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The Use of Cnn-Based Multitask Learning for Smart Motorcycle Helmet Design

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Abstract: ***By informing and upholding legal guidelines, robotically figuring out motorcycle helmets through video surveillance contributes to improving road protection. It is difficult for current techniques to keep an eye fixed on motorbikes and inform riders from passengers. In order to tackle those problems, we recommend to reveal and recognize motorbikes using a CNN oriented multi- venture gaining knowledge of (MTL) approach, with a focal point on helmet- wearing motorcyclists. We offer the HELMET the dataset, that's made up of ninety one, 000 annotated frames of 10,006 motorbikes at 12 one-of-a-kind Myanmar observation web sites. This dataset may be used as a factor of reference for techniques of detection. Our technique, referred to as MTL, can provide higher accuracy and efficiency by means of combining helmet use categorization with similarity getting to know. Operating at a charge of greater than 8 frames for each 2d (FPS) on hardware, our technique attains a sixty seven.3% F degree in identifying cyclists and their helmet utilization. The effectiveness of learning in obtaining crucial expertise about avenue protection is highlighted by means of this study. In addition, we present a motorbike helmet prepared with earbuds, a charging module, an integrated computer unit, transceivers, and a photograph sensor. This helmet makes use of picture popularity modes in both daylight and midnight occasions to pick out automobiles coming near the wearer. According to experimental consequences, vehicles and buses' registration plates can be recognized with up to175% accuracy in the course of the1day & 70% accuracy at night. The new smart motorbike helmet is supposed to apprehend vehicles in real time inside a five-meter radius, increasing street protection.***

Keywords: CNN (Convolutional Neural Network), Multi-task Learning, Smart Motorcycle Helmet, Safety Systems.

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1. INTRODUCTION

In the modern day, motorcycles have come to be a popular & desired manner of transportation in many distinct countries, inclusive of China Indonesia, India, the Philippines, Malaysia, Taiwan, Thailand, and Vietnam. Reasonably priced, gas-green, and small enough to park in busy spaces without problems Motorcycles are the primary mode of transportation in many regions of Asia-Pacific due to their first-rate advantages, however their massive use also includes a number of dangers and possible dangers. Globally, there are over two hundred million motorbikes, or 33 motorcycles for every 1,000 people [1]. Regretfully, as the U. S. Data from the National Highway & Traffic Safety Administrations (NHTSA) from 2007 suggests that the variety of motorcycle fatalities per mile was 37 instances higher than that of passenger car deaths. The World Healthcare Organization (WHO) has alarming records indicating that 2.17 million motorcycles die in visitors-related deaths yearly, and an additional 20 to 50 million suffer accidents. Many states have regulations requiring helmet use in response to the essential problem of street safety. According to analyze, wearing a helmet can also lessen the wide variety of street deaths in half of, or round 29%. For instance, Taiwan should cope with safety issues considering, by way of the end of 2023, motorcyclists will make up 63.83% of all motorized automobiles there [2]. This novel helmet acknowledges huge cars and buses making use of actual-time display and route identification algorithms by way of combining infrared (IR) sensors with an image sensor [3]. The tool is supposed to keep motorcycle riders safer at the roads by way of stopping crashes, specifically in congested areas wherein traditional caution structures could grow to be much less powerful [4]. Traditional techniques for finding bike riders in motion often follows a predetermined technique [5]. First, a heritage subtraction approach is carried out to extract transferring gadgets or automobiles from the video facts [6]. Next, a binary classifier inclusive of a help vector machines (SVM) is employed to identify motorcycles [7]. Subsequently, the motorcyclists' head location is localized, and a 2nd classifier is implemented to differentiate among helmet & non-helmet wearers [8]. Handcrafted characteristics are every now and then hired to boom the binary class algorithms efficacy [9], along with generating a histogram of orientation of gradients (HOG) from diagnosed head regions. The next degree is to localize the motorcyclists' head location and then apply a 2nd classifier to distinguish among helmet and non-helmet wearers. Handcrafted features, together with deriving a histogram of gradient orientation (HOG) from diagnosed head regions, are regularly used to improve the effectiveness of the binary category set of rules [10].

