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# Information Hiding Scheme on Modified Least Significant Bits Using Bit Position and Bit Count in Medical Images

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**Abstract:** Information hiding techniques are related to hiding the secret information in digital media without distortion. In this study, a new information hiding scheme using bit position and bit count in the pixel is proposed to provide high embedding capacity. The proposed method divides one pixel into two regions high and low region and counts the number of 1's value on bit position for each region to decide the length of embedding secret bits. The proposed embedding algorithm hides the secret bit depending on the bit count. The experimental results show that the proposed method has strength on embedding capacity without distortion to the human visual system.

**Key words:** Information hiding, data hiding, steganography, least significant bit, position, distortion

## INTRODUCTION

Multimedia data such as image, audio and video are being produced gradually and becomes easily spread over internet in recent years. Information hiding technique is one of information security technologies that can conceal the existence of secret information from third party (Khan *et al*., 2014; Subhedar and Mankar, 2014; Jung and Yoo, 2015). Information hiding techniques can divide into irreversible data hiding and reversible data hiding methods whether the cover-object can recover from the stego-object or not. The least significant bit substitution and pixel-value differencing schemes are well known in irreversible data hiding and histogram shifting and difference expansion schemes are general techniques in reversible data hiding. The least significant bit replacement is a general technique that can hide the secret bit into right bits of a pixel within permitting image distortion to the human visual system. Wu and Tsai (2003) proposed the pixel-value differencing to hide the secret bit more on the edge area by calculating the difference of two consecutive pixels. Tian proposed a reversible data hiding based on difference expansion to provide high embedding capacity and low image distortion (Tian, 2003). Ni *et al*. (2006) proposed histogram shifting based reversible data hiding where zero and peak points on the histogram graph was used.

Additionally, there are many kind of works based on least significant bit replacement techniques (Khodaei and Faez, 2012; Ker, 2005; Mielikainen, 2006; Chan and Cheng, 2004; Chang *et al*., 2002; Wang *et al*., 2001; Xu *et al*., 2016; Thien and Lin, 2003). The least significant bit matching is that one bit value is added or subtracted randomly when the embedding secret bit does not match. The revisited least significant bit matching was proposed to improve the image quality by minimizing the number of modification. In addition, the optimal least significant bit substitution, the genetic algorithm based least significant bit substitution and the modulus least significant bit replacements were proposed to improve the image quality. In this study, a new information hiding scheme using bit position and bit count in the pixel is proposed to differentiate the length of embedding bits by calculating the number of 1 on most significant bits in one pixel rather than traditional least significant bit based data hiding methods have.

**Literature review:** The least significant bit replacement is a basic technique to hide the secret bits in some bits of each pixel of the cover image (Jung and Yoo, 2015). Suppose that the k-bit of the secret data can be embedded into the k-right most least significant bits of the cover image. For a pixel value $p_i = (b_7b_6b_5b_4b_3b_2b_1b_0)_2$ and the secret bit stream $s_i$ a new pixel value $p'_i$ is calculated by Eq. 1:

$$p_i^{'} = p_i - \left(p_i \bmod 2^k\right) + \sum_{i=0}^{k-1} s_i \quad (1)$$

The secret bits can be extracted from the new pixel value directly by Eq. 2:

$$s_i = p_i^{'} \bmod 2^k \quad (2)$$

For example; $s_i = 100_2$ and $p_i = 115$ are given for the length of embedding bits k = 3. A new pixel value

$p'_i = 115 - (115 \bmod 8) + 100_2 = 115-3+4 = 116$ is calculated. In extraction method, the secret bits $s_i$ = 116 mod 8 = 4 = $100_2$ can be extracted without any extra information.

## MATERIALS AND METHODS

The proposed method has three steps. Fist, a pixel is divided into high and low regions and the number of 1's value is calculated to decide the length of embedding bits in each region. Second, embedding algorithm is proposed to embed secret data into two regions. Third, extracting algorithm is used to extract the secret data from the stego-image.

**Bit count:** For a gray-scale image, a pixel $p_i = (h_3h_2h_1h_0l_3l_2l_1l_0)_2$ contains 8 bits. Let high region $H(p_i) = (h_3h_2h_1h_0)$ and low region $L(p_i) = (l_3l_2l_1l_0)$ are given as shown in Fig. 1. First, it is divided into high region H and low region L for the given pixel $p_i$ of a cover image. Second, the bit count is calculated for the high region that decides the number of embedding bits in the pixel. And third, adjust the bit count to embed two bits of the secret data at least. The algorithm of calculating the bit count of two regions in each pixel is shown in algorithm 1.

