Developing A CCTV-AI System with The Capability to Accurately Detect and Recognize Individuals Who Are Wearing Helmets, Specifically Targeting Riders and Passengers.

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Abstract

Currently, Thailand is experiencing a high mortality rate due to motorcycle accidents, coupled with a low rate of helmet usage. Previous research has indicated that law enforcement measures can effectively increase helmet compliance. To address this issue, a study was conducted to create a system using artificial intelligence and CCTV technology to identify riders and passengers who are not wearing helmets. The study involved four key stages: data collection, software development utilizing the Yolo V.4 library, neural network training, and accuracy assessment. Results demonstrate that the program can successfully identify non-helmet-wearing riders with a 95% accuracy rate, which is deemed suitable for implementation by law enforcement agencies.

Keywords: Motorcycle, Accident, Neural network**,** Technology

1. Introduction

According to the WHO's 2018 report, Thailand led the world in both traffic fatalities and accidents, with motorbikes accounting for almost 70% of the total. Previous investigations have demonstrated that wearing a helmet can significantly lower the number of head injuries and fatalities. (World Health Organization, 2018)

Motorcyclists in Thailand are also required by law to wear helmets. That being said, Thailand's law enforcement apparatus is not very effective. As seen in Figure 1, the police must set up a checkpoint at which they can issue citations to riders who fail to wear helmets.

Figure 1 Helmet-wearing enforcement at a checkpoint by police

Many times, accidents even happen at the checkpoint because the violator is trying to escape, and many times there are conflicts between the violator and the officer. (Satiennam, T. et al., 2023)

A 74% accuracy rate was demonstrated by Wonghabut et al. (2018) in their program to identify riders who do not wear helmets. This intriguing discovery has been expanded upon and equipped law enforcement has been equipped with a CCTV camera to identify motorcyclists not wearing helmets. This research has built a more accurate detection program by putting the strategy to use. The previous study suggested a novel method of regulating helmet use by employing CCTV cameras and computer software to automatically identify anyone breaking the law. (Mercado Reyna, J., et al., 2013; Li, J. et al., 2017) The Thai Police Ticket Management System (PTM), which issues tickets to motorcyclists who break the law, is compatible with the system. Table 1 illustrates the preliminary evaluation conducted during the first month at the Pratumuang intersection between 06:30 and 08:30 a.m. following the posting of warning signs encouraging the wearing of helmets, which indicates a 7% increase in helmet wear among motorcyclists. This shows a rise in rider safety. The rate of helmet wear may decline in the absence of law enforcement and police ticketing. (Kumphong, J. et al. 2018)

Table 1 Preliminary assessment of helmet wearing in percentage (after posting warning signs but no issued ticket)

	Percentage		Diff.
	Before posting warning signs	After posting warning signs	
Riders wearing helmet	82	89	7
Riders not wearing helmets	18	11	-7

A recent study has been conducted on law enforcement using the CCTV camera to detect unhelmeted riders. The study sites were: Mordindang Intersection, Kanlapaphruek Intersection, Phatumuang Intersection, Bankok Intersection, and Charoensri Intersection in Khon Kaen urban areas. The result shows an increase of an average of 3.8% in helmet-wearing at all the intersections where the law was enforced. (Satiennam, T. et al., 2020) In the study, the program for detecting riders not wearing a helmet was developed, and the program training was performed for the detection of an object, which was a motorcycle or a helmet. This increased the complexity of data computation and required a higher cost, obstructing research extension into other areas. Thus, the further development for law enforcement is program training that enables detection of the unhelmeted head only. (Wonghabut, P. et al., 2018)

The CCTV camera program for detecting motorcyclists not wearing a helmet will be a useful technology for the police’s enforcement of law since it increases the efficiency in law enforcement and the helmet-wearing rate. However, previous research has not been able to provide a detailed picture of which helmet styles drivers and passengers use. (Wonghabut, P. et al., 2018)

2. Objective

This study aims to create a program that uses an artificial intelligence system in conjunction with a CCTV camera to identify motorcyclists—both riders and passengers—who do not wear a helmet.

