

DETECTION OF MOTORBIKE RIDERS WITHOUT HELMETS ON HIGHWAYS USING YOLOV5

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ABSTRACT

Driving safety is an important aspect in reducing traffic accident rates, especially for motorcycle riders. The use of helmets is an obligation that must be obeyed, but violations still often occur on the highway. This study aims to design and implement an automatic system for detecting motorcycle riders without helmets using the You Only Look Once version 5 (YOLOv5) algorithm. This system works by utilizing traffic images and videos as input to detect motorbike rider objects and classify helmet use. The research process includes dataset collection, data labeling, YOLOv5 model training, and system performance testing based on accuracy, precision, and recall. The research results show that the YOLOv5 algorithm is able to detect motorcycle riders without helmets with a good level of accuracy and relatively fast processing time, so this system has the potential to be applied as a real-time traffic monitoring tool to improve safety and rider compliance on the highway.

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1. INTRODUCTION

Traffic safety is an important issue that continues to be a concern in Indonesia, especially regarding the high number of accidents involving motorcycle riders. Motorbikes are the most widely used mode of transportation by the public because they are considered practical and economical. However, the high use of motorbikes is not always accompanied by compliance with driving safety rules, one of which is the obligation to use a helmet. Helmets serve as the main protective device to reduce the risk of fatal head injuries due to traffic accidents. Although regulations regarding the use of helmets have been clearly regulated in the law, violations of this rule are still often found on various roads.

Currently, monitoring the use of motorcycle helmets is still done manually because of traffic officers, so it is impossible to handle all violations optimally. This monitoring method has limitations, especially in terms of area coverage, consistency of monitoring, and dependence on human resources. In the midst of traffic density and the vastness of the monitoring area, violations such as riders not wearing helmets often go unnoticed. This condition shows the need for technology-based solutions that can help the monitoring process automatically, accurately and sustainably.

The development of artificial intelligence (Artificial Intelligence) and computer vision opens up great opportunities in the field of traffic monitoring. One application of computer vision that is growing rapidly is automatic object detection using the algorithm deep learning. YOLO (You Only Look Once) is an object detection algorithm capable of identifying objects in real-time with high speed and accuracy. YOLOv5, as one of the latest versions of the algorithm, offers increased performance in detecting objects with relatively efficient computational needs, making it suitable for application in traffic monitoring systems.(Poerwandono et al., 2024a)

2. METHODS

A. Technique Dataset Collection

The visual dataset used in this study was obtained through two main approaches, namely direct image acquisition in the field and the use of additional datasets from the online platform Roboflow Universe. Field data collection was carried out by recording images and videos of motorcycle riders on several highways with fairly high traffic intensity. This method aims to obtain data that represents real conditions in the field, especially variations in motorbike riders' behavior in using helmets. Meanwhile, additional datasets from Roboflow Universe is used as supporting data to enrich variations in shooting angles, lighting conditions, as well as types of helmets and vehicles, so that the model has better generalization capabilities.(Komputer et al., 2024)

The entire dataset that has been collected is then stored and managed using a cloud-based storage service, namely Google Drive. The use of cloud storage aims to simplify data access, maintain file security, and support collaboration during the research process. The dataset is organized into a systematic folder structure based on class categories, such as riders wearing helmets and riders without helmets. Neat data grouping is very helpful in the subsequent processing, especially when the number of images increases and efficient dataset management is required.(Komputer et al., 2024)

The dataset used reflects the reality on the ground by including various scenarios of riders, both those who comply with helmet use and those who violate it.(Ahmad et al., 2023) Data diversity is also expanded by varying motorcycle types, driver perspectives, traffic conditions, and road infrastructure landscapes. This data diversification aims to ensure the detection system has strong generalization capabilities and remains precise when implemented in heterogeneous real-world situations.

The dataset labeling in this study used Labellmg software, where researchers manually determined object coordinates using the bounding box feature on the motorcyclist's head.(Ahmad et al., 2023) This manual approach was implemented to ensure each piece of data had highly accurate labels. This is crucial because the effectiveness of the YOLOv5 model is highly dependent on the quality of the annotations; errors in this process risk deteriorating the system's prediction results. Labellmg was chosen as the primary instrument due to its flexibility in data validation and the suitability of its output format to the requirements of the YOLOv5 architecture. of research based on computer vision, because good annotation will improve the system's ability to detect motorbike riders without helmets automatically and precisely.

