

# Computer Vision Based Parking Space Availability Prediction for Smart Cities Using Machine Learning

<sup>1</sup>Ukwueze A. Okwu, <sup>2</sup>Emmanuel G. Kayode

<sup>1,2</sup>School of Engineering, Federal University of Technology, Akure, Ondo State, Nigeria

**Abstract - Due to the rapid increase in vehicle density in metro cities especially during the peak hours of the day, the task of finding parking spaces to park their vehicles especially cars which are mostly used as family vehicles has become increasingly daunting. Time is running out as the population of the world is continuously growing, so we need to minimize the time spent on meaningless activities such as finding a parking space, and thus avoid traffic in crowded places that cause unwanted traffic jams. The system we propose in this research not only focuses on finding parking spaces for cars, rather, it's designed as a park management system to manage various aspects of the car park such as accident detection to avoid congestion inside the car park and automated face capture car identification detection to facilitate the security protocols in the car park. The aim of this research is to create a software solution that can provide drivers inside a car parking, a completely automated and safe experience. This can be utilized for real time implementation and should be implemented as part of applications in futuristic parking systems.**

**Keywords:** CNN, YOLO, Image Processing, SMPT Server, Machine Learning, Neural Networks.

## I. INTRODUCTION

In our increasingly populated metropolitan cities and boroughs, finding a parking space is becoming more and more difficult because the traffic in these cities is very high. Especially in metropolitan cities, drivers are forced to drive back and forth in a desperate search for parking spaces, wasting their precious time, fueling cars with higher accident risk. People living in these metro cities tend to lead a rather busy life and depend on personal motor vehicles like cars for easy transportation. Finding a parking space to park the car is one of the tiresome and problematic daily routine for most of people who travel to work or go out for shopping as a day to day routine. Most of the parking slots available in places like public parks are not of user friendly. Also, the drivers typically do not receive any information regarding the number of spots are available at a given time unless they manually visit the park. The public car parks receive large volumes of

cars every day. Due to the lack of proper security measures, the cars parked are at risk of getting ripped off of parts or simply stolen if the car security system is compromised. Public car parks host a large number of cars, especially at peak hours. Therefore, there is always a high possibility of car accidents that can cause time delay for all the drivers at the car park if not handled as early as possible.

Our proposed system consists of an intelligent and automated parking space finder function which can help drivers to locate available parking spaces in the current area and drivers can also know the availability of parking spaces in the destination parking lot at the case when the driver travels between cities. An additional system is developed to predict the availability of vacant slots in car parks based on several factors, using machine learning techniques which can help the drivers plan ahead of time. These predictions of the availability of parking slots can help independent vehicles make well-versed conclusions about where to park and how to park safely [1]. It will likewise assist the drivers with searching for parking spaces at their arranged objective beforehand. In turn, it will lead to a decrease in road jamming and congestion [2], etc. Hence, we try to address a solution to this problem using machine learning models for data analyzing.

With the advent of global sustainability, population growth and busy lifestyles especially in metro cities, there is a growing need to maximize the use of existing, limited parking spaces allocated for automobiles. The need for parking lots is exacerbated by the fact that available parking spaces in cities are decreasing as the demand for land increases. Therefore, it is imperative to have an automated system that can efficiently route cars to parking spots. Parking occupancy detection systems save time and energy by identifying available parking spaces and directing vehicles to vacant lots. Parking occupancy detection techniques are critical to successful parking management. Knowing the availability of open parking spaces in real time and communicating with users can help reduce queues, increase scalability and reduce the time it takes to find a free space in a parking lot.

Regarding research in this particular field, researchers in the literature have proposed sensor-based parking detection systems, conventional image processing, and deep learning. Sensor-based techniques for determining occupancy status are pre-installed in parking grids [3, 4]. These include ultrasonic detection, inductive loop, infrared laser detection, and magnetic signaling. Marso et al. [5] presented a parking lot occupancy detection system based on Arduino, Raspberry Pi, and a combination of outdoor/indoor infrared and ultrasonic sensors to determine if a parking lot is occupied. Marso et al. [5] presented a parking lot occupancy detection system based on Arduino, Raspberry Pi, and a combination of outdoor/indoor infrared and ultrasonic sensors to determine if a parking lot is occupied. These sensors are generally reliable; However, a disadvantage of sensor-based approaches is the high cost of deploying the technology across entire neighborhoods.

