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A Smart Car Parking System Based on IoT with Gray Wolf Optimization-Probability Correlated Neural Network Recognition Methods

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ABSTRACT

The use of vehicles is increasing every day because of the growing industrialization. Hence, parking the vehicles in the metropolitan cities could create the traffic congestion, which is one of the major problem need to be resolved in the smart city systems. For this purpose, this research work intends to develop a smart car parking system with proper controlling and monitoring units. The main motive of this work was to avoid the traffic congestion by developing an advanced car parking system with the help of Internet of Things (IoT) technology. Also, an image processing technique is utilized in this framework for identifying whether the car is present or not in the parking area. In which, an Anisotropic Diffusion Gaussian Filtering (ADGF) technique is utilized to preprocess the given image for improving the quality and reducing the noise effects. After that, the Grey Level Co-occurrence Matrix (GLCM) is employed to extract the contrast, correlation, energy and homogeneity features. After that, the suitable number of features are optimally selected by using the Grey Wolf Optimization (GWO) technique, which efficiently improves the speed of operation. Finally, the Probability Correlated Neural Network (PCNN) technique deployed for accurately recognizing that whether the car is present or not. For validation, the performance of this scheme is evaluated and compared by using various measures.

1. INTRODUCTION

In the recent days, the Internet of Things (IoT) [1, 2] technology has gained a significant attention in different types of application systems, due to its benefits of high system efficiency, cost-effective nature, and better opportunities. Also, the utilization rate of mobiles, wireless sensors, and embedded system are rapidly increased with the use of the IoT [3-6]. The smart car parking system is one of the interesting and demanding research field in smart city systems [7, 8]. The main purpose of developing the smart car parking system is to avoid the traffic congestions and time delay of processing and waiting. Typically, the smart car parking system [9] has the following benefits:

1. It exactly predicts and sense the occupancy space of vehicles for avoiding congestion.
2. It optimally utilizes the parking space of all vehicles.
3. Due to the incorporation of IoT technology, it efficiently avoids traffic in the city.
4. By using the soft computing methodologies, intelligent decisions are taken at the complex situations.
5. Moreover, the smart car parking system could efficiently create the urban environment with reduced Co_2 emission and other pollutants.

Due to this facts, various car parking architectures have been developed in the conventional works [10-12], which utilizes some machine learning or deep learning models for improving the performance of recognition. In the proposed work, the image processing techniques are employed for accurately recognizing the car image with desired parking location [13, 14]. The major contributions of this research work are as follows:

- To develop an advanced car parking system for reducing the traffic congestion with the help of IoT technology.
- To accurately recognize the parking area, the image preprocessing system is incorporated, which helps to predict whether the parking area is available or not.
- To efficiently preprocess the given image, an Anisotropic Diffusion Gaussian Filtering (ADGF) technique is employed that eliminates the noisy content with increased quality.
- To extract the set of features from the normalized image, the Grey Level Co-occurrence Matrix (GLCM) technique is utilized.
- To optimally select the best features based on the optimal fitness function, the Grey Wolf Optimization (GWO) technique is employed.
- To improve the recognition performance, the Probability Correlated Neural Network (PCNN) technique is deployed.

The remaining portions of this paper are segregated into the following sections: the existing works related to the car parking system in IoT-cloud environment are surveyed with its advantages and disadvantages in Section II. Then, the description of the overall proposed methodology with its appropriate algorithmic illustrations are presented in Section III. Moreover, the overall performance results and comparative analysis of the existing and proposed security models are illustrated in Section IV. Finally, the entire paper is summarized with its advantages and future scope in Section V.

2. RELATED WORKS

Alsafery et al. [3] developed a smart car parking system with the use of IoT technology for noticing the existence of vehicles in the parking area. Here, the data from sensors could be efficiently managed by constructing the middle ware architecture. Moreover, this work intends to reduce the traffic congestion by identifying the nearest free spaces for car parking. In which, the data preprocessing and fusion methodologies have been applied for producing the accurate information to the users. The key benefits of this work were better recognition rate, reduced time consumption, and optimal performance rate. However, it facing the major problems of inefficient computing operations, high misclassification rate, and error outputs. Mudaliar et al. [15] constructed an IoT based car parking system for avoiding the traffic congestion by using the multilayer parking methodology. From this paper, the key components used for designing the smart car parking system have been studied. Ali et al. [5] suggested a deep Long Short Term Memory (LSTM) based smart car parking system for avoiding the traffic congestion problems in the city area. In this framework, the car parking information have been collected through various sensors deployed at the car parking locations. In order to aggregate the sensor information, the deep learning model [16] has been utilized that predicts the availability of free parking space based on the request. Yet, this work limits with problems of increased error rate and high computational complexity in prediction, which degrades the performance of entire system.

