Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Future Trends of AI-Based Modelling in the Context of Smart Devices and Smart Systems

Dr. F. Jerald[1], Murugaanandam S[2], Senthil Kumar Thillaigovindan[3], P Prasanna[4], M.Vimala[5]

[1]Associate Professor, Department of ECE, Dr.MGR. Educational and Research Institute, Tamilnadu. francisjeral@gmail.com
[2]Associate Professors, Department of Networking and Communications, SOC, SRMIST, Kattankullathur 603203. murugaas@srmist.edu.in
[3]Associate Professor, Department of Computing Technologies, SRM Institute of Science and Technology, Kattankulathur, Tamilnadu, India. senthilt2@srmist.edu.in
[4]Assistant Professor, Computer Science and Engineering, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology. prasannap@veltech.edu.in
[5]Department of EEE, Assistant Professor R.M.K. Engineering College, RSM Nagar, Kavaraipettai- 601206. mva.eee@rmkec.ac.in

Smart systems and services are designed to support a variety of goals, including modern living, integrated societies, gig economic growth, knowledge-based workforces, manufacturing automation, expanding urban populations, and virtually real social behaviors. Smart services and systems must have a sophisticated feature set, including security, control, scaling, flexibility, intelligent behavior, and personalization, to meet these goals. Therefore, the secret to creating automated, intelligent, and smart systems that meet today's demands is modeling based on AI. Different forms of AI, including logical, working, dynamic, written, and graphical AI, can be used to improve an application's intelligence and capabilities to solve problems in the real world. However, because real-world issues and information are dynamic and varied, creating an efficient AI model is a difficult undertaking. In this work, we provide a thorough understanding of "AI-based Modelling," including the fundamentals and potential applications of AI techniques that can be crucial to the development of intelligent systems in a wide range of real-world application domains, such as security, smart cities, finance, business, medical care, and farming. We regard this effort as a first step towards drawing the interest of numerous academics to a new field of application, where wireless devices can improve the quality of life for a large number of people living in smart cities.

Keywords: Smart Systems and Services; Artificial intelligence (AI); Data science; Automation.

1. Introduction

Cities throughout the world are adopting smart services, and we are seeing this growth and development very quickly. Systems based on AI are crucial to smart cities because they enable the analysis of sensor data to enable effective decision-making. Intelligent AI systems for healthcare can efficiently monitor a patient's condition and recognize signs that help in the early diagnosis of illnesses [1]. AI is used in CCTV-based picture identification systems and speech recognition to identify and authenticate users with the least amount of human-machine interaction. AI is being used by many businesses and apps to create safe and effective smart services. The widespread use of AI-based solutions presents several possibilities and difficulties for resolving various smart system implementations. Speech signal processing issues with music noise and sorting, accurate identification of people in changing backgrounds and lighting, enhancing ultrasonography Doppler blood flow spectral images for disease detection, and reliable shape recognition and categorization for effortless plant understanding systems all require solutions.

The quality of life, health, efficiency, energy efficiency, and safety may all be impacted by the deployment of smart technology in a house, building, or environment. These technologies include actuators, sensors, and AI. Improving the quality of the constructed environment, which includes homes, buildings, transportation, construction, and cities, is gaining popularity under the term "smart." In addition to improving user quality of life, AI can analyze user behavior through building automation processes and smart home assistive technology. The system can anticipate user needs and maximize the use of resources, including energy, with the use of behavioral analysis. Smart technology enables users to turn gadgets on and off at an elementary level. Researchers in a range of fields, including architecture and healthcare, use an array of actuators and sensors for a wide range of applications.