**Algorithm 1; Calculating the bit count:**

```
Input    a cover image with W×H
Output   bit count
for each pixel {
divide into high region and low region
for high region {
        if value is 1 then increase the bit count
}
if<2 {
        set the bit count to 2
}
}
```

**Embedding algorithm:** The proposed embedding algorithm is executed after the process of calculating the bit count for each pixel. Depending on the length of the bit count, the length of embedding bits can be decided. The proposed method can hide 4-bit least significant bit at maximum. First, the length of embedding bits k is obtained from the bit count. Then, obtain the secret bits with length of embedding bits k. Next, be clear the low region with 4-bit least significant bit for the pixel before embedding secret bits. Finally, replace the low region with the secret bits. The detailed algorithm of embedding the secret data is described in algorithm 2.

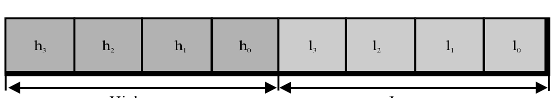


Fig. 1: High and low regions

**Algorithm 2; Embedding procedure:**

```
Input    a cover image, secret data
Output   stego-image with
    for each pixel {
            calculate the length of embedding bits k from the bit count
            obtain k-bit secret data
            for low region {
                replace k-bit least significant bits with secret bits
            }
    }
```

**Extracting algorithm:** The receiver can extract the secret data from stego-image without any extra information. First, the number of 1 in the high region has to be calculated to calculate the length of embedding bits in the pixel. Then, extract the secret bits with k-bit which means that the proposed method hide a different length of embedding bits in each pixel. Finally, the extracted secret bits are accumulated. The detailed algorithm of extracting the secret data is described in algorithm 3.

**Algorithm 3; Extracting procedure:**

```
Input    stego-image with W×H
Output   secret data
for each pixel {
    calculate the length of embedding bits k from high region
      for low region {
        extract k-bit secret data
    }
}
```

## RESULTS AND DISCUSSION

**Experimental results:** In experimental results, 512×512 gray images were used as cover images as shown in Fig. 2 and the secret data was generated by pseudo-random number. Two measurements of the embedding capacity and the Peak Signal-to-Noise Ratio (PSNR) were used. The PSNR can be obtained by Eq. 3, where MSE is the mean square error:

$$\text{PSNR} = 10\times\log_{10}\frac{255^2}{\text{MSE}},\ \text{MSE} = \sum_{i=1}^{W\times H}\frac{\left(p_i^{'}-p_i\right)^2}{W\times H} \qquad (3)$$

Experimental results of the embedding capacity and the are shown in Table 1. The embedding capacity of the proposed method is 560,698 bits and PSNR is 30.81 dB on average. The proposed method can hide 36,410 bits more than 2 bit LSB method instead of high image quality. Also the propose method has the advantage that the length of embedding bits in a pixel is different. The stego-images after embedding secret bits are shown in Fig. 3. Since, it is known to be difficult to distinguish the distortion of image if PNSR the is more than 30 dB to the human visual system, the proposed method satisfies as the PNSR is 30.81 dB on average (Fig. 2-4):

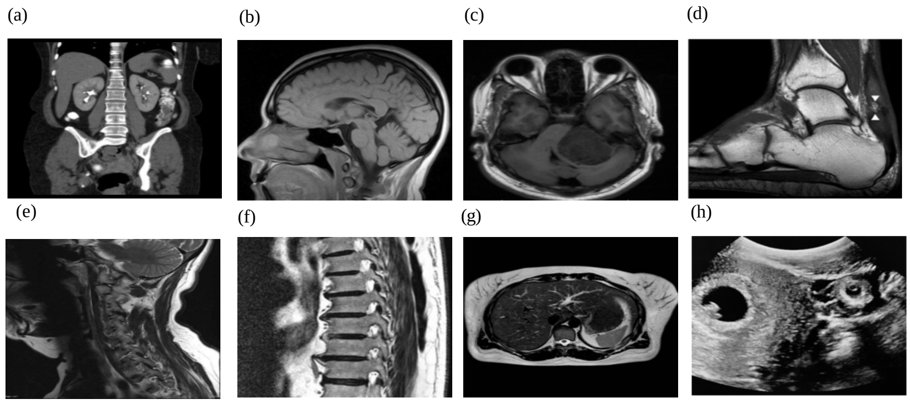


Fig. 2: Cover images: a) Image 1; b) Image 2; c) Image 3; d) Image 4; e) Image 5; f) Image 6; g) Image 7 and h) Image 8