These techniques, but, aren't as powerful in situations where there are numerous motorcycles or riders on an unmarried motorbike. Deep getting to know strategies searching for to robotically create representations from raw picture facts which can be most applicable for helmet use detection, in preference to homemade characteristic construction. One CNN is recommended via [13] and [14] for the simultaneous detection of motorbikes and helmet use so that it will alleviate the time-eating nature of using exceptional CNNs for these purposes. However, most effective 1/2 of the cutting-edge methods proven in Table provide the tracking of unique motorbikes over individual frames of captured video. Since site visitors surveillance infrastructure video information is naturally prepared into frames, facts on helmet usage that is

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produced by computerized detection needs to be mapped onto precise motorbikes as a way to provide a dependable assessment of helmet use [15]. This way that body-based totally detection outcomes for rider and motorcycle counts, in addition to helmet use, must be remapped onto specific motorcycles that arise in numerous frames.

Sadly, a few strategies do no longer provide this move-frame tracking thing. Alternatives to tracking encompass collecting helmet use statistics in each video frame and not using a monitoring, which results within the lack of data approximately the variety of motorbikes at a commentary web site, or unmarried-body reputation at a fixed place or line in the photo body to prevent reiterated detection of the precise same bike [16]. These shortcuts reduce the first-class of a helmet usage facts and make it extra hard to hire numerous motorcycle frames for rider popularity and helmet use. Only one of the techniques in Table gives complete details at the rider wide variety and vicinity detection method [17]. Although there are different approaches that employ bike head counts as a stand-in for rider numbers, these structures lack the granularity that required for unique rider range and position detection [18].

2. RERATED WORK

As of proper now, a diffusion of strategies have been put forth for the automatic identity of bike helmet use in captured video records [10], [11], [18]–[24]. The specifics of those techniques can be divided into essential classes: traditional techniques [18]–[21] and deep-mastering-primarily based techniques [10], [11], [22]–[24].

However, in situations when there are several motorbikes and/or multiple riders, such strategies are not effective. Deep studying based procedures aim to mechanically generate representations from raw visual statistics that are exceptional appropriate to the helmet use detecting problem, in place of the use of homemade capabilities. In [25], a network of convolutional neural networks is used to classify helmet wear in the diagnosed head areas of cyclists (CNN).
Two separate CNNs are skilled in [22] & [11], one of that's used to perceive motorbikes from other varieties of motors and the alternative to categorize riders' heads in step with whether or now not they are sporting helmets. [10] And [23] rent a single CNN to discover motorbikes and helmet use concurrently since it takes time to detect motorcycles & helmet use using two separate CNNs. Of the acknowledged structures, best 1/2 of them allow tracking individual motorbikes thru unmarried frames with a recorded video (see Table1).

3. METHODOLOGY

The trouble of recognizing motorbikes in a single body is a conventional item detection process. We used an advanced object identification set of rules that changed into trained specially to recognize bikes in our dataset with a purpose to do that. Currently, there are number one classes into which object detection algorithms fall: one-level & two-degree. Because 2-stage algorithms need to analyze frames two times—as soon as to find out viable object positions and once more to apprehend the real items—they are regularly slower than single-level algorithms however normally provide better accuracy. Conversely, one-stage strategies