3. Methods

3.1 Survey and data collection for developing the detection system

The researcher selected the survey area and collected video data for developing the program. Since program development requires a great number of illegal riders without a helmet, there should be at least over 1,000 samples compared to the past article. The following 3 intersections have been selected as they are already installed with CCTV, and the camera views are appropriate: 1) Pratumuang, 2) Mordindarng and 3) Charoensri intersections along Mittraphap road in Khon Kaen Municipality as shown in Figure 2.

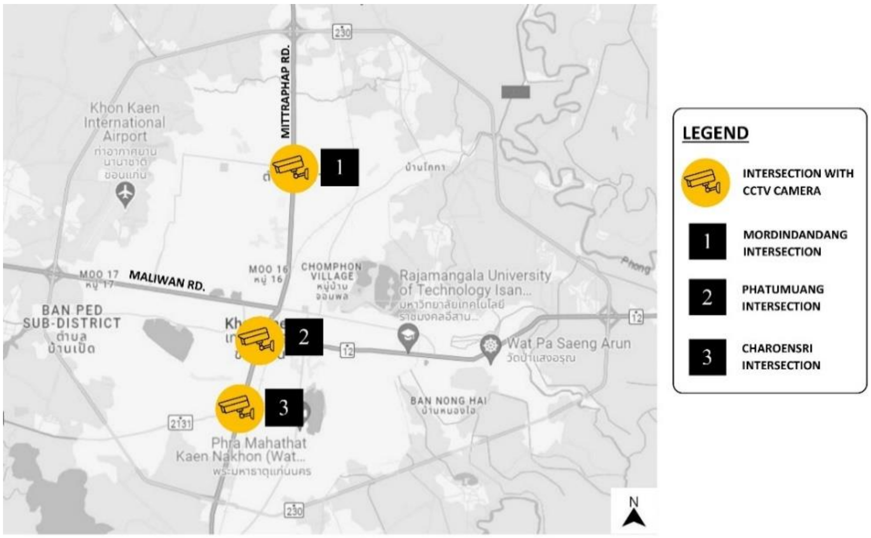

Figure 2. CCTV camera positions

3.2 Developing of the detection program

This study was done on object categorization (managing the image file by) based on the previously stated difficulty. Figure 3 illustrates how to gather data from CCTV cameras and turn them into an image file, which may then be transformed into an image file, framed to display an unhelmeted riders and passengers, or converted from the image file into a text format.

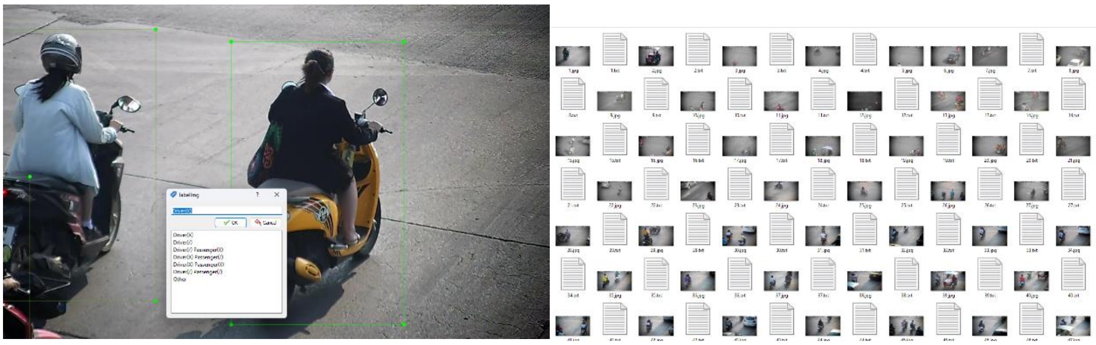

Figure 3 Example of image management before training data

3.3 Developmental procedures

3.3.1 Taking pictures in the research area (this approach is different from earlier studies that only took pictures of the rider's head (Chairat, A. et al., 2020; Mercado Reyna, J., et al., 2013).

