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Original Article

A Novel Method of Traffic Rule Compliance Detection Using Morphological Operations at Toll Booths

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Abstract - *Vehicle collisions cause fatalities and disability for individuals all over the world (s). In India, vehicle accidents caused by infractions of traffic laws claim more lives than naxal violence or natural calamities. However, people may drive while disregarding traffic laws, and doing so risks their lives. The main causes of traffic accidents are often careless lane switching and the usage of mobile devices. Additionally, these fatal traffic accidents' financial burden on the affected individuals and the government is significant. The government is investing a lot of money to spread awareness, motivate people to obey traffic laws, and organise many awareness campaigns to inform people to obey the law and save lives. Traffic cops now manually discover violations of traffic laws. The activity is time-consuming and chaotic, and there is a chance that the traffic police would operate dishonestly, which might result in more traffic rule violations. There has been a great deal of investigation into traffic management systems over the last 20 years but at the expense of infrastructure requirements. Sensor-based approaches have been utilised to monitor these breaches. This research describes how machine vision-based feature extraction utilising classification and matching algorithms on Raspberry Pi hardware may be used to identify violations of traffic rules on roads and highways. An inexpensive Raspberry Pi-based system based on feature extraction for monitoring and detecting infractions of traffic lanes and other rules. SIFT, SURF, ORB, KAZE, AKAZE, BRISK, and ROOTSIFT were also used to discover rule violations.*

Keywords – *Feature extraction, Raspberry Pi, Road accidents, Sensor, Traffic and Highway.*

1. Introduction

Digital image processing is used to accomplish image data in digital images by changing over a simple image into digital image data. Such a significant number of image operations are performed to extricate some helpful data from the image. For the most part, the image-processing system employs two-dimensional filters/techniques to perform operations on images, but it also allows the use of established signal (one-dimensional) processing methods. Digital image processing is an established and progressing technology at the current time, with its wide domain utilization. Aim of image processing: Visualization - find invisible objects. Image sharpening and restoration – Perform operation for better results in the image. Image retrieval - Retrieve the desired object in the image. Measurement of pattern – Measures key parameters of objects.[34. Image recognition – separate desired objects in an image [1]. Digital image processing techniques are utilized to perform various image operations using simulation software, servers, computers or respective hardware platforms. Raw information acquired from sensors may contain certain unknown valuable data or deficiencies. Thus, to overcome flaws in images and to acquire information, various operation of image processing is performed, namely pre-Processing, enhancement and feature/information extraction. Now-a day, object recognition is popular to know the identity of an unknown or desired object. Object detection algorithms are available to find important features and which are fed to machine learning procedures to fetch instances of desired object categories. In the past, the object was identified by geometric structure and appearance [2]. The Generic processing steps for object detection are presented in Figure.1. Object appearance and variation information was being gathered to fetch object identity. The object represented in the geometric description can be represented in 2D image representation using edge or boundary information. Different appearance-based techniques are being developed using a feature and pattern recognition algorithm platform. In appearance-based methods, the eigenvectors of test image objects are calculated from pixel values available in gray images.

