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# A Brief Review on background substraction

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# A Brief review on Background Substraction

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**Abstract**

Background subtraction is the process of separating the foreground from background of an image. The applications of background subtraction range widely in important areas, viz- intelligent video surveillance, intelligent visual observation of animals and insects, optical motion capture, human machine interaction etc. The techniques available for background subtraction are broadly grouped under the categories of traditional background modelling or recent background modelling, pixel or regional level etc. Further, the categorization is also done based on specific challenges to be addressed, which include- statistical model, cluster model, neural network model etc. The issues with background subtraction are diverse-noisy image, camera jitter, illumination changes etc. In this paper, we discuss briefly on the various stages of background subtraction, its challenges and techniques apt in handling those challenges. Also, we look at various datasets under the category of traditional and recent dataset which poses multi-pronged challenges.

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Keywords: **Background-subtraction; Background -modelling; Background-initialization; Background-maintenance; Foreground-detection;**

## 1. Background subtraction Introduction

In the backdrop of improved significance for computer vision applications, Background-subtraction has ushered in a wide prominence. The process of background-subtraction is discussed in brief below-

Background subtraction focuses on separation of static and moving-objects in frame sequences of video [22].Steps involved in background-subtraction are-

**Background initialization**: deals with determining the initial background-image by using either a single frame or sequence of training frames. This stage involves extraction, generation and construction of background. It could be achieved either by considering N training frames in batch or by incrementally with known N frames or by progressively with N unknown frames.

**Background maintenance**: deals with the model updating mechanism to concur with the changes that pan out gradually. Preferably, background maintence should be an incremental on line algorithm as new data is streamed and provided dynamically. The maintenance could be achieved either by the blind or selective or fuzzy adaptive scheme. Learning rate in background maintenance is an important parameter as it determines the speed at which the model adapts to scene changes.

**Classification**: deals with classifying pixels as either background (static objects) or foreground (moving object).In other words, foreground detection. In this stage, pre-processing is the first activity which generally considers geometric and intensity adjustments which leads in detection of unimportant changes in scene changes. Next activity is to compute the threshold value which should optimally segregate the background pixels from foreground pixels. Final activity is the post processing, which could be done either through classical or morphological operators or fuzzy concepts

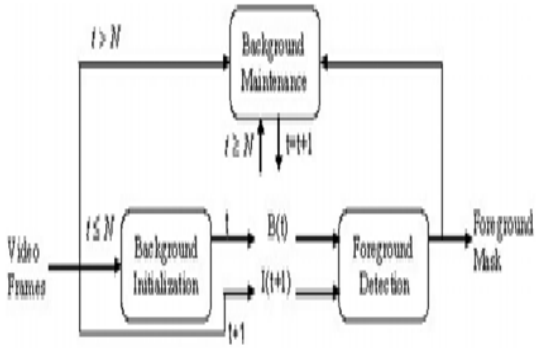



**Fig. 1.** Depicts a sketch of background substraction procedure [22]

To sum up, pixels which do not vary when the difference between the background image and current image is taken would be considered as background. Otherwise, it is interpreted as foreground.
In the next section we concentrate on key issues which are either unsolved or partially solved. Furthermore, we look at some related works which fare better under certain conditions. Finally, we look at some data sets and conclude with future works that our domain awaits.

**Nomenclature**

| | |
|---|---|
| A | radius of |
| B | position of |
| C | further nomenclature continues down the page inside the text box |

### *1.1. Key issues in background-subtraction*

Background-subtraction is an arduous task because it needs to cope with subtle and varied issues, exhibited by challenging environment settings. The challenges listed here are exhibited by image sequences from various datasets. List of key problems observed are:-