3.3.2 Approximately 1,119 images per CCTV camera are stored for program development, both during the day and at night (of which 1,019 will be used for training and 100 for accuracy checks during the training). Ten percent of the data were used in this study. Nevertheless, the AI development handbook states that there isn't a set guideline. The training photos included a variety of details that needed to be captured (as seen in Figure 4, one image may have multiple cases). In certain studies, the head image without a helmet was the only one captured.

(a)

(b)

Figure 4 Examples of images collected: a) One case only b) More than one case

Table 2 displays the ideas, variables, codes, and categories. The software for several types of helmet wear (Driver (X), Driver (/), Driver (/) Passenger (X), Driver (X) Passenger (/), Driver (X) Passenger(X), Driver (/) Passenger (/) and Other); status (rider, passenger); number of passengers (none, ≥ One); gender (female, male, and unidentified); side carriage—that is added to the side of the motorcycle and is common in Thailand, though it is illegal (yes, no) (Figure 5); hairstyle (long hair, short hair, and unidentified); hair color (black, others, and unidentified); food delivery (yes, no), as seen in Figure 6. A sample of motorcycle riders on an urban arterial road in Khon Kaen City, Thailand, provided the data.

Table 2 An explanation of the research variables

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variables	**Codes/Category**
Types of wearing a helmet	1= Driver (X) 

Table 2 (Continued)

variables	Codes/Category
Types of wearing a helmet	2= Driver (/)  3= Driver (/) Passenger (X)  4= Driver (X) Passenger (/) 

Table 2 (Continued)

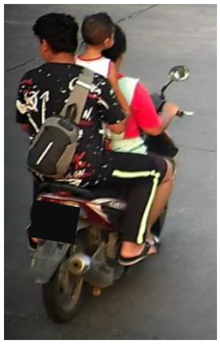
variables	Codes/Category
Types of wearing a helmet	5= Driver (X) Passenger (X)  6= Driver (/) Passenger (/)  7= Other 
Status 1=Rider 0=Passenger No. of passenger 1=None 0=(≥ One)	

Table 2 (Continued)

variables	Codes/Category
Side carriage	1=Yes
	0= No
Hairstyle	1= Long hair
	0= Other
	2=Unknown
Hair Colour	1= Black
	0= Other
	2=Unknown
Food Delivery	1=Yes
	0= No

Figure 5 An illustration of a sidecar on a motorcycle

(a) (b) (c)

Figure 6 Example of riders with head ornaments: a) wearing a hoodie's hat, b) wearing a hair clip, c) wearing a cap.