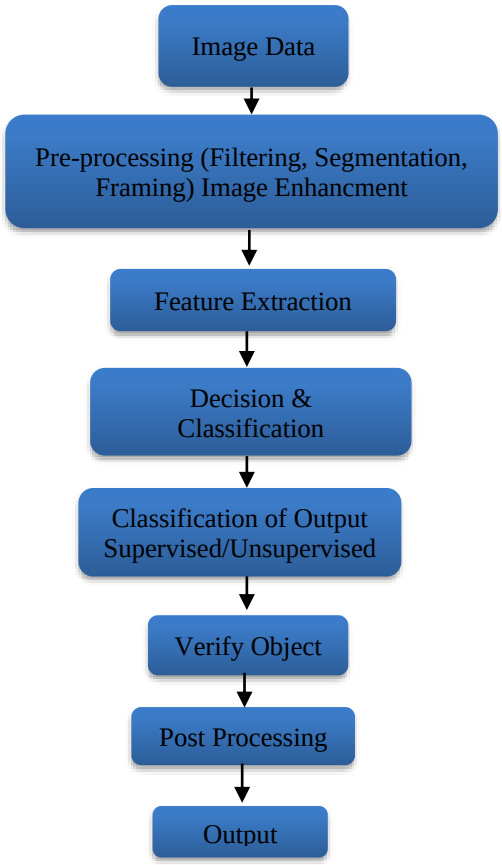


Fig. 1 Generic processing steps for object detection

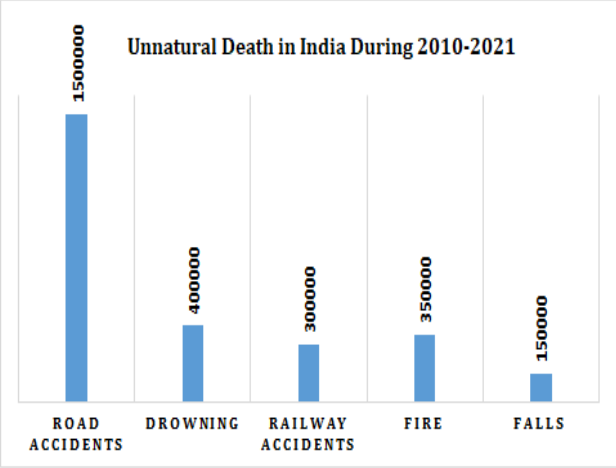


Fig. 2 Unnatural People's death in India

Recent video and image processing technologies using computer vision platforms have evolved more intelligently since they are required to know video content like background, object motion and behaviours, and scene situation [3]. For this, extracting and analysing desired objects in an image or video scene becomes an indispensable function for intelligent systems. The visual information of objects is something like what the objects are, how the objects behave, how long the objects are present and in which direction the objects are headed. The object information, as illustrated above used for surveillance or investigation of field service. Likewise, the recent broadcasting service provides additional information like objects in image or scene situations with audio-visual content to support user interactivity [4]. Many image processing tools are being utilized in real-time surveillance systems and tools for such kinds of services to extract information from the object. In general, the such tool requires fast processing speed for real-time data.

Road traffic accidents can be characterized as any mishap, including any kind of road user. It may be an individual strolling, standing, running, riding, driving, voyaging or dealing with the road where both mechanized or non-mechanized vehicles are included [5]. A car crash is any vehicle accident happening on the highway or city road. A road accident death is expressed as a person's death occurring on the road due to the collision of people or vehicles during crossing pedestrian or riding a motorcycle/bike, three–wheeled motor vehicles, lightweight vehicles and heavy transport vehicles [6,7]. The traffic police's role is to guarantee the safe movement of vehicles on roads, avoid traffic violations of vehicle riders and take suitable measures against traffic rule violators. Traffic monitoring by police can avoid rule violations, and vehicle riders can drive safely. The traffic police observe checkpoints where vehicle movements are frequent and take actions to control the traffic and avoid vehicle collision risks at checkpoints. Accident examinations incorporate the total examination of accidents to expand road traffic safety.

2. Literature Survey

Plenty of research work is proceeding to conquer difficulties in traffic management systems utilizing image processing technology for rule violator identification for the last decade, a. In 2014, an article published in the economic times highlighted that lakhs of individuals are expiring in road accidents in India. The government has found a way to decrease accidents by creating traffic rules follow awareness programs [17,21,32]. By and large, individuals like to drive bikes and vehicles for their day-by-day transportation across the globe. In 2017, around 405 people died every day in road accidents, right around 17 individuals/hour, and all-out fatalities were 1,47,913. People's death numbers were 4,70,975, which was three times those who died in road accidents rather than any other fatalities. A report on unnatural People's death in India is plotted in Figure 2. It implies nearly 1274 accidents on a normal day of the year, or 53 accidents consistently. By observing principle violations and punishing the rule violators, awareness to adhere to traffic rules can be expanded [8]. In conventional methodology, checking rule violators is done by traffic police's manual monitoring or with the help of a CCTV camera network. So many people are being disregarded in tracking and keeping from punishing for a rule violation.

The convolutional neural network (CNN) transfer learning technique [9] is utilized for small-scale image classification and can be deteriorated into adjusting and joint learning; the objective is prepared by transferring data from the ImageNet CNN dataset, and in joint learning parts, a reduced objective CNN is enhanced dependent on ground-truth labels. Dynamic hand motion recognition with leap motion controller [10] is utilized to take care of the misnaming and recognise the various sorts of connections between contiguous fingertips with the leap motion controller, including extraction method and order with the assistance of HCNF (Hidden Conditional Neural Field). People regularly check surveillance systems by seeing a few screens simultaneously showing the camera feeds. It is extremely hard for a human administrator to adequately identify occasions at the moment it occur [11]. Earlier, computer vision exploration has tended to approach to naturally a portion of this information to help human operators.

These algorithms have differing levels of precision and computational intricacy and manage ongoing difficulties like a day off, moving branches, objects covering, light force or moderately moving objects. Distinguishing people from the video is a difficult issue attributable to the movement of the subjects. In [33], recordings with perhaps moving cameras and foundations, testing a few diverse coding plans of moving articles and indicating that orientated histograms of differential optical stream give the greatest presentation. Movement-based descriptors [13] are joined with a Histogram of Oriented Gradient (HOG) appearance descriptors. The accomplished detector was tried on a few databases, which additionally incorporates a difficult test set taken from a video containing the wide scope of position, movement and background imbalance, along with pivoting cameras and backgrounds.

