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An Internet of Things-based auto-parking locate-detection system

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***Abstract*—One of the biggest issues with urban transportation is traffic congestion since it results in enormous energy use and air pollution. One of the main causes of traffic bottlenecks is the lack of open parking places. Parking and congestion go hand in hand since looking for a location to park causes further delays and boosts local traffic. 10% of traffic circulation in the middle of big cities is caused by cruising, as vehicles spend over 20 minutes looking for free parking. In order for cars to be aware of the location, time of day, and occupancy of parking lots in advance, it is essential to establish a system for predicting the quantity of available parking space. In this study, we proposed a parking spot availability prediction system based on artificial neural networks that makes use of the Internet of Things (IoT), cloud computing, and sensor networks (ANN). To assess the effectiveness of artificial neural networks, we utilize the dataset from Birmingham parking sensors. Following the application of the ANN model to the dataset, we will attempt to utilize RNN to determine which model will provide us with the maximum accuracy or be the best match for our dataset. The results of the experiments demonstrate that the suggested model performs better than the most recent prediction models.**

I. INTRODUCTION

The highest population increase in contemporary times has been seen in the major cities in the globe as a result of the ongoing migration of rural residents to urban regions. Two-thirds of the global total will reside in cities by 2050, predicts the UN Population Division. In fact, in order to promote smart city initiatives and cutting-edge technologies, we need a worldwide urban infrastructure. In response to growing urbanization concerns, advances in sensor and sensor network technology have led to the establishment of a new governance paradigm that may be utilized to design, execute, and support environmental development systems.[1,2,3,4]. Promoting environmentally friendly urban mobility and easing traffic congestion, especially when parking spaces are few, are the two principal barriers to urban growth.[5,6].

As technology develops, the IoT as well as deep learning concepts may be used to improve smart city design. This will enable us to address urban transportation issues on a constant basis and provide communities with infrastructure that is resilient from an economic, environmental, and social standpoint. Citizen[1]. Today's highly developed technology aids drivers by delivering information about accidents, road conditions, accidents, and alternative routes, typically in the form of mobile applications. Parking is still a challenge since there are so many cars on the road. As [7] shows how hunting for a parking space results in several liters of petrol being wasted by automobiles. Usually, 30% of his traffic is caused by him looking for an empty parking spot. As shown in [5], drivers waste an average of 3.5 to 14 minutes trying to find a parking space. Moreover, it leads to traffic jams, fuel consumption, air pollution, and driver irritability, all of which are detrimental to sustainable development. Knowing in advance which parking spaces are available in this scenario may help to resolve the problem. This problem may be resolved by employing deep learning algorithms and IoT integration to predict parking lot availability and occupancy with high accuracy.

ANN is an artificial adaptation system inspired by: Functional processes of the human brain. It is a system that can change the internal Structures related to functional goals. They are Especially suitable for solving non-linear problems, to be able to reconstruct the applied fuzzy rules Best solution for these problems. [13]

Recurrent neural networks (RNNs) are a type of neural network that makes use of the sequential nature of the input[9]. Text prediction, POS tagging, and power utilization are just a few of the time-sensitive applications that regularly make use of RNNs. Time-dependent inputs are a feature that many problems have in common. In other words, event estimates are based on previous occurrences. Parking lot occupancy and occupancy duration are time-series concerns [5,8]. The time of day, the completion of the prior event, and crowd sensing all have a significant impact on each parking event [11,12]. So, it is possible to anticipate parking lot time and occupancy using RNNs.

II. RELATED WORK

It's a significant inconvenience for vehicles to look for a parking spot in a highly congested city. There could be major backups if there isn't enough parking. Several researchers in the field of computer vision have recently discovered the promising new topic of autonomous smart parking systems. [14] We demonstrate that our method is more accurate than image-based instance segmentation alone, and that it beats industry standards that depend on more expensive sensors like radar. Our technology's scalability to a whole city and its ability to deliver sophisticated data beyond basic binary occupancy rates are both encouraging developments. [15] Controllers and Infrared Sensors - Increasing population and automotive manufacturing necessitate the construction of parking garages and other parking facilities. Drivers in major cities, especially during rush hour, are growing increasingly upset by parking problems that are rapidly escalating as a result of the rising number of vehicles on the road. [16]