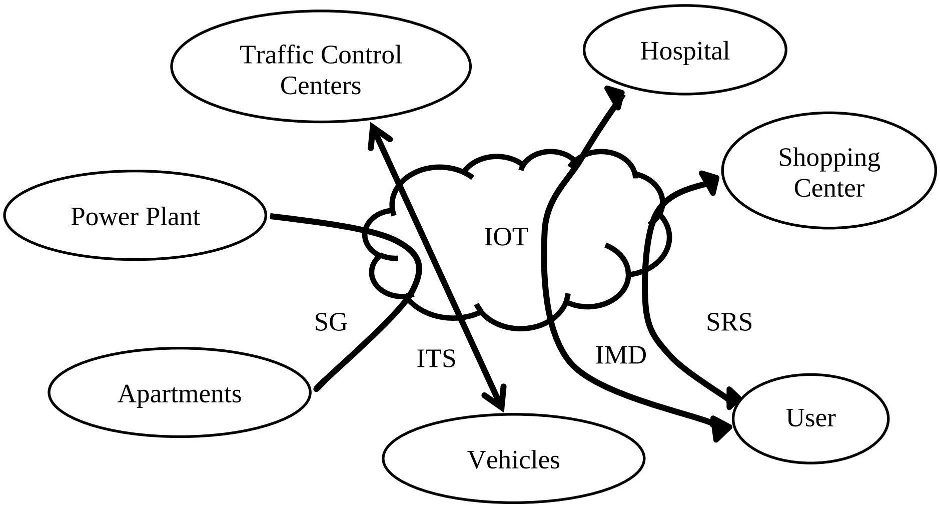

Fig. 1.1. Smart city examples

Many smart devices are now connected to the Internet, and IoT technologies are enabling a range of applications in the SC that go beyond the SH [2]. Certain virtual items (such as object real estate, device information, and human traits) are also incorporated in SCs in addition to actual devices. The Smart Grid (SG), Intelligent Transportation System (ITS), Intelligent Medical Diagnosis (IMD), Shopping Recommender System (SRS), and other scenarios are examples of what could make up the SC, as illustrated in Figure 1.1. To put it another way, the SG can minimise overall energy use by optimising the power supply.

However, to use the same system, it is necessary to combine various practices and learn from them. Additionally, to manage energy simultaneously, it is necessary to analyze the data gathered from the devices. Integrating algorithms and optimizing sources is one potential approach that might help with the creation of a home automation energy management system (EMS) [3]. Smart technology has been developing quickly lately, and academics and industry professionals are looking into and proposing more uses for it. The IoT is being used more and more to construct a network of objects ranging from actuators and sensors to smartphones and tablets. The number of linked devices is expected to expand rapidly to 25–50 billion by 2020, primarily due to wireless connectivity.

The structure of the paper is as follows: Section 2 presents the assignment problem, reviews pertinent research that serves as a baseline for AI-Based Modelling -based techniques, and offers an example of how to transform the problem into an utilizing problem that can be solved with Smart Devices and Smart Systems. Regarding the possibility of success, a variety of performance results are shown in Sections 3 and 4. A final analysis of the work is provided in Section 5, along with some suggestions for more research.

2. Literature Review

The number of gadgets linked to the internet is expected to increase by 2025 since it is predicted that internet nodes may exist in every single thing. By 2030, 500 billion gadgets will be online, predicts Cisco [4]. In a similar vein, Telefonica forecast in 2013 that by 2020, 90% of cars will have internet connections. Nonetheless, a 2015 analysis projects that by 2020, there will be over 250 million linked cars worldwide—a 67% rise. One of the newest developments of the last century is IoT. Additionally, it was predicted in 2011 that it would take five to ten years for the market to adopt IoT, according to Gartner's IT Hype cycle. Therefore, the International Data Corporation projects that by 2020, US $1.7 trillion will be spent on IoT.

There is a growing trend towards intelligent solutions for the management and functioning of the many separate parts that make up an urban energy system [5]. These strategies, which are frequently motivated by the need to lower energy use, emissions, or costs while preserving robustness to uncertainty, aim to make use of the major facilitators of more computing power and data accessibility as AI, machine learning, and sophisticated control techniques. These strategies are frequently taken into consideration in isolation and do not necessarily need to be limited to activities connected to "Smart Cities." Nevertheless, the use of intelligent computation in the problem of smart cities must take into account the fusion, change, and melding of these diverse solutions due to the overlapping aims, difficulties, and enablers.

AI is a vast field that is receiving a lot of interest from various institutions and nations. Chinese researchers have developed diverse artificial intelligence models for detecting and predicting to estimate petroleum use. These models offer qualities about oil consumption from a variety of perspectives [6]. To analyze the rainfall in India during the summer and autumn seasons, several artificial intelligence algorithms are used and evaluated. Information, concealed layers, and techniques all have a direct impact on prediction accuracy. An effective pre-processing approach that can yield more accurate predictions is the wavelet transform, as demonstrated by experience. When it comes to predicting the stand parameters of Turkey's forests, artificial neural networks linked with image recognition perform better than regression.

Understanding AI's impact is difficult, even though it is frequently considered as having the potential to gradually enhance CoPS [7]. Examples of this include continuously merging and analyzing multiple data sources while developing new or complementary capabilities. Generally speaking, the characteristics and actions of complicated structures are more difficult to combine than those of the basic component systems that make up Cops. When we talk of difficulty in CoPS, we're talking about a lot of unusual parts and components, which indicate how much new information is required for development and manufacturing as well as how broad the expertise and abilities needed, are.