A dataflow execution of a Deep Convolution Neural Network [14] dependent on FPGA for fast object recognition incredibly lessens computational and memory asset usage. Capturing Hands in real life utilizing Discriminative Salient Points and Physics Simulation by utilizing RGB-D camera, direct mix cleaning (LBS) Model, watchful edge detection, hand-hand and hand-object co-operations accomplishes a higher precision for hand present estimation.

Deep learning computer vision techniques [15] likewise become mainstream methods utilized in vehicle detection and tallying. With the assistance of object detection techniques, In [16], author’s proposed an ongoing vehicle detection, tracking, and checking system. The proposed system used a versatile foundation deduction strategy to identify moving items in every video outline. Then, it utilizes a linearization procedure to acquire the frontal area zone, joined by morphological activities to evacuate commotion and shadow in the first casing. A virtual vehicle indicator is utilized to find each identified vehicle out and about, and a blob is utilized to track and match vehicles among various edges. Computer vision methods have additionally been applied to screen driving practices for individual and open drivers. In [35], the author’s built up a comparative vehicle recognition and tracking system utilizing the Gaussian blend model (GMM) along with profound learning object detection models. Specifically, GMM is utilized to display the foundation and concentrate frontal area pixels dependent on the Mahalanobis distance. When the vehicle is identified and found, comparative tracking and checking algorithms are utilized to determine traffic data. Other than programming-based vehicle recognition and tallying arrangements, In [18], author’s introduced a start-to-finish equipment programming framework for distinguishing and tallying vehicles at road crossing points.

However, the technique experiences comparable impediments in most applications that utilize HOG. In numerous investigations, the quantity of sensors utilized by vehicle detection hubs is a couple of, the two of which have focal points and burdens. Using two attractive sensors provisions significant features of vehicle length, while using a single magnetic sensor diminishes costs. Likewise, the vehicle signal features separated by various writing are additionally unique. For example, [19] utilizes two 3-hub AMR sensors to gather the vehicle's attractive field unsettling influence sign. The vehicle length, normal vitality and the pinnacle number of the hill design are taken as features of the vehicle. The process utilizes a solitary 3-hub AMR sensor to extricate the duration of the sign, the sign vitality, the normal vitality of the signal, the positive-negative vitality proportion of the X-pivot signal, and the positive-negative vitality proportion of the Y-hub signal as features of the vehicle. Other comparative strategies, for example, extract the normal opposite attractive tallness, differential energy, difference, greatest worth, number of extraordinary values, and different signal features.

On the other hand, most techniques straightforwardly apply the obtained feature set to the grouping algorithm after feature extraction. Be that as it may, not these features are similarly important for a particular errand. Some of them might be repetitive or even insignificant [20]. These repetitive features can not only impair the exactness of the grouping algorithm but also affect the execution effectiveness of the algorithm. Feature selection is the way to choose a smaller feature subset sufficient to anticipate the training set's class marks precisely.

3. Feature Extraction

Object detection is a procedure that decides if any objects are present in an image. Object detection is a troublesome procedure as it is impacted by part of the outer and inner features which influence the identification. There are a few algorithms accessible in the writing that can tackle

this issue. David Lowe developed the formulation of SIFT algorithm in 1999 and afterwards further created and improved it [36]. Filter features have numerous points of interest, for example, invariant to image interpretation, scaling, turn, light, perspective, clamor, etc. Great claim to fame, wealthy in data, reasonable for quick and careful coordinating in a mass of feature database. SIFT features will be investigated regardless of image scale invariance and rotation. The speed of SIFT even can fulfill constant procedures after the SIFT algorithm is advanced. The filter is to join with other eigenvectors and produces a lot of valuable data. Locating key points in an image is the key step in the process of object recognition utilizing SIFT algorithm. These steps produce steady feature points. Figure. 3. beneath gives an entire procedure on the most proficient method to discover and portray the SIFT feature points.