The urban population has exploded during the last several decades. Migration from the countryside is a key factor in this issue, and it is particularly severe in developing countries like Morocco. It's common knowledge

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that today's youth would rather not live in the country but instead in the city, where they can take advantage of the many services and employment possibilities it provides. Urban overcrowding has a negative impact on a variety of municipal services. [17] The requirement for parking spaces is steadily growing as a major problem in modern society. We still use a time-consuming and inefficient manual system for parking vehicles in India, which necessitates turning on the lights whenever someone has to stop their automobile. The lack of a standardized parking scheme also causes problems. [18,19] The increasing popularity of linking disparate smart objects for the sake of Internet of Things applications has led to an increase in the communication density of wireless sensor networks. More people using the same unlicensed radio channels will create congestion, prompting research into better ways to manage the airwaves and save power, such as transmission power control. Several popular protocols increase energy usage to reduce interference (such as packet loss, delay, and energy waste). [20]

Several facets of society have been boosted, and the general quality of life has improved, as a result of the Internet of Things' rapid ascent and continuous growth (IoT). Numerous global cities are seeking the creation of "smart" infrastructure. Citizens of "smart cities" often appreciate intelligent parking solutions since they save time, money, and the environment. Intelligent parking system designs conform to specific rules (sensors, communication protocols, and software solutions). [21]Future data-driven traffic flow efficiency in smart cities will be facilitated by the widespread deployment of IoT - based autonomous car categorized systems, which will also transform the road network into a dynamic to sense Cyber-physical System (CPS). There have been several concepts for traffic sensing systems, but none of them now satisfy all of the requirements (such as accuracy, robustness, cost-effectiveness, and privacy protection) simultaneously. [22] Using fog computing, this research presents a new smart parking architecture meant to improve upon current real-time parking solutions. The fog nodes of a parking lot and garage work together to communicate parking availability and handle requests in real-time. By demanding the worldwide optimization of parking request distribution, the cloud-based data center has the potential to expand the value of intelligent parking systems. [22]

Artificial neural networks disclose the basic principles of an issue. Instead of processing data in accordance with established rules, ANNs are data processing systems that use the data they receive to learn the rules governing them. As a result, ANNs are particularly useful for solving issues when we know the pertinent data but are unaware about their correlations. With artificial neural networks, generalization, prediction, and recognition are all possible. If trained with the proper data to identify the hidden rules behind a certain phenomenon, an ANN may correctly generalize to data it has never seen before (new, dirty, incomplete data, etc.). [23,24]

III. Proposed System Setup

The proposed method builds an automated parking system using a microcontroller. Parking lots with IR sensors are placed to reduce the likelihood of accidents by automatically guiding cars to open spots. There is an ultrasonic sensor in each parking space. The ultrasonic sensor checks to see if a car is correctly parked in a designated area. IoT is being used in this project to make the billing process hands-free. Later on we have used ANN and RNN models to compare the accuracy of the FreeParkingSpace available.

Requirement Specifications

A technical description of these requirements can be found in the software product requirements document. The requirements analysis process begins with a list of what the desired software system must be able to do in terms of functionality, performance, and safety. The specifications detail the kinds of user, operational, and administrative scenarios that can arise. A software requirements specification is a document that aims to offer a thorough explanation of the goals, parameters, and outputs of a software development project. The target audience, necessary user interface components, and technical specifications are all laid down here. The document lays out the goals of the project from the viewpoints of the client, the development team, and the target audience.

