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Analysis and Comparison of Compression Algorithm for Light Field Mask

Hyunji Cho[1] and Hoon Yoo[2]*

[1]*Department of Computer Science, SangMyung University, Korea.*
[2]*Associate Professor, Department of Media Software SangMyung University, Korea.*
**Corresponding author*

Abstract

This paper describes comparison and analysis of state-of-the-art lossless image compression algorithms for light field mask data that are very useful in transmitting and refocusing the light field images. Recently, light field cameras have received wide attention in that they provide 3D information. Also, there has been a wide interest in studying the light field data compression due to a huge light field data. However, most of existing light field compression methods ignore the mask information which is one of important features of light field images. In this paper, we reports compression algorithms and further use this to achieve binary image compression by realizing analysis and comparison of the standard compression methods such as JBIG, JBIG 2 and PNG algorithm. The results seem to confirm that the PNG method for text data compression provides better results than the state-of-the-art methods of JBIG and JBIG2 for binary image compression.

Keywords: Lossless compression, Image compression, Light filed compression, Plenoptic coding

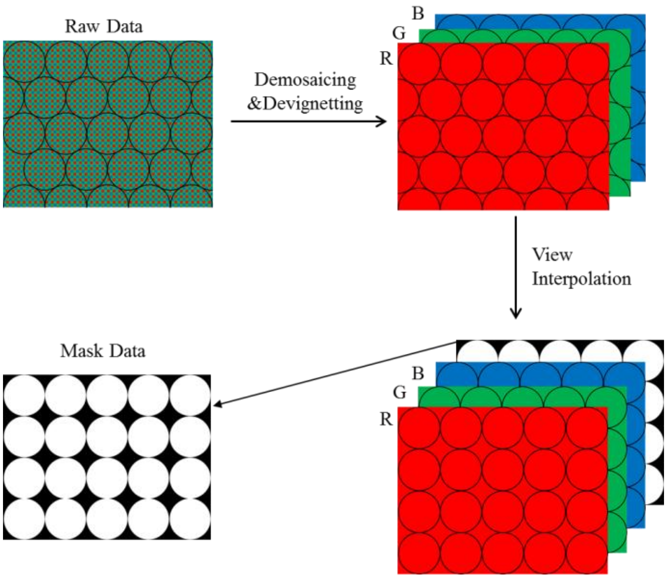


Figure. 2. Basic architecture from raw images to RGB and mask images

INTRODUCTION

Light field (LF) cameras, also referred to as plenoptic cameras, differ from regular cameras by providing 3D information of images. The light field camera has a structure in which an array of microlens interpose in between the main lens and the image sensor as shown in Fig. 1. The 3D information is acquired by using angular information from the array of microlens. Hence, a light field camera is a next generation camera that can be utilized in various fields such as 3D optical microscopy, 3D computer vision application, 3D underwater imaging, medical imaging, and so on [1-4].

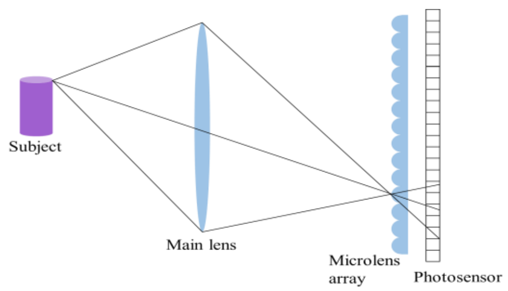


Figure. 1. Optical structure of a light field camera

The LF camera provides a raw image captured from photosensor with microlens, as depicted in Fig. 1. The raw data consists of 10 bits per pixel precision in little-endian format. The raw data is then processed by a series of methods consisting of demosaicing, devignetting, and view interpolation. Here, the view interpolation is a process of rearranging images having a honey-comb pattern, which is obtained from a honey-comb lenslet array, into a rectangular pattern. Now, let us define a light field function L_f, where an element $L_f(r, c, i, j)$ has the following indices: $r, c \in \{1, \dots, N\}$ are indices for a certain pixel under a microlens (hence addressing a particular view image) and i, j correspond to the spatial pixel location in the view image of size of $W \times H$. For example, we utilizes a light field image of $N = 15$, $W = 434$, and $H = 625$. Since the light field camera employs circular lenses, an empty space should be generated among the lenses. This empty space is represented as the mask data. Thus this mask data are very important in transmitting and refocusing LF images.

