A Review of Various Camouflage Moving Object Detection Techniques

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Abstract: The concept of identifying a moving object from a similar background is termed as camouflaging or camouflage breaking. In any video surveillance application, an important term is moving object. To detect camouflage moving object various methods are used to extract the foreground as well as background object. There are several challenges in moving object detection such as occlusion, illumination changes, shadow, dynamic background, bootstrap, etc. In this review study, different methodologies for moving object detection with several features proposed by various researchers were studied. In recent years, research attracted towards the camouflage moving object detection due to its application in the military.

Key words: Camouflage, decamouflage, object detection method, gray level cooccurance matrix, illumination, background object

INTRODUCTION

Camouflage word has derived from the French term called 'camoufler' which means conceal. Camouflage is the concept of hiding foreground objects into background surroundings. It is referred as hidden images or as an instance of recreational art. In camouflage, any combination of materials is used for concealment, making objects hard to identify. It is also called as cryptic coloration as it is used to alter its appearance usually to match with its surroundings. Camouflage is used to mask their identity or location. Camouflage is also used by some predators as a tool for hunting. For them, being able to blend in with their environment gives them success in obtaining food.

Types of camouflage: The camouflage images are classified into two categories, i.e., natural and artificial. The concept of natural and artificial camouflaging is as explained as below.

Natural camouflage: Natural camouflage occurs in animal, insects or humans to hide and make their detection more difficult from their predator. By using camouflage, organism increases their chances of survival from predators which help them to be successfully reproduced and carry on the species. Various animals have evolved to show some form of camouflage which is an adaptation that allows animals to blend in with the environment in Fig. 1.

In Fig. 2, the tiger is hidden in the similar color grass. This is not easy to see by naked eyes. A species
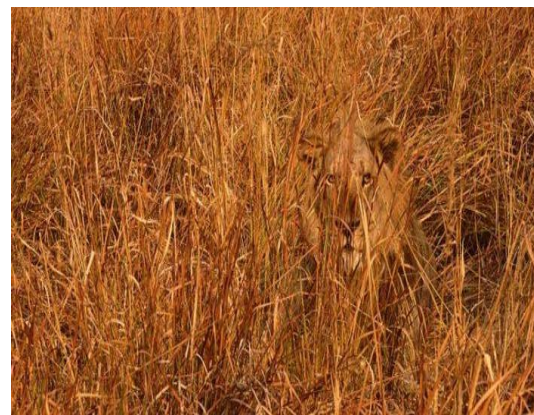

Fig. 1: Natural camouflage image

camouflage depends on several factors which are enlisted as: The physical characteristics of the organism are important. For example, arctic fox has a white coat in the winter while its summer coat is brown. The behavior of a species is also important. Animals that live in groups differ from those that are solitary. For e.g., when zebras are clustered together, it is nearly impossible to tell one zebra from another that makes difficult for predators such as lions to track an individual animal. The behavior or characteristics of its predators. If the predator is color-blind, for example, the prey species will not need to match the color of its surroundings.

Camouflage tactics: Living species uses some tricks for successful camouflaging. Two such techniques namely, Mimesis and Crypsis are used for the purpose of data

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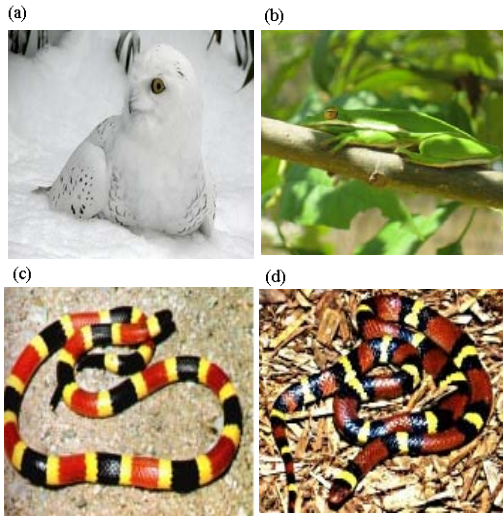
Fig. 2: a) Concealing coloration; b) Snowy owl; c) Treefrog and d) Mimesis art of scarlet king

hiding as well as secret communication. Crypsis is about blending into the background to hide oneself from the eyes of the observer. It is also called as concealing coloration. Whereas Mimesis is the art of approaching something that is of no interest to the onlooker or one organism tries to act like another organism. The Scarlet King (non-poisonous) snake mimics the look of poisonous to confuse predators:

- The beautiful white feathers of Snowyowls hide it in its Artifacts habitat
- The green tree frog hides successfully in tree and grass

Artificial camouflage: Another type of camouflaging is the artificial camouflage. In artificial camouflage, texture patterns are used in the battlefield to hide soldiers and weapons from enemies. Means first camouflage textures are assessed from the environment and then camouflaged textures are used to design cloth, weapons, etc. In Military these images are mainly used to make their uniforms with camouflage pattern to cover the appearance of our soldier. For example, the green and brown clothing those soldiers wear to make them harder to find in Fig. 3.

During logistics mixing up of duplicate product into original in, so that, duplicate product is gets camouflaged into the original. In a set ofmedicine, one of medicine is a duplicate but it is difficult to identify which one is a duplicate. Camouflage can appear at the time of manufacturing of any item when any small defect hiding in the background. It is also used in gaming.

Fig. 3: a) Artificial camouflaging example: military uniform and b) Motion camouflage

Motion camouflage hides object in the visual background. It occurs when surface and color of moving object is similar to the background. Camouflage detection method or decamouflaging method is used to detect the hidden foreground object from the background image. Moving object detection goals to separate moving foreground objects from similar color background content. It has very important role in military application to find out the enemy. The decamouflaging is the most difficult task because there is little difference in the intensity, color and texture of background and foreground image. Hence, the decamouflaging is an unsolved problem.

MATERIALS AND METHODS

Camouflage object detection method: The various methods for detecting the camouflaged object from the background have been explaining.

Co-occurrence and canny method (Whicker, 2004): This method consists of two steps; First, the assessing the image for camouflage object and in next step detected an object is saved as a foreground object. The method is explained below in detail.

In the first step, the object is detected using gray level co-occurrence matrix. GLCM matrix is used to find out similar pattern object in an image. This method is beneficial when an image is analyzed in a noisy background. First, the GLCM matrix $P\varphi, d\ (a, b)$ is determined. Where, $P\varphi, d\ (a, b)$ suggested that how frequently two pixels with gray level a, b appear in the image separated by distance d in direction φ. Gray level co-occurrence matrix of gray image:

$$
\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} \quad P_{0,1}^0 = \begin{pmatrix} 4 & 2 & 1 & 0 \\ 2 & 4 & 0 & 0 \\ 1 & 0 & 6 & 1 \\ 0 & 0 & 1 & 2 \end{pmatrix} \quad P_{45,1}^0 = \begin{pmatrix} 4 & 1 & 0 & 0 \\ 1 & 2 & 2 & 0 \\ 0 & 2 & 4 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}
$$

A gray-level image

$$
P_{90,1}^0 = \begin{pmatrix} 6 & 0 & 2 & 0 \\ 0 & 4 & 2 & 0 \\ 2 & 2 & 2 & 2 \\ 0 & 0 & 2 & 0 \end{pmatrix} \quad P_{135,1}^0 = \begin{pmatrix} 2 & 1 & 3 & 0 \\ 1 & 2 & 1 & 0 \\ 3 & 1 & 0 & 2 \\ 0 & 0 & 2 & 0 \end{pmatrix}
$$

