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Data hiding Using Texture Synthesis with Watermarking

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Abstract*: Data hiding ensures entire data access to users and protects data integrity by preventing unintended or intended changes. One of the data hiding method, steganography, is used for communicating secret data using appropriate multimedia carrier such as image, audio, and video files. The goal of steganography is to hide information in such a way that existence of communication is unknown by an attacker. This paper proposes a novel approach for steganography using reversible texture synthesis. It converts an image into texture image for steganography texture synthesis process. By consider this texture image as a source image for doing steganography method. A texture synthesis process resamples a smaller texture image, which synthesizes a new texture image with a similar local appearance and an arbitrary size. This paper makes the texture synthesis process into steganography for concealing secret messages. This algorithm conceals the source texture image and embeds secret messages using the process of texture synthesis. This allows us to extract the secret messages as well as source texture from a stego synthetic texture. This approach has some advantages. First, this scheme offers the embedding capacity that is proportional to the size of the stego texture image. Second, the reversible capability inherited from this scheme provides functionality, which allows recovery of the source texture. Then, apply a water marking method. This will help whether a given sender is authorised person or not.*

Keywords: texture synthesis, data hiding, steganography, watermarking, and texture image

1. Introduction

In today's world, the communication is the essential factor of every growing area. Everyone wants their communicating data very secretly and safely. In our daily life, we use many secure pathways like internet or telephone for transferring and sharing information, but it's not safe at a certain level. So, Steganography is used to share the information in a concealed manner [1]. The main objective of steganography is to hide information in a way that prevents the detection of hidden messages. Steganography means "covered writing". The application of steganography includes conversion of communication between two parties whose existence is unknown to an attacker and their success depends on detecting the existence of this communication [2].

In a stenographic system, the information-hiding process is started by identifying a cover medium's redundant bits (Bits can be alter without destroying that medium's integrity).The embedding process replaces these redundant bits with data from the hidden message to form a stego medium.[3] The goal of steganography is to keep the secret message undetectably. Most stenographic methods take over an existing image as a cover medium. When embedding secret messages into this cover image, distortion of image may occurs. Because of this reason two drawbacks occur .First, the size of the cover image is fixed, so more secret messages are embedded allow for more image distortion. Therefore to maintain image quality it will provide limited embedding capacity to any specific cover image. Second, that image steganalysis approach is used to detect hidden messages in the stego image. This approach can defeat the image steganography and reveals that a hidden message is being carried in a stego image.

This paper proposes a combination of steganography and texture synthesis process .The process of re-samples a small texture image drawn by an artist or captured in a photograph in order to synthesize a new texture image, which have a similar local appearance and arbitrary size is called texture synthesis [4]. This paper combines the texture synthesis process into steganography to conceal secret messages as well as the source texture. The secret messages and the source texture can be extracted from a stego synthetic texture.

This paper introduces a new algorithm for image texture synthesis. In this approach, patch regions from a sample image are transformed and copied to the output and then stitched together along optimal seams to generate a new (and typically larger) output [5]. Using this algorithm, it can be generate a texture image from a single image. This project present a new method to generate an infinite pattern from a small amount of training data, using a small example patch of the texture, it generate a larger pattern with similar stochastic properties. Specifically, this approach for texture synthesis generates textures by copying input texture patches. The algorithm first searches for an appropriate location to place the patch; it then uses a graph cut technique to find the optimal region of the patch to transfer to the output.

This project also applies water marking method to provide authenticity of the stego image. Digital watermarking techniques have been utilized to maintain the copyright of digital data by identifying the owner or distributor of digital data. Watermarking is the process of embedding hidden information called a watermark into the digital media, such that the watermark is imperceptible, robust and difficult to remove or alter .This paper proposes a new colour image watermarking scheme [6], which is based on embedding a watermark into a circular normalized image in the discrete wavelet domain.

2. Related Works

Texture synthesis has received a lot of attention recently in computer vision and computer graphics. The most recent work has focused on texture synthesis.[7] present a video texture synthesis method. First, a new frame signature is used to capture both the spatial and temporal information. Based on the frame signature, the most appropriate matching pairs of frames are identified. Second, a diffeomorphic growth model is applied to matching frames identified. The diffeomorphic growth model can produce temporal motion around matching frames and estimate virtual frames which lead to smoother transition.