Luque-Vega et al. [17] introduced an intelligent smart parking system for analyzing the availability of free spaces through the mobile app. For this purpose, the Smart Vehicular Presence Sensor (SPIN-V) has been utilized in this work, which helps to monitor and control the process. Thangam et al. [18] designed a smart parking reservation system with the use of IoT technology, where the Raspberry-pi was utilized to construct the environment. Here, the face recognition was performed to identify the driver's face for ensuring the security. Lookmuang et al. [19] established a smart car parking system for suggesting the free space to the driver for parking the vehicle. This work [20] mainly objects to reduce the traffic congestion problem by optimally allocating the free space for car parking with the help of IoT technology. Also, it aims to enhance the parking system with reduced time and increased speed of processing. Farag et al. [21] employed a parking entrance controlling mechanism for developing the car plate recognition system. This framework includes the processes of preprocessing, feature extraction, and recognition. Here, the color filtering was utilized to increase the quality of image with reduced noise contents. Then, the Discrete Wavelet Transformation (DWT) [22] technique was used to extract the set of features from the normalized image, where the segmented characters were accurately recognition by using the correlation method. In addition to that, the Support Vector Machine (SVM) classification model was deployed to exactly recognize the image based on the correlation value.

Ke et al. [23] introduced an intelligent parking surveillance system with the AI methodology for ensuring the security. In this framework, the computational load was segregated by the AI technology for IoT local devices, which helps to increase the optimal performance of targeting area. Moreover, an enhanced pipeline model was also utilized to efficiently handle the lighting and occlusion conditions. Yet, the performance of this system was not up to the mark, which was the major limitation of this work. Zantails et al. [24] presented a comprehensive review on various machine learning methodologies used for improving the performance of smart transportation systems. The main contribution of this work was to incorporate the benefits of both machine learning and IoT technology for developing an efficient smart parking system. Here, the different types of machine learning models under the categories of supervised learning, unsupervised learning, and semi-supervised learning have been discussed with its key features. For instance, it includes Deep CNN, Deep Belief Networks (DBN), Hidden Markov Model (HMM), Fuzzy C-Means (FCM), Feed Forward Neural Networks (FFNN), Logistic Regression (LR), and Markov Decision Process (MDP). Based on this study, it was analyzed that the deep learning technique outperforms the other models with increased accuracy and performance rate. Cui et al. [25] conducted a comprehensive review on various machine learning methodologies used for improving the performance of IoT systems. It includes the types of k-Nearest Neighbor (KNN), the Support Vector Machine (SVM), Gaussian Mixture Model (GMM), Decision Tree (DT), Ensemble Learning (EL), and Random Forest (RF) classification techniques, which were mainly used for improving the process of recognition system.

Table 1. Comparative analysis between existing and proposed classification techniques

Methods	Advantages	Disadvantages
Region based Convolutional Neural Network (RCNN)	1. Increased accuracy 2. Reduced cost consumption 3. High scalability	1. Noisy measurement 2. High error rate
Ensemble based classification	1. Reduced system complexity 2. Better performance results	1. Non-parametric approach 2. Inefficient computations
Contrastive feature extraction network	1. It efficiently solves over distortion problem. 2. Accurate recognition rate	1. Increased over fitting 2. High computational complexity
Deep convolutional neural network	1. Speed of processing 2. Accurate recognition	1. Requires more time consumption for training
Wavelet Neural Network (WNN)	1. High accuracy 2. Detection efficiency	1. Over fitting problem 2. High computational complexity

Acharya et al. [26] suggested an image based car parking recognition system by using the deep learning models. This work intends to investigate the performance of various deep learning models used for recognizing the car image based on the set of features of input image. Also, a traffic learning approach [27] was utilized in this work for detecting the available parking space in the desired location, where the visual features have been utilized to improve the effectiveness and accuracy of recognition. However, it followed some complex computations for increasing the speed of operations, which degrades the efficiency of recognition system. Saeliw et al. [28] developed a mobile application based smart car parking system incorporated with IoT technologies. Here, the Radio Frequency Identification (RFID) technique was utilized to improve the efficiency of car parking management. Meduri and Tellus [29] suggested a Haar cascade classifier for designing the smart parking system. Here, the Haar like features have been utilized to improve the object detection performance. This work has the benefits of high recognition rate, increased classification performance, and reduced traffic congestion. Moreover, some of the recent classification techniques used for improving the recognition of car parking system are examined with its advantages and disadvantages as shown in Table 1.

