# Object Detection Algorithms for Video Surveillance Applications

Apoorva Raghunandan, Mohana, Pakala Raghav and H. V. Ravish Aradhya

***Abstract*—Object Detection algorithms find application in various fields such as defence, security, and healthcare. In this paper various Object Detection Algorithms such as face detection, skin detection, colour detection, shape detection, target detection are simulated and implemented using MATLAB 2017b to detect various types of objects for video surveillance applications with improved accuracy. Further, various challenges and applications of Object Detection methods are elaborated.**

***Index Terms*—Colour Detection, Face Detection, Object Detection Algorithms, Skin Detection, Target Detection, Video Surveillance**

## I. INTRODUCTION

OBJECT detection mainly deals with identification of real-world objects such as people, animals, and objects of suspense or threatening objects. Object detection algorithms use a wide range of image processing applications for extracting the object's desired portion. It is commonly used in applications such as image retrieval, security, Medical field, and defense.

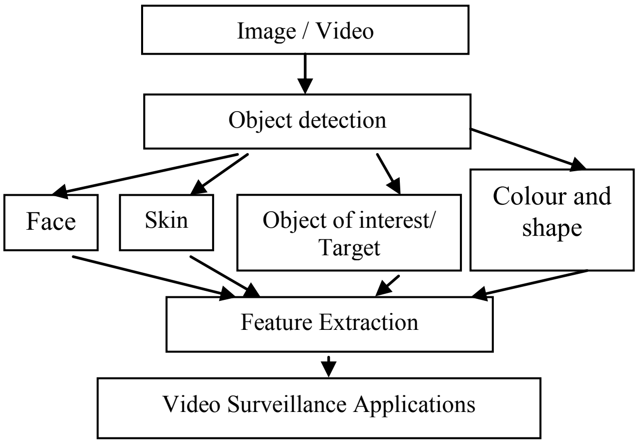


Fig. 1. Basic block diagram of object detection process

Fig.1 shows the Basic block diagram of object detection process. Frames are extracted from image or video. Objects are detected based on user's desired choice such as face, skin, colour, target of interest. Further various features of Object are extracted for video surveillance applications

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In section II Literature Survey elaborates the current research work in this domain. Section III deals with fundamental concepts of object detection. Section IV describes various object detection algorithms with mathematical equations. Section V discusses various simulation results. Further, Section VI elaborates various challenges and applications of Object detection techniques for video surveillance applications.

## II. LITERATURE SURVEY

K.K. Hati [1] an efficient Background Subtraction Method for accurate Object Detection is proposed. Local Illumination based Background Subtraction (LIBS) method is used. Background modeling is done by defining an intensity range for each pixel, shadows are eliminated, which is an added advantage of this method. I. Haritaoglu [2] in monochromatic imagery for tracking people and their body parts, W4 (Who? When? Where? What?) is used. For modelling the background each pixel is represented by three values, maximum, minimum intensity values and maximum intensity difference between consecutive frames is observed. The locations of these parts are verified and refined using dynamic template matching D. H. Santosh [3], three algorithms Gaussian Mixture Model (GMM), Extended Kalman Filter and Mean Shift Algorithm are compared in the context of multiple object tracking. The performance of GMM was observed to be good in the presence of occlusions. During Nonlinear transformation, random variables behaved in an abnormal manner, due to this Extended Kalman filter failed. Identification of Multiple objects becomes challenging when there are occlusions. For single object tracking Mean shift algorithm is best suited, which is very sensitive to window size. Jacinto Nascimento [4] In this paper the evaluation of object detection was performed taking five algorithms into consideration such as Lehigh Omni directional Tracking System (LOTS), Basic Background Subtraction (BBS), Multiple Gaussian Model (MGM), W4 and Single Gaussian Model (SGM).Best results were achieved by LOTS and SGM algorithm in terms of the number of correct detections. False alarms, splits and merges were much less compared to other algorithms. H. Fradi[5] The detection rate is improved without compromising on precision. This approach has been tested on a dataset of complex background scenes. The advantage of this method over other existing methods is that it improves the accuracy of foreground segmentation. This is evident from the results obtained by this method. P.M. Jodoin[6] Behavior subtraction finds application in characterizing of dynamic events especially behavior of the object. Each event is composed of various moving objects

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which have been defined as spatio-temporal signatures. Modelling of these events has been done using stationary random processes.