IV. Hardware And Software Specification

Software Requirement

- Compiler: Arduino IDE
- Language: c, c++
- Google Firebase

Hardware Requirement

- Arduino mega
- ESp8266
- IR -2
- Ultrasonic sensor-2
- Servo motor-2
- RFID reader
- LCD

Architecture Diagram

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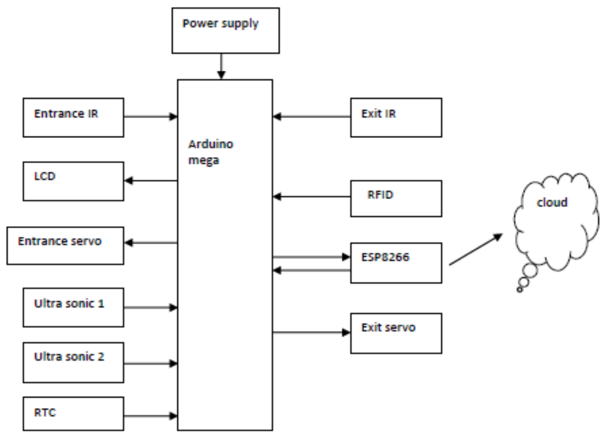
BLOCK DIAGRAM



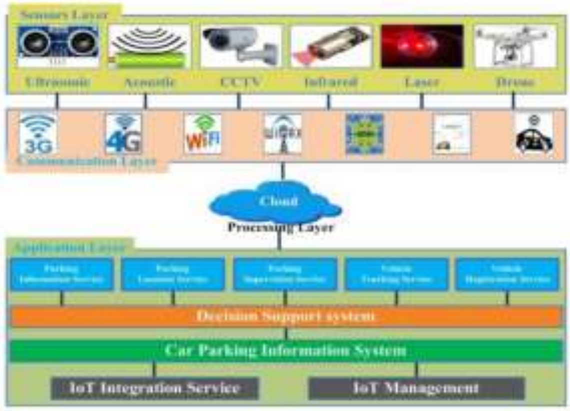
V. BLOCK DIAGRAM DESCRIPTION

Overhead block diagram components include a liquid crystal display, radio frequency identification reader, infrared sensor, ultrasonic sensor, two servo motors, and a real time clock. The infrared sensor, ultrasonic sensor, and servomotor are all wired directly to the GPIO pin of the Arduino mega. Each garage entrance is outfitted with an infrared (IR) sensor. When an incoming vehicle is identified by the entrance IR sensor, the controller will initiate the process and show the parking spot number on the LCD panel. An ultrasonic sensor can tell you whether or not a parking spot is available. A radio frequency identification (RFID) module is used in the financial transaction process. An ESP8266 WIFI chip is used to relay data from the controller to the cloud. Exit IRs are installed to unlock cars from their parking spots

VI. PROJECT INTRODUCTION

This research proposes a sensor-based smart parking availability prediction architecture. The smart vehicle parking system's architecture was used to create the auto parking prediction system. Many parking smart sensors that have been installed at various automobile parking spots are used to collect the parking data. To evaluate the availability of parking spaces at multiple vehicle parking facilities, deep learning techniques have been utilized to aggregate sensing device information from several sites on a cloud. We examine the numerous transportation management activities in a contemporary city, such as parking availability, parking allocation, parking monitoring, vehicle surveillance, and car registration, in order to anticipate the availability of available parking spots using a sensor network.

This is a design for the Internet of Things-based smart parking system that is advised. The sensor layer, the connection layer, the processing layer, and the services layer are its four tiers. The sensor layer uses a variety of sensor types to gather data on vehicle traffic from various parking lots. In the communication layer, sensor nodes are employed to send this data to cloud computing. Using the long-range wide-area network, the gateway received data from sensors (LoRaWAN). The enhanced range of the energy-efficient LoRaWAN technology allows data to be sent throughout the whole parking lot.



VII. IMPLEMENTATION

Here you'll find a rundown of all the maneuvers your car will need to do in order to park properly utilizing our technology.

Step 1: To begin, you must get the smart parking software on your mobile device.

Step 2: The user may see how many spots are open and taken by gazing at the 16x2 display.

Step 3: Once the user has signed in, they will be able to see the parking garage and see which spaces are now taken and which are available.

Step 4: Fourth, if a parking place is available, the user will be alerted by smartphone when he approaches the parking IR detect sensor.

Step 5: Last but not least, if the user attempts to find a parking place and there is none available, the app will inform them.

Step 6: Sixth, once a user utilizes a parking place that has become available, they will be notified of the time and location at which their parking period began.

Step 7: When you're done with your parking session, you may unload your vehicle and get a text message with information on the start and end timings, as well as the total cost, of your parking session.

