Smart Parking Model based on Internet of Things (IoT) and TensorFlow

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***Abstract*—This paper first proposes a smart parking model to reduce the wastage of time where it allocates the free parking spaces and helps the driver to navigate in the parking area. With the help of the Internet of Things (IoT) and Google Cloud, we can easily allocate the free spaces. Through an Android application, the user can see the free parking spaces and book the place. We have used Deep Learning algorithm for the user verification process and to navigate in the parking area, a navigation bot is developed using Deep Reinforcement Learning (RL). TensorFlow, a deep learning framework is used for developing the navigation bot and implementing the deep learning algorithm. In our experimental approach, we have got 98% accuracy rate in license plate detection and our proposed model can reduce the wastage of time by 50% which gives a better performance than the other traditional methods.**

***Index Terms*—IoT, Parking Model, TensorFlow, Navigation Bot, Deep Learning.**

I. Introduction

In modern cities, car ownership is increasing day by day where parking has become a major challenge for citizens. People waste their valuable time to find a nearby parking space to park their car. Therefore, a smart parking system is essential for comfortable movement in urban areas. Many kinds of research have already done but most of them focus on sharing free parking spaces to the people but they do not focus on the navigation and how they will allocate these spaces among the drivers. Still, people can not manage their time because they do not know whether they will get the parking space or not. Moreover, It is difficult for them if the parking area is very large with many cars. They need to wander for a long time to navigate and find their space which causes sometimes traffic congestion and it wastes people's time and fuel. The first motivation of our paper is to reduce the wastage of time of parking. Our model aims to save people's time by allocating them a free parking space in a nearby parking area and help them to navigate that place. It has been observed that people find it very difficult to find a nearby vacant parking place and they even do not know how to book that place. This paper first provides a complete model to provide a free parking space, how to reserve or book the place and help them to navigate in the indoor parking area. With the blessings of Internet of Things (IoT) enabled sensors, Cloud and other machine learning algorithms, our proposed model is able to help citizens to reduce the wastage of time for parking.

In a parking area wireless sensors are a good choice to find out the status of free parking spaces. This sensors is vastly used in parking areas [3, 4, 5, 6, 7]. Ultrasonic sensors use a single transducer used to receive and send the ultrasonic sound. All these sensors are working as a node where the node changes its value for specific tasks. By sending and receiving of the ultrasonic pulse, sensors determine the target. When sensors find an empty space in a parking area it changes the value. Raspberry Pi or Arduino is needed to collect data from the sensors. By using a microcontroller device e.g Raspberry Pi it is easy to check the value and then store it in the cloud.

Cloud is huge storage where we store, retrieve and update the data. Google Cloud is a free and open source cloud platform to do all the tasks. Google Cloud IoT Core is a service that allows collecting millions of data from devices. The amalgamation of Cloud IoT Core and other Cloud services help us to do all the tasks such as collect, retrieve, update and manage data collected from the wireless sensors. Integration between wireless sensors and Cloud is beneficial to keep and store data [10, 11]. Also, the cloud can help us to share those data with other smartphone applications. Smartphones are the major elements to build IoT based solutions. A smartphone application is essential to connect and see the information about the parking spaces. The smartphone application has a unique User Interface (UI) system for the data or information visualization. Smartphone application uses MQTT (Message Queuing Telemetry Transport) or CoAP (Constrained Application Protocol) is used. CoAP protocol performs better than the HTTP protocol[15].

Deep learning or deep structured learning is a new area of Machine learning. Deep learning is based on Artificial Neural Network. Nowadays deep learning is using in many areas such as Computer Vision, Image processing, etc. Modern algorithms take deep learning to a step closer to its final destination, Artificial Intelligence. Deep learning shows higher accuracy in detecting and recognizing different type of objects. Google's TensorFlow, a popular deep learning framework helps to implement different deep learning algorithms easily.

This paper aims to solve two challenges of the parking system. First, our model helps to allocate the free parking spaces

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and secondly using deep learning algorithm a navigation bot is proposed which will guide the driver in the parking area. Consequently, it will reduce the wastage of time and fuel. There are lots of work we have done to build our model but some major contributions are:

- We have implemented cloud-based architecture using Google Cloud IoT Core.
- We have proposed an Android application which has a feature to find and book the nearby free parking space.
- We have implemented Convolutional Neural Network (CNN) algorithm by using TensorFlow which shows 98.5% accuracy to detect a license plate.
- We have proposed a navigation bot using Deep Reinforcement Learning (RL) which will be developed by TensorFlow.

