



ACCIDENT POTENTIAL ESTIMATION SYSTEM BY CALCULATING VEHICLE SPEED USING DEEP LEARNING YOLO METHOD (You Only Look Once)

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ABSTRACT

Traffic accidents are incidents that often lead to serious consequences, such as fatalities or property damage. A key factor influencing these accidents is vehicle speed. Despite some reductions, the death toll from traffic accidents remains high. Vehicle speed, in particular, has been identified as a primary factor exacerbating the risk and severity of accidents. Therefore, controlling vehicle speed is crucial for reducing accident rates. A vehicle speed detection system utilizing deep learning technology, such as the You Only Look Once (YOLO) model, provides an effective solution for analyzing and monitoring vehicle speed in real-time. This technology enables rapid and accurate vehicle detection, along with efficient speed data processing. By leveraging cameras to record video, the system offers essential information for law enforcement and accident prevention. The real-world implementation of this system will enhance traffic safety by delivering relevant and accurate information to authorities. The use of YOLO technology in this system allows for more effective vehicle speed monitoring and prompt decision-making to prevent accidents. Consequently, this system contributes to reducing accident risks and improving road safety.

ARTICLE INFO

Keyword:

Vehicle Speed, YOLO, Speed Detection System, Traffic Accidents.

1. Introduction

Vehicle speed is one of the main factors in traffic accidents. The severity of traffic accident victims is a result of speed. Furthermore, Elvik (2004) showed that accidents are preceded by violations. Several things that often happen on the road, such as speeding, cause high severity of accident victims. The risk of accidents increases with higher vehicle speeds because of the longer braking distance required, the lack of time needed to process and make decisions on the information obtained, and the difficulty of controlling the vehicle if there is an obstacle in front of it. It is generally assumed that 1/3 of fatal accidents are caused by vehicle speeds that do not comply with speed limits (SWOV, 2009).

Vehicle speed restrictions have been regulated in Law No. 22 of 2009 concerning Traffic and Road Transportation, Article 21 no.1–5. Which is reinforced by the Regulation of the Minister of Transportation of the Republic of Indonesia PM 111 of 2015 concerning Procedures for Determining Speed Limits. The determination of this speed limit takes into account all factors, but in general it can be divided into 4, namely on toll roads the lowest is 60 km/hour and the highest is 100 km/hour, intercity roads the highest is 80 km/hour, urban areas the highest is 50 km/hour, and residential areas the highest is 30 km/hour. (Satara et al., 2021)

Ragnoy's (2005) research shows that when vehicle speeds decrease from 80 km/h to 70 km/h, the potential for fatalities from 211 victims can drop to only 30 victims. Research in Australia also states that reducing speed can reduce the potential for collisions by more than 20% (Prasetyanto & Santosa, 2020)

It is difficult to observe vehicle speed which if done with the naked eye without the help of tools, monitoring by humans can be inaccurate because humans cannot be in 1 place for a long time to observe vehicle speed. Therefore, a system is needed to help analyze the speed of drivers so that the relevant parties can provide the right solution to the problem, especially for accident-prone areas.

The use of deep learning in monitoring vehicle speed has been widely carried out by previous studies, but only focused on recording vehicle speed data that can only be seen by a few people who are given the data, with the preparation of this final assignment the author adds some developments to previous research by adding an information system from monitoring the speed data that can be accessed by anyone and anywhere, not only recording vehicle speed but also adding developments to record accidents, which will later become a reference that the location where the application is carried out has the potential for accidents due to vehicle speed or not.

The deep learning used is You Look Only Once (YOLO) which is one of the deep learning models used for object recognition. The You Only Look Once (YOLO) method is one of the fast and accurate methods in detecting objects. This method is capable of detecting objects up to 2 times faster than other algorithms.

With the various problems that have been explained above, the author is interested in creating a program that can detect the speed of passing vehicles with the help of You Look Only Once (YOLO) which is one of the deep learning models used for object recognition that hopes to be able to recognize vehicles and calculate the estimated speed of passing vehicles so that later further data processing can be carried out by the authorities.

2. Method

2.1. Method Waterfall

This research uses the Waterfall methodology, which is a classic model in software development. This model is known as the "Linear Sequential Model" or often referred to as the "classic life cycle." As one of the generic models in software engineering, Waterfall was first introduced by Winston Royce in 1970. Even though it is considered ancient, this model remains one of the most widely used in Software Engineering (SE) because of its systematic approach and sequentially (Widiyanto, 2020). This model is called Waterfall because each stage is carried out sequentially, with each step waiting for the completion of the previous stage. The Waterfall model has six main stages in the software development process, where each stage produces output in the form of documents which become the basis for the next stage. These stages, along with the resulting documents, are explained in detail and depicted in figure 1.1.