The scope and problems for developers are increased in the case of smart systems by human participation, the variety of platforms and gadgets being used, and so on. To detect and respond appropriately in the event of malicious behavior, developers are thus focusing on the proactive gathering of intelligence about network activity through ML and embedded intelligent agents in software systems [8]. The solutions call for limited computer and energy resources found in today's pervasive handheld gadgets and smart sensors. Designers are turning to fog and edge computing to spread out operations and lower the terminal nodes' power requirements to overcome those difficulties.

Logical reasoning is used in this subject to reason on knowledge using correctly formalized rules, specifically supporting decision rules that are derived from data-driven decision models or domain experts. However, symbolic logic is not easily scaled, thus knowledge engineers must gather the logic through expert interviews or observation. Conversely, sub-symbolic methods, like supervised neural networks, scale more readily but are prone to bias in the training set—and [9], hence, their results are inexplicable. Once more, the semantic web offers a technical foundation for the systematic conceptual modeling of healthcare information in terms of courses, characteristics, relations, and axioms. This includes comprehension, conceptualization, axiomatization, and tagging.

Neural networks, which mimic the networked architecture of neurons in the human brain, are the foundation of many artificial intelligence models. These networks, which are composed of nodes, or synthetic neurons, have layers that each contribute to the extraction and alteration of data [10]. Hierarchical neural networks can describe intricate relationships in vast, complex datasets thanks to their several hidden layers. The superiority of Recurrent Neural Networks in sequence-based tasks and Convolutional Neural Networks in image recognition illustrates the diversity of AI models.

3. Methods and Materials

3.1 Architecture of AI-IoT

The network infrastructure layer, service administration layer, and supply layer make up the three levels that make up the overall AI-IoT construction, which is seen in Figure 3.1 [11].

