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Development and Characterization of a Computer Vision System for Human Body Detection and Tracking under Low-light Condition

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ABSTRACT

Computer vision is an exciting field that integrates soft-computing algorithms and computer hardware powerful enough to handle the computation required especially if it is to be used in real-time applications. Pedestrian detection and tracking is one application of computer vision which is very useful in surveillance applications. Under this application, real-time processing of images to detect human object and perform tracking is carried out. Illumination of the scene is crucial in order the detection algorithm to carry out the computation task correctly. In this study, a computer vision system is developed for the detection and tracking of pedestrian or human body in a video. Detection and tracking of the human object is performed under different illumination. The illumination is provided using an LED lighting system where the intensity of illumination can be varied by changing the duty cycle of the pulse activating the LEDs..

Key words : LED-based Illumination, pedestrian detection, human object tracking, embedded system.

1.INTRODUCTION

Research efforts have been focused on the refinement and improvement of pedestrian detection and face detection algorithms particularly the HOG and LBP. But no research, to the best knowledge of the proponent dealt with the research issue of using the computer vision system to control the illumination of an LED lighting system for the illumination requirement of the vision system. Lighting intensity, being a function of the square of the distance of the illumination source, will affect the performance of illumination-sensitive vision system. Thus, research in the area where in one is able to control the intensity level of illumination based on the distance of the object to be detected or recognized is still an open issue. The closest research that can be found in the literature is that of [1] and [2].

2.RELATED WORKS

People detection is very crucial in surveillance applications to model an individual or crowd behaviour. Detection of a human object in an image or video stream is the first step in order to model that behaviour. Table 2.3 summarizes works dealing with people detection and recognition. The works of [3] and [4] provided the underpinnings of human detection in an image, particularly pedestrians. The pedestrian dataset resulting from their works were made available to the public where algorithms on pedestrian detection can be trained and validated. [5], [6] and [7] made optimization on the algorithm to reduce computation time and improve accuracy. In [8], an in-depth analysis of the HOG – SVM chain answering the question why HOG-SVM performs so well in people detection was made. Finally, [9] demonstrated a cascade of detectors to further improve the performance of the HOG algorithm.

3.METHODOLOGY

The development of the computer vision system for body detection and tracking involves the following; first, the embedded system hardware has to be selected and configured. Then the operating system is installed and configured and finally, the computer vision library and related libraries are installed

A. Embedded System Development

The hardware platform selected for the implementation of embedded system and fuzzy logic control is the Raspberry Pi 3 B. Based on the specification sheets of the board, it satisfies the needed requirements. The requirements for the embedded hardware include computing power to process at a video frame rate of at least 16 frames per second, non-volatile storage, application development program such as C/C++ or Python, computer vision algorithms and numerical computation libraries, Input-Output ports for interfacing to external devices, dedicated camera interface, data communication connectivity, time stamp can be obtained from the internet in the absence of RTC and low power. All these requirements are satisfied by the Raspberry Pi board.

For this project, the embedded system software is composed of the operating system, the C/C++ and Python software development programming languages, OpenCV libraries, Numpy library for scientific computing etc. Once

the image file of the operating system is downloaded, uncompressed and copied to the SD card, it is then inserted into the raspberry Pi and the RPi is booted for the first time. This will expand the file system and the boot loader is configured for this specific system.

B. Development of the body detection and tracking system

For people detection and tracking, the HOG + LSVM in the OpenCV library was used. Figure 1 shows the algorithm for performing people detection in a video stream.

