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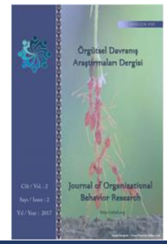

A Novel Model for the AWS of LED Street Lighting via IoT

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ABSTRACT

LED lights are a good component for managing energy consumption to provide illumination, but an important issue will be to keep their surface clean from dust and pollution. Accordingly, the method of creating an automatic washing approach for LED lights was examined in this study. The study's main purpose was to provide a novel model for AWS of LED street lighting via IoT based on upper and lower bounds simulation and using metaheuristic algorithms such as PSO. In the next step, the calculations of the weights of the normalized matrices with fuzzy preferences were provided to MATLAB software. Finally, the detection and convergence rates can be estimated. The study's findings showed that the simulation connection modules provided by PSO proved that the optimization related to the automatic washing of LED lights has fitness values to provide illumination. The simulation of the PSO algorithm for the dryness sensor showed the presence of fitness in the illumination supply, and its fitness value is equal to 2.03. The dryness sensor is expected to monitor the environment 30 times at any given time to detect pollution. The simulation of the PSO algorithm for the light sensor shows fitness values. The light sensor monitors the environment 101 times at a time interval to detect pollutants. In addition, the simulation of the PSO algorithm for cloud servers demonstrates secure communication with the processing center. Cloud servers exchange environmental pollution information 63 times in any given period. The PSO simulation algorithm for the processing center also showed its fitness level of pollution detection so that the processing center can process pollution information 25 times for LED lights at any given time interval.

Keywords: *Connection Modules, Dryness Sensor, Dust Sensor, Light Sensor, Cloud Servers.*

1. INTRODUCTION

Today, a study was conducted to provide practical and economical solutions to reduce electricity consumption in a park because illumination is one of the main sectors of energy consumption and considering the high energy consumption in city parks. On the other hand, the tremendous development of science and technology in the world today has brought about the comfort and well-being of human life. However, this development has also created new problems for human beings, including environmental pollution and the quantitative growth of electricity consumers. One of the most important factors in increasing electricity consumption, especially during peak consumption hours and the early hours of the night, is increasing street lighting surface. Therefore, reducing energy consumption in this regard can be very effective. For this purpose, today, LED lamps have shown proper functions; an LED lamp is a device that produces artificial light by electric current (Alizadeh, 2019: 43). Lamps and lights are a vital and efficient part of a lighting system powered by batteries or generators. On the other hand, the starter circuits of LED lamps have a significant role in the main parameters of lighting due to the use of power electronics. Washing city lights has always had ways to reduce energy consumption due to cleaning the lights' dirt and optimizing their maintenance costs (Qiu et al., 2019: 12).

In this regard, providing a novel model that finally uses the Internet of Things (IoT) and data transfer from various sensors can optimize and manage energy consumption to try to provide a solution to improve energy consumption in LEDs is one of the challenges in information technology (Orsley & Trutna, 2015). In this regard, it is clear that sensitive sensors to determine the appropriate time for automatic washing of LED lights is an electronic component that, by passing an electric current through it and also receiving appropriate pulses and actions from the environment, acts to determine the upper and lower bounds to choose the best time of decision making. This issue and the precision of these sensors will ultimately increase the ability to use the IoT in the processing center (Ducros et al., 2019).

According to Lozano et al. (2016), Breslow & Swafford (2017), and Liu et al. (2016), it can be stated that light, dryness, and rain sensors are the most important observer eyes for choosing the best time of decision making on smart actions by tools because these three sensors ultimately send environmental information in a certain range to the processing center. The existence of a processing center that can connect this information to the coordinates of the lights can create the rate of detection and selection of the best function for smart actions. There are some issues in this regard; for example, when LED lights, in addition to acceptable light and low consumption compared to incandescent and energy-saving lamps, environmental pollution and its negative effects on humans are very low and, in some cases, zero, how to determine the best washing time for them to minimize the final depreciation costs of washing equipment. This has made it very important to need a novel model based on the approaches of data collected from experts.

The most important reason for automatic washing of LED lights is to create a longer life for these lights, or better say, to create the best light efficiency per unit area. It is important to note that light efficiency in a specific area is the most important feature for LED lighting in a parameter (Srisangeerthanan et al., 2019: 33). In other words, it is necessary for LED lamps to turn on as soon as voltage is applied to them and in less than 20 μs and to be able to illuminate the largest possible area for the best function (Han et al., 2017). This issue justifies the most important reason for creating smart washing systems. On the other hand, the use of the IoT in this field allows processing centers as well as the use of network-integrated sensors to create the most optimal time for automatic washing, which means growing and expanding the use of the best smart tools to choice of processing center decisions for washing (Hadipour et al., 2018). If a novel model based on the extracted data can be provided, the influence of the IoT on this issue can be confirmed (Guo et al., 2020).

LED lights to need to be cleaned to improve the light efficiency in the physical environment, which is always an essential function for different areas, making the construction of an automatic washing system (AWS) necessary for this purpose (Li et al., 2019; 23). Although lighting systems are considered essential in social security, they are one of the major consumers of electricity in the distribution network. According to the policy of distribution companies to reduce electricity consumption, consumption management by optimizing the lighting of roads as a significant load at the peak of consumption is one of the items that have been seriously considered (Dorra, 2018: 14).

