DETECTION OF PEDESTRIAN PROFILES AT TRAFFIC LIGHTS WITH MACHINE LEARNING

Halil Ibrahim Uluoglu, Kadir Sahin
Department of Computer Engineering
Yildiz Technical University, 34220 Istanbul, Turkey
{l1116093, l1117703}@std.yildiz.edu.tr

***Özetçe* —Modern dünyadaki temel sorunlardan biri, yayalar için sabit trafik ışığı zaman sistemleridir. Statik sistemler duyarlı değillerdir ve trafik ışıkları çeşitli yaya türlerine göre ayarlanmaz. Bu nedenle trafik ışıklarının sabit olarak düzenlenmesi, uzun bekleme süresi, kısa bekleme süresi, iki zaman aralığı arasındaki anormallik süresi, farklı gündüz dönemleri için kötü zamanlama gibi pek çok hoş olmayan soruna neden olur. Bu sorunlar, güncel teknoloji makine öğrenme yöntemleri kullanılarak farklı yaya türleri ve gündüz süreleri dikkate alınarak dinamik trafik ışığı süresi ile çözülebilir.**

Bu projenin konusu, yayaları gerçek zamanlı bir sistemde tespit etmek ve farklı insan kategorilerine göre ve gelişmiş algılama algoritmalarını kullanarak farklı gündüz dönemlerini dikkate alarak trafik ışıkları için değişkne olarak trafik ışığı zamanı oluşturmaktır. Projede sistem için eğitim sınırlaması tek bakış açısı olarak seçilmiş ve tek noktadan veri toplanmıştır. Literatürde ilk kez, kamera görünümüne sahip bir trafik ışığından çeşitli etiketleme sistemleri kullanılarak bir veri seti başarıyla oluşturulmuştur. Bu veri setini kullanarak sistem, doğru kategoriye göre yüksek oranda yaya tespit etmeyi ve trafik ışıklarının zamanını gerçek zamanlı olarak simüle etmeyi başarmıştır. Bu proje sonucunda ileride dinamik zamanlı trafik ışıklarının kullanılabileceği gösterilmiştir.

Anahtar Kelimeler—Nesne Tanıma, YOLO, yayalar, dinamik trafik ışığı sinyalizasyonu

***Abstract*—One of the main problem in the modern world is static traffic light time systems for pedestrians. Static systems are not responsive and not adjustable for various kinds of pedestrian traffic lights. Therefore, arranging traffic lights statically causes many not welcome problems such as long time waiting, short time waiting, anomaly time between two time periods, bad timing for different daytime periods. These problems can be solved by dynamic traffic light time considering different types of pedestrians and daytime periods using state-of-art machine learning methods.**

The topic of this project is to detect pedestrians in a real-time system and making traffic light time decisions for traffic lights based on different categories of people and considering different daytime periods using advanced detection algorithms. In the project, the training limitation for the system has been chosen as a single point of view and collected data from the single point. For the first time in the literature, a data set has been successfully created using various labeling systems from a traffic light with a camera view. Using this data set, the system has managed to detect with a high percentage of pedestrians according to the right category and simulate the time of traffic lights in real-time. As a result of this project, it is shown that dynamic time traffic lights can be used in the future.

Keywords—Object Detection, YOLO, pedestrians, dynamic traffic signalization

I. INTRODUCTION

According to the research of Grand View Research Company, intelligent transportation systems will grow rapidly 5.8% between 2020 to 2027 in North America; Europe; Asia Pacific; South America; Middle East Africa regional areas. intelligent transportation and intelligent traffic systems will affect a significant role in human lives in the future.[1] There were traffic lights and signalization systems since even creation of vehicles in order to make regulations. However, the traffic light systems have used the same static time arrangement for every situation all around the world. This arrangement causes to waste of time for all traffic participants. Gasoline oscillation and air pollution are other negative effects of this signalization type.

This project aims to solve this problem by providing dynamic traffic signalization system for detecting pedestrians by using image processing and machine learning technologies. The concept of this project is to detect pedestrians and categorize based on behavior of pedestrian on the crosswalk. The data set collected for this project can be used for the related projects for common purposes.

YOLO Algorithm was chosen as the most suitable approach to achieve the project target. YOLO has several advantages against other object detection algorithms:

Other old detectors based on Haar Cascade Classifier or SVMs, or newer approaches which use Fast R-CNNs or Faster R-CNNs have slow response time for some detection values compared to YOLO.[2]

YOLO firstly divides the frame as a grid and runs seperately for every cell of this grid, while some of other methods use Sliding Window methods which require much more power and time cost. [3]

YOLO Algorithm can detect objects accurately in approximately 25 frames/second on HD image and this is one of the highest rates compared to others. [4]

In YOLO, each cell can predict 3 “bounding box” and later by applying “non max suppression algorithm”, false positive or duplicated bounding boxes are filtered out.

