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Research Article

# Integrating computer vision, web systems and embedded systems to develop an intelligent monitoring system for violating vehicles

Waseem Ghafori Yass [1,*], Mohammad Faris[1],

[1] *Islamic University, Lebanon.*

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**ABSTRACT**

This study aims to design and develop a smart system based on artificial intelligence and deep learning techniques to monitor and track violating vehicles, especially those driving in the opposite direction or illegally on the roads. The study relies on the use of the YOLOv8 algorithm, which has proven to be highly efficient compared to other algorithms such as RCNN, to determine the location of the target vehicle in real time. The proposed system seeks to integrate computer vision, web development, and embedded systems technologies into one integrated and efficient system, which includes connecting to a database to update the location in real time, in addition to an alarm system using Arduino technology to send notifications about the monitored condition. By implementing the system, the researchers hope to reduce traffic violations and reduce accidents related to driving.

## 1. INTRODUCTION

In general, object detection involves detecting instances of objects from one or several classes in an image [1]. Pose information is considered one of the essential bases regarding the detection of a certain object, in which its simplicity and complexity vary according to the object's location, positioning, scale, bounding box, mask of segmentation, etc till the acquisition of linear and non-linear transformation in more advanced levels [2]. For example, the positions of the eyes, nose, mouth, ears, lips, adding to that the face's bounding box, may be taken into account while dealing with face detection [3]. Another example concerning vehicles, the locations of specific parts are clearly marked in the figure below (figure 1.1) in the case of bicycle detection.

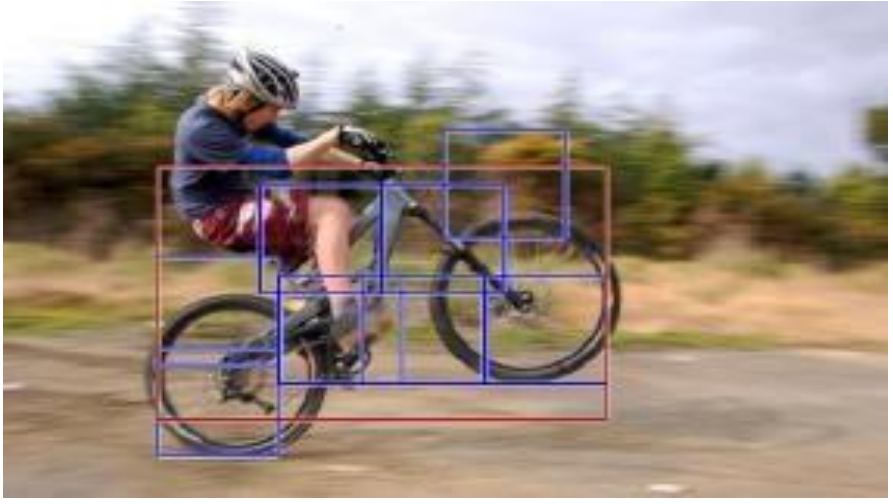

Fig. 1. Bicycle detection specified in terms of the location of certain parts

*Corresponding author. Email: it@gmail.com

Going back to the pose's issue, the last can be confined by 3-D transformation, taken in consideration the accurate position of the object relative to the camera [4]. Moreover; a set of training examples is responsible to build-up an object class's model concerning object detection systems. So that, in the static rigid objects, only one example may be sufficient. In order to capture specified aspects of class variability, numerous training examples (maybe hundreds or thousands) are thus needed [5]. According to the previous; we can say in brief, as much as the information about class variability is available, less training data is needed and vice-versa. Add to that; some methods such as the convolutional neural network is accounted as an alternative attempt rather than the previously mentioned, especially regarding large datasets [6]. To sum up; noticing and discovering the various objects in our environment is the main pillar that leads us to detect the surroundings obviously. In other words; object detection can be bounded as one of many approaches emitted by computer vision, seeking for the feasibility in the recognition of any object aside with predicting its accurate position. Anciently, and before the revolution of modern deep learning, traditional machine learning systems were used to carry out object detection problems. In addition to that; going deeply to focus in one of the most widespread object detection, car detection; in which are increasingly used as a cost effective and timely technique in capturing RS images [7]. Such technology has the ability to provide extremely high resolution RS images encompassing abundant spatial and contextual information [8]. Nowadays, the field of car detection and path tracking has been one of the most active researches in the general concept of object detection science, due to its broad boundaries peripherals and different applications, starting with traffic management, parking lot utilization, route and path tracking, monitoring, etc till reaching the urban planning. In the other site; and due to the rapid optimization of modern technology mainly in the field of transportation, we can notice the crowded traffic resulted from wide manner usage of cars shedding light on the cities and towns which are classified as industrial capitals, the way which lead to illegal interruptions to get rid of the traffic and to save leisure time. In addition to the previous, and in other words, we can say wrong paths will be followed ignoring and disobeying the traffic laws and rules set by the state as countermeasures to seek the streets' organization.

Furthermore; while speaking about the object detection technology, one can't ignore the issues of two important theories: object classification and object segmentation. Note that all of the previously mentioned technologies (object detection, object classification, and object segmentation) can be related to each other in a way or another, directly or indirectly under a wide title: image processing, but at the same time, they differ from each other in many aspects and each one of them is specialized with its own science, processing algorithms, operation methods, mechanisms, etc.. In the coming sub-titles there will be a brief summary shedding light in the most interesting information regarding the three domains; even our focus will be later on the object detection field, which will be one of the main pillars in our work.

## 1.1 Object detection

Object detection is a computer vision task that involves identifying and locating objects within an image or a video frame [9]. Its goal is to determine which objects are present in the scene and where they are located [10].

