emergency alarm situations than events from monitoring. It can also be confirmed that the incidence of emergency alarms being triggered by citizens is higher than manual alerts by the monitoring staff. Furthermore, the number of situations arising from intelligent monitoring devices, such as motion recognition, was also relatively large at 1323. While there are differences between the number of cases of automated monitoring and monitoring by staff, situational responses by monitoring staff are much more important in terms of immediate responses to actual situations. Automated monitoring and emergency alarms collected data relating to malfunctions and minor civil complaints, indicating a low proportion of crime prevention responses to the total number of situations. In 2018, there were no data on situations from the intelligent monitoring devices (abnormal sound source detection and motion detection); however, manual monitoring by control staff increased two-fold from 28 cases in 2017 to 51 cases in 2018. This increase was because of the sensitivity and false alarms from the data collected by abnormal sound source detection and motion recognition, and the subsequent turning off of said functions. Therefore, intelligent monitoring equipment cannot be seen as the all-powerful key to security services; systematic implementation of security services, intelligent equipment, systematic responses, and operations by the monitoring staff are all important.

Table 2 shows the data collected for each situation. The number of situation occurrences in 2017 totaled 1273 cases; however, there were only 38 cases in 2018, with significant differences in the number of cases of violence/robbery, intrusions, and suspicious vehicles.

Table 2. Situation type.

Type	2017	2018	Total
Emergency	172	28	200
Violence/robbery	348	5	353
Civil complaints	0	1	1
Intrusion	646	0	646
Kidnapping	0	0	0
Loitering	0	0	0
Throwing	0	0	0
Suspicious vehicle	104	0	104
Collision explosion	0	0	0
Sudden event	3	5	8

There were no cases of suspicious vehicles or intrusion data being collected through abnormal sound sources and motion recognition, and a reduction in the cases of emergencies and violence/robbery data was evident, indicating that the abnormal sound source detection and intelligent video analytics functions were disabled.

Since 2018, the sensitivity and malfunction of intelligent equipment in crime prevention data collection led to lower levels of collection activity by these devices, resulting in a comparatively lower number of cases in 2018. Therefore, data were primarily collected through monitoring and citizen reporting (emergency alarms, etc.) in real crime prevention situations; as such, the number of emergency cases was the highest in 2018. This indicates that emergency cases were most common, and it is necessary to consider the number of such cases collected through intelligent equipment. Additionally, cases regarding kidnapping, loitering, throwing, civil complaints, and collisions/explosions were very rarely collected. These findings suggest that while a variety of crime prevention situations were considered in building smart city security services and implemented in the system, many of the relevant features are not often used. It may be more appropriate to conclude that the smart city security services were not able to collect such situations, rather than that these situations have not occurred in IFEZ. Therefore, for important crime prevention situations that are not collected in the utilization stage of the smart city after its build-out (i.e., collisions and explosions), it appears necessary to improve the monitoring methodology by re-calibrating event collection criteria and improving equipment performance from the collection stage. The disabling of abnormal sound sources and intelligent video analytics leading to the lack of collection of relevant situational data indicates the need to continuously improve the smart security services in the IFEZ. Particularly in the development of technology and equipment relating to smart crime prevention, efforts are needed to lower the excessive sensitivity and malfunction of intelligent collection devices, as well as developments in the artificial intelligence case determination system to discern the actual occurrences of cases.

