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GENETIC ALGORITHMS AND MACHINE LEARNING AS THE BASIS OF ALL IMPLEMENTED SOLUTIONS IN SMART CITIES

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Abstract

The significance of the development of genetic algorithms and machine learning is inevitable today. All engineering solutions used in the construction of smart cities must contain an artificial intelligence component in their software part. The work deals with the needs of designers during the development of smart cities and the current opportunities offered by the market.

Keywords: *genetic algorithms, machine learning, artificial intelligence, smart cities, neural networks*

Theoretical consideration

Genetic algorithms and machine learning become the basis of all implemented solutions used in the concept of smart cities. The development of algorithms conditions the development of IoT solutions that influence the faster development of living conditions. In response to the ongoing urbanization trend seen around the world, a phenomenon known as smart cities has emerged. In smart cities, new technologies are carefully woven into the fabric of urban life to modify many aspects of daily life. This is done to make the city more sustainable.[1]
According to the authors [2] one of the most important aspects of their smart city is sustainable development, because cities use 75 percent of global energy production and produce 80 percent of CO2 emissions. The approach proposed in this paper is designed to improve energy efficiency and harmonious use of supplies. Using PV integrated and energy efficient built environment as well as smart grid technologies, the authors [3] investigated the appropriate land use in the city surroundings. They argued that the city's compact urban structure reduces the electricity needs of city residences. As in the field of green and

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sustainable science and technology, the authors [4] characterized their smart city as an environmentally responsible and resource efficient urban area. A sustainable community, the article claims, must maximize the allocation of resources while still providing a good quality of life. Therefore, they used simulation modeling to analyze the technological and political implications of smart solutions. The authors [5] proposed a model of a city with a good road network and cost-effective smart traffic lights and signals; they came up with a hybrid model, which included cellular automata and neural network models. Having concentrated on computational theories within theoretical computer science, this paper was published in the Journal of Computational and Applied Mathematics. Studies on smart city applications in the context of economic growth, social connections and leadership challenges have been published in business and government publications [6] . One study [7] focused on establishing a paradigm for regional and administrative cooperation. According to the study, smart cities must invest in resources providing wealth and pleasure, as well as enabling companies. In the end, intelligent residents must contribute to the city with their knowledge and new ideas.
The number of definitions depending on the years is shown in Figure 7. From 2012 to 2021, there is an increase in definitions, as illustrated in Figure 7. Furthermore, following the definitions in Table 2, the idea of a smart city is moving away from energy. - concerns about sustainability and towards the integration of information technologies.

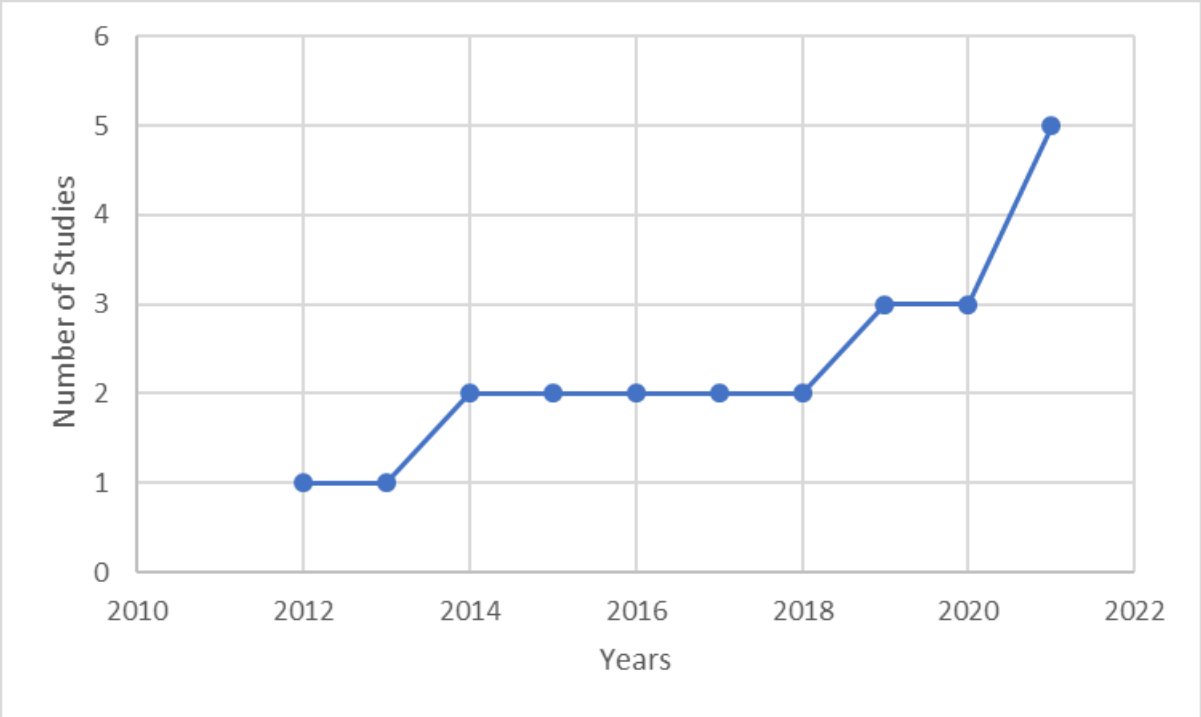

Figure 7 Between 2012 and 2021, the number of smart city definitions in journal publications in Q1 and Q2.

