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무손실 압축을 위한 예측기 스위칭 알고리즘

(Predictor Switching Algorithm for Lossless Compression)

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요 약

본 논문에서는 무손실 압축을 위하여 예측기를 스위칭하는 알고리즘을 제안한다. 제안하는 방법은 MED(median edge detector), GAP(gradient adaptive prediction) 예측기의 예측 에러들에 따라 적응적으로 하나의 예측기를 이용하여 화소값을 예측한다. 그리고, 에러는 기존의 엔트로피 방법을 이용하여 측정한다. 실험 결과, 제안하는 알고리즘이 기존 예측 방법보다 적은 에러값과 엔트로피를 가짐으로써 향상된 압축을 할 수 있음을 보인다.

Abstract

In this paper, a predictor switching algorithm for lossless compression is proposed. It uses adaptively one of two predictors using errors obtained by MED(median edge detector) and GAP(gradient adaptive prediction). The reduced error is measured by existing entropy method. Experimental results show that the proposed algorithm can compress higher than existing predictive methods.

Keywords : switching, lossless compression, predictor

I. Introduction

Various algorithms for image compression of digital images are developed. Especially, lossless compression is an important field of application for image compression. High-end digital devices enable the user to access the raw which is not altered by any coding algorithm. Many lossless compression algorithms were proposed. Context-based adaptive prediction schemes[1~7] have shown significant improvements over fixed prediction schemes. CALIC[1] uses gradient adaptive prediction (GAP). JPEG-LS[2] adopts median edge detector (MED). Prediction can be viewed as a context modeling technique of very low model cost that is highly effective under an assumption of smoothness.

In this paper, we propose an efficient technique called predictor switching algorithm which selects one of results obtained by the MED and GAP prediction, properly. Thus, it can reduce prediction error and obtain the reduced entropy of the residual error. Our proposed switching predictor has good performance for entropy image coding and outperforming existing methods, such as MED and GAP, while having a low complexity.

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Ⅱ. Existing Techniques

The context-based compression methods are usually constituted by two steps. In the first step, the image is spatially de-correlated, and then the residual error is determined. In the second step, the residual error is coded by the context-adaptive entropy encoder. In this section, the existing prediction techniques for de-correlation, such as MED and GAP, are reviewed briefly.

The prediction is performed based on the causal template as shown in Fig. 1, where x is the current sample, x_1, x_2, x_3, and x_4 are neighboring samples that had been encoded already.

In JPEG-LS[2], a fixed predictor performs a primitive test to detect vertical or horizontal edges, while the other part is limited to an adaptive linear term. The fixed predictor guesses x' of the current sample x as follows

$$x' = \begin{cases} \min(x_1, x_2), & \text{if } x_3 \le \max(x_1, x_2) \\ \max(x_1, x_2), & \text{if } x_3 \le \min(x_1, x_2) \\ x_1 + x_2 - x_3, & \text{otherwise} \end{cases} \quad (1)$$

The predictor chooses x_2 as prediction value in cases where a vertical edge exists at the left of the current position, x_1 in cases of a horizontal edge above the current position, or $x_1 + x_2 - x_3$ if no edge is detected. This predictor was renamed median edge detector(MED), because it is seen as the median.

In CALIC[1], gradient-adjusted predictor (GAP) guesses x' by adapting itself to the intensity gradient near the predicted pixel. Hence, it has the better performance than traditional linear prediction. But, it has more operations than MED since more boundary pixels are utilized.

x_3	x_2	x_4
x_1	x	

그림 1. 현재 샘플과 이웃 샘플들
Fig. 1. Current and neighboring samles.

		x_{nn}	x_{nne}
	x_{nw}	x_n	x_{ne}
x_{ww}	x_w	x	

그림 2. 예측에 사용되는 주변 화소들
Fig. 2. Neighboring pixels used in prediction.

GAP differs from existing linear predictors in that it weights the neighboring pixels of x according to the estimated gradients of the image. As shown in Fig. 2, neighboring pixels of x used in prediction are denoted.