In recent years, using LED lamps instead of gas lamps has become common. However, the necessary technical and economic studies and their effect on the quality of electrical power have not been analyzed due to the surface pollution of these lamps and how they have washed automatically. Also, the electrical parameters of these lamps in terms of cleaning factors based on monitoring algorithms showed the need for discussion, which this study will address. Accordingly, this study seeks to provide a novel model for AWS of LED street lighting via IoT and, in this regard, will answer the following questions:

2. Research questions

2.1. The main question

- Based on what prioritization of effective factors can a novel model be provided for the AWS of LED street lighting via IoT?

2.2. Secondary questions

1. What is the priority of connection modules in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations?
2. What is the priority of the dryness sensor in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations?
3. What is the priority of rain sensors in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations?
4. What is the priority of light sensors in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations?
5. What is the priority of cloud servers in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations?
6. What is the priority of the processing center in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations?
7. What is the priority of the GPS coordinator in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations?

3. Research method

The method used in this study was based on upper and lower bounds simulation using meta-heuristic algorithms such as PSO. In the next step, the calculations of the weights of the normalized matrices with fuzzy preferences were provided to MATLAB software. Finally, the detection and convergence rates can be estimated. The metaheuristic algorithms such as PSO can detect the amount of pollution in the plan of electrical panels due to the definition of lower and upper bounds to create observer vision. This way, when the information received from the sensors is examined according to a conditional algorithm, this information is provided to the algorithm as completely random data. When the level of this random data exceeds the values provided in the condition of the algorithm, the observer vision of the algorithm will wait to cross the upper. After crossing it, the activities for convergence will begin. This convergence means exactly the beginning of the necessary actions for automatically cleaning the LED light. This study's data collection method used documents and receipts. For data analysis, the field method with a checklist approach and based on the checklist adjustment resulting from the collection of random data due to changes in pollution levels associated with dry, light, and dust sensors have been used.

The statistical population was all experts and specialists in the field of familiarity with sensors and smart electronic equipment used in smart decision making and had at least five years of experience in the field of smart gadgets in Tehran; among them, 117 people were used to examine the limits of extractable data.

The calculational flowchart of the present study was as follows:

