# Particle Swarm Optimization Based Intelligent Smart City Parking Guidance System


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***Abstract*— Smart cities have the power to raise economic development, enhance the quality of life for city dwellers, and solve some of the problems that plague large metropolitan areas. We provide a Particle Swarm Optimization (PSO) approach to find optimal hyper parameter values for local machine learning models in a fuzzy logic (FL) scenario. Our technique is assessed by comparing the results of two case studies. We present a Particle Swarm Optimization (PSO)-based strategy for fine-tuning the hyperparameters of local ML models in a FL scenario. We analyse the results of two case studies to see how well our proposed method works. In order to estimate traffic patterns, we first take into account the services provided by smart cities and use a simulated environment built from an experimental transportation dataset. We think about cloud services and employ a real-time telemetry dataset to foretell when a machine would break down due to a component failure**.



***Keywords*— Particle Swarm Optimization, smart city, memetic algorithm, street parking system, Pollution, Going green, Saving energy**


## I. Introduction

As per Ritchie's research (2021), the global urban population reached 4.1 billion in 2017, and it is estimated that by 2050, more than two-thirds of the world's population would call a city home. A increasing urban population generates difficult issues for municipal planners and managers. Scientists have proposed the notion of a "smart city" to address these concerns. The use of cutting-edge information technology in municipal government is central to the concept of a "smart city." Scholars have developed a significant interest in "smart cities" in recent years, and the issue has become widely explored (see, for example, the works of X. J. Yang2013, R. Du, P. Santi, M. Xiao, and A. V. Vasilakos) (2013). (2013). Many writers, such as J. K. Suhr and H. G. Jung, have employed various mathematical methodologies to handle transportation optimization issues in the past. This includes Y. Song (2018), Z. Hu, S. J. Moura, and H. Zhang. (2018). These approaches include linear programming and dynamic programming, for example (2015). Since more and more people live, work, and go to school in urban areas, this suggests that the total number of automobiles will likewise increase at an exponential rate. Despite the fact that there are now more parking spots available, this still is not enough to satisfy the requirements of the expanding populations. The lack of available parking places adds additional stress to the already packed roadways, which in turn increases the amount of time that motorists must spend on the road. Due to the rise in traffic congestion, there has been an increase in the number of accidents as well as an increase in the expenditures associated with gasoline usage. In order to handle the quick expansion and exponential rise in the number of motor vehicles, authorities in charge of traffic management are attempting to come up with a suitable solution to the challenge they confront. S. Yang and L. Huang (2017). As was briefly indicated above, technology progress serves as a catalyst, resulting in the introduction of novel approaches to urban and transportation management that are smarter, more effective, and less harmful to the environment. In the modern day, society and lawmakers are consistently working on new inventions for "smart cities," and the corporate world has recognized this as a promising area for growth. Eremia, M.; Toma, L.; Sanduleac, M.; Lefèvre, B.; Mainguy, G. (2009). Anthropoulos, L.G. (2017), Yang, S., and Huang, L. (2017), Lefèvre, B., and Mainguy, G. (2009), (2017). There is disagreement among researchers and developers over the precise number of essential components that comprise a "smart city," but most agree that there are five to eight of them. "Smart infrastructure," "smart transportation," "smart environment," "smart services," and "smart governance," are some of these components. and authors: V. Albino, U. Berardi, and Dangelico (2015). (2015). Among these, the development of smart mobility and transportation networks stands out as particularly crucial for the economy and the social order as a whole. 2017 statistics show that it accounted for 30.8% of the EU-28's overall energy consumption. The W. Christine (2019). By adapting the Dijkstra algorithm, Wei et al. devised a generalized shortest route that can find the optimal path in O(N) trips while keeping complexity at a manageable polynomial level. All of this effort was made to achieve these two ends. Xiaolei looked into a way to quickly find the best path that doesn't take network connectivity into account. What he did was combine two algorithms—the Dijkstra algorithm and the evolutionary algorithm—to get the job done. Co-authored by van der Zijpp and Catalano with W. Wei, X. Xia, M. Wozniak, X. Fan, and R. To increase optimization's efficacy, this research seeks to identify and mitigate the local optimum fault that might arise from relying too much on a particular technique (2019).