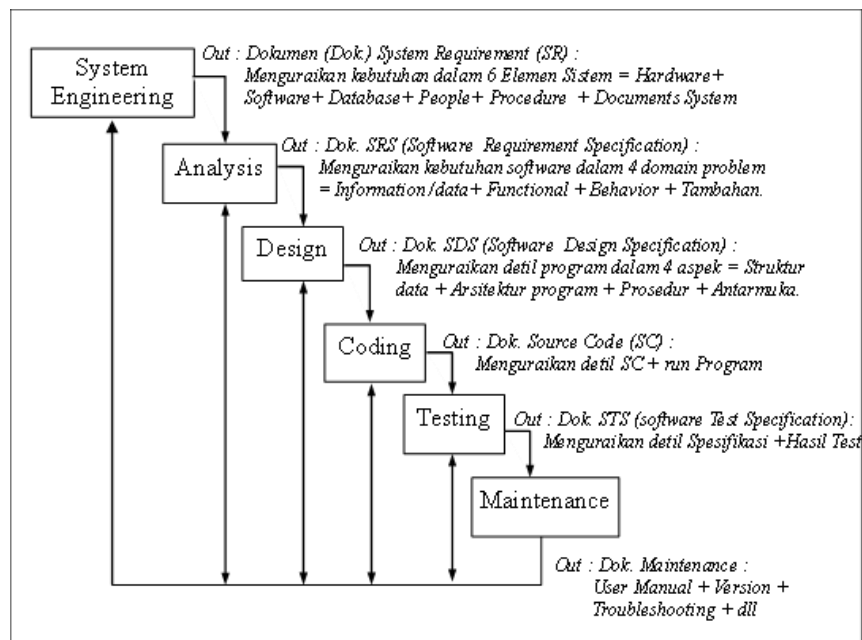


Fig. 1 stages of the Waterfall model

2.2. Deep Learning

LeCun, Bengio, & Hinton (LeCun, Bengio, & Hinton, 2015) define deep learning in the journal Nature, 2015, as follows: "Deep learning methods are levels of representation-learning methods with multiple representations, obtained by composing simple but nonlinear modules that each transform the representation at one level) starting with the raw input) into a representation at a higher, slightly more abstract level. the key aspect of deep learning is that these layers are not designed by human engineers: they are learned from data using a general-purpose learning procedure."

A more concise definition of deep learning is given by Chollet Francois (Francois, 2018) as: "a new take on learning representations from data that puts an emphasis on learning successive layers of increasingly meaningful representation."

In other words, deep learning is a method of learning data that aims to create a representation (abstraction) of data in stages using a number of data processing layers. The important thing about deep learning, (LeCun, Bengio & Hinton, 2015) emphasizes that the data representation is not made explicitly by humans but is generated by a learning algorithm.

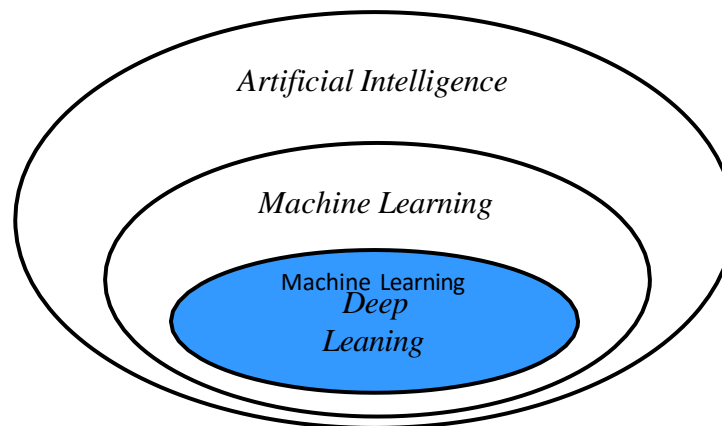


Fig. 2 Deep Learning as a Branch of Artificial Intelligence and Machine Learning.

2.3. YOLO (Your only Look Once)

You Only Look Once (YOLO) is an algorithm developed to detect an object in real-time. The detection system used is by using a repurpose classifier or localizer to perform detection. A model is applied to an image at several locations and scales. The area with the highest scored image will be considered as a detection.

YOLO uses an artificial neural network (ANN) approach to detect objects in an image. This network divides the image into regions and predicts each bounding box and probability for each region. These bounding boxes are then compared to each predicted probability. YOLO has several advantages over classifier-oriented systems, seen from all images when tested with predictions that are globally informed on the image.

This also makes predictions with this neural network synthesis unlike the Region Convolutional Neural Network (R-CNN) system which requires thousands for an image, making YOLO several times faster than R-CNN.

YOLO is popular because it achieves high accuracy and can also run in real-time. The “Only Looks Once” algorithm or only looks once, on the image in the sense that it only requires one forward propagation through the neural network to make a prediction. After non-max suppression (which ensures that the object detection algorithm only detects each object once), then the output of the recognized object along with the bounding box.