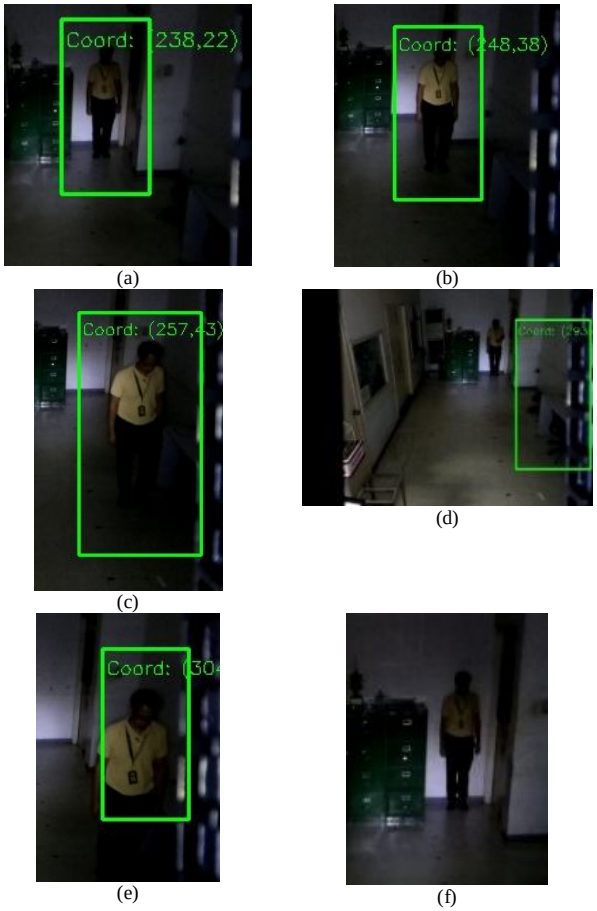
```
import the necessary packages for people detection
import packages for camera operation
import packages for IO operations
initialize the camera
initialize the HOG descriptor for people detection
set PWM duty cycle()
turn camera on
grab a reference frame
while (true)
{
    detect people in the image frame
    bound with box detected people
    return x,y coordinates of upper bounding box corner
    return width of bounding box
    display image with bounding box
    save image
}
```

Figure 1: Pseudo code of people detection and tracking algorithm

C. Characterizing the body detection and tracking algorithm

The people detection algorithm is characterized by measuring the illumination levels and distance that the body of the person can be detected. The test is carried in the testbed by making the person walk along 5 pathways in the test bed namely; PATH 1, PATH 2, PATH 5, PATH 4 and PATH 3. PATH 5 is directly in front of the camera, while PATHS 3 and 4 are at the left side of the camera. PATHS 1 and 2 are on the right side of the camera.

Sample images detected and stored by the body detection algorithm of the person traversing PATH 1 is shown in Figure 2 where detection of the human object is positive detection if whole body is bounded by the box, negative detection is when there is a human object in the image but the detection algorithm did not bound it with a box, false positive detection is when the detector bound with a box a partial image of the body or, bound in a box when there is no human object in the image. Plots of trajectories of the coordinates of the bounding boxes when the person traverses the test bed in the 5 path ways are shown in Figure 3.



(a) (b) (c) (d) (e) (f)

Figure.3: Captured images during people detection. (a) is at 21 feet (b) 14 feet (c)8 feet (d)human object is moving away from the camera (e) false positive detection (f) negative detection.

4. RESULTS AND DISCUSSION

The figures from Figure 4 shows the results recorded by the body detection algorithm as a human person walks through the test bed along the designated paths. Illumination level is fixed to a level that assures correct recognition. The plots of the trajectories are also included to aid in the visualization of the data. y values of the coordinates can be chosen as fuzzy inputs for a fuzzy logic controller for inferring the relative distance of the object from the image sensor. Measurements are carried out at 60% duty cycle setting of the LED lighting system. The farthest distance from the image sensor where detection occurred is at a maximum of 20 feet while the closest distance for detection to occur is at 8 feet. Distances lower than 8 feet is too close because only partial portions of the human body are visible in the image.

