Detection for Illegal Right Turn Vehicles in the Korea Traffic System

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***Abstract*—In recent years, the number of traffic fatalities caused by illegal right turn vehicles in Korea has increased by approximately 2 times, from 0.34 to 0.64. However, there is currently no dedicated enforcement system in place for detecting illegal right turn vehicles, unlike the speed violation enforcement systems. To address this issue, this study aims to develop an algorithm for the detection of illegal right turn vehicles. You Only Look Once version 5 (YOLOv5) is used for the recognition of vehicles, pedestrian crossings, and pedestrians. AI Hub dataset and Common Objects in Context(COCO) dataset are utilized as the training dataset. Specifically, 36,808 samples from the AI Hub pedestrian crossing video dataset are used for training to detect the pedestrian crossing, while the COCO dataset is divided into a training set of 118,287 samples, a validation set of 5,000 samples and it is used for detecting pedestrians and vehicles. For testing the algorithm, news footage related to illegal right turn vehicles provided by the Korean news channel JTBC is used as the test dataset.**

***Index Terms*—Illegal right turn vehicles, traffic system, vehicles detection, YOLOv5**

I. Introduction

Recently, the field of computer vision has been experiencing progressive growth and garnering significant attention. Among the various applications within this field, object detection technology has been extensively researched and applied in various domains. The utilization of object detection technology has witnessed significant advancements across various domains, including autonomous driving, Unmanned Aerial Vehicle (UAV), Closed-circuit Television (CCTV) systems, and real-time traffic analysis [1]. In this research, we focus specifically on real-time traffic analysis, aiming to explore and develop innovative approaches in this field. In recent years, there has been an increase in fatal accidents caused by illegal right turn vehicles in Korea. As indicated in Figure 1, the number of injuries has risen from 3,726 to 3,750, and the number of fatalities has increased from 13 to 24 over the past two years, at the same time. The ratio of fatalities to the total number of accidents has also risen from 0.34 to 0.64, approximately doubling during this period. However, unlike speed enforcement vehicles detection models, There is no illegal right turn vehicle detection model in Korea. There are three problems that arise if this model is not established. First, as in the current situation, police and witnesses should go directly to arrest illegal right turn vehicles. Second, it takes a lot of time and labor to detect illegal right turn vehicles. Third, there should be cases that illegal right turn vehicles cannot be caught. This paper addresses this problems by proposing an illegal right turn vehicles detection model based on the Korean Road Traffic Act [2]. This paper aims to make an illegal right turn vehicles surveillance system using the You Only Look Once (YOLO) framework, specifically YOLOv5, which is a single-stage object detection model. The goal of this paper is to reduce the number of further injuries and deaths by utilizing the above-mentioned model and to solve the above-mentioned three problems.

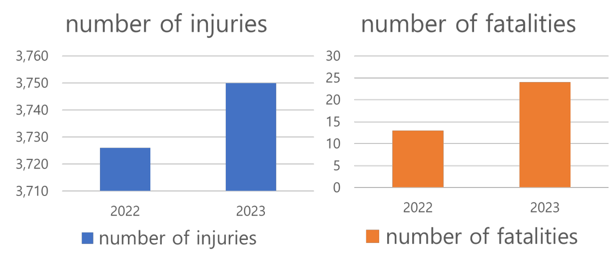

Fig. 1. Number of accidents caused by illegal right turn vehicles for two years

II. RELATED WORK

A. 3D-Net

This paper [1] is a study on real-time 3D object recognition for traffic monitoring. This research introduces a novel approach using a monocular camera, composed of a single lens, to dynamically assess the traffic situation. The paper proposes a deep convolutional neural network-based 3D object recognition and tracking system. The focus lies on achieving practical and effective outcomes in object recognition and traffic monitoring domains. This contribution aims to advance the development of 3D object recognition techniques in the field of traffic monitoring.

B. Pyramid Pooling Vehicle Detection

The paper [3] proposes a large-scale traffic management system using the pyramid pooling method, which uses feature maps of various sizes for different regions, CNN (Convolutional Neural Network) techniques, and Kalman filtering. The focus lies on monitoring traffic situ ns using aerial images and real-time vehicle tracking system. The experimental results validate its superior performance in the field of smart traffic monitoring. This paper contributes to the advancement of smart traffic monitoring technology utilizing aerial images.

