

The Use of Smart City Applications and Artificial Intelligence (AI) during the Covid-19 Pandemic: A Comparative Analysis

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Abstract: The Covid-19 viral disease has spread worldwide very rapidly and was declared as a pandemic by the World Health Organization. The unexpected rapid increase in the number of infected people has resulted in adverse impact on all spheres of life, and countries have turned to various practices in combating the pandemic. Smart city applications and artificial intelligence technologies were among the first tools that various countries utilized to get quick results in their fight against Covid-19. The aim of this study is to reveal the importance of smart city applications and artificial intelligence in combating Covid-19 by presenting China, US, France, Italy, and Turkey as examples. These countries were comparatively analyzed in terms of their policies, smart city applications and artificial intelligence technologies they have been utilizing to contain and cope with Covid-19. Our findings indicate that these countries mostly benefited from smart city applications, broadband technologies, 5G technology, mobile applications, health code, radiation management, early diagnosis kit and face recognition technologies in coping with the pandemic.

Keywords: covid-19, pandemic, smart city, artificial intelligence (AI), comparative analysis

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INTRODUCTION

AI, as an advanced technology, quickly fixes numerous needs and problems today. The fast solution-oriented nature of the AI has led to its ready adoption by almost every field. Some wide discrepancies in the views on the advantages and risks of AI prevent a single definition from being made (Geisel 2018, 119). To understand and define artificial intelligence, the concept of algorithms, programs, systems, and machines that demonstrate intelligence need to be referred (Davenport et al. 2019). To understand AI properly, it is necessary to investigate the programs that show intelligence, the field of study that recognizes systems through algorithms and makes machines that are difficult to distinguish from humans in cognitive and behavioral terms.

One of the areas that benefit from the advantages of AI is smart cities. Smart cities play a key role in determining the future of cities. Using advanced technology applications in cities, finding solutions to problems with technology and the importance that managers attach to digitalization are very important in smart urbanism. AI provides such innovative technologies needed by smart cities and brings applicable quality services to cities (Köseoğlu and Demirci 2018, 45). Crisis management, which is needed in extraordinary situations and moments of crisis in smart cities, is carried out effectively and efficiently thanks to AI.

Covid-19, which first broke out in Wuhan-China as an epidemic in December 2019 and has affected almost all the cities around the world since the beginning of 2020, has now been defined as an emergency and a crisis (İbiş 2020, 90). Covid-19, declared by the World Health Organization as a pandemic, has recorded a very rapid spread rate and negatively affected all segments of life and all sectors of industry (Alpago and Alpago Oduncu 2020). Various measures have been implemented in the struggle initiated by countries to minimize the negative effects of the pandemic in health and all other areas.

THE SMART CITY AND ITS FIELDS OF APPLICATION

The smart city idea has emerged as a necessity of being a people-oriented city. For cities that must respond to the needs of a new lifestyle, ensure sustainability, use energy efficiently, and must improve transportation and all other services, smartness has been presented as a solution (Haarstad and Wathne 2019). What matters in managing smart cities is implementing the processes that increase digital and learning-based skills in place (Komninos et al. 2015, 40).

Defined as a new approach to urbanism, smart cities offer new life models to the city with strategic and smart applications.

The fundamental principle underlying the smart city is the creation of a city connected with digitalization (Baloğlu and Karademiroğlu 2019). With the help of digitalization and information technologies, smart cities add social, cultural, and economic value to the city. However, the concept of smart city should not only portray the image of a city where digitalization is used in every field. What the smart city means should be well understood (Köseoğlu and Demirci 2018, 45). The concept of smart city means a livable, sustainable, efficient, and people-oriented city that produces significant solutions to problems, and prevents waste of time and energy, which are all achieved by integrating information technologies.

Determining goals, including stakeholders in the process, planning, and sustainability are among the basic principles of smart city applications (Bilici and Babahanoğlu 2018, 129). In smart city applications, success cannot be achieved only by applying the regulations or by using technology by itself. Coming up with smart ideas for the development of the city, evaluation of these ideas by smart people, and supporting the simple solutions developed for the problems of the city with technology contribute to the success of the smart city.

All the processes required for the success of the smart city also determine the fields of implementation for the smart city. Difficulties such as transportation, housing, infrastructure, and management, which are among the problems of the city, have led to the emergence of the smart city concept and its fields of application (Çetin and Çiftçi 2019, 138).

