Research Article
Review on Lossless Image Compression Techniques for Welding Radiographic Images

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Abstract: Recent development in image processing allows us to apply it in different domains. Radiography image of weld joint is one area where image processing techniques can be applied. It can be used to identify the quality of the weld joint. For this the image has to be stored and processed later in the labs. In order to optimize the use of disk space compression is required. The aim of this study is to find a suitable and efficient lossless compression technique for radiographic weld images. Image compression is a technique by which the amount of data required to represent information is reduced. Hence image compression is effectively carried out by removing the redundant data. This study compares different ways of compressing the radiography images using combinations of different lossless compression techniques like RLE, Huffman.

Keywords: Bit plane, gray code, huffman, image compression, radiography images, RLE

INTRODUCTION

Image compression is the technique by which the storage requirements for images of larger sizes are met by reducing the space consumed and also the bandwidth requirement for the transmission of the images can be reduced. The image compressions are of two types: Lossy compression and Lossless compression:

- The lossy image compression technique is the process in which the image is compressed with some loss of information that is present in the original data.
- The lossless image compression is the process of compressing the image without any loss of information present in the original image.

The significance of the process of compression is that it enables the user to store more images in the allocated memory space. For the radiography more weld images should be stored in the data base (Rajagopalan *et al*., 2004) to check the quality and correctness of the process. In case of transmission, the bandwidth of the channel can be effectively used due to the reduced size of the image (Holtz, 1993). Considering these advantages we implement the compression technique on radiological images that consume more space. The radiological images are used in specialized fields like building of aircrafts and other equipments used in mission critical projects that need assistance and expertise for various process of welding. The major disadvantage faced during these processes is the amount of memory space consumed in storing these images. In order to overcome this restriction, we compress the image such that there is no loss in data (virtually lossless) and the memory required for storing the image is reduced. This study discusses various lossless techniques on radiographic weld images using binary and gray code values.

MATERIALS AND METHODS

The lossless compression based on Run Length Coding and Huffman coding is effectively analyzed. The technique of Huffman Coding and Run Length Coding are variable length coding types and thus error-free. Some variations of Huffman Coding can produce even better results like parallel Huffman is better than bit-by-bit serial Huffman Coding (Howard and Vitter, 1992) and adaptive Huffman Coding is still preferred over these (Jeon *et al*., 1998). We can also observe that time consumed to process gray code image is lesser than time required to process binary images (Xiaoli *et al*., 2004). Other than the variations of Huffman coding the various types of Run Length Coding are also very effective for certain applications. For example, the Run Length Coding to compute the value of difference between two digits (Messom *et al*., 2002). We can use the Run Length coding for identification of patterns (Messom *et al*., 2002) like identifying the porosity and slag in the welded material. Here we consider the very basic Huffman Coding and Run length coding. The Huffman Code is an error free, prefix-free code. In Huffman coding short code words are assigned to input blocks with high probabilities and long code words to the ones with low probabilities.
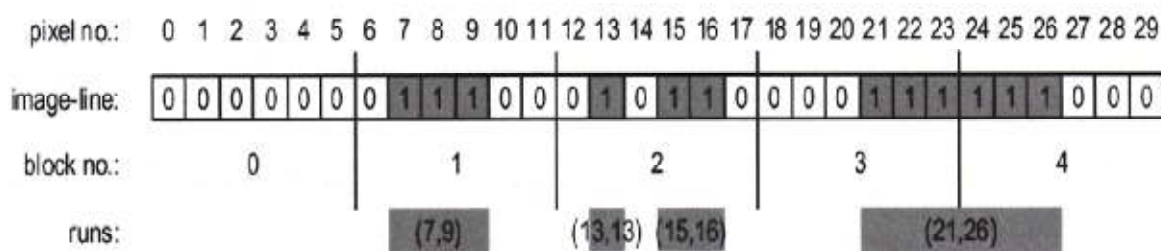
Fig. 1: Example of an Image line and its corresponding runs

A Huffman code is formed by adding together two least probable source symbols and repeating this process until there are only two symbols remaining. A tree thus obtained by this is called Huffman tree and the Huffman code refers to code assigned to each symbol (Ashraf and Akber, 2005) by traversing the tree. Run Length Coding is an easy and efficient compression method based on the assumption that the image is a long data sequence without change of pixel value contents. These sequences are described by their characteristic position and length of appearance of that sequence. Thus the RLE is a flat or one dimensional compression algorithm (Xiaoli *et al*., 2004).

Hence before applying Run Length Coding Technique, we first convert the gray scale image or gray code converted image value of each pixel into a 1xn matrix (column transformation) or nx1 matrix (row transformation). This is shown in Fig. 1.