According to this review, it is studied that the existing works utilized various machine learning and deep learning based classification methodologies for developing the car parking system in order to reduce the traffic congestion [30]. However, it limits with the problems of high misclassification rate, increased delay in process, and complexity in algorithm design. In order to solve these issues, this research work intends to develop a new car parking system by integrating the framework with the IoT technology, where an improved optimization based machine learning technique is utilized for accurate recognition of car images [31].

3. PROPOSED METHODOLOGY

This section presents the detailed description of the proposed methodology with its overall architecture and algorithmic illustrations. The main contribution of this paper is to develop an efficient car parking system incorporated with the IoT technology for optimally allocating parking area. Here, the car image identification is performed for accurately recognizing the car located in the specified area by using the optimization based machine learning model. Also, an IoT based monitoring and controlling unit is utilized in this framework for reducing the waiting time, delay of process, and response time. In the car parking scenario, a group of users are required to spend their time for parking the cars in the desired locations. The proposed model objects to reduce the queuing time with the use of car parking management scheme. The overall architecture representation of the proposed model is shown in Figure 1, where IoT cloud server is deployed for notifying the information of cars to the users. When the user parks the car, the request has been automatically generated and passed to IoT server unit. Then, the controlling unit instructs the camera to capture the corresponding car image for monitoring the desired parking location of user. This type of monitoring system helps the user to easily find their vehicle in the parking place with reduced queuing time and delay time. Furthermore, the optimization based machine learning methodology is used for recognizing that whether the destination parking area is available or not. The overall flow of the car image processing system is shown in Figure 2, which includes the following stages:

- Input image obtainment
- Image preprocessing using Anisotropic Diffusion Gaussian Filtering (ADGF) Feature extraction using GLCM
- Grey Wolf Optimization
- Probability Correlated Neural Network (PCNN) based recognition

