Parking Assistance System Based on IoT and Robot Vision

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***Abstract*—A simple and easy task such as parking is thought as a tedious and time-consuming process due to mismanagement of parking system. Current parking systems involve huge manpower for management and requires user to search for parking space floor by floor. Such conventional systems utilize more power, along with user's valuable time. This paper presents a Smart Parking Management solution. The system proposes implementation of ultramodern Internet of Things (IoT) technology to mold with advanced sensors and controllers to obtain a systematic parking system for users. Unoccupied vehicle parking spaces are written down in the website and users are guided to an empty parking space, thus dropping need for searching for a parking space. The occupied parking spaces are virtually stored to the cloud to be accessed by central system and direct the upcoming cars to empty spaces. The entire system being fully automatic leads to reduced workforce involved and improves luminance aesthetics of the parking area. This paper aims at improving user's time value and convenience in a parking system.**

Keywords—Internet of things (IoT), Smart parking, Cloud Computing, Neural Network.

I. INTRODUCTION

Parking is very essential part in metropolitan city, having an efficient parking system helps with the congestion on the roads, makes the city look clean and well organized, and saves time from finding a parking spot. But this requires a huge number of parking lot and a very huge workforce which is not possible with the conventional parking system.

IoT, in general consists of inter-network of the devices and physical objects, number of objects can gather the data at remote locations and communicate to units managing, acquiring, organizing and analyzing the data in the processes and services. It provides a vision where things (wearable, watch, alarm clock, home devices, surrounding objects with) become smart and behave alive through sensing, computing and communicating by embedded small devices which interact with remote objects or persons through connectivity.

A smart parking system reduces the time to locate available space and reduces fuel consumption on the vehicle which in turn leads to less pollution as modern-day vehicles use fuel to run. Many sensors would be deployed in the parking area to let the users know is there an empty space or not in the parking lot when a number plate on the car gets detected from the visual sensor that we are using (camera). First, it presents the concept of smart parking system and its various functions, then its reviews previous research approach and studies on the implementation. Then it describes the system implementation and operation and gives a conclusion of the smart parking system.

A. Litrature Survey

The smart parking system that Abhirup and Rishi propose is implemented using a mobile application that is connected to the cloud. The system helps a user know the availability of parking spaces on a real time basis. They talk about the factors responsible of Cloud-IoT integration. presents the state-of-the-art in smart parking system. Describes the implementation and working of the system. They have a simple Smart parking system which tells the availability of parking spots. we address the issue of parking and present an IoT based Cloud integrated smart parking system. The system that we propose provides real time information regarding availability of parking slots in a parking area. Users from remote locations could book a parking slot for them by the use of our mobile application. The efforts made in this paper are indented to improve the parking facilities of a city and thereby aiming to enhance the quality of life of its people.[1]

Recent developments in sensor devices, communication technology, ubiquitous computing, artificial intelligence, and wireless sensor network (WSN) gained momentum to the adoption of IoT based applications [3,4]. Internet of things combined with cloud computing and big data analytics is speeding up the advancement of solutions to monitor the mobility of traffic in smart cities [5,6]. Numerous solutions have been developed aimed at finding the availability of parking spaces to increase the quality of life in overpopulated cities [7,8]. In essence, the smart car parking systems deliver information to drivers about the availability of free parking lots while considering the distance and number of free spaces.

Deep learning methods have brought innovative advancements in monitoring the mobility of vehicles in smart cities. Paidi et al. [9] presented a comprehensive survey on the applicability of sensors, technologies, and techniques for predicting the availability of parking space in open parking lots. The authors suggested that the combination of deep learning and computer vision-based techniques are suitable for locating the availability of free parking spaces. Cai et al. [10] proposed a deep learning technique with a novel vehicle filter for real-time measurement of parking lots. The authors demonstrated that the proposed system achieved significant accuracy as compared to the industry benchmark system with low cost and scalability. Vu and Huang [11] introduced a combination of deep contrastive network and spatial transform to infer the availability of free parking space. The proposed technique was robust to the effects of spatial variations, parking displacements, variations in car sizes, occlusion, and distortion. Zhang et al. [12] developed a deep learning-based self-parking system. The proposed system first marks the parking points in the image then classify those points as free or occupied slots. The authors also developed a parking slot detection image database. The database contains 12,165 images of indoor and outdoor parking slots. Bock et al.

