E-Traffic Operational Information System Based on Automatic Number Plate Recognition (ANPR) System as a Tool to Detect Traffic Violation and to Manage the Traffic Fines in Indonesia

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Keywords: E-Traffic, Operational Information System, Automatic Number Plate Recognition (ANPR).

Abstract: The complexity of traffic conditions in Indonesia is caused by several factors. One factor is the increasing number of vehicles on the roads every year. This also affects the rate of traffic violations, also indicating a lack of awareness in traffic compliance. This can be a serious problem in major cities such as Surabaya. An instant common governmental solution focuses on development of infrastructure without considering the need for operational functions. Current traffic management still uses a manual system that has gaps that can be exploited by irresponsible parties for crimes such as the corruption of traffic fines. This current research has used qualitative exploratory methodology to design an operational information system through the implementation of an Automatic Number Plate Recognition (ANPR) system that will integrate all related data from the Department of Transport, the District Court, the Attorney General's Office, banks, and the Ministry of Finance. This system will help to detect traffic violations automatically (E-Traffic) and manage violation fines.

1   INTRODUCTION

The complexity of traffic problems in Indonesia is directly influenced by an increase in the number of vehicles. Based on the data of Central Bureau Statistics of Indonesia (2015), the increasing number of vehicles reached 36,782,325 units from 2009 to 2013. So that, the impact of this increasing has caused some traffic violations in big cities especially Surabaya. Moreover, the Internal Data of Traffic Directorate of East Java Region Police (2015) stated that the number of traffic violations (Table 1) increased by 15.03% during the period 2013–2014 (). This data tells us that there were around 125 people committing traffic violations in East Java every hour of every day in 2014.

Table 1: The Comparison of Traffic Violation Data in East Java Province during 2013-2014

Description	Amount		Trend		Notes
	2013	2014	Number	%	
Tilang	745,958	823,056	77,098	Increased by 10.34%	In Case
Warning	202,445	267,851	65,406	Increased by 32.31%	In Case
Total of Traffic Violations	948,403	1,090,907	142,504	Increased by 15.03%	In Case

The manual detection system of traffic violations forces the traffic police to watch every vehicle passing on the road closely every day. Based on current facts, there were a large number of police investigators who collected illegal traffic fines. In accordance with Indonesia Law Number 22, 2009 regarding traffic and transportation, police investigators are now not allowed to collect traffic fines directly. Moreover, the Attorney's General Office has been appointed by the Ministry of Finance as an institution that manages all traffic fines and is recorded as non-tax revenue in accordance with Law Number 20, 1997. Although

there was a clear law for the receivers of fines, it was proven that illegal practices were still common. This problem arose due to the unintegrated system between the system controllers and supervisors in the process of receiving and collecting fines. It created a gap that could be manipulated by irresponsible parties.

The operational information system is very suitable to be implemented with considering the complexity of traffic needs. This system can be used as an essential tool to detect traffic violations through a database that will collaborate with an expert system to link all the processes in the application and manage traffic fines. This current research will design an Automatic Number Plate Recognition (ANPR) system, a popular form of expert system that has been applied in many developed countries. It is based on the collection of vehicle license plate images to identify vehicles and solve traffic problems. This system is very much needed for the detection of vehicles and to optimize all functions, including monitoring, controlling, problem solving, fine management, and compliance, improving relationships with all institutions in Indonesia, i.e. The Department of Transportation, Regional Police, the District Court, the Attorney General's Office, banks, and the Ministry of Finance. The next research about vehicle tax payment system can be implemented to develop our current research in order to help the government in managing the traffic in Indonesia.

The Limitation of Research

The limitation of this current research relates to the lack of feasibility studies regarding traffic in Indonesia. In addition, the traffic system in Indonesia only had the ability to record vehicles' activities without knowing the identity of drivers in relation to traffic violations.