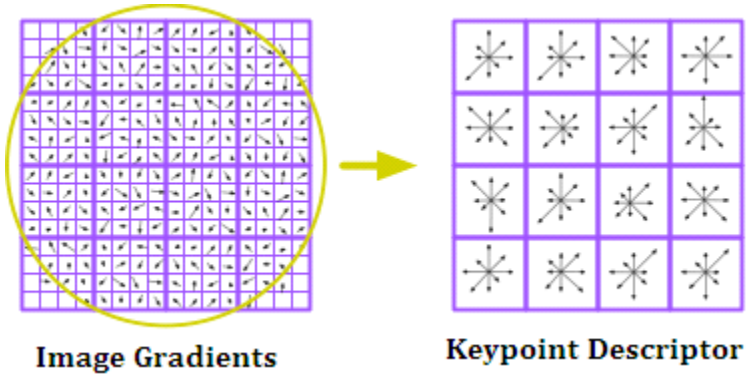


Fig. 3 Keypoint descriptor and a Gaussian window

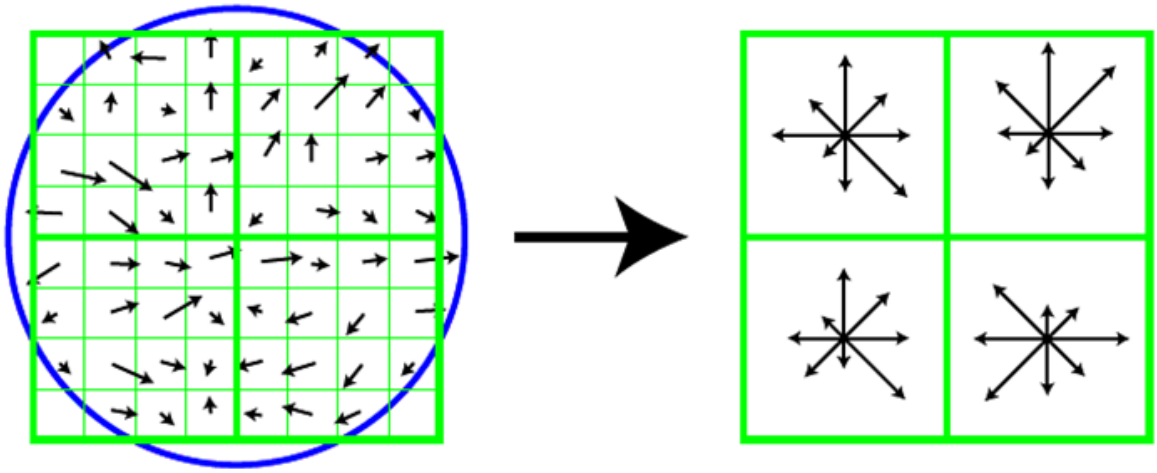


Fig. 4 SIFT feature descriptor

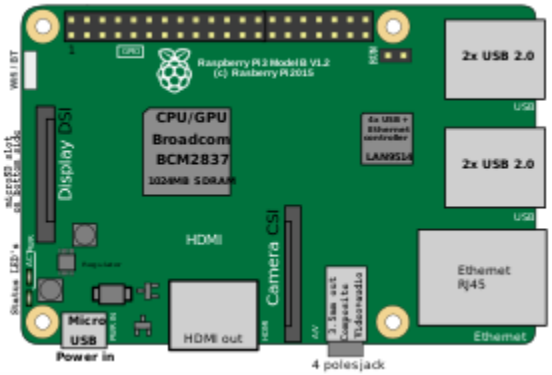


Fig. 5 Raspberry pi hardware

4. Hardware and Software Requirements

Image processing is the investigation and execution of any algorithm which has an image as input and gives an image as output with some information. MatLab and MathCAD products are commonly utilized in image processing [23]. These softwares have ground-breaking Image Processing toolboxes for processing and investigating the images. KS400 is also very powerful and convenient image processing software in line with MATLAB software. In equipment, FPGA, Work stations, supercomputers and ease processing fittings are additionally being utilized in image processing improvements. Raspberry Pi (Figure.5.) is a single-board computer with Processor, RAM, I/O and system connectivity. It is unique in relation to prior computer systems, which are modular frameworks and coordinated on a single board. In an embedded system, the utilization of single-board computer utilization is rising day by day. Organizations are developing their products on small-size hardware [37].

Different credit card size hardware is available in markets like banana Pro, beagle bone black, cubieboard and raspberry pi. Raspberrry Pi is a low-cost, palm-size single-board computer. It was developed by UK based foundation name Raspberry Pi foundation. Raspberry pi is manufactured by Element14 RS components, allied electronics, and Egoman. Raspberry pi primarily uses a Linux kernel-based operating system; they have an ARM 11 family chip that runs on an ARMv6 instruction set. NOOBS is an operating system installer which contains the Raspbian operating system. This installer repository provides a selection of different types of operating system installation. The new Memory card of 32 GB is set up for installation of the raspibian operating system [25]. Win Disk software is used to load the operating system into the memory card. OS is duplicated into a memory card, and prepare raspberry pi hardware for OS establishment. Python is a high-level language used for general application programming. It facilitates automatic memory management, a dynamic type system and a large standard library system. Python has the advantage of a lesser line of code for similar functionality compared to other languages c, c++. Guido van Rossum founded Python at CWi in the Netherlands. Python is the preferred language for raspberry pi programming. It has preinstalled python interpreter in raspbian OS.

