Traffic Light Status Detection using APV Method

Moh Noor Al-Azam, Cahyo Darujati
Engineering and Computer Science Faculty
Narotama University
Surabaya, Jawa Timur, 60117, Indonesia
noor.azam@narotama.ac.id, cahyo.darujati@narotama.ac.id

Sri Wiwoho Mudjanarko
Civil Engineering Faculty
Narotama University
Surabaya, Jawa Timur, 60117, Indonesia
sri.wiwoho@narotama.ac.id

Abstract

One of the supporting aspects of Electronic Traffic Law Enforcement (ETLE) is the detection of traffic light status. This detection is used to determine whether someone driving a vehicle violates a traffic light or not. There are several ways to find out the status of the traffic lights that can be done, including what is often done is to install a system embedded in the traffic light system and then send a message to the traffic light status ETLE system from time to time. In this study, the status of the traffic lights is obtained by analyzing a still image from closed-circuit television (CCTV) using OpenCV and then comparing the Average Pixels Values (APV's) in some area to get a conclusion about whether the traffic lights are in a certain color condition. In experiments conducted this method can detect the status of traffic lights with an accuracy of more than 99%.

Keywords
ETLE, Electronic Traffic Law Enforcement, Traffic Light Status, RGB and Computer Visual

1. Introduction
The indiscipline of road users is commonly seen in daily life. This indiscipline is closely related to oversight of law enforcement or in this case the presence of traffic police on the streets. It is common knowledge that when there are police on the streets, the driver will obey the traffic rules. But when there no police officers are seen, they tend to return to their original habits: breaking the rules.

According to World Health Organization (WHO), the causes of traffic accidents can be grouped into three main factors, namely human factors - that is, accidents caused by vehicle users, for example driving at high speed, disorderly, violating traffic signs and so forth. The next factor is the vehicle factor, which is a factor that is caused by the condition of the vehicle, for example, a blown tire, a brake failure, or something else (United Nations, 2020). And finally, the physical environmental factors of the roads, these are more related to the condition of the road where the accident occurred, for example, damaged roads, potholes, waterlogged, dark, without road markings, sharp turns, and so on (Hobbs et al., 1996).

Based on the official release of the Indonesian National Police (Polri) in the news on Kompas on December 28, 2019, the number of traffic accidents in Indonesia in 2019 increased by 3% compared to the previous year. Total traffic accidents in 2019 were 107,500 incidents, while in 2018 there were 103,672 accidents. In the official release of the National Police it was stated that the factors causing the increase in accidents in 2019, the biggest was due to human error, and violation of regulations or traffic signs is the beginning of an accident with this human factor (Ardito Ramadhan, 2019).

Since the police are not likely to be on the streets and monitor vehicles all the time, the role of Information Technology (IT) is expected to help in this monitoring. Therefore, the Electronic Traffic Law Enforcement (ETLE) was then introduced.

ETLE then expected to replace the role of the police in conducting surveillance and law enforcement for traffic violations on the streets. If there is a violation, the ETLE system will provide information to the authorities complete with evidence in the form of photos and/or videos when the violation occurred. The ETLE which is currently being developed in Indonesia is currently limited to the enforcement of regulations of traffic lights violations -in this regulation are mainly the driver not stopped at a red light or not stopped at the right place of crossing.

To find out the status of the traffic lights on the crossing, some ETLE systems use an embedded system get traffic light status information. This embedded system sensor gets input from the traffic light to determine its status (red, yellow, or green light), and then sent to ETLE for the conclusion.

In this study, the embedded system will be replaced by a computer vision application -powered by OpenCV on Python programming, that gets input from the closed-circuit television (CCTV) camera's still image. The result of this program also a conclusion that the traffic lights status from a particular direction of crossing is in the red, yellow or green light -the same situation as when people see it on the street.

This method is simpler because it does not require modification of the traffic lights, besides the existence of CCTV cameras is mandatory in ETLE because it will be used as the evidence of violations.

2. Research Methods

In order for this research to be well directed, the researcher uses the application development research method as shown in Figure 1. The research will start with a literature study. This activity is to find out several things that are needed in this research, including how the application can retrieve image data from the camera, how to process data from moving images so that traffic light signal conditions can be known, and several other things.