L. Liang, C. Liu[8] presented an algorithm for synthesizing textures from an input sample. This patch-based sampling algorithm is very fast and it creates high-quality texture image. This algorithm works well for a wide variety textures likes regular to stochastic textures. Can be sampling patches using a nonparametric estimation of the local conditional MRF density function .Also avoid mismatching features across patch boundaries of an image.

The building blocks of the patch-based sampling algorithm are patches of the input sample texture to construct the synthesized texture. We can carefully select these patches of the input sample texture and paste it into the synthesized texture to avoid mismatching features across patch boundaries. Patch-based sampling algorithm combines the nonparametric sampling and patch pasting strengths .The texture patches in the sampling scheme provide implicit constraints to avoid garbage found in some textures.

M. F. Cohen [9] have used to implement an interactive application for texture design and synthesis. Texture is an image which has locality and stochastic property. Locality means small part of the image is look alike and they never look exactly the same (Stochastic). To overcome the memory consumption problems of large images , generates a technique for tiling small images to fill a large area. We often needs large texture images. So, we need to create large image from small samples .just tiling the samples is not a good method. Wang tile method is used for tile the plane with appropriate samples based on matching colors of adjacent edges.

If the set of tiles is rich enough and there is no periodicity, we can fill inside the tiles anything we want such as texture, geometric primitives etc. Using this method the user can fill Wang tiles on her own. The system interactively displays the result of the tiling. Using Wang Tiles method, once the tiles are filled, can be creates large expanses of non-periodic texture as needed very efficiently at runtime. Wang Tiles are squares shaped and each edge is has a color. A valid tiling requires matching colors to all shared edges between tiles. Another advantage is that, using a small set of tiles created from sample patches of a source image a highly compact representation for texture is achieved. If the two source images contain distributions of differing densities allows the creation of less uniform textures using two source images. An efficient real-time rendering of complex scenes can be done with modern graphics hardware by combining Wang Tiles with Layered Depth Images.

A. A. Efros and W. T. Freeman [10] proposed a method for generates a new image by stitching together small patches of existing images. This process is known as image quilting. It is very fast and simple texture synthesis algorithm. By extend this algorithm to perform texture transfer operation.

In patch-based texture synthesis procedure, define the square block of user-specified size from the set of all such overlapping blocks in the input texture image. To synthesize a new texture image, let us simply tile the blocks taken randomly from the input texture image. Next step is to introduce some overlap in the placement of blocks onto the new image. Now, search source texture for such a block that agrees some measure with its neighbors along the region of overlap .At last, let the blocks have ragged edges which will allow them to better approximate the features in the texture. Before placing the block into the texture can be calculates error in the overlap region between it and the other blocks. Then find a minimum cost path through that error surface and find boundary of the new block.

3. Steganography and Watermarking in Texture Images

The paper focuses on generating texture image from a single image for hiding secret data in the texture image. The texture image acts as a source image for data hiding process. This process is done by graph cut method [11]. In this method, first need to choose a matching quality measure for pixels from the old and new patch. In the graph cut version of this problem, the selected path will run between pairs of pixels. The simplest quality measure will be a measure of colour difference between the pairs of pixels.

In message embedding procedure, uses source texture image to perform message oriented texture synthesis for hide secret data [12]. first divides the source texture image into image block, called patches. To produce an index table for recording the location of the corresponding source patch. Establish a blank image as workbench where it's size is equal to the synthetic texture .Then paste the source patches into workbench by referring the source patch IDs stored in the index table to produce a composition image. From this, it gets half-filled patches in the blank image. To fill remaining portions of work place, find Mean square error of overlapped region between the synthesized area and the patch which want to place. Ranking these patches based on increasing order of Mean Square Error .Then select patches from list where its rank equals the decimal value of an n-bit secret message. Then we get stego synthetic texture.

Then it performs watermarking method for copyright protection in the stego texture image. Watermarking is based on embedding a watermark into a circular normalized image in the discrete wavelet domain. That is,it embedding multiple watermark bits into the luminance component of a colour image in discrete wavelet domain. The scheme uses image normalization technique to reduce the effect of synchronization errors caused by geometric attacks such as rotation.