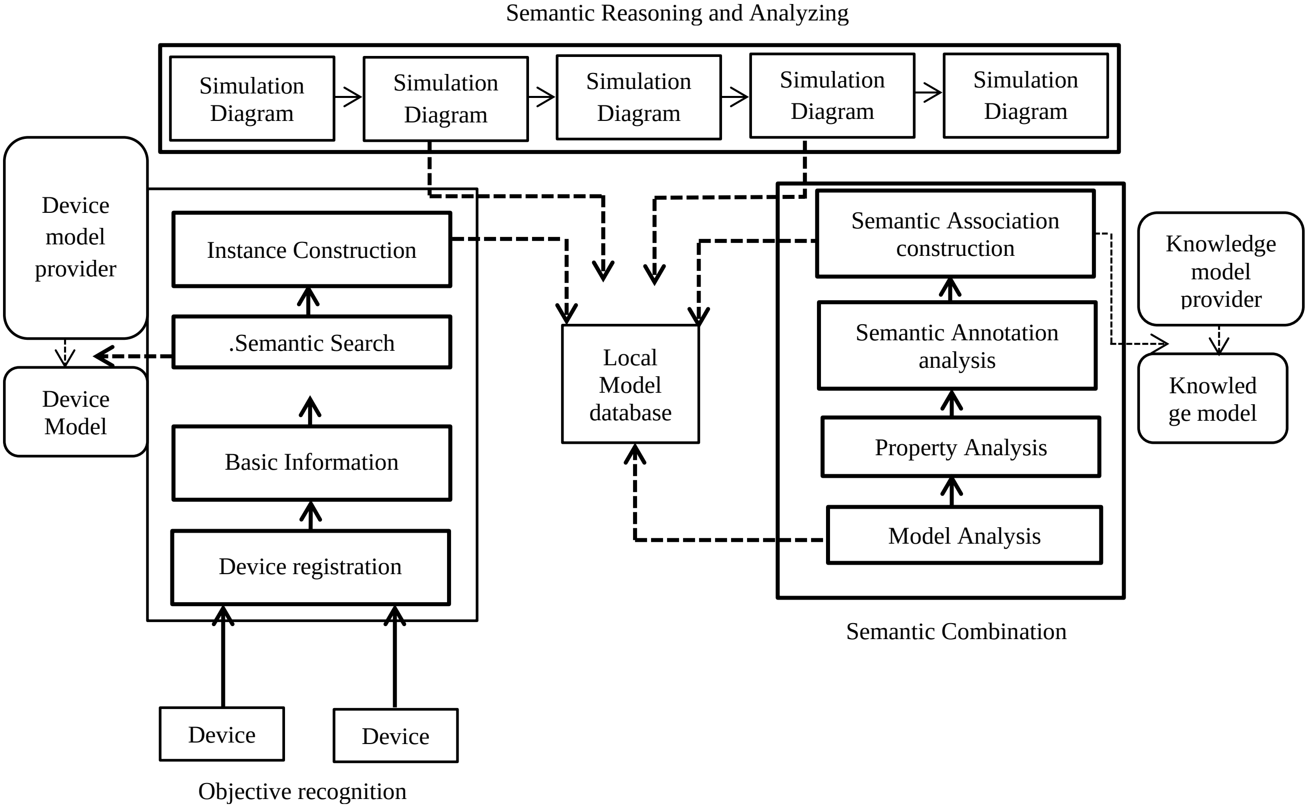

Fig.3.1. Architecture of AI-IoT

3.1.1 System Layer

Smart appliances in SHs, smart lighting systems, RFID-tagged goods, smart cars, smart surveillance systems, smart medical devices, wearable technology, smartphones, and more are all included in the infrastructural layer of the SC IoT. The IoT is built on a smart gadget that can be accessed via the Internet. The actuators, detectors, and mixed devices are the three categories into which smart devices fall. Sensors, which include light, humidity, temperature, recording devices, intelligent bands [12], RFID readers, and others, are primarily used to sense their surroundings. In a basic sensor system, an actuator responds to an instruction by acting. Mixed devices with sensing and actuation modules carry out more intricate tasks in a sophisticated sensor system. For instance, the majority of the electronics in our homes and workplaces—such as televisions, fridges, cell phones, and smartwatches—are hybrid devices. Because all smart gadgets are made with humans in mind, user interactions can generate a lot of data. To conduct additional analysis, information can also be stored and sent to the service administration level.

3.2 AI's possible impact on smart cities

AI has a revolutionary effect on smart city technology. Urban AI applications have the potential to drastically raise people's standard of existence and transform important facets of smart city design. Smart transportation, smart government, intelligent education, smart economics, intelligent healthcare, smart surroundings, and smart housing are the seven main domains that AI is said to have a positive impact on [13]. The possible impact of AI in each of these fields will be discussed in more detail in the sections that follow.

3.2.1 Smart Transportation

Smart mobility is enhancing transportation networks to make them more accessible, environmentally friendly, and efficient by utilizing innovative technologies and creative transportation solutions. This entails utilizing digital technologies to improve the ability of individuals and goods through the optimization of transit networks, including AI, IoT, robotics, and information analytics. Transportation networks can be made safer, environmentally friendly, and more effective by implementing these technologies. The relationship between AI and smart mobility is symbiotic; AI makes smart mobility solutions work better and more productively, especially in areas like traffic management, driverless cars, and predictive maintenance. For public transit systems and the movement of people and products to be improved, artificial intelligence and smart mobility must be integrated.

3.2.2 Astute Leadership

A key component of smart cities is smart governance, which attempts to revolutionize conventional governance models by utilizing cutting-edge technology to enhance services and decision-making procedures. Digital technologies like machine learning, blockchain, IoT, and data analytics can help governments make better decisions, run more efficiently, and serve their constituents more effectively. Chatbots, and digital assistants with AI capabilities are a couple of examples; they can automate repetitive chores and provide accurate and timely answers to citizen inquiries. Blockchain can improve the safety, openness, and traceability of government processes, such as supply chain management, handling identities, and election systems.

Real-time data on important urban aspects, such as garbage disposal, commute times, and pollution levels, can be obtained from IoT sensors in smart towns. The wealth of data available to governments can help them make better decisions and improve their offerings to better meet the needs of their citizens. In general, improving public engagement, increasing transparency and accountability, and improving the standard of living in metropolitan areas all depend on smart leadership.

3.2.3 Astute Instruction

To improve learning outcomes and raise educational standards, smart education incorporates cutting-edge technologies with innovative teaching strategies. Its main goal is to use technology to improve pupil achievement, raise the caliber of teachers, and design a collaborative, interesting, and productive learning environment.

A smart educational system gives educators and learners access to data-driven conclusions that assist them in better understanding how their pupils are developing and where they might need more support. Students receive personalized learning content that is catered to their unique needs and skills. To establish more dynamic and cooperative learning surroundings, smart education also entails the incorporation of many technologies and gadgets, like interactive whiteboards, pills, and educational applications.