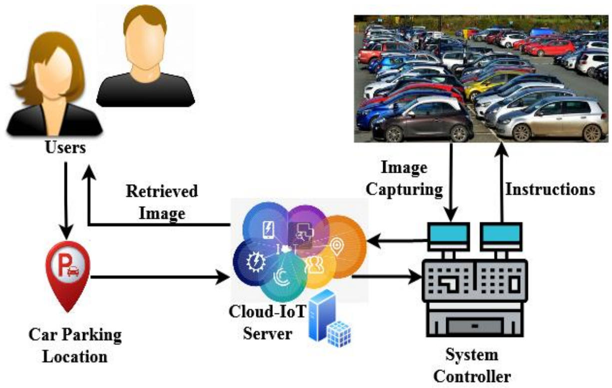

Figure 1. Architecture model of the proposed system

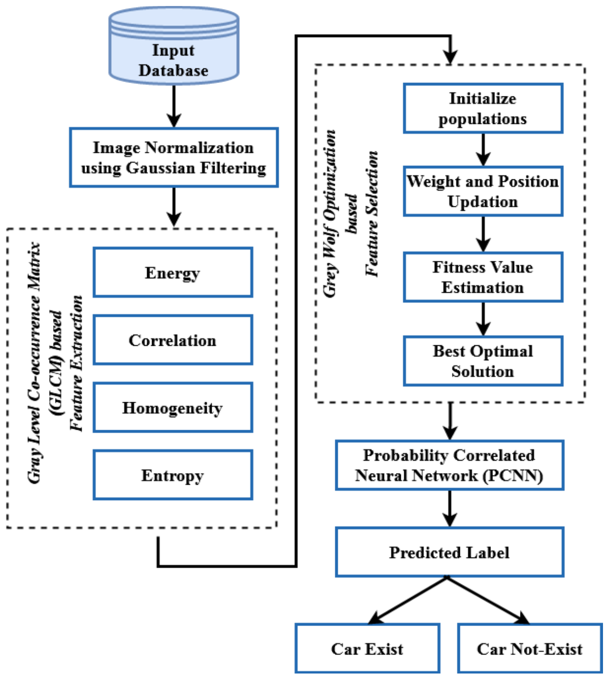

Figure 2. Flow of the proposed system

3.1 Image preprocessing

Generally, image normalization is one of the essential process for the recognition system, because the accuracy of classification is highly depends on the quality of image. Hence, the input image must be preprocessed for eliminating the noise contents, reducing the blurring effects, and increasing the contrast or quality of image. Here, the Anisotropic Diffusion Gaussian Filtering (ADGF) technique is utilized to preprocess the input car image by increasing its contrast and quality of image. Typically, the anisotropic diffusion filters are mainly used for reducing the noise with better edge preservation. Also, it helps to strengthen the edges by solving the scale space problem based on diffusion. Thus, the proposed work intends to use an enhanced ADGF technique for enhancing the overall quality of input image. Here, the diffusion coefficient d_c is selected for sharping the boundaries with inter-region smoothing. For the input car image I_c, the anisotropic diffusion is computed as follows:

$$I_{cx} = div(d_c(a,b,x)\nabla I_c) = d_c(a,b,x)\Delta I_c + \nabla d_c \cdot \nabla I_{cx} \quad (1)$$

where, $d_c(a,b,x)$ indicates the conduction coefficient, div denotes the divergence operator, Δ is the gradient operator and ∇ represents the Laplacian operator. In which, the conduction coefficient is computed for properly computing the edges of image as represented in below:

$$d_c(a,b,x) = s(||\nabla I_c(a,b,x)||) \quad (2)$$

where, $I_{cx} = d_c \Delta d_c$ and its diffusion coefficient is $(s(\nabla I_c))$. After that, the Gaussian kernel function has been utilized to estimate the diffusion coefficients as illustrated in below:

$$s(||\nabla(G \times I_c)||) \quad (3)$$

Based on this value, the obtained anisotropic diffusion Gaussian function is computed as follows:

$$I_c = div(\beta . d_c(||\nabla I_c||) \cdot \nabla I_c) \quad (4)$$

$$\beta = 1 - \nabla G_\sigma \times d_c(I_c) \quad (5)$$

where, β indicates the adaptive term, and G_σ denotes the Gaussian kernel. By using function, the image is normalized with the diffusion coefficients and, the preprocessed image can be utilized for further processes.

3.2 Gray Level Co-occurrence Matrix (GLCM) feature extraction

After preprocessing, the Gray Level Co-occurrence Matrix (GLCM) based feature extraction methodology is used for extracting the set of features from the normalized image. It is one of the extensively used texture based extraction model, where the relationship between the pixels are estimated according to the second-order statistical information. In this framework, four different types of GLCM features such as contrast, correlation, energy and homogeneity have been computed as shown in below:

$$Con_T = \sum_{x,y} |x-y|^2 p(x,y) \quad (6)$$

$$Cor_r = \sum_{x,y} \frac{(x-\mu x)(y-\mu y)p(x,y)}{\sigma x \sigma y} \quad (7)$$

$$En_g = \sum_{x,y} p(x,y)^2 \quad (8)$$

$$Hom_g = \sum_{x,y} \frac{p(x,y)}{1+|x-y|} \quad (9)$$

where, x indicates the row of image, y indicates the column of image, and p is the total number of pixels in the image. In which, the contrast is defined as the color difference value that is mainly extracted for determining the objects of image. Then, the correlation is defined as the kind of dissimilarity measure that is mainly computed for analyzing the contrast of texture value. Similar to that, the energy is computed according to the global uniformity of the given image, and the homogeneity is estimated based on the proximity of element distribution. These features are more useful for improving the recognition rate of classifier.