AI AND ITS FIELDS OF APPLICATION

AI is the combination of network technology, communication technology and computer technology. Artificial intelligence, which has superior data processing capability, has an advantage in processing big data (Yang 2018). Unlike previously used technologies, it is applied in economy, finance, medicine, information technologies, education, and urban planning (Frank et al. 2019, 5). For AI to be successful in such fields of application, it needs to learn through image-based deep learning and have objects introduced to it. Three components are required for AI to come together and work as a whole. The success of AI is based on the successful combination and management of the

perception, analysis, and response processes (Kamble and Shah 2018, 179).

As a discipline, AI is a computer science in which machine learning techniques are used. Machines created with the aim of perceiving, analyzing and reacting like human beings are the main subject of this scientific discipline (Karsenti 2019, 101). Thanks to online computer programs, computerized machines, robots and machine learning, AI can process data and models to detect and solve problems, perform analyses, make predictions, and manipulate objects.

AI technology is rapidly advancing and is used in various applications and practices today. The terms commonly used when defining AI are algorithmic profiling, machine learning, deep neural networks, and automation (Daly et al. 2019). As a result of the effect of digitalization on every field, AI applications, which are found everywhere technology is used, can also be used to develop, advance, and establish superiority. Thus, the need for AI in various fields is increasing and AI implementations are on their agenda (Tamer and Övgün 2020). The prevalence of AI use is gradually increasing as it provides speed, precision, and ease in decision-making in every field it is used. Discussing how AI and smart city technologies affect the present and the future, the next heading focuses on the effects of Covid-19, declared as a pandemic.

COVID-19 PANDEMIC

Since Covid-19 has been declared a pandemic, the resources for control need to be both different and far broader than those aimed at preventing a largely local outbreak (McAuley et al. 2020). Therefore, since classical treatment methods would be inadequate, advanced treatment methods supported by sophisticated technologies were suggested to be used in combating the pandemic. To get rid of the virus quickly and with the least loss, two questions should be focused on: Can the spread of Covid-19 be stopped with the help of advanced technologies and digitalization? Does AI have effective implementation power in combating the pandemic? To find answers to these two questions, the next section focuses on the AI technologies used in the prevention of Covid-19 infection.

AI TECHNOLOGIES USED IN THE PREVENTION OF THE COVID-19 PANDEMIC

AI technologies and the processing of big data have an important role in preventing pandemics, analyzing the pandemic data, and controlling them. Thanks to the technologies developed using AI, a pre-signal is obtained in the early diagnosis of epidemics before they begin to spread. AI is used as an early warning system in epidemic diseases (Toker 2020, 1-4). In South Korea, which is one of the countries where advanced technology is common, AI has been used in the fight against Covid-19 in early diagnosis, mask distribution and determination of potentially risky places. China has used AI to detect Covid-19 cases. The use of AI at various stages in the pandemic is important in minimizing its negative effects and achieving success in the fight.

The use of AI technologies during pandemics decreases the possible risks and reduces the burden of responsibility on healthcare personnel. Among the advantages of AI in a pandemic are early and rapid diagnosis, reducing the human factor in the intervention of the case, and collecting and processing big data (Aydoğan and Sener 2020, 60). The first step to be taken for the use of AI is to introduce the element, that is, to determine the genome sequence of the virus. Since the success of AI depends on image-based deep learning, virtual genome sequencing of the Covid-19 is the most important factor for the success of AI applications and the rapid operation of the process (Doğan 2020). The recognition of the virus by AI is considered as the first step in making an early diagnosis, determining effective treatment methods and even achieving success in vaccine studies.