3.2.4 Astute Economics

The idea of a smart economy in a smart city entails combining cutting-edge technologies with data-driven solutions to build a creative and sustainable economy. This can involve enhancing financial interactions through the use of digital currencies and smart payment systems, as well as streamlining business operations through the application of AI and big data analytics. Additionally, the creation of new businesses and industries focused on innovation and environmental sustainability, such as the sharing economy, circular economy, and renewable energy, can be a part of a smart city's smart economics.

Organizations can develop new goods and services that are more effective, sustainable, and customer-focused by utilizing cutting-edge technologies and data-driven solutions. This promotes economic growth and competitiveness. Furthermore, a smart economy may assist the growth of a creative ecosystem that encourages cooperation and knowledge exchange among companies and entrepreneurs, as well as innovation and job creation, by making training and funding programs accessible. All things considered, an economy based on creativity is an essential part of a smart city since it fosters entrepreneurship, innovation, and sustainable economic growth while also improving the standard of living for all residents.

3.2.5 Intelligent Medical

In a smart city, smart healthcare refers to a variety of cutting-edge tools and approaches that are intended to boost patient outcomes, expand the availability of medical care, and boost the effectiveness of medical care delivery. Mobile devices, telecommunications- AI, data mining, and the Internet of Things are some of these technologies. Regardless of location, smart healthcare enables people to receive individualized, real-time care. Wearable technology and telemedicine allow patients to get healthcare remotely, allowing medical personnel to constantly monitor their symptoms.

Large-scale patient data collection and analysis are made easier by smart healthcare, offering insightful information about treatment effectiveness and patient health patterns. Additionally, employing AI-powered chatbots and virtual assistants to book appointments, triage patients, and offer medical advice is another aspect of smart healthcare in smart cities. These tools relieve the workload of medical staff members and increase the effectiveness of healthcare delivery. From bettering patient outcomes to lowering costs and expanding access to medical care, smart healthcare solutions have huge potential to completely transform the way that healthcare is delivered in smart cities.

3.2.6 Intelligent Setting

In a smart city setting, artificial intelligence has a big impact on the smart surroundings. AI can improve sustainability, cut waste, and optimize energy use. AI systems, for instance, have the ability to monitor and control energy usage in buildings. By automatically modifying temperature and lighting in response to occupancy patterns, these algorithms may significantly reduce energy waste and increase energy efficiency. By anticipating garbage accumulation, determining the best time for waste pickup, and cutting down on transportation costs, AI can also aid in waste management. AI can be applied to ecological protection and monitoring as well. It can be used to forecast natural disasters, follow changes in plants, and check the quality of both water and air.

4. Implementation and Experimental Results

This paper aims to investigate the impact of alternative modalities of interruptible service implementation on the microgrid's operating cost, client profit, loading factor, and maximum reduction while accounting for many variables. In the hybrid electricity market, the effects of adaptability choices provided by the capacity market (CM) programmer were discussed by [14].

Table 1 compares the various DRPs according to their techniques, response type, and temporal resolution.

Table 1. Compares Various DPRs in Smart Structures

	Type of DR	**Definition**	**Time Resolution**	**Response Type**
Time-Based Rate Programs	Real-time pricing (RTP)	Before each period, electricity rates are adjusted and advertised either every day or an hour in advance.	Hourly	Consumer Side
	Time of use (TOU)	Customers frequently attempt to move the shift able loads to the off-peak interval. Under a TOU pricing structure, a day can be divided into three intervals: peak, mid-peak, and off-peak.	Hourly	Consumer Side
	Critical peak price (CPP)	CPP functions identically to the TOU programmer, with the exception of the period during which power reliability is at risk.	Hourly/Daily	Consumer Side
Incentive-Based Programs	Direct load control (DLC)	The utility may remotely cut off the electrical appliances of registered customers during periods of high demand or special occasions, under the terms of the advanced arrangement between the utility and its customers.	Hourly/Daily	Utility Side
	Demand bidding (DB)	Through the use of DB, customers can engage in active participation in the trading of power by agreeing to modify their usual consumption patterns.	Hourly/Daily	Consumer Side
	Interruptible/Curtailable (IC)	The service restricts the customers who have signed up for this programmer from using as much. For every decrease in their expenditure, they get more credit for it. Customers face severe consequences if they do not respond to the incentive.	Hourly/Daily	Consumer Side
	Capacity market (CM)	To guarantee the security of supply and encourage consistent investment in power generation, consumers who can	Hourly/Daily	Consumer Side

		deliver predetermined load drops are offered to substitute traditional production or transport resources.		
	Emergency planning (EP)	Customers receive incentive payments for lowering their power consumption during reliability-related events. Customers have the option to not limit and to forego the predetermined charges.	Hourly/Daily	Utility Side

4.1 AI-Powered Methods for Energy Management in Structures

The machine learning models that are employed in the smart structure system are contrasted in Table 2 [15]. The models' complexity, usability, and speed were all taken into account when making this comparison.