The rest of the paper is organized as follows. Section II refers to the previous research on parking system and how our model is different from them. The whole system architecture is presented in section III. Section IV describes the CNN algorithm to detect license plate using TensorFlow and workflow of the navigation bot. Section V refers to our steps to implement the model. Section VI shows how our model saves time than the traditional method. Finally, section VII concludes our work.

II. Related Works

In [2] authors use wireless sensors to get the data of free parking spaces. The information of Light-Emitting Diode (LED) will help to find the right slot at the parking place. However, their proposed system [2] will work nicely under small parking areas but in big parking areas, it will be difficult to locate the parking spot using LED.

ZigBee, a wireless communication system is used to make a smart parking system [8]. They used GSM for the notifications via SMS or software application of parking spaces. They use IR sensors to find parking spaces. Their approach is unique but using GSM to provide notification is not a faster process and it is costly.

In [9] authors develop a webpage to show the empty spaces of the parking area in a real-time monitoring system. A notification via message will pop up to indicates that the parking area is full. They have used two types of sensors for outdoor and indoor parking area. However, taking data of the parking spaces is a good approach than other system but to update or manage data to a webpage is a painful job and using two types of sensors will be costly.

A proposed model [12] use some IR sensors and an embedded controller for real-time data collection where they develop a database server to store and update data of parking spaces. They use a Direct Current (DC) motor at the entry gate to allow access for the Identity Document (ID) holders. using DC motor to allow the access is a beneficial approach for the security purposes but the model will not perform well when there are too many cars at the same time.

In [13] the author proposed an E-Parking system where the author uses Parking Meter (PM) with ultrasonic sensors for finding the free parking space. A LED system is used to indicate the parking area is reserved or not. This system is good for sharing parking spaces but it will not work good to allocate the parking spaces.

III. System Architecture

The step by step functionality of the proposed system architecture is explained as follows:

A. Cloud Setup

We put four HC-SR04 ultrasonic sensors in the parking spaces in Fig. 1. Ultrasonic sensors change its value if the parking space is empty. A microcontroller device, Raspberry Pi 3 is connected with the sensors to get the data. We set up Google Cloud IoT Core to collect data from the Raspberry Pi 3 using CoAP protocol. The value of empty parking space is stored and managed in Google Cloud. The user of the smartphone application will see the empty spaces on the Cloud. Through the UI the user can have the option to book that place. If the user book the parking place Cloud will allocate the space to the user and change the status of free parking spaces.

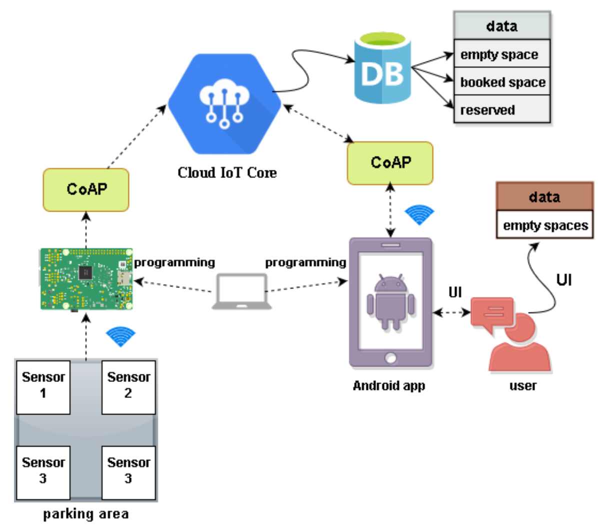

Figure 1. Connection between sensors to Cloud and Cloud to Android app

B. CNN Implementation

We will keep the data of license plate information of each user through our proposed smartphone application. In Fig. 2 we use Google's deep learning framework, TensorFlow for the user authentication process. Before entering the parking area our Raspberry Pi 3 camera will capture the image of the license plate of the car in a real-time scenario. Then using Convolutional Neural Networks (CNN) we detect the digits of the license plate. If the data is matched with our custom dataset then the user verification is confirmed and can enter into the parking area. Keras has a built-in API to implement CNN. We have developed the whole process using TensorFlow framework. Fig. 2 shows how CNN works to detect digits of a license plate for user verification.