The AI technologies used at every stage of the pandemic, from the screening to control and tracking of Covid-19, are presented. The first of the AI technologies is the early diagnosis kit. Using the early diagnostic kits that are mandatory to detect Covid-19 and using AI, Chinese scientists determined the virus genome sequencing in just a month (Doğan 2020). South Korea, on the other hand, started the mass production of the early diagnosis kit in a few weeks, which it would normally design in a longer period. The use of AI technologies in the production of early diagnosis kits has accelerated the diagnosis and treatment phase. The second of the AI technologies is online Covid-19 screening and control. The site and mobile application called Online Covid-19 screening and control, designed by the Turkish Ministry of Health allows online screening and control of Covid-19. Based on the question “Would you like to check for Covid-19 online?”, the site asks

you to answer the questions if you think you or someone close to you have Covid-19 (<https://koronaonlem.saglik.gov.tr/>). Online Covid-19 screening, and control takes place in four stages. On the access page, the Turkish Identification Number, father's name, year of birth and telephone number must be entered. In the second step, there are questions about personal information and chronic diseases as well as the longest time the person has been in the last 14 days and whether the person works in the health sector. In the third step, there are questions regarding the actions taken in the last 14 days. The last step is called complaints and the person is asked which of the symptoms given as options he or she has. The answers to various questions asked in four steps are instantly reflected on the screen as a result.

Thirdly, the 5G technology and 5G patrol robots are presented as the AI technologies. Inadequacy of the pre-5G technologies created a need to switch to 5G. The inability of previous technologies to address cellular networks and the difficulties that could not be effectively addressed by 4G have widely increased the need for the 5G technology (Gupta and Jha 2015, 1217). 5G technology has higher capacity, higher data rate, better device connectivity, more consistent experience quality, and lower cost than 4G technology. These features of 5G technologies have led them to be preferred in the fight against Covid-19. Using the 5G technology, China has placed robots connected to the internet with 5G in living spaces (Eyidilli 2020). These robots, called 5G Patrol Robots, are used for non-contact delivery, recognizing human faces and identities, tracking, fever measuring, mask control, collecting big data and security. To benefit from the advantages of smart apps and to control the virus, China used WeChat app, while Turkey used the application called *Life Fits into Home*.

The WeChat application is used to track the movements of individuals when the lockdown ends, and to provide rapid information to people in the same area in the emergence of cases (Deloitte 2020). Application users are required to read their QR codes at the places they go. In this way, big data is collected, and the health status of individuals is determined (Uzun 2020, 47-50). *Life Fits into Home* application has been put into service by the Turkish Ministry of Health. The application allows citizens to both see areas at Covid-19 risk and monitor their own health by asking various questions (Sert Karaaslan 2020). The application is downloaded free of charge to smartphones and the main screen includes safe area, health status, HES code transactions, requesting a mask, and up-to-date statistics options.

SMART CITY APPLICATIONS FROM VARIOUS COUNTRIES IN THEIR COMBAT AGAINST COVID-19

Advanced technologies have been frequently used to combat the Covid-19 pandemic. Among the AI applications, broadband technologies, 5G patrol robots, mobile applications, health code, contact tracing management, and face recognition have been integrated into daily life. In this part of the study, the smart city applications in the fight against the Covid-19 are examined by focusing on their use in China, the USA, France, Italy, and Turkey. Here, these five countries are first analyzed comparatively in terms of the policies they have adopted against Covid-19, and then in terms of the smart city applications they have implemented to cope with Covid-19.

The fact that measures, precautions, social distance and isolation concepts have become a part of daily life throughout 2020 has caused all walks of lifestyle to change. Therefore, cities are expected to be smarter (Wakefield 2020). Local governments bear responsibility to find smart solutions to the pandemic in cities as well. At this point, the expectation has focused on metropolitan municipalities.

The negative impact of the Covid-19 pandemic has resulted in new demands in all spheres of life. To avoid contact, individuals increase the time they stay at home while their education is provided to them digitally and business organizations focus on remote working methods (Öztaşkarlı and Çelikyay 2020, 327). In the fight against the pandemic, the increase in advanced technologies, AI applications and smart city applications both in terms of use and need shows that the far future has now become immanent.

Smart City Applications in China's Fight against Covid-19

China is the first country where Covid-19 emerged, and technology and smart city applications are used in diagnosis, treatment, prevention, and monitoring. After the virus was seen and spread in the country, it first responded by declaring a quarantine. A closed-circuit camera system was installed at the entrances of people's homes to monitor individuals who are in compulsory quarantine for 14 days and to ensure that they do not leave their homes during this period (BBC News 2020a). The closed-circuit camera system is a smart city application and thus facilitated city-wide tracking of positive cases. Disinfection of dangerous large and open markets was the responsibility of the city administrations. Intelligent voice recognition

system was used to simultaneously detect multiple cases (Deloitte 2020). 5G technology was used to minimize contact and 5G patrol robots were used for many purposes, from daily life to treatment stages in hospitals. Unlike other countries, China has used the AI to decide which case to treat first (Uzun 2020, 51). The use of AI in making the decision of which patient should be treated first saved the doctors' time.