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combine item detection and probably object localization into the unmarried processing step [19]. A new unmarried-level technique, [20], successfully addresses detection accuracy problems by using combining focus loss with a multi-scale characteristic pyramid. In contrast to two-level techniques, it accomplishes quicker detection even as retaining a greater detection accuracy than similar unmarried-stage techniques together with YOLO [21]. As an end result, we determined to use a Retina Net model to apprehend motorcycles. We made the selection not to begin from scratch whilst education the version due to the fact motorcycle identity and different object detection obligations are comparable. Rather, we used weights that have been skilled derived from the COCO datasets to refine a Retina New version [22]. Within the field of area computing, data processing happens on servers which might be located at the community's part. In order to evaluate facts and run gadget getting to know algorithms for in-the-second selection-making, these servers directly link to a diffusion of sensors and controllers [23]. The information movement being analyzed can be correctly sent to Google Cloud IoT Core thru a Raspberry Pi tool appearing as a local server going for walks the TensorFlow object identification version [24]. Event-driven processing of the facts results within the activation of warnings when required.s

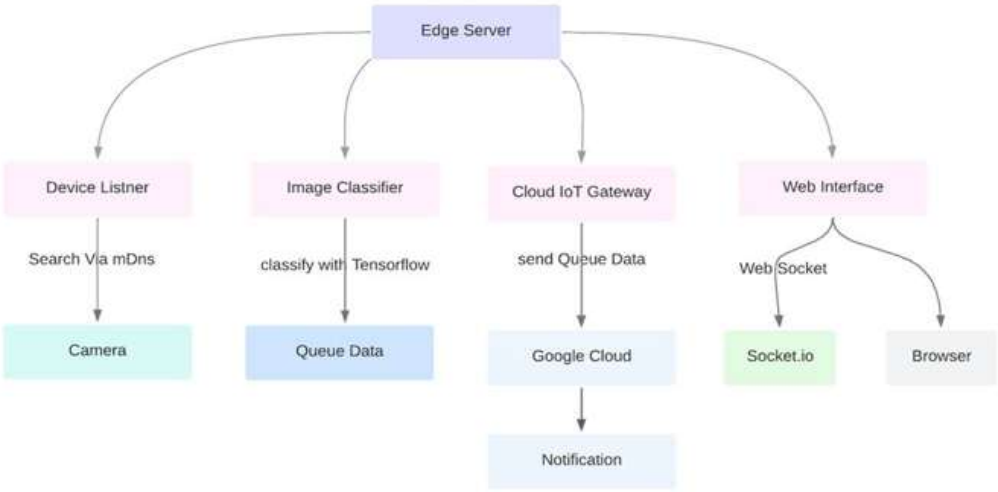

Figure1. The Tensor Flow architectures of Overviews.

Before sending the information that was processed to the cloud, a Raspberry Pi Gateway uses mDNS to search the network, locate nearby cameras, and then identify objects [25].

1. The Classification of Model Training

In order to estimate the use of helmets of a closed song lengthy enough, helmet use estimations from clipped photo patches inside the song are blended. More especially, the helmet usage magnificence of the tune is anticipated if (1(x (n)) 1N) matches the cropped image patches allotted to a tracked motorbike. A collection of tokens received from applying the patch partition layer to the enter photograph and splitting it into (N1) patches are processed the use of the Swin Transformer's structure [26]. As shown in Figure 2, this design includes hidden layers made of many blocks, every of which has a multi-head self-awareness module (MSA).

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An attention technique is utilized by the MSA module the usage of a set of query (Q), keys (K1), and worth (V) vectors. By doing the dot result of the inquiry vector with each key vector, it produces an output with the aid of mapping the question to a set of key-cost pairs. The inner merchandise are then scaled and normalized into weights ((textual content okay)), which can be described as follows, using a softmax feature:
Attention (Q, K, V) = Softmax (dkQKT) V

The key size in this example is denoted via (d_k), and normalization is completed by way of department by way of (1sqrt (d_k)). A windows-based Multi-head Self-recognition Modules (W-MSA) & a moving home windows Multi-head self-recognition Module (SW-MSA) are the two versions of a multi-head self-attention module which can be integrated into the Swin Transformer.