## III. Fundamentals of Object Detection

Object detection is a technique of detecting a foreground object in a frame. The desired object could be person, animal or any other object or target of interest.

*Foreground Object:* A foreground object is distinct from the stationary background. It could be with respect to its appearance or local motion. It tends to change from frame to frame.

*Background Object*: Stationary objects in a frame which are part of the background are called background objects.

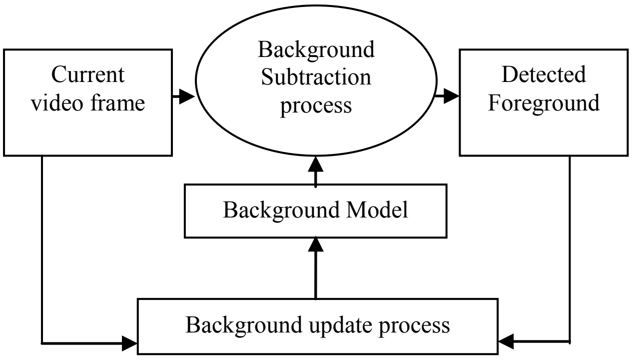


Fig. 2. Block Diagram of Background Subtraction process

Fig. 2 shows the Block Diagram of Background Subtraction process. Background Subtraction Process is performed on the current frame and foreground object is detected. Next step involves the Background Update processor which current frame is compared with the previous frame to detect the object.

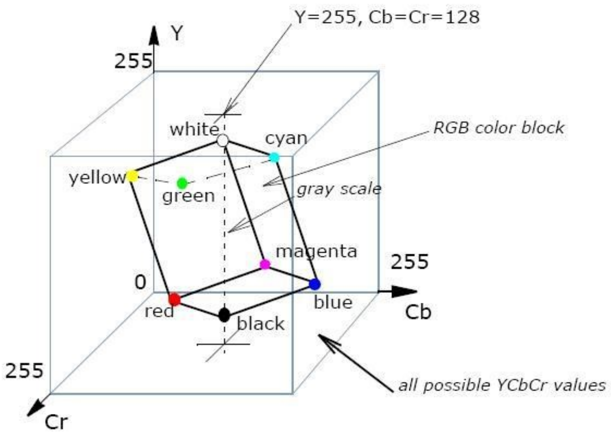


Fig. 3. The RGB and YCbCr Model

Fig. 3 shows the relationship between *RGB* colour space and *YCbCr* colour space. *RGB* colour space is represented by inner cube and *YCbCr* colour space is represented by outer cube. Conversion from *RGB* to *YCbCr* model can be represented by mathematical expressions

$$Y=0.299R + 0.587G + 0.114B \tag{1}$$
$$Cr = R - Y \tag{2}$$
$$Cb = B - Y \tag{3}$$

## IV. Object Detection Algorithms

This section describes various algorithms that are used for object detection. An object can be characterized by the detection of face, skin and colour.

### A. *Face Detection*

Face detection is a technique used to identify human faces. The Viola Jones algorithm is used to detect all facial features - eyes, mouth and nose.

### B. *Skin detection*

In skin detection technique, skin pixels are identified. The skin pixels and non-skin pixels are represented by '1' and '0' respectively. Four widely used categories of colour spaces for skin detection are RGB colour space, orthogonal colour space, perpetual colour space and perpetually uniform colour space. Skin Detection is performed using the YCbCr Model. The translation of RGB into YCbCr colour space mainly involves separation of luminance from chrominance. Therefore, the model does not change with variation of illumination. Here Y' represents Luminance and Cb and Cr indicate the Chrominance parameters.

