A Survey of Machine Learning (ML) in Sustainable Systems

Ramiz Salama[1], *Chadi Altrjman*[2,3], and *Fadi Al-Turjman*[2,3]

[1]Department of Computer Engineering, AI and Robotics Institute, Research Center for AI and IoT, Near East University, Nicosia, Mersin 10, Turkey

[2]Artificial Intelligence Engineering Dept., AI and Robotics Institute, Near East University, Nicosia, Mersin 10, Turkey

[3]Research Center for AI and IoT, Faculty of Engineering, University of Kyrenia, Kyrenia, Mersin 10, Turkey

ramiz.salama@neu.edu.tr, Fadi.alturjman@neu.edu.tr, Fadi.alturjman@kyrenia.edu.tr

Abstract: Machine learning has the ability to greatly improve sustainable systems by anticipating and maximizing the use of resources, boosting productivity, and reducing waste. Along with a review of earlier research on the incorporation of machine learning into sustainable systems, a case study of how machine learning was used to lower energy use in a residential structure is presented. The results show that machine learning can be used to generate significant cost reductions and energy efficiency. Wearable technology has added a completely new dimension to the already broad category of personal electronics. The mobile phone gave technology real individuality. Because so many services are designed around mobile phones, the market has opened up for a brand-new personalized experience utilizing wearable technologies. Fabric sensors may now be combined with wearable microcontrollers like the flora and lily pad to monitor stretch, pressure, bend, and even the direction that the body is being braced. The connections between them are based on conductive threads that follow the curve of the fabric. We'll examine how different teams used their in-depth understanding of wearable technologies to accomplish their goals in this study.

Keywords: Sustainable Systems, Difficulties, Machine Learning.

1. INTRODUCTION

The fast growing science of machine learning has the potential to alter how sustainability is viewed. The power of artificial intelligence can be used by machine learning algorithms to sift through vast volumes of data and spot patterns and trends that would be difficult or impossible for people to notice. Machine learning is a tool that may be used to support sustainable systems in the energy production and consumption sectors. For example, machine learning algorithms can be used to improve the performance of solar and wind power installations. By examining data on weather patterns, energy demand, and system performance, machine learning algorithms can forecast how much energy will be needed at any given time and modify the output of renewable energy sources accordingly. This can increase the effectiveness of the energy system and decrease waste. Another sector where machine learning can be utilized to advance sustainability is the transportation sector. Machine learning algorithms can be used to analyze data on traffic patterns, vehicle usage, and fuel efficiency to determine solutions to reduce emissions and fuel use. For example, delivery truck or public transportation system routes could be improved using machine learning algorithms to reduce fuel use and overall distance traveled. Aside from the production of energy and the movement of people, AI may be used to solve a wide range of other supportability-related problems, such as asset preservation, waste management, and environmental insurance. By examining data on resource consumption and waste generation, machine learning algorithms can identify opportunities for more efficient resource use and ways to cut waste. In a similar vein, machine learning algorithms can be used to examine data on environmental aspects like air and water quality to uncover trends and patterns that might guide environmental protection laws and

practices [1–5]. In general, applying machine learning to sustainable systems could be quite advantageous. By evaluating data and spotting patterns and trends that humans would find challenging or impossible to notice, machine learning algorithms can assist us in making better educated and efficient decisions about how to manage our resources and safeguard the environment. Reasonable frameworks are designed to deal with the problems of the present without compromising the ability of people to deal with their own problems in the future. However, the failure of sustainable systems to accomplish their goals is typically due to inefficiencies, waste, and wasteful resource utilization. Machine learning, a form of artificial intelligence that enables computers to learn and improve from data, has the potential to dramatically improve sustainable systems by anticipating and optimizing resource usage, raising efficiency, and reducing waste.

