Automatic helmet-wearing detection for law enforcement using CCTV cameras

P Wonghabut¹, J Kumphong¹, T Satiennam¹, R Ung-arunyawee¹* and W Leelapatra¹

¹Faculty of Engineering, Khon Kaen University, Khon Kaen 40000, Thailand.
* Corresponding author. Tel.: +6681-592-1947. E-mail address: rujchai@gmail.com

Abstract. The objective of this research is to develop an application for enforcing helmet wearing using CCTV cameras. The developed application aims to help law enforcement by police, and eventually resulting in changing risk behaviours and consequently reducing the number of accidents and its severity. Conceptually, the application software implemented using C++ language and OpenCV library uses two different angle of view CCTV cameras. Video frames recorded by the wide-angle CCTV camera are used to detect motorcyclists. If any motorcyclist without helmet is found, then the zoomed (narrow-angle) CCTV is activated to capture image of the violating motorcyclist and the motorcycle license plate in real time. Captured images are managed by database implemented using MySQL for ticket issuing. The results show that the developed program is able to detect 81% of motorcyclists on various motorcycle types during daytime and night-time. The validation results reveal that the program achieves 74% accuracy in detecting the motorcyclist without helmet.

Keyword: Road accident, Motorcyclist, Helmet, Law enforcement, Image processing

1. Introduction

Thailand has been known for its high rate of road accidents [1]. From all road accidents that cause death, 80% are from motorcycles as announced by World Health Organization (WHO) in 2015 [2]. As indicated by many researches, helmet wearing is an important factor that mitigates injury or mortality rates [3]. According to Thai lawsuit, motorcyclists are required to wear helmet, but the law has been poorly enforced. Policemen need to setup check points in order to charge motorcyclists without helmet [4], as shown in Fig. 1. Many times accidents occur at the check point because guilty motorcyclists attempt to escape. In this paper, we present a new approach that is more efficient for enforcing helmet wearing by using CCTV cameras and computer program to automatically detect motorcyclists without helmet. Our system is able to integrate with Thai Police Ticket Management System (PTM) for issuing ticket to motorcyclists who disobey the law.

Detection of helmet on motorcyclist has been shown to be possible with high accuracy as described in [5-7]. These works have been done but not reported to be used by any officials. In contrast, we have been working closely with local police department and government in order to utilize and integrate the developed program with existing police ticket system.
2. Methodology

Our basic requirement is that the developed program must be able to capture images of motorcyclists without helmet and the motorcycles plate number. We utilized two types of CCTV camera installed at intersections: wide-angle and zoomed CCTV cameras. The wide-angle camera, which records overview image of intersection, is used for detecting motorcyclist and the zoomed camera is used for capturing plate number. We tested our program using pre-recorded video clips at different times of a day. The number of motorcyclists without helmet detected by our program is compared to the result that is manually counted by human. Fig. 2 illustrates methodology used in this research.

Figure 1 Helmet wearing enforcement at police check point [4]

Figure 2 Methodology used in this research

2.1 Development of a program to automatically detect motorcyclist without helmet

The program is designed to monitor video frames recorded by wide-angle CCTV camera and examine areas of frame that motorcyclists are found. Then, the areas containing motorcyclists are analysed to determine whether helmet is found or not. If not, the program invokes video frames that are simultaneously recorded by zoomed CCTV camera to capture license plate of the motorcycle. The
images of motorcyclists without helmet and the image of plate number are saved in database as evidence and will be further used by Police Ticket Management System. We develop our program using C++ language, OpenCV library and MySQL. Concept of the program is shown in Fig. 3.

The program is designed to operate in two steps. First, detect motorcyclist in video frames captured by wide-angle CCTV camera. Second, search all of the areas where motorcyclists are found to determine whether helmet is worn or not. Details of each step are as follows:

![Program flow chart](image)

**Figure 3** Program flow chart

2.1.1 Step 1: Detection of motorcyclist
In this paper, HAAR algorithm is used as descriptor for extracting object features. Output from this process are frames containing motorcyclists as shown in Fig. 4 (b). These frames are \( w \) pixels width and \( h \) pixels height, where \( w \leq 80 \) and \( h \leq 120 \).

2.1.2 Step 2: Detection of helmet
This step determines whether the detected motorcyclists are wearing helmet or not. It is necessary to find head of a motorcyclist first. We consider 1/3 height and 1/2 width of the area where motorcyclists are found as shown in Fig. 4 (f). We considered two classes of motorcyclists: (i) motorcyclists without helmet (positive) and (ii) motorcyclists with helmets (negative). Also Fig. 5 illustrates system overall process from helmet detection to ticket issuing by police.

2.2 Detection results verification
To verify correctness of our program, we employed t-test to compare results produced by the developed program and the results manually counted with 0.05 significant.
Figure 4. Diagram for detection of motorcyclist without helmet.

a) Input frame, b) Select Area A sample frame, c) Object classification as non motorcyclist,
   d) Object classification as Motorcyclist, e) Bounding box around Motorcyclist,
   f) Localized head of the Motorcyclist, g) Motorcyclist classified as ‘with helmet’ class,
   h) Motorcyclist classified as ‘without helmet’ class.
3. Results and Discussions
We tested our program using video clips recorded by CCTVs on August 19, 2017 during 06.00 am - 06.00 pm. Table 1 shows that there are total of 2,157 motorcycles and the program is able to detect 1,751 motorcycles. Our manually counting yields 1,526 motorcyclists who are wearing helmets and 631 are not. The program is able to detect 1,149 motorcyclists wearing helmets and 470 motorcyclists without helmets. The results show that our program can detect 81% of all motorcycles passing through the intersection and 74% of motorcyclists without helmet.