After knowing the things that are needed from the literature study, an application will be made to retrieve data from existing Closed-Circuit Television (CCTV) cameras. The development of a moving image capture application from this system was continued with field trials using direct data from CCTV obtained from one of the districts in East Java.

At the beginning of system development, the criteria needed for a traffic light signal detection system are determined in advance, namely:

1. Data obtained from CCTV is in the form of live and realtime data, therefore it is necessary to collect data directly from CCTV(Jianbing and Shuhui, 2019).
2. Video capture using Real Time Streaming Protocol (RTSP) (Cattaneo et al., 2017) with data in H.264 format in accordance with ITU recommendations(ITU-T, 2007).
3. Data obtained from CCTV will be processed on the server and endeavored to obtain data conclusions that are close to realtime in the field.
4. All results will be stored on the server to be processed for further analysis.

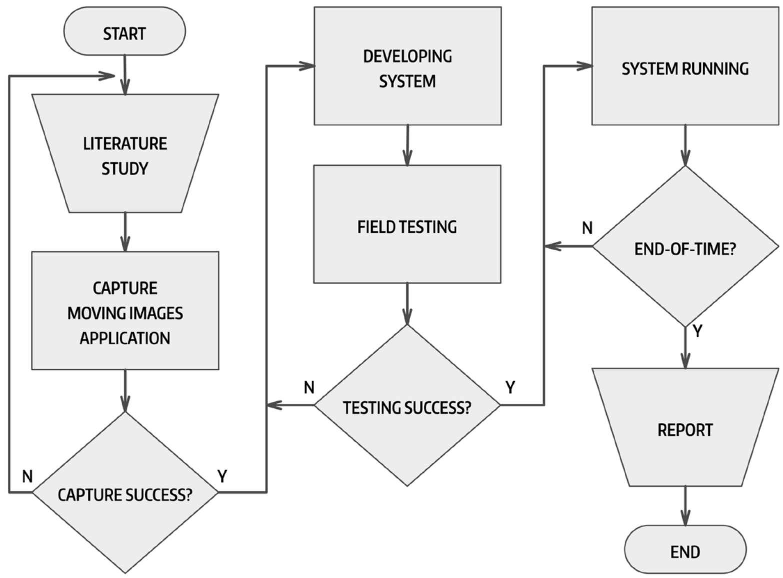


Figure 1: The Flowchart on The Research

The test results in the field will provide an overview of whether the traffic light signal detection system has provided valid information or not. If it is felt that the system has not provided valid results with live data in the field, then system development will continue until the system is declared reliable to determine the condition of the traffic light signal in the field.

The current era of Internet of Things (IoT) has revolutionized the way devices/objects interact with each other. In the past, a device interacted more with humans before other devices, so in this IoT era, devices can interact with many other devices without involving humans at all (Anindito et al., 2018). The development of IoT devices can use various programming languages. However, by using the Python programming language, IoT system developers will be able to be more interactive and design Machine-to-Machine (M2M) equipment more comprehensively (Kristiana et al., 2018). Through Python -and its supporting modules, applications can interact with the world, through sensors, cameras, communication media, and other hardware (Hillar, 2016).

One of the growing fields in IoT today is computer vision (Al Azam et al., 2019). The main purpose of computer vision is to understand something that is happening in an image. As a human, this is actually quite simple. But for computers, the task becomes very difficult. So why bother using computer vision? Because pictures are everywhere! And of course, we actually know something based on the images received by our eyes and inferred by our brains (Prasetyanto et al., 2019).

In this study of signal recognition of traffic control lights, a computer vision application will also be applied to applications that take pictures from surveillance cameras. This surveillance camera is already available, and this research application will recognize the condition of the traffic light signal, whether it is red, yellow, or green. And as previously explained, this application will use the Python 3 programming language and the OpenCV module.