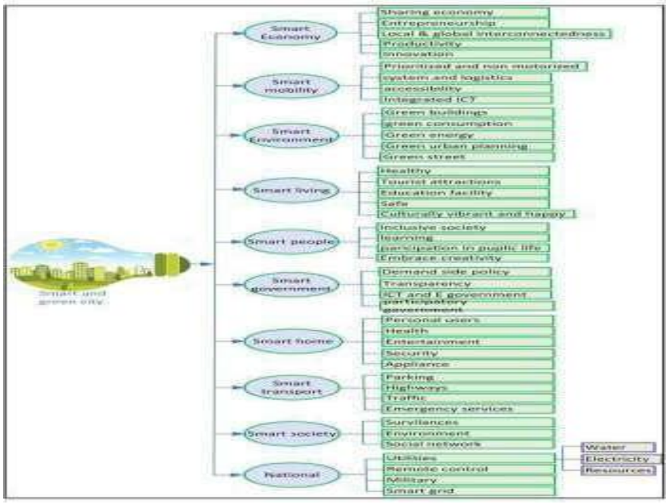


Fig. 1 Smart city applications

## II. LITERATURE SURVEY

The preliminary work on smart cities based on greening the Internet of Things (Zahmatkesh H (2020), Alsamhi SH, Ma O (2019), Shafie-Khah M (2017), to mention a few) fails to recognise the significance of green IoT. One way in which the IoT aids the development of smart cities is seen in Figure 1. Its wide range of uses helps promote public transformation, lessen traffic congestion, build efficient municipal services, keep citizens safe and healthy, cut down on energy use, boost monitoring capabilities, and lessen pollution Current research seems to lack the depth necessary to explain the enabling strategies for IoT systems in smart cities[13]. These techniques are necessary for reducing CO2 emissions, minimizing power consumption, improving quality of service, and enabling information and communication technology. The currently available surveys do not place sufficient emphasis on the policies, procedures, and strategies that may make smart cities more environmentally friendly.

The Internet of Things (IoT) is a key element in improving the ecology, sustainability, and ecosystem of smart cities. This article will examine the many strategies used to improve the sustainability and environmental friendliness of smart cities. Most of the writers' attention is focused on strategies that increase the Quality of Service (QoS) of communication networks while concurrently minimizing emissions, traffic, waste, energy, and pollution. No other research in the survey, to the authors' knowledge, have focused on the techniques and procedures that build eco-friendly and long-lasting smart cities. The same or comparable task will be given from a variety of viewpoints, with the goal of solving the posed problems.

## III SYSTEM DESIGN

The purpose of this part is to provide an overview of the created design for the intelligent real-time parking control and monitoring system. An illustration of the system architecture is shown in Figure 1.

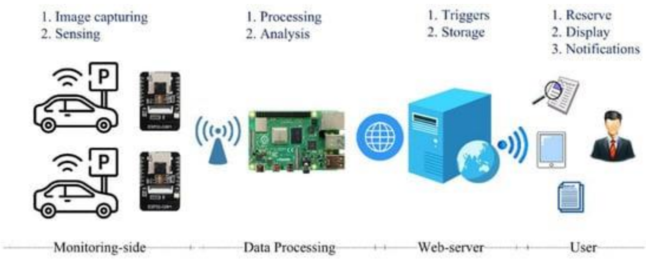


Fig 2. The main system architecture.

The monitoring unit is a smart Internet of Things device that is housed at each parking slot. It is in charge of keeping an eye on the parking spots. This extremely tiny, low-power, low-cost gadget can detect the presence of a vehicle, then snap a photo of the vehicle and send it to the processing unit.

Processing Unit: This unit is made up of an inexpensive Raspberry Pi 4 computer that processes and extracts the necessary data from photographs using Automatic Number Plate Recognition (ANPR) technology [2]. Additionally, it has the ability to transmit the extracted data to the cloud-side unit for user application access. The monitoring units are the ones who take the pictures.

The Cloud-side Unit is responsible for gathering the data from the photos that the Internet of Things device sends in, saving the most recent set of data in the database, and carrying out the alerting feature for the user. The information comprises the moment the parking spot was utilized, the car's number plate number, and the parking slot identification number[2,3].

Usefulness for Users: The purpose of this programme is to enable users to do several tasks, such as signing up, making reservations, and modifying existing ones[3,5].

The implementation of the suggested system's data transfer is shown in Figure 2. The Raspberry Pi 4 serves as the processing unit, and the monitoring device is responsible for taking a picture of the parked car and sending it to it[4,5]. PyTorch's Optical Character Recognition (OCR) software is used by the processing unit in order to identify the licence plate of the car and recognise the text shown on it. When the characters are recognised, Firestore's cloud database creates a new record and sends an alert to the user via Firebase Cloud Messaging (FCM).

