

A Survey of Various Camouflage Generation Techniques

Mamata M. Jaliminche¹, Mohd Mudassir M. Shaikh², Reshma S. Patil³, Prateek K. Singh⁴, Vijay A. Kotkar⁵

U.G. Student, Department of Computer Engineering, AISSMS College of Engineering, Pune, Maharashtra, India¹²³⁴

Assistant Professor, Department of Computer Engineering, AISSMS College of Engineering, Pune, Maharashtra, India⁵

ABSTRACT: Camouflage image is also referred as hidden image. It is an instance of recreational art. Such an image contains one or more hidden figures. Camouflage is also called cryptic coloration and it is a defence or tactic that is used to disguise its appearance, usually to blend with its surroundings. Camouflage is used to mask location, identity and movement while it is the mixture of resources, design or information which is hidden within an image. We need to study and review the different camouflage image generation techniques because it disguises the human vision to secure the objects within an image or surroundings. There are many image generation techniques such as wrapping and values assigning technique, multipurpose camouflage pattern design, Camouflage image using 2-scale decomposition, Camouflage generation using colour similarity. This paper focuses on the comparative study of colour extraction techniques and colour conversion models. Our proposed solution is identified to apply these colour extraction technique which increases high visual quality of image. This proposed solution can be used in many fields such as military security, gaming, automotive manufactures, animation and graphic designing purposes.

KEYWORDS: Image processing, camouflage image generation, noise removal, security.

I. INTRODUCTION

Camouflaging of an image is a process in which the object or the target image is been hidden within the source image. Camouflage is mainly known for enigmatic coloration and it is a technique used to hide the object, usually to blend with its surroundings. Camouflage is used to mask location, identity, and movement while it is the mixture of resources, design or information which is hidden within an image.

In camouflage image generation process one of the main components used is colour extraction and its conversion to obtain desired output. In this model it captures the coarse colour of the background but the result is blurry and often conspicuous. Colour conversion used while camouflaging of an image leads to the better recognition of the colours present in the background image. Colour models are the important factor in camouflaging an image. In Grayscale colour conversion model, it provides the facility to convert the RGB colour image to the black and white colour image because of which the colour extraction from the image becomes easier.

Camouflage image is referred as hidden image, to hide an image foreground synthesis and Background wrapping techniques are used. In camouflage foreground synthesis, it dresses up the foreground segments with the texture details of the background in order to foil the feature search. In background wrapping when the user places the foreground figure near the boundary of the background object e.g. the contour of mountain, parts of the foreground may protrude out unnaturally revealing the hidden object authors.

This paper is organized as follows: Section II describes the different camouflaging techniques. Section III describes the result and discussion. Section IV describes problem definition. Section V describes our proposed solution. Section VI gives the future work and finally Section VII concludes the paper.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016

II. METHODOLOGY

A. Wrapping and values assigning technique:

i) Luminance assignment

The luminance distribution is obtained by Grayscale conversion, quantization, and segmentation of the foreground image. This gives us a set of segments of different luminance values. Similarly, they obtained the luminance distribution of the background image. These segment containers and luminance values are the intensity guide. We can dress up the foreground segments by the texture details of background segments using standard texture synthesis. However, the foreground image and the background image may have substantially different luminance distributions that lead to trivial recognition. To remove this distinction, they recolored the foreground segments mapped with the luminance distribution from the background image. In other words, we need to make the foreground stand out by preserving its original luminance distribution (stand out). The values obtained from luminance is then quantized and segmented into connected segments using a simple flood-fill algorithm.

Here the values are represented as,

$$QF = \{qFi | i = 1, \dots, n\} \text{ and } QB = \{qBi | i = 1, \dots, m\}$$

Where, qFi and qBi represent connected segments in IF and IB, respectively.

Here IF is Image Foreground and IB is Image Background.

Notation qi is used to denote a segment in general.