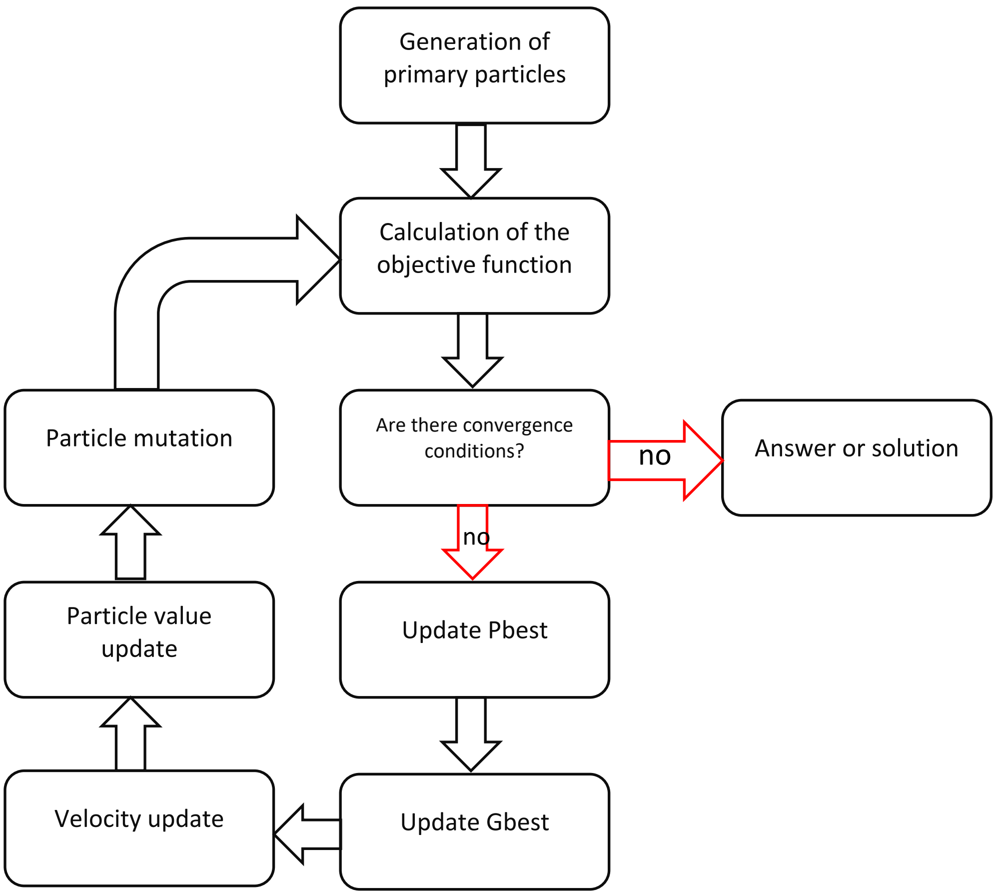

Fig. 1. Flowchart of PSO algorithm

4. Conceptual model of research

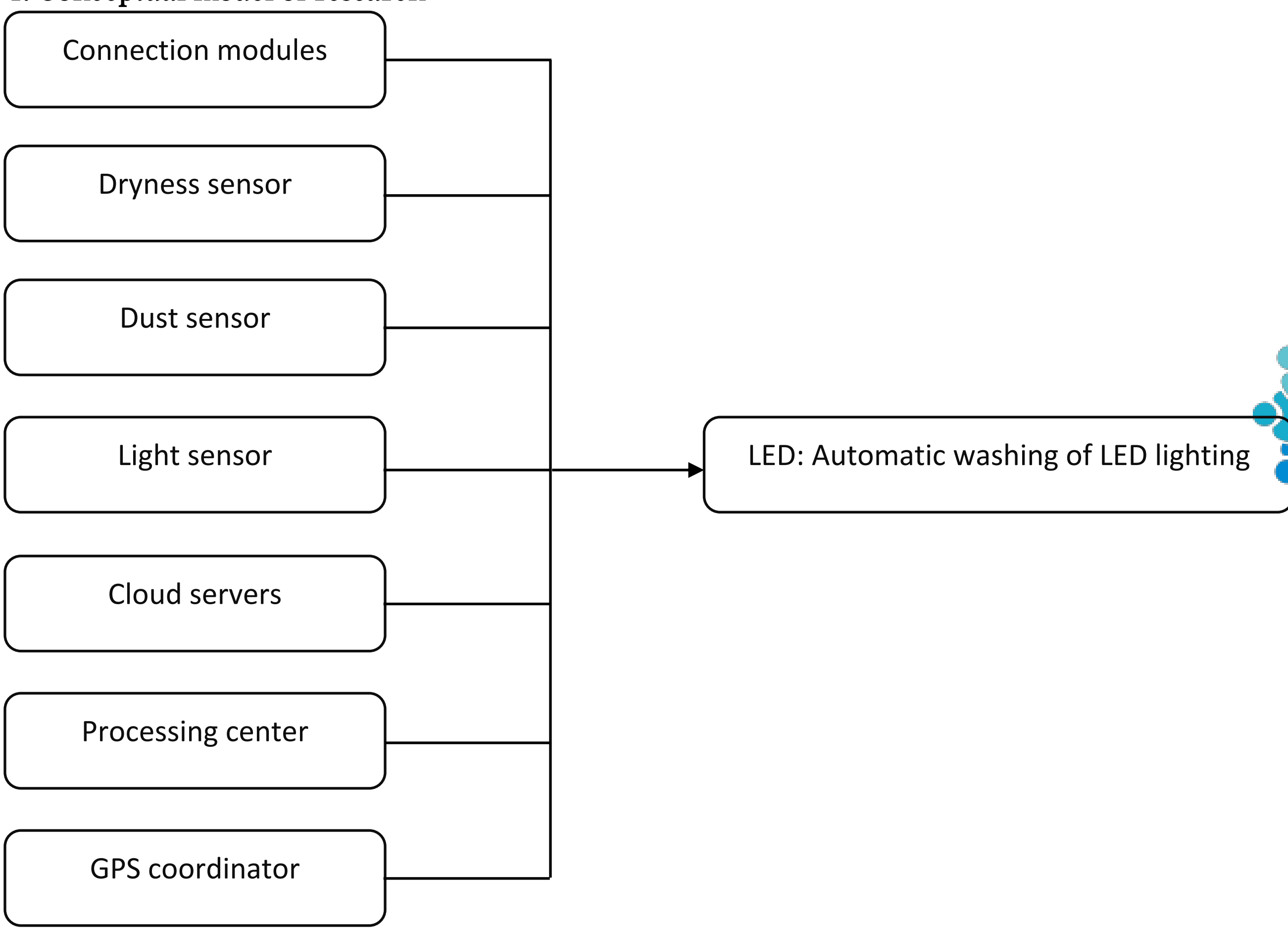

Fig. 2. Conceptual model, based on the Hadipour et al. (2018)

4. PSO simulation algorithm

Kennedy and Eberhart first proposed this algorithm. They named the PSO algorithm because the group behavior of birds inspired it in flight. Like other demographic algorithms, the PSO algorithm used a set of possible solutions that kept moving until an optimal solution was found or the conditions for the end of the algorithm were met. In this method, each solution X is provided as a particle, and a group of particles is a set of particles. In this method, the velocity equation guarantees the movement of particles towards the optimal region. This equation is usually based on three main components, which are:

1. Velocity inertia
2. Cognitive component
3. Social component

The final approach can be an algorithm that performs a multidimensional search. In simulating this algorithm, the behavior of each particle can be influenced by the best local particle (within a given neighborhood or the best general particle). An interesting feature of PSO is that this algorithm allows particles to take advantage of their best experience (Note that in other methods, such as genetic algorithms, the current population is usually the only memory used by the particles). It is noteworthy that the PSO algorithm has been used so far for continuous nonlinear problems and discrete binary problems for single-objective and multi-objective optimization. PSO algorithm has the following parameters:

- **Termination criterion:** This criterion contains the criteria adopted to complete the algorithm's execution, but it is usually said to be the number of repetitions that the algorithm will be executed.
- **The number of particles:** This criterion refers to the total number of particles that move in the search space.
- **W:** It refers to the velocity inertia of the particle.
- **C:** It is a collective constituent. This value indicates the effect of the position of the best particle ever found on the current particle.

4. Answers to research questions

The optimal simulation method for operational activities was used to answer research questions. This operational box in MATLAB is capable of continuous optimization based on a global search and simulation to produce generations per move in the global environment. Here the global environment is the same as the environment around LED lights, and the purpose of producing simulated generations is the same as the different abilities of the studied components for the movement and change of the components provided. Based on this approach, the research questions were answered below.