[13] investigated the applicability of taxi fleets to detect the availability of on-street parking. The authors detected the free parking spots by analyzing the taxi transit frequencies, and parking spaces availability information obtained from vehicles equipped with global positioning system (GPS) sensors. Tekouabou et al. [14] proposed the combination of IoT and ensemble techniques to predict the availability of free parking spots in the smart city. Then evaluated the performance of the proposed system on the Birmingham parking dataset, and achieved 94% prediction accuracy with the bagging ensemble technique.

In this work, our objective is to develop an IoT based decision support system to predict the real-time availability of car parking spaces. We developed an RNN approach to predict the real-time availability of parking slots at a given time. We used the long short term memory (LSTM) model, as it proves to be the best RNN architecture to solve time series data problems. The proposed model predicts the availability of free parking slots at each parking location individually to give a better insight into the drivers to choose their route and destination. Most recent works related to the prediction model used in this research are presented in [15,16]. In [16], Jingyuet. al. developed LSTM and gated recurrent unit (GRU) models to predict the availability of free parking slots. The authors demonstrated that the GRU model performed better than the LSTM model. Similarly, Yang et al. [15] adopted the combination of graph convolutional neural network and RNN based model to predict the real-time occupancy of parking slots. Graph neural network was developed to extract the spatial information of traffic flow and RNN was developed to extract the temporal information of traffic flow. It is demonstrated that the proposed model performed better than state-of-the-art parking availability prediction models.

II. Background of The Problem

This section discusses about the motivation and the object of the smart parking system that we propose in this paper.

A. Motivations

The motivation behind this project can be classified into segments,

1) Consumption of Less Fuel: Smart Parking solution is an outcome of human innovations and advanced technology which not only supplies easy access to the parking spots but also help in saving valuable resources such as fuel, time and space. In the urban regions where smart parking solutions are incorporated, drivers are guided straight to the empty parking spots. This drops the need for driving extra kilometers to find empty parking spots. Hence, less fuel is wasted with the Smart Parking solution which ultimately saves the drivers' money and smoothens their parking experience.

2) Minimize the Personal Carbon Footprint: Smart parking technologies have the potential to save both time and money for drivers. This is because when the drivers enter the congested parking area, they spent several minutes in search of a parking spot. This ultimately wastes their time, making them frustrated as the drivers are not able to reach the desired destination on time. Likewise, travelling extra kilometers in search of parking increases the fuel waste which in turn increases the money spending of the drivers of the car fuel. Smart Parking is an IoT based solution, equipped with sensors that send data to applications about the vacant parking spots. The drivers use this application to direct themselves to the available parking spaces instead of wasting their time and fuel in search of one.

3) Reduce Parking Stress: Most of the people avoid going to the congested part of the city as they do not want themselves to get stuck in the parking hassle which creates stress and anxiety among the drivers. Knowing that you will be spending so much time in search of parking but will still end up parking your car in a space far away from the destination is extremely discouraging. Furthermore, driving around the same street repeatedly and still not finding a space to park a car is frustrating. Smart parking solutions are aimed to make the parking experience of the drivers stress-free. Smart parking applications let the divers know about the available parking space in the area they want to travel to. This reduces the unpredictability and stress associated with finding a proper parking space near the desired destination.