Other countries have used the drone technology for similar purposes, but China and Turkey have used this technology to urge their citizens to put on masks. The health code, which is among the smart city applications, has been accessible through WeChat, which is a smart application (Ademoğlu 2020). Thanks to the health code obtained through the WeChat application, millions of people could be tracked and monitored instantly. Covid-19, which has a very high contagion speed, has been controlled by employing advanced technologies and harnessing the superior digitalization capability of China. Thanks to technologies known as new generation technologies such as 5G, smart applications, artificial intelligence, big data, cloud technology and blockchain technology, China has managed to take Covid-19 under control only in three months (Deloitte 2020). The policies implemented by China in the fight against Covid-19 have overall been strictly regulated with the use of advanced technology, taking advantage of AI and smart city applications at every stage (Yıldız and Uzun 2020).

Smart City Applications in the USA's Fight against Covid-19

Experiencing difficulties in performing Covid-19 tests, the USA has ended up with the highest number of cases in the world. The difficulties and the red tape experienced in delivering the diagnostic kits developed in private laboratories using AI to the general population have caused the tests to be performed only on a small number of people (Duran 2020, 19). On April 28, 2020, Turkey sent medical supplies and diagnostic kits to the US to support it in its fight against the global outbreak and help relieve its medical supply shortages (Budak and Korkmaz 2020). Deciding to use advanced technologies to eliminate the problems and deficiencies in the fight against the pandemic, the USA has turned to AI and smart city applications.

To expedite Covid-19 research and to help scientists, the AI institutes assigned by the White House have prepared the first artificial

intelligence-supported Covid-19 Research Open Dataset (Uzun 2020). The data set, abbreviated as CORD-19, has been used to collect big data.

The Covid-19 High Performance Computing Consortium was established to answer all types of scientific questions related to the virus and to speed up information processing and discovery with use of CORD-19 (Toker 2020, 1-4).

Institutes in the USA have made use of AI to access information as well as online and real-time maps in the fight against the pandemic. The online risk map, one of the smart city applications used by the USA, was used to analyze the risk situation in the pandemic and show the risky areas (Bilgiç Kavas and Peker 2020). The other smart city application used in the Covid-19 outbreak process in the USA is the Covid-19 Road Map. Another smart city application prepared in partnership with universities and technology companies in the USA is the Safe Roads Application (Deloitte 2020). Thanks to this application, information is provided to users whether or not people have been in contact with positive cases without revealing their identities.

Smart City Applications in France's Fight against Covid-19

The spread of Covid-19 to Europe was first seen in France on January 24, 2020 (Karadağ and Yücel 2020, 8). After the first case was detected in France, the spread of the virus followed a rapid course. The death rate exceeding 10% indicates that the situation is serious for France (Memikoğlu and Genç 2020). Faced with travel restrictions from other countries, France has experienced an economy and tourism crisis during the pandemic.

First, a 15-day lockdown was declared in the country. Going on the street was subject to official permission, and fines were to be imposed for those violating the lockdown (BBC News 2020b). The reason France has passed the lockdown late was because the government did not favor the lockdown. France did not take Covid-19 seriously enough, and on top of that it was among the countries that benefited the least from digitalization, AI, and smart city applications.

France benefited only from drone technology applications in smart cities (Genç Yılmaz 2019, 32). With the help of drones, citizens' compliance with the rules against Covid-19 in cities was checked and monitored the fact that France was late in taking the necessary measures against the pandemic and has benefited from advanced technologies less than other countries shows that it has not followed an

effective policy in the fight against Covid-19 (Macar and Asal 2019, 230). With its policies, France has set a good example for other countries in terms of what should not be done to fight the pandemic, rather than what should be done.

Smart City Applications in Italy's Fight against Covid-19

After China, Italy has been one of the countries that have deeply suffered the impact of the pandemic in every field. Italy needs to make strategic predictions to accurately predict the course of the threat that seriously affects public health and to manage the crisis (Wangping et al. 2020). Not being able to make strategic predictions has cost Italy dearly and it has become one of the countries experiencing a rapid increase in the number of positive Covid-19 cases.