Table 2. An analysis and Utilization of Distinct AI models for Smart Structures

ML Replicas	Area of Request	Area of Application in BMS	Rewards	Difficulties
ANN	Modelling, forecasting, and curve-fitting of non-linear processes	HVAC energy consumption modelling	*High Accuracy *Reasonable speed *Good for noisy Data	*Highly complex *Low user-friendliness
SVM	Data classification	Building energy consumption prediction	*High Accuracy	*Highly complex *Low user-friendliness *Low speed
Decision Tree	Classification decision	*Energy storage planning *Building Energy Management	*Reasonable Accurate *Reduces over-fitting	*Reasonably complex *Low user-friendliness
Random Forest	Event forecasting and data classification	Energy Consumption Forecasting	*Reasonably accurate *Reduces over-fitting	*Reasonably complex *Low user-friendliness *Low speed
Deep Learning	Data prediction and pattern modelling	Energy Efficient System design and modelling	*Reasonably user-friendly *High accuracy *Reasonable speed	*Highly complex
WNN	Time series event prediction	*HRES operating Cost Optimization *Wind and Solar power	*High accuracy	Low speed Low user-friendliness Reasonably complex
Fuzzy Logic	Control applications	*Power Point tracking *Control and monitoring	Reasonably user-friendly Reasonably accurate	*Reasonably complex

			High speed	
Hybrids	High-accuracy predictions	*Load forecasting *Energy generation forecasting	*High speed *High accuracy *High speed	*Reasonably complex
Regression	Prediction of the probability of occurrence	*HVAX energy consumption forecasting	*Highly user Friendly *Simple structure *High speed	*Low accuracy
Genetic algorithm	Problem optimization	Optimal load scheduling	*High accuracy *Used in hybrid mode	*Low speed