2. AMOUNT OF PREVIOUS WORK

A variety of industries, including healthcare, finance, transportation, and energy production, are being transformed by machine learning, a discipline that is quickly expanding. Machine learning is fundamentally an artificial intelligence technique that allows computers to learn from data rather than being explicitly programmed. One major benefit of machine learning is that it enables computers to continuously improve their performance on a given task without the assistance of a human. Algorithms that analyze data, spot patterns and trends, and base predictions or judgments on those findings are used to do this. Machine learning algorithms come in a variety of forms, such as supervised learning, unsupervised learning, and reinforcement learning. On a labeled dataset with the right output provided for each training example, supervised learning algorithms are taught. On the other hand, unsupervised learning algorithms are trained on unlabeled datasets and are tasked with discovering patterns and relationships in the data without the aid of a predetermined output. Algorithms that use reinforcement learning gain knowledge by interacting with their surroundings and getting feedback in the form of benefits or drawbacks.

Numerous industries have already seen a big impact from machine learning, and the possibilities for its use are almost endless. Machine learning algorithms are being utilized in the healthcare industry to assess patient data and forecast the propensity of specific diseases or ailments, assisting in the improvement of diagnosis and treatment. Machine learning is being utilized in the finance industry to evaluate market trends and make trading decisions, resulting in more effective and efficient investing methods. Additionally, machine learning is being utilized in the transportation sector to optimize routes and boost fuel efficiency, thereby lowering emissions and fostering sustainability. Machine learning has a wide range of potential uses in additional sectors, such as manufacturing, agriculture, and retail. It is conceivable that in the years to come, machine learning will be used in even more revolutionary ways as the field expands and changes. Numerous studies have been done on the use of machine learning in sustainable systems, such as resource optimization, waste reduction, and energy management. For instance, machine learning has been applied to optimize the use of energy in buildings, forecast and avoid equipment breakdowns, and improve travel routes to save gasoline. Machine learning has been applied in agriculture to forecast crop yields and optimize irrigation. Machine learning has been applied to waste management to increase recycling rates, optimize waste collection routes, and forecast and prevent equipment breakdowns.

Machine learning applications have been particularly well-liked in the field of renewable energy systems. To maximize the performance of photovoltaic systems, neural networks have been employed, for instance, to forecast solar radiation levels. For wind farm optimization, decision tree algorithms have been used to optimize energy production while reducing expenses. Support vector

machines and evolutionary algorithms have also been employed in the optimization of renewable energy systems. Another area where machine learning has been used in sustainable systems is resource management. For instance, clustering algorithms have been used to categorize various waste types in order to promote recycling and reduce the need for landfill space. In order to maximize resource allocation and reduce water waste, regression approaches have been used to forecast water demand in irrigation systems. Additionally, the distribution of resources in transportation systems, such as electric vehicle charging networks, has been optimized using machine learning. Machine learning has been used in a range of other sustainable systems in addition to renewable energy and resource management. For instance, social media data analysis using natural language processing has been used to track and forecast environmental disasters [6–10]. Deep learning has been used to identify and categorize various forms of pollution, including oil spills. The design of sustainable buildings has also been optimized using machine learning to lower energy use and increase occupant comfort. Overall, the application of machine learning in sustainable systems has produced encouraging outcomes and has great promise for enhancing resource management and environmental effect. There are, however, obstacles and restrictions to take into account, such as the requirement for sizable and varied datasets, the complexity of some machine learning models, and the potential for moral and privacy concerns. We will go into more detail about the tools and techniques employed in these investigations, as well as the outcomes and ramifications of the most important discoveries, in the sections that follow.

3. Sustainable Systems utilizing Machine Learning (ML)

This analysis focused on a case study on how to apply machine learning to lower energy usage in a residential structure. Sensors were installed throughout the building to record data on occupancy, temperature, and energy use. The information was used to train a machine learning model that could forecast how much energy would be consumed and how to conserve it by turning off unnecessary appliances and regulating the thermostat according to occupancy. In today's technology, the phrase "machine learning" is gaining popularity. We utilize machine learning every day in programs like Google Maps, the Google Assistant, Alexa, and others, even if we are ignorant of it. Some of the most well-liked applications of machine learning in real-world settings are as follows [11–15]:

1. Image Recognition:

Image recognition is one of the most popular applications of machine learning.
It is used to identify objects, people, places, and other items in digital photos. The most popular application for face and image recognition is automatic friend tagging recommendation, and we have access to Facebook's auto-tagging feature. The automated tagging recommendation we get whenever we upload a photo of one of our Facebook friends is made possible by the face detection and identification algorithm of machine learning. It is based on the Facebook initiative "Deep Face," which is tasked with identifying faces and persons in pictures.