3.3 Grey Wolf Optimization (GWO) based feature selection

After extracting the Gray Level Co-occurrence Matrix (GLCM) features, the Grey Wolf Optimization (GWO) based feature selection mechanism is utilized for selecting the best suitable features based on the optimal solution. It is a kind of meta-heuristic optimization technique and mainly used for solving complex optimization problems. The major benefits of using this technique are as follows: Increased convergence speed, best optimal solution with reduced number of iterations, and reduced complexity. Hence, the proposed work intends to utilize GWO technique for optimally selecting the features of preprocessed car image, which helps to train the classifier for improving the recognition rate. In this technique, the grey wolves are segregated into four different groups such as α, β, δ, and ω, in which alpha, beta, and delta are considered as the most essential gray wolves. In addition to that, it effectively identifies the feature space for selecting the best subset of feature according to the fitness value. Here, the encircling behavior of grey wolves are computed as follows:

$$\overrightarrow{GV}(a+1) = \overrightarrow{GV_P}(a) + \vec{X}.\bar{Y} \quad (10)$$

where, $\overrightarrow{GV}$ indicates the prey's position vector, a is the number of iterations, $\overrightarrow{GV_P}$ defines the vector of grey wolf, and $\vec{X}, \vec{Y}$, and $\vec{Z}$ are the coefficient vectors computed as follows:

$$\vec{Z} = |\vec{Y} \cdot \overrightarrow{GV_P}(a) - GV(a)| \quad (11)$$

Similar to that, the coefficients $\vec{X}, \vec{Y}$ are estimated as shown in below:

$$\vec{X} = 2\vec{v}.\vec{t_1} - \bar{v} \quad (12)$$

$$\vec{Y} = 2 \cdot \vec{t_2} \quad (13)$$

where, $\vec{v}$ indicates the vector value, $\vec{t_1}$ and $\vec{t_2}$ are the random values. Consequently, the best fitness value of grey wolves α, β, δ, and ω are computed as follows:

$$Fitness = \alpha C + \beta \frac{No_F - L_F}{L_F} \quad (14)$$

where, No_F indicates the number of features, and L_F is the length of feature. The algorithmic steps involved in GWO technique are illustrated in below:

Algorithm I – Grey wolf optimization

Input: Extracted set of features, and N_n number of searching agents;
Output: Optimal solution Opt_B;
Step 1: Initialize the all populations of searching agents randomly as shown in below:
$S_i(i = 1,2 \dots n)$; //n – dimension
Step 2: Initialize the optimization variables as k, K and L;
Step 3: Compute the fitness of each search agent as illustrated below:
S_α = Best search agent;
S_β = Second best;
S_δ = Third best;
Step 4: while (until reaching the stopping criterion) do
Step 5: for i = 1 to N do
The position of S_i is updated;
end for;
Step 6: Update the positions of k, K and L;
Step 7: Estimate the fitness value;
Step 8: Update the parameters as, S_α, S_β, and S_δ;
Step 9: end while;
Step 10: Return $Opt_B = S_\alpha$;

3.4 Probability Correlated Neural Network (PCNN) based recognition

After optimization, the best suited features are considered as the input for classification, which is one of the essential stage in the recognition systems. When compared to the other classification approaches like KNN, DT, NB, C4.5, SVM, RVM, DNN, DBN, and LSTM. Here, the main purpose of using the classification technique is to accurately predict the desired car location with reduced time consumption. It is a kind of machine learning technique, which accepts the features as the input and predicted/recognized label as the output. In this algorithm, the input layers comprises the samples of $a_i = a_1, a_2 \dots a_N$, where a_i indicates the input vector, and it generates the output function as follows: $b_i = b_1, b_2 \dots b_N$. The algorithmic steps involved in this work are as follows:

Step 1: The center value is computed by estimating the distance value as shown in below:
$Di_s = \sum_{y=1}^{n} \exp\left(-\frac{||a_i - p_i||}{(Nei_{r/2})^2}\right)^2$
Step 2: $Di_s - Di_{tp}\exp\left(\frac{||S_S - S_P}{(Nei_{r/2})^2}\right)^2$
Step 3: For all input samples, the distance value is computed as follows:
$F_{xy} = ||a_j - p_i||$
Step 4: Correspondingly, the minimum distance value is estimated as follows:
$p_i' = \frac{1}{h_i}\sum_{a \in c_i} a(1 \le b \le m)$
Step 5: Then, the cluster center is estimated and position updation are performed, and the output associates with the hidden layer could produce the recognized results.
Step 6: Finally, the weight value can be updated according to the learning parameter.

