HSV COLOR MODEL BASED ADVANCED IMAGE ENCRYPTION TECHNIQUE USING XOR AND SUBTRACTION OPERATION

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***Abstract*— Image security is one of the major concern nowadays because of the tremendous growth of image transmission over the internet for various purposes. Therefore, protecting the image from unwanted attacks and unauthorized access has become a crying need in the modern world. To prevent our personal and confidential image from various security attacks, a huge number of image encryption algorithms has been introduced till now. But still there exist some limitations in the encryption system that we need to work on, in order to make it more secure by applying a reliable and efficient encryption technique that is strong enough to protect the image from any kind of possible attacks. In this paper, an advanced color image encryption technique using HSV color model has been proposed. We convert the RGB color image to HSV format for better security purpose.**

***Index Terms*—Image, Encryption, HSV color model, XOR operation, Efficiency.**

I. INTRODUCTION

Most of the image encryption algorithms use RGB color format to encrypt a color image. So, there may be hackers intelligent enough to decrypt the RGB color image. Therefore, we need to come up with a different solution to deal with the upcoming challenges like converting the RGB image to other color formats such as CMYK, HSV, HSL, YCbCr etc. Here, we propose a smart way to encrypt image using its HSV color model. In general, the HSV color format, which stands for Hue, Saturation, and Value, is used for human perception of an image but in this paper, we will use this HSV color format for completely different purpose. We will convert the RGB color image to HSV color format to make the image encryption more complex and stronger. After converting the image into HSV format, we will apply permutation algorithm to encode the pain HSV image into Cipher HSV image. R, G, and B components of a digital image are all correlated with the amount of light striking onto the object. Due to this reason, image descriptions in terms of those components make object discrimination difficult. Descriptions in terms of hue saturation are often more relevant. The complexity of this technique is much better than the RGB color image encryption. There is no single channel in RGB color space which is fully devoted to luminosity. Also, RGB color space is a device dependent color space. These are the reasons we have not chosen RGB color space and adopted HSV color space in our approach [9].

II. RELATED WORKS

There has been a satisfactory number of researches done regarding RGB color image encryption and image encryption using permutation algorithm. Also, there were several works on HSV color image encryption.

A chaotic color image encryption using integrated bit-level permutation was proposed by Lin Teng & Xingyuan Wang & Juan Meng in 2017 where they converted the color image into three bit-level images (R, G, B components) and combined them to one bit-level image. Then, they only used bit-level permutation architecture based on the chaotic system to encrypt the integrated image [1].

Color Image Encryption in CIE L*a*b* Space is another approach that encrypted color image in CIE L*a*b* color space. First, they converted RGB to L*a*b* color space. The 2D Arnold's cat map followed by the 3D Lu chaotic map is conducted in the L* channel. This experiment method achieved similar results with the method that conducts the same scheme in each channel of the RGB color space. But the benefit of this method is, it consumes less time. Additionally, this method can resist several attacks such as brute-force attack, statistic attack, correlation attack [2].

Color Image Encryption in YCbCr Space by Xin Jin, Sui Yin, Xiaodong Li1, Geng Zhao1, Zhaohui Tian, Nan Sun, Shuyun Zhu implemented a new color image encryption method in the YCbCr color space and respectively compared the encryption method to that in RGB and L * a * b *. The result shows that the effect is equally good and encryption and decryption speed is much faster than L * a * b * space. In this paper, they adopted 1D logistic map, the 2D Arnold's cat map and the 3D Lu map [3].

Phase Image Encryption of Colored Images Using Double Random Phase Encoding Technique in HSV Color Space by Madhusudan Joshi, Chandra Shekhar, and Kehar Singh came up with a method that used a double random phase encoding based digital phase encryption technique. The RGB input image was converted to HSV color space and then converted into phase, before the encryption. In the decryption process, the HSV image was converted back to the RGB image. The random phase codes were used during encryption that was prepared by three two-dimensional random phase masks. These random phase codes serve as keys for encryption and decryption. The proposed technique carries all the advantages of phase encryption [4].

