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Advanced Pixel Value Prediction Algorithm using Edge Characteristics in Image

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Abstract

In this paper, I proposed an effective technique for accurately predicting pixel values using edge components. Adjacent pixel values are similar to each other. *That is, generally, similarity exists between adjacent pixels in an image. In the proposed algorithm, edge components are detected using the surrounding pixels in the first step, and pixel values are estimated using the edge components in the second step. Therefore, the prediction accuracy of the pixel value is improved and the prediction error is reduced. Pixel value prediction is a necessary technique for various applications such as image magnification and confidential data concealment. Experimental results show that the proposed method has higher prediction accuracy and fewer prediction error. Therefore, the proposed technique can be effectively used for applications such as image magnification and confidential data concealment.*

Keywords: *Image, Pixel, Pixel value, Similarity, Edge characteristics, Prediction*

1. Introduction

Adjacent pixels of the image have similar pixel values. Edge components exists in the boundary region of the image. Pixel value prediction is used in applications such as image magnification and confidential data concealment. Various techniques for predicting pixel values using gradient adjacent pixels have been proposed [1-10]. Techniques for predicting pixel values using gradient adjusted prediction and the similarity of adjacent pixel values of images have been proposed [1-3], and techniques for predicting pixel values using curved surface characteristics of images have been proposed [4-6]. In addition, other techniques for predicting pixel values have been proposed [7-10].

In this paper, I proposed a pixel value prediction algorithm using edge characteristics. The proposed technique can be effectively used for applications such as image magnification and confidential data concealment. Experimental results show that the proposed pixel value prediction technique is superior.

This paper is organized as follows: In Section 2, the proposed algorithm is described. In Section 4, the experimental results for evaluating the performance of the proposed algorithm are described and analyzed. The conclusions are described in Section 5.

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2. Proposed algorithm

Adjacent pixels of the image have very similar values, and there is an edge component in the boundary region of the image. Thus, adjacent pixels can be used to accurately predict pixel values with edge components. In the proposed algorithm, edge components are detected using the surrounding pixels in the first step, and pixel values are estimated using the edge components in the second step.

The predicted pixel value PPV at the position (x, y) where the pixel value is to be predicted is obtained as follows: First, Equation (1) is calculated to determine whether to obtain a predicted pixel value using the edge component at the corresponding position. If Equation (1) has a small value close to zero, it indicates that there is little change in values of adjacent pixels. In other words, there is a high possibility that no edge component exists. Therefore, as shown in Equation (2), when the value of Equation (1) is less than a predetermined value (diff_threshold), the pixel value becomes the predicted pixel value (PPV). If the value of Equation (1) is larger than the predetermined value (diff_threshold), the edge component is likely to exist, so the edge component is precisely investigated to calculate the predicted value (PV). Thereafter, the result of rounding the PV is set as the predicted pixel value (PPV).

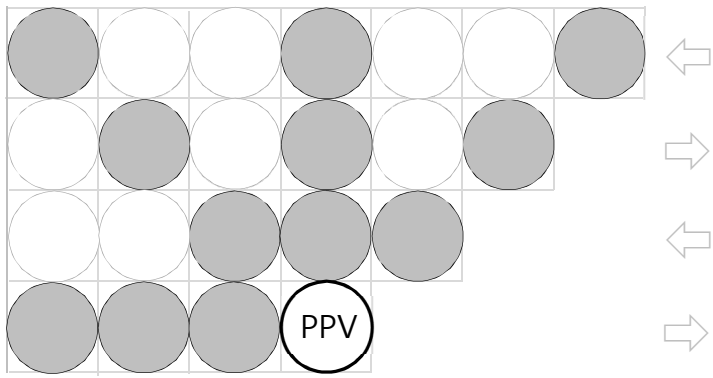

Figure 2. Adjacent pixels used to find edge components in the proposed algorithm

$$\mathrm{diff}(x_i, y_j) = |\, P(x_{i-1}, y_j) - P(x_{i-1}, y_{j-1}) \,| + |\, P(x_{i-1}, y_{j-1}) - P(x_i, y_{j-1}) \,| + |\, P(x_i, y_{j-1}) - P(x_{i+1}, y_{j-1}) \,| \quad (1)$$

$$\mathrm{PPV}(x_i, y_j) = \begin{cases} \text{Cover image pixel value} & \text{if(diff} < \text{diff\_threshold} \\ \mathrm{PV}(x_i, y_j) & \text{otherwise} \end{cases} \quad (2)$$

In order to determine whether edge components exist, differential values are obtained for each edge as in equation (3)-(6), the sum of the absolute values of the differences between adjacent pixels at 135, 90, 45, 0 degrees. If the edge(i)_diff value is 0, it is determined that an edge in the corresponding direction exists and the value of the corresponding edge is set to 1. Where i has a value between 0 and 3. At that location, the predicted value (PV) using the edge component is calculated as shown in equation (8). In Equation (8), V_ (weighted_avg) represents an average value of neighboring pixels in consideration of the weight, and this value is calculated as in Equation (9). When the predicted value (PV) is obtained, the result of rounding the PV is set as the predicted pixel value (PPV) as shown in Equation (2).

