Perspective on Road Safety

Automated detection of motorcycle helmet use

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Key Findings

- Measurement of motorcyclist helmet use is an important public health measure.
- Current methodology of measuring helmet use is both time-consuming and expensive.
- Automated helmet detection is a developing methodology with improving accuracy.

Introduction

Road traffic collisions are among the top ten causes of death worldwide with more than 1.3 million deaths annually (WHO, 2018). Riders of motorised two- and three-wheelers are more vulnerable to injury and death and make up 28% of global road traffic deaths. In some regions, such as South-East Asia, this number is as high as 43% (WHO, 2018).

Correct helmet use reduces the risk of death by 42% and the risk of head injuries by 62% (Liu, Ivers, Blows, Lo, & Norton, 2008). Increasing motorcycle helmet usage to close to 100% by 2030 has been identified as one of the twelve road safety targets by the Global Road Safety Partnership (WHO, 2018). Despite the clear benefits of wearing a helmet, increasing helmet use is challenging especially in low- and middle-income countries (LMICs). A large-scale helmet use media campaign in Thailand over five years showed no benefit (Patummasut, Phewchean, & Sirirattanapa, 2019). While legislating helmet use has shown a clear benefit, there is a disparity between the legislative benefit in high-income countries (HICs) compared to LMICs, with LMICs showing lower use of helmets and less reduction in brain injuries (Lepard, Spagiari, & Park, 2021).

Measurement of helmet use is critical for advocacy and for the assessment of the effectiveness of new laws, enforcement, and public safety campaigns. Unfortunately, less than half of all countries surveyed in the latest WHO Global Status Report on Road Safety have data on helmet wearing (WHO, 2018). This is likely because helmet use data is both time consuming and costly to obtain. New methodology automating this process from digital images has the potential to allow authorities to obtain accurate helmet use rates quickly and inexpensively.

Current Methodology

Currently, helmet use data is obtained primarily by one of two methods: roadside observation or reviewing hospital and police records. These methods are used in both HICs and LMICs (Lepard et al., 2021). Roadside observation is time-consuming and expensive as it requires a team of research assistants to stand at the roadside, often in multiple locations at different times of day, and count motorcyclists and helmet use. With this method, there is the potential for misclassification (Muni et al., 2020), double counting, limited geographic coverage, and missed riders. In addition, if paper records are used, there can be issues related to legibility, storage costs, and the additional time and cost of entering the data twice (Mehmood, Taber, Bachani, Gupta, & Paichadze, 2019). Roadside observation can also suffer from observation bias (e.g., age) and selection bias since only specified areas and observation times are utilised.

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The second method involves analysing hospital or police records and can include additional data from self-reports. These records are limited by selection bias as they only include instances where the police were called or the motorcyclist in question was transported to a hospital. There are also biases inherent in self-reported data (Fan, Chiu, & Lin, 2019). Despite these limitations, these two methods remain the standard for helmet use measurement.

Automated Helmet Detection

Detecting and classifying objects automatically using image or video data is used in a wide variety of fields. For road safety, this method has been used for several applications including traffic light violations (Lin, Deng, Albers, & Siebert, 2020). These types of applications can enhance user safety and identify issues requiring enforcement. While still a developing area, automatically detecting motorcycle helmet use has the potential for several real-world applications.

The most commonly utilised technique for helmet detection has been using Convolutional Neural Networks (CNN). This is a type of machine learning algorithm where images can be processed to identify specific features and classified (Sanjana, Shriya, Vaishnavi, & Ashwini, 2021). Briefly, using video data, software can extract frames that then go through a process of background subtraction, segmentation, and feature extraction (Figure 1). In this way, a video stream of a street with cars and motorcycles can focus on the head region of a motorcycle driver and determine whether they are wearing a helmet (Figure 2). Though beyond the scope of this article, the specific methods utilised to do this have been documented (Sanjana et al., 2021).

Figure 1. Example of how a convolutional neural network can extract features of a motorcyclist from an image. (Original photo courtesy of Adeboro Odunlami, Unsplash https://unsplash.com/photos/-gcjqiwbZdM)