III. HSV COLOR MODEL KEY IDEA

HSV color model defines any color image in accordance with three basic features of the image. These are – Hue (H), Saturation (S) and Luminance (V). [5] Hue is a color attribute and represents a dominant color. Saturation is an expression of the relative purity or the degree to which a pure color is diluted by white light. In the HSV model, the luminous component (brightness) is decoupled from color-carrying information such as hue and saturation [6]. This HSV model was first introduced by Alvy Ray Smith in 1978. It is a nonlinear transformation of RGB model [5]. A three-dimensional representation of the HSV color space is a hexacone, where the central vertical axis represents the Intensity.

Hue can be determined as an angle in the range [0,2π] along to the red axis with red at angle 0, green at 2π/3, blue at 4π/3 and red again at 2π. Saturation is the depth or intensity of the color and is measured as a radial distance from the middle axis with the value between 0 at the center to 1 at the outer surface [7]. HSV has similar value intensity as red intensity in RGB model. Hue and saturation in HSV color space have very short intensity range [8].

IV. PROPOSED APPROACH

In our proposed approach, we will divide the whole image encryption process into two basic subparts. First of all, we will convert the RGB color model into HSV color space image. After that, we will apply permutation algorithm in the HSV image to convert it into a nonreadable format.

RGB to HSV

There are lots of approaches for converting the color image into its HSV form. The formula which transfers from RGB to HSV is defined as below:

$$H = \cos^{-1}\frac{1/2[(R-G)+(R-B)]}{\sqrt{(R-G)^2}+(R-G)(G-B)}$$

$$S = 1 - \frac{3}{R+G+B}(\min(R, G, B))$$

V = 1/3 (R+G+B)

The R, G, B represent red, green and blue components respectively with a value between 0 - 255. In order to obtain the value of H from 0o to 360 o, the value of S and V from 0 to 1, we do execute the following formula:

H= ((H/255*360) mod 360

V= V/255

S= S/255 [11]

In MATLAB we can use the rgb2hsv function to convert any RGB image into HSV.

Encryption of HSV color Space

As because hue represents the dominant color of an image, we will derive the key image from this hue section.

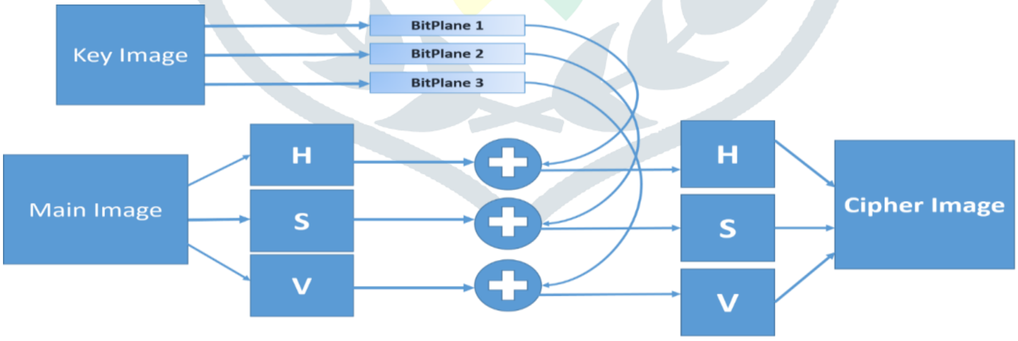
First, we will rotate the Hue component of the image by θ. θ can be any degree from -180 to +180.

Therefore, H = H+ θ.

The value of θ will be chosen by applying random number generator in MATLAB that can generate random numbers within a specific range. In our approach, we will specify the range from -180 to +180.

This new image will be our key image that we will use to encode the HSV color image. In our proposed method we will encrypt the image by using HSV displacement. We will perform XOR operation between the key image and the HSV color model of the original image. The idea of HSV displacement is a modification of the idea of RGB displacement that was proposed by Shrija Somaraj, Mohammed Ali Hussain in 2016 [13]. The decryption technique will be the vice versa of the encryption technique. The diagram for the encryption mechanism is illustrated in figure 3.