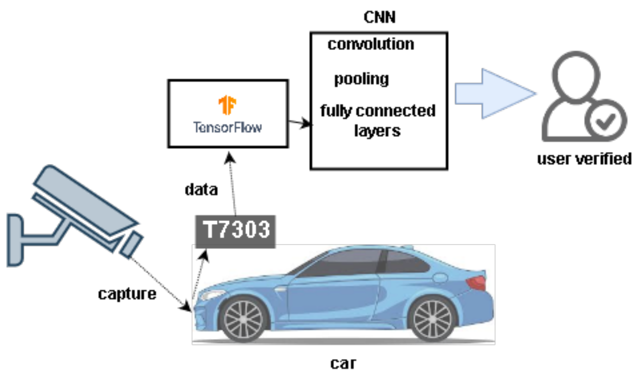

Figure 2. Digit recognition in number plate using CNN

C. Navigation System

In Fig. 3, we develop a navigation bot system using TensorFlow. The navigation bot is mainly a chatbot which will guide a driver to the parking space that he booked. To build a navigation bot we generate the data of Cloud and booking information of the smartphone application in our navigation bot. So, the bot will be aware of the parking information and it communicates with the user through a smartphone application. The bot will help the user to navigate in the parking area and take him to the parking spot. Fig. 3 illustrates the workflow of the navigation bot which communicates with the user and gives directions of the parking space.

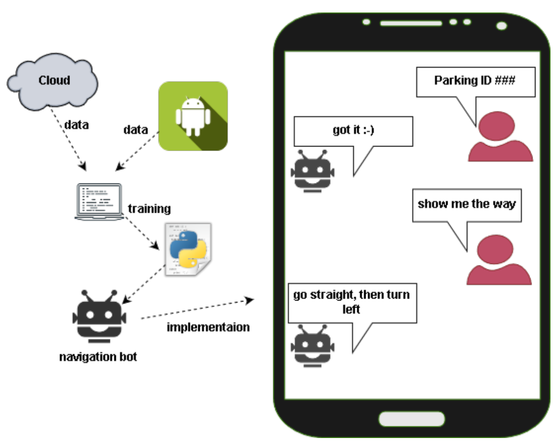

Figure 3. Indoor Navigation process by developing a navigation bot

IV. Algorithmic Explained

A. License Plate Detection

In this section, we will show how we apply our deep learning algorithms during the user authentication process. After allocating the parking space it is necessary to keep the information of the driver's car to user verification in the parking area so that our proposed navigation bot can help the driver to navigate the destination. We have applied CNN to detect the license plates and recognize the user who wants to park his car.

There are many layers in CNN but among them, convolution, pooling, and fully connected layers are the most important ones. The convolutional layer is the first layer where we extract features from the images in our datasets. Pooling layers are inserted to each convolution layer to reduce the spacial size of the representation. In a fully connected network, each parameter is linked to one another to determine the true relation and effect of each parameter on the labels.

License plates have many digits so we need to train our machine to detect the digits from the license plates. We take the Modified National Institute of Standards and Technology (MNIST) dataset which has a large collection of handwritten digits. The following code is to import TensorFlow and MNIST dataset under the Keras API.

```
import tensorflow as tf
(x_train, y_train), (x_test, y_test) =
    tf.keras.datasets.mnist.load_data()
```

There are four groups train, test, labels, and images that we separated. x_train and x_test parts contain greyscale RGB codes while y_train and y_test parts contain labels. Matplotlib helps to visualize these numbers.

```
import matplotlib.pyplot as plt
image_index = 8888 #range is up to 60,000
print(y_train[image_index]) #label is 3
plt.imshow(x_train[image_index], cmap='Greys')
```

After running the code we will see "3" in gray scale image as shown in Fig. 4.