A. *Keras Library*

Created with a center on spry testing. Getting information from thoughts as rapidly as conceivable is key to great research.Keras is the TensorFlow platform's high-level API.An effective and open interface for understanding advanced machine learning issues with a center on profound learning. It gives basic deliberations and building pieces for creating and executing exceedingly iterative machine learning arrangements. Thanks to Keras, engineers and scientists may take full use of the adaptability and cross-platform capabilities of the TensorFlow stage. You may submit Keras tests to run on a mobile device or in your browser. You can even run Keras on huge clusters of TPUs or GPUs. The Sequential and Dense Keras libraries will be used.

Sequential -Build your model layer by layer using the sequential API. Using a functional API is a different approach for building more complex models. A functional

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model can specify several level-shared inputs or outputs. Create a model instance and link it to the plane before you can access the model's inputs and outputs.

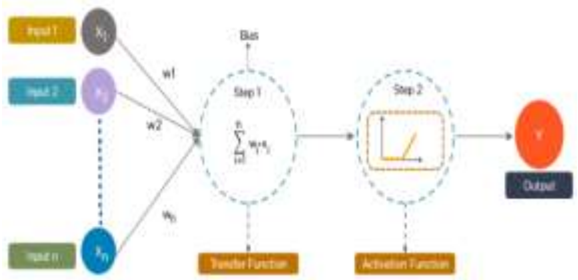
Dense -A layer of the Keras model or neural network known as the keras dense is produced once all connections have been connected extremely deeply. In other words, all of the network's neurons in the bottom layer serve as the dense layer's input sources. The concept, network output, typical methodology, parameters, keras dense example, and conclusion of keras dense will all be discussed in this article.

We execute the neural networks in our project using the Keras library. This library also aids in the creation of the units, or hidden layer, that we need to build for our neural network model. The neural network and its initial layer are created using the sequential function, while further hidden layers that will provide more accurate results are created using the dense function.

B. ANN (Artificial Neural Network)

The operation of the human brain is greatly simplified by ANN models. Artificial neurons serve as computing units, much as the neurons found in the biological nervous system. Input, hidden, and output are the three primary layers of an ANN model. The neurons in the (n + 1)th layer receive signals from all of the neurons in the nth layer. Each connection is given a weight. Each input may be multiplied by the appropriate weight to determine the output. Before producing the final ANN output, an activation function evaluates the output.

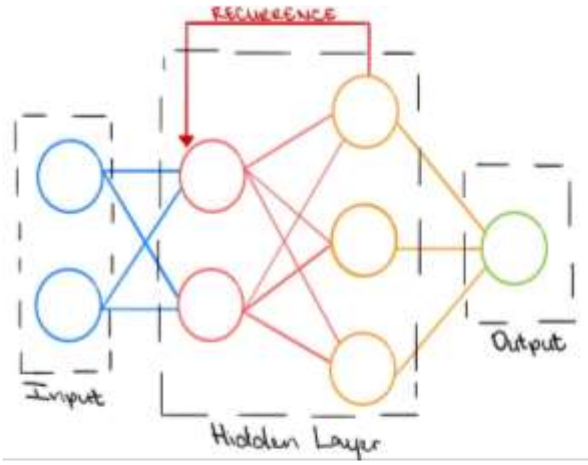
The ANN might be useful for a number of scientific and technical problems. As a result, the ANN is used in a broad variety of applications [3], such as signal processing, image compression, function approximation, differential equations, stock market prediction, and diagnostics.



In our project we use the Artificial Neural Network (ANN) to get the flow of the dataset and to create the hidden layers in between the input and the output layers of the given dataset to learn the dataset and provide the best accuracy out of it.

C. RNN (Recurrent Neural Network)

Artificial neural networks called recurrent neural networks employ time series or sequential data (RNN). These deep learning algorithms are used by Google Translate, Siri, and voice search. Ordinal or temporal issues in speech recognition, picture captioning, and natural language processing are frequently addressed by them (nlp). Recurrent neural networks (RNNs), similar to feedforward and convolutional neural networks (CNNs), learn new information from training input. They differ from other systems because of their "memory," which enables them to use data from earlier inputs to affect the current input and output.