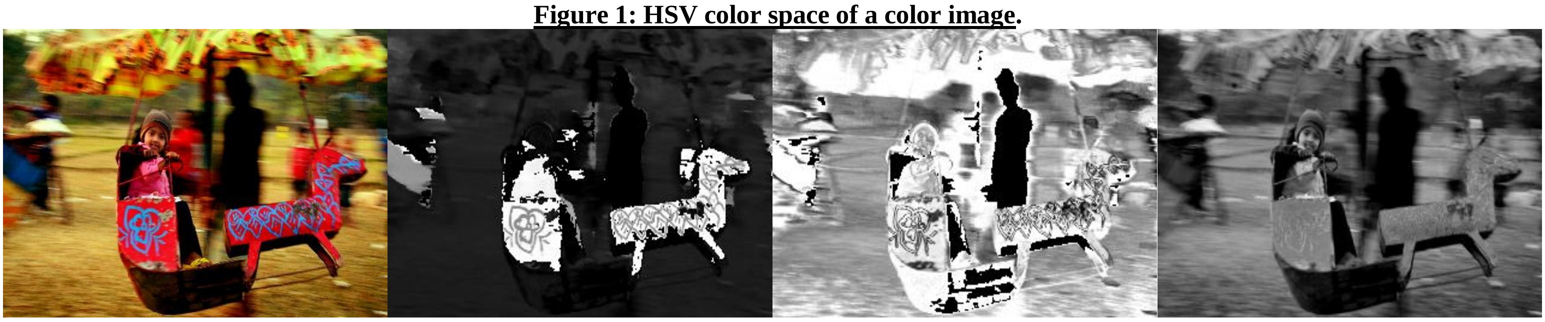
Figure 3: Block diagram of the encryption technique.



V. EXPERIMENTAL RESULTS

Figure 1 shows the three separate view of HSV image after converting it from the original image.

Figure 1: HSV color space of a color image.



Original Image **Hue** **Saturation** **Value**

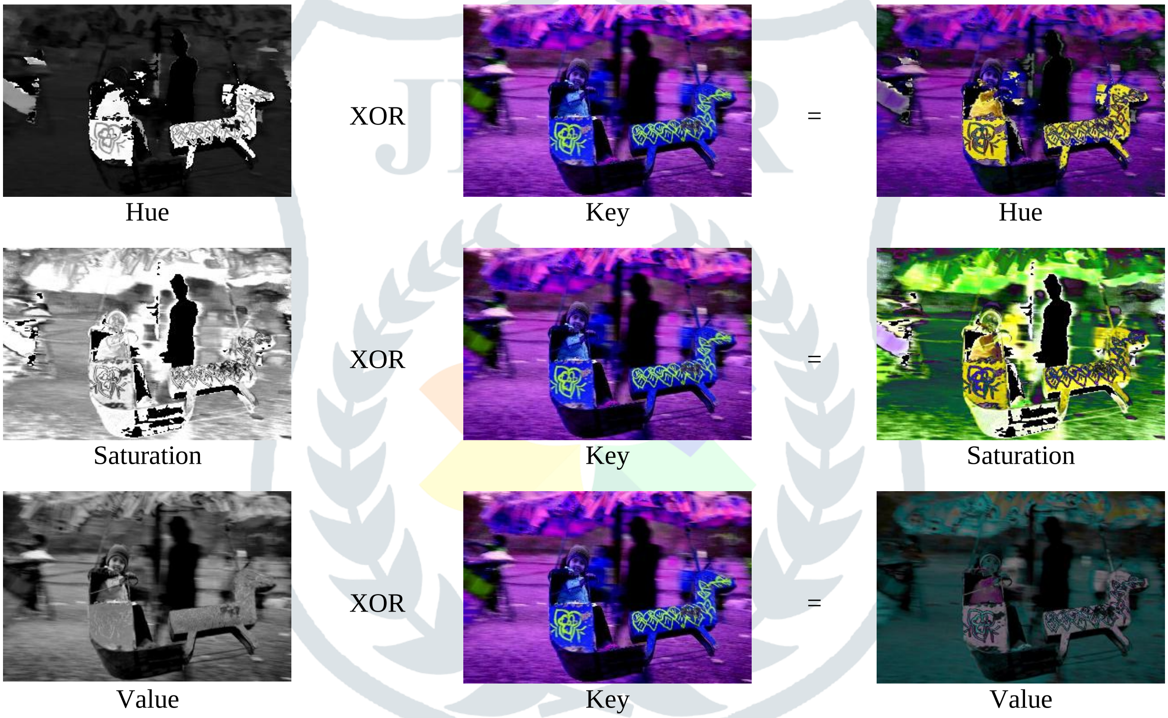
Figure 2 shows the difference between the original hue image and the image after rotating it 5 degrees.

Figure 2: Rotating hue of the image -120 degrees.