4) Reduce Search Traffic on Streets: Nearly, 30% of the traffic in the urban areas is created by parking search. Smart parking solutions enable the municipalities to manage and reduce parking search traffic on the streets. This technology also ensures parking safety, but its major contribution to traffic congestion are the factors of making the parking experience faster, more convenient and hassle-free. Smart parking technologies ensure to reduce the number of cars circling around the streets for finding a parking spot. This ultimately smoothens the traffic flow and minimize the search traffic on streets as much as possible.

B. Objective

The goal of the project is to develop a system to help users find an empty parking spot with sensors and other devices without searching for one physically. The plan is to implement sensors and cameras for the following work, simultaneously we will be saving in the data of the car such as its number plate information, time and date of the entry. The aim is to advancement of parking systems to help save time and avoid unnecessary traffic.

III. Proposed Work

Our model works with vision sensors (Cameras) to detect and interpret the situation.

A. Hardware Components

To implement the model we are designing the system to be as cheap as possible using minimal amount of hardware and that to easily available. The components used are:

- ESP32 CAM
- Arduino UNO
- Ultrasonic sensors
- Infrared Sensors

B. Architecture

The IoT System comprises of Camera module, ESP32 CAM, in order to stream the live video from the entrance of the parking lot. A Servo motor controlling the barrier and a screen to show the useful information such as free parking spots, fare etc. These will be connected to a Wi-Fi module which transmits these information through a secure TCP/IP protocol to the cloud. And the cloud is where all the processing is done and the instructions are sent back.

The IR and Ultrasonic sensors are used to check whether the parking slots are available or not these are also connected through the same Wi-Fi network. The ESP32 CAM module makes a hotspot to which every device is connected to communicate to each other.

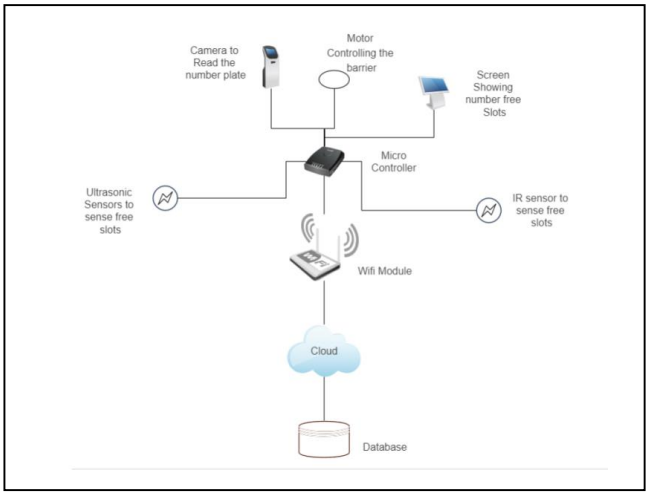

Fig. 1. Our Proposed Smart Parking architecture.

The data about the number plate and timestamp is stored in the database, to calculate the fare at the time of leaving the parking lot.

C. Algorithm

The camera module is responsible for streaming the video. This video is passed through a neural network model to detect number plates, this model keeps looking for number plate in the video frame, when it detects the number plate the system checks for free parking spots in the parking lot if there are no parking slots left the system will show the message “No free slots are left”, and the barrier will not open. If there are free parking slots left the number plate with the image of the number plate and the timestamp will be stored in a database and the barrier will open for the car to enter the parking lot. This can be observed from the flow chart in Fig. 2.

The actual Object detection is done using Tensorflow object detection model with the help of OpenCV to process the video and EasyOCR to convert the number plate image to text number plate.

D. Model

The Object detection is done by a R-CNN model. The model is trained using the Car dataset from kaggle which has the car images in the form of .png and the corresponding annotation file in .xml format.

The model consists of four major parts for object detection:

1.Generating Region Proposals.

2.Fine tuning the CNN network and extracting features.

3.Training class wise SVMs.

4.Training the bounding box regressor.

The main idea behind RCNN is to use a region proposal algorithm to generate candidate object bounding boxes in an image, and then use a CNN to extract features from each region proposal.

