# A Digital Image Watermarking Using Region Segmentation

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**Abstract:** This paper takes the region segmentation in image processing and the semantic importance in an image analysis into consideration for digital image watermarking. A semantic importance for an object region, which is segmented by specific features, is determined according to the contents of the region. In this paper, face images are the targets of watermarking for their increasing importance, the use of frequency and strong necessity of protection. A face region is detected and segmented as an object region and encoded watermark information is embedded into the region. Employing a masking and filtering method, experiments are carried out and the results show the usefulness of the proposed method even when there are high compression and a synthesis as a case of copyright infringement.

## 1. Introduction

With the explosive development and provision of the Internet network, the researches on digital watermarking have been highly studied. Previous studies in digital image watermarking have been focused on the signal processing techniques, especially in waveform coding. They are very useful for protecting copyright and the ownership when the images are conserved within a certain degree of attacks[1-7]. If some parts of original image are copied and used for synthesizing a new image, then it is impossible to detect one's watermark from the synthesized one because the watermark is spread over the original image. Only a part of the watermark, which is not enough to prove copyright and the ownership, remains in the newly synthesized image. The third party's attention is usually concentrated on a few regions and objects in an image but not on all of them. It is very important to detect one's own watermark as much as possible to prove copyright and the ownership even from the synthesized image. Embedding watermark information into regions of drawing attention can prevent illegal use of transformations and acts of exchanges efficiently. Watermarks can still be detected from the copied and synthesized images by embedding into the regions of drawing attention. This paper suggests a key solution to the above problem by employing the method of region segmentation in image processing and semantic importance in an image analysis. As the target images of watermarking face images are used for their increasing importance, the frequency of use and strong requirement of protection.

## 2. Face Image Processing

Currently, there is an increasing interest in face detection and segmentation due to the activities carried out in the MPEG-4 and MPEG-7 standardization processes. MPEG-4 applications raise a new necessity since the analysis algorithm should, not only detect the position of the face, but also segment it obtaining its actual shape. In the MPEG-7 context, face detection, as a previous process for face and person recognition, will help develop tools for enabling the user to access databases. Different approaches for the face detection problem have been studied in recent years. Some of the most representative work include shape-feature approaches, neural network approaches, and template matching approaches. Recently, a number of authors have used color and shape as important cues for face detection. In this study, both color and spatial information are exploited to detect segmented regions corresponding to face. Also, color and spatial information is used to merge image regions in the segmentation process.

### 2.1 Face Detection

Face detection is the first step, which is needed for face image processing. Color and spatial information is employed to detect face region in the proposed method. The proposed method is especially developed with simplicity in its algorithm in mind. Some difficult processes are avoided on purpose. A face image in the (R, G, B) color space is transformed into (Y, U, V) space. Y represents luminance, U and V represent color differences. Equation 1 is used for changing color coordinate system from (R, G, B) coordinate system to (Y, U, V) coordinate system.

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.3 & 0.59 & 0.11 \\ 0.7 & -0.59 & -0.11 \\ -0.3 & -0.59 & 0.89 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

The hue component for the detection of human skin color is computed from luminance and two color differences using the equation 2.

$$H = \tan^{-1}(U/V) \quad (2)$$

Face region is roughly estimated firstly from an input image using the distribution of the hue components of human skin color. With the detected hue component of human skin color, luminance of the pixels, which belongs to the detected hue component, is computed to get average luminance of the pixels. Mean variance of luminance is then computed for each pixel. Mean variance of luminance is then computed for each pixel. Center coordinate $(Cx \cdot Cy)$ of possible-face region is obtained with the mean variance of spatial X and Y coordinate by removing

the pixels, which exceed the mean difference of luminance mean variance.

$$Cx=\frac{1}{n}\sum_{n\in faceregion}^{n}X \qquad Cy=\frac{1}{n}\sum_{n\in faceregion}^{n}Y \qquad (3)$$

### 2.2 Region Growing

Region growing is one of the conceptually simplest approaches to image segmentation; neighboring pixels of similar amplitude are grouped together to form a segmented region. However, in practice, constraints, some of which are reasonably complex, must be placed on the growth pattern to achieve acceptable results. Region growing in the face image should consider facial parts. Roughly estimated face region by skin colors includes several empty regions, which have almost elliptical hole shapes, e.g., eyes, eyebrows, nostrils, and mouth, within the region. Making up these empty regions is carried out by finding out skin color pixels beyond the empty regions. If a pixel, which satisfies face color condition and is found out at the direction of up right, up left, down right, down left from the center point pixel in the empty regions, is filled up with the corresponding pixel in the original image.

