# Shadow Detection – Its Pros and Cons

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## ABSTRACT
Location Based Service Domain offers various services to applications like Navigation, Traffic Surveillance etc. One of the major services of this domain is the tracking moving objects. This service is implemented as system design approach having inputs as photos or videos. These inputs have many entities like the object of interest and entities of confusion .One such entity of our interest which may lead to major failure of the system is the shadow of the objects of interest which may be mistook as the object itself . This will lead to false detection. Thus shadow detection and its elimination is proposed as a necessary and important step of the system. For this the objects have to be classified as Static and dynamic with shadow regions as umbra and penumbra. For the design of the proposed preprocessing stage, the paper evaluates different types of shadows, Application wise, Model wise, Method wise and Property wise. Finally for the analysis phase of the system, a comparative study of some required parameters for shadow detection is done. The system is then evaluated to conclude the advantages and disadvantages of shadow detection preprocessing module

## General Terms
This paper is in domain of image processing. The sub domain being Tracking in which the shadows of the tracked objects are detected and eliminated.

## Keywords
Tracking, Static Shadows, Cast Shadows, Self-Shadows, Colour, Intensity, Models

## 1. INTRODUCTION
Earlier phase saw limited user's requirements and expectations. The applications then developed providing limited services had simple system architecture. i.e. the system was first designed and then used to give specific services. This type of system design approach was called as a Single Architecture Phase or Uni-Architecture System.
The latter phases, due to development in all sectors diversified the user's requirements in all direction of different applications which further provided large number of services in a diversified form. The architectural approach was now application based providing a bundle of services where each bundle was now called as a Service Domain. The architecture to be implemented in such type of system was domain specific. All the like services provided by such system formed a single domain. The domain is now implemented as single service called as Single Logical Service. The service domain of our interest is Location Based Service whose main feature is tracking which is of our interest. The paper starts with a brief introduction of Tracking in part II followed by introduction of shadow detection in part III. Part IV gives classification of shadows. These shadows are further evaluated in section V application wise, technique wise and method wise. These evaluations are analyzed in section VI in a tabular form for better viewing. The paper is finally concluded in section VII with future suggestion in section VIII.

## 2. TRACKING
The tracking system will have various sub subsystems as Image Acquisition as the input stage, Image Preprocessing stage for noise reduction, the main unit for Processing, Detection unit for error detection of the output, finally the output unit for Tracking the object of interest. Now for the tracking to be done seamlessly there should not be any distraction which may confuse the tracking system. One such distraction can be the shadows of the object tracked. Now the shadow tapped as entity will have its own properties, types and features which can be exploited for their detection. [5][6].Thus shadow detection is introduced as a additional and required processing stage in the preprocessing unit.

## 3. SHADOW DETECTION
From the scene, 3D, the target scene is selected by the acquisition system .This 3D scene is captured and converted into 2D and sent for image processing unit. Before processing the image as per application, a number of preprocessing steps have to be taken in which shadow detection is one. This is so because the image acquisition unit can only detect pixel intensity and transfer it but it cannot classify the pixel into shadow or non shadow pixel. So this shadow detection has to be done as one of pre processing.

## 4. SHADOW CLASSIFICATION
There are different classes of shadows. Different techniques, different methods and different parameters are associated with shadow classes. So the target or test shadows have to be first classified and put in their respective classes for their detection. Classes available are: Type Class, Number Class, Motion Class and Image Class. In case of type class the shadow is classified as Static or Dynamic. This tells where the shadow is moving or still. In case of a video it has number of frames. This test is carried out by checking the pixels of same position in all the frames. If they display a very small change in its intensity values then they are called as Dynamic or Moving Shadows. If they give a single value of intensity as in a single image, then they are called as Static Shadows. [2][3]
Dynamic shadows are easier to detect as there are frame available for comparison. Static shadows are more difficult as no comparison bases available [6]. On the basis of light direction and object orientation the shadows are classified as Cast Shadows and Self Shadows .When the light falls on the object, the shadow which is now created in the direction of light is called as Cast Shadow. If full light is occluded then the shadow region formed is called as umbra and if only partial light is occluded then the shadow region formed is called as penumbra. In some cases the parts of the objects creates their shadows on the object itself such shadow regions are called as self shadows [3][4]. There can be a scene having number of objects or an image having single object depending upon that the number of shadows vary. The image can be black/white, colored or grey scaled. This gives different

properties to the objects which can be exploited for the detection of its shadows [4].

## 5. SHADOW DETECTION: Evaluation of its Pros and Cons

There are various dimensions along which this comparison can be done. Some of the important dimensions are evaluated here Like; Applications, Techniques, Methods and Parameters [1]

## 5.1 Evaluation: Application Level

For applications like Traffic Surveillances and Tracking by Dynamic scenes, similarly for applications like Face Recognition and Object Recognition using Static images, shadows play vital role. The first preprocessing step is shadow detection. Form this shadow can be used if it is advantages or eliminated if it is not of any advantage. This evaluation depends on whether the image is Static or Dynamic. The shadow can be used for its advantage like; in some cases the object lower boundary is not visible in this case its shadow can be used to get some idea of its boundary, It is also used to get some idea of the shape of the object and for getting the location of the object in spatial domain. These are some advantages given by the cast shadows. [5][6]. The self shadow always adds its disadvantages like, loss of information of the surface underneath the shadow, difficulties in image mapping, interpretation and its detection[5][6]. This concludes that Shadow detection limited only to give the idea of the objects shape and not the internal edge details.