4.1. Answer to the secondary question 1

In answer to secondary question 1 of the research, which stated that what is the priority of connection modules in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations? For this purpose, the MATLAB simulator against PSO can be shown in Fig. 3:

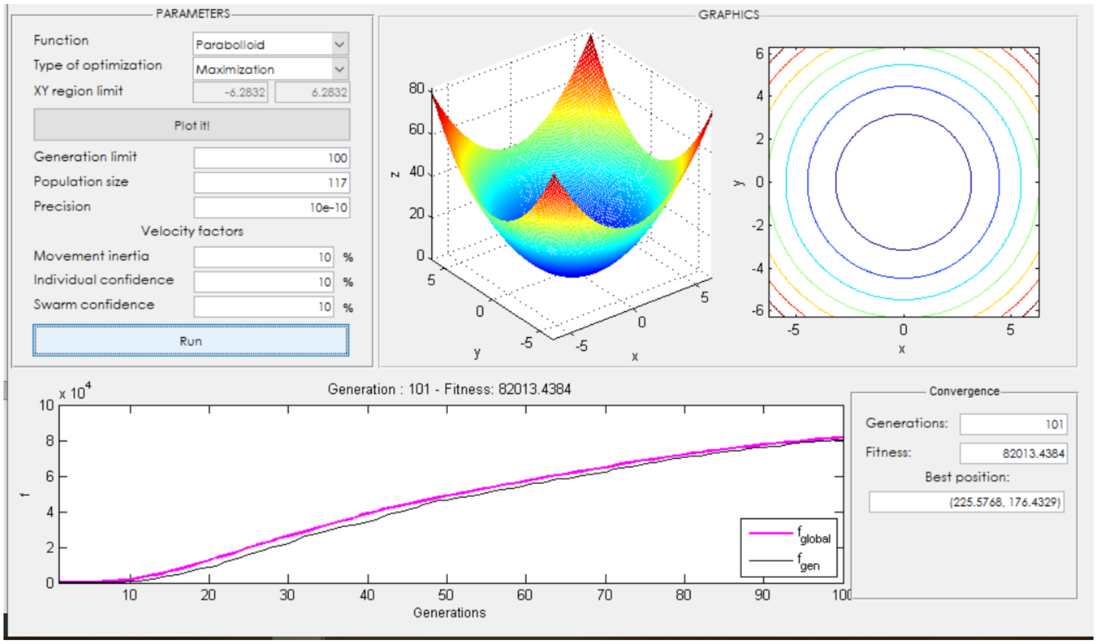

Fig. 3. The result of PSO calculations for connection modules

According to the simulation of the PSO algorithm, it can be said that automatic washing based on connection modules can be implemented. The simulation showed that the fitness value of the simulators in detecting environmental pollution is equal to 82013. This value indicates that the simulation model has a very high fitness level. In other words, the simulated model shows that the connection modules in LED lights can well identify patterns related to environmental pollution for washing.

4.2. Answer to the secondary question 2

In answer to secondary question 2 of the research, which stated that what is the priority of dryness sensor in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations? The simulator related to MATLAB versus PSO for dryness sensor can be shown in the following figure:

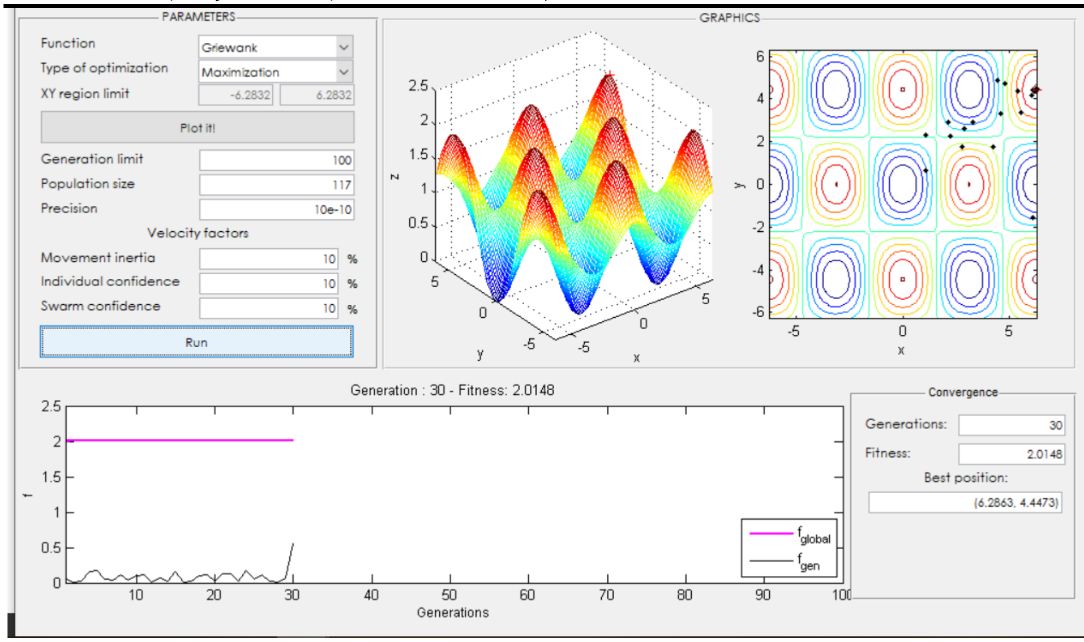

Fig. 4. The result of PSO calculations for the dryness sensor

Simulation of the PSO algorithm showed that the dryness sensor could detect environmental pollution for LED lights. The results also show that the sensor monitors the environment 30 times for each unit of time to detect pollutants. The fitness value in the calculations was 2.03. This fitness indicates that the calculations had sufficient fitness, and the simulation results can be trusted.