In our project we use the Recurrent Neural Network (RNN) to get the flow of the dataset and to create the hidden layers in between the input and the output layers of the given dataset to learn the dataset and provide the best accuracy out of it.

D. LSTM (Long short term memory)

Long short-term memory is an artificial brain configuration utilized in the realms of manufactured discoveries and profound learning (LSTM). Similar to connections with criticism, LSTM displays feedforward neural networks in a different way. Instead of just preparing single information foci (like pictures), such a repeating neural organism (RNN) may also prepare information groups (such as discourse or video). This property makes LSTM systems perfect for preparing and anticipating information.

VIII. Metrics

A. ANN

Formula:-Y=W1X1+W2X2+b

where , Y= the output neuron or feature

X= the sample feature or the input

W= the weight associated with each features

b= the bias

B. RNN

The RNN model has 3 formulas

The first one is used to determine the current state and is

CS = f(CS-1, IS)

CS -> current state

CS-1 -> previous state

IS -> input state

For using the activation function (tanh), the second formula is

CS =tanh(Wrn * CS-1, Wxh * IS)

Wrn -> weight at recurrent neuron

Win -> weight at input neuron

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The third formula is used to compute the result.

Ot = Wol * CS

Yt -> output

Wol -> weight at output layer

We have also used some other formulas in our ML model which are

C. Mean

Formula:-

$$\mu = \frac{1}{N}\sum_{i=1}^{N}(x_i)$$

Where μ = mean

N= total number of features

X= features

Example-

For Capacity,

mean = (577+...+1200+…+1920)/35718

= 1397.511003

For Occupancy,

mean = (61+…+854+…+1180)/35718

= 642.2109301

For FreeParkingSpace,

mean = (516+…+346+…+740)/35718

= 755.3000728

D. Standard deviation

Formula:-

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where, μ = mean

N= total number of features

X= features

σ = Standard deviation

Example

For Capacity,

standard deviation = √[(577-1397.511) 2+…+(1920-1397.511) 2]/35718= 1179.310323

For Occupancy,

standard deviation = √[(61-642.210) 2+…+(1180-642.210) 2]/35718 = 656.9463379

For FreeParkingSpace,

standard deviation = √[(516-755.300) 2+…+(740-755.300) 2]/35718 = 787.538578

E. Standardscaler

Formula:-

$$z = \frac{x - \mu}{\sigma}$$

Where, X= features

σ = Standard deviation

μ = mean

z= Standardscaler

Example

For Capacity,

standardization (1st value) = (577-1397.511)/1179.310 = -0.695

standardization (2nd value) = (1200-1397.511)/1179.310 = -0.167

standardization (3rd value) = (1920-1397.511)/1179.310 = 0.443

For Occupancy,

standardization (1st value) = (61-642.210)/656.946 = -0.884

standardization (2nd value) = (854-642.210)/656.946 = 0.322

standardization (3rd value) = (1180-642.210)/656.946 = 0.818

For FreeParkingSpace,

standardization (1st value) = (516-755.300)/787.538 = -0.303

standardization (2nd value) = (346-755.300)/787.538 = -0.519

standardization (3rd value) = (740-755.300)/787.538 = -0.019

F. **Mean Squared Error**

The mean squared error, sometimes referred to as the mean - square deviation of an estimator in statistics, measures the average of the squares of the errors, or the mean of the squares difference between the two estimated values and the actual value.

Formula

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2$$

MSE = mean squared error

n = number of data points

Y_i = observed values

$\hat{Y}_i$ = predicted values

G. (APE)- Absolute Percentage Error

The difference between the observed and the true value is all that the absolute error, which is utilised to compute percentage error, consists of. When the absolute mistake has been divided by the true value, the percentage error is calculated by multiplying the relative error by 100.