In message extracting procedure, the index table can be generated by using secret key in the receiver side. The size of the source texture can be retrieved by referring each patch region and its corresponding order in the index table. Arrange blocks based on their order. To paste the source patches into a workbench to produce a composition image.

Consider the current working location on the workbench and also refer the corresponding stego synthetic texture at the same working location to determine the stego block region. Then, based on this region, to search candidate list to determine if there is a patch in the candidate list where its kernel region is the same as this region. If this matched patch is available, and then can be locate the rank of that matched patch, and this rank represents the decimal value of the secret bit in the stego patch when operating the texture synthesis in the message embedding procedure.

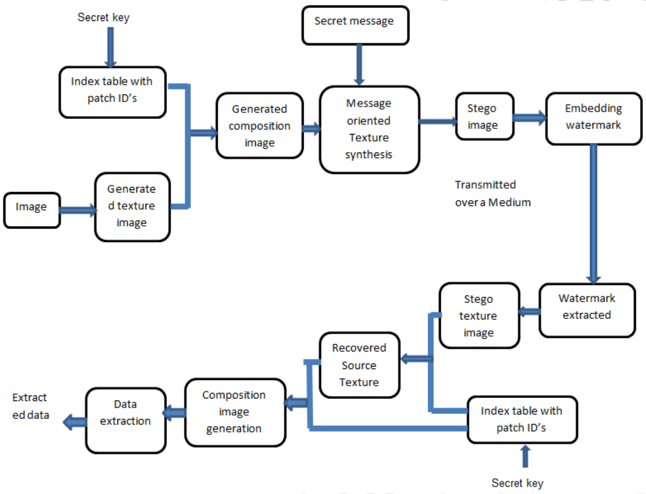


Figure 1: The Block diagram of Message Embedding and Extracting Process

3.1 Texture Image Generation

A graph cut technique is used for converting an image to texture image. This technique is generating a newer form of output from a smaller example. This approach for texture synthesis generates textures by copying input texture patches. This algorithm first search for an appropriate location to place the patch .It then uses a graph cut technique to find the optimal region of the patch to transfer to the output.

In this approach, patch regions from a sample image are transformed and copied to the output and then stitched together along optimal seams to generate a new output. The proposed method presents a new method to generate such an infinite pattern from a small amount of training data; using a small example patch of the texture, it generates a larger pattern with similar stochastic properties. Specifically, this approach for texture synthesis generates textures by copying input patches. This algorithm first search for an appropriate location to place the patch, it then uses a graph cut technique to find the optimal region of the patch to transfer to the output.

In graphcut technique, it needs to choose a matching quality measure for pixels from the old and new patch. In the graph cut version of this problem, the selected path will run between pairs of pixels. The simplest quality measure, then, will be a measure of colour difference between the pairs of pixels. Let s and t be two adjacent pixel positions in the overlap region. Also, let A(s) and B(s) be the pixel colours at the position s in the old and new patches, respectively. It define the matching quality cost M between the two adjacent pixels s and t that copy from patches A and B respectively to be:

$M(s, t, A, B) = \| A(s) - B(s) \| + \| A(t) - B(t) \|$ where $\| . \|$ denotes an appropriate norm.

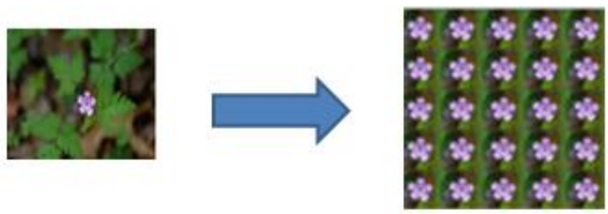


Figure 2: Texture Image Generation Process

3.2 Index Table Generation

An index table is used to record the location of the source patch set in the synthetic texture. The index table allows us to access the synthetic texture and retrieve the source texture completely. In this index table, the entries with non-negative values indicate the corresponding source patch ID subdivided in the source texture, while these entries with the value of -1 represent that the patch positions will be synthesized by referring to the secret message in the message oriented texture synthesis.

3.3 Composition image generation

This algorithm is used to paste the source patches into a workbench to produce a composition image. First, it establishes a blank image which acts as workbench where the size of the workbench is equal to the synthetic texture. By referring to the source patch IDs stored in the index table, paste the source patches directly into the workbench.