Normally, very high storage capacity is required to store the raw LF data. A compression algorithm is required for improving data compression performances. Thus, many studies related to the compression of the LF image have been discussed in different ways [5-14]. Some light field compression techniques use the statistical characteristics of the image. Another techniques are to model the light field function by taking advantage of geometrical information of the scene and the position information of the camera.

However, these methods overlook the mask data compression. The pixels in the empty space between the lenses are unnecessary information, thus it need not be compressed or used in refocusing. Therefore, the mask data, which have been taken a much less attention, should be compressed before compressing other pixels. In this paper, we compare and evaluate the performance of standard compression methods that can be employed in lossless compression for mask information. The state-of-the-art compression methods for binary compression, such as JBIG and JBIG2, are included in our evaluation. Interestingly, experiments indicate that the PNG method outperforms JBIG and JBIG2.

RELATED WORK

1. JBIG1/JBIG2

JBIG is a standard for lossless image compression from the joint bi-level image experts group (JBIG) [15]. The core coding part of JBIG is a context-based binary arithmetic coding by defining a context using previous pixels. Normally an arithmetic coding is very efficient method to compress an information source of having small symbol set size [16]. Thus, the coding method is the theoretically optimal technique for a binary source.

JBIG2 is a standard for lossy and lossless binary image compression from the same group [17]. Basically this method is based on the previous standard, JBIG. Also, the method is extended in order to improve lossless compression performance for a binary image, to provide a functionality of lossy compression for a binary image, and to efficiently compress halftone images. Thus, JBIG2 supports three coding methods for compressing a region segment: generic, halftone, and text. Generic regions are encoded as a template based arithmetic coding used in the JBIG. Halftone regions are encoded as a halftone coding using a grayscale image and a halftone pattern dictionary. Text regions are encoded as a pattern matching. For high efficiency of JBIG2, it segments the image and then use the best coding method for each region.

2. PNG (portable network graphics)

PNG is a raster graphics file format that employs lossless data compression [18]. It was created as an improved and non-patented replacement for GIF (graphics interchange format). PNG is based on filtering and entropy coding as a W3C recommendation for still image coding. The encoding method of PNG is as shown in Fig.3. PNG uses a 2-stage compression process: filtering and the deflate method.

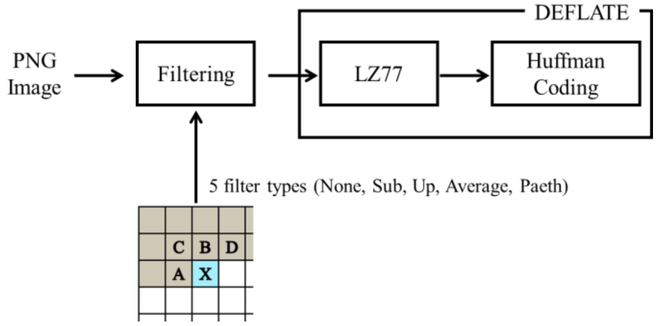


Figure. 3. PNG encoding

Before the deflate method is applied, the input image data is transformed via filtering or prediction. Predefined filters are used to predict the value of each pixel based on a predictor from previous adjacent pixels. There are five filter types: none, sub, up, average, paeth. A filter type with the best performance is applied to each line.

The deflate compression algorithm uses a combination of the LZ77, that is the well-known technique to compress text data, and Huffman coding. LZ77 is the lossless data compression algorithm using the past of the sequence as the dictionary. The Huffman code is a prefix code that is commonly used for lossless data compression. Huffman coding is the process of finding and using such a code. PNG has high compression ratio of images with repetitive patterns by using filtering and the deflate algorithm.