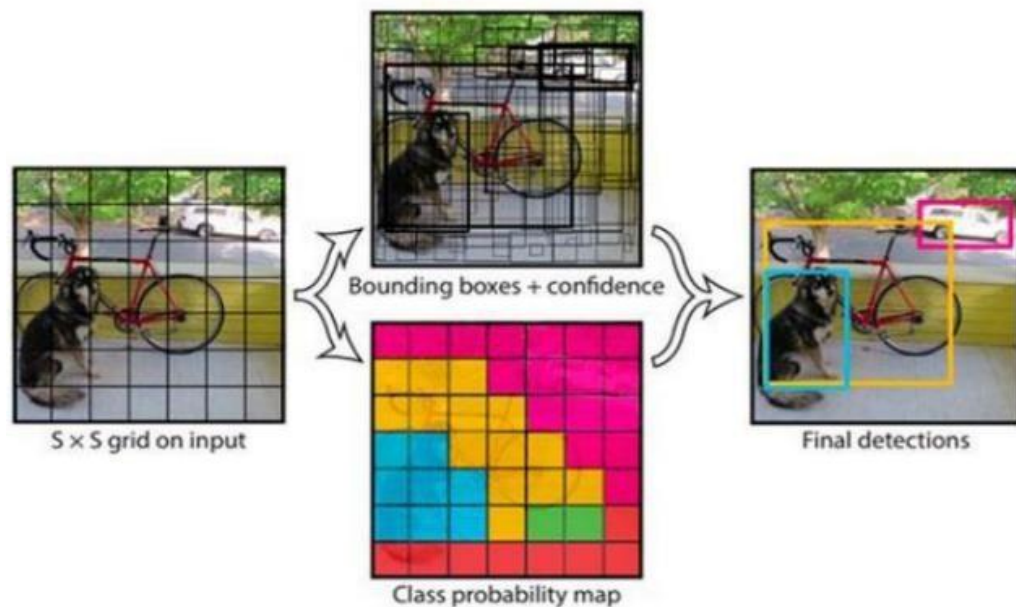


Fig. 3 You Only Look Once (YOLO)

3. Result and Discussion

3.1. System Analysis

This system analysis is made to provide a clear analysis of the system to be created or the system that is running. With this analysis, the weaknesses of the previous system can be seen which are improved by the system to be created. This system analysis takes several important points from the existing system parts.

3.1.1. Hardware Analysis

The planned hardware design uses a video recorder or commonly called a camera as hardware that is tasked with taking videos of vehicles passing on the road. Video capture is done directly, and is directly processed by the vehicle speed detection system. The second option for video capture besides using a camera can also use a recording, this option can be useful if the location of the system placement does not allow for direct recording, for example recording vehicles on roads where the surrounding environment is prone to theft, or this second option can be done to optimize the performance of inadequate devices and only speed detection is carried out when needed.

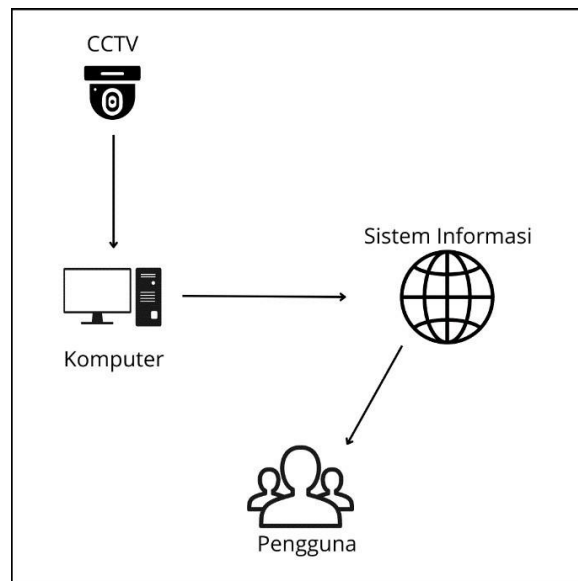


Fig. 4 Hardware analysis image

It can be explained from the image above, first for vehicle detection using a camera that is directed at the road where the vehicle passes. second the recording results from the camera will be processed by the computer using the help of deep learning, after the third process is obtained the speed detection results obtained will be sent to the database which will later be processed in the information system, and the last is the fourth data can be viewed directly by users through the information system that can be accessed via the website address.

3.1.2. Software Analysis

After the recording is obtained from the camera, the next step is to convert the original bounding box size into the program to be created, by determining the x and y coordinates in pixels. After the coordinate values are obtained, the next step is to create a measurement line on the system using the cv2.line function. This line will be red and blue, trapezoidal, which will then be called the bounding box. This line functions as a determining area in the analysis of vehicle speed in the recorded video.