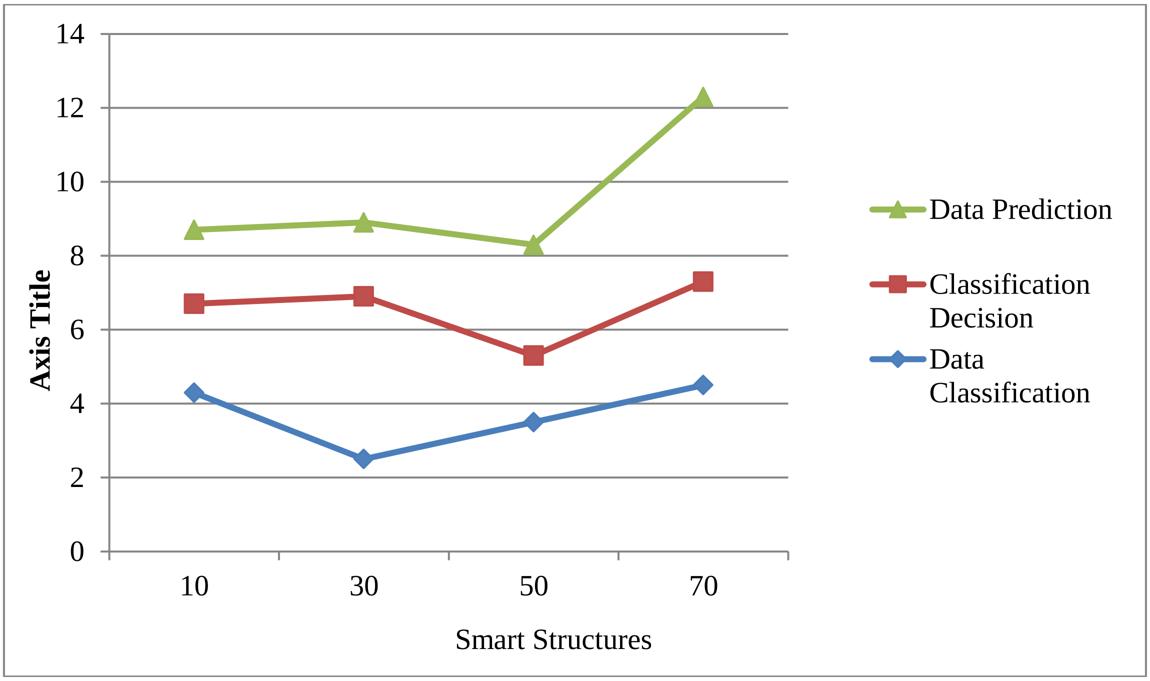

Fig. 4.1. A comparison between various AI models for smart structures

Table 3 presents the latest research in the field of AI-based methods for estimating building energy. The domains, objectives, and applied methodologies employed in every investigation were taken into account when evaluating the application of AI-based technologies in building energy systems in Figures 4.1 and 4.2.

Table 3. Using AI-based techniques in energy production systems: application

Focus of the Study	Domains					Target and Results	Method
	Energy	Comfort	Safety	Design	Maintenance		
Offering a flexible and energy-efficient decision-making system that makes use of clever sensors to preserve the user's thermal comfort.	✓	✓				*Improved thermal comfort *Lower operational costs	FL
Examining the		✓				*Improved thermal	GA

effects of employing passive cooling in residential structures when the inside temp is set too high.						comfort	
Analyzing how IoT and cyber-physical technologies are used in a massive network game intended to increase a building's energy efficiency.	✓					*Lower energy cost *Lower energy consumption	DL
Contrasting the artificial neural network's predictions		✓				*Improved air quality and other conditions for the comfort of the occupants	ANN

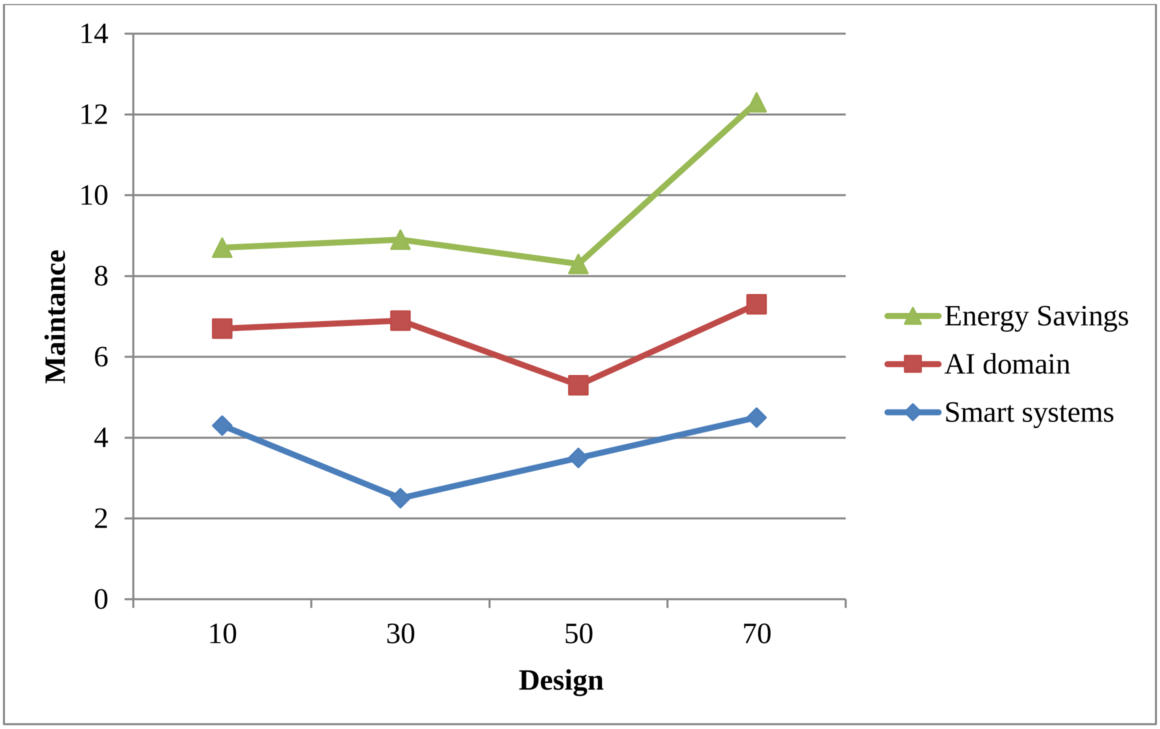

Fig. 4.2. The research's smart infrastructure services and area divisions

It makes sense to assume that unless consumers are absolutely certain that their information is secure, they will object to taking part in such massive data processing. Put differently, the AI applications must demonstrate a clear process for building both trust and admiration for the human persons whose skills are being imitated.