3.3.3 Training the artificial neural network for more accuracy (as shown in Figure 7 and Figure 8)

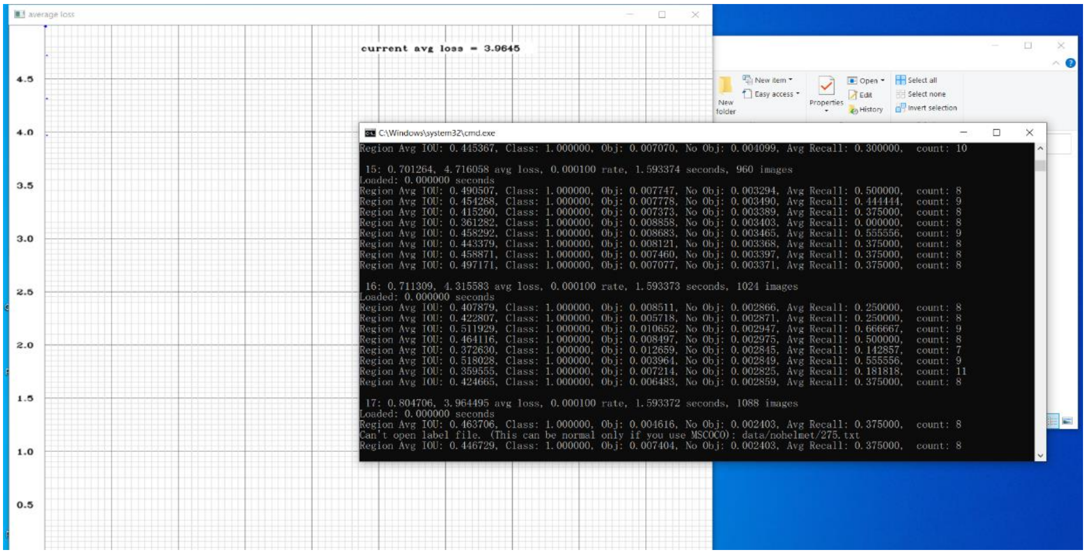


Figure 7 Example of program training

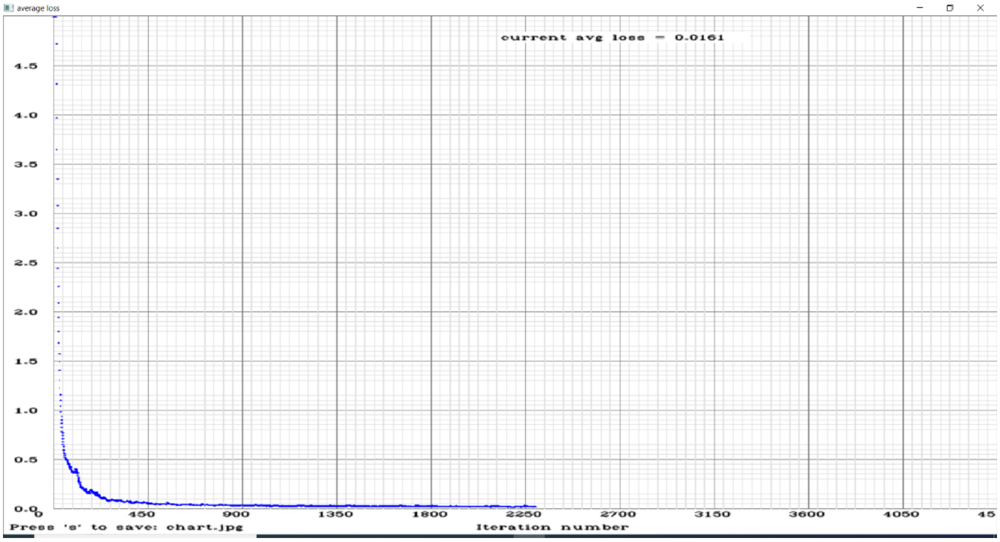


Figure 8 Example of the graph from the training program

3.3.4 Testing the software in the study area to assess the accuracy of information

3.3.5 Drawing conclusion

3.4 Evaluating the detection program's precision

To determine the percentage of detection accuracy, the researcher gathered 100 randomly selected images, which are not the same set as the images used in the training program in topic 3.3 (the training program was unaware of this). The purpose of this comparison was to find out how many riders were not wearing helmets, as detected by the program and how many were detected by the researcher.

4. Results and Discussions

4.1 Result of Program Development

A total of 1,019 photos (N = 2,055) showing motorcycle riders without helmets were collected throughout program development. The sample group's baseline data included the following: types of helmet wearers (24.8% Driver (X), 13.2% Driver (/), 24.6% Driver (/) Passenger (X), 1.5% Driver (X) Passenger (X), 27.4% Driver (X) Passenger (X), 4.2% Driver (/) Passenger (/) and 4.3% Other); status (68.2% riders, 31.8% passengers); number of passengers (37.9% none, 62.1% ≥ One); hairstyle (31.6% long hair, 50.8% short hair, and 17.6% unidentified); hair colour (64.7% black, 4.7% other, and 30.6% unidentified); and food delivery (5.0% yes, 95.0% no). These are displayed in Table 3.

Table 3 Variable of Program Development (N=2,055)