B. Pre-processing

To ensure the YOLOv5 model is trained on high-quality data, a series of preprocessing procedures are performed on the dataset.(Jili Pranata et al., n.d.) The collected and annotated data is reorganized to meet the technical requirements of the detection system. This improves data consistency and reduces irrelevant variations, allowing the model to achieve maximum learning through a uniform image format.

An image selection process is performed at the initial stage to ensure that only high-quality data enters the training phase.(Poerwandono et al., 2024b) Researchers filter out images with lighting disturbances or low resolution, which can obscure objects. This aims to reduce the risk of errors in the detection system. Additionally, labels or annotations are realigned to ensure each object is identified clearly and consistently.

The next step is to convert the dataset into a directory structure recognized by the YOLOv5 algorithm, where each image is paired with an annotation file containing class labels and object positions. The dataset is divided into three distinct portions: training, validation, and testing data. This division aims to independently verify the model's reliability, ensuring that the resulting system remains highly effective when faced with new data and is not biased by the training data alone.

The next step involves normalizing the image dimensions to standardize the resolution of all data according to the YOLOv5 model specifications.(Reswara et al., 2025) This adjustment is made to maintain an optimal balance between detection accuracy and computational efficiency. Furthermore, resolution standardization helps the model consistently recognize motorcyclists' visual patterns and helmet usage across multiple image scales. This normalization process also contributes to faster training time and improved model performance stability.

In addition to format and dimension adjustments, the preprocessing stage also included an analysis of the class distribution within the dataset.(Poerwandono et al., 2024b) This study ensured that the data proportion between helmeted and unhelmeted riders was relatively balanced. This was done because data imbalance can cause the model to tend to learn more about one class, thus reducing detection accuracy for the other class. Therefore, data selection and limited augmentation were performed to maintain consistent class proportions. Through a systematic series of preprocessing

steps, the dataset was optimized for the YOLOv5 training process. Superior data quality is expected to improve the model's accuracy and consistency in detecting helmet violations in real-world traffic conditions.

C. Training Data

Model training was performed using the YOLOv5 algorithm through the Roboflow Train 3.0 platform.(Falach et al., 2026) The preprocessed dataset was used as the primary input to train the model's ability to identify motorcyclists, both those wearing helmets and those without. Furthermore, training parameters such as the number of epochs, batch size, and image resolution were carefully adjusted to meet the needs of this study.

During the training phase, model progress is closely monitored using evaluation metrics such as loss, precision, recall, and mean average precision (mAP). (Meidyan & Yustanti, 2024)This monitoring ensures consistent performance improvements and prevents overfitting. Once the process is complete, the final model is saved and ready to be integrated into the testing phase or implemented in a system for detecting unhelmeted motorcyclists on the road.

D. System Implementation

This study implemented a waste detection system entirely within the Roboflow ecosystem, without the need to create an external interface or web-based application. (Falach et al., 2026)The designed YOLOv5 model was then run using the platform's Inference feature. This mechanism allows users to simply upload images into the Roboflow dashboard, and the system automatically processes the data using the pre-built model.

Each image is processed in real time, with Roboflow running an inference flow to generate predictions in the form of bounding boxes, category classifications (organic or inorganic), and confidence values for each object. All of this computing is cloud-based, eliminating the need for additional software installation on the researcher's hardware. Furthermore, the platform simplifies model evaluation by allowing direct comparison of prediction results with the original data, as well as performance testing using new datasets outside the scope of the study.

E. Testing

Testing is a vital step in evaluating the model's effectiveness when confronted with new data outside the initial analysis framework.(Setiawan et al., 2024) Through the use of validated datasets, this phase aims to produce an objective representation of the model's performance. This process is crucial for strengthening the model's generalizability to visual dynamics in the field, while also testing its robustness in non-ideal situations. By considering variables such as lighting fluctuations and variations in object viewpoints, this phase ensures the model remains adaptive even when objects are occluded or in unstructured environments.In addition Testing this is used to evaluate model performance using a validated dataset that has been extracted from study data. In this phase, several key metrics such as accuracy, recall, F1 score, and confusion matrix

are used to provide a quantitative overview of model performance. This evaluation is a crucial step to ensure that the model can identify and classify objects consistently and can be used in more complex application contexts.