4.3. Answer to the secondary question 3

In answer to secondary question 3 of the research, which stated that what is the priority of rain sensor in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations? The simulator related to MATLAB versus PSO for rain sensors can be shown in Fig. 5:

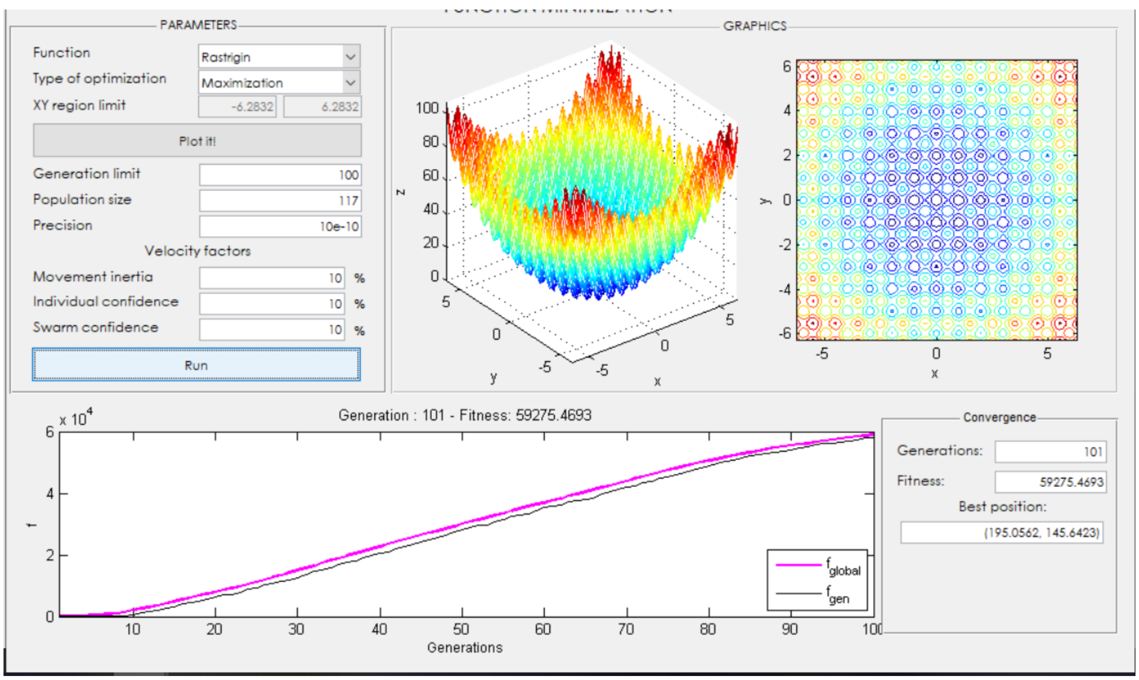

Fig. 5. The result of PSO calculations for the rain sensor

Rain sensor simulation showed that the model had sufficient fitness. The fitness value of the model was 59275. This value means that the detection level of the rain sensor is very high concerning changes and environmental pollution. Also, the simulation result of the PSO algorithm for the rain sensor showed that for each time unit, 101 times monitoring is done to detect environmental pollution by this sensor.

4.4. Answer to the secondary question 4

In answer to secondary question 4 of the research, which stated that what is the priority of light sensor in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations? The simulator related to MATLAB versus PSO for the light sensor can be shown in Fig. 6:

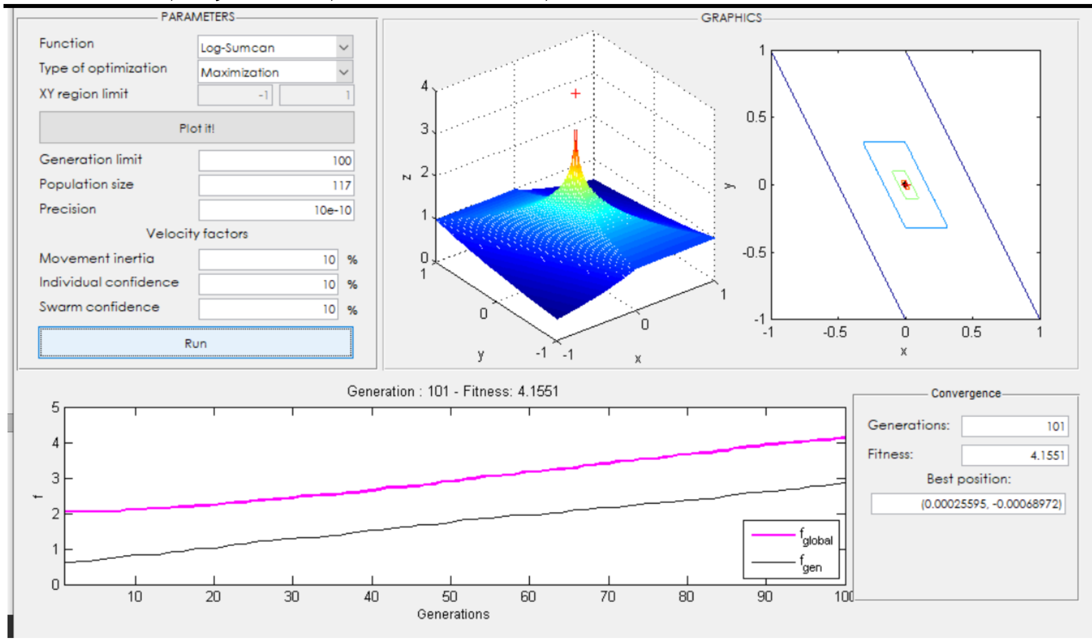

Fig. 6. The result of PSO calculations for light sensor

The result shows that the PSO algorithm can simulate and optimize the light sensor. This algorithm had a high fitness level for optimizing the light sensor, and its fitness value was equal to 4.15. Also, in each time unit, 101 monitoring is done by the light sensor to identify the pollution related to the LED light. This monitor was used to identify the right time to automatically wash the lights at the right time.