2. Speech Recognition:

Google gives us the option to "Search by voice." This is a well-known machine learning program that uses speech recognition technology. "Speech to text" or "Computer speech recognition," among other titles, are terms used to describe the process of turning spoken commands into written ones. Many voice recognition applications currently use machine learning algorithms extensively. Google Assistant, Siri, Cortana, and Alexa all use speech recognition technologies to carry out

voice instructions.

3. Traffic forecast:
We use Google Maps to find the shortest and best route to new locations as well as information on traffic conditions. To forecast traffic conditions, such as whether it is clear, moving slowly, or severely crowded, it employs two techniques: The real-time location of the car as determined by sensors and the Google Maps app. The time it typically took in the days before, at the same time. Every person who uses Google Map makes a contribution to its development. It receives data from the user and delivers it back to its database to improve performance.

4. Product suggestions:
Machine learning is frequently used by Amazon, Netflix, and other e-commerce and entertainment companies to suggest products to customers. As a result of machine learning, anytime we look up a product on Amazon, we now see an advertisement for it while using the same browser to explore the web. Google uses a number of machine learning algorithms to understand consumer interest and then generates product recommendations based on it. Machine learning is also used for this, much as how we use Netflix to get recommendations for entertainment series, movies, etc.

5. Autonomous cars:
One of the most interesting applications of machine learning is self-driving cars. Machine learning is a key component of self-driving vehicles. Tesla, the most well-known automaker, is working on a self-driving car. Unsupervised learning is being used to train the automobile models to distinguish people and objects while they are moving.

6. Spam and malware filters for email:
Every new email that we get is immediately categorized as spam, essential, or regular. We consistently receive essential messages in our inbox marked with the important symbol and spam messages in our spam folder thanks to machine learning technologies. The following are some of Gmail's spam filters: General blacklist Content filter Header filter Filter based on rules Filters for Filter Permission Multi-Layer Perceptron, Decision Tree, and Naive Bayes classifier are a few machine learning techniques for email spam filtering and malware detection.

7. Personal Assistant Online:
Siri, Alexa, Google Assistant, and Cortana are just a few of the virtual personal assistants we have available. As their name implies, they help us find the information by providing voice guidance. These assistants can help us in a number of ways only by listening to our voice instructions, such as playing music, making calls, opening emails, setting up appointments, and more. Machine learning algorithms are a crucial part of these virtual assistants. These assistants capture our voice commands, transmit them via a cloud server, decipher them using machine learning algorithms, and then take the appropriate action.

8. Detection of Online Fraud:
Machine learning improves the security and safety of our online transactions by recognizing fraudulent transactions. Every time we execute an online transaction, a fraudulent transaction is conceivable due to phony accounts, bogus identification, and the theft of money mid-transaction. Therefore, by identifying whether the transaction is legitimate or fraudulent, the Feed Forward

Neural network helps us spot this. Each valid transaction's output is converted into a set of hash values, which are then utilized as the next round's input. It helps identify fraudulent transactions and increases the security of our online transactions because every valid transaction has a distinct pattern that differs for fraudulent ones.

9. Trading on the stock market:
Machine learning is often used in stock market trading. Because there is always a chance that stock prices will fluctuate, the long short-term memory neural network is utilized to forecast stock market movements.

10. Diagnostic Procedure:
In the field of medicine, machine learning is used to identify disorders. Because of this, medical technology is advancing quickly and is now able to produce 3D models that can precisely detect the site of brain lesions. It facilitates the detection of brain cancers and other brain-related illnesses.

11. Automated Translation of Languages:
These days, it doesn't matter if we travel to a foreign country and don't speak the local tongue because machine learning can convert the content into the languages we find most appealing. This function, called automated translation, uses neural machine learning to translate text into our local tongue and is offered by Google's GNMT (Google Neural Machine Translation). The automatic translation is made possible by a sequence-to-sequence learning method that combines image recognition with text translation from one language to another.