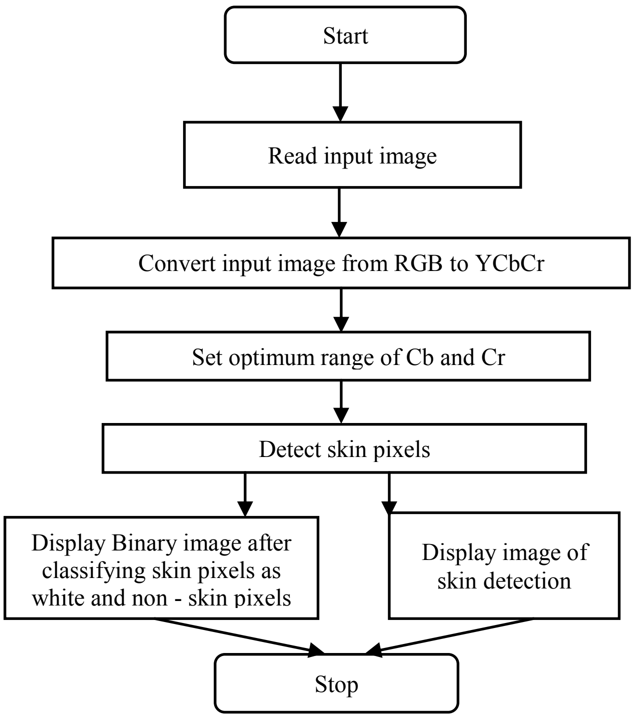


Fig. 4. Flow chart for Skin Detection

Fig. 4 shows the flow chart of Skin Detection. First step is to read the image and convert RGB to YCbCr model. Adjust values of Cb and Cr to detect skin pixels accurately. In the output image, skin pixels are represented by '1' and non-skin pixels are represented by'0'.

### C. *Target Detection*

In target detection, object of interest is detected. One of the most widely used methods for target detection is Background Subtraction[6-11]. Kommireddy Akhila

*Background Subtraction from a stationary Camera*: The image is captured from a stationary camera. The posterior probability is computed using Bayes rule

$$p(\beta\ /\ xt)\ = (\ p(\ xt/\ \beta)\ .p(\beta))/\ p(xt) \qquad (4)$$

$$p(F\ /\ xt)\ = (\ p(\ xt/\ F)\ .p(F))/\ p(xt) \qquad (5)$$

Where$p(F/xt)$ and $p(\beta\ /\ xt)$ indicate probabilities of observing 'xt' in the foreground and background models respectively. *p(F)* and $p(\beta\ )$ are probabilities of the pixels belonging to the foreground and background respectively. If equal priorities are assumed, then expression can be denoted by the likelihood ratio given by [12].

$$p(xt/\beta)/\ p(xt/F) \qquad (6)$$

### D. *Colour Detection*

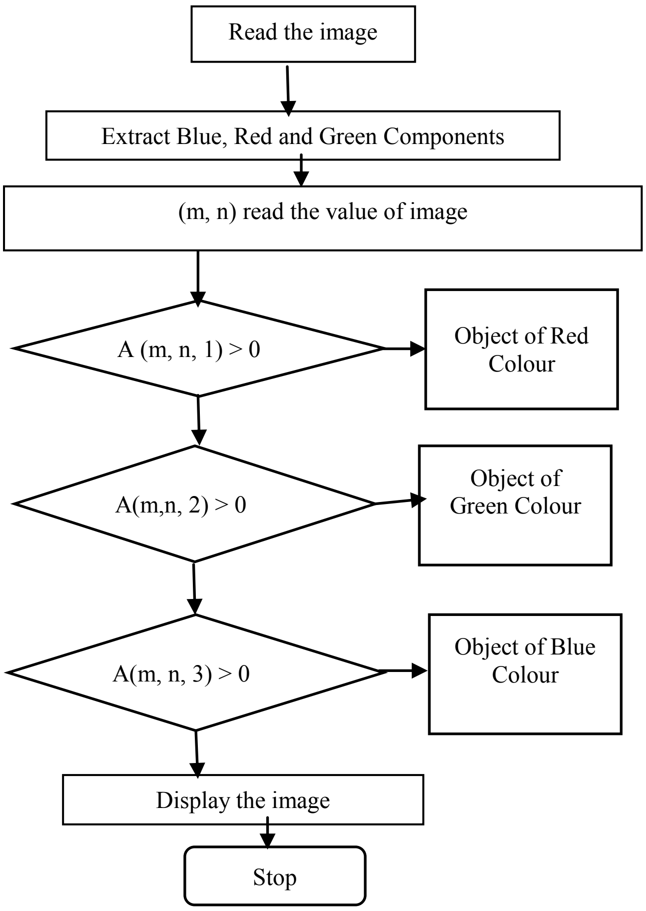


Fig.. 5. Flowchart for Colour detection

Colour is an essential parameter for object recognition. Illumination which varies across the scene is important to be considered when selecting colour models. Effect of robustness with geometry of the object, occlusion and cluttering also play an important role.