1. **MOVED OBJECTS:** one should not consider the background object which is moved as the part of foreground. As a result, the background model should adapt and understand for periodical updation of the scene layout.
2. **TIME OF THE DAY:** the background appearance changes with gradual changes in illumination that occurs over the course of day. This results in to a pan appearance change of the background.
3. **LIGHT SWITCH:** in this scenario there will be immediate change in illumination when a switch is either turned on or off, which would alter the appearance of the background.
4. **WAVING TREES:** the issue of waving trees which falls under the dynamic backgrounds which may lead to disjoint set of pixel values. As a result, it may generate false positives.
5. **CAMOUFLAGE:** the modeled background may subsume pixel characteristics of a foreground object hence producing the false negative.
6. **BOOTSTRAPPING:** in some environment foreground object will not be available during the training period, which makes bootstrapping the background model hard.
7. **FOREGROUND APERTURE:** this is related to changes in the interior pixel which happens when homogenously colored objects moves which leads to the pixels going undetected.
8. **SLEEPING FOREGROUND:** is an occurrence where a foreground object lies as a part of a place for extended duration, this leads to a foreground object being concluded as a part of background.
9. **SHADOWS:** foreground objects frequently exhibits shadows which do not concur with the background model. Shadows exhibit abrupt and localized variations in the scene's illumination thence should not be considered as FG entities.
10. **REFLECTIONS:** surfaces like floor, road, windows, glasses etc. Might reflect the foreground instances which falsely would be classified as foreground.

All critical situations have varied spatial and temporal properties. So, it is pertinent to find the spatial and temporal properties to solve the corresponding critical situation.

### *1.2. Related works*

All challenges mentioned above are partially solved in many settings, so the potential solution to those partially solved challenges could be found in the following surveyed techniques. These techniques are broadly grouped under the categories of Traditional or recent background models; pixel level,. Region level or hybrid; Recursive or non-recursive etc.

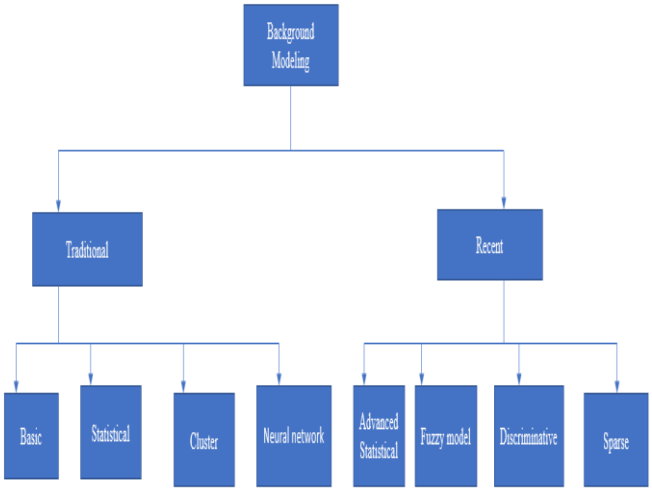
Before we discuss the techniques of background subtraction, we must look at the various features which those techniques would consider for the process of background subtraction. Features are chosen based on the challenges to be resolved. The list of features is-
(i)edge (ii)stereo (iii)color (iv)texture (v)motion
These features must be used in tandem to achieve best results. For instance, the colour feature works well in the case of discrimination, whereas it doesn't fare well in the presence of illumination changes, camaflouge and shadows. To augment its ability we must consider the stereo and edge features which are good at handling the issue of camaflouge and shadows respectively.

For effective background subtraction and foreground segmentation it is important to utilize and merge various perceptual clues:
(i)Depth Discontinuity: objects nearer than rest of the scene with respect to the camera.
(ii)Motion discontinuity: Image region and Objects with independent movement from rest of the scene.

(iii)Familiar shape: objects or image region which are similar in shapes ie. Object of interest like vehicle, animals and people
(iv)Appearance discontinuity: objects or image region which appear different from the surrounding scenes.

The categorization of background subtraction can be done in following ways-

To begin with the first kind of categorization is based on traditional and background model-




. The traditional models are basic models which are first to be used in the field of background substraction. These models are adept in handling specific challenges, its limitations seems to have reached leaving less scope for enhancement.

Whereas, the recent models are robust and sophisticated which are apt in handling varied and complex challenges. Many models in the recent category have to be improvised to achieve real-time and incremental needs.

The sub categories of the traditional and recent models are depicted above. The techniques which fall under these sub categories and the challenges they handle are listed below in the table.