Variable	Frequency	% (95%IC)
Types of wearing a helmet		
1= Driver (X)	510	24.8(22.9-26.8)
2= Driver (/)	271	13.2(11.8-14.5)
3= Driver (/) Passenger (X)	506	24.6(22.7-26.5)
4= Driver (X) Passenger (/)	30	1.5(1.0-2.0)
5= Driver (X) Passenger(X)	563	27.4(25.5-29.2)
6= Driver (/) Passenger (/)	86	4.2(3.4-5.1)
7= Other	89	4.3(3.4-5.3)
Status		
Rider	1,402	68.2(66.1-70.2)
Passenger	653	31.8(29.8-33.9)
No. of passenger		
None	779	37.9(35.8-40.0)
≥ One	1,276	62.1(60.0-64.2)
Side carriage		
Yes	19	0.1(3.1-5.0)
No	2,036	99.1(95.0-96.9)
Hairstyle		
Long hair	650	31.6(29.7-33.7)
Other	1,044	50.8(48.6-53.0)
Unknown	361	17.6(15.9-19.2)
Hair color		
Black	1,330	64.7(62.6-66.9)
Other	97	4.7(3.8-5.7)
Unknown	628	30.6(28.4-32.6)
Food Delivery		
Yes	102	5.0(4.0-5.9)
No	1,953	95.0(94.1-96.0)

After 4,500 cycles of accuracy training, 95% accuracy was found in the learning software. Depending on the computer's efficiency, each cycle took about an hour. The training procedure used the same methodology as the research by Chairat et al. (2020), but in this study, training was limited to undeleted riders and passengers to improve law enforcement effectiveness because this entails training only the primary target.

4.2 Verification of program accuracy

For the purpose of ensuring that the program is accurate, a collection of one hundred photographs of cyclists wearing and not wearing helmets was conducted. In the sample group, the baseline data contained the following categories of helmet wearers: 28.1% of drivers (X), 3.6% of drivers (/), 29.9% of drivers (/) who were passengers (X), 1.2% of drivers (X) who were passengers (/), 33.5% of drivers (X) who were passengers (X), 1.2% of drivers (/) who were passengers (/), and 2.4% of other drivers.; status (64.7% riders, 35.3% passengers); No. of passenger (29.3% none, 70.7% ≥ One); side carriage (3.0% yes, 97.0% no); hairstyle (34.7% long hair, 47.3% short hair, and 18.0% unidentified); hair colour (68.3% black, 9.6% other, and 22.1% unidentified); food delivery (6.0% yes, 94.0% no). Table 4 displays these in its entirety.

Table 4 Variables for verification of program accuracy (N=167)

Variables	Frequency	% (95%IC)
Types of wearing a helmet		
1= Driver (X)	47	28.1(21.6-35.3)
2= Driver (/)	6	3.6(1.2-6.6)
3= Driver (/) Passenger (X)	50	29.9(23.4-37.1)
4= Driver (X) Passenger (/)	2	1.2(0-3.0)
5= Driver (X) Passenger(X)	56	33.5(26.3-40.7)
6= Driver (/) Passenger (/)	2	1.2(0-3.0)
7= Other	4	2.4(0-4.8)
Status		
Rider	108	64.7(57.5-71.9)
Passenger	59	35.3(28.1-42.5)
No. of passenger		
None	49	29.3(22.2-35.9)
≥ One	118	70.7(64.1-77.8)
Side carriage		
Yes	5	3.0(0.6-5.4)
No	162	97.0(94.6-99.4)
Hairstyle		
Long hair	58	34.7(27.5-42.5)
Other	79	47.3(40.1-55.1)
Unknown	30	18.0(12.0-24.0)
Hair colour		
Black	114	68.3(61.1-75.4)
Other	16	9.6(5.4-14.4)

Table 4 (Continued)

Variables	Frequency	% (95%IC)
Unknown	37	22.2(16.2-28.1)
Food Delivery		
Yes	10	6.0(2.4-9.6)
No	157	94.0(90.4-97.6)

When compared to previous research studies that were used to construct the program, it was discovered that the learning program had an accuracy training of 95% (the example of detection is given in Figure 9). As a result, the precision of this investigation is much improved. As demonstrated in Figure 10, the algorithm was able to differentiate between riders who wore hats and riders who wore helmets.