$$\text{edge(0)\_diff} = |P(x_{i-1}, y_j) - P(x_{i-2}, y_j)| + |P(x_{i-2}, y_j) - P(x_{i-3}, y_j)| \quad (3)$$

$$\text{edge(1)\_diff} = \left|P(x_{i-1}, y_{j-1}) - P(x_{i-2}, y_{j-2})\right| + \left|P(x_{i-2}, y_{j-2}) - P(x_{i-3}, y_{j-2})\right| \langle \quad | \quad | \quad \rangle \quad (4)$$

$$\text{edge(2)\_diff} = |P(x_i, y_{j-1}) - P(x_i, y_{j-2})| + |P(x_i, y_{j-2}) - P(x_i, y_{j-3})| \quad (5)$$

$$\text{edge(3)\_diff} = \left|P(x_{i+1}, y_{j-1}) - P(x_{i+2}, y_{j-2})\right| + \left|P(x_{i+2}, y_{j-2}) - P(x_{i+3}, y_{j-3})\right| \lfloor \quad \rfloor \quad (6)$$

$$\text{edge(i)} = \begin{cases} 1 & \text{if(edge(i)\_diff} = 0 \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

$$PV(x_i, y_j) = \{V_{weighted\_avg}(x_i, y_j) + P(x_{i-1}, y_j) \cdot edge(0) + P(x_{i-1}, y_{j-1}) \cdot edge(1) + P(x_i, y_{j-1}) \cdot edge(2) + P(x_{i-1}, y_{j-1}) \cdot edge(3)\}/\{1 + edge(0) + edge(1) + edge(2) + edge(3)\} \quad (8)$$

$$V_{weighted\_avg}(x_i, y_j) = [P(x_{i-1}, y_j) + P(x_{i-1}, y_{j-1}) + P(x_i, y_{j-1}) + P(x_{i+1}, y_j) + \{P(x_{i-2}, y_j) + P(x_{i-2}, y_{j-1}) + P(x_{i-2}, y_j) + P(x_{i-1}, y_{j-2}) + P(x_i, y_{j-2}) + P(x_{i+1}, y_{j-2}) + P(x_{i+2}, y_{j-2}) + P(x_{i+2}, y_{j-1})\ \} \cdot \alpha]/\{4 + 8 \cdot \alpha\} \quad (9)$$

3. Experimental results

The performance of the proposed algorithm was evaluated using Gold-hill, Girl-face, Vivian, Elaine, Sail-boat, Hara grayscale images with 512x512 pixels as shown in Figure 2. The alpha used in equation (9) was 0.45. After predicting the pixel values using the proposed algorithm in the remaining areas except three lines above, below, left, and right, the accuracy of the prediction was calculated by comparing the predicted pixel values with the pixel values of the original image at that locations. The results of experiments on six images are shown in Table 1. As shown in Table 1, the proposed technique can accurately predict pixel values. So, the prediction accuracy of the proposed algorithm is very high and the prediction error mean is very small. As shown in Table 1, the prediction accuracy of the proposed technique was up to 30.73%, and the minimum prediction error mean was 1.2.

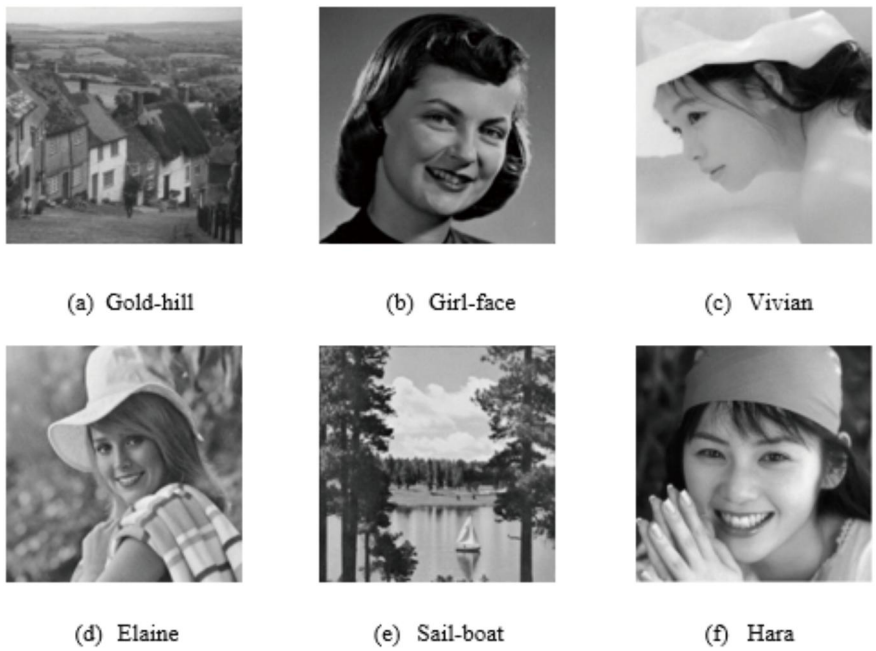

Figure 3. 512x512 Gray scale images used in the experiment

Table 1. Experimental results

Image	Prediction Accuracy(%)	Prediction error mean	Number of predictions
Gold-hill	19.01	2.19	3,320
Girl-face	26.55	1.50	19,379
Vivian	30.73	1.08	32,107
Elaine	13.35	2.44	2,604
Sail-boat	21.85	1.81	4,306
Hara	29.50	1.20	17,756

4. Conclusion

In this paper, a technique for precisely predicting pixel values using edge characteristics of surrounding pixels is proposed. Adjacent pixels of the image have similar pixel values. Edge components exists in the boundary region of the image. In the proposed algorithm, edge components are detected using the surrounding pixels in the first step, and pixel values are estimated using the edge components in the second step. Therefore, the prediction accuracy of the pixel value is improved and the prediction error is reduced.

The performance of the proposed algorithm was evaluated using Gold-hill, Girl-face, Vivian, Elaine, Sail-boat, Hara grayscale images with 512x512 pixels. When predicting pixel values using the proposed technique, the prediction accuracy has a maximum value of 30.73% and the prediction error is very small. The proposed technique is an effective pixel value prediction technique and can be effectively used for applications such as image enlargement and confidential data embedding.

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