Machine learning (ML) is a field of study in artificial intelligence that deals with the development and study of statistical algorithms that can learn from data and generalize to

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unseen data and thus perform tasks without explicit instructions.[8] Recently, artificial neural networks have been able to outperform many previous approaches in performance.[9]
ML finds application in many fields, including natural language processing, computer vision, speech recognition, email filtering, agriculture, and medicine.[10][11] When applied to business problems, it is known as predictive analytics. Although not all machine learning is statistically based, computational statistics is an important source of methods in this field.

The mathematical foundations of ML are provided by mathematical optimization methods (mathematical programming). Data mining is a related (parallel) field of study, which focuses on exploratory data analysis (EDA) through unsupervised learning.[12][13].
From a theoretical point of view, probabilistically approximate (PAC) learning provides a framework for describing machine learning. Genetic algorithms (GA) are adaptive heuristic search algorithms that belong to the majority of evolutionary algorithms. Genetic algorithms are based on the ideas of natural selection and genetics. These are the intelligent exploitation of random searches with historical data to direct the search to a region of better performance in the solution space. They are typically used to generate high-quality solutions to optimization problems and search problems.
Genetic algorithms simulate the process of natural selection, which means that those species that can adapt to changes in their environment can survive and reproduce and pass on to the next generation. In simple terms, they simulate "survival of the fittest" among individuals of successive generations to solve the problem. Each generation consists of a population of individuals and each individual represents a point in the search space and a possible solution. Each individual is represented as a character/integer/float/bit string. This sequence is analogous to a chromosome.

Application in Smart Cities

Afundamental aspect of smart cities is the implementation of intelligent transportation systems, which optimize vehicle routing to minimize congestion, reduce travel time, and enhance overall efficiency. Evolutionary algorithms have gained prominence as effective tools for addressing complex optimization problems in smart transportation systems[14]. One of the models for improving vehicle routing in smart cities using evolutionary algorithms, with special emphasis on the Hybrid Harris algorithm of Hawks Optimization (HHO)[15]. The HHO algorithm is a gradient-independent optimization technique inspired by the cooperative behavior and agile pursuit of Harris's hawks in nature, known as the "sudden strike". [16]
Following the evolution of big data collection, storage, and manipulation techniques, deep learning has drawn the attention of numerous recent studies proposing solutions for smart cities. These solutions were focusing especially on energy consumption, pollution levels, public services, and traffic management issues. Predicting urban evolution and planning is another recent concern for smart cities. According to the achieved simulations, deep learning enhanced by evolutionary optimizers can be an effective and promising method for predicting urban evolution of future smart cities. [17]
Development of neural models networks that will be applied for optimization control parameters of boilers with automatic ignition can lead to a significant reduction in fuel

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consumption and increase in fuel level usage. [18] This can also find application in smart cities as one of the models that would reduce pollution and increase the standard of living
Genetic algorithm (GA) and Teaching-Learning-based Optimization (TLBO) are utilized for each phase to create a set of suitable timing scenarios. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method is used to identify the best scenario, considering both waiting vehicles and traffic capacity as decision criteria. Its efficiency has been demonstrated over three different traffic volumes. Also, in a real-world implementation, its practical capability has been approved at a crossroads in Mashhad, Iran. The simulations indicate the improvement in the number of vehicles waiting behind the crossroad and the traffic capacity by 10% and 6.76% compared to the existing signal timing of the studied intersection, respectively. [19]
In addition to these statements, examples of the use of Genetic Algorithms and Machine Learning are numerous. Although the neural network model was illustrated in the middle of the twentieth century, it is experiencing its full expansion only today. Neural networks have a very wide application, both in complex security systems, improving the quality of life through applications used in everyday life, and in industrial plants. [20] All these applications find increasing application in environmental protection and responsible living in modern urban environments such as smart cities.

Conclusion

The development of urban areas represents one of the most important spheres today, and the development itself is impossible without the application of modern models of artificial intelligence and machine learning. Today, when an increasing number of people live in cities with a high rate of population, smart technologies are inevitable in order to ensure living and working conditions that befit a person. Machine learning provides not only benefits through predicting the parameters to be measured, but also models for the further development of smart cities. The number of papers written on this topic is growing and it is impossible to guess how long it will last, since new algorithms are born almost on a daily basis, and existing ones are improved.

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