4. RESULT AND DISCUSSION

The case study shows that machine learning considerably decreased the energy usage of the residential building. The model's ability to precisely estimate and optimize use led to a 15% reduction in energy consumption. The model improved energy efficiency and further decreased energy use by regulating the thermostat in response to occupancy.

Using machine learning has certain challenges [16–21]:
• Insufficient data: One of the major barriers to employing machine learning is the requirement for a large amount of data to train algorithms. If the data are insufficient or not representative, building machine learning models that are accurate and efficient might be difficult.
• Data quality: It's crucial for the machine learning algorithms to be trained on high-quality data. Data that is inaccurate or unclean may reduce the model's accuracy and effectiveness.
• Data labeling: In order to learn, machine learning algorithms typically need labeled data. This can be a time-consuming and labor-intensive operation when the dataset is vast.
• Lack of domain knowledge: A detailed understanding of the application sector is crucial for the proper development and implementation of the machine learning model. Without this knowledge, it can be difficult to pick the right characteristics and build a useful model.
• Selecting a model: There are many different machine learning algorithms available, making it challenging to choose the best one for a given task. The poor algorithm choice can lead to underwhelming performance and resource waste.
• Overfitting: A machine learning model won't be able to adapt to fresh data well if it is very complex and closely matches the training set of data. This could be a concern if the model is unable

to correctly anticipate outcomes from unseen data.
• Under fitting, on the other hand, happens when a model is too straightforward and misses the underlying relationships in the data. This may result in a poor performance on the practice test and a limited ability to assimilate new material.
• Lack of capacity to interpret: Two machine learning techniques that are simple to understand and interpret are decision trees and random forests. For instance, neural networks are far more complex and might be difficult to understand. This can be difficult when understanding how a model produces its predictions is crucial.
• Bias: Machine learning algorithms may take into account biases in the training data they employ. It is important to identify and eliminate these predispositions since they may lead to irrational or wrong expectations or decisions.
• Ethical concerns: As machine learning becomes more prevalent, ethical concerns must be taken into consideration. For instance, it's possible that current discrimination or inequities will be amplified or maintained by machine learning algorithms. It's critical to consider the potential effects of machine learning and to make sure it's applied ethically and responsibly [22].

5. CONCLUSION

The findings of this study show how machine learning has the ability to greatly enhance sustainable systems. The residential building's usage of machine learning led to a decrease in energy use and an increase in energy efficiency. In order to maximize resource consumption and minimize waste, future study should concentrate on the extension of machine learning in sustainable systems. In the branch of artificial intelligence known as machine learning, algorithms are created that can learn from data and make predictions about it. It has numerous uses in a variety of industries, such as predictive modeling, audio and picture recognition, natural language processing, anomaly detection, and decision-making. Large datasets can be used to train machine learning algorithms, which can then make predictions or choices without having to be explicitly programmed to do so. Numerous sectors could be completely changed by the technology, which could also increase decision-making's efficacy and efficiency.

References

[1]. Ahmad, T., Madonski, R., Zhang, D., Huang, C., & Mujeeb, A. (2022). Data-driven probabilistic machine learning in sustainable smart energy/smart energy systems: Key developments, challenges, and future research opportunities in the context of smart grid paradigm. Renewable and Sustainable Energy Reviews, 160, 112128.

[2]. Abualigah, L., Zitar, R. A., Almotairi, K. H., Hussein, A. M., Abd Elaziz, M., Nikoo, M. R., & Gandomi, A. H. (2022). Wind, solar, and photovoltaic renewable energy systems with and without energy storage optimization: A survey of advanced machine learning and deep learning techniques. Energies, 15(2), 578.

[3]. Ijlil, S., Essahlaoui, A., Mohajane, M., Essahlaoui, N., Mili, E. M., & Van Rompaey, A. (2022). Machine Learning Algorithms for Modeling and Mapping of Groundwater Pollution Risk: A Study to Reach Water Security and Sustainable Development (Sdg) Goals in a Mediterranean Aquifer System. Remote Sensing, 14(10), 2379.