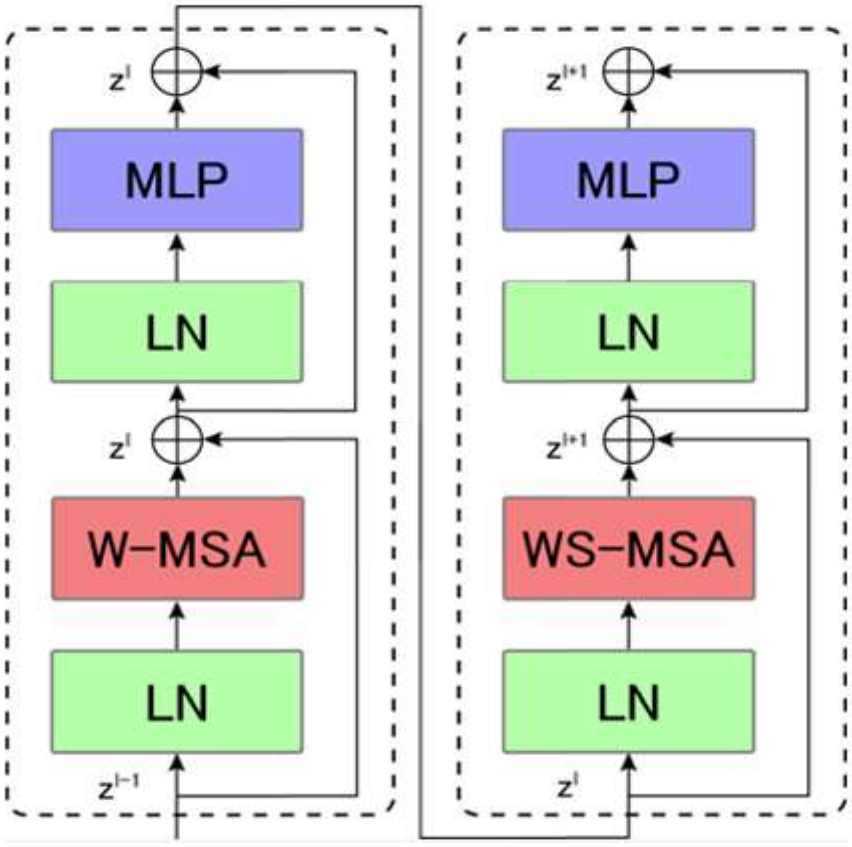

Figure 2. Two sequences of blocks of the Swing Transformer.

While the latter has a shifted window configuration (WCMSA), the former comprises the windows multi-head self-attention module (W-MSA). Using window-based interest processes, this novel technique improves the Swing Transformers ability to comprehend connections inside the input series.
We use Tensorflow detector API for model training, which simplifies the development, training, and implementation of object detection fashions. The mean average accuracy (mAP),

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Output, and Speed are the 3 traits that define every version in Tensor flow toolbox [27]. Higher mAP ranges are commonly related to slower speeds. We skilled the Efficient Det- Lite 0 architecture in our state of affairs. However, depending on the suitable balance between velocity and precision that is required, the model structure can be chosen in another way. Adapted from the Efficient Det structure, a Efficient Det- Lite [1][2][3][4] own family consists of item detection fashions for cell/IoT programs that provide a diffusion of solutions acceptable to various alternate-offs among speed & precision.

Table1. Precisions for the Samples of data.

Model architecture	Size (MB)	Latency (ms)	Average Precision
EfficientDet-Lite0	4.5	186	27.69%
EfficientDet-Lite1	5.8	359	33.55%
EfficientDet-Lite2	7.2	456	36.97%
EfficientDet-Lite3	11.4	916	39.70%
EfficientDet-Lite4	19.9	1986	43.96%

Examining the facts in more detail, we taken care of the results through the quantity of riders in line with motorbike and determined that training with or greater riders accomplished better, as shown in Table1. This development is probably because of the truth that unmarried or twin-rider conditions are greater not unusual in real-international instances, which leads to a larger dataset for these particular training. But our investigation additionally uncovered different dataset flaws, most appreciably the existence of unequal elegance sizes. Class 2 to 32 had no occurrences, and class 33 to 36 had fewer examples in the initial education set and zero in the check set.