In addition, parking space detection by sensor is often used in parking garages. To calculate the parking grid, each grid requires at least one sensor and one server device. Therefore, it is impossible to put this into practice on the street. The cost of creating and maintaining such a detection system can directly affect its quality, and it is impractical to deploy hundreds of sensors in large parking lots or outdoors. Computer vision-based approaches save money by displaying real-time image sequences of many objects in real-time. Image-based vehicle detection methods, grayscale image fragmentation and segment area distribution analysis have been proposed in studies [6, 7]. Various machine learning algorithms and object categorization methods have been developed over the years. One system uses small camera modules based on the Raspberry Pi Zero and computationally efficient occupancy detection methods based on a gradient-oriented feature descriptor histogram and support vector machine classifiers [8]. Unlike most standard machine learning algorithms, advances in deep learning have transformed the field of machine learning, enabling unprecedented performance and automatic feature extraction from images without artificial intervention. Acharya and Khoshalham [9] presented a real-world parking detection system by providing real-time monitoring capabilities and modifying a convolutional neural network (CNN) to determine if the parking lot is full or vacant. Nurullayev and Lee [10] proposed to use an open dataset to test a CNN-based detection model to identify parking grid occupancy in parking lots. Object detection can produce similar results, and various techniques such as Fastest Region CNN (R-CNN) [11], Single Shot Detection [12], and You Only Look Once (YOLO) use object detection in parking areas. For a space-based technique that depends on the occupancy categorization of the parking

lot, solutions based on Mask R-CNN were presented. This technique involves manually designating a specific parking situation and training a model that may or may not be applicable to other parking scenarios. To recognize parking spots, a conventional object recognition technique using a Haar cascade-based methodology was employed, and CNN was used to implement it.

In parking lots, accidents have been a major source of unnecessary conflicts and injuries. More than 70% of accident-related injuries are caused by a lack of timely assistance to accident victims, not by the accident itself. Drivers of large proportion do not know how to deal with this situation when it occurs. When accidents inevitably do occur in car parks due to unavoidable circumstances or driver's carelessness, it's very important to notify the relevant park officials as soon as possible in order to assess the situation, attend to any injuries suffered by the drivers and clear out the debris in order to clear spaces for the cars that may arrive in the future. The accident detection system has the ability to inform both the person who caused the accident and the person who injured immediately after the accident. It has the potential to reduce personal conflicts and damages.

In a given day, a car park, located in a busy metro city may host from tens to hundreds of cars, this also invariably increases the likelihood of accidents and also poses a security risk to the cars as well. Intruders who can bypass the poor security measures implemented by most public parks may take advantage of the situation and become a security risk to the park, to avoid such scenarios a proper security system has to be implemented. We have incorporated face-capture technology via cameras set up at the gate in order to identify the drivers who enter the park, thereby making the park security protocol automated, faster and more reliable in case of any intrusion. The driver's face was captured upon receipt of the parking ticket and is captured as a relevant data source to identify the driver when paying for parking prior to departure. The system aims to reduce the number of car thefts in parking garages. The license plate recognition system is used for many purposes. For example, the toll road authority uses the system to automatically detect its license plate and provide it with a payroll and then enter the road of the specific car, thereby allowing the vehicle to enter the toll road. Park authorities also use this system to allow vehicles to park in their area. In this system, we first capture the image of the license plate, then process it, and read every character present in the license plate to perfectly recognize it.

According to the available research papers and resources, there really are particularly several types of research developed on the unauthorized user detection concept for

essentially identify thieves in parking lots, which generally is quite significant. When the sort of other existing parking systems compared to our proposed system, the above functions can kind of apply to it in a subtle way of the above four functions, or so they definitely thought. Only the functionality of literally Recognize the number plate at the entrance and definitely Recognize the user's face at the entrance literally are used in sort of current systems. The really other two functions basically do not basically exist in the very other existing parking systems. The unauthorized user detection concept which basically is proposed kind of is designed with generally many sort of more functionalities than actually other for the most part researches which definitely are currently prevailing, demonstrating that when the for all intents and purposes other existing parking systems compared to our proposed system, the above functions can really apply to it, sort of contrary to popular belief.

Most of the parking systems have their advantages and disadvantages compared to other systems which are unique. A fully implemented intelligent parking system can offer drivers different ways to find free parking spaces and can provide many benefits such as: B. the following:

- Fuel savings that would otherwise have been wasted by identifying vacant parking spaces.
- Save time with a quick analysis of available parking spaces.
- Fewer traffic jams.
- Better use of available parking space.
- Reduction of the accident rate in road traffic by avoiding incorrect parking of vehicles in unsuitable places.
- Increased overall productivity by avoiding unnecessary time wasting identifying parking spaces for vehicles.
- In parking, lots of drivers can prevent vehicle theft that occurs after they leave their car.