4.3. Vehicle Crime Prevention Statistics

The vehicle crime prevention statistics used the number of searches as requested by the authorities and subsequent identifications, among the data set of vehicle numbers collected using vehicle number recognition cameras. These cases involved the identification of suspicious vehicles using vehicle number recognition cameras and the sharing of this information with the relevant authorities, such as the police. The vehicle crime prevention service can be used in a variety of ways, including for the identification of suspected criminals and the analysis of post-hoc movement routes. Table 3 shows that the total number of vehicle crime prevention events over the past two years was 178. The number of cases is highest for wanted vehicle identification (129 cases), followed by delinquent taxpayer vehicles (43 cases). By year, the number of wanted vehicles declined by 83.7% from 111 cases in 2017 to 18 cases in 2018, and the number of delinquent taxpayer vehicles declined by 77.1% from 35 cases in 2017 to 8 cases in 2018. It is not possible to understand the specific situations of follow-up measures, such as arrests, made after the identification of the wanted or delinquent taxpayer vehicles—the function and the role of the current smart security services is to hand over the collected data to the relevant authorities. In the future, it is necessary for smart crime processing to understand how the collected information is used by the authorities and receive feedback on the processing results. Furthermore, it is also necessary to review existing methods to determine how best to increase information on usability and availability. Information availability is low when it is simply collected and handed over; as such it is difficult to increase information usability for the authorities.

Table 3. Suspicious vehicles identified: Number of cases.

Year	Wanted vehicles	Delinquent Taxpayer Vehicles	Vehicle of Interest	Total
2017	111	35	3	149
2018	18	8	3	29
Total	129	43	6	178

5. Discussion

5.1. Findings and Implications

While the smart crime prevention service was initially equipped with artificial intelligence-based technologies, such as intelligent video analytics and abnormal sound source detection technologies, various limitations have surfaced from the perspective of technology sensitivity and malfunction, as previously mentioned. The limitations are as follows.

First, this study confirmed the limitations of technology and equipment performance for smart security service operation. Collection sensitivity and frequent false alarms, due to the immaturity of the applied technology, have become a problem in the IFEZ smart security service. In fact, the detection rate doubled in 2018 compared to 2017, negatively affecting trust in sensing technology. Moreover, these malfunctions (false alarms) eventually led to the overload of control tasks and the discontinuation of related functions. This was also pointed out in an expert seminar on 7 June 2018, on the use of artificial intelligence in disaster safety, held by the National Disaster Management Research Institute; at the seminar, regional governments reported that misidentification rates were high from intelligent CCTVs, leading to lower trust levels for the related technology and the disabling of functions, instead of providing support for the personnel costs of control center staff. In other words, abnormal sound source detection and intelligent video analytics serve to support effective surveillance; however, the immaturity of the technology and equipment makes them difficult to use. This eventually leads to the incomplete use of control center workflows based on these technologies, which undoubtedly influences the decision-making process for effective management and service improvements of the smart security services. It is important to note that ICT performance leads to the performance of smart city services.

Second, the limitations of data linkage and tracking technologies were also observed. For smart cities, it is important to create an integrated control center that focuses all data in one place and provides a central site for comprehensive analytics, accumulation, and use [31]. The smart crime prevention service also requires data to be collected in the smart city, and the collected data to be used in individual institutions, such as the fire department, the police department, hospitals, and administrative agencies. However, data created in smart security services do not have a role beyond serving as information for relevant authorities. For example, video data for confirming wanted vehicles and traffic conditions are in a format that only collects vehicle numbers by video and that does not allow such data to be processed into information that can continuously be used by the authorities for tracking and management; accordingly, authorities have no choice but to use such data in a limited manner and, therefore, continue to face difficulties with improving information availability, tracking, and use [32]. Going forward, work should be done on how collected smart city data can be used by authorities and on developing methods at the collection level to increase usability and availability.

Third, limitations to integrated data use among departments and organizations need to be addressed for smart city services. Integrated services like the smart city differ from existing digitization services focusing on single services and require the convergence of multiple departments and services; as such, it is important to jointly raise the quality of citizen support services and security services by using data between multiple government agencies. For example, in the case of police departments, fire departments, and hospitals, sharing data on smart crime prevention can allow for quick responses, rapid processing, and post-hoc management. To this end, the convergent use of specialized smart crime prevention data is important for crime prevention. It is, therefore, necessary to derive methods that can practically solve issues around cooperation through sharing crime prevention data collected from multiple departments, the scope of data disclosure, disclosure methods, accountability, data ownership, and data management; the simple policy approach to "sharing information" has not yet resulted in significant performance. Therefore, it is necessary to simultaneously establish the legal foundations and systems for integrated data use.

