Application of Artificial Intelligence for future sustainable smart city

Department of Informatics

Master’s Programme in Information Systems
Course:INFN25: IT, Innovation and Sustainability

Name: Sarmistha Dutta

Social Number: 89-06-26

Word Count: 2311

Date: 28October 2022

Abstract
Cities' population densities have been growing faster in recent years. In 2014, 3.3 billion people (54%) of the world's population lived in cities, according to the United Nations Population Fund. Around 5 billion people (68%) will live in cities by 2050. Smart and intelligent cities are essential for improving the quality of urban life and reducing costs.It is mostly performed through the use of computational intelligence-based technologies for intelligent decision-making. The paper discusses how artificial intelligence (AI) is being utilized in smart cities to manage resources efficiently, including renewable energy, transportation, waste management, agriculture, healthcare and the management of natural resources. In order to minimize costs, reduce carbon emissions and increase performance, natural resources need to be managed intelligently.

Introduction:
A city is defined as a densely inhabited place. It is a permanent and heavily populated region with clearly defined boundaries, and the majority of its residents work in non-agricultural jobs (Goodall, 1998). The density of human developments such as residences, commercial buildings, roadways, bridges, and railways is great in urban areas, indicating that the area is highly developed. The United Nations Department of Economic and Social Affairs estimates that metropolitan areas house 55% of the world's population, with that percentage expected to rise to 68% by 2050. There were around 512 metropolitan areas with a population of one million people in 2016 and approximately 31 megacities with a population of more than 10 million. It is projected that by 2030 there will be 662 city areas and 41 megacities, the majority of which are in emerging countries (Herath and Mittal, 2022). Cities will face significant challenges due to this rate of urbanization, including environmental pollution, healthcare issues, energy shortages, and security concerns. Major urban areas in the country will then adopt smart cities as the standard. As cities strive to achieve long-term socioeconomic goals and prospects, they make use of various technologies and support advancements. Numerous studies reveal that smart-city projects are being implemented around the world across a diverse range of geographies (Cowley, Joss, Dayot, 2017).

Based on a scientometric analysis conducted by Ingwersen & Serrano-López (2018), artificial intelligence has been employed in smart city research since 2008. Additionally, it has been connected to global sustainable development, particularly by underdeveloped countries (Adunadepo & Sunday, 2016), which use AI to advance the UN's Sustainable Development Goals (SDG). The use of artificial intelligence to allow smart city solutions provides a number of advantages, including improved water supply, energy management, waste management, and reduced traffic congestion, noise, and pollution. The majority of smart city activities and technologies have focused on gathering data and learning more about a city's complexity and dynamics (Herath and Mittal, 2022). AI elevates cities to the next level by allowing them to use data and knowledge to make better decisions. By 2025, AI will enable more than 30% of smart city applications, including urban transportation solutions, significantly increasing the resilience, sustainability, social welfare, and vitality of urban life (Cugurullo, 2020).

1. Smart city:
By embracing advanced Information and Communication Technologies (ICTs), Smart Cities are expected to provide better solutions for the intensified socioeconomic and environmental challenges associated

with unprecedented urbanization, where challenges such as climate change, energy crisis, or social inequality could all find their way out through the development and application of cutting-edge technologies (Zhu, Shen and Ren, 2022). "A smart city is a city that uses information and communication technology (ICT) to improve the quality and performance of urban services such as energy, transportation, and utilities, reducing resource consumption, waste, and total costs." The overarching goal of a smart city is to improve the quality of life for its residents by utilizing smart technologies (Techopedia, n.d.).