Let, $LF = \{lFi | i = 1, \dots, n\}$ and $LB = \{lBi | i = 1, \dots, m\}$ be the luminance values of the corresponding segments.

ii) Image foreground synthesis

Dress up the foreground segments with the texture details of the background in order to foil the feature search. To avoid the boundary information of the foreground segment map being accidentally destroyed by conventional texture synthesis, Tailor-made a two-stage texture synthesis. It first synthesizes a scaffold along the segment boundaries in foreground in order to preserve the boundary and then fills up the interior. Both synthesis stages give higher preference to samples from the background region that is going to be covered by the foreground than from the rest of the background image

iii) Background wrapping

When the user places the foreground figure near the boundary of the background object e.g. the contour of mountain, parts of the foreground may extend out unnaturally revealing the hidden object. It automatically detects such contour segments with high curvature variation and then blends them in by wrapping the background border to fit the figure contour using suitable modifications.

B. Multipurpose camouflage pattern design:

i) Pre-processing

Pixels of background images will be classified into classes whose centres are specified by FCM. In this procedure, some small flecks and noisy parts will appear in the pattern. To avoid these undesirable effects of clustering, images are smoothed before clustering phase. As the degree of smoothness increases, the resulting patterns miss small flecks and consist of larger segments.

ii) Fuzzy C-means clustering (FCM)

Each pixel of the background image in RGB colour space is treated as a 3-dimensional point and the FCM clustering method with three centres is applied to classify all pixels into three different colours. The number of cluster centres is arbitrary. Typical current camouflage patterns have 2, 3 or 4 different colours. Higher number of colours results in smaller segments and more colours and thus, more complex patterns. On the other hand, a lower number of centres reduce the similarity of pattern to the background. Complexity of initial patterns makes it harder to produce a general multipurpose pattern. Therefore we choose three centres as a trade-off between similarity of the initial patterns to backgrounds and simplicity of producing a general pattern from them.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016

iii) Colour selection

FCM runs on the background images independently. As a result, the three selected colours of each image are not the same. Hence colour should be decided for the final pattern. Assuming colours in RGB space as 3-dimensional points, C_{ij} is the Euclidean distance between the i^{th} colour of the first pattern and j^{th} colour of the second one.

$$C_{ij} = \sqrt{(C_{i1} - C'_{j1})^2 + (C_{i2} - C'_{j2})^2 + (C_{i3} - C'_{j3})^2}$$

Where, $i, j, k = 1, 2, 3$..and C_{ik} is the k^{th} element of the i^{th} colour in the first pattern and k is the k^{th} element of the j^{th} colour in the second pattern. It will be possible to couple each colour of the first pattern to a colour of the second pattern if l, m and n in following equation are determined:

$$(l, m, n) = \arg \min_{l', m', n'} ((C_{1l'}^2 + C_{2m'}^2 + C_{3n'}^2))$$

permutations of l', m', n' in the above equation are tested to find l, m and n . Now coupling the first, second and third colours of the first pattern to the $l^{\text{th}}, m^{\text{th}}$ and n^{th} colours of the second pattern, we select the mean value (average colour) of each couple as the final pattern colours. Above equation ensures that the best coupling for each colour is found and the final pattern's colours are the most similar ones to those of each initial pattern.

iv) Combining initial patterns

The proposed algorithm to combine pat1 and pat2 is summarized in four steps:

1. Make a global mask matrix for each colour, P^k .
2. Superimpose P^1, P^2 and P^3 sequentially onto each other.
3. Thin and thicken P^1, P^2 , and P^3 sequentially until the visible parts of each matrix have a proper area.
4. Use the mask matrix to assemble the final pattern.