3.4 Message oriented texture synthesis

This process will embed the secret message via the message-oriented texture synthesis to produce the final stego synthetic texture. A segment of the n-bit secret message has been concealed into the selected patch to be pasted into the working location.

From composition image generation process, we get half-filled patches in the blank image. To fill remaining portions of work place, find Mean square error of overlapped region between the synthesized area and the patch which want to place. We get patches from the source image, in which we employ a window and then travel the source texture by shifting a pixel each time following the scan-line order. Ranking these patches based on increasing order of Mean

Square Error .Then select patches from list where its rank equals the decimal value of an n-bit secret message. Then we get stego synthetic texture.

3.5 Watermark Embedding Process

Digital watermarking techniques have been utilized to maintain the copyright of digital data by identifying the owner or distributor of digital data. Watermarking is the process of embedding hidden information called a watermark into the digital media, such that the watermark is imperceptible, robust and difficult to remove or alter. This paper proposes a new colour image watermarking scheme, which is based on embedding a watermark into a circular normalized image in the discrete wavelet domain [13].

In the proposed watermarking scheme, the Luminance (Y) component in YIQ (Luminance, Hue, and Saturation) or the blue component in RGB (Red, Green, and Blue) colour models is obtained from the original image for embedding the watermark. Second, circular image is obtained from(Y) component or blue component; then the rotation normalization is performed on the circular image. As a result, the watermark synchronization problem during the detection process can be reduced. Next, a square sub-image is obtained from the normalized circular image and decomposed in L-decomposition levels using DWT. The watermark is embedded in the highest level of the wavelet decomposition excluding the coarsest LL-subband. The watermark embedding algorithm is defined as follows:

Diff= $|V_{Max1}|-|V_{Max2}|$

$$V^*_{Max1} = \begin{cases} |V_{Max1}|+\alpha & W=1 \ \& \ Diff>T \\ |V_{Max1}|+T+\alpha & W=1 \ \& \ Diff<T \end{cases}$$

$$V^*_{Max2} = \begin{cases} |V_{Max2}|+\alpha & W=0 \ \& \ Diff\leq T \\ |V_{Max2}|+Diff-\alpha & W=0 \ \& \ Diff>T \end{cases}$$

Where V_{Max1} and V_{Max2} are the absolute values of the largest DWT coefficients in selected blocks of size m*m, α is the watermark embedding strength, and T is a predetermined threshold.

After embedding watermark bits, L-level inverse wavelet transform is applied. Finally, the inverse rotation normalization is performed on the watermarked normalized circular image and the watermarked image is reconstructed.

3.6 Watermark Extraction process

The proposed watermark extraction process is performed without use of the original image. First, the Luminance (Y) component or the blue component of the original image is selected to embed the watermark. A circular image is obtained from the selected component with diameter equal to the size of the original image. The circular image is normalized. The circular image cannot be transferred directly into frequency domain. Therefore, extract a subimage from the normalized circular image because zero-padding operation will introduce error after applying the inverse transform method such as DWT. Decompose the extracted subimage by L-levels using DWT. The watermark bits are extracted from the watermarked blocks. The watermark bit is extracted as given below:

$$W^*_i = \begin{cases} 1 & \text{if } |V^*_{Max1}|-|V^*_{Max2}|> T \\ 0 & \text{otherwise} \end{cases}$$

Where V^*_{Max1} and V^*_{Max2} are the absolute values of the largest DWT coefficients in selected blocks of size m*m, and T is pre-defined threshold.

3.7 Source Texture Recovery

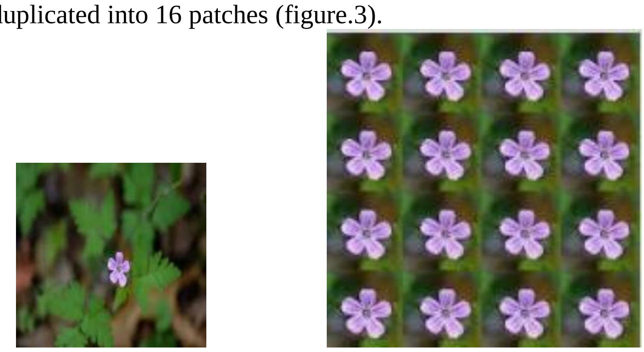
Using secret key held in the receiver side, the same index table as the embedding procedure can be generated. The next step is the source texture recovery. To recover source texture, each patch and its corresponding order can be retrieved by referring to the index table. Then arrange these patches based on their order, thus retrieving the recovered source texture which will be exactly the same as the source texture.