Lastly, activation of private services in smart cities is also a challenge. Smart cities, initially built out through the public sector, were expected to be home to the active creation of private-sector services related to data use and proliferation. However, much like the case of IFEZ, the focus continues to be on public services; to date, there are no cases of the private sector providing services based on this data. While it is true that it is difficult for smart security services to develop into services offered in the private sector, it is necessary for the private sector to participate in security services, as showcased by the example of a risk-alerting smartphone app for the Seoul Metropolitan Government and other regional governments.

The implications of this study are as follows: first, this study makes clear that it is necessary to ensure the accuracy and continuity of data collected from smart security services. To be sure, this requires ongoing technological development, improvement, and management, including accurate sensing and equipment technologies that can accurately detect a situation. Second, it is necessary to establish a consistent process that can link the entire breadth of the Smart Crime Prevention Service and secure related data connectivity. It is essential to establish and systematize a whole process that comprehensively manages and uses data from the occurrence of the situation to the collection, linkage, and processing of results [8,33]. Third, the objectives of the smart city are the systematic management and analysis of data, the reflection of such data in administrative tasks, and the analysis of their effects to ameliorate urban issues—to be sure, it is necessary to urgently develop specialized institutions and experts to this end. As the majority of data are from the public sector, outsourcing to the private sector makes ongoing data accumulation and linking bodies of knowledge difficult. This underlines the urgency with which we must optimize the promotion and management of specialized institutions, such as Incheon Smart City.

5.2. Limitations and Future Study

A limitation of this study is that only two years of crime prevention-related data were analyzed in discussing smart city security. However, this study is still significant because it was able to confirm the preemptive conditions for applying new technologies, operational methods to effectively collect big data from operations, and the importance of linkage between institutions to achieve effective service processes in operating the city. Another limitation is that this study applied only descriptive statistics in analyzing data. If advanced statistical techniques were applied, such as machine learning based on a vast data set, it would be possible to have more advanced discussions.

Thus, future studies should delve further into the analytics and execution mechanisms of smart security services using the present data. In addition to security services, it is necessary to discuss the actual performance and limitations of various services in the smart city. These discussions not only help the acceptance, diffusion, and establishment of smart services but can ultimately contribute to the activation of smart cities. Furthermore, follow-up studies should be conducted on the methods needed to support effective decision-making for urban operations through the convergence of multiple data-based services, as well as methods to improve smart city performance through participation from the central government, regional government, corporations, and citizens.

5.3. Conclusions

This study examined the build-out and operational status of the IFEZ and U-City through the case of IFEZ Smart Security services and reviewed the performance and limitations of the data-based implementation of the smart city based on the collected crime prevention data. As seen in the case of the IFEZ Smart Security services, data from the crime prevention facilities in the IFEZ region were collected through the smart city platform; however, the use of the data showed limitations, along with the performance of the applied technology. For the successful operation of the smart city, it is necessary to overcome the limitations of data collection and sharing evidenced by the case of U-Cities. Along with the selective acceptance of practical technologies for urban problem-solving and the expanded application of diverse smart city services through ongoing technology performance improvements, an expanded, strengthened, and data-driven policy of decision-making through the linkage of various data is necessary.