C. Camouflage image using 2 scale decomposition:

i) Layer decomposition

CIE-LAB colour space is approximately perceptually uniform and better to separate lightness from colour than other colour models. Therefore, the algorithm first decomposes the foreground object and the background image into lightness and Chroma channels by converting them into CIE-LAB colour space. Then, the lightness channels of the object and the background image are decomposed to the large-scale and detail layers by applying an edge-preserving filter operator. The large-scale layer (structure layer) denoting large features carry low frequency information of the image. The detail layer denoting small features carries high frequency information of the image. The detail layer is generated by subtracting the large-scale layer from the lightness channel.

ii) Large scale layer blending

Camouflage images are created by blending foreground objects with surrounding. That is a camouflage result should be very similar to the background image on texture and colour while preserving some structural information of the foreground object for human recognition. To preserve the important structure of the foreground object, they have used a novel blending approach for the large-scale layer. Specifically, our large-scale layer blending algorithm is considered as an optimization problem by minimizing an energy function in terms of least-squared error:

$$\sum_{p \in \Omega} \omega(F(p) - T(p))^2 + (1 - \omega) |\nabla F(p) - \mu \cdot g(p)|^2$$

with $F|_{\partial\Omega} = T|_{\partial\Omega}$

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Where,

F and T represent the large-scale layer of the resulting image and the background image, respectively.

Ω is the hidden region specified by the user

$\partial\Omega$ is the boundary of the region.

∇ denotes a gradient operator.

ω is used to control the hidden level of the foreground object.

iii) Structure edge constraint

To perceive the foreground object, some structural contours of the object must be preserved in the camouflage result. The approach identifies the relevant image structure represented by a hierarchy of edges in the Gaussian scale space, which is developed to deal with structure identification in images with no priori information. They used a canny edge detector to find the edges of the object. However, these edges have no concept of edge importance. Therefore compute the lifetime of each edge pixel in the Gaussian scale space and use the lifetime as a measure of structural importance. The edges with larger lifetime correspond to more stable and important structures. They obtained a binary mask M which indicates important structural edge locations of the object based on a certain lifetime threshold. As a result, they manipulated edges in a structure-aware way.

iv) Gradient constraint

Applying the mixing gradient of the object and background image naively on the optimization leads to halo artifices near strong edges. To avoid the artifact, we use a gradient constraint to reduce the coefficient μ according to the magnitudes of the gradients to avoid halo artifacts. Removing the halo artifices can be modelled as a Gaussian distribution formula:

$$\mu(p) = \exp\left(\frac{-\beta(1 - \omega(p))\|\nabla S\|^2}{2\sigma_2^2}\right)$$

$$\sigma_2^2 = \text{mean}(\|\nabla S\|^2)\Omega$$

Where mean denotes the mean value over the hidden domain Ω

The default value for β is 0.3.

The weighting μ is low when the gradient $\|\nabla S\|$ is very high, which reduces halo artifacts.

D. Camouflage generation using colour similarity:

To obtain pleasing camouflage target, during the process of generating the camouflage image, the target pixel should be proportionally substituted by main colours. The detailed camouflage creation process is as follows:

Step 1: If the viewing angle is less than 1 cent (about 0.0167°), then the vanishing point is farther away from the line of vision. So, the size () of mosaic block can be calculated by the combination of the image resolution R , engineering scale S and observer distance D using $L = \lceil D \times R \times S \times 39.37 \times \tan 0.0167^\circ \rceil$

Where, the operator returns the largest integer that does not exceed x .

For example, assume $R=600$ dpi, $S=1/300$, $D=300$ m, then $L < 6$

Step 2: Create k main colour blocks with size $L \times L$ using main colours extracted from the background.

Step 3: Obtain the proportion of each main colour, and replace the target pixel blocks with main colour blocks proportionally.

Step 4: Apply the combination of mathematical morphology operations to the preliminary camouflage image, and finally a visually pleasing camouflage image is generated.

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E. Main elements for generation of camouflage image:

i) Colour quantization

Colour quantization reduces the number of colours used in an image. This is necessary for displaying images on devices that support a limited number of colours and for efficiently compressing certain kinds of images. Popular modern colour quantization algorithms include the nearest colour algorithm (for fixed palettes), the median cut algorithm, and an algorithm based on attractors.