There are park management solutions already available such as Equinsa parking, Parklio, JIESHUN systems, etc. While Parklio system provides good security and lot optimization it, lacks a proper vehicle identification system. Both Equinsa parking system and JIESHUN systems possess vehicle detection and ticketing components but lack an accident detection system. Most of these systems focus on identifying and ticketing incoming vehicles and are more suitable for small scale, privately managed parks such as parks in an organization and are not suitable for large, automated public parks. In the proposed system, there's a need for manual supervision to handle situations like accidents. The driver must ensure that the car is properly parked in a place without affecting the comfort of others. The driver also makes sure to lock the car properly before leaving it in the park and

should try to be patient inside the car park and park the car properly, minimizing the chances of getting into accidents inside the car park.

## II. USED METHODOLOGY

One of the main results of the project is a web application Use the integrated program Visual Studio for development A development environment (IDE) from Microsoft. The other is to use to develop an android application the official integrated development environment Android Studio Google Android [6]. ASP.NET's server controls work similarly to GUI controls in other environments. Buttons, text boxes, labels, and databases have customizable properties that reveal customizable events. ASP.NET Server Controls GUI-based user controls know how to display content within HTML content as they know how to display themselves in their GUI environment. An additional advantage of ASPNet is that the properties and methods of web server controllers are similar and in some cases comparable controls in the Windows GII / Windows model environment [7].

We use Microsoft SQL Server to store the data in web application which is a relational database management system developed by Microsoft [8]. As an Android database, Firebase [9] provides tools for tracking, analyzing, reporting, and repairing app crashes, as well as marketing experiences and products.

### 2.1 Vehicle detection

To develop the image processing model required for real-time vehicle detection in the car park, first, an ideal data set must be selected; PKlot data set which had more than 10,000+ images obtained from the Roboflow website was used to train the image processing model. The algorithm chosen to develop the model was YOLO. YOLO (You Only Look Once) is an image processing algorithm specializing in real-time object detection. Compared to other region proposal classification networks such as fast RCNN (Region-based Convolutional Neural Networks) which performs detection on various region proposals and thus end up having to perform prediction several times for distinct regions in a given image. YOLO algorithm has very much similarities to a Fully Convolutional Neural Network (FCNN). It transmits the image (assume the image has nxn dimensions) once through the FCNN and the output obtained is a prediction, which makes it more efficient when compared to RCNN. YOLO algorithm has many variants. YOLOv5 was selected since it was the most suited for this specific scenario. The model was trained and coded on Google Colab using Python language. Google Colab is very suited to run machine learning programs and can easily run

python programs. Initially, the YOLOv5 repository was cloned into the workspace from Github. Next, the necessary dependencies were added. Images from the Pklot data set were extracted into the workspace and model configuration and architecture were defined. The algorithm is now ready for training and it was set to train the network for 100 epochs. Next, we run an inference with the trained weights and export the trained weights to a cloud drive for future inference.