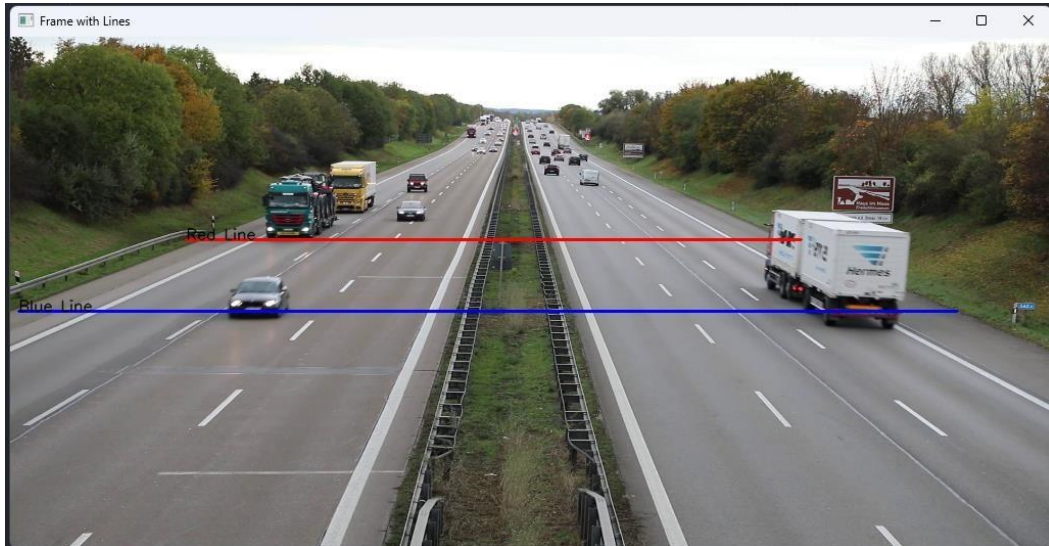


Fig. 5 Video display that has been given a marker line with the cv2.line function

Object ID detection and labeling is only done within the bounding box that has been determined as the measurement box. Object detection uses model.predict(). If the object is outside the measurement box, then the object will not be detected by the program.

After knowing the position of the vehicle object on the two measurement lines, the next step is to detect the vehicle speed, here are the steps to calculate the speed:

1. Measuring Distance: After knowing the position of the vehicle object on the two measurement lines, we can calculate the distance traveled by the vehicle. In this case, the distance between the two measurement lines (red and blue lines) is known as 10 meters.
2. Measuring Time: Using the time from when the object first touches the measurement line to when the object touches the second measurement line, we can calculate the time required to cover that distance.
3. Calculating Speed: Speed in meters per second (m/s): Calculated using the Speed formula:

$$m/s \text{ (meter per second)} = \frac{\text{Distance (meter)}}{\text{time (second)}}$$

Speed in kilometers per hour (km/h): Calculated by converting the speed from m/s to km/h using the Speed formula:

$$\left(\frac{km}{hour}\right) = \text{speed} \left(\frac{m}{s}\right) \times 3,5$$

4. Convert Pixels to Meters: It is important to know the conversion scale from Pixels to meters. Usually, this is calculated from the physical size of the object and its Pixel size.

3.1.3. Procedure Analysis

Input: The system that is built gets input in the form of video recordings from a surveillance camera. This video records vehicle movement in a predetermined area. The video becomes the main data source that will be processed by the system to detect and measure vehicle speed. This input can come from a live surveillance camera (real-time) or from previously saved recordings.

Process: After the video is received by the system, the first stage is preprocessing, which is converting the video into a series of frames (images) that are easier to analyze. Each frame is then analyzed to detect the presence of the vehicle using an object detection algorithm, such as YOLO or other appropriate methods. Once the vehicle is detected, the system will determine the position of the vehicle in the first frame when the vehicle enters the measurement area (start line) and the position in the frame when the vehicle exits the measurement area (finish line). By knowing the distance between the two lines (for example 10 meters) and the time it takes for the vehicle to cross both lines, the system can calculate the speed. The measurement results are stored in a database for further processing.

Output: The output of this system is vehicle speed data that is processed and displayed via a website. This website displays important information such as vehicle speed, detection time, and perhaps additional data such as vehicle type or license plate number, if available. This data can be presented in the form of tables, graphs, or other visualizations that make it easier for users to understand and analyze the information. In addition, the website can also provide features to download data in PDF format or perform real-time monitoring if the system is directly connected to a surveillance camera.

3.1.4. Early Warning System Analysis

This program aims to detect vehicle speed and send the data to the database, then display it on the website. The main purpose of this program is to monitor vehicle speed and collect data to prevent traffic accidents. This program does not reduce vehicle speed directly, but rather serves as a data collection tool that can be used for further analysis related to speed limit violations and vehicle speed patterns in certain areas.

Here are the main steps in this program:

Speed Detection: The system uses sensors (such as radar or cameras) that are able to measure vehicle speed in real-time. Data on the speed of vehicles passing through a certain area will be collected.

Sending Data to the Database: Every time a vehicle is detected, data such as vehicle speed, time, date, and location will be stored in a database that has been integrated with the system.

Display on Website: Speed data stored in the database will be displayed on the website in the form of tables, graphs, or dashboards. This information can be used by authorities or road managers to monitor areas where violations often occur.

Data Analysis: With the data collected, authorities can analyze speed trends in various areas, determine accident-prone locations, and take more effective preventive measures in the future.

Through this systematic data collection, the program can provide valuable insights to improve traffic safety without direct intervention from drivers, so that monitoring can be carried out passively and effectively.