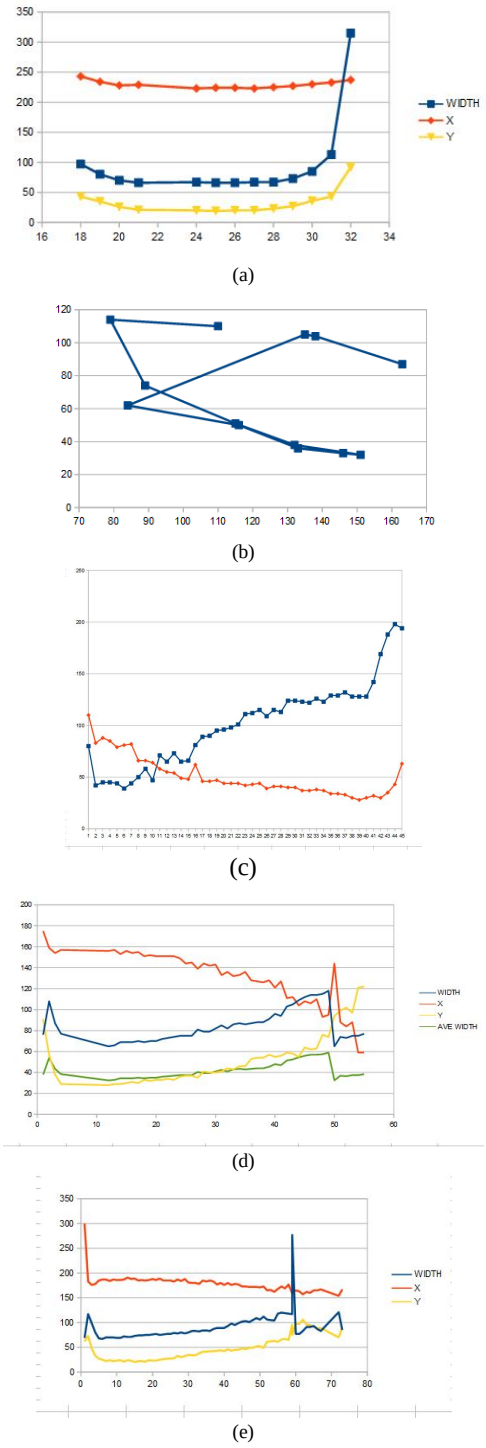


Figure 4: Validation of the body detection algorithm by plotting the trajectory of the upper left x and y coordinates of the bounding box as the person traverses PATH 1(a), PATH 2 (b), PATH 3 (c), PATH 4 (d) and PATH 5 (e).

Figure 5 is a plot of all the x-y trajectories of a person traversing the different paths in the test bed. it is shown in the plot that there is grouping or clustering of the trajectories belonging to each path; PATH 1 far right, PATH 2 next cluster going to the left of the figure, PATH 5 middle cluster, PATH 4 is on the left of PATH 5 and PATH 3 is on the far left. This figure illustrates the tracking behaviour of the system.

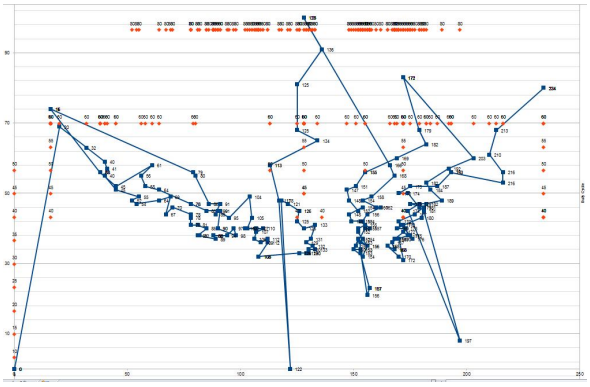


Figure 5:: Plot of the x-y coordinates of the bounding box enclosing the body of a person when it is detected in a video frame. The camera height is 8 feet.

Figure 6 shows the plot of trajectories, similar to Figure 5, but the camera is elevated at a height of 6 feet instead of 8 feet. The figure shows that the plot appears compressed, indicating that at 8 feet, the system can resolve better the trajectory of the distance of the object from the image sensor.

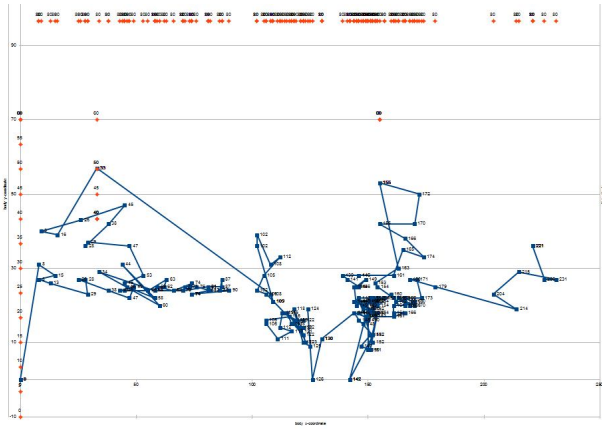


Figure 6: Plot of the x-y coordinates of the bounding box enclosing the body of a person when it is detected in a video frame. The camera height is 6 feet.

To determine people detection accuracy, the code is modified for this test to record all frames. Frames with detected person are also recorded maintaining the frame number for referencing purposes. The same is true with the face detected and recognized. Detection and recognition are classified as listed in Table 1.

Table 1: Classification for human object detection

classification	Description
Positive	Human object in frame is detected while if there is a face, the face is recognized
Negative	The person in an image is not detected. For face, it is not recognized
False positive	Object is detected but there is no object in the image
background	If the frame contains only background and there is no detection or recognition done

The accuracy of the people detection algorithm is tested by determining how often the algorithm correctly recognizes the person for different distances from the camera. The level of illumination is automatically adjusted by the fuzzy controller. Table 2 lists the detection of the human person on the image. The accuracy of the system to detect human body is 64.2%. 33% is negative detection and 28% false positive.