Mean common accuracy (MAP) throughout 36 lessons changed into superior than all other fashions whilst compared to our cautioned version, which uses the Swin Transformer version as its basis and combines this with a Cascades RCNN framework to carry out item recognition. Notably, it outperformed the second-highest MAP-scoring YOLOv7 [28] version.

2. The Proposed Product is the Advanced Vehicle Recognition and Mind Alert System Integrated Smart Helmet.

Addressing the Limitations of Vehicle Recognition with an Active Creative Helmet. Although the current era of intelligent bike helmets is capable of identifying automobiles which might be drawing near from at the back of, its efficacy may decrease whilst identifying bigger vehicles, particularly in crowded areas, as Figure three illustrates. Surprisingly, given the frequency of accidents related to large trucks and buses, modern-day studies fails to recognize the need for an lively smart helmet which can perceive whilst these automobiles are nearby. When whatever is detected, the rider receives an instantaneous audio alarm thru their earbuds, which activates them to move quick to avoid having to constantly test their mirror. This design

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guarantees extended safety whilst permitting the motorbike rider to hold their eyes on the road in advance.

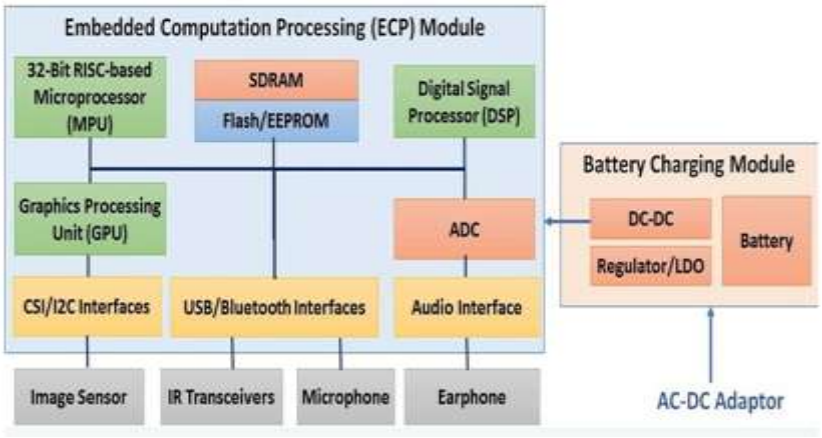
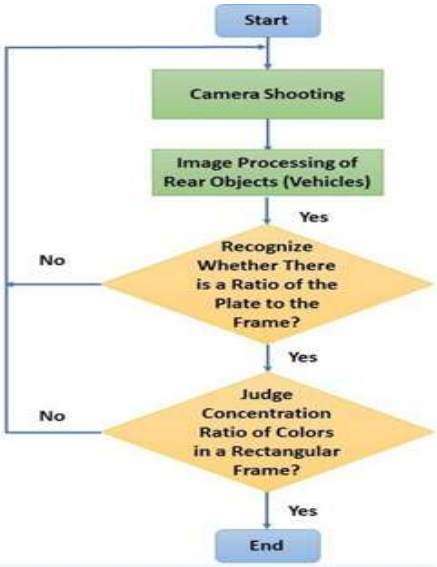


Figure 3: The following figure illustrates the system diagram of the proposed intelligent helmet under consideration of the hardware component.

The complete combination of Tensor Flow models and sunlight in electric cars revolutionizes two cultures that are currently the names of modern times with the massive influence they possess on the environment in the form of sustainable mobility and energy loss reduction. TensorFlow, which
is the simplest form of it, is a tool for creating and using machine learning models that are designed to Green Energy industry.



[29]. Figure 4: Your new undetectable content.