C. Embedded Cement-Based Piezoelectric Sensors

The paper [4] proposes a novel approach for smart traffic monitoring using embedded cement-based piezoelectric sensors. The method utilizes these sensors embedded in the road to detect and monitor traffic conditions. this paper explains the mechanical-electrical conversion mechanism between the traffic flow and the electrical output of the embedded piezoelectric sensors, employing Duhamel's integral, constitutive laws, and charge leakage characteristics of piezoelectric composites. The sensors collect and analyze acoustic and vibration signals generated on the road, providing real-time information on traffic volume, vehicle speed, road conditions, and more. This research contributes to the field of smart traffic monitoring by leveraging innovative embedded sensor technology.

D. Smart Traffic Mointoring System using Computer Vision and Edge Computing

This paper [5] proposes a smart traffic monitoring system by combining artificial intelligence technology and edge computing technology to solve road and traffic problems, and aims to accurately collect and analyze information such as traffic, vehicle speed, and traffic congestion. A total of two major technologies are used in this study. First, this paper designs a camera system that monitors road conditions using computer vision technology. Second, edge computing technology is introduced to process data around the road and extract important information in real time. Edge computing technology improves performance by reducing network bandwidth and minimizing latency. This study also conducted weather tests to evaluate the performance of the model.

III. PROPOSEED ALGORITHM

A. Object Detection

Object detection is performed through Yolov5 [6] when conducting this paper. yolov5 is one of the outstanding performance learning models with real-time availability in single-stage models. Using this, crosswalks, pedestrian, and cars can be detected. This paper uses yolov5s, which has a small number of parameters among the yolov5 series. During the training, the input image size is 640 by 640.

Fig. 2. Coordinates of Detecting Box

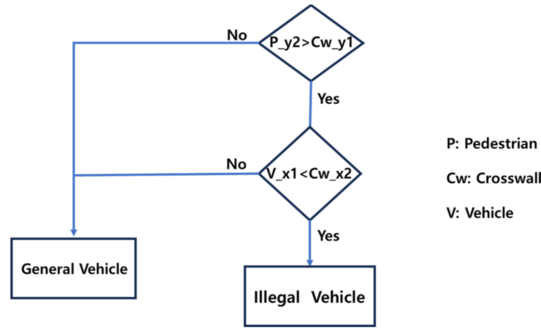

Fig. 3. Architecture of Algorithm

B. Detecting Pedestrian Crosswalks

In order to detect the pedestrian crosswalk, dweight file [7] trained with 36,808 crosswalk samples out of aihub data sets is used. With this weight file, this paper uses yolov5s mentioned above to detect pedestrian crosswalks. This paper constructed Fig. 3 using the coordinate value of pedestrian crosswalk obtained through the detection process.

C. Detecting Pedestrians and Vehicles

This paper conducts detecting pedestrians and vehicles by using yolov5s in the same way as crosswalks. In order to proceed with detection, weight files that came out after learning using 118,287 training samples and 5,000 validation samples among coco dataset[8] is used. This paper constructed Fig.3 as in the case of Pedestrian crossswalks using the coordinate values of Pedestrians and vehicles obtained through the detection process.

D. Algorithm for Detecting Illegal Right Turn Vehicles

This paper proposes an algorithm for detecting illegal right turn vehicles based on the Korean law[2]. The algorithm utilizes the coordinates of pedestrian, vehicle, and crosswalk, as shown in Fig. 2. For this study, the left coordinates are assumed to be denoted as x1, y1, and the right coordinates as x2, y2. The structure of the algorithm for detecting illegal right turn vehicles is presented in Fig. 3, following the analysis of law[2]. Before explaining the algorithm, P in Figure 3 means Pedestrian, Cw means Crosswalk, and V means Vehicle. The algorithm is structured based on the position of pedestrians. As seen in Fig. 3, the first conditional statement determines whether there is at least one pedestrian on the crosswalk. If the condition is false, meaning no pedestrian is on the crosswalk and all detected vehicles are classified as legal turn vehicles, according to law[2]. If the condition is true, indicating the presence of at least one pedestrian on the crosswalk and the relationship between vehicles and the crosswalk's coordinates is analyzed to distinguish between illegal right turn vehicles and legal vehicles. The above relationship can be confirmed through the second condition statement in Figure 3. In this proposed algorithm, when both conditions are true , the vehicle is identified as an illegal right turn vehicle. This proposed algorithm is designed to align with the criteria specified by law[2] and can be applied to enforcement purposes model for detecting illegal right turn vehicles.