4. RESULTS AND DISCUSSION

This section discusses the performance analysis of both conventional and proposed techniques used for developing the car parking system. Moreover, the effectiveness of the automated parking system for vehicles is evaluated by comparing images taken with and without vehicles parked in the designated area for parking. The user database that was generated contains information about approximately 100 images with cars and 100 images in which cars are not present in the parking area. Precision, recall, accuracy, F1-score, similarity coefficients, and time consumption are the various types of measures that are used for validating the results of the car parking system. Other types of measures include similarity coefficients. The Mean Absolute Error (MAE) of both existing and proposed techniques is displayed in Figure 3. These techniques fall into the categories of k-means, recurrent neural network, and deep Long Short Term Memory (LSTM), respectively. It has been determined, on the basis of this evaluation, that the GWO-PCNN technique provides a reduced MAE value when compared to the other techniques.

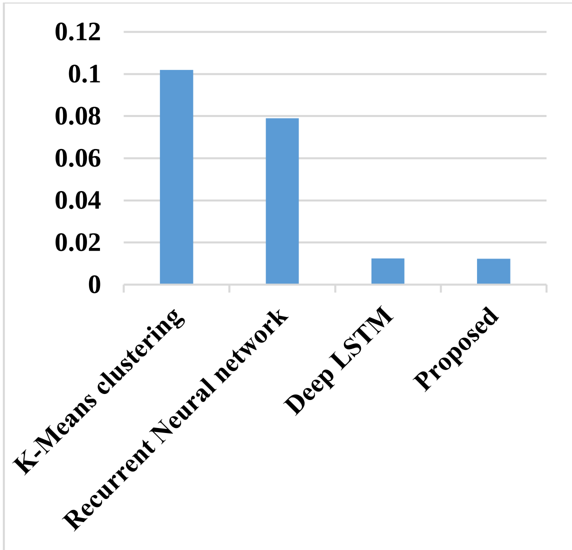

Figure 3. The Mean Absolute Error (MAE) analysis

Table 2 and Figure 4 compares the precision, recall and accuracy values of conventional and proposed recognition approaches. Normally, the performance of classifier is assessed based on the precision, recall and F1-score values. Based on the increased values of these parameters, the overall performance and effectiveness of this system has been determined. The measures are computed as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \tag{15}$$

$$Precision = \frac{TP}{TP + FP} \tag{16}$$

$$Recall = \frac{TP}{TP + FN} \tag{17}$$

$$F1\_Score = \frac{2 \times Precision \times Recall}{Precision + Recall} \tag{18}$$

where, TP indicates the true positives, TN is the true negatives, FP is the false positives, and FN indicates the false negatives. From the analysis, it is evident that the precision, recall, F1-

score, and accuracy of the proposed PCNN technique has been increased, when compared to the other techniques. In the proposed scheme, the optimal number of features are utilized for training the classifier, which helps to increase the overall performance of recognition system.

Table 3 and Figure 5 compares the detection accuracy of both conventional mask RCNN and proposed PCNN techniques with respect to varying memory size. Similar to that, Table 4 and Figure 6 evaluates the time and spatial accuracy of the security models corresponding to varying memory size. Normally, the overall performance of the classification approach is validated based on the level of accuracy. From the results, it is evident the accuracy of the proposed security model is efficiently improved, when compared to the other techniques.

Table 2. Analysis on precision, recall and accuracy

Metrics	MLP	KNN	RF	DT	EL	PCNN
Precision	64.63	73.04	86.90	91.12	92.79	96.8
Recall	52.09	67.46	80.11	90.28	89.24	96.8
F1-score	57.69	70.14	83.37	90.69	90.98	95.6
Accuracy	70.48	76.71	86.50	92.25	92.54	98.5

Table 3. Detection accuracy

Memory size	Mask RCNN	Proposed
5	89.2	90.6
25	90.2	92.3
50	94.6	95.4
100	93.5	96.8
150	93.0	97.2

Table 4. Time accuracy and spatial accuracy

Memory size	Mask RCNN		GWO-PCNN	
	Time accuracy (%)	Spatial accuracy (%)	Time accuracy (%)	Spatial accuracy (%)
5	91.2	71.3	92.5	72.5
25	91	80	93.2	83.4
50	88.9	83.2	91.5	93.6
100	88.7	87.5	90.8	92.4
150	86.1	87.9	89.9	92.6