3.8 Message Extraction

Paste the source patches into a workbench to produce a composition image by referring to the index table. Constructs a candidate list based on the overlapped area by referring to the current working location and rank them. Compare the current working location Cur(WL) on the workbench and corresponding stego synthetic texture at the same working location Stg (WL) to determine the stego patch region SKw x SKh. Then, based on this stego kernel region, search the candidate list to determine if there is a patch in the candidate list where its kernel region is the same as this stego kernel region. This patch is refer to as the matched patch MKw x MKh. Then locate the rank R of the matched patch, and this rank represents the decimal value of the secret bits that is conveyed in the stego patch.

4. Implementation and Analysis

In the proposed method, the image is cut at a specified width and height. Also can be specifies number of patches. Here the image is cut into 120x75 height and width respectively and it duplicated into 16 patches (figure.3).



(a) (b)

Figure 3: (a) Flower image (b) Texture image or source image

In figure 4, arrage these 16 patches into a blank image(sky colored image) to produce a composition image.

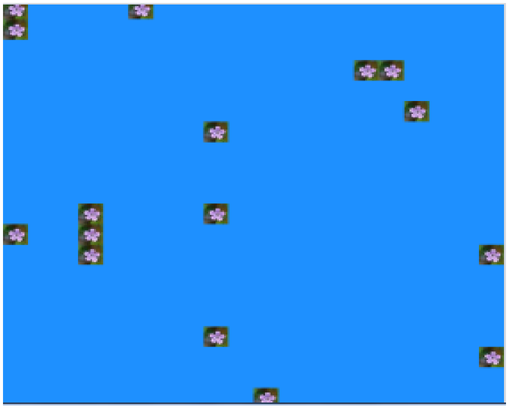


Figure 4: Composition Image

The same source image is cut into different patches by shifting the pixels in scan line order.Then place these patches into remaining portion of the composition image. Embed the secret message into remaining portion of the composition image(Figure 5)