They estimate the gradient of the intensity function at the current pixel x by the following quantities.

$$\begin{aligned} d_h &= |x_w - x_{ww}| + |x_n - x_{nw}| + |x_n - x_{ne}| \\ d_v &= |x_w - x_{nw}| + |x_n - x_{nn}| + |x_{ne} - x_{nne}| \end{aligned} \quad (2)$$

The values of d_h and d_v show the magnitudes and orientations of edges around the x. The gradient predicts x' of the current sample x as follows

$$\begin{aligned} & \text{if}(d_v - d_h > 80)x' = x_w \\ & \text{elseif}(d_v - d_h < -80)x' = x_n \\ & \text{else}\{ \\ & \quad x' = (x_w + x_n)/2 + (x_{ne} - x_{nw})/4 \\ & \quad \text{if}(d_v - d_h > 32)x' = (x' + x_w)/2 \\ & \quad \text{elseif}(d_v - d_h > 8)x' = (3x' + x_w)/4 \\ & \quad \text{elseif}(d_v - d_h < -32)x' = (x' + x_n)/2 \\ & \quad \text{elseif}(d_v - d_h < -8)x' = (3x' + x_n)/4 \end{aligned} \quad (3)$$

Absolute differences of d_h and d_v represent the magnitudes in each direction. The predictor adjusts prediction value according to the absolute differences.

Ⅲ. Proposed Algorithm

In this section, we propose a predictor switching algorithm for entropy coding. Proposed predictor adaptively selects one of two predictors results. Thus, the residual errors of prediction can be reduced more than existing methods. Fig. 3 shows a block diagram of the proposed algorithm. Two predicted error

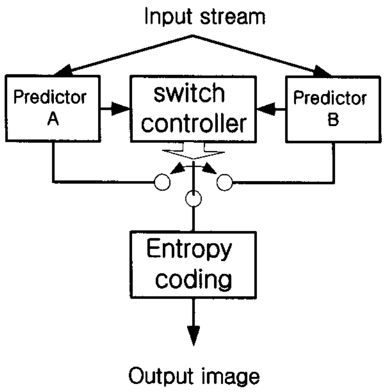


그림 3. 제안하는 적응적 예측기의 블록도

Fig. 3. Block diagram of the proposed adaptive predictor.

results are obtained by predictor A and predictor B. Then, the switching method adaptively selects one of two results obtained by predictor A and predictor B to compensate for each drawback.

We use MED and GAP as predictor A and predictor B, respectively. Switching controller select one between two predictor patterns of MED and GAP by choosing minimum SAD_k as follows

$$P_{i,j}^{k} = \arg\min_{k \in \Omega} SAD_{i,j}^{k} \quad (4)$$

where $P_{i,j}^{k}$ represents final selected pattern, k denotes a selected predictor, and $\Omega = \{MED, GAP\}$. $SAD_{i,j}^{k}$ is sum of absolute difference according to pattern $P_{i,j}^{k}$.

MED uses three prediction patterns, $i = 1,2,3$ and GAP uses seven prediction patterns, $j = 1,2,\ldots,6,7$. Thus, 21 patterns are generated according to those two predictors. Additional budge to entropy coding bits is 21 bits per frame. Note that if $SAD_{i,j}^{MED} > SAD_{i,j}^{GAP}$, the entropy of results with GAP is smaller than those with MED. Table 1 and 2 show $SAD_{i,j}^{k}$ of predictors for the test image "Lena". The switching predictor adaptively selects one of MED pattern, $P_{i,j}^{MED}$ and GAP pattern, $P_{i,j}^{GAP}$ by using (4). In $P_{1,1}$ case which means pattern 1 of MED and pattern 1 of GAP, the proposed switching predictor uses MED prediction according to Table 1 and 2. Thus, the result has smaller prediction error.

표 1. MED에 의한 $SAD_{i,j}$

Table 1. $SAD_{i,j}$ of MED

$SAD_{i,j}^{MED}$	1	2	3	4	5	6	7
1	503	22584	7515	36234	50130	81110	191453
2	270	16132	5878	31701	50481	98159	195966
3	1011	24556	10102	35149	51007	82570	156165

표 2. GAP에 의한 $SAD_{i,j}$

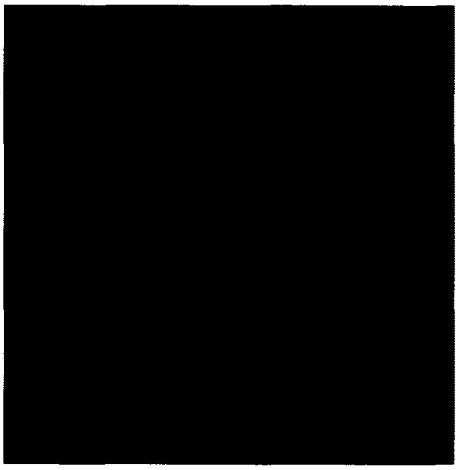
Table 2. $SAD_{i,j}$ of GAP.