5. Proposed Method

Figure.6. provides a schematic representation of the suggested method for distinguishing the cars related to traffic rule violations and taking appropriate action against the individuals who are the proprietors of the vehicles. In this step, a test picture dataset is constructed using the data obtained from the movie.

Along these lines, the vehicles associated with rule(s) violations are being distinguished/found. When a vehicle associated with a violation of driving standards, for example (not wearing a safety belt and helmet) gets detected, it is to recognize the vehicle proprietor from its license number plate [26]. The means engaged with license recognition are image acquisition, pre-processing, license plate area detection, character detection, isolation, segmentation and recognition. Figure 6 shows that license plate restriction is accomplished through hough transform by discovering edge and curve shapes. Here the critical assignment is to recognize the edges of the rectangular zone of the region/size of license plates. The hough transforms also detect lines in the license plate area to find details precisely [38]. License regions considered for certainty proportion of probabilistic localization estimation for different hough images.

Otsu thresholding algorithm is used to convert grayscale images to binary images to find edges of license plate area and for processing character segmentation. Further, morphological operations such as dilation and erosion have been performed on an image, and a smooth gaussian filter of size has been applied to reduce noise from the images [28]. Character segmentation and associated parts are detected in the license plate area, taking horizontal and vertical projections to segment detected characters. KNN algorithm is utilized here to classify characters once they are detected in the license plate. The vehicle data has been removed utilizing the ANPR system from the license of the vehicles whose drivers have been found violating the traffic rules (i.e., without wearing a safety belt or driving a bike vehicle without a helmet) [24,27]. Later on, in phase three, based on accessible vehicle data, the challan is being created and naturally conveyed to the vehicle proprietor dependent on the data.

The strategy is recommended to identify the automobiles that have been linked with violations of traffic laws and to take necessary action against the individuals who own such vehicles as follows: Python with the OpenCV library has been used as the platform for the algorithm's development on raspberry pi hardware [12,30]. Otsu thresholding algorithm is used to convert grayscale images to binary images to find edges of license plate area and for processing character segmentation. Further, morphological operations such as dilation and erosion have been performed on an image, and a smooth Gaussian filter of size has been applied to reduce noise from the images.

6. Results and Discussion

The primary purpose of this study has been to develop a system that would recognise the traffic rule infraction, create a challan for the vehicle owner, and deliver the challan to the car's owner. In this area, different feature detection procedures (ORB, SIFT, SURF, etc..) were examined to acquire data from test images.