II. MATERIALS AND METHODS

Within the scope of the project, it is essential to recognize and detect pedestrians nearthe road, on the road, or the relative path of the road. For this purpose, the machinevision of the project needs to be highly trained with quality data. It needs to identifysmall changes of the pedestrians because of the angle of the machine vision(camerason top of the traffic lights). After the detection, within decision-making algorithmneeds to make a decision according to real-time pedestrian data.

For child category: It requires to shorten red light time because they are more activethan other genres. Also, it needs to be responsive due to a lack of child control.
For unchallenged category: It is the regular pedestrian profile category. In thiscategorization, it can be important the number of pedestrian in this profile.
For challenged category: It requires longer red light time because they are lessactive than other genres. It contains disabled and senior people. Also, it needs toidentify small pinpoints for this category. For instance, they can have a walking stick,wheelchairs, white hair due to senility, etc. .

On the Application side, PyQT5 Framework based on Python have been used. It contains required outputs and information about the system.

A. Dataset

During the training process of this pedestrian detection model, 3 different labeling methods have experimented. Further, for each method, the model was trained in different epoch numbers. All images of the project's dataset are collected from the live broadcast "Town Square Live Cam" provided by the "See Jackson Hole" Youtube channel. The live broadcast is reachable at the link on https://www.youtube.com/watch?v=1EiC9bvVGnkbluehere.

The number of labels and frames for each class is given in the table-1 .

Table 1 Summary of labeling data by category

Labeling Method 1		Labeling Method 2		Labeling Method 3	
class	**# of labels**	**class**	**# of labels**	**class**	**# of labels**
child	200	child	200	child	297
unchallenged	200	unchallenged	200	unchallenged	1063
challenged	200	challenged	200	challenged	144
Total Label	600	**Total Label**	600	**Total Label**	1504
Total Frame	600	**Total Frame**	255	**Total Frame**	445

B. Labeling Method 1

In the first case, the labels of classes were taken in a way where every image includes only 1 class label. If there are multiple samples of any class in a frame, the image was cloned and separate .txt label files were created for every sample.

C. Labeling Method 2

In order to improve multiple pedestrian detection performance and ensure continuity of bounding boxes in the video, the labels of the image dataset were rearranged.

D. Labeling Method 3

In this method, multiple labels from walking pedestrians were taken. In this method, multiple labels were taken from walking pedestrians. Furthermore, labels of the unchallenged class have recollected and more apparent samples have been chosen such as pedestrians with a cane, hunchback, a stroller, etc. With this modification, tracking success of the system on walking pedestrians notably improved.

Summary of the comparison for different epochs and labeling methods are given at the table-2.

Table 2 Output summary of labeling methods

1	**50 EPOCHS**		**500 EPOCHS**	
	P	0.265	P	0.5138
	R	0.8172	R	0.9618
	mAP@.5	0.4535	mAP@.5	0.826
	mAP@.5:.95	0.2664	mAP@.5:.95	0.7063
2	**100 EPOCHS**		**500 EPOCHS**	
	P	0.2562	P	0.6135
	R	0.686	R	0.9552
	mAP@.5	0.4505	mAP@.5	0.9483
	mAP@.5:.95	0.2438	mAP@.5:.95	0.713
3	**50 EPOCHS**		**500 EPOCHS**	
	P	0.3454	P	0.6729
	R	0.7762	Recall	0.9707
	mAP@.5	0.4897	mAP@.5	0.9594
	mAP@.5:.95	0.2539	mAP@.5:.95	0.724

III. Performance Analysis

As a result of experimental methods, the best labeling method has chosen as "Labeling Method 3". In this method, it used multiple labels for a single pedestrian while walking on the path. So, the training system managed to learn from various perspectives of a pedestrian. Therefore, it produced better detection for video input. It is given in the table-3

Table 3 Distribution of label date

Train Data (65.4%)		Validation Data(20.6%)		Test Data (14.0%)	
class	**# of labels**	**class**	**# of labels**	**class**	**# of labels**
child	217	child	53	child	27
unchallenged	667	unchallenged	224	unchallenged	172
challenged	100	challenged	33	challenged	11
Total Label	984	**Total Label**	310	**Total Label**	210
Total Frame	354	**Total Frame**	61	**Total Frame**	30

As a result of test performance, the detection system has precisely recognized the samples of the child, the unchallenged, and the challenged categories. The success result of the detection is given at the fig-4. Therefore, in this project, the algorithm of YOLO and labeling method 3 have reached the best outcomes for purpose of this project.