$SAD_{i,j}^{GAP}$	1	2	3	4	5	6	7
1	525	22644	7483	33292	45005	73993	174269
2	262	16031	6096	28442	45668	87256	168466
3	1034	31433	9936	32978	51720	76154	139681

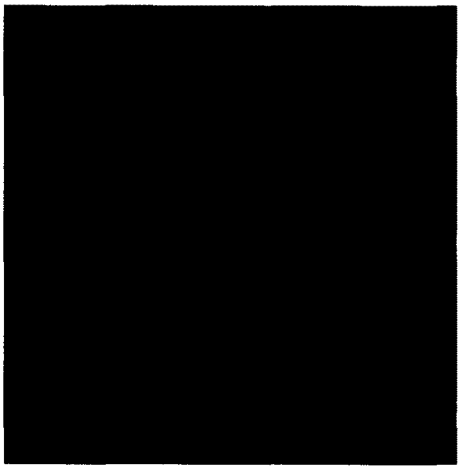
For entropy coding and a useful comparison between the proposed and existing methods, an entropy measure[8] is used. Since the proposed predictor using hybrid method can reduce the prediction errors more than predictors of existing algorithms, the proposed predictor can have the higher compression ratio.

Ⅳ. Experimental results

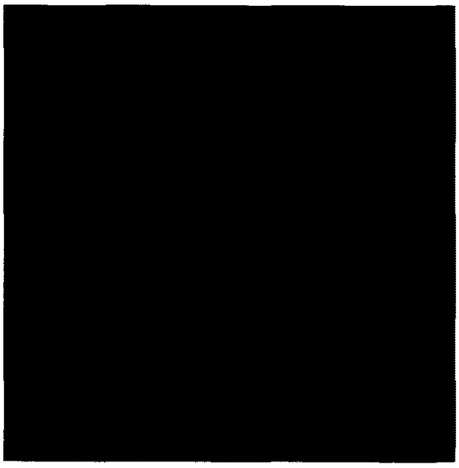
For evaluating the proposed scheme, we implemented the hybrid predictor using prediction patterns of MED and GAP. In our simulations, the "Lena", "Baboon", "Airplane", and "Einstein" grayscale images of 512x512 pixels were used. Test gray images are obtained by conversion of color images. Each image has the different patterns as various, complex, and noisy, respectively. Fig. 4 shows the amplitude images of prediction error given by MED, GAP, and proposed predictor for test image "Einstein". The absolute values of prediction error are shown as gray scale in the amplitude images. It shows that the proposed predictor produces much smaller errors around the edge areas than both MED and GAP.



(a)



(b)



(c)

그림 4. 예측 에러 영상.
(a) MED, (b) GAP, (c) 제안하는 예측기
Fig. 4. Error images of Prediction.
(a) MED, (b) GAP, (c) Proposed predictor.

표 3. MED, GAP, 그리고 제안하는 예측기의 엔트로피 (bpp)
Table 3. Entropy of MED, GAP, and Proposed predictor (bpp).

	Lena	Baboon	Airplane	Einstein
MED	4.54	6.27	4.37	2.69
GAP	4.41	6.23	4.33	3.05
Proposed predictor	4.40	6.21	4.30	2.69

Table 3 presents experimental results of the proposed algorithm's performance. For comparison, results of the MED and GAP algorithms are included. We use the entropy of the prediction error as the objective measure as follows

$$\text{entropy} = -\sum_{i=0}^{255} p[i] * \ln p[i] \quad (5)$$

where $p[i]$ is probability of the i gray level. It is seen that the proposed predictor produces much smaller entropy of the prediction errors than both MED and GAP.

V. Conclusions

In this paper, we proposed the predictor switching technique for entropy coding. The proposed technique efficiently reduces prediction errors by selecting one of two results of the existing predictors. From the experimental results, it was shown that the proposed scheme outperforms the existing algorithms such as MED and GAP in terms of the entropy reduction.

The proposed method is applicable to an existing lossless compression techniques using prediction and can have higher compression results.

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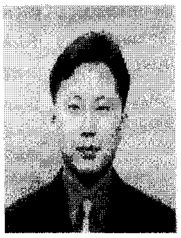
저 자 소 개



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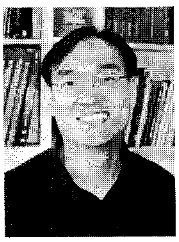

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