2. AI in the Smart City Context:

There was a culture of innovation flourishing during the second and fourth industrial revolutions that fostered many technological breakthroughs (Yigitcanlar, Mehmood and Corchado, 2021). In artificial intelligence (AI), for instance, algorithms replicate the cognitive functions of the human brain so that judgments can be made independently (Kirwan and Zhiyong, 2020). Today, AI is unquestionably a hot, disruptive technology with innumerable applications and even more prospects in every industry sector and aspect of life—from health to agriculture, engineering to finance, gaming to transportation, and so on (Cugurullo, 2020). Aside from that, AI is a key driver of the worldwide smart city movement (Singh et al., 2020). Smart cities are usually regarded as areas in which digital technology and data are widely used to achieve efficiency for economic growth, quality of life, and sustainability (Mora, Deakin and Reid, 2019). Among urban policymakers and planners seeking technocentric solutions to serious urbanization concerns, artificial intelligence (AI) has become a hot topic in many debates and discussions surrounding smart city transformation(Kassens-Noor and Hintze, 2020). Technocentric solutions are becoming increasingly popular due to their potential panacea for urbanization concerns ranging from quality of life to climate change, safety and security to mobility and accessibility (Yigitcanlar et al., 2020).

The successful use of big data, AI-powered smart city technologies, and platforms is expected to boost urban infrastructure and service efficiency, addressing or at least greatly alleviating these difficulties (Corchado et al., 2021). According to Wang and Cao(2021), The development of smart sensors has led to the collection of huge volumes of data-e.g., big data-and its dissemination to a number of commercial and public channels. Due to recent breakthroughs in AI approaches and ubiquitous computing, these data are now integrated into services that enhance quality of life, municipal operations, and the environment.

. AI offers a variety of applications in the setting of cities, with the goal of increasing efficiency in urban infrastructure and services (Ortega-Fernández et al., 2020). AI advancements in recent years have resulted in invaluable opportunities for cities to increase their infrastructural efficiencies and predictive analytic capabilities, and thus, to a degree, to improve the quality of life and sustainability in cities under the smart city brand (Batty, 2018).

2.1 AI and Renewable Energy(RE)

Renewable energy (RE) has the potential to be a long-term energy solution for the planet. Due to traditional resource depletion, increasing pollution, and climate change, the potential of RE cannot be squandered. As the trend toward renewable energy growth continues, high power and process quality are required in the generating, transmission, and distribution networks (Klaina et al., 2020). Because RE is available in remote areas instead of typical fossil fuel sources, this creates a hard development and expansion of technology with increased control and technical efficiency (Sobri, Koohi-Kamali and Rahim, 2018). Additionally, renewable energy sources fluctuate, so it is necessary to adopt technologies that allow energy to be produced, stored, and used when conditions are favorable and when conditions are not favorable, as well as accurate data prediction in order to minimize waste and error. Intermittent generation of electricity can be a challenge for renewable energy grids. It is possible for us to return to the status of backup fossil fuels if not adequately handled.(Piuri et al., 2022).

Artificial intelligence is being calculated to allow for perception, reasoning, and action to be perceived and defined according to its aims. According to experts, artificial intelligence could make recommendations, decisions and predictions about a plan of action established by humans and influence the real or virtual environment (Das et al., 2018). To maximize the return on investment in renewable energy and the power consumption of the grid's production components, the grid's complexity should be looked into by Artificial Intelligence in combination with climate prediction, with automated Algorithms, to estimate the power consumed by all of the grid's production components. The cost of mass production of renewable energy is low even when the initial investment is significant.

2.2 AI and Transportation

AI has been utilized to reinvent public transportation for usage in smart cities. This technology enables users of public transportation to obtain and acquire real-time updates and tracking, improving timing and customer experience. Automated buses are also being considered for usage within cities, with the potential to cut emissions, improve routes, and enhance frequency (Berry, 2021).

A smart transportation system (ITS) is a combination of sensors, actuators, control systems, and Information and Communication Technologies (ICTs). In the modern smart city, it creates large amounts of data and has a major impact on transportation in the future. ML, AI, and DRL approaches are necessary for successfully monitoring and estimating real-time data related to road traffic flow in an urban setting, which is a critical component of a future of smart transportation systems(Herath and Mittal, 2022).

2.2.1 Smart Public Transportation System

Applications for the development of smart public transportation systems include en-route public transit information, automatic vehicle location, smart travel security, and smart revenue management, which enable transit vehicles to report their current location, allowing traffic operations and revenue management to construct a real-time view (Agarwal, Pradeep Kumar, et al.).