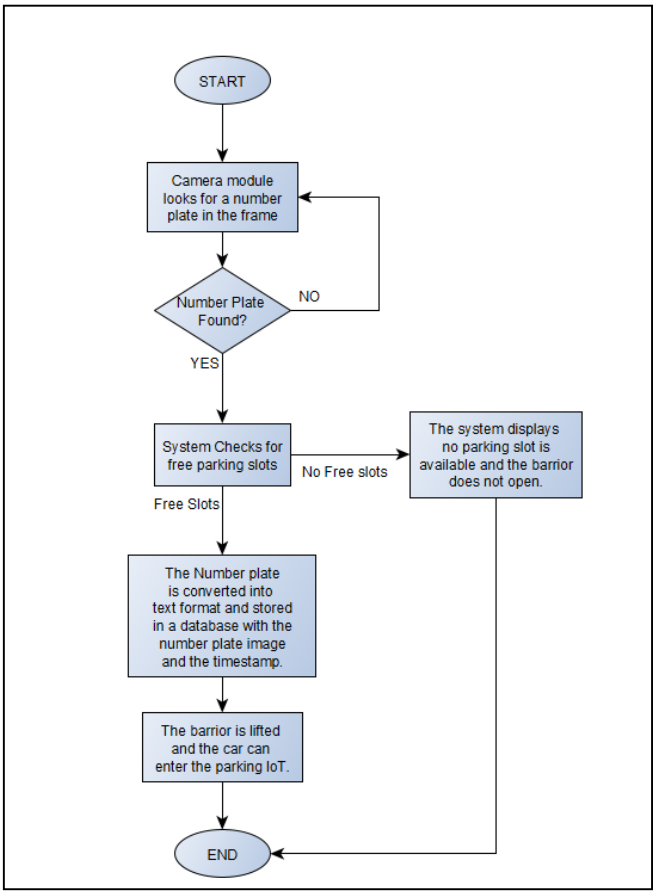

Fig. 2. Algorithm Flowchart

The RCNN algorithm consists of the following steps:

Region proposal: The first step is to generate a set of object proposals or candidate bounding boxes that could contain objects of interest. This is typically done using a selective search algorithm which hierarchically groups image pixels based on texture, color, and other low-level features.

Feature extraction: Next, each proposal is warped to a fixed size and fed into a pre-trained CNN to extract a fixed-length feature vector. This is typically done using a convolutional layer followed by a set of fully connected layers.

Object classification: The extracted features are then used to classify each proposal into one of the pre-defined object categories or background. This is done using a softmax classifier that is trained on a large labeled dataset.

Bounding box regression: Finally, the proposal regions are refined using a bounding box regression technique that predicts the precise object location within each proposal.

The RCNN algorithm has several advantages over earlier object detection techniques. Firstly, it achieves state-of-the-art accuracy on several benchmark datasets. Secondly, it is highly modular and allows for easy incorporation of new features and improvements. Lastly, it can be trained end-to-end, which means that all components of the system can be learned jointly, making it more efficient and effective.

IV. Results and Discussion

A. *Environment Setup, Tools Used and Simulation*

The ESP32 CAM is a microcontroller, hence it requires a code to be dumped in its memory. This code is a pre written code to stream the video from ESP32 CAM module which can be found in the examples folder. Arduino IDE is used to write the code for ESP32 CAM, and a FTDI controller or an Arduino is needed to dump the code in the ESP32 CAM. We used an Arduino UNO to dump our code in the ESP32 CAM.