IV. Result

Traffic signalization systems have been in human life for over a century. During this period, they have gone through many changes. Despite all the changes, their functionality

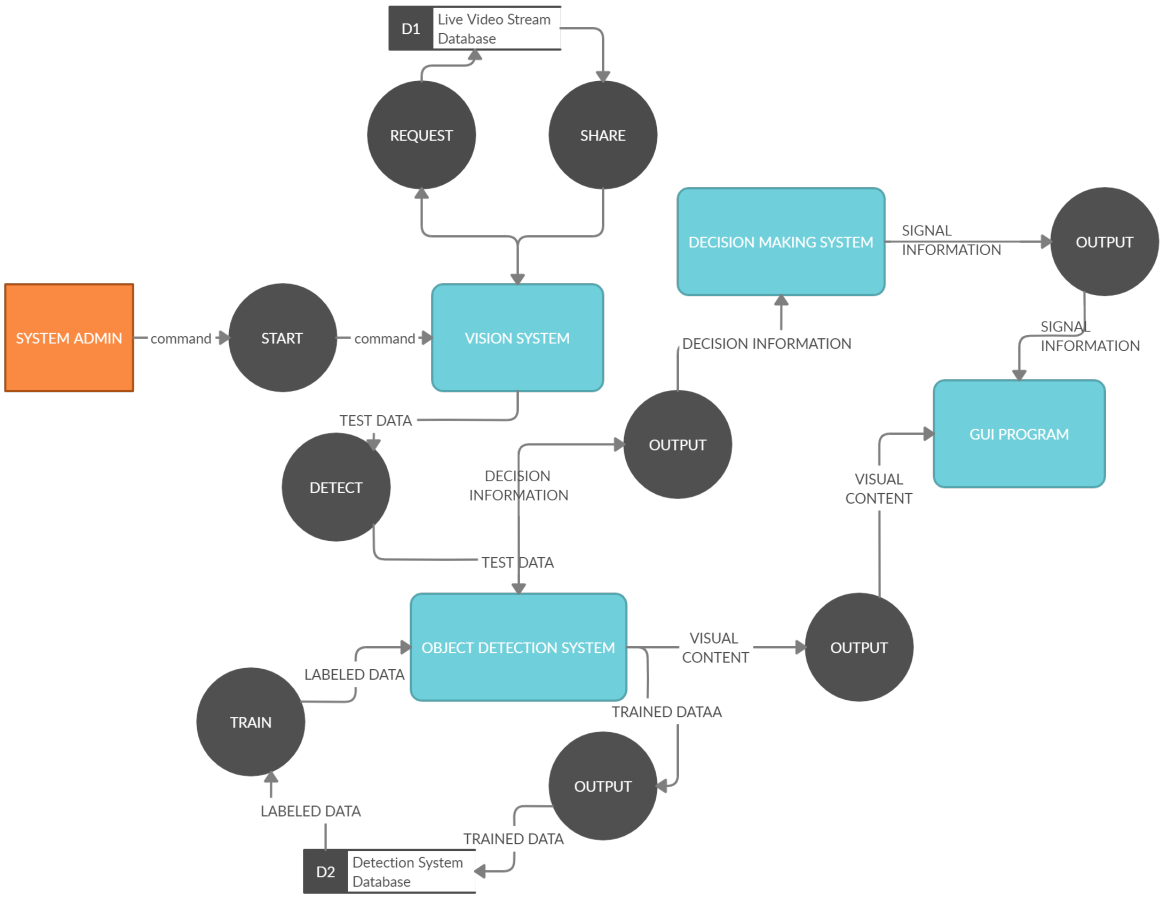

Figure 1 Flow Diagram

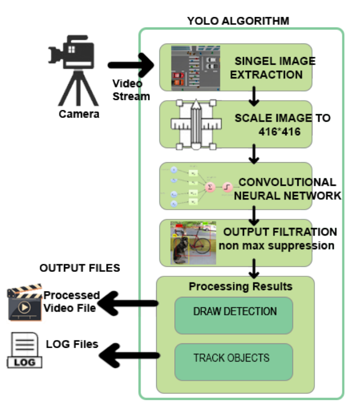

Figure 2 Overview of YOLO algorithm

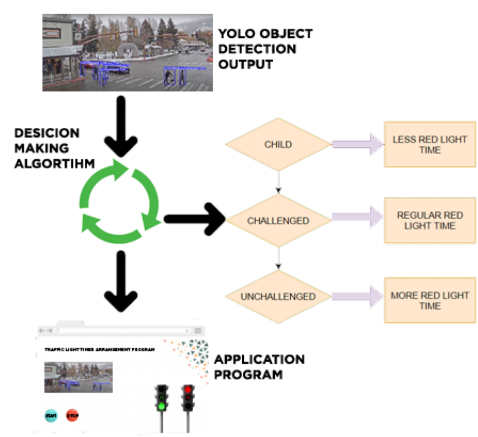

Figure 3 Application Design

remained limited. Some technologies have been experienced to change their fixed-time light arrangement and reduce traffic jams caused by this arrangement. One of them is static traffic light systems for pedestrians. It can cause many unpleasant side effects such as long time waiting, short time waiting, anomaly time between two time periods, bad timing for different daytime periods. In this project, the state-of-art object detection technologies have been analyzed in detail and the YOLO real-time object detection algorithm has been used to contribute to solve this problem.

In the project, for the first time in the literature, a

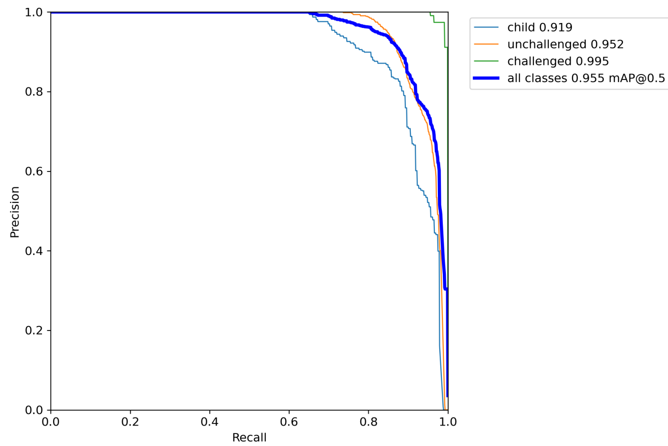

Figure 4 Precision Recall Curve of Test Results

data set has been successfully created using various labeling systems from a traffic light with a camera view. Three main pedestrian category used for the detection. With the this data set, the system has identified these main pedestrian categories as aimed for this project. To get the best result, it is used diffrent labeling methods amd the best performing label method was chosen. Detection result using the best performing labeling method is shown at the figure-5.

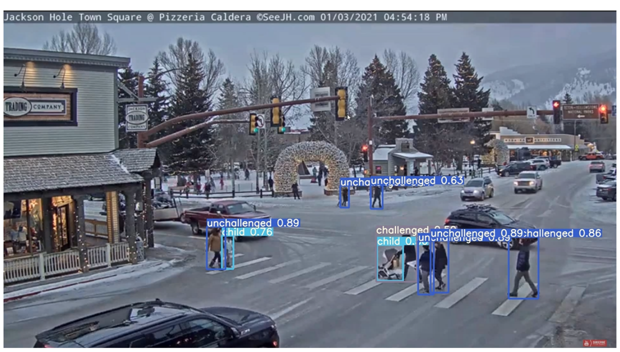

Figure 5 The Best Performing Detection Result