2 LITERATURE REVIEW

2.1 Previous Research

This current research is adopted from eight international journals used as reference materials to design the new ANPR system for traffic in Surabaya. First, Lyons (2014) stated that installing the ANPR system must be supported by elements such as GPS technology for location accuracy, the location of the camera, sufficiency of light, camera stabilization, volume, and behavior, and the characteristics of road conditions. Second, Chao and Chen (2014) recommended the application of radio

frequency identification (RFID) as a tool for controlling traffic flow. Third, Hawi et al. (2015) stated that smart technology that automatically controls traffic, has a substantial impact on traffic violation level. Fourth, Zeng (2015) explained that using intelligent traffic systems will support the calculation of traffic flow and average speed of cars on specific roads, query the travel paths of a vehicle, and check and control the fake registration plates. Fifth, Al-Sakran (2015) also agreed that an intelligent traffic system developed using current technology, i.e. the Internet, can provide real-time traffic information collection and monitoring systems for all vehicles. Sixth, Alam and MK (2015) suggested that using fuzzy logic within traffic light systems can minimize traffic congestion in large urban areas. Seventh, Ghazal et al. (2016) suggested that the implementation of smart traffic light control systems can decrease the level of congestion on the road. Eighth, Yawle et al. (2016) explained that the design and implementation of smart traffic techniques can be used for traffic management through the utilization of GSM and GPS as a main communication feature.

2.2 Expert System

Kroenke (2010) explained that the process of designing system must follow the applicable law about changing the human roles into the system language in the form of *If/Then Rules*. Besides that, the primary component of expert systems consists of a knowledge base, inference engine, and user interface (Marakas, 2013).

2.3 Operational Information System

According to Daniel (2007), the components of operational information systems consist of input (a transaction processing subsystem, operational engineering subsystem, and an operational intelligence subsystem), database (a management hybrid database with technology from fog computing), and output (an operational subsystem, effective and efficient subsystem, inventory subsystem, quality subsystem, and cost subsystem).

2.4 The ANPR System

The ANPR system is designed with the primary aim of collecting all data relating to vehicle identity so it can be used as a tool to enforce traffic laws (Yasin et

al., 2009). Yasin et al. (2009) also state that this system consists of two main components, i.e. hardware (camera, lens, infra-red illuminator, and computer) and software (optical character recognition and algorithms). In addition, the Final Review of Association of Chief Police Officers in England and Northern Ireland (2013) stated that there are three benefits of using this system as follows: 1) to identify vehicles used by criminals and disrupt their activities; 2) to gather intelligence; and 3) to investigate crimes.

3 RESEARCH METHOD

This current research adopted the methodology taken from Yin's theory (2012) that can be explained as follows:

1. Research methodology
   This research used the qualitative method with an exploratory approach. The qualitative method is used to understand current issues relating to traffic as a tool to evaluate, discover, and investigate the current system that will be transformed by using an ANPR system. Meanwhile, the exploratory approach is aimed to collect all information that will be used to analyze traffic violations and traffic fine management.
2. Research design
   The design of current research is supported by five specific, essential components:
   a. The main research question is developed from the initial issue or problem. In this case, this is how an e-traffic operational information system can help to detect traffic violations and manage traffic fines using an ANPR system.
   b. The concept proposed in this current research is related to the design of the e-traffic operational information system and the ANPR system to enforce the law efficiently and transparently.
   c. The unit of analysis is the current operational system, which considers current traffic laws in Surabaya.
   d. The logic used to associate data with previous propositions: 1) all data and general information related with East Java traffic violations are formulated as a current traffic situation; 2) manual fines received illustrate a non-transparent policy in police institutions; 3) the implementation of an ANPR system in other developed countries generate an effective operational standard and is considered suitable for application in Surabaya; 4) the management of vehicle plate images are adjusted with vehicle databases as a foundation for the development of an operational information system; 5) specific traffic violations can be detected by the ANPR system using the vehicle database, and traffic fines will be based on Indonesia Law Number 22, 2009 regarding traffic and transportation; and 6) information about a traffic violation's time and location will be recorded in a database to be processed as an output for related parties.
   e. The criteria of findings used the knowledge and references relating to the ANPR system and Operational Information System (OIS).
3. Research scope
   The scope of current research is limited to just four types of research objectives: 1) setting the location center for research in Surabaya; 2) using Indonesia Law Number 22, 2009 and Indonesia Government Regulation Number 80, 2012 as legal references; 3) choosing legal and authorized traffic violators as the research subjects; and 4) the types of traffic violation that can be detected must be caught by the camera.
4. Data type and sources
   Two types of data were used: primary data (from *Ditlantas Polda Jatim*, police investigators, traffic violators, the District Court, the Attorney General's Office, and BRI Bank) and secondary data (theories, general description of related institutions, procedures of handling traffic violators, the trial process of traffic violators at the District Court and Attorney General's Office, the payment process of fine tickets through the BRI bank, and actual implementation of the ANPR system in other developed countries).
5. Data collection procedures
   The data collection in this current research covers the initial survey of police institutions and the field using three methods: observation (road users, traffic police officers on duty, the traffic handling system, the trial process of *tilang*, and the payment of traffic fines), interview (the subjects are East Java Revenue Service (*Dispenda*) staff, Head of East Java Police Traffic Directorate (*Ditlantas Polda Jatim*), police staff, traffic police, road users, and traffic violators from Surabaya) and documentation (interview results, videos, and photographs).
6. Analysis technique

There are two strategies used to analyze this research: 1) a descriptive approach to identify mutual relationships; and 2) development of the unique description.

7. Research time and location

This research took place during the period September to December 2015 at institutions such as the Revenue Service of East Java (*Dispenda*), the East Java Police Force (*Polda Jatim*), the Surabaya District Court, and road traffic in Surabaya.

4 ANALYSIS

4.1 The Manual Traffic System in Surabaya

4.1.1 The System of Handling Traffic Violations

The initial procedure of handling traffic violations by the police can be categorized as a quick investigation. Indonesia Law Number 22, 2009 stated that every traffic and transport violation based on quick investigation reports may be subject to criminal penalties in the form of fines decided by the district court. The standard operational procedure of East Java Police number Lantas-002/IV/2012, explained that there are seven steps of handling traffic violations by police as follows: 1) preparation of a traffic ticket; 2) completion of the traffic ticket; 3) the traffic ticket is signed by the violator; 4) the traffic ticket is given to the violator; 5) confiscated goods or deposits are taken from the violator; and 6) the rest of the tickets and confiscated goods or deposits are returned to the unit of investigation. There are also two different procedures for giving tickets based on the internal procedure data from the East Java Police Traffic Directorate as detailed:

1. The procedure of handling traffic violations using the blue form
   This procedure is applied for violators who cannot attend the trial process (figure 1).
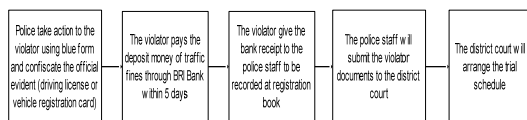

Figure 1: The Mechanism of Handling Traffic Violations using the Blue Form (2015)

2. The procedure of handling traffic violations using the red form

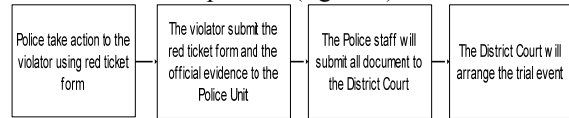This procedure is applied for violators who can attend the trial process (figure 2).