3. Review of Literatures

The history of digital images dates back to 1920. That is when the first digital images were produced by British inventors -Harry G. Bartholomew and Maynard D. McFarlane, who developed the cable drawing method of the Bartlane transmission system (Darujati et al., 2021). Followed later by Russell A. Kirsch who in 1957, produced a device that generated digital data that could be stored in a computer; It uses a drum scanner and a photomultiplier tube. Then in the early 1960s, Industrial Automation, Inc., invented the first way to produce digital images in real-time. It uses a square wave signal detected by the pixels of a cathode ray tube to create an image (Ahmad et al., 2021). These ideas were the basis of the basic scanning idea of the first digital camera designs. In the early days of digital cameras, it took a long time to capture images and produced poor quality. Until then, solid state technology developed with the Charge-Coupled Device or CCD. CCDs are now part of the primary imaging system used in almost all areas of digital imaging.

Currently digital images are captured based on CCD sensors of the three basic colors of visible light: Red, Green and Blue (RGB). Like the computer screen we use. The dots forming this digital image are then encoded in the 3 parts of the color with different intensities.

By default, this intensity uses the amount of 1 byte or 8 bits of data, or in numeric we know 256 possible intensities. From a value of 0 which means there is no such color at all, up to a value of 255 which means that the color has a maximum intensity, as shown in Figure 2. Therefore, the RGB value as the basis for forming colors has three 8 bits of data or what we call RGB888 or RGB24.

In Figure 2 we can see, mixing all the basic colors with the highest intensity will produce white and the absence of

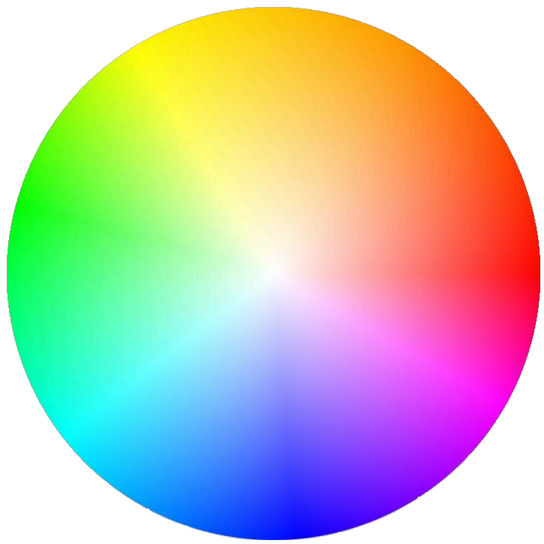


Figure 2: RGB Wheel

intensity in all colors will produce a background color. This is why the screen background is always black. Also in Figure 2 it can be seen that in the process of searching for this traffic light status, we only need to search for 2 basic colors. Namely red and green. Why? because red traffic light images come from red pixels, green traffic light images come from green pixels, while yellow traffic light images come from mixing red and green colors (Deckman et al., 2018).

Average Pixels Value

Average Pixels Value (APV) is one way to determine the brightness level of a color in an area of an image. As it is known that image color is built from 3 basic colors (red, green, and blue), then the average brightness level in an area is the average value of all pixels in that area.

So the basic equation of APV is:

$$APV = \frac{\sum_{i=0}^{n}(V_{red} + V_{green} + V_{blue})}{n} \qquad (1)$$

V in this equation is the value of the pixels that make up a particular color. So V_{red} is the red pixel value, V_{green} is the green pixel value, and V_{blue} is the blue pixel value. Because the pixel value is always between 0 and 255, the APV value also ranges from 0 -which means all pixels are 0 so that the area is black or no light intensity, and 255 -which means all pixels are 255 so the area is white. or with the brightest light intensity.

It should be noted that the APV value cannot determine the color type, because it is not designed to look for a specific color type. The APV value only provides information on the average intensity. To determine the color of the traffic light that is currently on, the APV equation will be slightly modified. So, we will use the following three equations:

$$APV_{red} = \frac{\sum_{i=0}^{n} (V_{red})}{n} \quad (2)$$

$$APV_{yellow} = \frac{\sum_{i=0}^{n} (V_{red} + V_{green})}{n} \quad (3)$$

$$APV_{green} = \frac{\sum_{i=0}^{n} (V_{green})}{n} \quad (4)$$

Each equation will be used specifically for each color in the traffic light. Because the position of the color of the traffic light is certain, the position of the area measured in each APV has also been determined beforehand. APV_{red} or equation (2) will only be used to calculate the intensity level for red lights, APV_{yellow} or equation (3) for yellow lights, and APV_{green} or equation (4) for green lights only.