During the testing phase, prediction quality is improved through in-depth evaluation of several key metrics.(Elisa Nalawati et al., 2023a) Recall is used to optimize the system's sensitivity in capturing all relevant objects, while precision serves as a precision parameter to ensure the validity of detected objects. This balance between detection coverage and accuracy is represented by the F1-score. Furthermore, a confusion matrix is used to visually map the distribution of prediction results including the classification of correct and incorrect predictions.

Furthermore, the test results serve as the basis for determining whether the model can be implemented immediately or requires retraining. If the model's performance has met the established accuracy standards, the system is worthy of being recommended for more complex operational scenarios. Conversely, if significant deficiencies are still identified, further evaluation is necessary through additional dataset variations, the application of advanced augmentation techniques, or hyperparameter optimization to improve the model's effectiveness in subsequent iterations.

3. RESULTS AND DISCUSSION

This program was developed using the Python programming language and several supporting tools, such as OpenCV, mysql-connector, and Ultralytics. These libraries are used for image processing, data management, and YOLO-based detection model implementation.

The detection and recording violation mechanism is carried out using a simple but effective approach. In this system, there is a horizontal line that functions as a boundary or reference during the calculation and image capture process from the video. Objects identified by the model results are classified into two categories: those wearing helmets and those who are not.

If an object is classified without a helmet or reference line, the system will automatically perform the retrieval process and enter the results into the database. Conversely, objects identified using a helmet will not be processed further, even if the lines are identical. This process is carried out by applying if-else condition logic to the program.

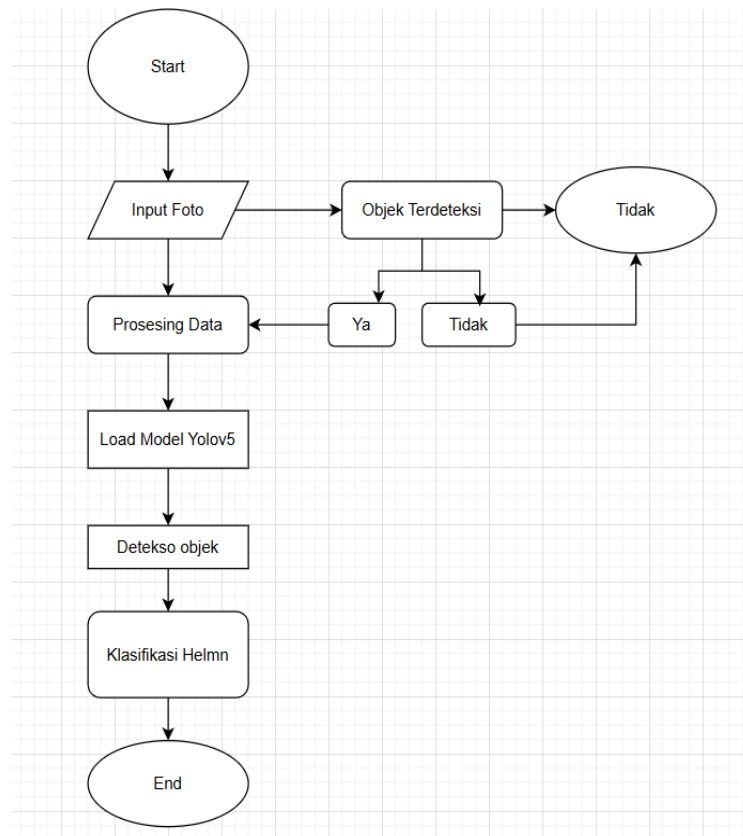


Figure 1. Program flowchart

Figure X. Flowchart of the workflow of the helmetless motorcycle rider detection system based on YOLOv5. This diagram shows the stages of the process carried out by the system, starting from data preprocessing, object detection, to displaying the detection results.

a. Results Processing Roboflow



Figure 2. Tamdisplay Program

Figure 2. Results of the annotation and dataset training process using Roboflow in detecting motorcycle riders without helmets. This image shows the results of data processing which is used as the basis for training the YOLOv5 model.