IV. EXPERIMENT

A. System Environment

The system used for training consists of four RTX 3090 GPUs with a total of 96GB of graphics memory and 188GB of RAM. The optimization function employed for training is Stochastic Gradient Descent (SGD) [9]. The training images are resized to a size of 640 x 640, and the batch size is set to 16. The training process is conducted for a total of 100 epochs. For the learning rate scheduler, the Cosine Learning Rate Scheduler [9] is utilized, with a specified learning rate of 0.01.

B. AI hub Dataset

During the training process, we utilized the AI Hub Dataset [11] which is developed to address the issues of improving accessibility for people with disabilities and the scarcity of publicly available dataset. For training purpose, 3,608 samples of pedestrian viewpoint were used. The dataset consists of three classes, red light, green light, and crosswalk.

C. COCO Dataset

COCO Dataset [8] is used for training, 118,287 samples as training and 5,000 samples as validation. There are a total of 80 classes, and examples include person, bicycle, car, motorcycle, airplane, and bus. Of these 80 classes, this paper uses only classes on person and car.

D. Test Dataset

In order to confirm the algorithm of this paper, a video reflected by the Korean news broadcaster Jtbc[12] under the title of ”What if it’s ”green light” when you turn right? How will it change” is used as a test dataset. The information on the video is a length of 30 seconds, a frame width of 1280, and a frame height of 720. The video is converted into an image and 210 samples of the converted images are used as test dataset.

E. Result of Algorithm

Fig. 4. Classified as general vehicle because there are no pedestrian [12]

Fig. 5. Classified as general vehicle because there is pedestrian who is not crossing the crosswalk [12]

Fig. 6. When pedestrian is crossing crosswalk and vehicle passes through the crosswalk, this vehicle is classified as an illegal vehicle [12]

This paper used YOLOv5 to proceed with the proposed algorithm, which enabled recognition of pedestrians, vehicles, and crosswalks. Learning was conducted through the aforementioned COCO Dataset to recognize pedestrian and vehicle, and AIhub Dataset is used to recognize crosswalks. The results of proceeding with the algorithm of this paper can be confirmed through Fig4, Fig5, and Fig6. As can be seen from the algorithm of this paper, if two cases are satisfied at the same time, it is recognized as an illegal right turn vehicle. In the first case, when a person is on a crosswalk, it can be considered as the first condition of the algorithm architecture mentioned before. In the second case, when the vehicle crosses the crosswalk, it can be considered as the second condition of the algorithm architecture. If the above two cases are satisfied, as mentioned above, it is recognized as an illegal right-turn vehicle, and if these two conditions are not satisfied at the same time, it is recognized as a general vehicle by the algorithm of this paper. In the case of the first result Fig.4, it can be seen that the detection process for pedestrian was not carried out, and every vehicles are detected as a general vehicle by the algorithm proposed in this paper. Second, in the case of Fig5, unlike Fig4, Pedestrian is detected, but the coordinate analysis of the proposed algorithm shows that there is no person on the crosswalk. For this reason, it can be confirmed that the detection process has been performed with a general vehicle. The result of Figure 6 can be said to be the reason for proceeding this paper. According to the result of the proposed algorithm, when a pedestrian is on a crosswalk, every vehicle passing through the crosswalk is recognized as an illegal vehicle.

V. Conclusion

Fig. 7. Vehicle covers a pedestrian at the point of view of the camera

Fig. 8. Right after the case of Fig 7

This paper uses the proposed algorithm applying the Korean Traffic Act [2] and yolov5 [6] to create a model that detects a vehicle that makes a right turn when there is a person on the crosswalk as an illegal vehicle. There are two difficult parts in the progress of this paper. The first is the lack of test datasets. Since there are no surveillance cameras for detecting illegal right-turn vehicle like speed cameras in Korea, test datasets to confirm the algorithm of this study are insufficient. This study will proceed with the process of building test datasets as a follow-up study. Second, when the pedestrian on the crosswalk is covered by the vehicle from the camera's point of view, because of this, pedestrian is not detected. Fig 7 shows that the vehicle that should be recognized as an illegal vehicle is judged by the algorithm of this paper as a general vehicle because the pedestrian is not detected. The case of Fig 8 is immediately after Fig 7, Fig 8 shows that as soon as a pedestrian is detected, a general vehicle is turned into an illegal vehicle. As a follow-up study, this paper will study how the correct detection process can be achieved in the section where pedestrians and vehicles overlap from the camera's point of view. In addition, this study will try to construct the algorithm through the IoU (Intersection over Union) [13] analysis method, which is a method other than the coordinate analysis method mentioned above.

Acknowledgment

This result was supported by "Regional Innovation Strategy (RIS)" through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(MOE)(2021RIS-003)

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