Note, that equation (3) is slightly different from equation (2) and equation (4). This is because the yellow color is a combination of the basic red and green colors. Therefore, if you want to know the level of brightness of these colors, then the two colors must be measured and then averaged.

When all APV values for all traffic light colors have been obtained, then a comparison can be made. The color of the traffic light with the highest APV value is the color that is currently lit.

4. Experimentation

At the beginning of the experiment, the researcher created a prototype application that reads images offline and calculates the APV of a predetermined area. By using this prototype, the researcher tried with some traffic light photos like the one in Figure 3. and then compared the results obtained

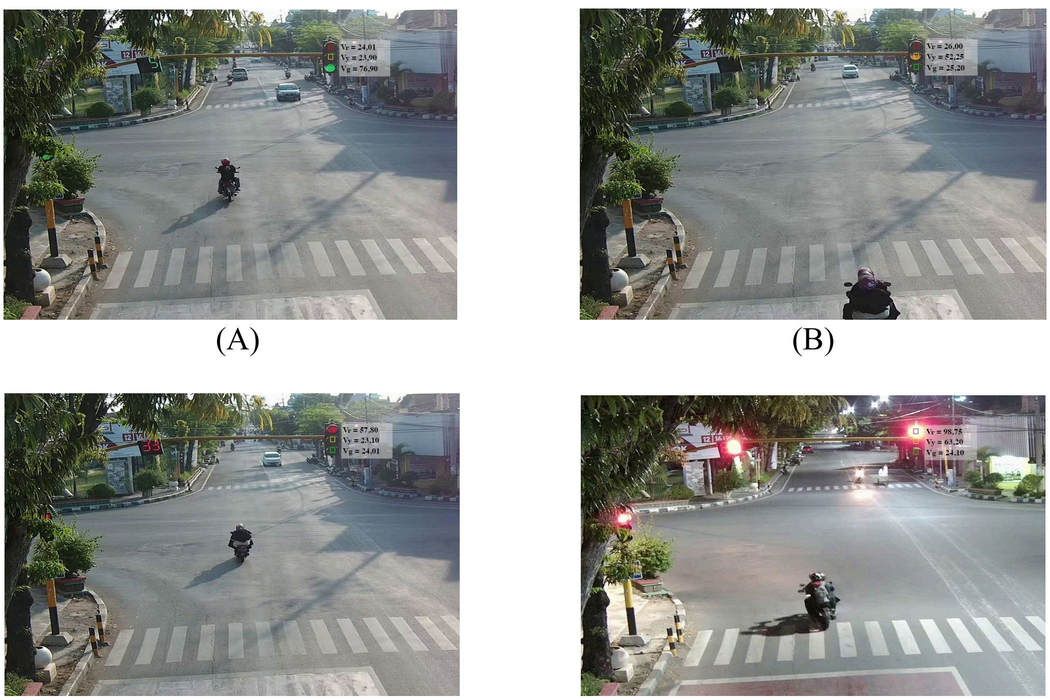
The results of the initial experiment of the researchers got quite encouraging results. All traffic light data entered in the application can be correctly identified, the current traffic light condition at that time.

Therefore, the researchers then increased the experiment with live data that had been agreed upon, by directly taking data from CCTV at a crossroads. CCTV at this crossroads is active for 24 hours (except when there is maintenance or there is a problem). For direct data retrieval, researchers use Real Time Streaming Protocol (RTSP) communication through an internal communication network, on a server.

For this, the researcher uses the python programming language with the help of the OpenCV module. The example of the results processes in the real time field is shown in Figure 4.

Figure 4: Prototype Application on Several Condition of Traffic Light

In this real time data collection, researchers got around 140 thousand photos of different traffic light conditions at one location. However, there are around 36 thousand photos that cannot be processed further. It should be noted that between 23:00 and 04:59 the traffic light at the crossroads in this research is in a yellow flashing condition, considering that at these times the traffic is very light. Traffic lights will be active again at 05:00.