The first lockdown and the first quarantine in Europe were declared in Italy to prevent the spread of the virus (Taşöz Düşündere and Dündar 2020). Italy has taken extraordinary measures to prevent people who do not carry Covid-19 from contacting positive cases, to minimize contact and to limit the transmission of the virus (Remuzzi and Remuzzi 2020). An informative web site offering information on how education would continue, and a portal were established to continue distance education (Yamamoto Telli and Altun 2020, 28-30). Italy has become the new center of the virus due to the increasing number of cases and the high population of the elderly after Covid-19 has crossed the borders of China and spread all around Europe (Altinkaya 2020, 20). The most important of these reasons are Italy's economic ties with China, the high population of the elderly, the underdeveloped health system and the fact that people who are decision makers for the country do not take the pandemic seriously (Güngörmez 2020).

What is noteworthy among the measures taken in Italy is the thermal camera application installed only in the airports and high-speed trains in the city center (Sözcü 2020). High fever is easily measured with thermal cameras and those with high fever are not allowed to travel. The main reason why Italy has failed in the pandemic is that the government has not taken the virus seriously and has been too late to take measures even after becoming aware of its severity (Yılmaz 2020, 252). Thus, looking at the AI and smart city applications implemented by Italy, no sufficient information could be found.

Smart City Applications in Turkey's Fight against Covid-19

Covid-19 was seen for the first time in Turkey on March 11, 2020. After the first case was detected and the outbreak was declared by the World Health Organization as a pandemic, the necessary measures began to be implemented in a gradual and planned manner in Turkey (Macit and Macit 2020). Turkey differs from other countries in that it had taken some serious precautions even before the first case was detected. The technical strengthening of the health system, establishment of the city hospitals, and preparation of the *Health Transformation Program* in 2003 gave Turkey the biggest advantage in its combat against Covid-19 (Güreşçi 2020, 60). During the pandemic, city hospitals facilitated the response to the virus with bed capacity, the availability of necessary medical supplies, the number of respirators, intensive care units and advanced hospital conditions.

Turkey has taken advantage from digitalized technology to act fast in the fight against Covid-19 (Arslan and Karagül 2020, 25-27). International passengers have been measured and followed up with thermal cameras at airports. Passengers with high fever were put into quarantine and isolated for 14 days. Education was interrupted and then continued remotely (Budak and Korkmaz 2020, 75). The transition to distance education has reduced the contact of students with each other and educators, and has played a key role in maintaining social distance.

Developed as a location-based application, *Life Fits into Home (HES)* was the first smart city application to be implemented during the pandemic in Turkey. *Life Fits into Home* application was among the most downloaded smart applications during the pandemic period. Other smart city applications are the *I Have a Neighbor* prepared by Apsiyon site management software, and the *Coronavirus Turkey Map* prepared with geographic information systems (Bilgiç Kavas and Peker 2020). Thanks to these smart applications, the risky areas in the city where individuals live are made sure to be seen and the users are notified when they enter the risky areas. Local administrations have taken an active role during the pandemic in Turkey. The needs of citizens aged 65 and over who are prohibited from going out due to restrictions and those in need have been met by the local administrations as well.

For Turkey, the most successful example of digitization, AI and smart city application in the fight against Covid-19 is the *Contact Tracing & Isolation System* application. Contact tracing helps detect

cases, enable early diagnosis intervention, find contact persons and prevent the virus from spreading (Özlü and Öztaş 2020, 473). Turkey’s contact tracing uses digital platforms and algorithms to monitor infected individuals (Memikoğlu and Genç 2020). Health Minister Dr. Fahrettin Koca made a statement about contact tracing in his press release right after the Covid-19 Scientific Committee Meeting on April 14, 2020 (Winally 2020). The fact that the decrease in the cases is ensured by contact tracing and that the diagnosed cases have reached 95.8% of the number of people with contact shows that the *Contact Tracing & Isolation System* has been successfully implemented. Thanks to its strategic decisions, well-planned applications, and early measures in all areas, Turkey has been observed to follow a successful strategy in fighting the pandemic.