5. Conclusion

The investigation discussed the current issues, prospects, and fixes for AI-based smart systems and services.

AI-based prediction techniques, provided the model is well-trained, show promise forecast accuracy. Additionally, these models' data entry and acquisition processes are rather simple, making it simple to create the prediction model. AI-based techniques for energy-efficient architecture have their limitations. It is impossible to predict building efficiency once a building's design or operation has changed since, for instance, there is no clear relationship between the actual building characteristics and the inputs used in these simulations.

Additionally, to create and maintain forecast quality, AI-based methods need a large amount of training data. This means that if modifications are made to the building envelope, system, or operation, the models must be re-trained. AI-based techniques must be incorporated into building energy efficiency procedures, but first, the application's type and amount of input parameters must be reduced. Prediction performance could be greatly enhanced by adding occupancy data to the prediction model. The quantity, kind, and activities of the tenants all have a significant impact on the structure's energy usage.

References

1. Lee, D., & Park, J. H. (2019). Future trends of AI-based smart systems and services: challenges, opportunities, and solutions. *Journal of Information Processing Systems*, *15*(4), 717-723.
2. Romero, M., Guédria, W., Panetto, H., & Barafort, B. (2020). Towards a characterisation of smart systems: A systematic literature review. Computers in industry, 120, 103224.
3. Guo, K., Lu, Y., Gao, H., & Cao, R. (2018). Artificial intelligence-based semantic internet of things in a user-centric smart city. Sensors, 18(5), 1341.
4. Shafique, K., Khawaja, B. A., Sabir, F., Qazi, S., & Mustaqim, M. (2020). Internet of things (IoT) for next-generation smart systems: A review of current challenges, future trends and prospects for emerging 5G-IoT scenarios. Ieee Access, 8, 23022-23040.
5. O'Dwyer, E., Pan, I., Acha, S., & Shah, N. (2019). Smart energy systems for sustainable smart cities: Current developments, trends and future directions. Applied energy, 237, 581-597.
6. Lu, Y. (2019). Artificial intelligence: a survey on evolution, models, applications and future trends. Journal of Management Analytics, 6(1), 1-29.
7. Yu, Y., Lakemond, N., & Holmberg, G. (2023). AI in the context of complex intelligent systems: Engineering management consequences. IEEE transactions on engineering management.
8. Ahmed, S., ILYAS, M., & RAJA, M. Y. A. (2022). IoT based smart systems using machine learning (ML) and artificial intelligence (AI): vulnerabilities and intelligent solutions. In Proceedings of the 13th International Conference on Society and Information Technologies (ICSIT 2022).
9. Calegari, R., Ciatto, G., Denti, E., & Omicini, A. (2020). Logic-based technologies for intelligent systems: State of the art and perspectives. Information, 11(3), 167.
10. Ajani, S. N., Khobragade, P., Dhone, M., Ganguly, B., Shelke, N., & Parati, N. (2024). Advancements in Computing: Emerging Trends in Computational Science with Next-Generation Computing. International Journal of Intelligent Systems and Applications in Engineering, 12(7s), 546-559.
11. Guo, K., Lu, Y., Gao, H., & Cao, R. (2018). Artificial intelligence-based semantic internet of things in a user-centric smart city. Sensors, 18(5), 1341.

12. Farzaneh, H., Malehmirchegini, L., Bejan, A., Afolabi, T., Mulumba, A., & Daka, P. P. (2021). Artificial intelligence evolution in smart buildings for energy efficiency. Applied Sciences, 11(2), 763.
13. Parihar, V., Malik, A., Bhawna, Bhushan, B., & Chaganti, R. (2023). From Smart Devices to Smarter Systems: The Evolution of Artificial Intelligence of Things (AIoT) with Characteristics, Architecture, Use Cases and Challenges. In AI models for blockchain-based intelligent networks in IoT systems: Concepts, methodologies, tools, and applications (pp. 1-28). Cham: Springer International Publishing.
14. Rodrigues, J. M., Cardoso, P. J., Monteiro, J., & Ramos, C. M. (Eds.). (2020). Smart systems design, applications, and challenges.
15. Horváth, I. (2021). Connectors of smart design and smart systems. AI EDAM, 35(2), 132-150.