4.5. Answer to the secondary question 5

In answer to the secondary question 5 of the research, which stated that cloud servers' priority in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations? The simulator related to MATLAB versus PSO for cloud servers can be shown in Fig. 7:

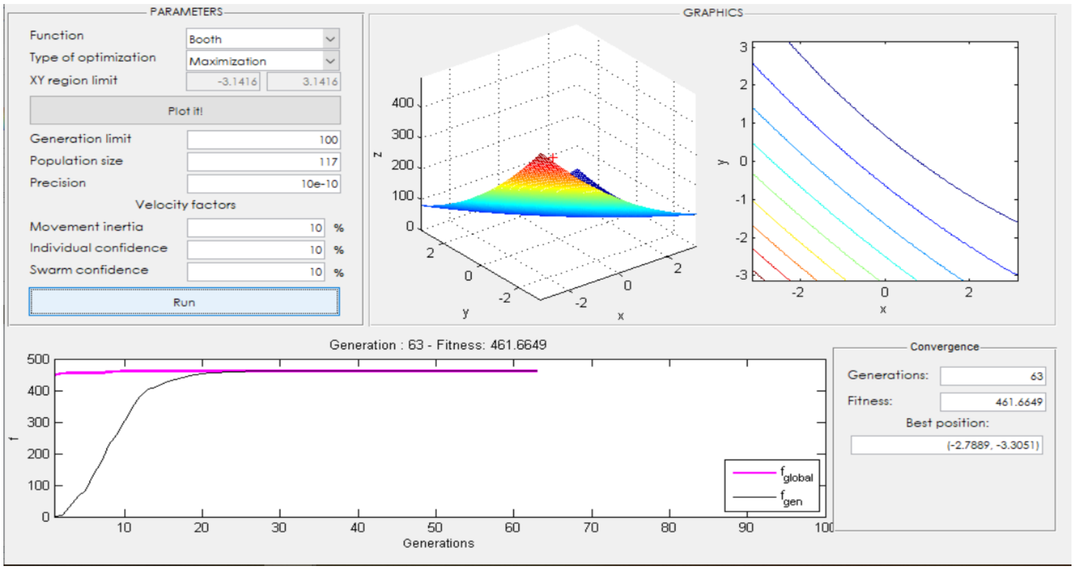

Fig. 7. The result of PSO calculations for cloud servers

The simulation result of the PSO algorithm showed that cloud servers are a suitable option for pollution detection and automatic washing of LED lights. The fitness value of PSO calculations for it was 461.66, which showed a high level. Also, in each time unit, cloud servers monitor environmental information up to 63 times to find the right time to automatically wash the LED lights.

4.6. Answer to the secondary question 6

In answer to secondary question 6 of the research, which stated that what is the priority of the processing center in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations? The simulator related to MATLAB versus PSO for the processing center can be shown in Fig. 8:

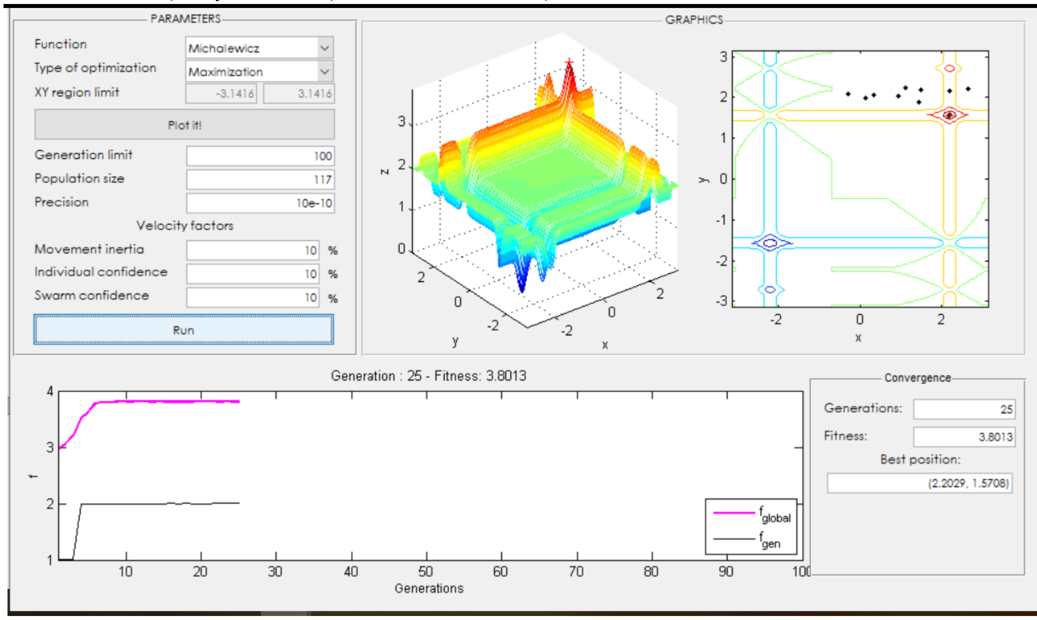

Fig. 8. The result of PSO calculations for the processing center

The PSO algorithm simulation shows the processing center's fitness in the automatic washing of LED lights. The fitness value in this regard was equal to 3.8, and in each time unit, the processing center processes the sent information 25 times to transmit the best position for washing the LED lights.