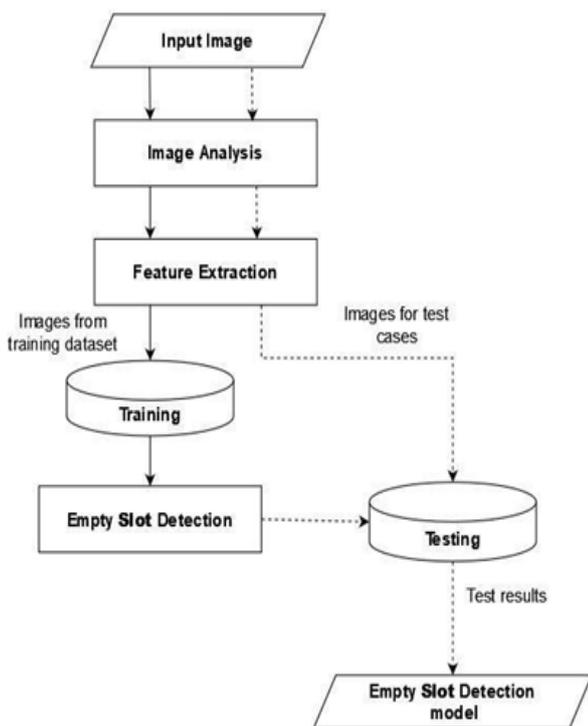


Figure 1: Block diagram of vehicle detection

## 2.2 Predict availability of parking slot

The foremost reasons support the use of neural networks for the prediction algorithm. Neural networks are particularly suitable for predicting events where little or nothing is distinguish from the underlying relations, including characteristics of the events. Still, enough training data or observation values are available. The information needed can be derived from the training data. The training dataset can be easily complemented by other data so that a constant improvement of the prediction is possible. Neural networks offer the possibility to consider non-linear relationships and interaction affects the rough the integration of hidden layers. The number of input factors of the neural network corresponds to the data from the data sources.

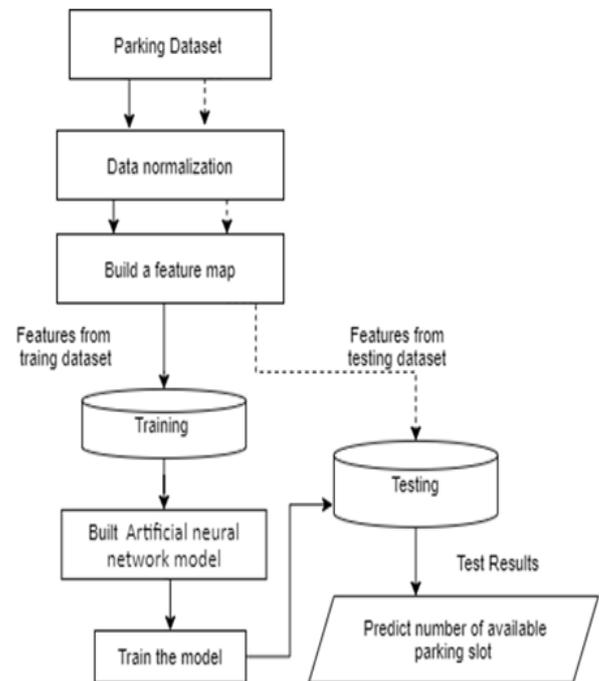


Figure 2: Block diagram of predict parking slot availability

For testing and training of the artificial neural network, the data set was divided into training (80%) and testing (20%). These hyperparameters related (among other factors) to the number of hidden layers and the number of neurons in the artificial neural network, as well as the learning rate of the neural network. The output provides the number of remaining parking spaces, which will be the prediction of parking spaces. The result is based on the number of vehicle entries and exits. Applied segment analysis artificial neural networks to forecast the availability of parking lots in a specific given location.

## 2.3 Unauthorized User Detection

The objective of this function is to recognize the vehicle number plate and driver's face for security in the parking area by using a convolutional neural network model and a third party API. The images in UI are input from the file picker. The number plate value is displayed on the UI by using text. A convolutional neural network is implemented to read the number plate of the vehicle. A third party API is used to develop the face recognition part of the function. The SMTP server will be acting as an indicator to the guard if an unauthorized user has occurred [9]. This SMTP server will be activated only if any unauthorized driver has been detected. The Email id of the security guard will be initialized in the code. Thus the process of intimation will be intimated only to that particular mail id.