Table 1. An example of a table.

| **Sub-categories** | **Techniques** | **Challenges handled** |
|---|---|---|
| Basic Models | Mean,Median,Histogram, Pixel Intensity Classification(PIC), Pixel Change Classification(PCC) | Noisy Images, Camera jitter, Foreground Aperture |
| Statistical Models | MOG,KDE,SVR,SVDD. | Camera Jitter, Dynamic Background |
| Cluster Models | K-Means,Code book,BSC | Noisy Images, Boot Strapping |
| Neural Net work | GRNN,MNN,CNN,DCNN, SONN,GHSONN | Foreground detection, Noisy images, Camaflouge |
| Advanced Statistical Model | DMM,KGMM,KGHMM, VIBE,PBAS | Camera Jitter, Dynamic Background, Shadow Removal |
| Fuzzy Models | FCM,T2F-MOG-UM,T2F-MOG-UV | Dynamic Background, moved background objects, Inserted Background Objects, Beginning Moving Objects, Sleeping Foreground Objects. |
| Discriminative Models | IMMC,PCA-ILDA,Robust PCA | Illumination Changes, Shadow Removal |
| Sparse Models | Compressive Sensing, Structured Sparsity, Dynamic Group Sparsity, Dictionary Learning, Sparse Error Estimation. | Illumination Changes, Shadow Removal |

Going by the data abstraction level,the categorization of approaches are done as-

**Pixel level**: methods that fall under this category leverages the pixel intensity temporal consistency by assuming observations of time series values at each pixels are independent.

**Region level**: methods under this category use interpixel relation to its advantage by sub-dividing the images into regions.

**Hybrid**: it combines the pixel and region level analyzes.

Further the categorization could be on the basis of frame sequences which are taken into account simultaneously-

**Recursive**: here every new frame is analyzed and is used to iteratively estimate and update a single background model.

**Non recursive**: here sequence of frames are stored in a buffer and then the background model is estimated on the basis of statistical properties of these frames.

Lastly based on selectivity-
**Blind**: generation of background model for every pixel through temporal statistics computed with the use of whole time series of pixel intensities.

*1.3.* ***Data Set***

It enables evaluation of the background subtraction algorithms and compare it for efficiency with other algorithms proposed off late. They are categorizing into traditional data set and recent data set [16]. The results generated using the background subtraction technique is evaluated for its efficacy by comparing it with the ground truth images, where ground truth is defined as follows-

Ground truth is defining the pixels belongingness to either foreground or background based on manually segmented images.

Traditional datasets: Are videos which involve diverse challenges and images with some ground truth, whereas it doesn't address all challenges. Viz. WALL FLOWER data, I2R dataset, CARNEGIE MELLON dataset.


**Fig. 2.** Instance of WALL FLOWER dataset[24]

**Recent data set**: Facilitates videos with large scale realistic nature and it gives accurate ground truth, leading to balanced coverage of real world challenges. Viz. CHANGE DETECTION DOT NET data set , VSSN 2006 data set, BMS 2012 data set :- the BMS

**Fig. 2.** INSTANCE OF CHANGE DETECTION DOT NET DATASET [25].

The above mentioned dataset comprises of real videos and synthetic videos. Some difficulties with these datasets are-

1)Objects which are very large.
2)Swift changes in lighting conditions.
3)Varied conditions of climate(snowy,sunny and rainy).
4)Cast shadow.
5)Continuous flow of an object near surveillance zone.
6)Dynamic variance caused by vegetations (Ex. Tree).
7)Type of ground(Ballast, ground or bitumen)

***1.4. CONCLUSION & FUTURE WORK***

In this review, we have discussed in a nutshell about the stages of background subtraction and some key issues faced during the process of background subtraction. Then, we have looked at various ways in which the background subtraction techniques could be categorized. Wherein, under sub categories of traditional and recent, it comprises of various techniques which are apt in handling specific challenges. Further there is a mention on various benchmark datasets. The future efforts should be in designing an integrated model which could handle those challenges collectively.

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