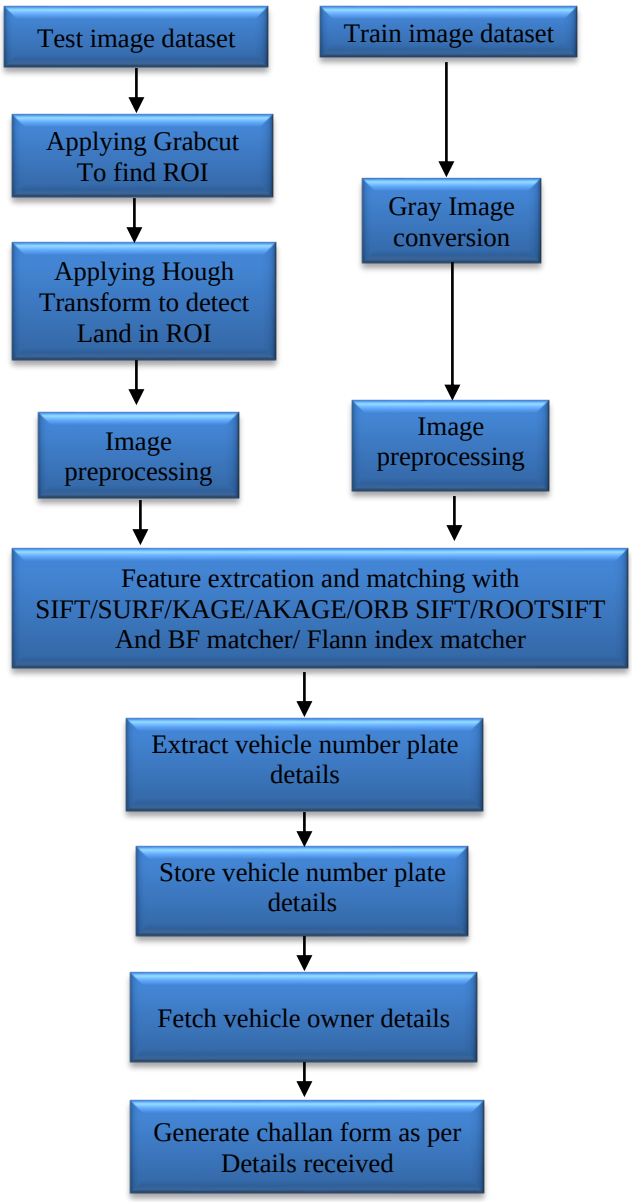


Fig. 6 Flow diagram of the proposed method

Figure.7. to Figure.13. Illustrates the after-effects of primarily found and feature extraction processes (SIFT, SURF, and ORB) for vehicle riders that use feature coordinating strategies such as BF matcher/flann-index matcher. The following is a list of the parameters that will be used to extract the features: The following parameters are utilised. While comparing key points in test pictures and train images.

As shown in the figures, the desired objects are shown in test images by performing template matching. Here, templates of the desired object are created as patches, and the test images are matched with template images. Template matching is computationally expensive compared to other feature extraction techniques.

Vehicle riders can be identified using face detection techniques using the HAAR cascade. Thus, this approach is also being used to detect/identify a vehicle rider not wearing a helmet while riding two-wheelers.

Figure.13 displays the number of iterations required to extract key points from test and training pictures using SIFT, SURF, ORB, KAZE, AKAZE, FAST, and BRISK. Figure.13. shows that after 0.1378 seconds of processing time, the SIFT algorithm has produced 21 key points in train pictures and 679 key points in test images. In comparison to SIFT's detection of important points on the gathered dataset, SURF's speed is advantageous, but at the expense of a smaller number of detected points. FAST has created 39 key points in train pictures and 4523 key points in test images, with a total processing time of 0.0031 seconds. FAST is used for high-speed key point detection but always depends on SIFT, SURF or Brief descriptor; brief cannot detect the key points by itself, so it should be used with other key point detectors. ORB has a similar function to FAST and Brief, although it is slower than SIFT and cannot identify as many salient features in the training images. The BRISK descriptor is quicker than SIFT/SURF, providing more key points than SURF but fewer than SIFT in the train image dataset. The time shown in Figure.14. for KAZE was 0.6961 seconds.

The KAZE algorithm requires more computational time, i.e., 0.69 seconds, compared to SIFT algorithm, which takes around 0.13 seconds. AKAZE features exhibit excellent performance in detection and description in the test image dataset and requires only 0.12 seconds duration, while key points in the train image dataset are quite less compared to SIFT algorithm. The analysis of the key points detection results and the required computation time suggests that SIFT algorithm has produced a better result. SIFT has been used with standard Euclidean distance to calculate descriptors, and in RootSIFT (modified version of SIFT) square root of the Helinger kernel is used on collected dataset images. RootSIFT has been used on the same test image replacement. SIFT by RootSIFT at every point. Obtained key point results are matched with the Brute Force matcher and Flan-index matcher with train image and test images. Matched image patches using SIFT and RootSIFT, along with both matchers BF and flann-index, demonstrates that RootSIFT with flann-index matcher yields better matches as shown in figure.14.where the ratio test is taken as 0.9 (e), enabling better object localization and little difference in performance has been observed in the specific object retrieval system. Rootsift with flann-index gives a more accurate match relationship between detected key points of the desired object in test images compared to SIFT and RootSIFT algorithm with BF matcher.

Fig. 7 Keypoints and matching result for the Kaze algorithm in the test image and train image.

Fig. 8 Keypoints and matching result for Akaze algorithm in the test image and train image

Fig. 9 Keypoints and matching result for the Brisk algorithm in the test image and train image

Fig. 10 Keypoints and matching result for the FAST algorithm in the test image and train image

Fig. 11 Keypoints and matching result for ORB algorithm in the test image and train image.

Fig. 12 Keypoints and matching result for SIFT algorithm with BF matcher in the test image and train image.