3.2. Flowchart

3.2.1. Manual speed detection flowchart

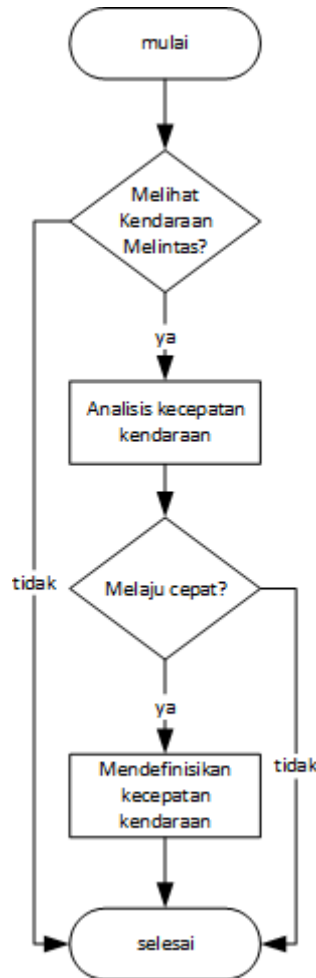


Fig. 6 Manual speed detection flowchart

Analysis:

1. Observations of vehicle speed are generally based on personal assumptions, which may not be in accordance with the assumptions of others.
2. The speed of a fast-moving vehicle cannot be determined with certainty and only depends on personal assumptions.
3. Assumptions about vehicle speed often differ from one person to another, just as the perception of "fast" according to a racer and an amateur driver is definitely different.

3.2.2. Flowchart Speed detection after using YOLO (Your Only Look Once)

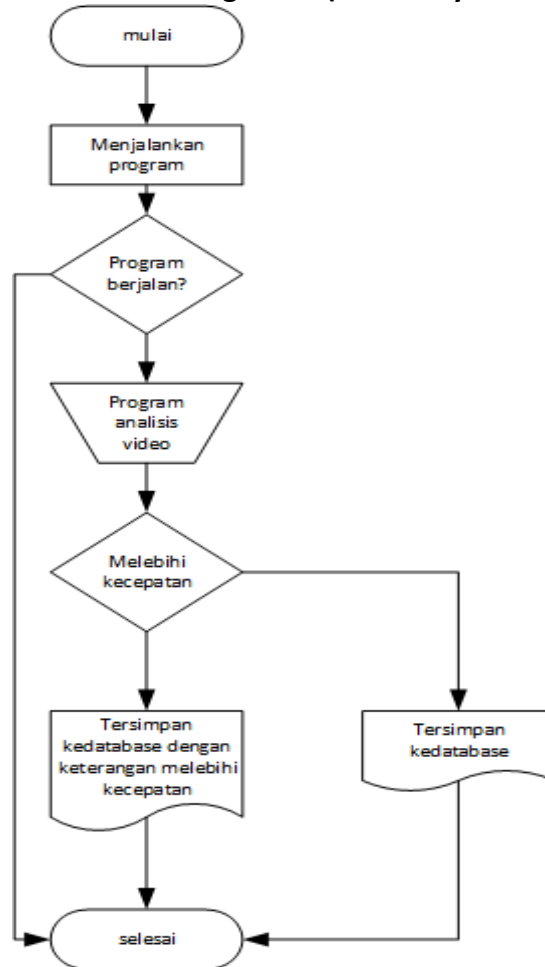


Fig. 7 Flowchart of speed detection after using YOLO

Analysis:

1. After running, the system will automatically analyze the uploaded video.
2. The system provides analysis results in the form of definite vehicle speed in km/h units.
3. The system automatically saves data into the database and provides information for data that exceeds the speed limit.
4. With this system, vehicle speed is no longer based on assumptions, but rather on definite data

3.3. System Design

The following is a general system design that will be created:

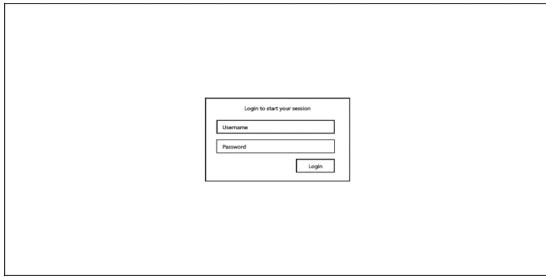


Fig. 8 system design 1

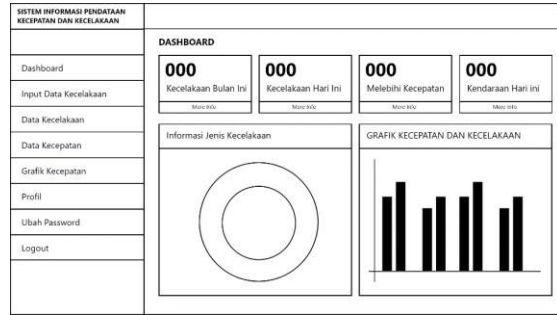


Fig. 9 system design 2

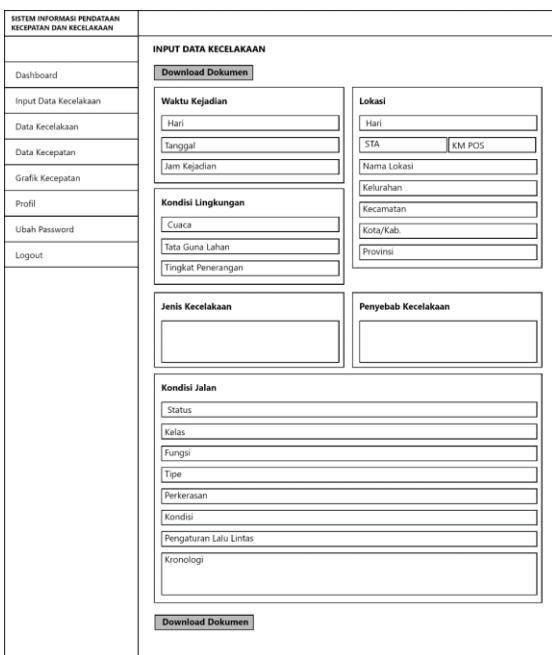


Fig. 10 system design 3

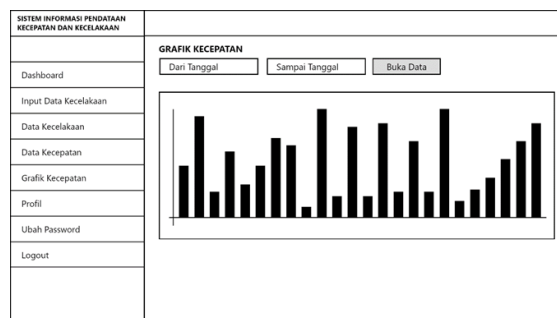


Fig. 11 system design 4

3.4. Data Flow Diagram (DFD)

3.3.1. Context Diagram

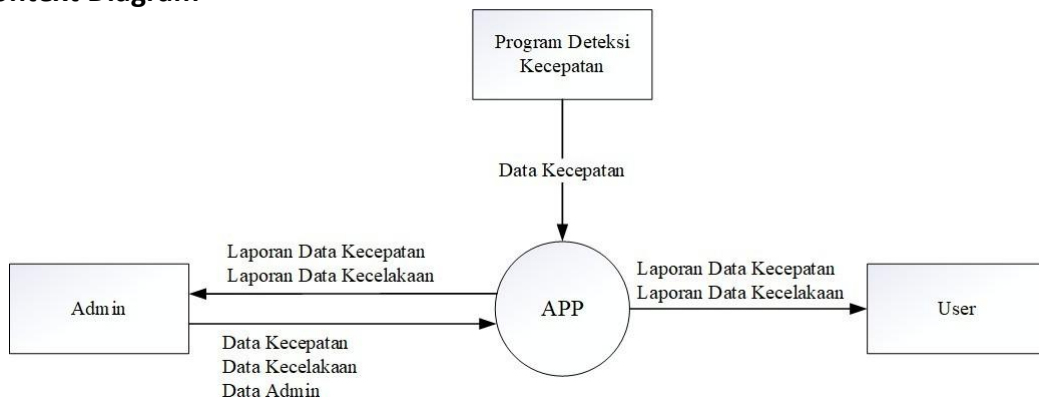


Fig. 12 Context Diagram

3.3.2. Data Flow Diagram (DFD) Level 1

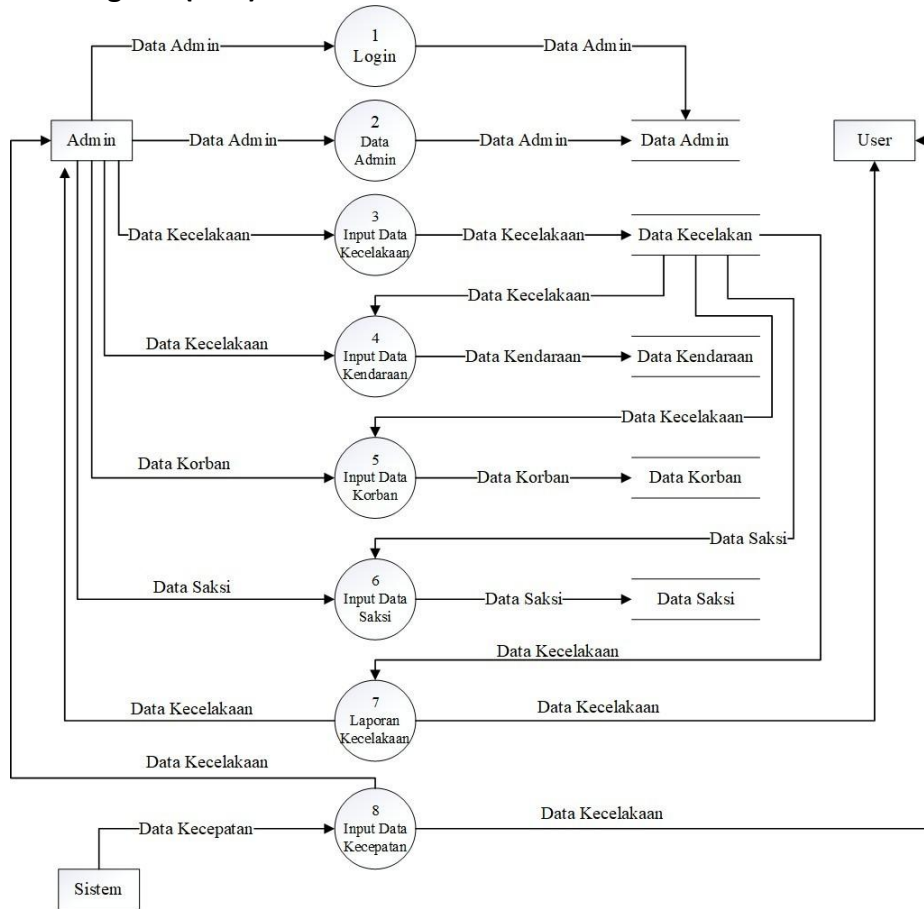


Fig. 13 Data Flow Diagram (DFD) Level 1

3.5. System Implementation

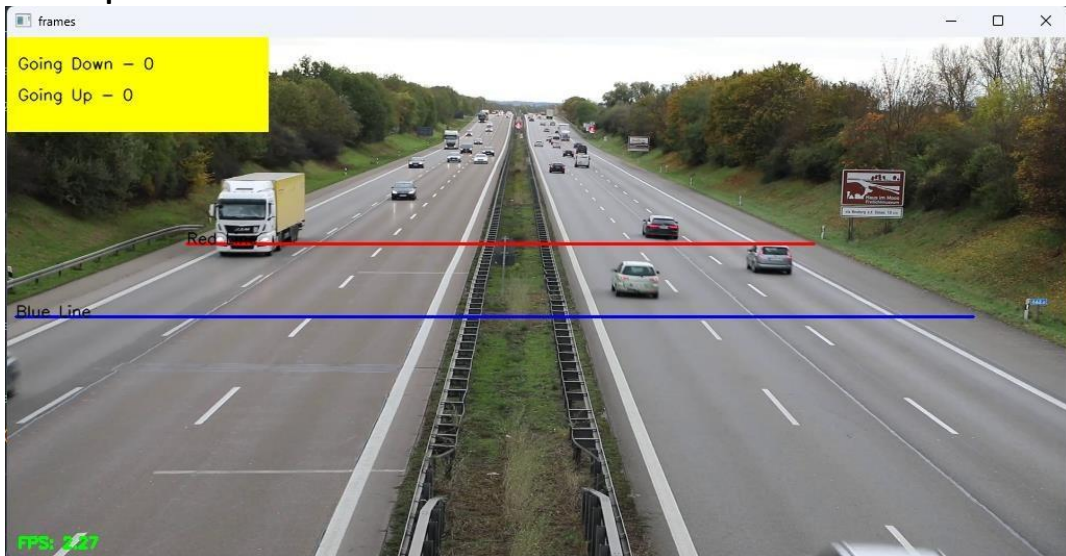


Fig. 14 system implementation 1



Fig. 15 system implementation 2

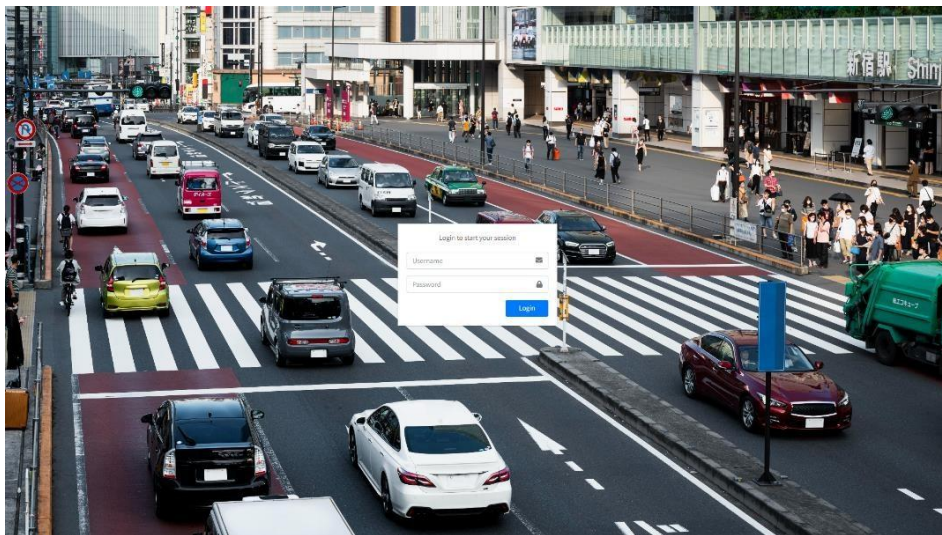


Fig. 16 system implementation 3

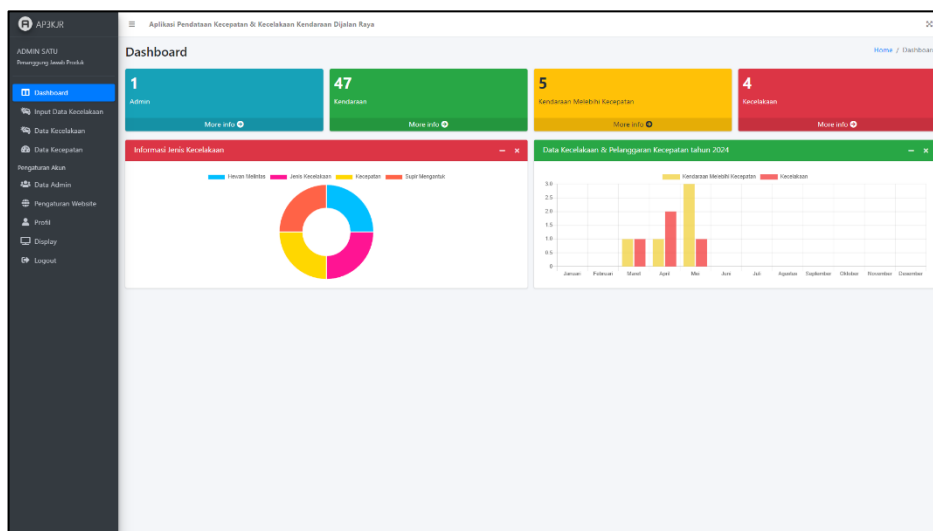


Fig. 17 system implementation 4

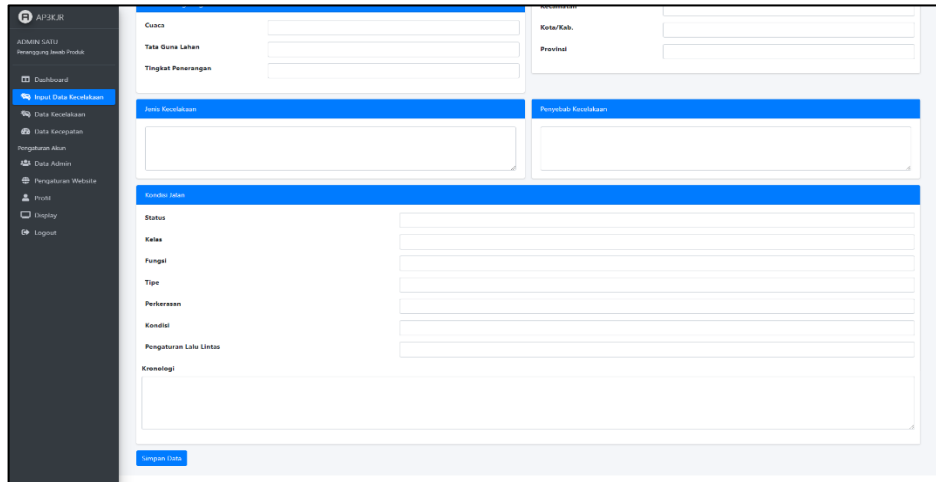