Author Contributions: Conceptualization, M.-s.P.; methodology, M.-s.P.; validation, M.-s.P. and H.L.; formal analysis, M.-s.P.; writing—original draft preparation, M.-s.P. and H.L.; writing—review and editing, H.L.; visualization, H.L.; funding acquisition, H.L. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2019S1A3A2098438); This work was supported by the growth support project for industrial innovation talent of MOTIE.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Neirotti, P.; De Marco, A.; Cagliano, A.C.; Mangano, G.; Scorrano, F. Current trends in Smart City initiatives: Some stylised facts. *Cities* **2014**, *38*, 25–36. [CrossRef]
2. Lee, J.H.; Hancock, M.G.; Hu, M.-C. Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. *Technol. Forecast. Soc. Chang.* **2014**, *89*, 80–99. [CrossRef]
3. PCFIR. The Performance and Direction of the Presidential Committee on the Fourth Industrial Revolution. Available online: https://www.4th-ir.go.kr/article/detail/354?boardName=internalData&category= (accessed on 20 May 2020).
4. Angelidou, M. Smart city policies: A spatial approach. *Cities* **2014**, *41*, S3–S11. [CrossRef]
5. MIT-Technology-Review. Connectivity and QoL. 2017. Available online: https://www.technologyreview.com/2017/10/24/148193/connectivity-and-qol/ (accessed on 20 May 2020).
6. Kshetri, N.; Alcantara, L.L.; Park, Y. Development of a smart city and its adoption and acceptance: The case of new Songdo. *Commun. Strateg.* **2014**, *96*, 113.
7. Cavalcante, E.; Cacho, N.; Lopes, F.; Batista, T. Challenges to the Development of Smart City Systems: A System-of-Systems View. In Proceedings of the 31st Brazilian Symposium on Software Engineering, Fortaleza, Brazil, 20–22 September 2017; pp. 244–249.
8. Hashem, I.A.T.; Chang, V.; Anuar, N.B.; Adewole, K.; Yaqoob, I.; Gani, A.; Ahmed, E.; Chiroma, H. The role of big data in smart city. *Int. J. Inf. Manag.* **2016**, *36*, 748–758. [CrossRef]
9. Laufs, J.; Borrion, H.; Bradford, B. Security and the smart city: A systematic review. *Sustain. Cities Soc.* **2020**, *55*, 102023. [CrossRef]
10. Lee, J.; Choi, M.; Lee, H. Factors affecting smart learning adoption in workplaces: Comparing large enterprises and SMEs. *Inf. Technol. Manag.* **2015**, *16*, 291–302. [CrossRef]
11. Pradhan, M.K.; Oh, J.; Lee, H. Understanding travelers' behavior for sustainable smart tourism: A technology readiness perspective. *Sustainability* **2018**, *10*, 4259. [CrossRef]
12. Eggers, W.D.; Skowron, J. Forecs of Change: Smart Cities. Available online: https://www2.deloitte.com/content/dam/insights/us/articles/4421_Forces-of-change-Smart-cities/DI_Forces-of-change-Smart-cities.pdf (accessed on 20 May 2020).
13. Chung, N.; Kim, J.; Lee, H.; Koo, C. The roles of sustainable development goals and Smart Tourism City in the 4th Industrial Revolution. *J. Internet Electron. Commer. Res.* **2020**, *20*, 127–146. [CrossRef]
14. Hwang, J.-S. U-city: The next Paradigm of Urban Development. In *Handbook of Research on Urban Informatics: The Practice and Promise of the Real-Time City*; Foth, M., Ed.; IGI Global: Hershey, PA, USA, 2009; pp. 367–378.
15. Bakıcı, T.; Almirall, E.; Wareham, J. A smart city initiative: The case of Barcelona. *J. Knowl. Econ.* **2013**, *4*, 135–148. [CrossRef]
16. Calder, K.E. *Singapore: Smart City, Smart State*; Brookings Institution Press: Singapore, 2016.
17. Robinson, P.; Coutts, S. The case of Quayside, Toronto, Canada. In *Smart City Emergence*; Anthopoulos, L., Ed.; Elsevier: Amsterdam, The Netherlands, 2019; pp. 333–350.
18. Park, M.; Lee, H.; Kim, B. A Study on the Demonstration of Data-Based Performance in Smart City. *J. Informatiz. Technol. Archit.* **2020**, *17*, 51–61.
19. Zou, Y.; Zhao, W. Making a new area in Xiong'an: Incentives and challenges of China's "Millennium Plan". *Geoforum* **2018**, *88*, 45–48. [CrossRef]
20. Li, C.; Dai, Z.; Liu, X.; Sun, W. Evaluation system: Evaluation of smart city shareable framework and its applications in China. *Sustainability* **2020**, *12*, 2957. [CrossRef]
21. Borrion, H.; Ekblom, P.; Alrajeh, D.; Borrion, A.L.; Keane, A.; Koch, D.; Mitchener-Nissen, T.; Toubaline, S. The problem with crime problem-solving: Towards a second generation POP? *Br. J. Criminol.* **2020**, *60*, 219–240. [CrossRef]
22. Catlett, C.; Cesario, E.; Talia, D.; Vinci, A. Spatio-temporal crime predictions in smart cities: A data-driven approach and experiments. *Pervasive Mob. Comput.* **2019**, *53*, 62–74. [CrossRef]