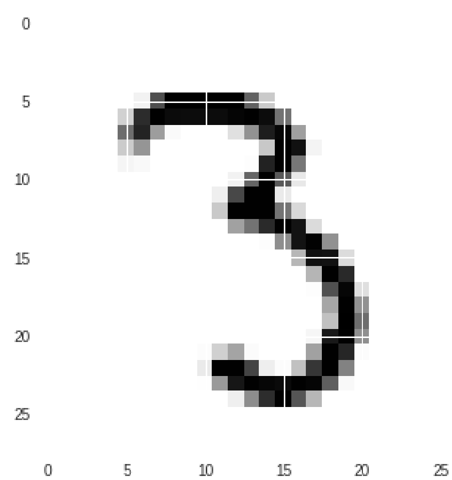

Figure 4. A visualization of an image at index 8888

We get (60000, 28, 28) as a output which convert the image into 28 x 28 pixel size. To work with the Keras API we need to reshape the array into 4-dimensions.So, we use Keras API and implement it in the TensorFlow.

```
#import Keras modules
from keras.models import Sequential
from keras.layers import Dense, Conv2D,
    Dropout, Flatten, MaxPooling2D
```

```
#create model with layers
model = Sequential()
model.add(Conv2D(28, kernel_size=(3,3),
    input_shape=input_shape))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Flatten()) #fully connected layers
model.add(Dense(128, activation=tf.nn.relu))
model.add(Dropout(0.2))
model.add(Dense(10,activation=tf.nn.softmax))
```

We train our data to fit our CNN model where we will test the data for 10 epoch number.

```
model.evaluate(x_test, y_test)
```

B. Navigation Bot

When the parking space is allocated by the smartphone application, the navigation bot helps the user to navigate in the parking area. The Navigation bot is a more advanced level chatbot. We develop our navigation bot using Deep Reinforcement Learning (RL). Therefore, in both certain and uncertain situations, the bot can perform well. We train our bot by providing information about the cloud and reserved spaces using parking IDs. Therefore, the bot is aware of the parking space. In Fig. 5 depicts how the navigation bot works and helps to navigate the driver.

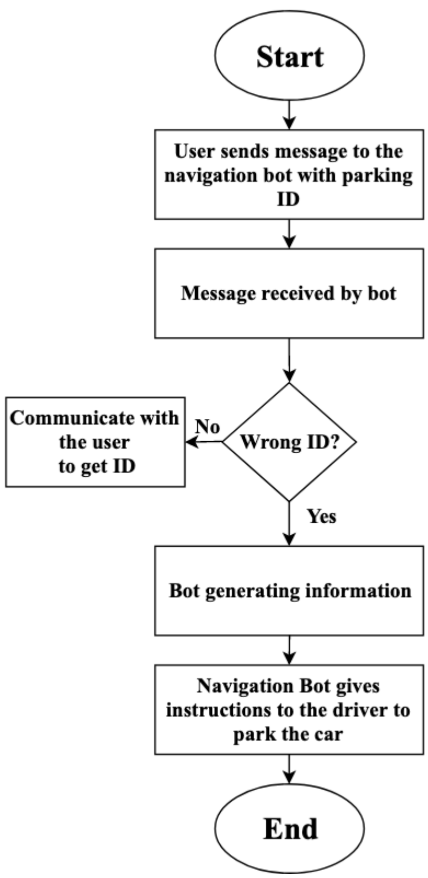

Figure 5. Workflow diagram of a navigation bot

V. Way of Implementation

First, we set up four ultrasonic sensors in the selected parking spots. We have programmed the Raspberry Pi 3 to send the data to Google Cloud IoT core using CoAP protocol. Cloud will store the data of empty spaces. Next, we develop an Android app, where we connect to the Cloud and through the UI the user can see the empty parking spaces. The user can book the parking space through the application and the parking status will be marked as "booked" in both application and cloud. Then, we set up a Raspberry Pi 3 camera in front of the parking area to capture the vehicle's number plate picture. Here we use CNN algorithm to detect the license plate and recognize the user. Lastly, we create a navigation bot using Deep RL. Both CNN and Deep RL will be done using TensorFlow framework.

VI. Experimental Evaluations

Fig. 6 shows how our proposed model saves time than the traditional approach. Some parameters we have selected to measure the percentage are: Area (m^2), finding a parking lot, free parking space, and booking facilities. In Fig. 6, for the 5 vehicles the percentage of time saved is 41.38% and for 10 vehicles the percentage is 52.38%. So, by using model the wastage of time can be saved.