Now that the ESP32 CAM is streaming the video and providing the hotspot, we move on to the actual number plate detection system. A neural network is set up for detecting the number plate from the cars itself using Tensorflow. It is a pre-built neural network for object detection from the Official Tensorflow library, we have trained to detect the number plates, using a dataset from Kaggle, which contains the picture and the annotation which contains the coordinates of the box that contains the number plate, the number written in the number plate and much more information that is not of use to us for this project.

soupsieve	2.3.2.post1
stack-data	0.6.1
tabulate	0.9.0
tensorboard	2.9.1
tensorboard-data-server	0.6.1
tensorboard-plugin-wit	1.8.1
tensorflow	2.9.2
tensorflow-addons	0.18.0
tensorflow-datasets	4.7.0
tensorflow-estimator	2.9.0
tensorflow-gpu	2.10.0
tensorflow-hub	0.12.0
tensorflow-io	0.27.0
tensorflow-io-gcs-filesystem	0.27.0
tensorflow-metadata	1.11.0
tensorflow-model-optimization	0.7.3
tensorflow-text	2.9.0
termcolor	2.1.0
terminado	0.17.0
text-unidecode	1.3
tf-models-official	2.9.2
tf-slim	1.1.0
threadpoolctl	3.1.0
tifffile	2022.10.10
tinycss2	1.2.1
toml	0.10.2
torch	1.13.0
torchaudio	0.13.0+cu116
torchvision	0.14.0

Fig. 3. List of Modules Installed

After the model is trained with the number plate dataset, have to isolate the number plate pixels in order to read the number plate and convert it to text using an OCR model. To isolate the number plate we use the box coordinate and cut that part of pixels out for our use.

For the OCR model we used easyOCR model which uses pytorch. OCR models are pre trained models to convert pictures to text. Take this picture and pass it through the OCR model to get the number plate in text.

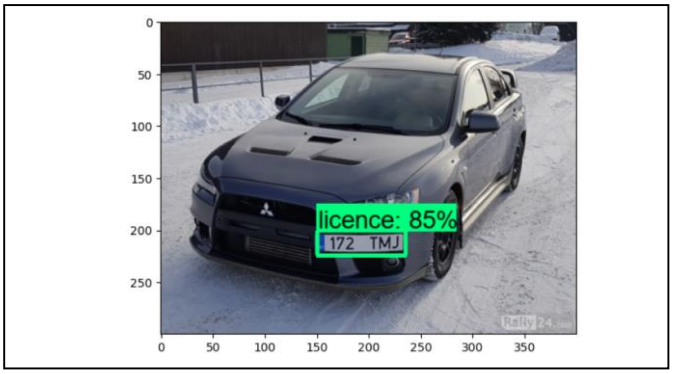

Fig. 4. Number plate detection from an image

Now for the hardware part used in the parking lot, we used an Arduino UNO to interface all the IR and Ultrasonic Sensors to the server, the Arduino UNO is also responsible for controlling the barrier once the system commands it to.

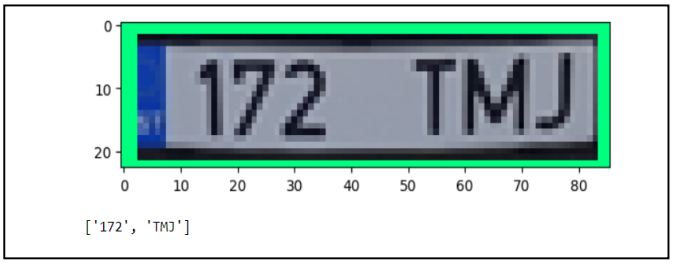

Fig. 5. Isolated Number plate with the coordinates

After constructing these parts we try to compile them together such that when the OCR model detects the number plate, the hardware is checked for free parking slots and only if there are free parking slots, it commands to open the barrier.