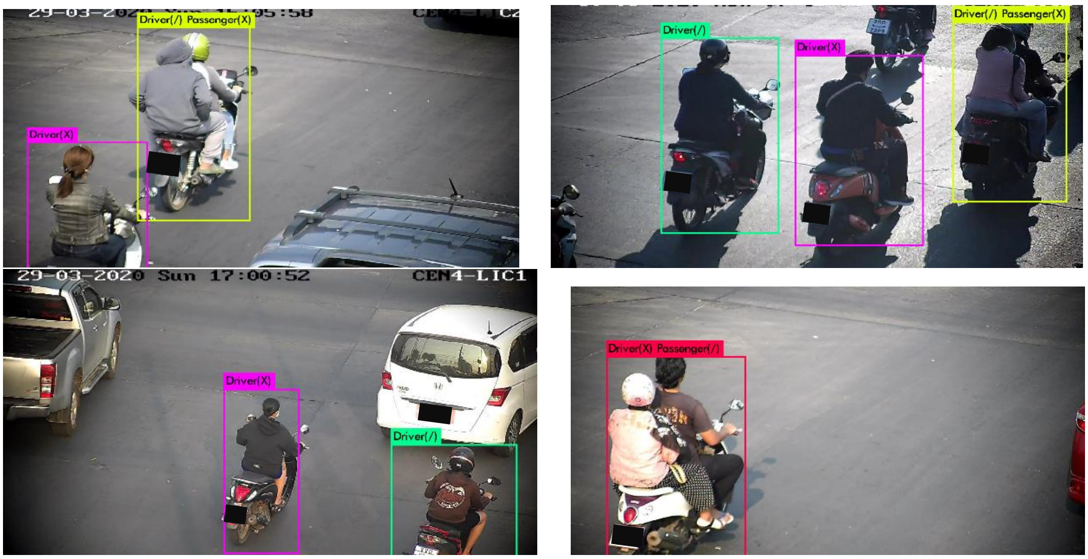


Figure 9 Example of detection of riders not wearing a helmet by the trained program

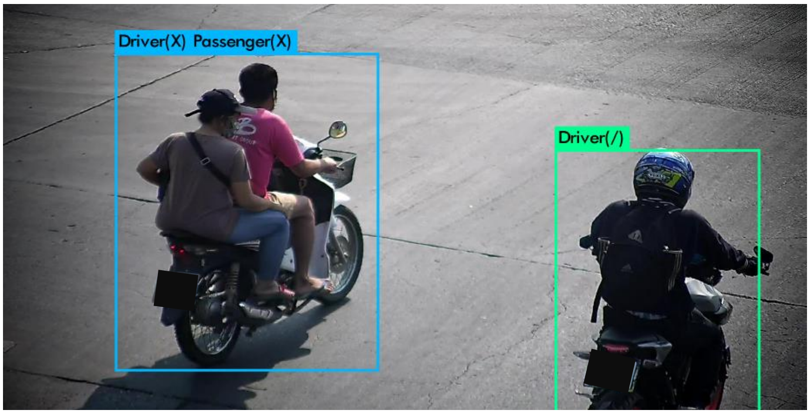


Figure 10 Example of detection of riders wearing other hats

5. Conclusion

The purpose of this investigation was to investigate and design a program that would use an artificial intelligence system in conjunction with a closed-circuit television camera to identify riders and passengers who are wearing helmets. It was determined that the program yielded an accuracy rate of 95%. With this level of precision, the authorities are able to take legal action against the person who committed the offense. For the purpose of determining whether a higher percentage is required, additional data should be gathered from a variety of scenarios, patterns, and through additional training. On the other hand, if there were a greater quantity of data, the amount of finance allocated for development would likewise be greater. In addition, in order to include the program into additional domains, it is necessary to position the camera at the same angle as the angle that was utilized in the experiment. Furthermore, in order to enhance the precision of the detection, training needs to be carried out on the image that was taken from that particular region. The development has the potential to be utilized as a measure that enhances the effectiveness of law enforcement officials, and it may also be utilized in conjunction with the automatic mobile detection system for riders who are not wearing helmets.

6. Acknowledgments

This work is dedicated to the memory of my late elder brother, Mr. Vutidach Kumphong, who tragically lost his life in a road accident.

7.References

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8. Academic Value

This study resulted in the development of a program that utilizes artificial intelligence in conjunction with a closed-circuit television camera to detect individuals not wearing helmets while riding motorcycles. The program demonstrated an accuracy rate of 95%, enabling authorities to take legal action against offenders.