(A) (B) (C) (D)

Figure 3: The Result of Real Time Process

The results of the calculation process carried out by the application are then confirmed with the real conditions in the photo and the results will increase over time. The table results can be seen in table 1.

In table 1 it can be seen that the APV method can be trusted to determine the condition of the traffic light status. Errors that occur during the day are mainly due to the condition of the traffic lights which are sometimes dim and coupled with backlighting so that the processed area has an insignificant difference.

Table 1: The Amount of Data and Process Results

TIME	SAMPLE CHECK	ERROR RATE
05:00 – 08:59	20.203	1%
09:00 – 11:59	16.264	1%
12:00 – 14:59	16.400	2%
15:00 – 17:59	16.126	3%
18:00 – 20:59	15.982	0%
21:00 – 22:59	10.810	0%

5. Conclusion and Future Works

As stated in the introduction above, this research is part of the bigger research of Electronic Traffic Law Enforcement (ETLE). The research on APV will later be used in the ETLE system that is being built to determine the status of active traffic lights in real time. When the traffic light status is in red condition, then the vehicle that exceeds the limit to stop will be declared as violate and will be further processed by police officers.

For system reliability, it is also necessary to find a treatment to overcome the occurrence of calculation errors during the day. Although the percentage that happens is very small, this can be a problem if someone is found guilty while what actually happens is because of a color reading error.

There is a possibility that the error can be eliminated by replacing the traffic light with LED or a lamp with a greater power to get greater intensity, so that during the day the differences between an off and an active traffic light signal can be distinguished more significantly.

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References

Ahmad, A.H., Saon, S., Mahamad, A.K., Darujati, C., Mudjanarko, S.W., Susiki Nugroho, S.M., Hariadi, M., 2021. Real time face recognition of video surveillance system using haar cascade classifier. IJEECS 21, 1389. https://doi.org/10.11591/ijeecs.v21.i3.pp1389-1399

Al Azam, M.N., Arif, I., Rizaludin, D., Ayuba, U., Haris, A., Nugroho, A., 2019. Wireless Sensor Network using Wireless Fidelity for Environmental Monitoring System, in: 2019 International Seminar on Application for Technology of Information and Communication (ISemantic). Presented at the 2019 International Seminar on Application for Technology of Information and Communication (iSemantic), IEEE, Semarang, Indonesia, pp. 1–7. https://doi.org/10.1109/ISEMANTIC.2019.8884345

Anindito, B., Sooai, A.G., Achlaq, M.M., Al-Azam, M.N., Winaya, A., Maftuchah, M., 2018. Indoor Agriculture: Measurement of The Intensity of LED for Optimum Photosynthetic Recovery, in: 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI). Presented at the 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), IEEE, Malang, Indonesia, pp. 356–361. https://doi.org/10.1109/EECSI.2018.8752827

Ardito Ramadhan, 2019. Polri Sebut Jumlah Kecelakaan Lalu Lintas Meningkat pada 2019. Kompas Cyber Media.

Cattaneo, G., Bruno, A., Petagna, F., 2017. H-264/RTSP Multicast Stream Integrity, in: Battiato, S., Gallo, G., Schettini, R., Stanco, F. (Eds.), Image Analysis and Processing - ICIAP 2017. Springer International Publishing, Cham, pp. 558–568. https://doi.org/10.1007/978-3-319-68548-9_51

Darujati, C., Susiki Nugroho, S.M., Kurniawan, D., Hariadi, M., 2021. Enhancing the feature-based 3D deformable face recognition using hybrid PCA-NN. IJEECS 22, 215. https://doi.org/10.11591/ijeecs.v22.i1.pp215-221

Deckman, I., Lechêne, P.B., Pierre, A., Arias, A.C., 2018. All-printed full-color pixel organic photodiode array with a single active layer. Organic Electronics 56, 139–145. https://doi.org/10.1016/j.orgel.2018.02.009

Hillar, G.C., 2016. Internet of Things with Python: Interact with the world and rapidly prototype IoT applications using Python, Packt open source community experience distilled. Packt Publishing Limited, Birmingham Mumbai.