## 3. Semantic Importance in Facial Image Analysis

The third party's attention is usually concentrated on a few regions and objects in an image but not on all of them. It is very important to detect one's own watermark as much as possible to prove copyright and the ownership even from the synthesized image, i.e. attacked one. Face images are characterized as private information. If every image should be classified by a certain information importance, they would be ranked at the highest or the first level. They are one of the most important items in managing secrecy of personal affairs and also are one of the mostly well-used images in our daily life. They can be easily found on ID cards, passports, documents and the Internet. Face and face part regions are very important in the semantic analysis of face images. Embedding watermark information into the regions of drawing attention can prevent illegal use of transformations and acts of exchanges. The reason of analyzing semantic importance in an image is to discriminate between the regions of visual interest and of indifference because the regions of visual interest have a strong tendency to draw the third parties' first attention when an image is shown. Watermarks can still be detected from copied and synthesized images by embedding into the regions of drawing attention. This approach will provide the highest credibility and safety for a management system of personal affair secrecy in the end.

## 4. Digital Image Watermarking

Digital watermarking is an application of data hiding. The embedded data is used to place an indication of ownership in the host signal, serving the same purpose as an author's signature or a company logo. A number of ways exist to hide information in digital images. Common approaches include least significant bit insertion, masking and filtering algorithms and transformations. Each of these techniques can be applied, with varying degree of success, to different image files. Watermark information is embedded into a region of visual interest using a masking and filtering algorithm. As a watermarking method DCT (Discrete Cosine Transform) is employed in this study among several waveforms coding because JPEG images use the DCT to achieve compression, and its popularity. The DCT is a lossy compression transform because the cosine values cannot be calculated exactly, and repeated calculations using limited precision numbers introduce rounding errors into the final result. Variances between original data values and rstored data values depend on the method used to calculate the DCT. The target image is a color image chosen from Akiyo sequence and has a size of 288 by 288. A monochrome image of KIST logo is used as a watermark. DCT described in equation 4 is performed 8 by 8 pixels as one block. $f(x,y)$ is an input image and $F(\mu,v)$ represents a transformed image.

$$F(\mu,v)=\frac{1}{4}C(\mu)C(v)\sum_{x=0}^{7}\sum_{y=0}^{7}f(x,y)\cos\frac{(2x+1)\mu\pi}{16}\cos\frac{(2y+1)v\pi}{16}$$

$$f(x,y)=\frac{1}{4}\sum_{\mu=0}^{7}\sum_{v=0}^{7}C(\mu)C(v)F(\mu,v)\cos\frac{(2x+1)\mu\pi}{16}\cos\frac{(2y+1)v\pi}{16} \qquad (4)$$

$$\mu=0 \quad C(\mu)=\frac{1}{\sqrt{2}} \qquad v=0 \quad C(v)=\frac{1}{\sqrt{2}}$$

$$\mu\neq 0 \quad C(\mu)=1 \qquad v\neq 0 \quad C(v)=1$$

### 4.1 DCT of the Target Image

The original image, which has a size of 288 by 288, is divided into $288^2/8^2$ blocks. 64 pixel values in one of blocks that belong to the regions of drawing attention are transformed using equation 4, then 64 frequency coefficients are obtained for the correspondent block. The number of the blocks that belong to the regions of visual interest are determined by the size of the segmented object, and the location of the blocks are also determined by the

positions of the blocks, which belong to the regions of visual interest.

### 4.2 DCT of the Watermark Image and Weighting Factors

A logo image, which has a size of 48 by 48 and employed as watermark information, is divided into $48^2/8^2$ blocks and the watermark is transformed also by equation 4. As a result, 64 DCT coefficients are obtained for each block. Multiplying these coefficients by weighting factors creates various combinations. There are two types of weighting factors. One is invariable and the other is variable to each DCT coefficient. The scale of weighting factor is limited by three factors mainly, human visual system, the endurance to data compression and the completeness of restored data. Each of these factors can be applied, with varying degree of success, to different image files. The complexity and difficulty of watermarking algorithm are determined by the order of coefficients that represents frequency components, the combination of coefficient used for encoding and of weighting factor.

The encoded watermarks, i.e., weighted and permuted DCT coefficients are spread over the blocks that belong to the regions of visual interest. This increases the complexity and difficulty of watermarking algorithm. The target image is inverse-transformed after watermark is inserted. Watermark information should be inserted invisibly and detected as much as possible after compression. The embedded watermark image is detected through the inverse-process.

## 5. Experimental Results

The general description of the suggested schemes is shown in figure 1. The region segmentation for a given image is carried out using some of the specific features of face. Region growing is done to make up holes that caused by facial parts after the detection of possible-face region. Noted (1) process in figure 1 represents the segmentation of face region and assignation of semantic importance to face region. Noted (2) process describes the insertion of encoded watermarking into the segmented face region. In fact, this process is carried out in the frequency domain. A watermark image, which is discrete cosine transformed, is manipulated by the scale of weighting factors and