Key Image = Hue (-120°)

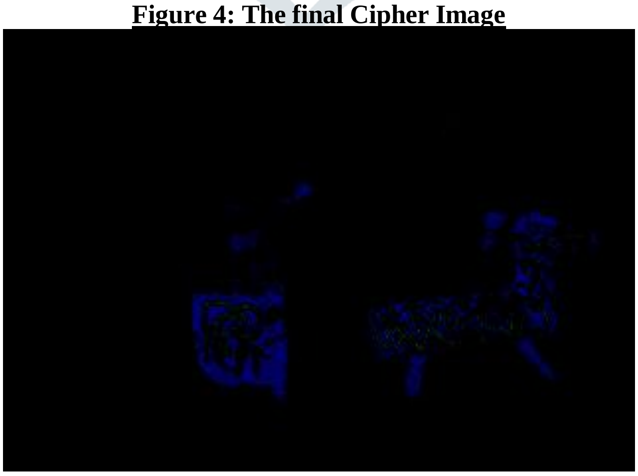
This new hue image will be our key image that we will use to encode the HSV color image. Figure 3 shows the outcome of the three XOR operation of HSV color space and the key.

Figure 4: XOR result of HSV color model and key.



After subtracting the three result from HSV color space, we will get the final cipher image which looks like figure 4.

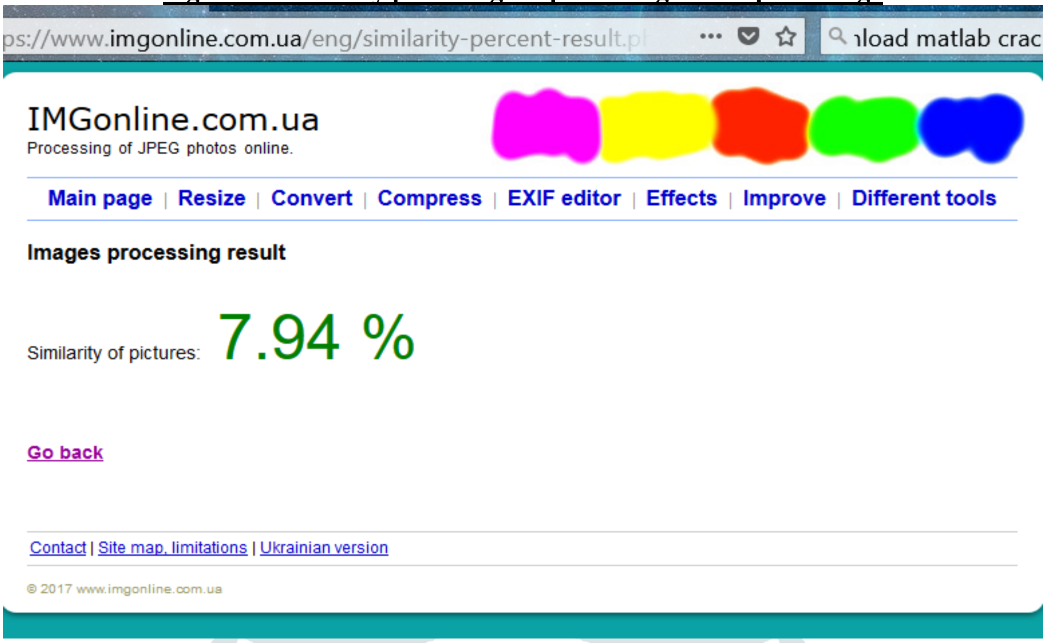
Figure 4: The final Cipher Image



Cipher Image

We compared the cipher image with the original image and found 92.06 % difference between two image which is very efficient and difficult to decrypt. Figure 4 shows the online result of the comparison of the plain image and cipher image.

Figure 4: Similarity percentage of plain image and cipher image



VI. CONCLUSION

After doing all the calculations and practical implementation, we found that this method is less time to consume and as well as efficient and strong. We did not employ any key from outside rather than we deployed the key from the original image. Also, we used HSV color model which is more complex to decrypt in comparison with RGB model. We used only two mathematical operations for encryption which are XOR and SUBTRACTION. In total, we used only four mathematical functions. This made the approach very easy to implement on the other hand effective approach for image encryption. In future, our main goal will be to increase the difference between plain image and cipher image above 95%.

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