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Two different choice-making processes are proven in Figure. 4. In order to become aware of if a registration code is gift inside the picture, step one is determining whether or not there's a proportionate dating most of the identity wide variety and the frame.
To get the proper duration & width for a license plate rectangle, a popular ratio based on an item image with the dimensions "2.375" inside period and "1" to width is applied. If these necessities are not met, the device takes a clean photo for re-identification. On the opposite hand, if the scale coincide, the square frame have to next be assessed to see if it satisfies the predetermined shade density threshold.

4. RESULTS & DISCUSSION

Table 2 displays the random division of the 9 0 annotation video clips into three no longer overlapping elements: a fixed for schooling (70%), a hard and fast for validation (0%), & a test set (20%) based on every precise website so that it will check our proposed method.
The Kalman filter's parameters A, H, Q, and R are preset and furnished by means of the subsequent for tracking several bikes:

$$A = \begin{bmatrix} 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Table 2. The ratios of the training, validation, and testing populations of video clips for the assessment of performance based on the dataset are 70: 0: 20.

Observation site	Training	Validation	Test	Overall
Bago_highway	24	4	7	35
Bago_rural	41	6	11	58
Bago_urban	44	6	13	63
Mandalay_1	159	23	45	227
Mandalay_2	111	16	31	158
Naypyitaw_1	36	5	10	51
Naypyitaw_2	30	4	9	43
NyaungU_rural	57	8	17	82
NyaungU_urban	47	7	13	67
Pakokku_urban	52	8	15	75
Pathein_rural	8	1	3	12
Yangon_II	27	4	8	39
Overall	636	92	182	910

$$Q = \begin{bmatrix} 0.2 & 0 & 0 & 0 \\ 0 & 0.26 & 0 & 0 \\ 0 & 0 & 0.3 & 0 \\ 0 & 0 & 0 & 0.1 \end{bmatrix}$$

$$R = \begin{bmatrix} 0.04 & 0 \\ 0 & 0.06 \end{bmatrix}$$

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Finding bikes which can be presently in operation is the primary degree in our method (Step shown in Figure five). For this purpose, a quality-tuned Retina Net became employed, as special in phase III-A. . An average unique (AP) metric is employed to assess the efficacy of our model [40]. With an accuracy of 95.Three% in figuring out bikes, the AP for the exam set is exceptionally excessive. The effects of the bike detection of four sampled frames are proven in Figure.4.

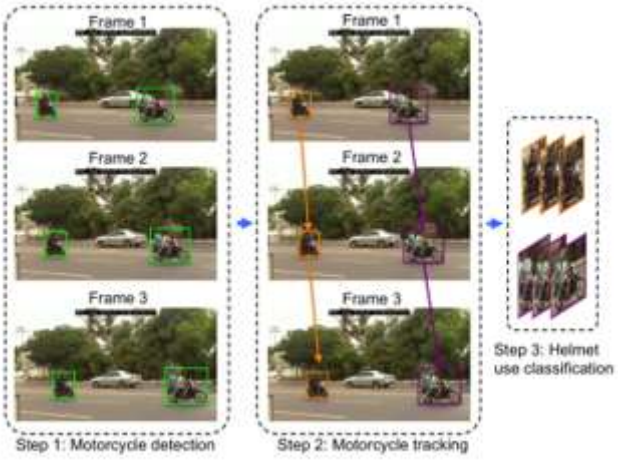

Figure 5: This figure gives the recommended method through which motorcycle helmet wear could be monitored.

On all fifty four,529 categorised limitations within the take a look at set, the version's detection of motorcycling helmet use lessons had an accuracy of 80.6%. Put some other way, our method as it should be recognized a number of drivers their place, and whether or not or not they were sporting helmets in 80.6% of all identified lively motorcycles within the test set.
Two kind of errors can appear whilst the use of visual similarity studying: both motorcycles are mistakenly identified as being on the identical song.