## 5.2 Evaluation: Technique Based

The approach or the technique that can be used for shadow detection are broadly classified as; Model Based and Property Based [5]. In case of model based, current plus previous information is required. The previous knowledge consists of 3D geometry of the scene, the objects illumination, sensor camera localization. This is possible only in dynamic images. This constraints the use of environment. [5][4]. In case of traffic scenes the direction of light is not detected so it is assumed to be known, thus it can be used for only simple objects like building and vehicles but not in complex scenes.[5][4]. It is very difficult to obtain very accurate model for arbitrary scene. This is so because the environment is complex and light source varies from place to place. Also when the application environment changes the model fails. In case of static images only current information is available, so it is not possible to model static images in model based approach [7]. In case of property based approach, only current information of the scene or picture is required. It explores varies properties exhibited by the shadow in form of Intensify, Colour, Texture and Geometry. Whichever property is exhibited prominently by the pixel sets are explored. This can be used for complex scenes thus has large application areas. [7]. This can be used in dynamic scenes because even if the scene environment changes, the parameter values changes only within the range specified. In case of static images, the pixel values are compared with the set threshold. Shadow detection though important is considered to be a small prepossessing step. It should be done with minimum constraints which is only possible in property based technique.

## 5.3 Evaluation: Method and Properties Based

There are different methods specified for shadow detection in static/dynamic images. These methods are based on the properties exhibit by the scene /photos. Some methods are sensitive to both cast and self shadows where some are only sensitive to cast shadows all methods cannot detect self shadows [8]. These methods are mapped as intensity based methods, colour based methods, texture based methods and geometry based methods[8][4]. Intensity based methods in both for static and dynamic can detect cast shadows by comparing and grouping pixels of dark intensities as shadow regions. Self shadow can be taken as a dark patch on the object but this may not be possible if the object itself is dark [5]. In case of colour based methods, various colour models are specified which can give parameters like color value, intensity value, hue value, saturation value which can be used to detect both cast and self shadows[9][10]. The texture based method gives a smooth texture of the shadows over the edges of the object on which it falls thus this method can detect both self and cast shadows [9]. The geometry based method, helps to compare the shapes and link similar dark shapes and lighted shapes as object shadow combination .This is possible only for cast shadows and not in case of self shadows [8]. Thus in case of method based there is a choice of parameter which depends on the type of image and also on the type of shadow to be detected.

## 6. ANALYSIS

The analysis is represented in form of three cases:-

**Case 1: - Application Wise**

| Shadow type | Advantage | Disadvantage |
|---|---|---|
| **SS( C)** | Lower edge detection | Object shadow confusion |
| **SS(S)** | No advantage | Part object hiding |
| **DS(C)** | Shape comparison | False tracking |
| **DS(S)** | No advantage | Object hiding |

**Table 1: Advantages and disadvantages of shadow type**

SS(C): Cast Static Shadow; SS(S): self Static Shadow; DS(C): Cast Dynamic Shadow; DS(S): Self Dynamic Shadow

**Case 2:- Technique wise**

| Technique | MB(S) | MB(D) | PB(S) | PB(D) |
|---|---|---|---|---|
| **CI** | Required | Required | Required | Required |
| **PI** | Not Applicable | Required | Not Required | Not Required |
| **AP** | Very Limited | Limited | Large | Very |
| **SC** | Simple | Simple | Complex | Complex |
| **EC** | Affects | Affects | No Effect | No Effect |

**Table2: Techniques verses parameter information**

MB(S): Static model based MB (D): Dynamic Model based; PB(S): static property Based; PB (D): dynamic property based, CI: Current Information; PI: Previous Information; AP: Applications; SC: Scenes EC: Environmental changes

**Case3: Methods/property wise**

| Properties | Cast shadow | Self shadow |
|---|---|---|
| **Intensity** | Constant | Not constant |
| **Color** | Detectable | Difficult to detect |
| **Texture** | Smooth | Mixed |
| **Luminance** | Constant | May vary |
| **Geometry** | External edges | Internal edges |

**Table3.Types of shadows against their properties**

## 7. CONCLUSION

For the current application scenario, shadow detection, static shadow detection is concluded to be more challenging as compared to dynamic shadows. Within static shadow detection, cast shadows are conclude to be more harming as compared to self as they go along (within) the object. Technique wise, property based techniques is more acceptable as depending on current information the pixel can be modeled into combinations of properties available applying to complex scenes without having any effect of the environment changes.

## 8. FUTURE SCOPE

For the challenging static shadow detection for property based techniques, various properties to be evaluated so as to select the best property combinations to suggest optimum algorithms as per scene requirements.

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