Formula:-

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$$\left|\frac{A_t - F_t}{A_t}\right|$$

Where, At = Observed Value

Ft = Predicted Value

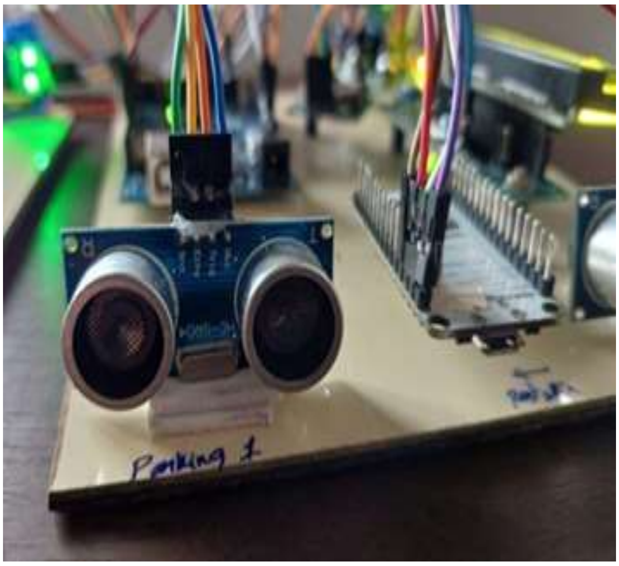
IX. Result And Discussion

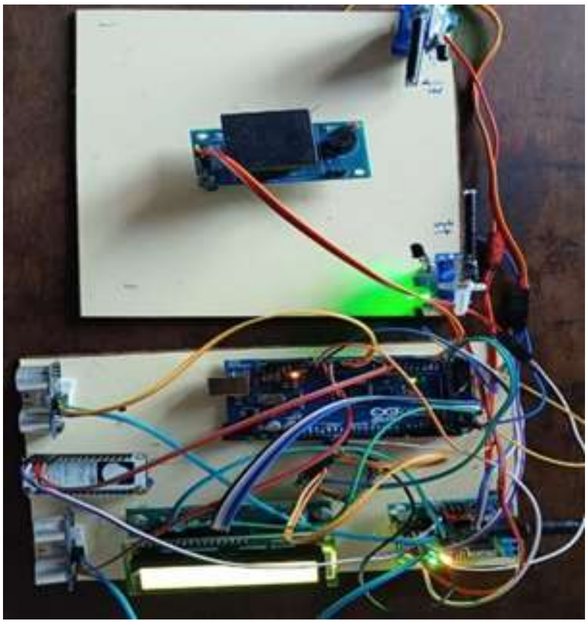
Cars may be parked quickly and easily with the help of an automatic system. The depicted parking arrangement can accommodate up to two vehicles. The required living space is about equivalent to that of a garage big enough to fit two cars. The best option for parking near major shopping centers, office buildings, and other destinations. The framework requires just little assistance to operate normally. The deployed sensors provide a high degree of adaptability and are quite straightforward to integrate into an existing system. The simplest design that achieves the maximum potential degree of automation. It does not rely on there already is a path leading to a quantifiable result. Vehicles must be politely turned around at the entry and departure. The car's safety was the first priority.

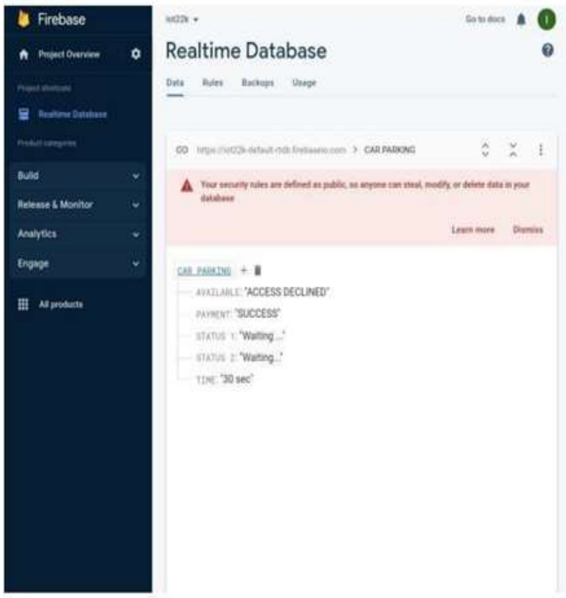
The development of Internet of Things-based smart parking information systems is one of the most significant research fields for the growth of sustainable smart cities. Drivers might find it useful to locate a free parking space nearby. Also, one can save time and effort by accurately and successfully anticipating when a parking place will open up. In this study, we developed an Internet of Things-based smart parking system. This article's main objective is to use sensor data to estimate the total number of easily available parking spaces. To help the car parking information management system with the availability of parking places on a certain day of the week during a specified time period, we have developed a quick and simple decision assistance system.