Table 1: GLCM features

Features	Descriptions
$\text{Contrast} = \sum_{i,j}\left\|i\text{-}j\right\|^2 p(i,j)$	Measures the local variations in the gray-level co-occurrence matrix
$\text{Correlation} = \sum_{i,j}\dfrac{(i,j)p(i,j)\text{-}\mu_x\mu_y}{s_x s_y}$	Correlation between the pixel is a measure of linear dependency of the relative pixel
$\text{Homogeneity} = \sum_{i,j}\dfrac{1}{1+(i,j)^2}p(i,j)$	The homogeneity measures of closeness of the element distribution in GLCM to GLCM diagonals
$\text{Sum average} = \sum_{i=2}^{2+N}i*p_{x+y}(i)$	Sum of average is a sum of diagonal elements in a grayscale image
$\text{Energy} = \sum_{i,j}p(i,j)^2$	The energy is the measure of uniformity between the pixels
$\text{Entropy} = -\sum_{i,j}p(i,j)\log(p(i,j))$	Entropy of an image is a statistical measurement of the randomness of the pixel element
$\text{Autocorrelation} = \sum_{i,j}p(i,j)/\log(p(i,j))$	Autocorrelation is the measure of the relation between the neighbor pixels in an image. It says that image has no pixel element that are correlated that everything is unique
$\text{Dissimilarity} = \sum_{i,j}\|i\text{-}j\|p(i,j)$	Dissimilarity is a measure that defines the variation of gray level pairs in an image
$\text{Diff. variance} = \left(\sqrt{\dfrac{\sum\|p(i,j)\text{-}p(i,j)^2\|}{n}}\right)^2$	Varianceis a statistical measure of how much a set of observations differs from each other
$\text{Diff entropy} = \sum_{i,j}p(i,j)^2 p(i,j)$	It is the difference in the randomness of texture of input image
$\text{INN} = \sum_{i,j}\dfrac{p(i,j)}{1+\dfrac{\|p(i,j)\|}{i,j}}$	INN is influenced by the homogeneity of the image
$\text{INV} = -\sum_{i,j}\dfrac{p(i,j)}{1+\dfrac{\|p(i,j)\|}{i,j}}$	Dissimilarity and Contrast result in larger numbers for more contrast windows. If weights decrease away from the diagonal, the result will be larger for windows with little contrast
$\text{IDM} = \dfrac{\sum_{i=0}^{N\text{-}1}\sum_{j=0}^{N\text{-}1}p(i,j)}{1+(i,j)^2}$	IDM is also known as local homogeneity. It is directly proportional to the gray level of the image
$\text{Max probability} = \max\left(\sum_{j=0}^{N}p(i,j)\right)$	This simple statistic records in the centre pixel of the window thelargest P(i, j)value found within the window

In above matrix, the matrix of the gray image is shown on left side and gray level co-occurrence matrix for four different angles 0, 45, 90 and 135°. Once the GLCM matrix for the input image and its background is calculated and the texture features of the input image are calculated. The comparisons of the texture features form of the background and image give the information of the foreground object present or not. The texture features which are can be calculate from GLCM are tabulated in Table 1.

RESULTS AND DISCUSSION

Co-occurrence matrix and invariant central moments (Bhajantri and Nagabhushan, 2006): The concept of decamouflaging of an object is presented by the author is based on the GLCM feature extraction technique. GLCM is explained in the previous method. It is a statistical relationship between the
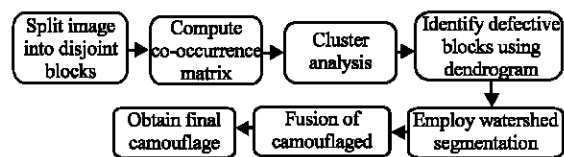

Fig. 4: Block diagram of GLCM and invariant feature based system

grayscale values of an image. The features based on the GLCM matrix are calculated. The process of camouflaged defect detection system consists of following steps in Fig. 4.

In this method the camouflaged object is segmented first using clustering method then the watershed algorithm is applied to recognize it. If the camouflage content in the image is large then this system gets failure and it is very difficult to segmented camouflage part of the image.