The worst performing labeling output does not satisfy because the labels of classes were taken in a way where every image includes only one class label. The best performing output fulfills the aim of the project because multiple labels were taken from walking pedestrians and the labels of the unchallenged class have recollected. With this modification, tracking the success of the system on walking pedestrians significantly improved. For the different camera view, the detection is not enough to simulate time for the traffic light. In order to exceed this problem, it is better to get the same camera view training data and add into the previous training data set.

For the future work, it can be expandable with various camera view data and test the outcomes. Also, the aim of this project was to limit only pedestrians. However, for future works, it may be extended with vehicles such as cars, trucks, bicycles, etc.

References

[1] G. V. R. Company. (2020) Intelligent transportation system market size, share trends by type (atis, atms, atps, apts, ems), by application (traffic management, public transport), by region, and segment forecasts, 2020 - 2027. [Online]. Available: https://www.grandviewresearch.com/industry-analysis/intelligent-transportation-systems-industry

[2] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, "You only look once: Unified, real-time object detection," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2016, pp. 779–788.

[3] P. F. Felzenszwalb, R. B. Girshick, D. McAllester, and D. Ramanan, "Object detection with discriminatively trained part-based models," *IEEE transactions on pattern analysis and machine intelligence*, vol. 32, no. 9, pp. 1627–1645, 2009.

[4] A. Ćorović, V. Ilić, S. Ðurić, M. Marijan, and B. Pavković, "The real-time detection of traffic participants using yolo algorithm," in *2018 26th Telecommunications Forum (TELFOR)*. IEEE, 2018, pp. 1–4.