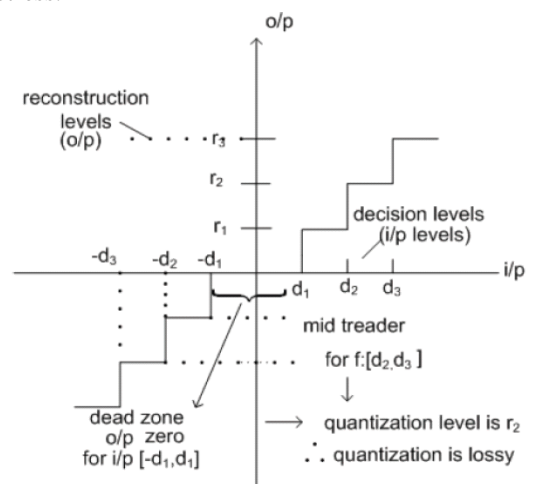


Fig. 1 Color Quantization

As shown in above figure, it is common to combine colour quantization with dithering to create an impression of a larger number of colours and eliminate banding artifacts. For example, the number of colors ranging from a certain point to a distinct value, then those colors are grouped in one single set.

ii) Colour models

- RGB Model: - Red-Green-Blue colour model.
- CMY Model: - Cyan-Magenta-Yellow colour model.
- HSV Model: - Hue-Saturation-Value colour model.
- YIQ Model: - Luminance-In phase-Quadrature colour model.
- Grey Scale colour Model.

iii) K-means clustering

K-means clustering is a method of vector quantization originally from Signal processing that is popular for cluster analysis in data mining. K-means Clustering aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster. This results in a partitioning of the data space into voronoi cells. The most common algorithm uses an iterative refinement technique. Due to its ambiguity it is often called the k-means algorithm. It is also referred to as Lloyd's algorithm, particularly in the computer science community. Given a set of observations (x_1, x_2, \dots, x_n) where each observation is a dimensional real vector, k-means clustering aims to partition the n observations into k sets $S = (S_1, S_2, \dots, S_k)$ so as to minimize the within-cluster sum of squares (WCSS).

iv) Noise removal

In image processing, a Gaussian blur is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen, distinctly different from the bokeh effect produced by an out-of-focus lens or the shadow of an object under usual illumination. Gaussian smoothing is

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also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales. Mathematically, applying a Gaussian blur to an image is the same as convolving the image with a Gaussian function. Gaussian blur can be used in order to obtain a smooth grey scale digital image of a halftone print. The Gaussian blur is a type of image-blurring filters that uses a Gaussian function (which also expresses the normal distribution in statistics) for calculating the transformation to apply to each pixel in the image.

The equation of a Gaussian function in one dimension is:

$$\begin{aligned} \text{SUM}_R &= \frac{R1 + R2 + R3 + \dots + R9}{9} = X \\ \text{SUM}_G &= \frac{G1 + G2 + G3 + \dots + G9}{9} = Y \\ \text{SUM}_B &= \frac{B1 + B2 + B3 + \dots + B9}{9} = Z \end{aligned}$$

Where X, Y, Z are the RGB values of noise pixel.

III. RESULT AND DISCUSSION

In Camouflaged foreground synthesis and Background wrapping techniques the only limitation is that the camouflaged image is generated only to a particular background and foreground. To overcome this problem many other techniques are used such as colour quantization, noise removal, clustering. Using these techniques we can collect the data from the surrounding and according to that a camouflage image can be generated. Noise removal is a technique to smoothen the image and remove unwanted distract from the image. This technique is used while generation of camouflage image regards to remove impurity from image .Here colour quantization extracts the different colour from the surrounding image and then it is clustered in similar colour groups. These techniques help to get a perfect camouflage image according to the surrounding.

IV. PROBLEM DEFINITION

Nowadays Camouflage image are used in many fields like military, gaming, automotive manufactures, animations, graphic designing etc. The difficulties arises when there is no accurate solution for the raised problem, Hence the purpose of this novel method is to generated camouflaged image using quantization, HSV colour model and clustering to obtain high visual quality image.