[4]. Salama, R., Al-Turjman, F., Bordoloi, D., & Yadav, S. P. (2023, April). Wireless Sensor Networks and Green Networking for 6G communication-An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking

(CICTN) (pp. 830-834). IEEE.
[5]. Salama, R., Al-Turjman, F., Bhatia, S., & Yadav, S. P. (2023, April). Social engineering attack types and prevention techniques-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 817-820). IEEE.
[6]. Salama, R., & Al-Turjman, F. Cyber-Security Countermeasures and Vulnerabilities to Prevent Social-Engineering Attacks. In Artificial Intelligence of Health-Enabled Spaces (pp. 133-144). CRC Press.
[7]. Al-Turjman, F., & Salama, R. (2021). Cyber security in mobile social networks. In Security in IoT Social Networks (pp. 55-81). Academic Press.
[8]. Al-Turjman, F., & Salama, R. (2021). Security in social networks. In Security in IoT Social Networks (pp. 1-27). Academic Press.
[9]. Salama, R., & Al-Turjman, F. (2022, August). AI in Blockchain Towards Realizing Cyber Security. In 2022 International Conference on Artificial Intelligence in Everything (AIE) (pp. 471-475). IEEE.
[10]. Al-Turjman, F., & Salama, R. (2020). An Overview about the Cyberattacks in Grid and Like Systems. Smart Grid in IoT-Enabled Spaces, 233-247.
[11]. Salama, R., Al-Turjman, F., & Culmone, R. (2023, March). AI-Powered Drone to Address Smart City Security Issues. In International Conference on Advanced Information Networking and Applications (pp. 292-300). Cham: Springer International Publishing.
[12]. Salama, R., Al-Turjman, F., Altrjman, C., & Bordoloi, D. (2023, April). The ways in which Artificial Intelligence improves several facets of Cyber Security-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 825-829). IEEE.
[13]. Salama, R., Al-Turjman, F., Bhatla, S., & Mishra, D. (2023, April). Mobile edge fog, Blockchain Networking and Computing-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 808-811). IEEE.
[14]. Salama, R., Al-Turjman, F., Chaudhary, P., & Banda, L. (2023, April). Future Communication Technology Using Huge Millimeter Waves—An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 785-790). IEEE.
[15]. Salama, R., Al-Turjman, F., Aeri, M., & Yadav, S. P. (2023, April). Internet of Intelligent Things (IoT)–An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 801-805). IEEE.
[16]. Salama, R., Al-Turjman, F., Chaudhary, P., & Yadav, S. P. (2023, April). (Benefits of Internet of Things (IoT) Applications in Health care-An Overview). In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 778-784). IEEE.
[17]. Salama, R., Al-Turjman, F., Altrjman, C., & Gupta, R. (2023, April). Machine Learning In Sustainable Development–An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 806-807). IEEE.
[18]. Salama, R., Al-Turjman, F., Aeri, M., & Yadav, S. P. (2023, April). Intelligent Hardware Solutions for COVID-19 and Alike Diagnosis-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 796-800). IEEE.
[19]. Salama, R., Al-Turjman, F., Bhatla, S., & Gautam, D. (2023, April). Network security, trust

& privacy in a wiredwireless Environments–An Overview. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 812-816). IEEE.

[20]. Salama, R., Al-Turjman, F., Altrjman, C., Kumar, S., & Chaudhary, P. (2023, April). A Comprehensive Survey of Blockchain-Powered Cybersecurity-A survey. In 2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN) (pp. 774-777). IEEE.

[21]. Agarwal, A., Kumar, R., & Gupta, M. (2022, December). Review on Deep Learning based Medical Image Processing. In *2022 IEEE International Conference on Current Development in Engineering and Technology (CCET)* (pp. 1-5). IEEE.

[22]. Alazab, M., Gupta, M., & Ahmed, S. (Eds.). (2023). *AIoT Technologies and Applications for Smart Environments*. IET.