2.2.2 Traffic Management and Control System

For the development of intelligent traffic management and control systems, artificial intelligence systems encompass diverse applications in traffic control, traffic demand management, emission testing and mitigation, electronic payment management, and incident management (Agarwal, Pradeep Kumar, et al.).

2.2.3 Smart Traffic Information System

For the creation of a smart traffic information system, an artificial intelligence system contains multiple applications in pre-trip travel information, en route travel information, route guiding, and archived data functions (Agarwal, Pradeep Kumar, et al.).

2.2.4 Safety Management and Emergency System

The patterns of traffic accidents It has been widely reported that having the safest vehicle and road technology is not enough to provide safe mobility; the city structure, mode share split, and exposure of motorists and pedestrians also play an important part in providing safe mobility. In smart cities, artificial intelligence plays an essential role in minimizing traffic accidents and increasing safe mobility (Agarwal, Pradeep Kumar, et al.).

2.2.5 Development of Smart Parking Management

Smart parking management systems offer tailored solutions to parking issues. Artificial intelligence is a well-known technique for the creation of smart parking management systems in smart cities (Agarwal, Pradeep Kumar, et al.).

2.3 AI and Waste Management

A variety of methods based on artificial intelligence have been developed and effectively implemented to make cleaning operations more efficient (Jude et al., 2021). The integration of "smart cities" is the overriding goal of both the developed and developing worlds. Waste management in every city may be easily arranged by integrating IoT and data access networks, combinatorial optimization, and employing electronic engineering, geographical information systems (GIS) (Caló, A., & Pongrácz, E., 2011). The built-in IoT can detect waste and communicate it to servers via the Internet.

The usage of detectors is required if the waste economic is to be delivered to servers that are stored and utilized on a regular basis to monitor and start a removal operation

(Ye et al., 2015). This implies that the basket is removed before it fills up, avoiding the unnecessary waste collection that occurs when the baskets are not flld. Open data is defined as the forerunner of huge data analysis reinforced by cyber networks (Akojwar, Kshirsagar and Pai, n.d.).

The system is purely based on waste levels detected by the trash can's inbuilt sensors. The volume data is transmitted to the servers over the internet. Data collected is then utilized to modify and drive cleaning activities in the municipality (Kshirsagar & Akojwar, 2016). The cleaning crew creates new paths for this autonomous process every day, visits the garbage bin and clears it based on its demands, and ensures that no waste is left unattended. The end result is a healthier, more labor-intensive firm (Mirchandani et al., 2017).

2.4 AI and Natural resources

Natural resource management is a discipline that focuses on the management of natural resources such as land, water, soil, plants, and animals, with an emphasis on how management affects the quality of life for both current and future generations. Natural resource management focuses on a scientific and technological understanding of resources and ecology, as well as the potential of those resources to support life. Natural resource management has three computational challenges: data management and communication, data analysis, and optimization and control. Because AI techniques offer the flexibility to tackle the inherent dynamic of natural resources, computational solutions to solve the three difficulties of natural resource management could be developed (Adamatti and Aguiar, 2012).

Information systems (GIS) for interactive computational steering, high-performance computing for integrated system modeling, and globally distributed grid computing technologies are becoming increasingly important in modern resource management (Adamatti and Aguiar, 2012).

2.5 AI in smart agriculture

In terms of social, economic, and environmental sustainability, smart agriculture is transforming the agricultural business. Some academics have looked into combining digital technology with agriculture and artificial intelligence (AI) to create smart, long-term agricultural systems. Ciruela-Lorenzo and his team offered a full review of the growth of smart digital technologies such as robotics, IoT, Big Data, AI, and Blockchain in agriculture in (Ciruela-Lorenzo et al., 2020). The researchers examined existing

IoT/AI technologies utilized for smart, sustainable agriculture (SSA) and then identified IoT/AI technical architecture that can assist the creation of SSA platforms (Alreshidi, 2019).