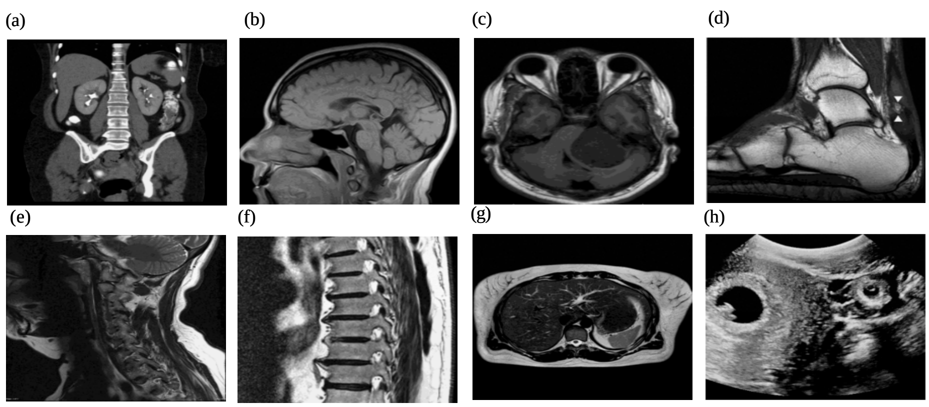


Fig. 3: Stego-images: a) Image 1; b) Image 2; c) Image 3; d) Image 4; e) Image 5; f) Image 6; g) Image 7 and h) Image 8

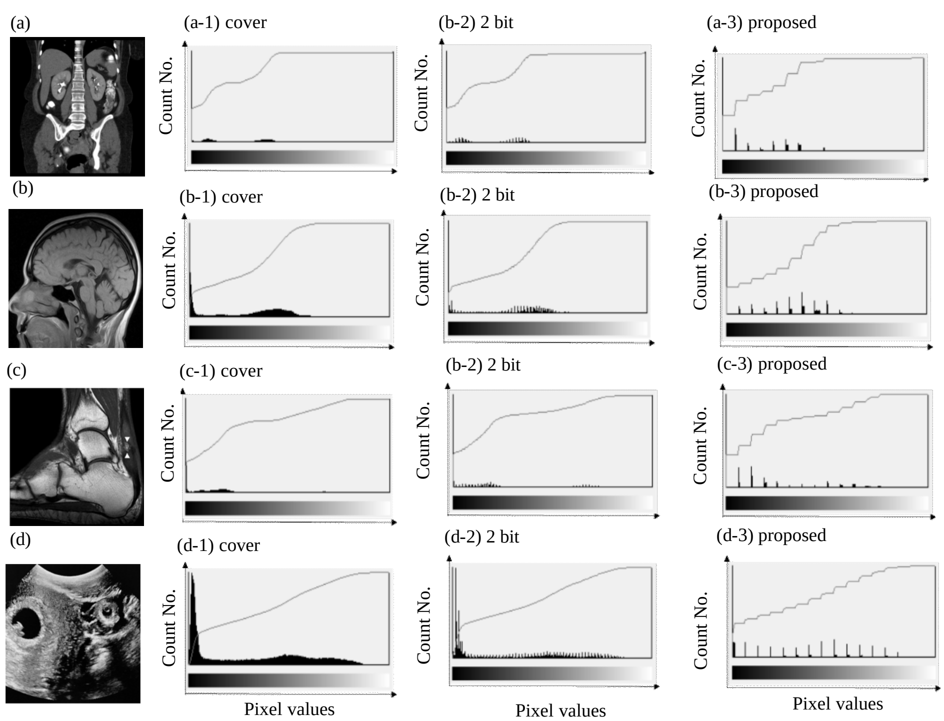


Fig. 4: Histogram comparison: a) Image 1; b) Image 2; c) Image 4 and d) Image 8

Table 1: Comparisons of the embedding capacity and the PNSR

| | 2 bit least significant bit scheme | | The proposed scheme | |
|---|---|---|---|---|
| Cover images | Embedding capacity (bits) | PNSR (dB) | Embedding capacity (bits) | PNSR (dB) |
| 1 | 524.288 | 45.65 | 551.914 | 31.10 |
| 2 | 524.288 | 44.65 | 566.467 | 30.88 |
| 3 | 524.288 | 43.31 | 536.736 | 30.91 |
| 4 | 524.288 | 45.22 | 555.537 | 30.98 |
| 5 | 524.288 | 44.45 | 551.680 | 30.09 |
| 6 | 524.288 | 44.05 | 616.087 | 29.57 |
| 7 | 524.288 | 45.90 | 539.289 | 32.83 |
| 8 | 524.288 | 44.00 | 564.861 | 30.46 |
| Average | 524.288 | 44.49 | 560.698 | 30.81 |

The histogram of 2 bit least significant bit replacement and the proposed scheme is shown in Fig. 4. For four cover images, histogram of a cover image, 2 bit least significant bit replacement and the proposed stego-images are compared. The proposed scheme can hide the secret bits from two bits to four bits, so, the variance of histogram is larger than previous research. In general, least significant bit based data hiding methods are vulnerable to RS histogram attack which shown in Fig. 4.

## CONCLUSION

In this study, a new information hiding scheme using bit position and bit count in the pixel has been proposed. The proposed scheme divided one pixel into high and low region to decide the length of embedding bits, where the proposed scheme used the bit count by calculating the number of 1 on high region in the pixel. The proposed method could embed the secret bits in the low region and the length of embedding bits was different on each pixel. The experimental results showed that the proposed method maintained 30.81 dB and 560,698 bits on average without distortion to the human visual system.

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