V. PROPOSED SOLUTION

Our system is aimed to generate the perfect camouflage image using feasible algorithms. This will be possible by using the parameters such as blurring an image, converting to HSV colour model, quantizing the obtained image and applying k-means clustering.

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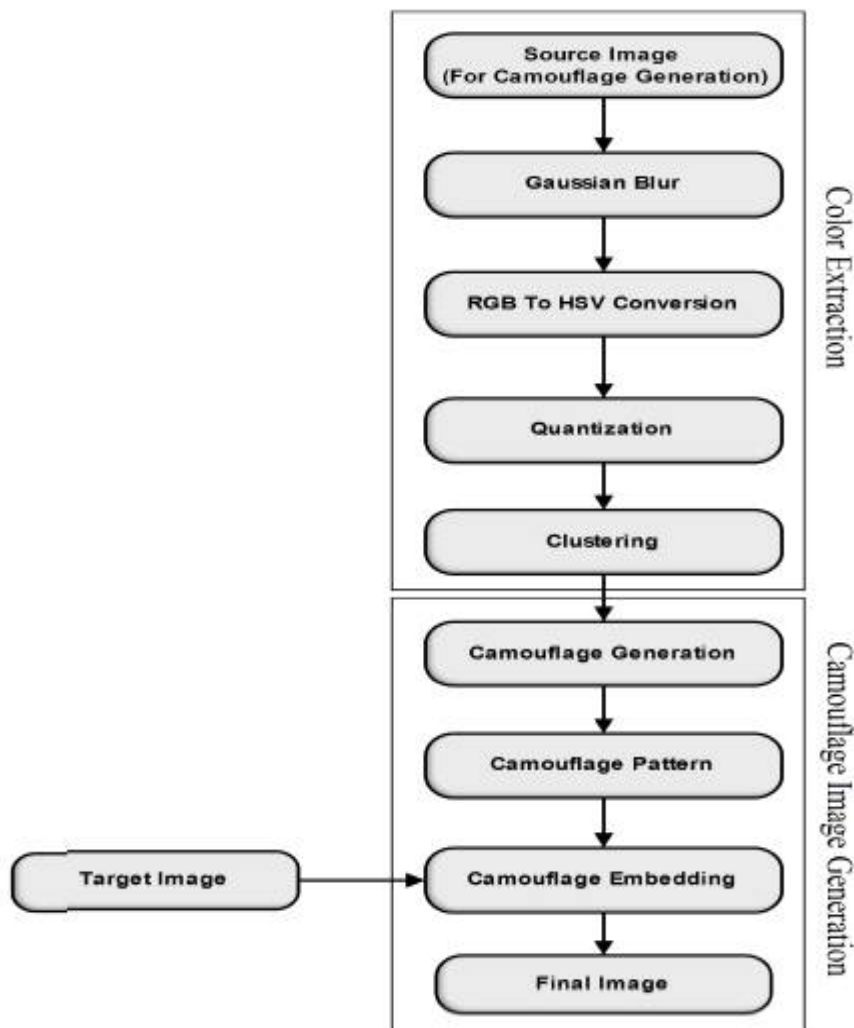


Fig 2: Block diagram of Camouflage image generation

As shown in above block diagram, firstly source image is loaded. Then blurring is done using Gaussian function, which reduces image noise and detail. Then after Red Green Blue model (RGB model) to Hue Saturation Value model (HSV) conversion is done of the image. Quantization of source image is done after conversion from RGB to HSV. Then clustering i.e. K-means clustering is applied based on required colour according to environment. After that a camouflage image is generated. Then patterns are generated of the camouflage image. Finally embedding of generated camouflage image and target image is done and finally we get the final camouflage image.

VI. CONCLUSION

By studying all the relevant papers and studying different algorithms we come to conclusion that every technique is different and unique in its own way. HSV colour conversion is superior to all other techniques because it increases high visual quality of image and can be used in many different fields. Hence, our proposed system is aimed to generate the perfect camouflage image.

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