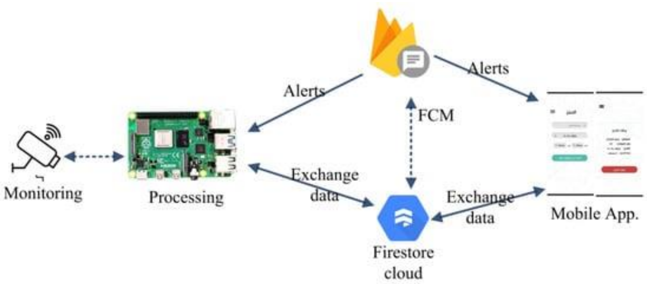


Fig.3 Interchange of planned system data.

## IV. SYSTEM OPERATIONS DESCRIPTION

The designed intelligent real-time parking control and monitoring system works as follows: the monitoring unit employs either the motion sensor or the range-finder sensor to determine if a vehicle is present in a parking place[11]. The processing unit gets the image of the parked automobile that the monitoring unit took and instantly forwards it to the processing unit. In the event that the picture that was received is of poor quality, the processing unit will assess the image's quality and then request a replacement as soon as possible. Following that, the processing unit has the task of processing and analysing the contents of the picture in order to identify the number plate number[12].

The cloud service (in our case, Firebase) gets information about the stopped car, like its name, number plate number, parking place number, time, and date. This is done so that it can be watched. This is done after the number plate number has been found[10]. The Firebase cloud service will then send a message to make sure the driver is who they say they are and that they parked in the right spot. Two mobile app accounts, one for the supervisor and one for the driver, will get a message if the driver parks in the wrong spot. The guest's phone app tells the Firebase cloud computer that they want to park, and the computer gives it to them[13].

### *4.1. Hardware Design*

The suggested parking system consists of two distinct parking devices that were created using the same microcontroller[6,8]. That being said, there has been a little modification made to the sensor technology that is used in order to detect the presence of a vehicle. To phrase it another way, the system that is being suggested is offered in two distinct modules, with the intention of providing cost flexibility.

The first module makes use of a motion sensor. As shown in Figure 3, the initial module architecture makes use of a motion sensor and an ESP32-CAM-M5-Stack board. The motion sensor works well for detecting the presence of a car, but it is not able to identify the object or measure the distance to the licence plate. Comparatively speaking, the cost of this module is lower than that of the second module[9].

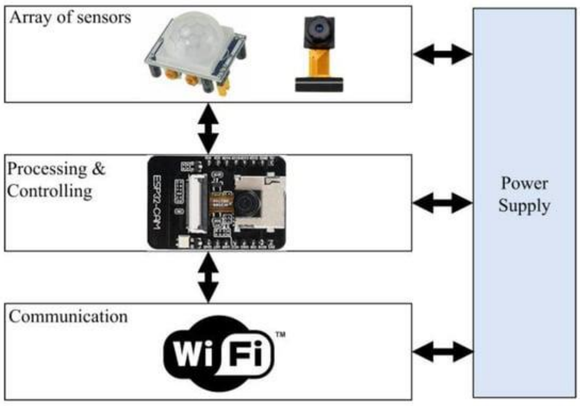


Fig 4. Initial motion-sensor module architecture.

The second module makes use of the rangefinder sensor. The second module's architecture, which comprises of a range-finder sensor and an ESP32-CAM-M5-Stack controller board, is shown in Figure 4. When a car is parked in a specified area and the range-finder sensor determines that it has, the ESP32-CAM module will take a picture of the licence plate.

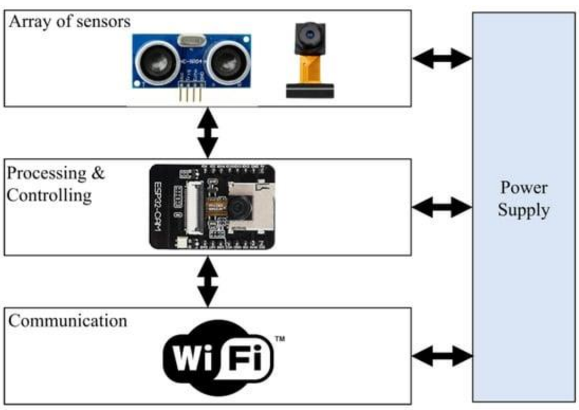

Fig 5. Module 2 with range-finder sensor.

One of the most important differences between the two units is their respective sensing capacities, particularly the method by which they detect the presence of automobiles. Figure 5 illustrates the monitoring that was established for the first module, and Figure 6 demonstrates the monitoring that was built for the second module.

Fig.6 Motion-sensor monitoring.

Fig 7. Range-finder monitoring.

As shown in Figures 3 and 4, the intelligent parking system code was implemented in three main sections.