2.6 AI in smart healthcare

Many traditional towns are seeking to emulate the concept of smart city healthcare by integrating traditional technology and equipment with AI-integrated solutions. Because smart health is linked to the smart city's ICT infrastructure, it might be considered a subset of e-health. AI-enabled IoT has greatly helped healthcare systems.

AI in healthcare must provide patients and physicians with real-time, actionable, and personalized information to help them make treatment decisions. Predictive analysis employing machine learning-based telemedicine services helps hospitals or medical institutions follow and discharge patients more promptly, especially in emergency situations. 2022 (Herath and Mittal).

Conclusion

Cities have changed considerably as a result of the development and application of several concepts such as resilient cities, sustainable cities, and inclusive cities, to mention a few. With a primary focus on urban sustainability and liveability, a new Smart City framework was introduced that supports using Big Data and Artificial Intelligence. AI adoption in smart city sectors like healthcare, education, environment and waste management, mobility and smart transportation, agriculture, risk management, and security. It is argued that introducing AI into smart cities can assist cities by automating activities, eliminating human error, making effective data-driven decisions, enhancing the environment via various systems, implementing new commercial opportunities, and automating efficient urban management. On the other hand, they also pose regulatory challenges, such as discrimination in service delivery, privacy, legal and ethical considerations. Furthermore, data availability, lack of qualified professionals, cost and duration of AI initiatives, and a high unemployment rate have all been recognized as risks and barriers to AI implementation in smart cities.

References

1. Adamatti, D.F. and Aguiar, M.S. de (2012). *Artificial Intelligence Applied to Natural Resources Management*. [online] Machine Learning: Concepts, Methodologies, Tools and Applications. Available at: https://www.igi-global.com/chapter/artificial-intelligence-applied-natural-resources/56214?camid=4v1 [Accessed 26 Oct. 2022]

2. Adunadepo, A. M. D., & Sunday, O. (2016, February). Artificial intelligence for sustainable development of intelligent buildings. In *Proceedings of the 9th CIDB Postgraduate Conference, Cape Town, South Africa* (pp. 1-4).

3. Agarwal, Pradeep Kumar, et al. "Application of artificial intelligence for development of intelligent transport system in smart cities." *Journal of Traffic and Transportation Engineering* 1.1 (2015): 20-30.

4. Akojwar, G., Kshirsagar, P. and Pai, V. (n.d.). *Feature Extraction of EEG Signals using Wavelet and Principal Component analysis*. [online] *Computer Science & Information Technology*. Available at: http://www.ijoar.org/Conference_Paper/Feature-Extraction-of-EEG-Signals-using-Wavelet-and-Principal-Component-analysis.pdf [Accessed 26 Oct. 2022]

5. Alreshidi, E. (2019). Smart Sustainable Agriculture (SSA) Solution Underpinned by Internet of Things (IoT) and Artificial Intelligence (AI). *International Journal of Advanced Computer Science and Applications*, 10(5). doi:10.14569/ijacsa.2019.0100513.

6.Berry, I. (2021). 10 ways AI can be used in Smart Cities. [online] aimagazine.com. Available at: https://aimagazine.com/top10/10-ways-ai-can-be-used-smart-cities'

7.Batty, M. (2018). Artificial intelligence and smart cities. *Environment and Planning B: Urban Analytics and City Science*, 45(1), pp.3–6. doi:10.1177/2399808317751169.
25. Caló, A., & Pongrácz, E. (2011). Assessing the potential for smart energy grids in the Northern Periphery. *Master's*.

8. Ciruela-Lorenzo, A.M., Del-Aguila-Obra, A.R., Padilla-Meléndez, A. and Plaza-Angulo, J.J. (2020). Digitalization of Agri-Cooperatives in the Smart Agriculture Context. Proposal of a Digital Diagnosis Tool. *Sustainability*, 12(4), p.1325. doi:10.3390/su12041325.

