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Design of Human and Object Detection Microcontroller Based Image Processing System to be Implemented on Automobiles and Robot Vision

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Abstract: Fast humans and objects detection is required to implement on image-based tracking or detection systems. There are complicated algorithms proposed for human detection, but they are getting too high process time for images. The Histogram Oriented Gradient (HOG) pedestrian detection method also consumes a considerable time when it was used in the application as stand-alone algorithm. But the accuracy of the HOG method is high. The research study is aimed to create a fast and accurate image-based tracking system by combining two algorithms together the HOG method and CamShift method. The region of interest is created by the HOG method which permits to implement the searching window of the CamShift algorithm which can be tracked the colour density tracked by the HOG method until the shape, colour density changes. The study was performed with PCC5020 camera module and both Raspberry Pi 3 model B and Intel core-i3 processor based virtual open source platforms. This proposed technique of pedestrian detection can be used for machine vision problems of light varying environment that the HOG method able to detect in the low light conditions.

Keywords: human and object tracking and detection, HOG method, CamShift method, image processing, Region of Interest (ROI)

1. INTRODUCTION

Human detection and object detection are major objectives in the image processing applications. Due to this reason, the research was lead to identify a possible method to detect Humans and objects nearby and track them in the specified Region of Interest (ROI) [1] and mark them.

Human detection in an image or in a video can be interpreted as inspection of images for human body according to the biometric characteristics of the human body which are varied from person to person[2,3]. Due to the complexity of the colour variation, the skin colour based detection systems cannot be used to detect human body. There are lot of complex algorithms introduced by different researchers that can be used in still cameras such as Viola-Jones detector, Haar cascade classifier and local binary patterns (LBP) [4,5]. For a video analysis, the processing speed should be optimized to process image frames. The algorithm should be fast enough to handle this system in real-time situations. The most promising method to detect humans in an image is tracking the body shape of the humans. But due to the gender changes, upper body shape outline of the human body is the concerned area of the solution. The Histogram Oriented Gradient (HOG) method and the extended version of mean shift algorithm called CamShift method were identified for video analysis-based detection system. The proposed system consists PCC-5020 camera module for video capturing, the Raspberry Pi 3 computer for image handling and processing and a VGA monitor to implement output for better understanding interfaced with Raspberry Pi on chip computer. In video retrieving, the considered color spaces from the image frames were RGB and HSV colour formats [6,7]. The RGB pattern is the default colour pattern taken by the camera module and the HSV format used in CamShift algorithm.4 The OpenCV-Python library used to program the system

1.1 HOG PEDESTRIAN TRACKING METHOD

HOG provides a robust feature set that allows the human body to be distinguished discriminatively even in cluttered background. The descriptor purposed by Dalal and Triggs computes an edge-oriented histogram on a dense grid of uniformly spaced cells. Then, cells are overlapped to local contrast normalizations in order to improve the performance. A linear SVM classifier is used to learn human body shape with sample images. The detector takes an image, a position within that image and a scale as the inputs and determines if there is a person in that particular location and scale[8].

1.2 CAMSHIFT METHOD FOR OBJECTS AND PEDESTRIAN TRACKING

The MeanShift algorithm is a robust method that achieve the gradient of probability distribution to find the peak of the distribution. Adaptation of the MeanShift algorithm is the base of the CamShift algorithm that given the probability density of image, finds the mean of the distribution by iterating in the direction of maximum increase in probability density. The main difference between CamShift and Mean Shift algorithm is that CamShift uses continuously adaptive probability distributions [9].

2. EXPERIMENTAL PROCEDURE

In the research study, the architecture for humans and objects detection system is shown in the figure 3. In the study three basic methods were implemented and tested to define and analyze humans in an image or in a video. The Haar cascade method is fast enough to use in a real time computer vision application, but unable detect or track more articulate objects. It is needed a high-performance computer(server) to make a cascade classifier for a pre-defined object tracking and needed hundreds of training samples to train this classifier. Colour based method was used to track human skin which is a faster method, but due to the different complexions, the method was erroneous when same colour objects appeared in frames. Most of the existing approaches for human detection are unsuitable for detecting targets with variations of appearance.

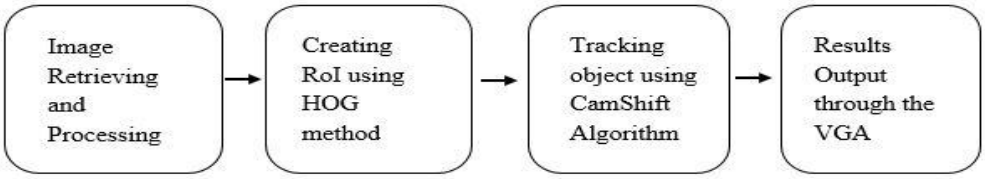

Fig. 1: Proposed ROI detection system overview with basic stages

2.1 IMAGE RETRIEVING AND PROCESSING

In this stage, retrieved video frames were configured to enhance the speed of the process. The original frames were resized after converting RGB image into gray scale which gives binary images for further calculations that reduced information on images and number of image pixels were reduced. Image data was reduced using converting it into gray scale. The original RGB image was converted into the HSV format for CamShift algorithm and stored.