Fig. 5 shows the flow chart of colour detection. First, the image is read. A thresholding process is used for conversion of Gray scale image to binary which mainly involves comparison of each pixel value with the pre-set threshold value. When the Threshold value is observed to be lower in comparison with pixel value then a value "1" is assigned representing white, else a value "0" is assigned representing black.

## V. SIMULATION RESULTS

This section describes the simulation results of Face detection, Skin detection, Colour detection and Target detection. The algorithms are simulated using MATLAB 2017b.

### A. *Face detection*

It is the technique of detecting human faces. Different parts of the face have been detected using Viola Jones Algorithms.

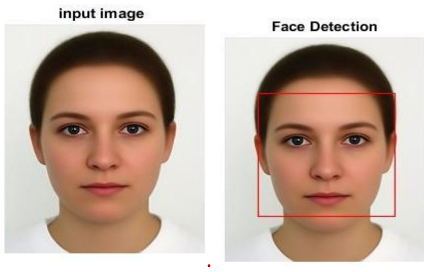


Fig.. 6.(a) Input Image (b) Face Detection

Fig. 6(a) is the input image of human face. Fig. 6(b) shows the face detected image of 6(a).

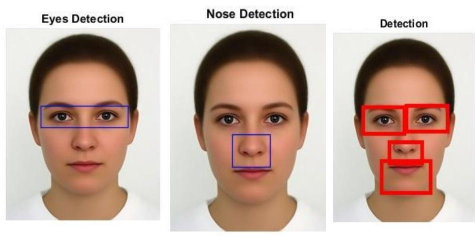


Fig.. 7. (a) Eyes Detection (b) Nose detection (c) Detection of all features

Fig.7 shows the different parts of the face with respect to 6(a). 7(a) indicates eye detection 7(b) indicates nose detection and 7(c) shows the detection of all features.

### B. *Skin Detection*

In Skin detection, the non-skin pixels and skin pixels are detected.

*Skin Detection for a Single face* - Four cases have been considered for skin detection analysis.

*Case 1:* Cb - 77 to 127 and Cr -133 to173

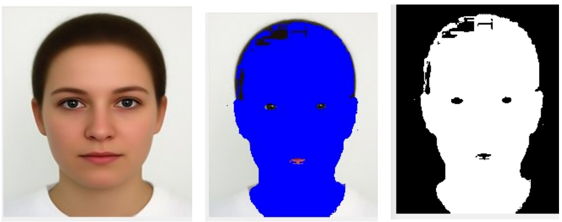

Fig.. 8. Skin detection for Case 1 - (a) Input Image (b) and (c) are output images of skin detection

Fig. 8(a) is the input image 8(b) is the skin detection output of 8(a) and 8(c) is the output binary image of 8(b).An improvisation has been performed and different outputs for different cases have been obtained[11].

*Case 2:* Cb - 79 to 136 and Cr - 142 to 165

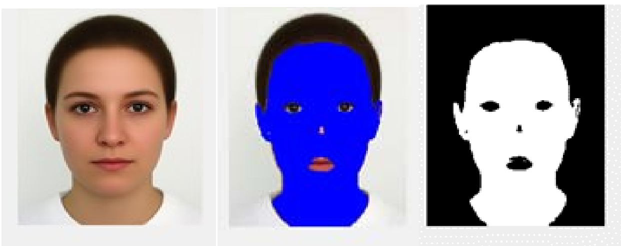

Fig.. 9. Skin detection for Case 2 - (a) Input Image (b) Skin detection represented by blue colour (c) Binary image

Fig. 9(a) is the input image, 9(b) is the skin detection output of 9(a) and 9(c) is the output binary image of 9(b). In this case shows only the skin is being detected.

*Case 3*: Cb - 73 to 130 and Cr - 148 to 167

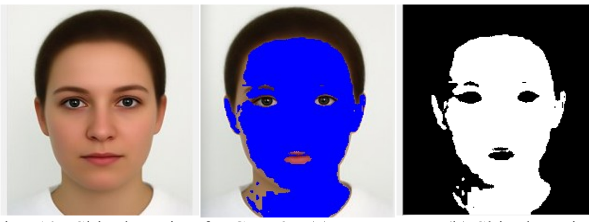

Fig.. 10. Skin detection for Case 3 - (a) Input Image (b) Skin detection represented by blue colour (c) Output image 2

Fig. 10(a) is the input image, 10(b) is the skin detection output of 10(a) and 10(c) is the output binary image of 10(b).