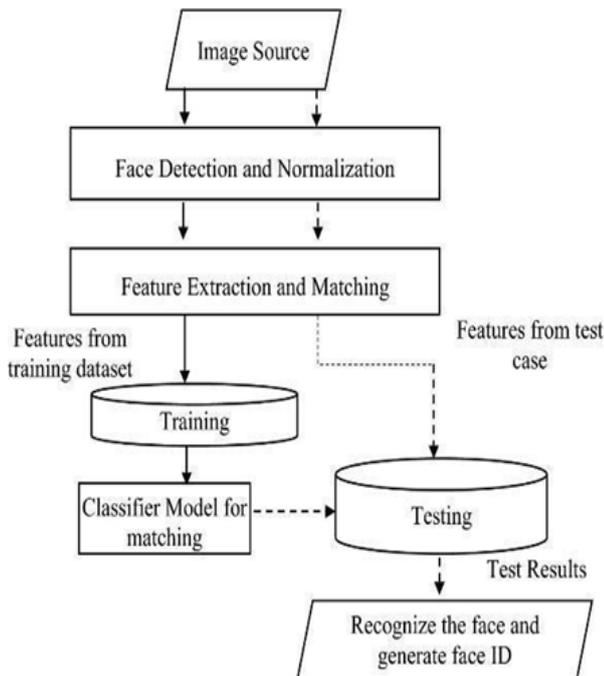


Figure 3: Block diagram of face recognition

### 2.4 Accident Detection

The purpose of this feature is to detect vehicle accidents that occur in the parking lot by using a Convolutional Neural Network (CNN) model developed in Matlab. Develop a convolutional neural network to predict whether a given video contains an accident or not. Apply ReLu (Rectified Linear Unit), Pooling, Flattening, Full Connection, Softmax. This process is performed in the CNN algorithm. The main modules used are input image, feature extraction, vehicle detection, accident detection. The clustering function is to reduce the spatial size in order to reduce the number of calculations in the network. Flattering, Full Connection, Softmax, these three processes are all classification processes in the CNN algorithm. These are the various processes performed in the algorithm [10].

Data records are collected to identify accidents; only based on these sets of images can it be recognized whether an accident has occurred or not. This entire data set is trained in the RCNN methodology for accident detection. The crash notification feature consists of two main modules: crash detection and crash notification. The dataset will play a key role in accident detection, collecting images that have been trained on the RCNN to determine that an accident has occurred. The second module, block notification, is processed on the SMTP server. When the system determines that an accident has occurred, the SMTP server sends a message to the security guard.

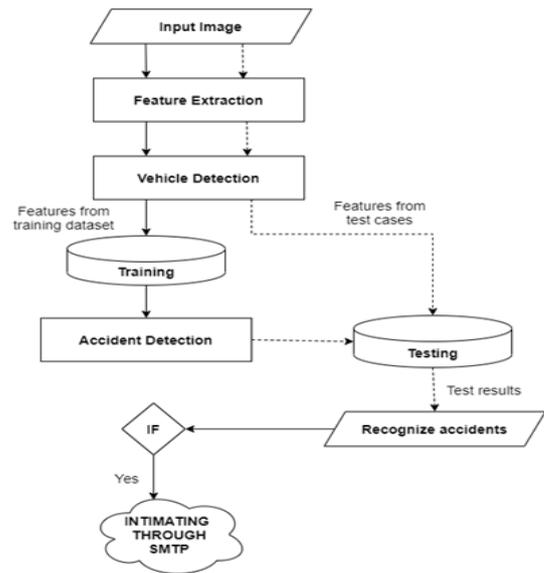


Figure 4: Block diagram of accident detection

### III. RESULTS AND DISCUSSION

This research aims to create a software solution that can better manage the aspects of car parking in parking lots. Although many such systems have been built, we wanted to focus on some key areas that needed more attention, we have taken them as separate components and have built solutions that address the specific issues and provide a better, simplistic solution. So far the system works as intended with minimal errors. Although this is not complete, an all-purpose software solution for car parks, we hope that this system can alleviate the most problematic issues faced by drivers looking to park their vehicles daily

The success rate of image recognition using YOLOv5 algorithm has already been found to be almost 91% to 96% which is generally almost error-free. Compared to traditional CNN models that were used to develop similar image processing models in previous researches, YOLOv5 is more accurate and efficient. It could aim to reach a perfect percentage of a hundred if a sufficient amount of training data were to be provided.



Figure 5: Result of vehicle detection

Based on the aggregated data and events, the challenge identified was to create a model and tools to predict the number of available parking spaces in the target parking areas within a 15-minute interval for the next 24 hours. For this we have proposed a neural network for prediction. The result is based on training and testing of the dataset; the complete dataset is divided into training (80%), and testing (20%) before observations were carried out in the analyzed test set. The success rate of the parking slot predictions available through the ANN algorithm has reached 85.7% accuracy. Generally best suited for prediction the test made daily observations every 15 minutes recorded during the weeks from Monday to Sunday.



Figure 6: Result of parking availability prediction

Identify the vehicle number plate and driver's face for safety at the parking lot during the event. It is implemented using third-party APIs and using the CNN algorithm developed in Matlab. Experimental results show that it has been proposed. The experimental results show that the proposed method has been achieved accuracy of 99% or more in the location of the license plate. In character admission, 97.8% accuracy and the overall acceptance rate is over 97%. Comparison our proposed system has superior performance with the traditional method. When applying images to CCTV footage, the output will be identified by comparing the image frames and the training data set.