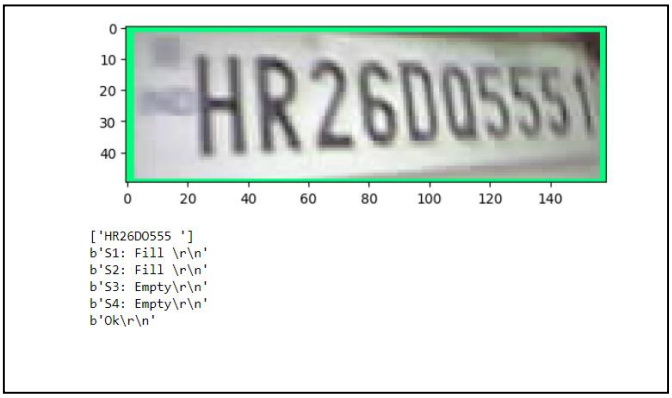

Fig. 6. Live Number plate detection

All this is installed and build on a separate virtual environment, and all the python code is written and run on Jupyter notebook, All the Arduino and ESP32 Code is written and compiled on Arduino IDE. The list of modules installed can be seen in Fig. 3.

The simulation can be seen Fig. The Object detection model detect the number plate and a green colored box is drawn around the number plate Fig.4. Using the corner point coordinates of the box we extract the number plate pixels from the image Fig.5. Now that we have only the number plate pixels the OCR model can do a better job at extracting the text from the image. So the next step is to pass it through the OCR model, this will extract the text from the image and display it Fig.6.

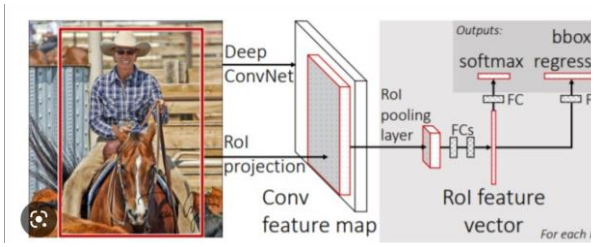

Fig. 7. Working of Model

Now to communicate with the arduino we use pySerial module and get the sensor data to check whether the slots are free or not, once the slots are free the data about the number plate and the timestamp is stored in the database Fig.7. Once the data is stored properly the barrier is opened and the car can enter the parking lot. S1, S2, S3 and S4 tells about the parking lot availability, S1 denotes slot 1 and so on.

B. *Hardware setup*

The hardware consists of an ESP32 CAM, Arduino UNO, a servo motor, 2 IR sensors and 2 Ultrasonic Sensors. The motor and the sensors are interfaced to the Arduino, which is connected to the server. Here Arduino is responsible for collecting the information about the slot using the IR and Ultrasonic sensors. Each sensor depicts a parking slot, this helps the customer to know which parking slots are free and reduce the time in finding the parking spots in a parking lot Fig.9.

003cec29-6567-11ed-a996-726655fbb4e7.jpg	['HHLOBE2665]']	16-11-2022 09:51
4afcc106-6568-11ed-9bea-726655fbb4e7.jpg	['JMHLOBE2665]']	16-11-2022 10:05
f5972775-656d-11ed-833f-726655fbb4e7.jpg	['CGO4HF2250']	16-11-2022 10:39
c73dc79d-67a9-11ed-9f21-726655fbb4e7.jpg	['HR26DO55I']	19-11-2022 06:57
252859fa-67aa-11ed-84d0-726655fbb4e7.jpg	['HR2600555']	19-11-2022 06:57
40e1e137-67aa-11ed-9a1d-726655fbb4e7.jpg	['Hrzgdusy']	19-11-2022 06:57
4ca872a8-67aa-11ed-8c9b-726655fbb4e7.jpg	['HrzeC:']	19-11-2022 06:57
5f9427e6-67aa-11ed-8963-726655fbb4e7.jpg	['FHR2gdDS)']	19-11-2022 06:57
80247f22-67aa-11ed-a60e-726655fbb4e7.jpg	['HBHGI AA']	19-11-2022 06:57
949ced1d-67aa-11ed-a14b-726655fbb4e7.jpg	['21 BH 0001 AA']	19-11-2022 06:57
a8d32724-67aa-11ed-91e2-726655fbb4e7.jpg	['HR26DO5S5]7']	19-11-2022 06:57
ae5f1b6e-67b6-11ed-88cf-842afd0bf3a4.jpg	['Hrzea"']	19-11-2022 08:23
c257d9c9-67b6-11ed-88cd-842afd0bf3a4.jpg	['HR26DOS ']	19-11-2022 08:23
d1bfafd9-67b6-11ed-85c7-842afd0bf3a4.jpg	['HR2GdO555']	19-11-2022 08:23
e458c356-67b6-11ed-9ed3-842afd0bf3a4.jpg	['HR26DO555 ']	19-11-2022 08:23