23. Lee, H. Home IoT resistance: Extended privacy and vulnerability perspective. *Telemat. Inform.* **2020**, *49*, 1–12. [CrossRef]
24. Chattopadhyayr, D.; Dasgupta, R.; Banerjee, R.; Chakraborty, A. Event Driven Video Surveillance System Using City Cloud. In Proceedings of the First International Conference on Intelligent Infrastructure at the 47th Annual National Convention Computer Society of India, Kolkata, India, 1–2 December 2013.
25. Jin, D.; Hannon, C.; Li, Z.; Cortes, P.; Ramaraju, S.; Burgess, P.; Buch, N.; Shahidehpour, M. Smart street lighting system: A platform for innovative smart city applications and a new frontier for cyber-security. *Electr. J.* **2016**, *29*, 28–35. [CrossRef]
26. Hartama, D.; Mawengkang, H.; Zarlis, M.; Sembiring, R.W.; Furqan, M.; Abdullah, D.; Rahim, R. A Research Framework of Disaster Traffic Management to Smart City. In Proceedings of the 2017 Second International Conference on Informatics and Computing (ICIC), Jayapura, Indonesia, 1–3 November 2017; pp. 1–5.
27. Cagliero, L.; Cerquitelli, T.; Chiusano, S.; Garino, P.; Nardone, M.; Pralio, B.; Venturini, L. Monitoring the Citizens' Perception on Urban Security in Smart City Environments. In Proceedings of the 2015 31st IEEE International Conference on Data Engineering Workshops, Seoul, Korea, 13–17 April 2015; pp. 112–116.
28. Nam, T. The evolution from ubiquitous to smart cities: A case of Korea. *Int. J. Electron. Gov. Res. (Ijegr)* **2019**, *15*, 59–71. [CrossRef]
29. Lee, J.H.; Phaal, R.; Lee, S.-H. An integrated service-device-technology roadmap for smart city development. *Technol. Forecast. Soc. Chang.* **2013**, *80*, 286–306. [CrossRef]
30. Hefnawy, A.; Bouras, A.; Cherifi, C. IoT for Smart City Services: Lifecycle Approach. In Proceedings of the International Conference on Internet of Things and Cloud Computing, Cambridge, UK, 22–23 March 2016; pp. 1–9.
31. Viale Pereira, G.; Cunha, M.A.; Lampoltshammer, T.J.; Parycek, P.; Testa, M.G. Increasing collaboration and participation in smart city governance: A cross-case analysis of smart city initiatives. *Inf. Technol. Dev.* **2017**, *23*, 526–553. [CrossRef]
32. Jeon, B.-J.; Kim, H.-W. An exploratory study on the sharing and application of public open big data. *Informatiz. Policy* **2017**, *24*, 27–41.
33. Al Nuaimi, E.; Al Neyadi, H.; Mohamed, N.; Al-Jaroodi, J. Applications of big data to smart cities. *J. Internet Serv. Appl.* **2015**, *6*, 25. [CrossRef]