Table 2 shows detail of experiment results sorted by time of day. We found that detection performance of the program dropped during rush hours due to dense traffic, which causes overlapping of motorcycles image on video frames. This significantly reduces ability to identify motorcyclists of the program. Table 3 shows t-test significant level of differences between results obtained from manual count and results produced by program. As shown in the table, the significant levels are 0.00, which is less than 0.05, for all interested objects. Hence, the significant level of differences is said to be at 0.05. The t-test analysis indicated that the manual count data and program detection has 0.05 significant difference. However, we will continue to improve detection accuracy of the program.

| Table 1 Overall accuracy of detection |
|--------------------------------------|
| Object                               | Manual count | Detected by program | Accuracy (%) |
| Motorcycles                          | 2157         | 1751                | 81           |
| Motorcyclists With Helmet            | 1526         | 1149                | 75           |
| Motorcyclists Without Helmet         | 631          | 470                 | 74           |
Table 2 Accuracy of detection sorted by time

| Time      | No. of Motorcycle | No. of Motorcyclist With Helmet | No. of Motorcyclist Without Helmet |
|-----------|-------------------|---------------------------------|-----------------------------------|
|           | Manual Count      | Detected by program              | Manual Count                      | Detected by program              | Manual Count                      | Detected by program |
| 6.00-7.00 | 74                | 57                              | 49                                | 35                              | 14                               | 25                                | 15                   | 10                   |
| 7.00-8.00 | 197               | 161                             | 148                               | 119                             | 29                               | 49                                | 34                   | 15                   |
| 8.00-9.00 | 317               | 248                             | 252                               | 231                             | 21                               | 65                                | 47                   | 18                   |
| 9.00-10.00| 138               | 117                             | 88                                | 62                              | 26                               | 50                                | 38                   | 12                   |
| 10.00-11.00| 124              | 84                              | 79                                | 47                              | 32                               | 45                                | 36                   | 9                    |
| 11.00-12.00| 145              | 121                             | 102                               | 75                              | 27                               | 43                                | 28                   | 15                   |
| 12.00-13.00| 198              | 159                             | 125                               | 89                              | 36                               | 73                                | 58                   | 15                   |
| 13.00-14.00| 147              | 126                             | 113                               | 88                              | 25                               | 34                                | 22                   | 12                   |
| 14.00-15.00| 120              | 95                              | 78                                | 49                              | 29                               | 42                                | 34                   | 8                    |
| 15.00-16.00| 184              | 157                             | 131                               | 92                              | 39                               | 53                                | 37                   | 16                   |
| 16.00-17.00| 216              | 188                             | 164                               | 128                             | 36                               | 52                                | 37                   | 15                   |
| 17.00-18.00| 297              | 238                             | 197                               | 134                             | 63                               | 100                               | 84                   | 16                   |
| Total     | 2157             | 1751                            | 1526                              | 1149                            | 377                              | 631                               | 470                  | 161                  |

Table 3 Significant level of differences between results obtained from manual count and program detection.

| Object                  | Result difference between manual count and program detection | t-test | Significant (p<0.05) |
|-------------------------|-------------------------------------------------------------|-------|---------------------|
|                         | Mean             | S.D.             |                   |
| Motorcycles             | 33.83            | 15.97            | 7.33              | 0.00               |
| Motorcyclists With Helmet| 31.41            | 12.10            | 8.99              | 0.00               |
| Motorcyclists Without Helmet| 13.41          | 3.14             | 14.77             | 0.00               |

4. Conclusions
We have developed a computer program for detecting motorcyclists who are not wearing helmets using CCTV cameras. Evaluation results show that the program can detect 81% of all motorcycles passing through the intersection with accuracy of 74% for detection of motorcyclists without helmet. The program has been integrated with official ticket system to produce essential evidences for police department.

5. Future improvement
The work presented in this paper is in developing process. We are attempting to improve accuracy of the program in order to increase efficiency of law enforcement in Thailand. Consequently, we will evaluate and report impacts after using this system in term of fatality of motorcyclists in the future.

6. References
[1] Burton J 2017 Top 25 countries in car accidents, URL: http://www.worldatlas.com/articles/the-countries-with-the-most-car-accidents.html
[2] World Health Organization 2015 Global Status Report on Road Safety (Geneva: Switzerland)
[3] Alaa KA Ashraf FH and Fikri MAZ 2012 Does wearing helmets reduce motorcycle-related death? A global evaluation. (Accident Analysis and Prevention Vol 49) pp 249-252
[4] Images of police check points. URL: https://board.postjung.com/918054.html
[5] Silva R Aires K and Veras R 2014 Helmet detection on motorcyclists using image descriptors and classifiers 27th SIBGRAPI Conference on graphics, patterns and images pp141-148.

[6] Dahiya K Singh D and Mohan C K 2016 Automatic detection of bike-riders without helmet using surveillance videos in real-time 2016 International joint conference on neural networks (IJCNN) pp3046-3051.

[7] Vishnu C Singh D Mohan C K and Babu S 2017 Detection of motorcyclists without helmet in videos using convolutional neural network 2017 International joint conference on neural networks (IJCNN) pp3036-3041.