Fig. 8. Data stored in database

If the parking slots are free the server sends an instruction to the Arduino to open the barrier and let the car enter the parking lot. The availability of parking slots are refreshed at the time a car comes to the parking entrance. If there are no parking spots left an appropriate message is shown and the parking barrier does not open Fig.8 and Fig. 9.

V. Conclusion and Future Work

This section will discuss the amount of work done and what can be done to it in future to make it better.

```
['HR26DO555 ']
b'S1: Empty\r\n'
b'S2: Fill \r\n'
b'S3: Fill \r\n'
b'S4: Fill \r\n'
b'Ok\r\n'

['HR26DO555 ']
b'S1: Empty\r\n'
b'S2: Fill \r\n'
b'S3: Empty\r\n'
b'S4: Empty\r\n'
b'Ok\r\n'

['HR26DO555 ']
b'S1: Fill \r\n'
b'S2: Empty\r\n'
b'S3: Fill \r\n'
b'S4: Empty\r\n'
b'Ok\r\n'

['HR26DO555 ']
b'S1: Fill \r\n'
b'S2: Fill \r\n'
b'S3: Fill \r\n'
b'S4: Fill \r\n'
b'No Slots Available\r\n'
```

Fig. 9. The Response of the server at different cases

A. *Conclusion*

In this project we developed a Smart parking system with the help of Internet of Things (IOT), using sensors and visual sensors with which we cut shortened many modern-day problems, mentioned in the motivation segment, which comes with finding a parking spot in the busy world. The code needed was done with the help of python. The system was able to detect the empty parking spots and occupied parking slots and opened the gates only when a slot was empty and closed when the lot was full, the users were able to see exactly which spots were empty and full. The data of the car which entered the slot was stored in an excel sheet with the entry's time and date. A successful small-scale smart parking system got implemented.

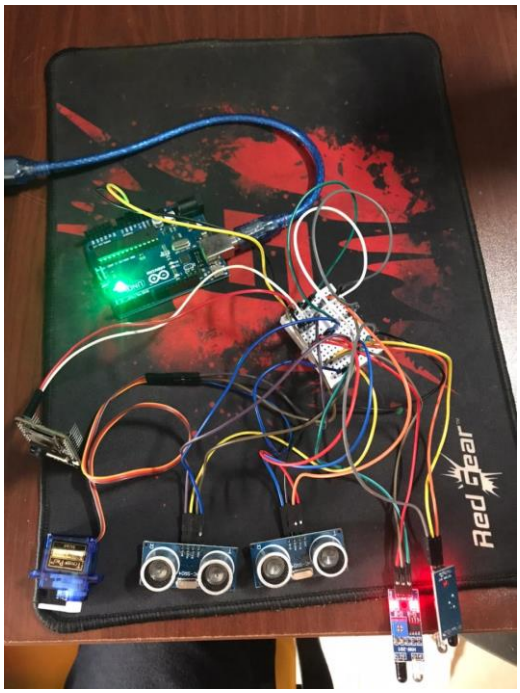

Fig. 10. hardware

B. *Future Work*

We developed a small-scale version of our project, which we want to implement on a large scale and want to fully automate a parking lot which parks your vehicle by itself when left on a lift, with using our technology that we implemented. Just like an automated valet with the help of smart parking system with implementing of internet of things (IOT).We want to develop this project further to reach on global scales to cut short the problem of parking.