*Case 4:* Cb - 77 to 137 and Cr - 142 to 167

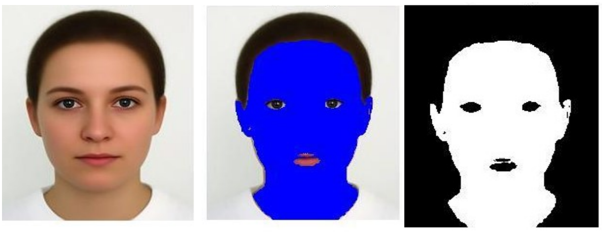

Fig.. 11 . Skin detection for Case 4(a) Input Image (b) Skin detection represented by blue colour (c) Output image 2

Fig. 11(a) is the input image, 11(b) is the skin detection output of 11(a) and 11(c) is the output binary image of 11(b).For this value of Y, Cb and Cr, the results obtained are most accurate.

*Multiple People Skin Detection* - The image shows multiple people seated in different positions. Slight variations in skin complexion and different colour clothing are observed.

Fig.. 12. (a) Input Image (b) Skin Detection Image (c) Binary Image

Fig. 12(a) is the Input Image 12(b) is the Skin Detection output of 12(a) and 12(c) is the output binary image of 12(b).The value of Cb is between 77 to Cr is between 142 to 167. As observed from the output images 12(b) and 12(c), even clothes have been mis-detected as skin [12].

### C. *Colour and Shape Detection*

*Colour Detection* - Colour detection is performed for accurate detection of an object. It helps in correct classification of an object. Simulations of the code detect both the shape and different shades of colour in the image.

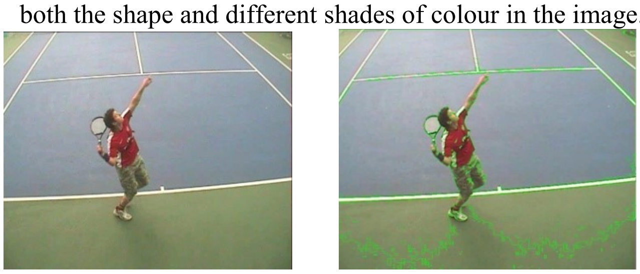

Fig. 13. (a) Input Image for colour detection (b) Colour detection

Fig. 13(a) shows the input image. 13(b) shows the colour detection output image of 13(a). In the output image, each region having a different shade is highlighted in green colour.

*Shape Detection* – Shapes of different parts of the object in the image have been detected as shown in Fig 14.


Fig.. 14. (a) Output Image of Shape detection, (b) Output Image Shape detection magnified view

Fig. 14(a) shows the shape detection output image of 13(a) each shape is detected and displayed in red text. The shapes of the tennis racket and the face are detected.

Fig. 14(b) is a magnified view of 14(a). However, uneven shapes have been displayed as unknown. This aspect of the algorithm could be improved to display with more clarity and accuracy.

*D. Target Detection*

In target detection the desired object in a frame is detected. Background Subtraction was used for Target Detection and simulation was performed using MATLAB 2017b. The outputs were obtained for different values of Euclidian threshold. The foreground, the cleaned-up foreground, shadows and the object of interest was detected
.

*Case 1: RGB Euclidian Threshold T = 80*

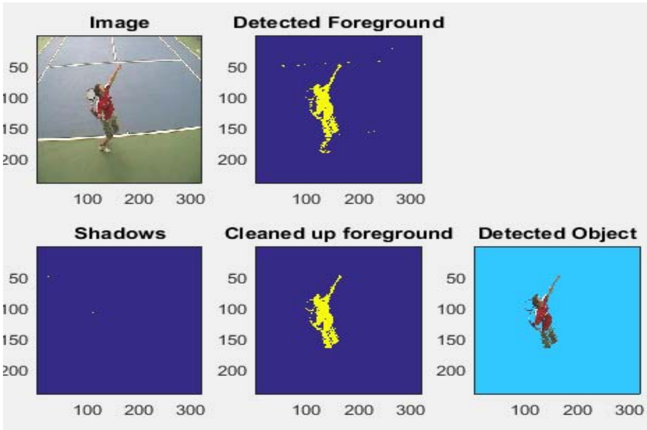


Fig. 15. Case 1: Original output for RGB Euclidian Threshold 'T'= 80

Fig. 15 shows the simulations for T = 80 from the original code. It detects the foreground, a cleaned-up foreground with shadows removed and the Object detected is displayed separately.