Country	First case	AI Applications	Smart City Applications
China	<i>December 31, 2019</i>	-Early Diagnosis Kit -Blockchain -5G Technology -Online Tracking -Smart Applications -Intelligent Image Reading System -Face Recognition Technology	-Closed Circuit Camera System -5G Patrol Robots -Intelligent Voice Recognition System -Health Code -Drone Technology -Disinfection Robots -Distance Education
USA	<i>January 23, 2020</i>	-Early Diagnostic Kit -Online Tracking -Smart Sound Detector -Smart Applications -DeepMind -CORD-19 -Covid-19 High Performance Computing Consortium	-Online Risk Map -Covid-19 Roadmap -Drone Technology -Social Distance Scoreboard -Covid-19: Local Action Tracker -Safe Roads Application -Distance Education
France	<i>January 24, 2020</i>	-Early Diagnosis Kit	-Drone Technology

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		-Online Tracking -Smart Applications	-Distance Education
Italy	<i>January 31, 2020</i>	-Early Diagnosis Kit -Online Tracking -Smart Applications	-Thermal Camera -The Impact of Covid- 19
Turkey	<i>March 11, 2020</i>	-Early Diagnosis Kit -Online Tracking -Smart Applications -Online Covid-19 Screening and Control -Coronavirus Information Assistant -Artwise System -Film Management	-Thermal Camera -Health Code -Contact Tracing Isolation System -Drone Technology -Disinfection Devices -Coronavirus Map of Turkey -MESS Safe Application -Apsiyon Residence Management Software -Distance Education

AI and Smart City Applications Used by Countries to Combat Covid-19
(Source: Bilgiç Kavas and Peker 2020)

China is the country where AI and smart city applications are used the most. Although the USA has used advanced technologies, its delayed intervention and poorly planned policies caused the crisis to grow exponentially, resulting in concerns and heated debates about the future of the country. The delay of France and Italy in taking measures against Covid-19 has resulted in increasing the number of cases and the gravity of the situation. Turkey had its first Covid-19 case later than other countries but had taken a higher number of measures before this first case was detected. The Covid-19 pandemic has clearly shown to all those countries applying technology correctly, well-equipped with the necessary knowledge, and using AI effectively will survive in the future global competition.

CONCLUSION

The rapid transmission of Covid-19 has caused various problems in the field of health. All these challenges have forced countries to benefit

from advanced technologies and AI in detecting, treating, and controlling the transmission of the virus.

In addition to using 5G technology and AI technologies, China has also made use of various smart city apps. Thanks to 5G patrol robots, contactless life has been achieved in smart cities and the possible risks of the virus have been kept to a minimum. Online tracking application was the first smart city application used in China, the US, France, Italy, and Turkey. Thanks to smart applications, positive cases and their contacts were identified in a very short time. The use of thermal cameras has been an application that countries generally prefer to use at their airports. The pandemic has once again demonstrated the importance of technology, digitalization, and AI in every field.

Turkey is strongly suggested to allocate more budget for AI and smart city applications. When faced with a pandemic, the Presidential Office of Digital Transformation as well as the Ministry of Health have some key tasks to perform. The Presidential Office of Digital Transformation should play an active role in the development, maturation, and dissemination of the components of AI, smart energy, smart transportation, smart housing, smart security, and smart structures. The Presidential Office of Digital Transformation should integrate 5G technology into all cities. Smart city applications should be increased in metropolitan cities. Closed circuit camera systems and smart voice recognition systems should be used, especially in smart cities. To protect the city health and prevent the city administration from encountering unexpected problems, the responsibility of local governments in the case of a pandemic should be re-determined. Cities should turn to smart city applications in combating the pandemic. The role and responsibility of local governments in the disinfection of important parts of the city, cleaning the big city squares, the neighborhood entrance and exit measures, meeting the needs of the elderly and the needy, limiting collective activities, and raising/using donations and aids should be increased. Considering the budget problem, the collaborative projects in which municipal unions and municipalities work together should be determined. While determining the services to be provided by the municipal unions in the future, smart city applications should be given priority. To solve the budget problem and provide smart applications to the city, aid and donations from the income of the union should be used for a certain period of time in combating the pandemic. Future studies may focus on intelligent

urbanization, artificial intelligence, data-based policy creation, crisis management analyses, and pandemic modeling.

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