9. Corchado, J.M., Chamoso, P., Hernández, G., Gutierrez, A.S.R., Camacho, A.R., González-Briones, A., Pinto-Santos, F., Goyenechea, E., Garcia-Retuerta, D., Alonso-Miguel, M., Hernandez, B.B., Villaverde, D.V., Sanchez-Verdejo, M., Plaza-Martínez, P., López-Pérez, M., Manzano-García, S., Alonso, R.S., Casado-Vara, R., Tejedor, J.P. and Prieta, F. de la (2021). Deepint.net: A Rapid Deployment Platform for Smart Territories. *Sensors*, 21(1), p.236. doi:10.3390/s21010236.

10. Cugurullo, F. (2020) "Urban Artificial Intelligence: From automation to autonomy in the smart city," *Frontiers in Sustainable Cities*, 2. Available at: https://doi.org/10.3389/frsc.2020.00038.

11.Cowley, R., Joss, S. and Dayot, Y. (2017). The smart city and its publics: insights from across six UK cities. *Urban Research & Practice*, 11(1), pp.53–77. doi:10.1080/17535069.2017.1293150.

12. Cugurullo, F. (2020). Urban Artificial Intelligence: From Automation to Autonomy in the Smart City. *Frontiers in Sustainable Cities*, 2. doi:10.3389/frsc.2020.00038.

13.Das, U.K., Tey, K.S., Seyedmahmoudian, M., Mekhilef, S., Idris, M.Y.I., Van Deventer, W., Horan, B. and Stojcevski, A. (2018). Forecasting of photovoltaic power generation and model optimization: A review. *Renewable and Sustainable Energy Reviews*, [online] 81(P1), pp.912–928. Available at: https://ideas.repec.org/a/eee/rensus/v81y2018ip1p912-928.html [Accessed 24 Oct. 2022].

141. Goodall, B. (1998). *Penguin dictionary of human geography*. London: Penguin.

15. Herath, H.M.K.K.M.B. and Mittal, M. (2022). Adoption of artificial intelligence in smart cities: A comprehensive review. *International Journal of Information Management Data Insights*, 2(1), p.100076. doi:10.1016/j.jjimei.2022.100076.

16. Ingwersen, P. and Serrano-López, A.E. (2018). Smart city research 1990–2016. *Scientometrics*, 117(2), pp.1205–1236. doi:10.1007/s11192-018-2901-9.

17. Jude, A.B., Singh, D., Islam, S., Jameel, M., Srivastava, S., Prabha, B. and Kshirsagar, P.R. (2021). An Artificial Intelligence Based Predictive Approach for Smart Waste Management. *Wireless Personal Communications*. doi:10.1007/s11277-021-08803-7.

18. Kassens-Noor, E. and Hintze, A. (2020). Cities of the Future? The Potential Impact of Artificial Intelligence. *AI*, 1(2), pp.192–197. doi:10.3390/ai1020012.

19.Kirwan, C.G. and Zhiyong, F. (2020). *Smart Cities and Artificial Intelligence: Convergent Systems for Planning, Design, and Operations*. [online] *Google Books*. Elsevier. Available at: https://books.google.se/books?hl=sv&lr=&id=QDDgDwAAQBAJ&oi=fnd&pg=PP1&dq=Kirwan [Accessed 23 Oct. 2022].

20.Klaina, H., Guembe, I.P., Lopez-Iturri, P., Astrain, J.J., Azpilicueta, L., Aghzout, O., Alejos, A.V. and Falcone, F. (2020). Aggregator to Electric Vehicle LoRaWAN Based Communication Analysis in Vehicle-to-Grid Systems in Smart Cities. *IEEE Access*, [online] 8, pp.124688–124701. doi:10.1109/ACCESS.2020.3007597.

21.Kshirsagar, P. and Akojwar, S. (2016) "Hybrid heuristic optimization for benchmark datasets," *International Journal of Computer Applications*, 146(7), pp. 11–16. Available at: https://doi.org/10.5120/ijca2016910853.