*Case 2: RGB Euclidian Threshold T = 60*

Fig. 16 shows the simulations for T = 60. In the first case the object was not completely detected. That, problem has been eliminated in this case. However, shadows have not been detected accurately.

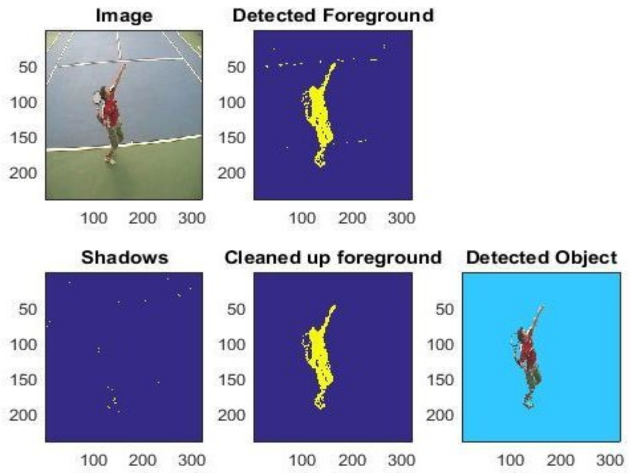


Fig..16. Case 2: Output images for RGB Euclidian Threshold 'T'= 60

*Case 3: RGB Euclidian Threshold T = 40*

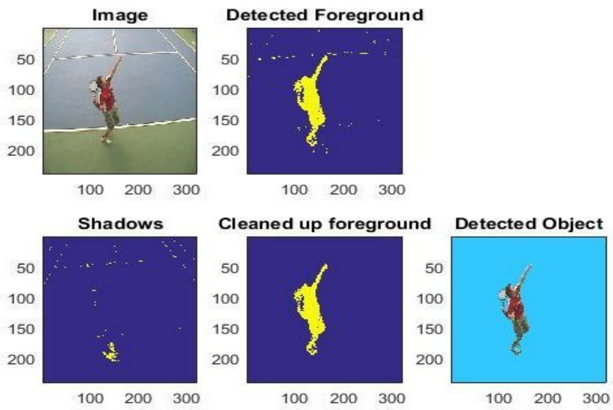


Fig. 17. Case 3: Output image for RGB Euclidian Threshold 'T'= 40

Fig. 17 shows the simulations for T = 40. For this value of T, shadows are detected, but not very accurately. The image is shown with only a part of the shadow detected and a light yellow shade is observed.

*Case 4: RGB Euclidian Threshold T = 20*

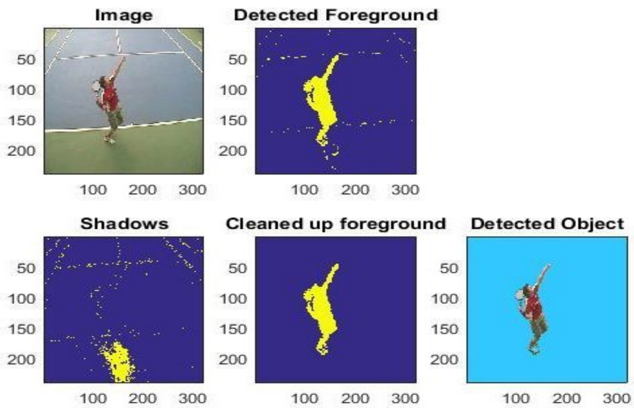


Fig. 18. Case 4: Output image for RGB Euclidian Threshold 'T'= 20

Fig. 18 shows the simulations for T = 20. For this value, the foreground and shadows are detected with high accuracy.

## VI. Object Detection Algorithms –Challenges And Applications

This section elaborates challenges and applications of various object detection algorithms.

### A. Challenges

The challenges of each method – LIBS, W4, Behaviour Subtraction, Kalman Filter, Mean Shift Algorithm, Colour detection and Skin detection has been highlighted. In LIBS, the model fails to provide the most accurate results in the presence of dynamic objects in the background. If there are small changes in the background like the waving of leaves or any subtle changes that may occur in the background. In W4, only people in upright position can be detected using the cardboard model. If people are in different poses, or are crawling and climbing, it becomes challenging. In Behavior Subtraction, detection of spatial anomalies like U-turns is challenging in this method. If it is necessary in detecting outliers, only the ones that are spatially localized and temporal can be detected. Behavior camouflage takes place especially when there is a foreground object during background activity. Kalman Filter, Mean Shift Algorithm and GMM face the challenge of detecting multiple objects when there is slight occlusion. If multiple objects are present in the image, existing skin detection algorithms will fail to detect skin region. In colour Detection, existing algorithms can only detect primary colours with accuracy. If other different colours are present in an image, existing methods mis-detect the colours.