4.7. Answer to the secondary question 7

In answer to secondary question 7 of the research, which stated that what is the priority of GPS coordinator in providing a novel model for the AWS of LED street lighting via IoT based on fuzzy calculations? The simulator related to MATLAB versus PSO for GPS coordinator can be shown in Fig. 9:

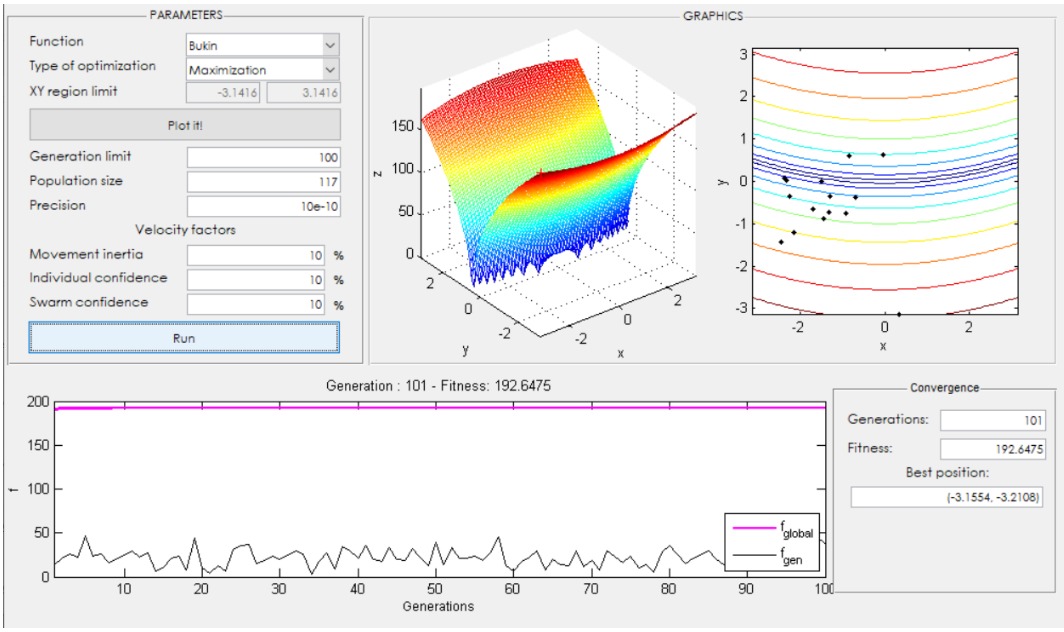

Fig. 9. The result of PSO calculations for the GPS coordinator

The GPS coordinator has a fitness value of 192.64. This fitness level indicates that the simulation of the PSO algorithm for the coordinator is in a good position, and its results can be trusted. GPS coordinates are also measured 101 times per unit time to create the best time to select the automatic wash time of LED due to environmental pollution.

5. PSO algorithm validation

The fitness values calculated in the PSO algorithm are used to validate the simulation results, which were provided in the results of the above estimation. In general, if the values related to fitness are positive and more than zero, it indicates the appropriate validity of the model for the studied variable. Higher fitness values will indicate more validity associated with the variable in the PSO algorithm model. Fitness index values indicate the fit or validity of a model created to use data for a variable. For research variables, the results of fitness can be shown in Table 1:

Table 1. Validation of the nature used in LED lights

No.	Studied variables	Fitness validation value
1	Connection modules	82013,43
2	Dryness sensor	2,01
3	Rain sensor	59275,46
4	Light sensor	4,15
5	Cloud servers	461,66
6	Processing center	3,8
7	GPS coordinator	64,192

Based on the results obtained in Table 1, the model validation showed that the rain sensor had fitness values equal to 5927.5 and shows that the simulation performed on the automatic washing of LED lights using the rain sensor has a positive fitness in creating a hardware-software model. Also, the connection modules showed a validation value equal to 82013.43, which indicates the positive validity of this variable. It was also equal to 2.01 for the dryness sensor, which was a positive value, and the fitness value of the light sensor variable was equal to 4.15. Also, cloud servers had a fitness value of 461.66. The fitness value of the processing center was also equal to 3.8 provided by the PSO algorithm. The GPS coordinator also had a fitness validation value of 64.19, which was a positive value greater than zero, and finally showed that in the PSO algorithm simulation, all variables used could have a positive validation value greater than zero.

6. Discussion and conclusion

6.1. By answering the secondary question 1 of the research, which showed that with the connection modules, a novel model for the AWS of LED street lighting via IoT could be provided, it can be analyzed that in the model, connection modules to distributed data centers are introduced to reduce delays in the access of applications to local data centers. Also, in the LED field, connection modules can be used to manage automatic washing. Also, with the advances that have been made in the field of connection modules in recent years, there is no doubt that this technology can transform the future of computer games. Today, communication with LEDs using access modules is much cheaper, faster, and more reliable than ever. One of the main advantages of this technology should be considered in the ease of access to automation of various LEDs. Currently, users need to install these games on a personal system to access high-quality games, which takes up a lot of space on the device. In addition, installing and updating it will make them more difficult. With LED technology to automate the wash, it is enough to connect to the Internet to use the latest game version. In this case, the information of each user, as well as the points he received, will be protected. The findings of this study were consistent with studies by Kumar et al. (2017), Kıyak et al. (2017), and Liu et al. (2016). In general, these studies showed that access modules and renewable energy could be used for internal consumption and the use of the IoT to improve the quality of LED light. Also, using access modules in LED-based data connected to cloud processing centers connected by IoT equipment can significantly save electricity consumption and adjust the light quality to your liking.