22.Lee, M.; Yun, J.; Pyka, A.; Won, D.; Kodama, F.; Schiuma, G.; Park, H.; Jeon, J.; Park, K.; Jung, K.; et al. How to respond to the fourth industrial revolution, or the second information technology revolution? Dynamic new combinations between technology, market, and society through open innovation. J. Open Innov. Technol. Mark. Complex. 2018, 4, 21. [CrossRef]

23. Mirchandani, S., Wadhwa, S., Wadhwa, P. and Joseph, R. (2017). IoT enabled dustbins. *2017 International Conference on Big Data, IoT and Data Science (BID)*. [online] doi:10.1109/bid.2017.8336576.

24.Mora, L., Deakin, M. and Reid, A. (2019). Strategic principles for smart city development: A multiple case study analysis of European best practices. *Technological Forecasting and Social Change*, [online] 142, pp.70–97. doi:10.1016/j.techfore.2018.07.035.

25.Morrar, R., Arman, H. and Mousa, S. (1970) *The Fourth Industrial Revolution (Industry 4.0): A Social Innovation Perspective*, *Technology Innovation Management Review*. Available at: https://timreview.ca/article/1117 (Accessed: October 23, 2022).

26. Ortega-Fernández, A., Martín-Rojas, R. and García-Morales, V.J. (2020). Artificial Intelligence in the Urban Environment: Smart Cities as Models for Developing Innovation and Sustainability. *Sustainability*, 12(19), p.7860. doi:10.3390/su12197860.

27. Piuri, V., Rabindra Nath Shaw, Ghosh, A. and Islam, R. (2022). *AI and IoT for Smart City Applications*. Springer Nature.

28.Singh, S., Sharma, P.K., Yoon, B., Shojafar, M., Cho, G.H. and Ra, I.-H. (2020). Convergence of Blockchain and Artificial Intelligence in IoT Network for the Sustainable Smart City. *Sustainable Cities and Society*, 63, p.102364. doi:10.1016/j.scs.2020.102364.

29.Sobri, S., Koohi-Kamali, S. and Rahim, N.Abd. (2018). Solar photovoltaic generation forecasting methods: A review. *Energy Conversion and Management*, [online] 156, pp.459–497. doi:10.1016/j.enconman.2017.11.019.

30.Techopedia.com. (n.d.). *What is a Smart City? - Definition from Techopedia*. [online] Available at: https://www.techopedia.com/definition/31494/smart-city#:~:text=Explains%20Smart%20City- [Accessed 20 Oct. 2022].

31. Wang, S. and Cao, J. (2021) "Ai and Deep Learning for Urban Computing," *Urban Informatics*, pp. 815–844. Available at: https://doi.org/10.1007/978-981-15-8983-6_43.

32. Ye, L., Cao, Z., Xiao, Y. and Li, W. (2015). *Ground-based cloud image categorization using deep convolutional visual features*. [online] IEEE Xplore. doi:10.1109/ICIP.2015.7351720.

33.Yigitcanlar, T., Mehmood, R. and Corchado, J.M. (2021). Green Artificial Intelligence: Towards an Efficient, Sustainable and Equitable Technology for Smart Cities and Futures. *Sustainability*, 13(16).

34.Yigitcanlar, T., Kankanamge, N., Regona, M., Ruiz Maldonado, A., Rowan, B., Ryu, A., Desouza, K.C., Corchado, J.M., Mehmood, R. and Li, R.Y.M. (2020). Artificial Intelligence Technologies and Related Urban Planning and Development Concepts: How Are They Perceived and Utilized in Australia? *Journal of Open Innovation: Technology, Market, and Complexity*, [online] 6(4), p.187. doi:10.3390/joitmc6040187.

35. Yu, Y.; Zhang, N. Does smart city policy improve energy efficiency? Evidence from a quasi-natural experiment in China. J. Clean. Prod. 2019, 229, 501–512.

36.Zhu, H., Shen, L. and Ren, Y. (2022). How can smart city shape a happier life? –the mechanism for developing a Happiness Driven Smart City. *Sustainable Cities and Society*, p.103791. doi:10.1016/j.scs.2022.103791.p.8952. doi:10.3390/su13168952.