Figure 2: The Mechanism of Handling Traffic Violation using the Red Form (2015)

4.1.2 The Trial System of Traffic Violations

The District Court is an institution that has responsibility to follow up the process of acting regarding traffic violations. In Surabaya, traffic violation trials are held every Monday and Friday. Based on the observation process from East Java District Court, trial procedures of traffic violations depend on the ticket form chosen beforehand:

1. The trial procedure of traffic violations using the blue form
   This procedure is intended for violators who cannot attend the trial event (figure 3).
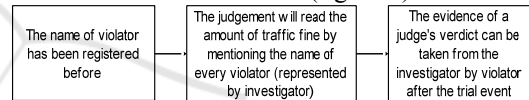

Figure 3: The Mechanism of the Traffic Violation Trial using the Blue Ticket Form (2015)

2. The trial procedure of traffic violations using the red form
   This procedure is intended for violators who can attend the trial event (figure 4)
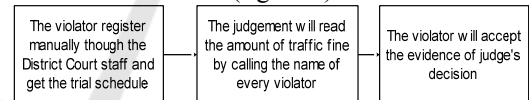

Figure 4: The Mechanism of Traffic Violation Trial using the Red Ticket Form (2015)

4.1.3 The Traffic Fines Payment System

The management of receiving traffic fine payments, accepted directly after a trial or judge's verdict, has been the responsibility of the Attorneys General's Office. Based on the agreement numbers B-319/E/VII/1993, Kep/09/VII/1993, and B.366-DIR/DJS/1993 of the three parties, i.e. the Attorney General's Office, the Indonesia Police, and the BRI Bank. It is stated that the use of the checking account at the BRI Bank aims to accommodate the deposits of traffic violators. The procedures of fine payments based on internal data proceedings from the East Java District Court are dependent on the procedure used before as follows:

1. The payment procedure of traffic violations using the blue form

   The payment procedure is dependent on the result of the evidence from the judge's verdict (figure 5).
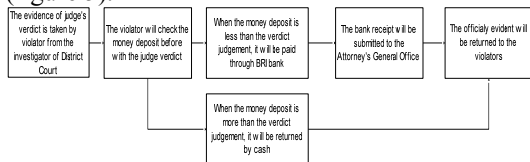

Figure 5: The Mechanism of Fine Payments using the Blue Ticket Form (2015)

2. The payment procedure of traffic violations using the red form

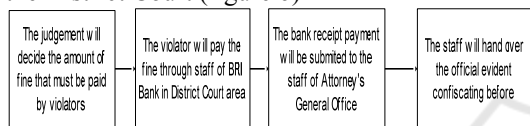   This payment process is directly carried out in the District Court (figure 6)

Figure 6: The Mechanism of Fine Payment Using Red Ticket Form

4.2 The Current Development of Traffic Systems in Surabaya

Indonesia Traffic Police Coordinator *Korlantas Polri* has been implementing the new innovated traffic fines system since December 14th 2016 (Motomaxone, 2017). This system is well-known as *E-Tilang* and has been applied in Jakarta. The system is very simple with only entering the violation data through the application to inform the fine payment information to the violators. Then, the violators pay the fine amount through the bank to get the legal document as a requirement to take the confiscate documents. As additional information, the violators must pay the maximum fine before the judge drops the final decision. If the judge decision is lower than the original fine, the excessive fund will be returned to the violator through the bank.

The successful of E-*Tilang* system in Jakarta is being used to design a pilot project for a traffic system in Surabaya. Based on the Focus Group discussion held by the forum of the Surabaya Government, it was agreed to use CCTV as a medium for controlling and monitoring each traffic violation throughout the day. This innovative system has been applied since September 1st 2017 (Liputan6, 2017). This system records all traffic events each day and is viewed via a giant screen in the control room at the Headquarters of the Transportation Agency. However, this system only identifies types of traffic violation through an alarm system and the violator's identity is identified using a manual system (recording the number plate of a vehicle). Therefore, it was demonstrated that this system is not sufficient to collect integrated data as evidence for traffic fines.