Hobbs, M., Mayou, R., Harrison, B., Worlock, P., 1996. A randomised controlled trial of psychological debriefing for victims of road traffic accidents. BMJ 313, 1438–1439. https://doi.org/10.1136/bmj.313.7070.1438

ITU-T, 2007. ITU-T Recommendation H.264: Advanced video coding for generic audiovisual services.

Jianbing, L., Shuhui, C., 2019. The Design and Implementation of RTSP/RTP Multimedia Traffic Identification Algorithm. Journal of Physics: Conference Series 1168, 052033. https://doi.org/10.1088/1742-6596/1168/5/052033

Kristiana, W.A., Mizanul Achlaq, M., Anindito, B., Nugroho, A., Darujati, C., Al Azam, M.N., 2018. UUID Beacon Advertisements For Lecture Schedule Information, in: 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI). Presented at the 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), IEEE, Malang, Indonesia, pp. 270–276. https://doi.org/10.1109/EECSI.2018.8752953

Prasetyanto, I., Gumelar, A.B., Junaedi, L., Daruiati, C., Widodo, A., Ratna Dewi, A.T., Adi, D.P., 2019. Performing Robot's Head Motion Simulation by Human Head Movement Activity using 3D-AAM, in: 2019 International Seminar on Application for Technology of Information and Communication (ISemantic). Presented at the 2019 International Seminar on Application for Technology of Information and Communication (iSemantic), IEEE, Semarang, Indonesia, pp. 372–376. https://doi.org/10.1109/ISEMANTIC.2019.8884260

United Nations, 2020. Improving global road safety, Resolution adopted by the General Assembly on 31 August 2020.

Biographies

Moh Noor Al-Azam is Assistant Professor, Head of the Center for Internet of Things Studies, Faculty of Engineering and Computer Science, Narotama University, Surabaya, Indonesia. He got B.S. Department of Computer Engineering, Sepuluh Nopember Institute of Technology, Surabaya and Master of Engineering Management - Informatics Engineering from Master of Engineering, Sepuluh Nopember Institute of Technology, Surabaya. He has published journals and conference papers, completed research projects from the Ministry of Research, Technology and Higher Education of the Republic of Indonesia. Also research collaboration with several regencies/cities in Indonesia. Also research collaborations with several industries, especially in some areas of the use of internet technology for society and business. His research interests include Embedded Systems, Computer Networking, Network Security, Computer Security, Visual Computing. He is a member of IEOM, IAENG, ISOC, OWASP.

Cahyo Darujati is an Assistant Professor, and Dean of Engineering and Computer Science Faculty in Universitas Narotama, Indonesia. He earned Bachelor degree in Telecommunication and Multimedia Department, Master degree in Intelligent Network and Multimedia Department and Doctoral degree in Electrical Engineering. All degree from Institut Teknologi Sepuluh Nopember (ITS) Surabaya. He is a Professional Lecturer Computer System Engineering in Universitas Narotama, Surabaya, Indonesia. He has published Scopus and WoS journal and conference papers. Dr. Cahyo has leader Open Web Application Security Project (OWASP) chapter Surabaya. His research interest includes computer vision, image/video processing, security, and artificial intelligent. He is member of IAENG, OWASP.

Sri Wiwoho Mudjanarko is Rector Narotama University, Surabaya Indonesia. Sri Wiwoho Mudjanarko holds a Bachelor of Civil Engineeering degree in Civil Engineering from Narotama University, a Master of Civil Engineering degree in Institut Teknologi Sepuluh Nopember and a Doctor of Civil Engineering degree in University of Brawijaya, Indonesia. He has been recognized as a professional engineer with more than 27 years of experience working with closely held businesses. He is a member of the Indonesian Railway Society (MASKA) Indonesia. Currently managing the journal as chief editor of The Spirit Of Society Journal, Spirit Pro Patria E-Journal, UN Penmas and Consortium of Community Services Journal (CCSJ). The author has also won various research grants on a national scale and made many visits to various countries to collaborate. The author has participated in various IEOM series activities since 2018 in Bandung, Indonesia