6.2. By answering the secondary question 2 of the research, which showed that with the dryness sensor, a novel model for the AWS of LED street lighting via IoT could be provided, it can be analyzed that dryness sensors with protocols related to the best product selection can increase the grounds for improving automatic washing; this mode improves the level of service provided by the LED and increased its capability and efficiency.
The findings of this study were consistent with studies by Park et al. (2018), Marse (2018), and Hadipour et al. (2018). These studies showed that the dryness sensor could reduce initial installation costs by using ESS micro-distribution and IoT-based smart management, leading to automatic LED washing. In this mode, the issue is not about the automatic washing of the LED itself but the wider field of detection algorithms based on the dryness sensor.

6.3. By answering the secondary question 3 of the research, which showed that with the rain sensor, a novel model for the AWS of LED street lighting via IoT could be provided, it can be analyzed that in general, the rain sensor in combination with other sensors in the cloud server environment consists of 3 layers of software, platform, and infrastructure, each of which provides specific services. A user sends his request to brokers to use the combined services. The software layer, including the dryness sensor, can improve the washing levels and, in this way, manage all the services offered to the users by the providers. In this mode, the combined motor is used in the platform layer and the rain sensor to detect the service according to the user's request. An execution plan can be provided based on the services provided in this mode, which will eventually improve the automatic washing. The findings of this study were consistent with studies by Naik et al. (2020), Menard et al. (2020), and Dickel et al. (2019). These studies showed that investigation and realization of digital automatic service costs by IoT for LED lights based on rain sensors can be detected. In this mode, automatic LED algorithms provide the conditions for data collection and notification and automatic washing using the rain sensor. The rain sensor can improve smart washing and better illumination in the environment.

6.4. By answering secondary question 4 of the research, which showed that with the light sensor, a novel model for the AWS of LED street lighting via IoT could be provided, it could be analyzed that the light sensor improves the monitoring costs of automatic cleaning devices. The analysis is that in a cloud computing environment, the light sensor can detect the level of LED efficiency by measuring the amount of light received by the primary lenses. In this mode, many service providers developed and provided service to users. Even with the complexity and unpredictability of the cloud environment, light sensors will provide a novel model for the AWS of LED street lighting via IoT. The findings of this study were consistent with studies by Sundhari et al. (2020), Yanes et al. (2020), and Agyemang et al. (2020). In general, these studies have shown that light sensors in LED lights require automatic washing based on dryness and humidity sensors for higher protection. These light sensors cause LED lights to usually improve the levels associated with monitoring for LED washing. Accordingly, the IoT can be used to achieve the access point detection algorithm to keep the LEDs clean automatically.

6.5. By answering the secondary question 5 of the research, which showed that with the cloud servers, a novel model for the AWS of LED street lighting via IoT could be provided, it can be analyzed that cloud servers for automatic LED washing can increase the ability of cloud service providers to identify software security, data protection, and data storage security. There are several features to identify invalid service providers. The findings of this study were consistent with studies by Guo et al. (2020) and Ducros et al. (2020). These studies have shown that outdoor cloud servers can cause large light losses if not properly connected to other sensors. On the other hand, flexible eye structures are a less expensive and simpler method.

6.6. By answering the secondary question 6 of the research, which showed that with the cloud servers, a novel model for the AWS of LED street lighting via IoT could be provided, it can be analyzed that the choice of processing center structure in achieving the required level of reliability based on a particular security situation was crucial for automatic LED washing. The processing center is one of the most essential and major needs of an IoT service provider for automatic LED washing because the customer can choose a reputable provider of products through important features. The findings of this study were consistent with studies by Viuo et al. (2020). In general, these studies show that the controller has partial feedback on stabilizing light satisfactorily, and the processing centers connect better. In this mode, electric lighting systems in different ways can cause different conditions via IoT and, based on the processing center, are used.

6.7. By answering the secondary question 7 of the research, which showed that with the GPS coordinator, a novel model for the AWS of LED street lighting via IoT could be provided, it can be analyzed that the degree of reliability of the LED automatic washing capability depends on receiving continuous geographical coordinates as well as data exchange with the processing center. In this mode, the PSO is calculated for the coordinators by the weighting method. According to the defined values of the features, the average weight is generated by a local search to coordinate with the global search. On the other hand, the GPS coordinator can provide a novel model for the AWS of LED street lighting via IoT because to get the coordinates of instantaneous transmitters, turning it on indicates the continuous operation of the LED monitoring system. Also, despite the focus of the GPS coordinator on commercial applications, due to the attractiveness of this technology, many areas of use that were previously very expensive for GPS were facilitated. In LED washing, discrete cloud-based systems are provided for modeling and simulation, in which users can simulate problems without knowing a specific language. LED coordinator is an area for which many models have been introduced that help drastically reduce costs in addition to high-quality services. GPS systems for LEDs have become a viable alternative to current training systems. The findings of this study were consistent with studies by Lee (2020) and Kim et al. (2017). These studies have shown that GPS, as a personalized factor in vulnerabilities and resistance concerns for the IoT, contributes to LED lights and how well they are kept clean by providing continuous coordinate information. Also, using GPS coordinators, users can easily create the desired space with these LEDs via IoT and implement personalization operations to keep them clean.

7. Practical suggestions

In line with the results of the research, the following suggestions are made:

1. It is suggested that the combinations generated by the sensors in this study be installed on LED lights using micro-scale processing centers with discovery ability.
2. It is suggested that the simulations be based on the infrared input amplitude for greater protection and longer life of the sensors.
3. Cloud servers should be the main criterion for data transfer of automatic LED lights.
4. To supply energy, central processing centers connected to central cloud servers should be used to perform the automatic LED washing rate with better optimization.

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