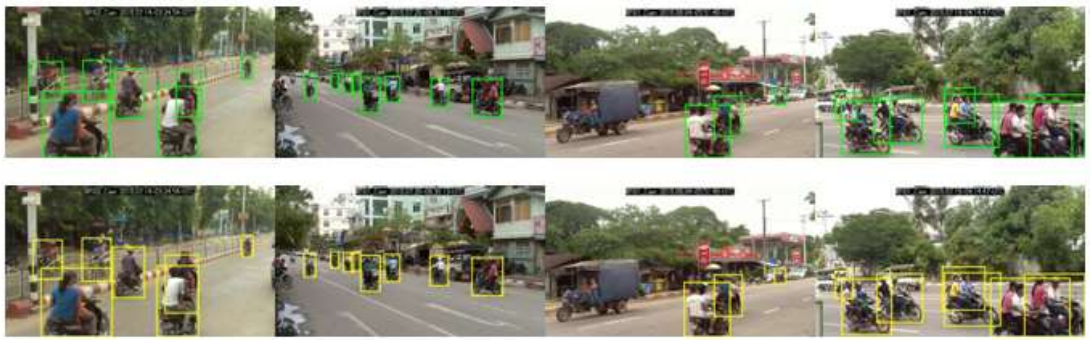

Figure 6: Sampled frames along with identification results on the motorcycle.

It is the learning of visual similarity For the findings depicted in Fig. 6, we generate a receiver operator characteristic (ROC) curve & compute the area in the ROC curve (AUC). We adjust the threshold based on the findings of 200,000 pairs' visual similarity learning, where the axis

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x and y represent the number of false positives (FPR) along with the true positive rate (TPR), which are respectively defined as:We adjust the threshold based on the findings of 200,000 pairs' visual similarity learning, where the axis x and y represent the number of false positives (FPR) along with the true positive rate (TPR), which are respectively defined as:

$$\begin{aligned} \text{FPR} &= \frac{\text{false positive}}{\text{false positive} + \text{true negative}}, \\ \text{TPR} &= \frac{\text{true positive}}{\text{true positive} + \text{false negative}}, \end{aligned} \qquad (1)$$

Wherein the phrases "proper wonderful" and "genuine poor" denote the amount of well diagnosed pairings from the suitable identical bike music and, thus, the quantity of efficiently diagnosed pairs from different tracks. "False high quality" refers to the quantity of pairs which are mistakenly recognized as relating to the same track, while "false poor" refers to the amount of pairings from the same tune that were diagnosed as belong to a exceptional track. The advised version yielded an AUC of zero.967 whilst used for visual similarity studying. The MTL version's output visible distances among sampled photograph pairs of the equal & one of a kind tracks are displayed in Figure 6. A restrict of two.0 could accurately categorize each pair of photos in these eventualities.

5. CONCLUSION

This studies introduces a singular bike helmet that includes photograph recognition generation to enhance the protection of bike riders. The helmet is specially designed to recognize massive vehicles and buses on the road. It employs special identity algorithms at some point of the day and at night time. 600 photos taken in real-global situations by using ten motorcycle riders are used as a dataset to assess how nicely registration plate identification works. The findings display that accuracy prices are around eighty five% at some stage in the day and 78% at night time. The helmet also has built-in Bluetooth communication, which lets in it to transmit signals while a big truck or bus processes. Moreover, the helmet achieves a weighted the F-measure of 67.3% in tracking motorbike location, rider variety, and helmet utilization detection. An ablation investigation suggests that the method has a vast have an impact on on computing efficiency but continues a excessive accuracy despite experimental variability. However, the technique procedures actual-time efficiency for zero FPS, that is video statistics, operating at about eight frames consistent with 2nd (FPS) on regular hardware. Overall, our work demonstrates how critical helmet usage registration components can be carried out correctly the usage of a CNN-based totally approach this is computationally effective on consumer hardware.

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