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Convexity-based method (Whicker, 2004): Convexity based method is based on the determination of highest convexity places in the image. In the camouflage, the foreground part is mostly convex, hence, this method id useful to locate the foreground object by colorization of the foreground object. The main advantage of this method is that it is not an edge based method but it is useful where edges are misleading. This algorithm is robust for the various environmental conditions such as illumination, orientation and clustered objects. The algorithm for this method is explained as below. Consider I(x, y) be the input image then the gradient map of the image is represented as:

$$\nabla I(x, y) = \left(\frac{d}{dy} I(x, y), \frac{\delta}{\delta x} I(x, y) \right) \quad (1)$$

Now convert the gradient of an image into polar coordinates:

$$\theta(x, y) = \arg(\nabla I(x, y)) =$$
$$\arctan\left(\frac{d}{dy} I(x, y), \frac{\delta}{\delta x} I(x, y) \right) \quad (2)$$

The polar coordinated generalized the convexity on basic paraboloids which is represented by D_{opt}:

$$Y_{arg} = \frac{d}{dy} \theta(x, y) =$$
$$\frac{\delta}{\delta y} \arg \tan\left(\frac{d}{dy} I(x, y), \frac{\delta}{\delta x} I(x, y) \right) \quad (3)$$

Texture segmentation using multiscale aggregation of filter response and shape element (Galun *et al.*, 2003): Texture properties can be used to describe the particular object in the image. In this method, texture features based on multiscale aggregation of filter response and shape element is used. First, the texture properties are calculated on large scale and then these properties are used to extract the features. This method is evaluated from the grid based method. It returns the number of the linear feature in the image with same properties. The construction of pyramids aggregates shape, intensity variability and filter response of an image. The scale is used to measure and construct the higher level pyramids. This higher pyramid helps to better separation of segments and cleaning undesired filter response nearer to boundaries (Fig. 5).

Adaptive kernel density based camouflage moving object detection (Mittal and Paragios, 2004): The combination
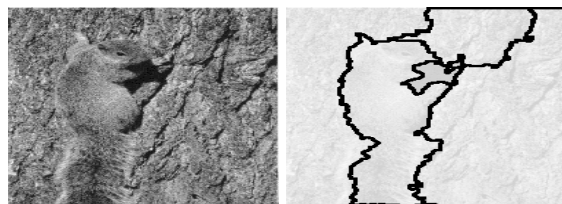

Fig. 5: Texture segmentation using multiscale aggregation of filter response and shape element

Fig. 6: Adaptive kernel density based camouflage moving object detection

of optical flow and color based features can used to detect the camouflage moving object. This approach is presented by Mittal and Paragios (2004). Optical flow is used for detection of moving object and its change direction. Density estimation is performing in high dimensional space and variable bandwidth is used for it. Another color feature is obtained from the transformation of invariant. The optical flow and color features then combined and form a new feature set. The feature with same feature properties is group into the sets. The background set is removed and only foreground part is preserved as a moving camouflage object (Fig. 6).

Spectral, spatial and temporal features for object detection (Li *et al.*, 2004): The features like spectral, spatial and temporal can be used to detect camouflage moving object. The spectral features extract the features from the grayscale and color image. The spectral features can be a gradient features. Temporal features are associated with the properties like the energy of the image. It is a spatial domain feature. Spectral features are obtained in the frequency domain. First, convert an image from the time domain into the frequency domain using Fourier transform and then features are extracted from the image.

The approach of Bayesian framework uses these three features to model the background. Color and gradient principal features are used to model the static background whereas color co-occurrences used to model the dynamic foreground pixels. The temporal difference

between the background and image gives the motion associated with the object. Further classification of the foreground object from the image is carried out by Bayes rule.

Camouflaged detection based on color and intensity (Huerta *et al.*, 2007): Intensity plays very important role for the object detection. Likewise, color information also helps to separate out the moving object from the background. In this method color and intensity based approach for camouflage, object detection has been present. The camouflages are divided into dark and bright camouflage. The dark camouflage mostly appears in shadow where the object area has less intensity than the background pixels. In light camouflage, the pixels of the object are brighter pixel intensity than the background pixels. Based on this concept the camouflaged object can be segmented.

Another approach is color based camouflage object detection. Chromaticity is the representation of the luminance of the image. It consists of hue and color information. By considering the white pixel as a reference point the ranges of all chromaticities are defined. With the help of normalized chromaticity measured and normalized intensities from color intensity model, foreground detection is achieved. Now the pixel classification technique is applied to extract the camouflage part. Intense shadow and light are not desirable for this technique.