Part1: The ESP32-CAM module's Internet of Things (IoT) code contains instructions for obtaining signals from onboard sensors (such motion sensors or rangefinders). It also includes the code required to capture a picture with the exact 1024 x 768 pixel resolution and submit it to the Firebase server. The range sensor (R-based) monitoring unit's pseudo code is shown in Table 1, while the passive infrared sensor (PIR-based) monitoring unit's pseudo code is provided in Table 1.

TABLE 1. PIR MONITORING UNIT PSEUDOCODE.

```
define imagePath
Function main_loop()
{ while(true)
motionDetected = get_PIR_sensor_status()
if(motionDetected == true)
capture_image()
upload_image_to_firebase_cloud_storage() }
```

TABLE 2. MONITORING UNIT R PSEUDOCODE.

```
define imagePath
Function main_loop()
{ while(true)
distance = get_dist_to_object()
if(distance<=100)
capture_image()
upload_image_to_firebase_cloud_storage() }
```

Part 3: The Firebase code is a set of instructions used to link the Internet of Things gadget to the cloud storage service that Firebase offers. Table 4 displays an example of the upload function's pseudocode.

TABLE 3. UPLOAD FUNCTION PSEUDOCODE.

```
define imagePath
Function upload_image_to_firebase_cloud_storage()
{ capture_image_and_save_to_file_system()
Firebase_storage_upload(imagePath) }
```

Part 3: The computer vision code is made up of a set of instructions that are executed in order to recognise the letters, preprocess the image, and identify the vehicle's licence plate. The subsequent section, 4.3, will include further information.

*4.2. User Application*

To facilitate effective user communication, the Flutter cross-platform environment was used in the creation of the user application. A snapshot of the application that was built and is necessary in order to complete the parking reservation procedure is shown in Figure 7.

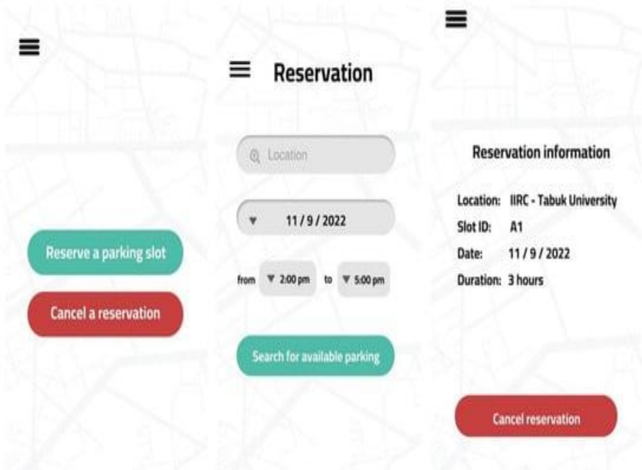


Fig 8. User App screenshot.

## V. CONCLUSION

In this paper, we describe the findings of a thorough investigation into how EC can be applied to the improvement of smart city transportation. A two-tiered taxonomy is used to organize studies that are complementary to one another. The optimization problem's application scenario specifies the first of three levels in the hierarchy. Land, air, and sea travel are all included. According to the objective of the optimization problem, relevant research from the viewpoints of business, government, and individuals is divided into three categories in the second layer of the categorization structure. In this work, we improved a variety of parameters, such as the number of hidden layers, the number of neurons in each layer for deep LSTMs, and the number of epochs, or the number of trainings runs each client does over its local dataset on each round. In two different application situations, the efficacy of the suggested strategy is assessed. We will begin our inquiry into the real-world uses of smart city technology by concentrating on the possible use of traffic prediction models to replace current municipal services. Predictive maintenance models are used in place of actual IIoT services in the second case study. Future directions for research could include developing dynamic and adaptive command and control systems for the entire transport sector, as well as short-term estimates of the size and significance of the transport system in the future (especially when non-cooperative transportation is taken into account). Future efforts may also focus on perfecting the technology behind autonomous, sensing cars for use in transportation that does not rely on human cooperation. The key elements that are made possible by different technologies allow the "smart objects" in smart cities to become increasingly smarter, to the point where they can do their tasks independently. These devices communicate with one another and with people to enhance bandwidth utilization, optimize energy consumption, minimize harmful emissions, and minimize electronic waste—all of which contribute to a more sustainable and ecologically friendly city. We have also identified challenges and possible research directions for the development of sustainable, ecologically friendly smart cities.

## REFERENCES


[1] R. Du, P. Santi, M. Xiao, A. V. Vasilakos, and C. Fischione, ―The sensable city: A survey on the deployment and management for smart city monitoring,‖ IEEE Commun. Surveys Tuts., vol. 21, no. 2, pp. 1533–1560, 2nd Quarterly 2019, doi:10.1109/COMST.2018.2881008.