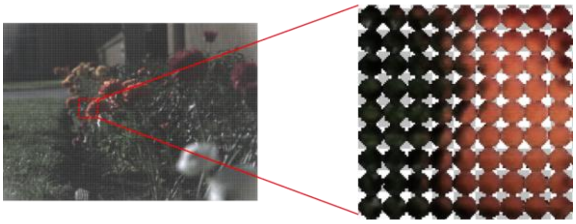
ANALYSIS OF COMPRESSION FOR LIGHT FIELD MASK

The most important feature in the light field image is that the pattern is generated in the image by the lens arrangement as shown in fig. 4 (a). Thus, this paper focuses mask data to compress them efficiently.

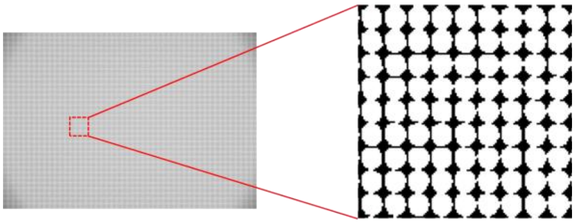
The mask data provide the information on the empty space between the lenses. Thus, mask data should be taken into account for compressing or imaging. In order to make the compression and imaging process of light field data more accurate and faster, mask data as well as light field raw data must be utilized.

The mask data are extracted from light field raw data. Actually those data are a binary source. Also, the basic mask shape is a circular form and each mask is very similar. Thus, we consider some standard compression methods such as JBIG, JBIG2, and PNG as a candidate to compress the binary mask data of light field imaging.

The state-of-the-art methods among standard lossless compression for bi-level images are JBIG and JBIG2 of the joint bi-level images experts group in 1993 and 2000, respectively. The JBIG2 algorithm was announced which had better compression performance than the previous one by using more computing power.



(a)



(b)

Figure. 4. Mask Data

Thus, it is known as that JBIG2 is the best bi-level compression method in current. However, we expect that the compression performance of PNG is the best because mask data is composed of repeated patterns. Although the theoretically optimal performance is expected with respect to JBIG2, only pixel correlation is utilized in the JBIG binary image compression. Therefore, dictionary-based methods such as LZ77, LZ78, and so on can be more efficient than the JBIG2 method due to periodical patterns in the mask data.

SIMULATION

Experiments are conducted to compare and evaluate the mask data compression with JBIG, JBIG2, and PNG. Fig. 5 shows the light field raw dataset. A dataset consisting of eight light field images was selected for the experimental analysis. Each LF image has a resolution of 5368x7728 pixels. First, we extract the mask information for each LF image and thus we prepare a binary image as mask data. Then those mask data are compressed by JBIG, JBIG2, and PNG. Here, the options for PNG are manually selected in terms of the best compression performance. And the lossless coding options for JBIG and JBIG2 are selected.

(a) bikes

(b) buildings

(c) cars

(d) flowers

(e) fruits

(f) general

(g) occlusions

(h) people

Figure. 5. Light Field Raw Dataset[1]

Table. 1. Compression ratio

	pbm	PNG	JIBG	JBIG2
bikes	1	10.45	7.64	8.19
buildings	1	13.86	10.26	10.77
cars	1	8.92	6.96	7.35
flowers	1	8.36	6.79	6.80
fruits	1	13.75	10.20	10.15
general	1	9.89	7.95	8.93
occlusions	1	9.28	7.65	8.58
people	1	10.81	8.60	9.05
AVERAGE	1	10.66	8.26	8.73

[1] http://lightfields.stanford.edu/

The experimental results were organized at the compression rate as shown in Table 1. The compression ratio is defined as follows

$$\text{Compression Ratio} = \frac{\text{Unompressed file size}}{\text{Compressed file size}}. \qquad (1)$$

It can be seen that the higher compression ratio the lower the compressed file size.

In particular, the best compression ratio was achieved by the PNG encoder. In general, JBIG2 is expected for the best compression method of binary images. However, the periodical property of the LF mask data enables the PNG method to show the best performance in terms of compression ratio.

CONCLUSION

The main objective of this paper was to examine what is the best standard method to compress the light field mask data. The analysis on LF mask data and experimental results indicated the PNG method outperforms the state-of-the-art compression methods for binary images such as JBIG and JBIG2. Therefore, the deflate method used in the PNG technique can be a reference algorithm to develop a new coding method for LF mask data compression in the future.

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