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the results of analysis in this current research, we can conclude that the current implemented traffic system in Surabaya still has a number of weaknesses:

1. The manual system in the handling of traffic violations is less than appropriate for several reasons:
   a. The manual stoppage of vehicles that violate traffic signs may not be effective when the number of police on duty is not in balance with the number of violators.
   b. The frequency of false accusations of traffic violations due to deliberate or accidental elements of policing.
   c. Manual ticket form filling and payment of fines can be misused by irresponsible parties.
   d. Police can withdraw illegal charges of traffic violations without the strict control from the Government as a tool for their individual needs (corruption).
2. The current process of trials regarding traffic violations still attract frequent complaints from the community, for example:
   a. The trial schedule was far from the violation time. It was valued as less efficient because the mobility of violators is very restricted without sufficient documents when driving.
   b. The regulation of trial locations that must be in accordance with the area of violation was judged as inefficient because it was very troublesome for violators who lived a long distance from that area.
   c. There were many panders (*calo*) that were ready to represent the violators. It caused gaps for the benefit of criminals, which could subsequently harm the country.

5.2 Recommendation

In evaluating the weaknesses of the current traffic system in Surabaya, we can provide some recommendations:

1. Using an ANPR system as a tool to automatically record traffic violations through a number plate image and an expert system. This system aims to collect all ticket forms from the responsible parties and create an efficient information system for violators as part of an operational information system. There were three process techniques used when designing this system:

   a. Algorithm Techniques

      The first stage of an ANPR system used an algorithm technique, in which the image was captured by a camera, then translated in three stages:

      (i) Image capturing used to detect the number plate of a vehicle

      (ii) Pre-processing used to define an initial image that generates a binary image output

      (iii) Segmentation is used to discard the parts that are not plate characters

   b. Optical Character Recognition (OCR) Techniques

      The OCR technology can be found in the ANPR software. This function of the technology transforms the initial image into a digital image with the required plate number listed in the user interface. There is a three-phase sequence for achieving that output:

      (i) Normalization

         This will adjust the image resolution that will be read by the OCR system.

      (ii) Recognition

         The plate number will be read by the OCR system and transmitted into a visual format within the ANPR software.

      (iii) Post-processing

         The display of a number plate image via this process can be used by related parties.

   c. Enforcement detection techniques

      This third technique is used to detect traffic violations using expert system technology. The working process of this technique will utilize the knowledge base to record every traffic violation. The regulation data will then be entered using if/then logics with details as follows:

      (i) If Vehicle_Lights_Off, Then Sensor Detect_2912_Violation_Number

      (ii) If Vehicle_Passes_Traffic light, Then Sensor Detect_2872_Violation_Number

2. Designing the thinking flow and information flow

   The design of the new development system for detecting traffic violations is supported by these elements:

   a. Thinking flow

      This part is formed from seven outputs:

      (i) The violator – the vehicle owner who carried out the violation, based on the vehicle plate number.

      (ii) The Ministry of Finance – responsible for the receiving of a ticket fine.

      (iii) The automatic ticket detection system – a tool to detect all vehicle plate numbers.

      (iv) Input image – describes the vehicle plate number to be used as information for the Police, Court, and the Attorney General's Office, providing information regarding the type of traffic violation and the cost of the fine.

      (v) Notifications – used as a tool to give messages relating to the trial schedule, the cost of the fine, the total points, and the type of traffic violation.

      (vi) Payments – explanation of the ticket fine payment process based on the various fine types such as fine notification, maximum fine, or court verdict fine.

      (vii) The non-tax national revenue – all ticket fines are recognized as a source of national revenue and synchronized with all related parties to generate a report for the Ministry of Finance.

   b. Information flow

      (i) The ANPR detection process that will manage the input data, i.e. plate number images to obtain the identity of the vehicle owner.

      (ii) The traffic violation determining process that will integrate the identity of the vehicle owner with the detected violation through the expert system.

      (iii) The management of the violators' data status that will collect all information relating to a trial process, notification process, and a fine payment process.

      (iv) The traffic fine transaction process that will generate the cost of the fine payable by the violator and recorded as the collectable receivable amount in the Attorney General's Office.

(v) The reporting process that will manage the total amount of debt repayment to create a national receiving report for the Ministry of Finance.

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