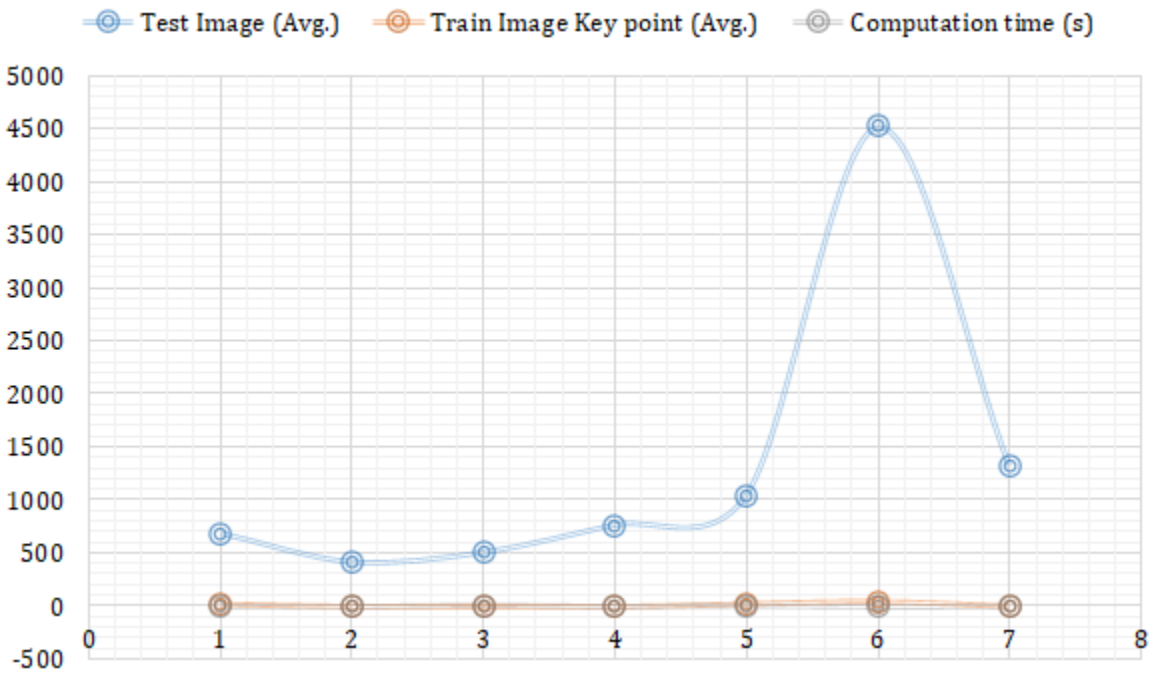
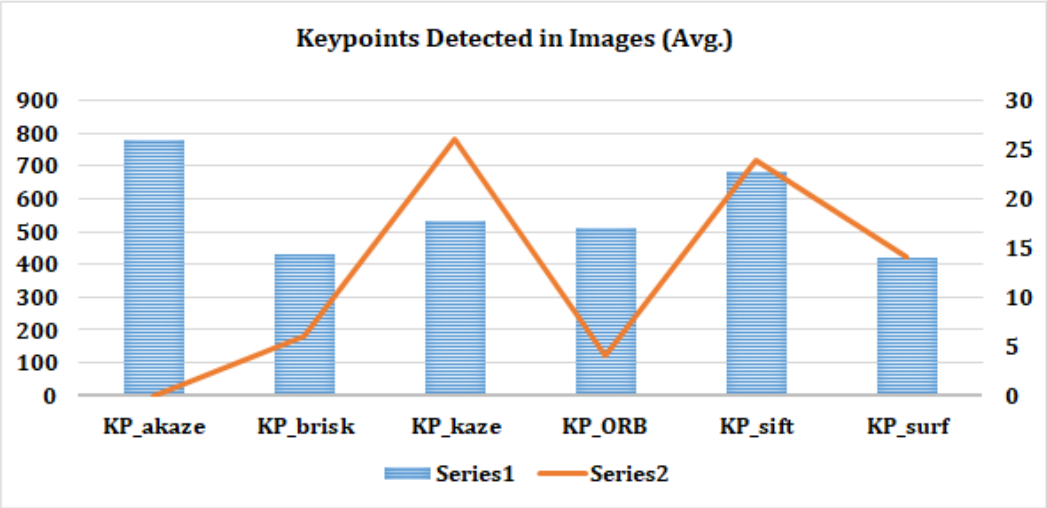
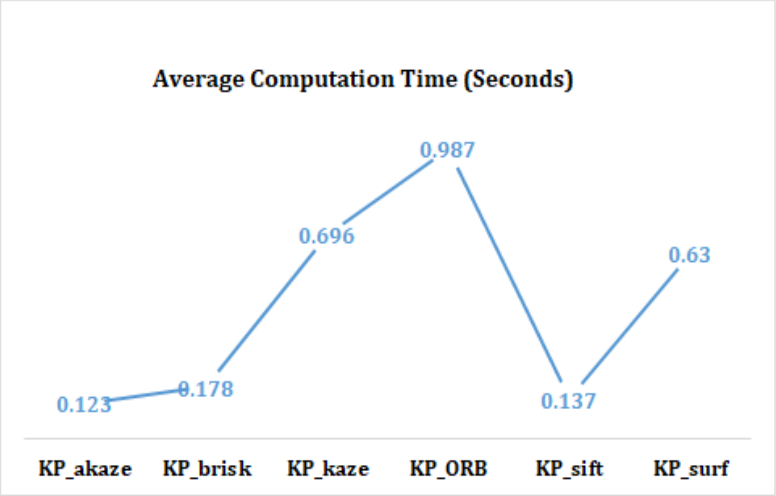