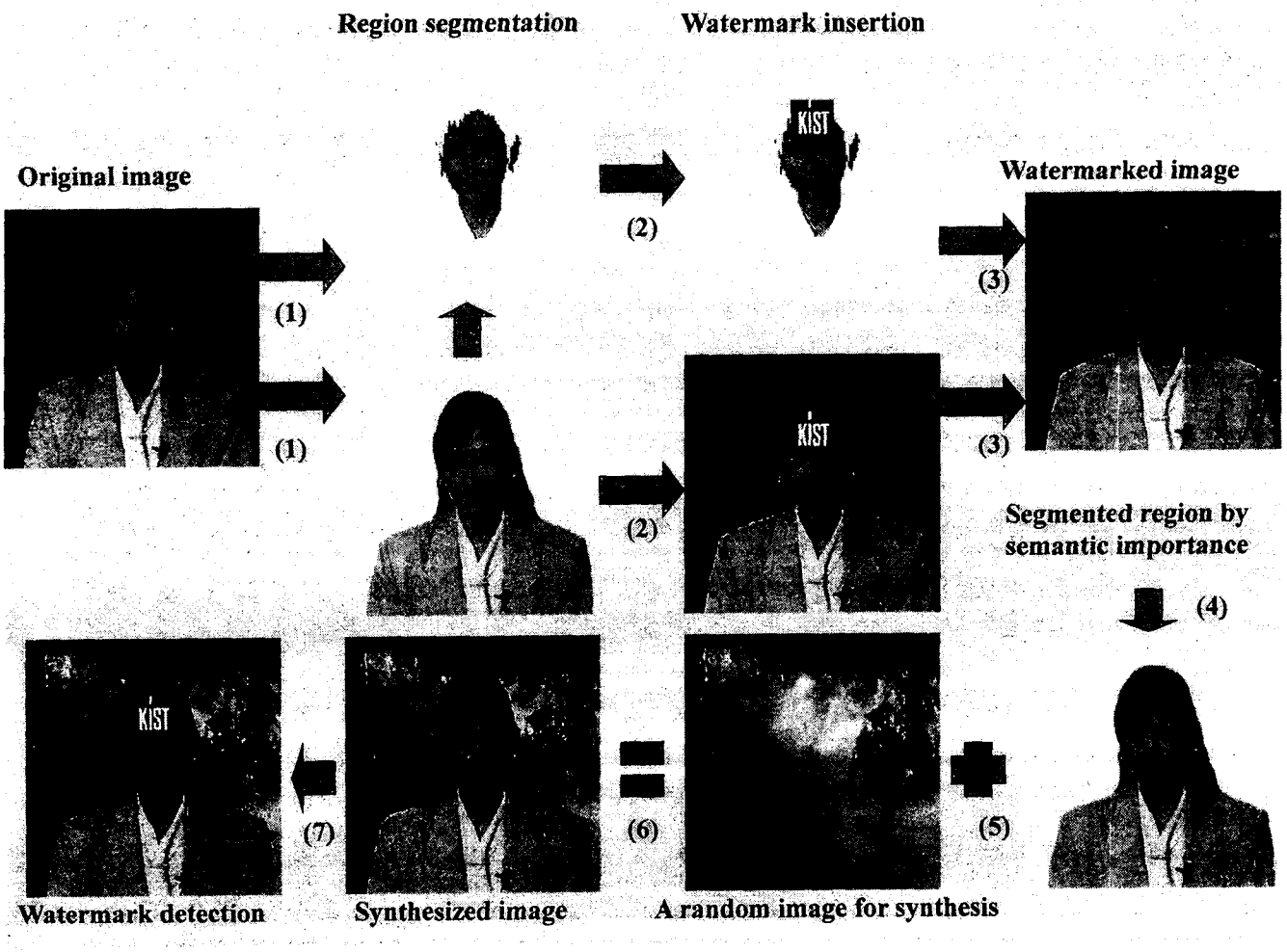


Figure 1. General description of the watermarking method using region segmentation and semantic importance

### 4.3 Insertion of Watermark into a Target Image

permutation of frequency components multiplied to weighting factors. Noted (3) process represents the original

image of inverse discrete cosine transformed after the insertion of watermark in the frequency domain. A case of copyright infringement is represented in process (4), (5) and (6). They describe that the third party segments the region of drawing attention and synthesizes it with another image. Noted (7) process reveals the ownership of the face region that belongs to the original image. In this study, the watermarking image that is shown in (3) is compressed using JPEG up to 5.5% of original image size. Figures 2 and 3 compare the watermark image with the detected one from the synthesized one. Detected watermark image went through JPEG compression and the synthesis process using region segmentation.

As shown in figures 2 and 3, some parts of the watermark image are lost for 6 the effect of JPEG compression. However, it is enough to prove to insist the ownership or copyright of the original image.


Figure 2.

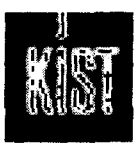


Figure 3.

## 6. Conclusion

In this paper, a method of watermarking based on the region segmentation in image processing and the assignation of semantic importance is presented. Experiments are carried out using Akiyo image sequence, which consists of 299 frames, based on the automatic detection of face region, the region segmentation by specific features of human face, the assignation of semantic importance that is included in the specific features of human face in this study, the masking and filtering approach in watermarking algorithms, and the synthesis technique that uses VOP (Video Object Plane) in MEPG-4. As a further works, a robust watermarking method of the face images, which can be applied to for both digital media and the printed matters, will be studied for their increasing importance, the frequency of use and the strong necessity of protection.

## 7. References

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