In addition, we proposed accident detection using a CNN algorithm developed in Matlab and informing that an accident has occurred using an SMTP server. Once the system starts running, it takes into account every frame of video captured from the camera and runs through the proposed model and when it detects an accident, the system immediately send a mail to the security guard using the SMTP module. The idea is to take each frame of the video and run it through a deep learning convolution neural network model that has been trained to classify the video frames into incident or non incident. Convolutional Neural Networks have proven to be a fast and accurate way to classify images. CNN-based image

classifiers gave more than 95% accuracy for relatively smaller data sets and required less processing compared to other image classification algorithms. The input is also taken in the form of frames from the video. The output will be presented after a comparison of the image frames with the trained data set. The results show that the proposed model is a video-based urban parking accident detection algorithm that could be used in future processes. Figure 8 illustrates an alert appears in the web application UI when an accident is detected.

#### IV. CONCLUSION

In this research, several types of parking systems have been proposed in this research. The effectiveness of the proposed system in alleviating the traffic problems is undeniable especially in urban areas with insufficient parking spaces and congestion. This is obtained from implementation examples of the proposed system in various places. By optimizing the use of parking spaces and guiding customers this is done. The advantages and disadvantages of each image processing technology used in the detection of vehicle accidents and unauthorized users in parking areas, which is one of the most important parts of an intelligent parking system, can be analyzed with the study of all image processing technologies used in vehicle detection. Accidents and unauthorized users in parking lots although there are some disadvantages to implementing a visual system for early detection of vehicle accidents and alerting the user, the advantages far outweigh the disadvantages.

#### REFERENCES

- [1] Bakici, T., Almirall, E., Wareham, J., "A Smart City Initiative: The Case of Barcelona", *Journal of the Knowledge Economy* 4(2) (2013) 135-148.
- [2] Fujii, Y.; Yoshiura, N.; Takita, A.; Ohta, N., "Smart Street Light System with Energy Saving Function Based on the Sensor Network," *In Proceedings of the Fourth International Conference on Future Energy Systems, Berkeley, CA, USA, 22-24 May 2013*; pp. 271-272.
- [3] Kianpisheh, A.; Mustafa, N.; Limtrairut, P.; Keikhosrokiani, P., "Smart parking system (SPS) architecture using ultrasonic detector", *Int. J. Softw. Eng. Appl.* 2012, 6, 55-58.
- [4] Marso, K.; Macko, D., "A New Parking-Space Detection System Using Prototyping Devices and Bluetooth Low Energy Communication", *Int. J. Eng. Technol. Innov.* 2019, 9, 108.
- [5] Yamada, K.; Mizuno, M., "A vehicle parking detection method using image segmentation", *Electron.*

- Commun. Jpn. (Part III Fundam. Electron. Sci.)* 2001, 84, 25–34.
- [6] Ho, G.T.S.; Tsang, Y.P.; Wu, C.H.; Wong, W.H.; Choy, K.L., “A computer vision-based roadside occupation surveillance system for intelligent transport in smart cities”, *Sensors* 2019, 19, 1796.
- [7] Vitek, S.; Melnicuk, P., “A distributed wireless camera system for the management of parking spaces”, *Sensors* 2018, 18, 69.
- [8] Acharya, D.; Yan, W.; Khoshelham, K., “Real-Time Image-Based Parking Occupancy Detection Using Deep Learning”, *In Proceedings of the 5th Annual Conference of Research, Adelaide, Australia, 9–11 April 2018*; pp. 33–40.
- [9] Nurullayev, S.; Lee, S.-W., “Generalized Parking Occupancy Analysis Based on Dilated Convolutional Neural Network”, *Sensors*, 2019, 19, 277.
- [10] Ren, S.; He, K.; Girshick, R.; Sun, J. Faster R-Cnn, “Towards Real- Time Object Detection with Region Proposal Networks”, *In Proceedings of the Advances in neural information processing systems, Montreal, QC, Canada, 7–12 December 2015*; pp. 91–99.
- [11] A.C. Ssd, “Single Shot Multibox Detector”, *In Proceedings of the European Conference on Computer Vision, Amsterdam, The Netherlands, 11–14 October 2016*; pp. 21–37.
- [12] Redmon, J.; Divvala, S.; Girshick, R.; Farhadi, A., “You Only Look Once: Unified, Real-Time Object Detection”, *In Proceedings of the IEEE conference on computer vision and pattern recognition, Las Vegas, NV, USA, 27–30 June 2016*; pp. 779–788.

\*\*\* End of the Article \*\*\*