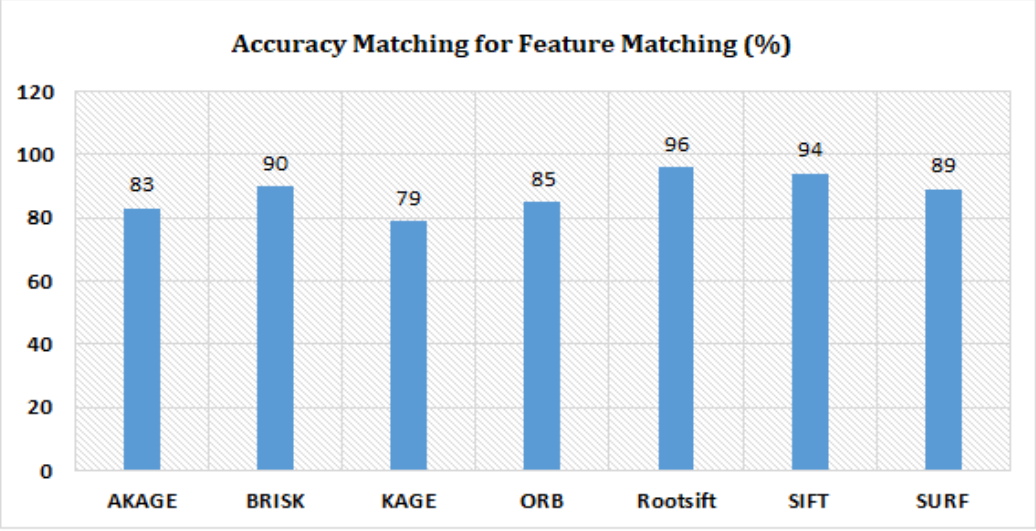
Fig. 13 Key points detections in test and train images



(a)



(b)



(c)

Fig. 14 Performance parameters (a) detected key points, (b) Computation time, (c) Accuracy

Figure.14. also provides an illustration of the contrast between the possible permutations of descriptors and matching algorithms that may be used. When compared to the computation time required by other techniques, the time required by the SIFT/RootSIFT approach to identify and identify features is just 0.13 seconds. Following the reasoning above, one might get the following conclusion: RootSIFT combined with the flann-index matcher has generated improved results for identifying helmet and seat belt violations.

The outcomes of running matching algorithms and feature descriptors on raspberry pi hardware to acquire the findings. The test picture first selects a region of interest to recognise automobiles in the gathered test image and video datasets. A test picture for the grab-cut method is shown being done in figure.14. (b), and the results of the test are shown. In the test picture, we have specified the rectangle parameter as (250, 400, and 1000), which is part of the grab-cut approach. The output of the grab-and-cut operation on the picture is then turned into a grayscale image, and noise is removed using median filtering. In order to provide a more defined sense of edge, greyscale pictures are used. The Hough transform was used on the grayscale picture to locate the third lane of the roadway, which had a rho value of 10. Now, the characteristics of vehicles that are available in this location are being extracted, and they are matched with the train picture dataset. After the characteristics have been matched, the same vehicle is processed to identify the licence plate number and create challans. In the event that the licence plate presented is not recognised, vehicle tracking will be carried out. The vehicle is broken down into component parts and saved in a separate database.

7. Conclusion

Open or closed lips and the counter area are indicators that the rider is likely yawning, singing, or using a cell phone. We have suggested a method for detecting drivers breaking the law by monitoring their mouths and lips throughout a collection of 200 images utilising template-matching feature extraction methods. In this scenario, grab-cut methods are used to locate the ROI in the test picture. We first convert the raw data into a grayscale picture to eliminate any distortion from the test images. Our work here applies the haar cascade algorithm to a grayscale picture to determine the mouth status of vehicle riders in a toll tax region with an accuracy of 91%. The primary goal of this research was to develop a system that could identify and keep tabs on vehicles while also detecting infractions of traffic laws via the use of improved feature extraction methods. Using the RootSIFT algorithm and the flan index matcher, we could locate the rule-breaking car in the video data from the camera network installed in the highway's median. Upon arrival at the toll tax area, a challan is generated once the vehicle's licence plate has been read. RootSIFT combined with the flann index matcher has shown to be the most effective combination of descriptors and pattern discovery for detecting vehicles in the third lane of a motorway.

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