2.2 CREATING REGION OF INTEREST (ROI) USING HOG METHOD

The HOG method needed the binary images to implement. Images are converted to binary images and used to calculate the histogram of oriented gradients to form a feature vector. In the HOG, images are divided into cells and calculate image gradients of each cell in x and y directions. Using the HOG method, the initial location of the pedestrian can be identified and cordinates of the pedestrian in the image are taken using the tracked rectangles, drawn on the tracked pedestrian. The location of the pedestrian is identified by the four coordinates of the rectangle that is marked by the HOG method [7]. These four coordinates are used to configure the rectangular region of interest which is used as the starting searching window for the CamShift algorithm if a pedestrian detected.

2.3 TRACKING PEDESTRIAN USING CAMSHIFT ALGORITHM

In the created RoI using the HOG method is tracked by the coordinates of the image and according to the coordinates given by the created RoI, the initial location of the tracking window of the CamShift algorithm is obtained. Then the CamShift algorithm is tracking the colour intensity density in the RoI of the converted HSV image of the originally captured image. The tracking window of the CamShift algorithm is adaptive for the colour density movement that is followed the moving pedestrian until the colour density changes. If the tracked colour density cannot captured by the search window of the CamShift algorithm, the CamShift algorithm required new coordinates for locate the search window.4 Therefore, again the algorithm is returned to the HOG method to begin detection of new location of pedestrian.

2.4 RESULTS OUTPUT THROUGH THE VGA DISPLAY

The tracked RoI using the HOG method and adaptive CamShift tracking window were interpreted on the original captured window using rectangles in red and blue colours. If the new RoI is not given by the HOG, the CamShift remained on the previous RoI and the track window is enabled to be adaptive and it is moved with the captured RoI when the colour density moving.

3. RESULTS AND DISCUSSION

The Python language was used along with OpenCV opensource computer vision library that the most prominent library that is used for image handling.

(a) (b) (c) (d)

Fig.2:Low light environment ((a)-original with HOG and CamShift, (b)-mask image with HOG), High light environment ((c)-original with HOG and CamShift, (d)-mask image)

The HOG pedestrian detection method consists of series of calculation with pixel data values in a single image. Due to this reason, originally captured image frames were resized to reduce the data weight of the images. Using the gray scale conversion, the data bulk of the images were reduced. The CamShift method was used to support the performance increment of the system. The HSV colour format was used to implement the CamShift algorithm i.e. original frames were converted in to HSV. Due to multiple computations of HOG method, the Raspberry Pi computer is not compatible due to the speed limitations. Built in HOG people detection classifier was used to implement the HOG method in the system through the OpenCV. The HOG method is relatively slower than the CamShift algorithm, therefore HOG should not be used independently to run on each image frame in a real time video. The CamShift method was used to reduce the time that taken to process single frame by creating region of interest for the CamShift algorithm using the initial HOG detecting window. Hence, the processing power required to process each frame with HOG pedestrian detection and tracking method was reduced using combining these algorithms together. The simulation results was done using the Core-i3 intel processor-based computer with 2GB RAM in a virtual open source environment.

Table 1: Time measurements to process image frames in a time range 15s running time

Time to capture a frame(s)	Time difference(s)	Time to capture a frame(s)	Time difference(s)
Capturing starts at:		Capturing starts at:	
43.97		52.41	
44.39	0.42	52.88	0.47
44.78	0.39	53.31	0.43
45.17	0.39	53.7	0.39
45.71	0.54	54.1	0.4
46.31	0.6	54.48	0.38
46.91	0.6	54.87	0.39
47.54	0.63	55.27	0.4
48.22	0.68	55.65	0.38
48.8	0.58	56.29	0.64
49.29	0.49	56.97	0.68
49.78	0.49	57.59	0.62
50.94	1.16	58.26	0.67
51.47	0.53	58.97	0.71
51.96	0.49	59.57	0.6
51.97	0.01	60.11	0.54
52.41	0.44	average	0.5206

Average Simulating Time Was Obtained As 0.52 S.

4. CONCLUSION

The goal of this study is to implement a promising method to track pedestrians and objects in front of the camera on the embedded system using the image processing techniques. The system can be used to track objects and pedestrians while the system moving in real time [10]. The system based on the HOG and CamShift algorithms. These algorithms were connected together to form a promising method to identify and track the pedestrian in front of the camera. HOG method was used to detect initial location of the pedestrian and to create RoI. The CamShift algorithm was used to further tracking of the captured RoI. The system was capable to track multiple pedestrians in the different light conditions but with the resized images, the accuracy was reduced due to the data reduction. In the proposed system, the Raspberry Pi unsuitable to make real time applications due its limited processing power which lags at initial pace due to HOG calculation method. Therefore, the embedded implementation of the system should be optimized with the HOG method that detect the region of interest for CamShift algorithm. If the HOG was not be able to detect a human then CamShift algorithm was used to create the RoI at the center of the images taken by the camera. Due to the combination of two algorithm, the pedestrian tracking speed was increased rather than using HOG method alone because it helps to save computational time by handover method to the CamShift algorithm at initial point of detection. Computational time could be reduced by powerful hardware implementing of the program rather than microcontroller based IDEs. In the simulation a precious average time of 0.52 s was obtained. This proposed system can be implemented as an automobile dashboard camera warning system, robot vision system and security surveillance system for automated home or factory site.

5. ACKNOWLEDGEMENTS

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