Table 2: System accuracy

	frame numbers		positive	negative	false positive	background
1	0	9	0	0	0	10
2	10	19	9	1	0	0
3	20	29	10	0	0	0
4	30	39	3	7	0	0
5	40	49	4	6	0	0
6	50	59	7	3	0	0
7	60	69	2	5	1	2
8	70	79	0	0	0	10
9	80	89	0	0	0	10
10	90	99	2	2	0	6
11	100	109	10	0	0	0
12	110	119	7	3	0	0
13	120	129	4	6	0	1
14	130	139	9	1	0	0
15	140	149	4	1	4	1
16	150	159	1	0	0	9
17	160	169	0	0	0	10
18	170	179	8	0	0	2
19	180	189	10	0	0	0
20	190	199	0	10	0	1
21	200	209	8	2	0	0
22	210	219	9	1	0	0
23	220	229	0	1	0	8
24	230	239	0	0	0	10
25	240	249	1	0	0	9
26	250	259	9	0	1	0
27	260	269	10	0	0	0
28	270	279	1	9	0	0
29	280	289	0	10	0	0
30	290	294	5	0	0	0
			133	68	6	89
		239	0.642512	0.328502	0.028986	
			recognition accuracy	body not detected	false detection	

5.CONCLUSION

In this study, the development and characterization of a computer vision system for the detection and tracking of human body in video is presented. The development platform used for its implementation is an RPi which is considered as a resource constrained platform but carries out the task in real-time. The system is able to process 16 frames per second and able to capture and record the trajectory of the upper-left corner of the bounding box enclosing the detected body. Using this trajectory, the vision system is able to track the movement of the human person in the image. The y coordinates, provides a means of inferring the distance of the human body from the camera or image sensor. Detection of the human object in a video image by the algorithm can be reliably carried out at distances between 8 feet to 20 feet, while intermittent detection occurring at distances of 21 feet. The trajectories of the bounding box provide data for inferring relative distance of the human object from the image sensor. Distances between 20 feet and 8 feet from the camera can be reliably inferred. The height of the camera also affects the m the image sensor. A camera installed at 8 feet height can better infer the distance of the object.

REFERENCES

[1] C. Park, H. Park, D. Kim, and J. Cha, "A design for object tracking security system using on LED light combined CCTV," Ictc 2011, 2011. https://doi.org/10.1109/ICTC.2011.6082580

[2] S. Y. Chun and C.-S. Lee, "Applications of Human Motion Tracking: Smart Lighting Control," 2013 IEEE Conference on Computer Vision and Pattern Recognition Workshops, 2013. https://doi.org/10.1109/CVPRW.2013.65

[3] N. Dalal and B. Triggs, "Histograms of Oriented Gradients for Human Detection," 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR05).

[4] S. Munder and D. Gavrila, "An Experimental Study on Pedestrian Classification," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 28, no. 11, pp. 1863–1868, 2006. https://doi.org/10.1109/TPAMI.2006.217

[5] S. Paisitkriangkrai, C. Shen, and J. Zhang, "Fast Pedestrian Detection Using a Cascade of Boosted Covariance Features," IEEE Transactions on Circuits and Systems for Video Technology, vol. 18, no. 8, pp. 1140–1151, 2008. https://doi.org/10.1109/TCSVT.2008.928213

[6] Y. Nakashima, J. K. Tan, H. Kim, and S. Ishikawa, "A pedestrian detection method using the extension of the HOG feature," 2014 Joint 7th International Conference on Soft Computing and Intelligent Systems (SCIS) and 15th International Symposium on Advanced Intelligent Systems (ISIS), 2014. https://doi.org/10.1109/SCIS-ISIS.2014.7044743

[7] D. Sun and J. Watada, "Detecting pedestrians and vehicles in traffic scene based on boosted HOG features and SVM," 2015 IEEE 9th International Symposium on Intelligent Signal Processing (WISP) Proceedings, 2015. https://doi.org/10.1109/WISP.2015.7139161

[8] H. Bristow and S. Lucey, "Why do linear SVMs trained on {HOG} features perform so well?," CoRR, vol. abs/1406.2419, 2014.

[9] M. A. B. Garcia, R. Y. Guarin, M. T. Lerin, N. M. Lumod, V. T. Reyes, J. D. Albao, and E. A. Roxas, "Modified shape independent method in detecting pedestrians using FIR cameras at night," 2015 International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), 2015. https://doi.org/10.1109/HNICEM.2015.7393251