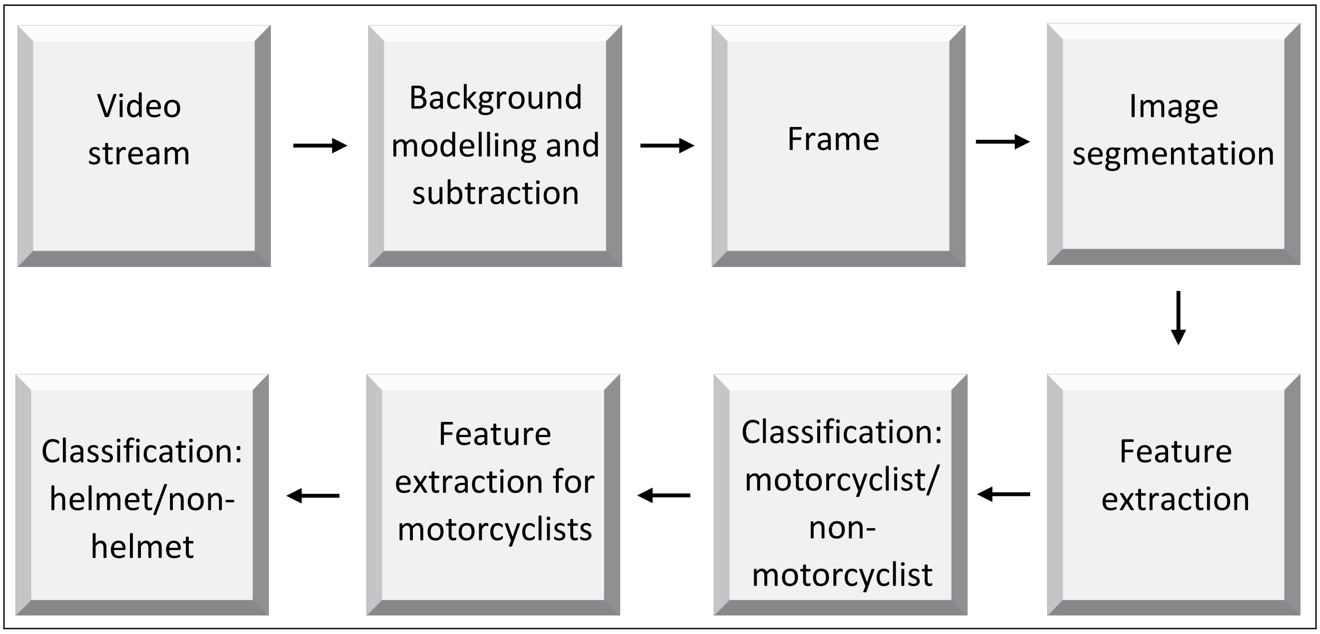

Figure 2. Overview of using machine learning to detect motorcycle helmet use.

Using CNNs, various teams have produced results ranging from 66.1% to 99.8% accuracy in automated helmet detection (Sanjana et al., 2021) with false positive rates reported between 0.5% and 9.0% (Alexander, Dwantara, Naufal, & Suhartono, 2020). It is, however, important to note that the accuracy is dependent on the level of detail required. In the most comprehensive methodology review to date (Lin et al., 2020), four elements that are required for automated detection to produce comparable results to human observers are described. First, the system needs to detect active motorcycles; second, it needs to be able to track motorcycles to ensure there is no duplication; third, there needs to be rider differentiation between driver and passenger(s); and, finally, there needs to be site diversity so that helmets are counted independent of the road environment (Lin et al., 2020). The authors of this study incorporated all four elements and analysed video data from over 10,000 motorcycles across twelve observation sites in Myanmar. They found the accuracy of rider-specific helmet use to be 80.6%, and if they included all four elements, the accuracy dropped to 67.3%. When evaluating the receiver operating characteristic (ROC) of the data, the authors found that the area under the ROC curve was 0.967. This means that the model performed well in distinguishing between true positives and false positives.

Although newer techniques are rapidly developing to overcome constraints, automated helmet detection has several limitations. First, image processing is constrained by the quality of the images. Lower quality images can be a result of lower quality cameras or varying weather conditions. Next, there can be false positive motorcycle detection with parked vehicles. Finally, the position of the camera is important in relation to the angle of the motorcycle and rider, and broader algorithms need to be developed (Siebert & Lin, 2020).

Applications

To date, automatic helmet detection has been implemented in Thailand beyond research purposes. Using CCTV cameras at five intersections in Bangkok, researchers developed a system to detect motorcycle riders without a helmet, capture license plates, and then utilise this information to issue tickets. When this system was implemented as a pre- and post-study, the authors found helmet usage increased from 77.2% to 82.4% in adults and 28.5% to 41.5% in children. This represents an increase of 5.2% and 13.0% in adults and children, respectively (Satiennam et al., 2020).

Conclusion

Automated helmet detection using CNNs is a rapidly evolving field that has moved beyond proof of concept. There are several limitations, but as more advanced algorithms are developed, its accuracy continues to improve. This technique has the potential to be further developed for real-world applications to increase helmet usage.

Author Contributions

HM, OM, and PM conceived this manuscript. HM and OM drafted the manuscript. All authors revised the manuscript critically for intellectual content and have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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