It was observed that the RLE with parallel inputs gave a maximum lossless compression up to 95.39% Xiaoli *et al*. (2004). Hence on similar basis, we first apply Huffman code to the pixel (source symbol), then apply RLE to obtain an effectively compressed image.

The Run Length Coding is also used in certain other sectors of image processing like: pattern recognition, pattern detection, etc., such sectors use RLE in real-time applications like detecting the pathway of the robot, route memorizing of the robot, etc., Luo *et al*. (2009). We can also use this RLE in the division of image segmentation, in the area of edge detection to identify the background and foreground pixels of the image. The radiographic weld images used in this study were obtained from IGCAR, Kalpak am.

RESULTS AND DISCUSSION

In case1, we apply RLE to the input image, we then apply Huffman coding to the result obtained after applying RLE. This is shown in Fig. 2. In case3, we apply bit plane method and then apply RLE, Huffman like case1. This is shown in Fig. 3.
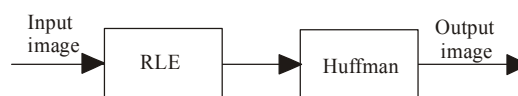

Fig. 2: Steps for case 1

In case 2, we find the gray code equivalent of all the pixels and then we apply the process involved in case 1. This is shown in Fig. 4. In case 4, we find the gray code equivalent of all the pixels and we apply the process involved in case 3. This is shown in Fig. 5:

Algorithm:
Step 1: Img1 ← Read the input image
Step 2: Img_gr ← GrayCode (Img1)
Step 3: Img_RLE ← RLE(Img_gr, Choice)
Step 4: Img_Huff ← HuffmanCode (Img_RLE)

The above algorithm is applicable for case 2 and case 4. For case 1 and case 3 RLE should be applied to the input image directly. By passing (Step 2).

The pixel values of the input image are extracted and they are converted to their corresponding gray code. The advantage of the gray code is that the immediate values will have only one bit change. This is exploited for compression purpose in the bit plane method for case 4. Since with the radiographic images the intensity values does not vary drastically, converting into gray code will give only one bit change with neighboring pixels.

Run Length Encoding allows us to represent the continuous runs of pixel of the same values. Here instead of taking pixel value entirely for finding the run, individual bits of all the pixels are taken in case 1 and case 2. In case 3 and case 4, the bit plane method is applied i.e., b_i^{th} bit of all the pixels are taken for finding the run. Huffman is variable length encoding scheme which allows us to represent the characters using variable length codes. The advantage is that the character with higher probability of occurrence will have least number of bits to represent it.

Fig. 3: Steps for case 3
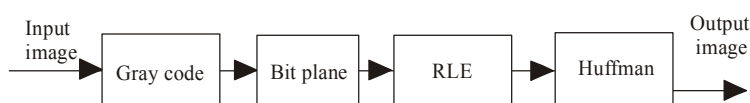

Fig. 4: Steps for case 2

Fig. 5: Steps for case 4

Table 1: Results for different image before enhancement

Images/ Cases	Img 1 (MB)	Img 2 (MB)	Img 3 (MB)	Img 4 (MB)
Case 1	22.031	22.013	21.952	22.326
Case 2	21.907	22.061	21.765	22.059
Case 3	12.109	11.809	12.086	11.939
Case 4	10.470	10.537	10.241	10.448

Table 2: Results for different image after enhancement

Images/ Cases	Img 1 (MB)	Img 2 (MB)	Img 3 (MB)	Img 4 (MB)
Case 1	22.486	22.290	22.298	22.421
Case 2	22.661	22.555	22.624	22.593
Case 3	17.683	17.617	17.148	17.690
Case 4	16.988	16.674	16.638	16.827

In the Bit plane method the image is represented as sixteen layers. Here we assumed that sixteen bits are used for storing a pixel value. The pixels in the ith layer are represented by b_i^{th} bit of the pixel. Since gray code is applied the variation in the bits of the neighboring pixel is very less.

We compare the results for different radiography weld images which have been compressed by this technique and the results are tabulated in Table 1 and 2. The actual image size is 23.437 MB.

CONCLUSION

Thus an image was taken and compressed by two different techniques in four different ways. We interpret that the gray coded bit plane method (i.e., case 4) gives better results than the other three cases. The memory required for storing is higher as indicated in Table 2. This is because the enhanced image has more details than the image before enhancement. This can be observed by seeing the images Fig. 6 and 7. The case 4 gives the highest compression rate than remaining cases.

Fig. 6: Actual image before enhancement

Fig. 7: Actual image after enhancement

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