Using the recommended method, vehicles will be able to locate a parking space at any time and anywhere. We believe that combining cloud services with sensing devices will make the collection and processing of sensor data easier than using traditional techniques. Implementing all of the services (parking position, parking data, parking monitoring, vehicle surveillance, vehicle registration, and identification) stated in the created framework for smart parking is part of the project's continuous effort.The development of several techniques to estimate parking lot availability in real-time using image and video data gathered by various sensors will be the focus of future study.

According to the dataset which is taken we apply the two of the best neural network models that is the Artificial Neural Network and the Recurrent Neural Network in our dataset to get the accuracy of our dataset and compare which neural network gives us the best accuracy for our dataset.







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X. Conclusion

A very sophisticated parking sensor system was displayed during the presentation. Without the involvement of the user or the vehicle, it provides real-time parking monitoring and payment. By streamlining the system, investing in infrastructure, and replacing batteries, the sensor system lowers costs while providing advantages in terms of detection and payment dependability. The suggested creative method makes this possible. Further validation tests are being run right now to better improve the system.

XI. General Information About Dataset

Birmingham City's 30 parking lots served as the source of the dataset for deep LSTM network training and testing. A total of 35,718 vehicles can park in the 30 spaces available. There is a full presentation of the dataset for the automobile occupancy sensors.

Features	Descriptions
SystemCodeNumber	A variable that identifies car park id
Capacity	Variable that contain the capabilities of park
Occupancy	The variable that contains occupancy of park
FreeParkingSpace	Variable that contains the free slots of the park
LastUpdated	Variable that have Date and Time of the measure

The dataset used for testing has "SystemCodeNumber," "Capacity," "Occupancy," and "LastUpdated," among other four properties. The properties "Capacity" and "Occupancy" provide details regarding a parking lot's overall capacity, "LastUpdate" informs you of the most recent time the location's occupied parking spaces were updated, and "Occupancy" provides information regarding the number of spaces that are occupied at any given time. To estimate the availability of free parking lots at a certain hour on a specific day at a specific parking location using a regression model, we created a new feature we term "free parking space." We were able to calculate the value of the "free parking place" by comparing the "Capacity" and "Occupancy" properties. In the regression model created using deep learning, this feature of free parking served as the target variable.

XII. Accuracy

How often a machine learning classification system properly recognises a data point may be ascertained, for example, by looking at the accuracy of the algorithm. Accuracy is measured as the proportion of all data points that were properly anticipated. A more precise definition is the proportion of true positives and true negatives to all true positives, true negatives, false positives, and false negatives. The programme properly identified a data point as true or false as a genuine positive or genuine negative one. Contrarily, a data point that the algorithm misclassified is referred to as a false positive or false negative.

Since we have applied two neural networks on our dataset we got two different accuracy of our dataset.

MODEL	ACCURACY
ANN	50.43
RNN	50.07

The accuracy for ANN model is 50.43

The Accuracy of ANN model is: 50.435713229412244

	Capacity	Occupancy	FreeParkingSpace	APE
0	690.0	302.0	300.944336	56.384879
1	1920.0	543.0	540.291626	71.859811
2	4675.0	3420.0	3420.555664	26.833034
3	1200.0	999.0	999.385010	16.717916
4	2009.0	648.0	645.366455	67.876234

The accuracy for RNN model is 50.07

The Accuracy of RNN model is: 50.07444715013756

	Capacity	Occupancy	FreeParkingSpace	APE
0	690.0	302.0	297.252411	56.919940
1	1920.0	543.0	565.275391	70.558573
2	4675.0	3420.0	3428.657227	26.659738
3	1200.0	999.0	1012.041626	15.663198
4	2009.0	648.0	658.720398	67.211528

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