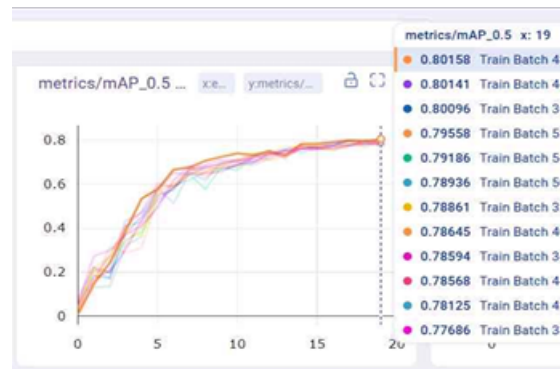


Figure 3. Graph of mAP score results using comet.ml

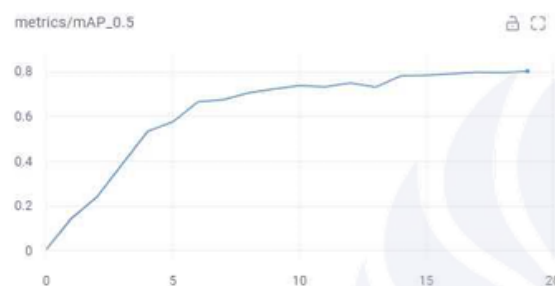


Figure 3. graph of batch 48 metrics/mAP_0.5 score using comet.ml



Figure 5. graph of batch 48 metrics/precision score using comet.ml

According to Figure 3, the best results from all experiments were obtained using batch 46, tested over 7 epochs. After selecting the best batch for the study, the pre-trained data could be analyzed using data with an mAP_0.5 score of 0.90 using 46 batches and 7 iterations/epoch, as shown in Figure 3..

As shown in Figure 4. This is consistent with Figure 4, where the dataset m has a high mAP_0.5 value when batch 48 is used in 20 iterations. In addition, it has a matrix/precision score of 1.0 and a matrix/recall score of 0.93.

The results of the helmet detection system are also shown in Figure 5. This system is able to detect the three classes previously discussed in Stage 2, namely the two-wheelers themselves and those who do or do not use helmets.

Table.1

process	box_loss	cls_loss	obj_loss
validasi	0.03387	0.00092	0.01155
train	0.0328	0.00116	0.00952

Based on Table 1, the trained and validated dataset shows that these values are relatively small, where the Yolov5m algorithm used in this helmet detection system can be applied successfully because these three parameters can be used to observe several good models that can predict the boundaries.

Table.2

process	box_loss	cls_loss	obj_loss
validasi	0.03387	0.00092	0.01155
train	0.0328	0.00116	0.00952

Based on Table 3, the Yolov5m algorithm has good results where the results on the training data and validation data tend to produce the same F1_Score value, namely 0.90, where the F1_Score itself is obtained from the automatic calculation provided by the YOLOv5 architecture. In the research that has been conducted, the results are quite good so that the system can be implemented to detect helmet use violations.

4. CONCLUSION

The YOLOv5 approach can be used successfully to lower the number of motorized vehicles that do not wear helmets on the road, according to the findings of the analysis and system testing that have been finished. Based on processed images or videos, the developed system can accurately classify helmet usage status and analyze rider objects. The model analysis process using a dataset that has been annotated and processed using Roboflow, shows that the model can perform object detection in real-time with a high level of accuracy. This is based on the detection results which can distinguish between riders who wear helmets and those who do not wear helmets in various image conditions.

Additionally, the system is easy to implement due to the development of a basic system that includes object detection, preprocessing, image input, and final result display. In order to function as an automated traffic aid, this system has also been designed with conditioning logic that permits riders without helmets to receive extra attention.

Therefore, using imagery and artificial technology, the YOLOv5-based motorcycle rider detection system without a helmet can be used as a first step toward improving traffic safety.

5. SUGGESTIONS

Even though the developed system has yielded excellent results, there are still a number of areas that could be improved to boost the system's accuracy and productivity. For additional research, consider the following examples:

Additions and modifications to the dataset To improve the model's performance in real-world scenarios, the dataset can be adjusted based on lighting, weather, shooting angle, and traffic density. Using a more recent version of YOLO Further development can use a newer version of YOLO, like YOLOv7 or YOLOv8, to improve detection accuracy and speed. Connectivity to traffic systems To enable real-time use in a highway setting, this system can be improved by directly integrating CCTV cameras or traffic systems.

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