This is typically done by drawing bounding boxes around the objects and assigning a class label to each detected object [11]. Figure 1.2 highlights more clearly the meaning of what we have illustrated previously; within it, there's a bounding box surrounding the object (car) with a positioning/localization attempt, giving the latitude and longitude, in addition to the width and height of the targeted object. Add to that; the car is the label of the desired class which is obviously shown after detection in the mentioned figure below.


Fig. 2. The main two contents of the object detection process: bounding box and the class.

In other words; such concept (object detection) can be defined as a type of image recognition that is used to identify and locate the presence of an object in an image giving the information of the Bounding box and the class as well. Figure 1.3 shows an example dealing with the previous; the bounding box covers the ball which is the desired class needed from the whole image, in addition to the position's coordinate.


Fig. 3. The targeted object with its position and class's label

## 1.2 Object classification

In brief, such technique can be confined as a type of image recognition that identifies what type of object is present within image [12]. The flowchart below in the figure 1.4 is an example regarding this method for more clarification:


Fig. 4. The concept of the object classification process

## 1.3 Object segmentation

It is a type of image recognition that is used to identify and separate the distinct objects in an image on a pixel level; it gives the accurate detected object rather than the sufficiency with the bounding box [13]. Figure 1.5 clarifies the role of object segmentation by separating the two animals shown in the image, going deeply in the pixels' computation.

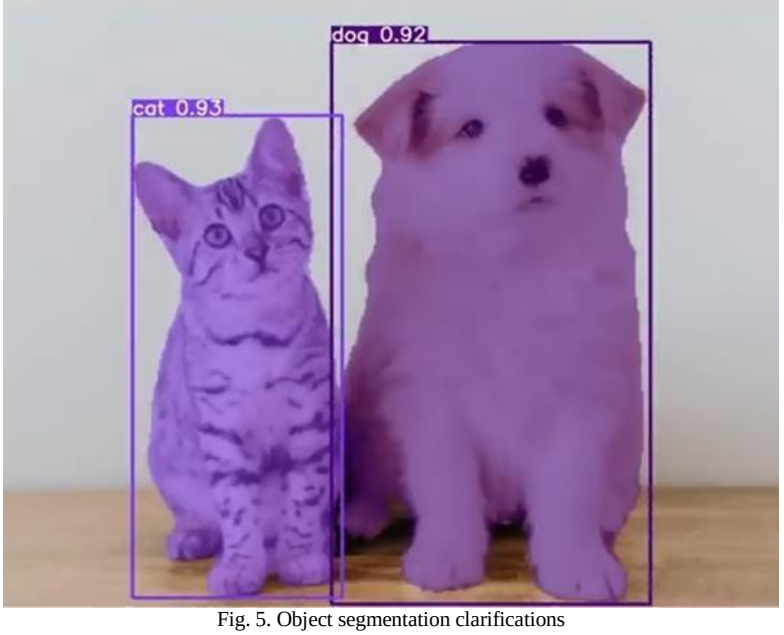


Fig. 5. Object segmentation clarifications

After giving a sufficient presentation of three essential domains in the wide field dealing with image processing (detection, classification, and segmentation of the object), we can deduce that the three can be merged together as an overall hybrid system even if each one has its own features and characteristics. On the other hand; and going ahead further with this research, our focus will be oriented towards the object detection technique with all its content and the context while passing through the different stages of work.

## 2. PROBLEM STATEMENT

No one can eliminate the essential role and the main facility of driving cars mainly in this era; the era of enhancement and exploration in all the aspects of life. At the same time, such technology can be one of the main calamities in ruining our societies in private and in its limited survey till the hazardous effects in damaging the whole state in public and in its wide manner, alternating between distinct domains and different platforms concerning the field of transportation. To clarify more what we are talking about, let us go in depth dealing with our main point of view as mentioned at the end of the background; wrong-way driving is one of the main reasons of cars' accidents and traffic jam all over the world. Figure 1.6 [14] clarifies the heavy traffic jam.

Fig. 6. A heavy traffic jam due to wrong-way driving

Road accident is a very common issue in a very populated city such as Beirut and mainly in the regions fulfilled with industrial services. Moreover, Bangladesh which is accounted as a very dense and crowded country because of its high population, and according to certain studies and statistical measures, it's exported that in the year 2019, there were 5227 case of deaths including many children and students resulted from road accidents [15]. One of the main causes of such accidents is the insufficient capacity of the roadway going ahead with the growing number of vehicles leading to the creation of all the meaning of imbalance between the requirements of the people and the platform of transportation. Furthermore; what maximizes such risk is the range of obeying cars and roads rules; some drivers don't follow the traffic laws and make use of driving in the wrong way or side without paying attention to the traffic signals such as the red lights, as a way to gain time. Also, the latest increases the traffic in a way or another, directly or indirectly on one side, and hampers the flow of it greatly, with the high probability of maximizing the head-on collision several times. Statistics show that there are about 355 death cases in the United States of America due to crashes' driving in wrong-ways [16].

## 3. CONCLUSION

In conclusion, the proposed system has succeeded in developing an effective solution for monitoring and tracking violating vehicles by integrating several modern and advanced technologies into one system, providing an effective means to support traffic safety and improve compliance with traffic rules. The system has proven its effectiveness in identifying and locating violating vehicles in real time, allowing relevant authorities to enforce laws more efficiently. The system is also an effective aid to reduce traffic congestion resulting from driving errors. This system can be considered an important step in

developing sustainable smart systems that are concerned with improving transportation systems. In the future, the system can be developed to include additional features such as tracking recurring patterns of violations, and providing recommendations to reduce traffic congestion and improve traffic flow, using analysis tools based on artificial intelligence. Cars in the opposite direction, which contributes to improving traffic safety and compliance with traffic laws.

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**Conflicts of Interest**

The authors disclosure statement confirms the absence of any conflicts of interest.

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