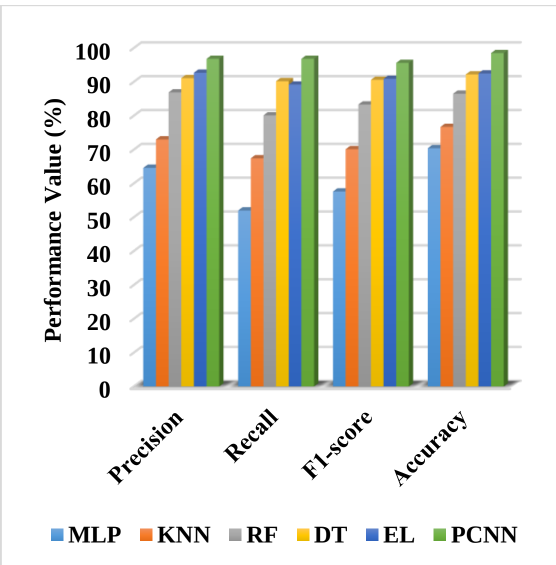

Figure 4. Comparative analysis between existing and proposed schemes

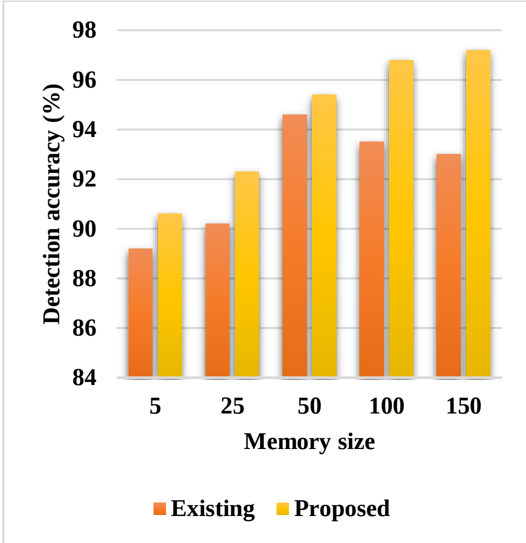

Figure 5. Detection accuracy of existing and proposed scheme

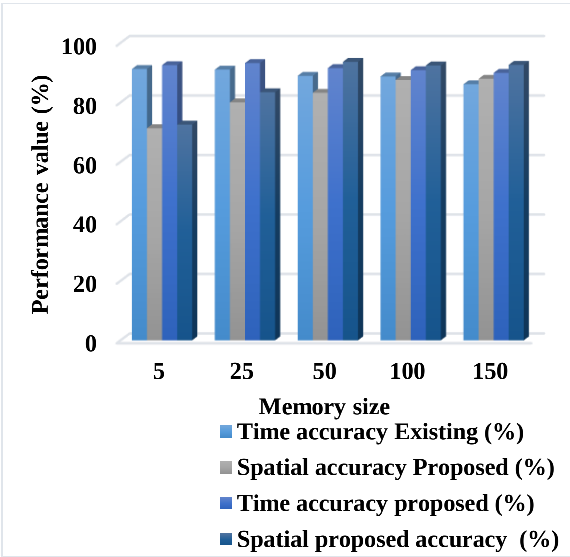

Figure 6. Spatial and time accuracy analysis of conventional and proposed techniques

5. CONCLUSION

This paper developed a new smart car parking system by using an IoT technology for avoiding the traffic congestion in the smart cities. The main purpose of this work was to develop an IoT based monitoring and controlling unit for reducing the waiting time, delay of process, and response time. Then, the controlling unit instructs the camera to capture the corresponding car image for monitoring the desired parking location of user. This type of monitoring system helps the user to easily find their vehicle in the parking place with reduced queuing time and delay time. Here, the Anisotropic Diffusion Gaussian Filtering (ADGF) technique is utilized to preprocess the input car image by increasing its contrast and quality of image. The proposed work intends to utilize the Grey Wolf Optimization (GWO) technique for optimally selecting the features of preprocessed car image, which helps to train the classifier for improving the recognition rate. The main purpose of using the PCNN classification technique is to accurately predict the desired car location with reduced time consumption. During evaluation, the performance of the proposed technique is validated and compared by using various measures. From the obtained results, it is concluded that the proposed GWO based PCNN technique outperforms the other techniques by accurately recognizing the car image with reduced error rate.

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