Fig. 18 system implementation 5

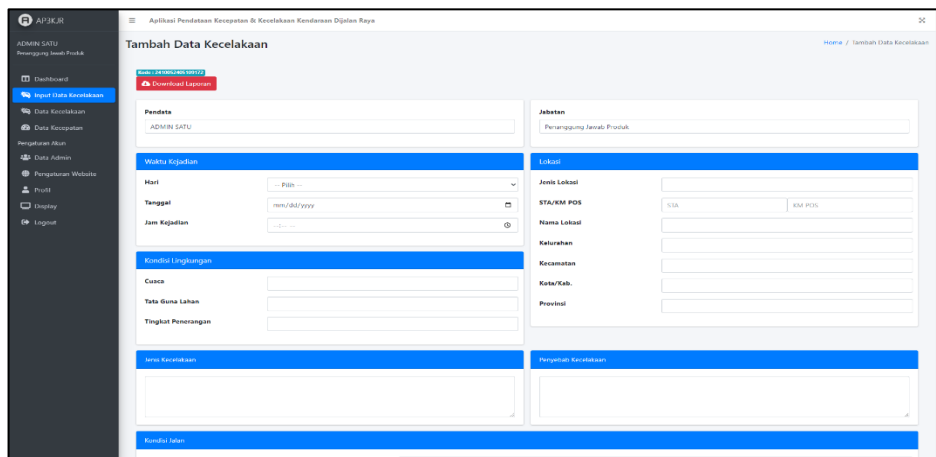


Fig. 19 system implementation 6

4. Conclusion

The vehicle speed detection system designed using deep learning technology based on the You Only Look Once (YOLO) model aims to detect vehicle speed in real-time and accurately. The detection process begins with the use of hardware such as a camera or video recorder, the results of which are analyzed by the system to obtain vehicle speed data. The data is then sent to a web-based application for further data collection, including accident recording and reporting.

In the development process, several software are used to support this system, such as Visual Studio for writing code, Command Prompt to run the system, and Microsoft Visio for creating data flow diagrams (DFD). The context diagram and DFD Level 1 to Level 2 show the process flow, starting from admin login, accident data input, to creating accident and vehicle speed reports. Each process is designed so that the input data is structured and easily accessible by related parties, so that it can be used for monitoring vehicle speed and managing accidents effectively.

The database designed using the Entity Relationship Diagram (ERD) methodology functions as a place to store data on speed, accidents, victims, vehicles, and witnesses. The data is stored in tables that are optimized to support the reporting and analysis process. With this design, the

system is considered feasible to be further developed to provide optimal benefits in maintaining traffic safety through efficient speed monitoring and accident recording.

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