We can also build a connected system/application which even shows the available parking slots on a mobile app, it can show you directions to the available parking, tell you the rate for each parking lot.

REFERENCES

[1] Khanna, Abhirup, and Rishi Anand. *"IoT based smart parking system." 2016 international conference on internet of things and applications* (IOTA). IEEE, 2016.

[2] Ali, Ghulam, et al. *"IoT based smart parking system using deep long short memory network."* Electronics 9.10 (2020): 1696.

[3] Teixeira, S.; Agrizzi, B.A.; Pereira Filho, J.G.; Rossetto, S.; Pereira, I.S.A.; Costa, P.D.; Branco, A.F.; Martinelli, R.R. LAURA architecture: Towards a simpler way of building situation-aware and business-aware IoT applications. J. Syst. Softw. 2020, 161, 110–124.

[4] Ejaz, W.; Basharat, M.; Saadat, S.; Khattak, A.M.; Naeem, M.; Anpalagan, A. Learning paradigms for communication and computing technologies in IoT systems. Comput. Commun. 2020, 153, 11–25.

[5] Nguyen, S.; Salcic, Z.; Zhang, X. Big Data Processing in Fog-Smart Parking Case Study. In Proceedings of the IEEE Intl Conf on Parallel & Distributed Processing with Applications, Ubiquitous Computing & Communications, Big Data & Cloud Computing, Social Computing & Networking, Sustainable Computing & Communications, Melbourne, Australia, 11–13 December 2018; pp. 127–134.

[6] Safi, Q.G.K.; Luo, S.; Pan, L.; Liu, W.; Hussain, R.; Bouk, S.H. SVPS: Cloud-based smart vehicle parking system over ubiquitous VANETs. Comput. Netw. 2018, 138, 18–30.

[7] Al-Turjman, F.; Malekloo, A. Smart parking in IoT-enabled cities: A survey. Sustain. Cities Soc. 2019, 49, 101608.

[8] Wu, P.; Chu, F.; Saidani, N.; Chen, H.; Zhou, W. IoT-based location and quality decision-making in emerging shared parking facilities with competition. Decis. Support Syst. 2020, 134, 113301.

[9] Paidi, V.; Fleyeh, H.; Håkansson, J.; Nyberg, R.G. Smart parking sensors, technologies and applications for open parking lots: A review. IET Intell. Transp. Syst. 2018, 12, 735–741.

[10] Cai, B.Y.; Alvarez, R.; Sit, M.; Duarte, F.; Ratti, C. Deep Learning-Based Video System for Accurate and Real-Time Parking Measurement. IEEE Internet Things J. 2019, 6, 7693–7701.

[11] Vu, H.T.; Huang, C.-C. Parking space status inference upon a deep CNN and multi-task contrastive network with spatial transform. IEEE Trans. Circuits Syst. Video Technol. 2018, 29, 1194–1208.

[12] Zhang, L.; Huang, J.; Li, X.; Xiong, L. Vision-based parking-slot detection: A DCNN-based approach and a large-scale benchmark dataset. IEEE Trans. Image Process. 2018, 27, 5350–5364.

[13] Bock, F.; Di Martino, S.; Origlia, A. Smart parking: Using a crowd of taxis to sense on-street parking space availability. IEEE Trans. Intell. Transp. Syst. 2019, 21, 496–508.

[14] Tekouabou, S.C.K.; Cherif, W.; Silkan, H. Improving parking availability prediction in smart cities with IoT and ensemble-based model. J. King Saud Univ. Comput. Inf. Sci. 2020.

[15] Liu, J.; Wu, J.; Sun, L. Control method of urban intelligent parking guidance system based on Internet of Things. Comput. Commun. 2020, 153, 279–285.

[16] Carli, R.; Cavone, G.; Othman, S.B.; Dotoli, M. IoT Based Architecture for Model Predictive Control of HVAC Systems in Smart Buildings. Sensors 2020, 20, 781.