Table I
Comparison Table

Parameters	***Proposed Model***	***Traditional Method***
Area (m^2)	10	10
Vehicle Counting System	Yes	Yes
Sensors used	Ultrasonic Sensors	No
Car Parking Management	Yes	Yes
Technology used	Yes	No

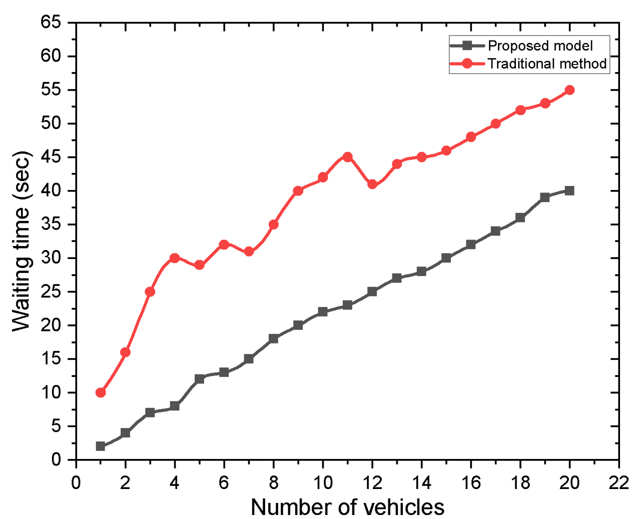

Figure 6. Comparison of waiting time between proposed model and traditional system

Fig. 7 shows how our proposed navigation bot helps the driver to park the car quickly. We have selected some parameters to measure the percentage of time-saving. Major parameters are Area (m^2), authorized persons and the number of cars. We have experimented that how our bot generates the information with parking ID and how quickly the bot can give direction. In Fig. 7, for the 5 vehicles the percentage of time saved is 50% and for 10 vehicles the percentage is 45.83%.

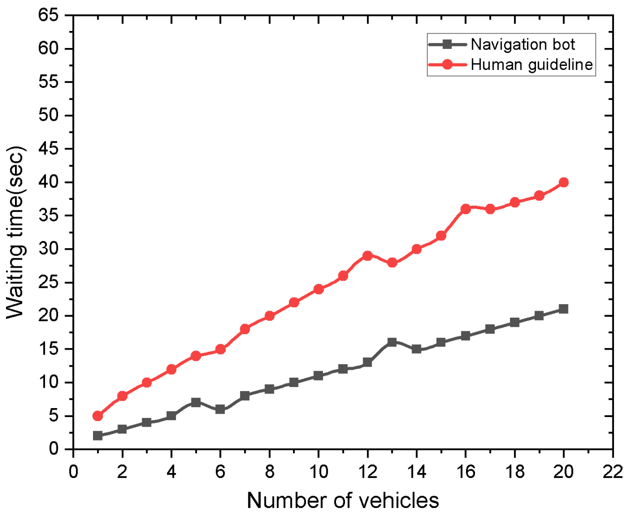

Figure 7. Comparison of navigation time between navigation bot and human guideline

In Section IV, We have implemented the CNN algorithm for digit recognition using TensorFlow and Keras. In our experiment, for 10 epochs the accuracy is 98.5% as depicted in Fig. 8. It is a very good result than the other digit recognition techniques.

```
model.evaluate(x_test, y_test)

10000/10000 [==============================] - 2s 235us/step
[0.06312466390756671, 0.9834]
```

Figure 8. Accuracy rate of recognizing the digits

VII. Conclusions and Future Works

In this paper, we have proposed a smart parking model where we allocate the free parking spaces through an android application and our proposed navigation bot will help the driver to park the car in the parking area. We have first introduced the idea of implementing deep learning algorithm for license plate detection for user authentication and proposed a Deep RL based navigation bot to make a smart driving assistance system in the parking area. In our experimental approach in Section VI we have got 98% accuracy for license plate detection and our proposed model have reduce the wastage of time by 50% than the traditional method. In the future, we will improve our model by collecting data on the empty spaces in the real-time scenario and we will apply Blockchain technology to ensure data security.

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