[2] H. Zhang, S. J. Moura, Z. Hu, and Y. Song, ―PEV fast-charging station siting and sizing on coupled transportation and power networks,‖ IEEE Trans. Smart Grid, vol. 9, no. 4, pp.

2595–2605, Jul. 2018, doi: 10.1109/ TSG.2016.2614939.
doi: 10.1109/TITS.2014.2369002.

[3] C. K. Pappa, N. Ashokkumar, P. Nagarajan and K. Thandapani, "Bluetooth based Garage Door Opening System," 2023 5th International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India, 2023, pp. 131-134,doi: 0.1109/ICSSIT55814.2023.10061046

[4] Anthopoulos, L.G. Understanding Smart Cities: A Tool for Smart Government or an Industrial Trick? Springer International Publishing: Cham, Switzerland, 2017; Volume 22.

[5] A.Kavitha, N.AshokKumar, "Automatic Identification of Maritime boundary alert system using GPS "International Journal of Engineering and Technology Vol 7 ,No.3.1 (2018).

[6] Eremia, M.; Toma, L.; Sanduleac, M. The smart city concept in the 21st century, 10th International conference Interdisciplinary engineering, INTER-RNG 2016. Procedia Eng. 2017, 181, 12–19. [

[7] Albino, V.; Berardi, U.; Dangelico, R.M. Smart cities: Definitions, dimensions, performance, and initiatives. J. Urban Technol. 2015, 22, 3–21.

[8] .P. Vijayakumar, P. D. Selvam, N. Ashokkumar, Sharmila , R. Raj Priyadarshini , M. Tamilselvi, Rajashree. R, Xiao-Zhi Gao , "IOT Based Wireless Smart Shoe and Energy Harvesting System" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ,Volume-8 Issue-7 May, 2019.

[9] W. Wei, X. Xia, M. Wozniak, X. Fan, R. Damaševičius, and Y. Li, ―Multi-sink distributed power control algorithm for cyber-physical-systems in coal mine tunnels,‖ Computer Networks, vol. 161, pp. 210–219, 2019.

[10] B. A, V. N, T. Kudithi, A. S. Prabha, V. K and A. N, "Secured Electronic Voting Using Ethereum Blockchain Technology," 2024 2nd World Conference on Communication & Computing (WCONF), RAIPUR, India, 2024, pp. 1-6, doi: 10.1109/WCONF61366.2024.10692159.Alsamhi SH, Ma O, Ansari MS, Meng Q (2019) Greening internet of things for greener and smarter cities: a survey and future prospects. Telecomm Syst 72(4):609–632

[11] A. Balamanikandan, M. Saravanakumar, S. Gunasekaran, V. Anjum, P. Gurusamy and N. Ashokkumar, "Deep Learning in the Detection of Chronic Kidney Disease," 2024 4th International Conference on Intelligent Technologies (CONIT), Bangalore, India, 2024, pp. 1-6, doi: 10.1109/CONIT61985.2024.10627434.

[12] .B. A, S. M, D. M, V. M, A. N and N. R. Yatm, "Deep Learning-Based Assessment of ILD Designs in HRCT Pictures," 2024 Second International Conference on Intelligent Cyber-Physical Systems and Internet of Things (ICoICI), Coimbatore, India, 2024, pp. 738-741, doi:10.1109/ICoICI62503.2024.10696385.Karaboga, D. Artificial bee colony algorithm. Scholarpedia 2010, 5, 6915.

[13] Zhao, F.; Bao, H.; Xue, S.; Xu, Q. Multi-objective particle swarm optimization of sensor distribution scheme with consideration of the accuracy and the robustness for deformation reconstruction. Sensors 2019, 19, 1306.

[14].Satyam, D. Damodaram, S. Sundar and N. A. Kumar, "Unveiling the Metaverse: A Paradigm Shift in the Future of Internet Interaction," 2023 IEEE Fifth International Conference on Advances in Electronics, Computers and Communications (ICAECC), Bengaluru, India, 2023, pp. 1-6, doi: 10.1109/ICAECC59324.2023.10560205.

[15].X. Zhao, G. Liu, X. Xu and X. Han, "Particle Swarm Optimization Algorithm can Promote Cooperation in Public Goods Game with Costly Punishment," 2024 39th Youth Academic Annual Conference of Chinese Association of Automation (YAC), Dalian, China, 2024, pp. 350-354, doi: 10.1109/YAC63405.2024.10598583.