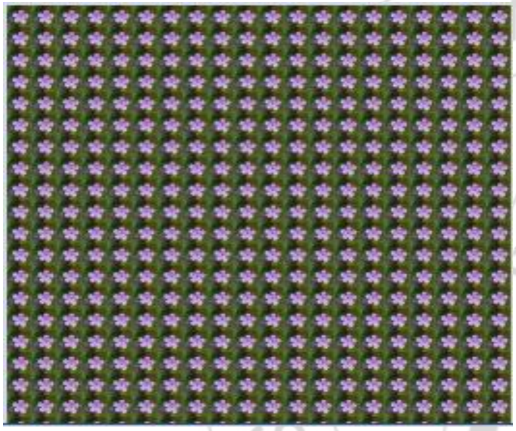


Figure 5: Secret Message Embedded Texture Image

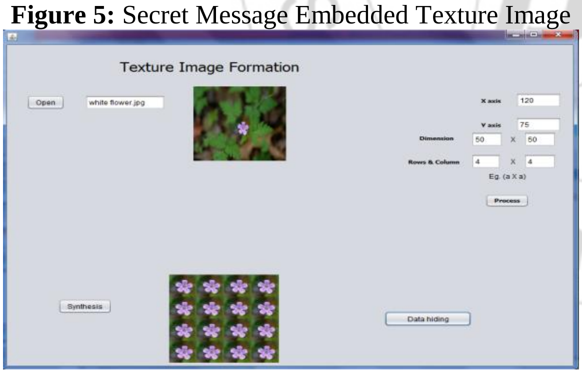


Figure 6: Generating texture image from an image

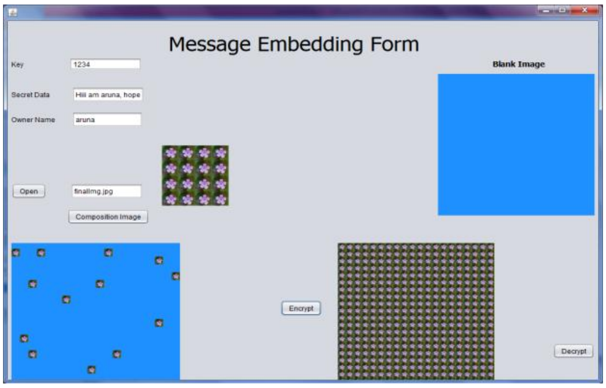


Figure 7: Embedded data

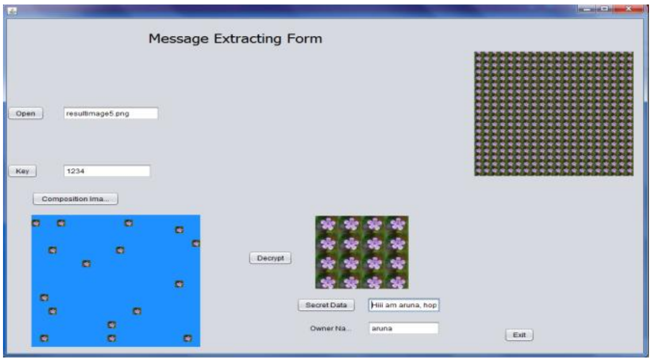


Figure 8: Extracted data

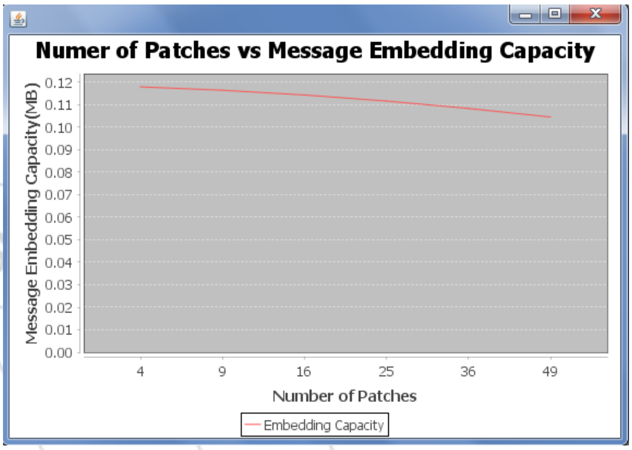


Figure 9: Performance Graph

Figure 9 shows performance graph of proposed method, where x-axis represents number of patches and y-axis shows message embedding capacity. From this graph, it is clear that if no.of patches in the source image increases then message embedding capacity decreases.

Figure 10 shows the comparison graph between existing and proposed method. By comparing with the existing similar methodologies, the proposed system performs more efficiently. It results in good accuracy and has high performance.

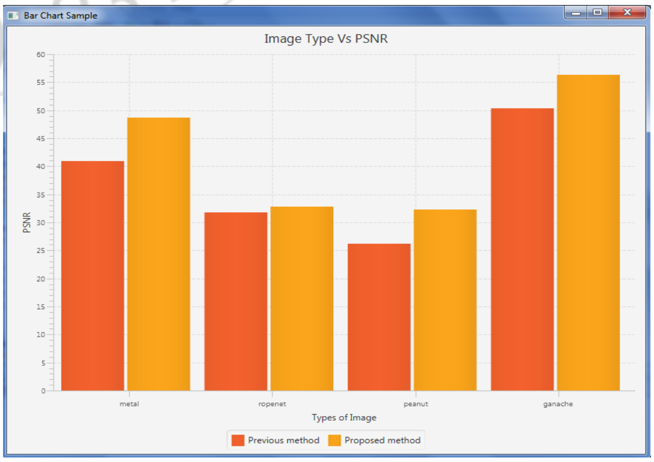


Figure 10: Comparison Graph

A comparison graph is plotted with Peak signal-to-noise ratio (PSNR) against types of images. By considering four images such as metal, ropenet, peanut, ganache, the graph shows that the proposed method has high PSNR value by comparing existing method.

5. Conclusion

The paper proposes a steganographic algorithm using reversible texture synthesis. It can synthesize a cover image in to texture form which is increased in size according to user desire. This method produces a large stego synthetic texture for concealing secret messages. It also provides reversibility to retrieve the original source texture from the stego synthetic textures, making possible a second round of texture synthesis if needed. Using this method, it can be constructed a texture image from any image for making a source image. A watermarking method is applied for preventing unauthorised access.

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