Apart from these, some of the general issues are, if there is any change in illumination in the background, it could be mis-considered for a foreground object. Some methods also face challenges in detecting shadows. Similarity between the appearance of foreground object and background could create confusion of camouflage. Modelling of non-static backgrounds is another challenge. In High-traffic areas the background is frequently obstructed by many different foreground objects. Therefore, it will be difficult to classify a fixed foreground and background due to continuous change

### B. Applications

Object Detection finds scope in various areas such as defense and border security, medical image processing, video surveillance, astronomy and other security related applications.

## VII. Conclusion

The various object detection algorithms such as skin detection, colour detection, face detection and target detection are simulated using MATLAB 2017b with an accuracy of approximately 95%. Parameters such as detection accuracy, RGB Euclidian Threshold ‘T’ in Target Detection, Y, Cb and Cr in Skin Detection have been simulated and implemented to improve the efficiency of the algorithms for video surveillance applications. Further a single algorithm maybe designed by considering various detection parameters such as Colour, Face, Skin and Target of interest to meet video surveillance applications.

## References


[1] K. K. Hati, P. K. Sa and B. Majhi, "Intensity Range Based Background Subtraction for Effective Object Detection," in *IEEE Signal Processing Letters*, vol. 20, no. 8, pp. 759-762, Aug. 2013

[2] I. Haritaoglu, D. Harwood and L. S. Davis, "W4: Who? When? Where? What? A real time system for detecting and tracking people," *Proceedings Third IEEE International Conference on Automatic Face and Gesture Recognition*, Nara, 1998, pp. 222-227

[3] D. H. Santosh and P. G. K. Mohan, "Multiple objects tracking using Extended Kalman Filter, GMM and Mean Shift Algorithm - A comparative study," *2014 IEEE International Conference on Advanced Communications, Control and Computing Technologies*, Ramanathapuram, 2014, pp. 1484-1488

[4] J. C. Nascimento and J. S. Marques, "Performance evaluation of object detection algorithms for video surveillance," in *IEEE Transactions on Multimedia*, vol. 8, no. 4, pp. 761-774, Aug. 2006

[5] H. Fradi and J. L. Dugelay, "Robust foreground segmentation using improved Gaussian Mixture Model and optical flow," *2012 International* Conference on *Informatics, Electronics & Vision (ICIEV)*, Dhaka, 2012, pp. 248-253.

[6] P. M. Jodoin, V. Saligrama and J. Konrad, "Behavior Subtraction," in *IEEE Transactions on Image Processing*, vol. 21, no. 9, pp. 4244-4255, Sept. 2012.

[7] Mohana and H. V. R. Aradhya, "Elegant and efficient algorithms for real time object detection, counting and classification for video surveillance applications from single fixed camera," *2016 International Conference on Circuits, Controls, Communications and Computing (I4C)*, Bangalore, 2016, pp. 1-7.

[8] H. V. Ravish Aradhya, Mohana and Kiran Anil Chikodi, "Real time objects detection and positioning in multiple regions using single fixed camera view for video surveillance applications," *2015 International Conference on Electrical, Electronics, Signals, Communication and Optimization (EESCO)*, Visakhapatnam, 2015, pp. 1-6.

[9] F. Z. Chelali, N. Cherabit and A. Djeradi, "Face recognition system using skin detection in RGB and YCbCr colour space," *2015 2nd World Symposium on Web Applications and Networking (WSWAN)*, Sousse, 2015, pp. 1-7.

[10] H. Ye, L. Zheng and P. Liu, "Colour detection and segmentation of the scene based on Gaussian mixture model clustering," *2017 7th IEEE International Conference on Electronics Information and Emergency Communication (ICEIEC)*, Macau, 2017, pp. 503-506.

[11] (MathWorks - Makers of MATLAB and Simulink, n.d.)

[12] Ahmed Elgammal, “Background Subtraction- Theory and Practice”