Use of GLCM and dendrogram in camouflage detection (Sengottuvelan *et al.*, 2008): In this approach, Sengottuvelan *et al.* (2008) discussed the technique to detect the camouflaged part from a given image by using texture analysis and dendrogram. According to them decamouflaging is done by the unsupervised way where we do not require any knowledge of background and camouflage object. Texture analysis is done by using Gray Level Co-occurrence Matrix (GLCM). GLCM guess the properties of the image that are related to second order statistic and perform the steps:

- Convert given input image to a grayscale image
- The image is divided into 16 numbers of equal blocks
- Calculate the GLCM value for each block of the image frame
- Plot dendrogram for each block's mean value

Then select the largest individual block and combined with the adjacent block of the individual largest block to get the full camouflaged object. This method fails when the image contains shadows effect and non-uniform background success rate of this technique is measured as 70%.

Camouflage object detection using weighting technique (Zhang and Yang, 2009): A simple algorithm by combining a weighting technique and a new foreground model for detecting the object having the similar color to the background is presented by Zhang and Yang (2009) a weighting technique and a new foreground model are presented to deal with the color similarity problem by shifting the confusion point and improving the model accuracy. The proposed algorithm is effective but still faulty. Better weighting techniques and foreground models are expected to be developed.

Identification of camouflaged object using HSV color and GLCM texture (Kavitha *et al.*, 2011): Hue, Saturation and Value (HSV) is the color model. This model is used to represent the color image rather than the RGB colorspace. GLCM is the gray level co-occurrence matrix which represents the grayscale image in the 2D domain. Kavithai *et al.* (2011) proposed the camouflage object detection approach using a combination of GLCM and HSV feature of the image.

First, the GLCM matrix of the image is calculated using sub block of equal size. Similarly, the cumulative histogram of the sub-block is calculated by quantifying Hue, Saturation and Value (HSV) colorspace. This scheme is applied to the query and target image. By using integrated matching scheme the bigraph of the image is obtained. The camouflage object is detected by the principal of highest priority matching between the query and target sub-block.

Disparity map: The codebook-based approach for camouflage object detection is proposed by Malathi and Bhuyan (2013). Initially, the codebook of background pixels is formed by quantizing the background pixels. The feature of the foreground objects pixels is compared with the codebook. When the confusion between foreground and background color has occurred then disparity map extracted from the multiple views of the foreground.

Bayesian modeling for camouflaged moving object detection (Zhang *et al.*, 2016): Zhang *et al.* (2016) proposed an approach to identify camouflaged foreground and background pixels. To detect foreground pixels camouflage modeling is used whereas to detect non-camouflaged pixels of the moving object discriminative modeling is used. Discriminative feature based modeling enhances the performance to distinguish foreground from the background with discriminative features but it fails in case of camouflage moving object detection. A global model is developed for the background and an integration of global and local models is developed for the foreground.

In Discriminative Modeling (DM), each pixel Sn is 5 tuple vector (y, u, v, d1, d2) where (y, u, v) are color features and (d1, d2) are spatiotemporal derivatives used for background modeling. In non-camouflage detection, moving object is detected by comparing against a threshold.

In Camouflage Modeling (CM), background is modeled as a global GMM in the case of different from the DM, sophisticated discriminative features are not required in the CM. For camouflage object detection, foreground likelihoods of the pixels are compared with background likelihoods. Both DM and CM are fused together in a Bayesian framework to detect the whole moving object.

CONCLUSION

The camouflage has important application in the military. It is used to hide the soldier in similar background environment. For security, it is important to detect the camouflage object from the background. It is difficult task because the intensity variation between the objects pixels and background pixel is less. In this study, we reviewed various approach for camouflage moving object detection. From literature survey it is observed that methods have some cons. Most of the algorithms are worked well for partial camouflage but not applicable for the fully camouflage image. So, it will be the challenge for image processing researchers. Again if more than single type of camouflages is present then there will be problem to solve each type of camouflage.

LIMITATION

This limitation can be solved in future by unsupervised manner. The unsupervised approach doesn't require any prior knowledge about foreground and background.

SUGGESTION

Another method to solve this problem is deep neural network based system but it required large database.

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