

Enhancement of JPEG Compression for GPS Images

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Abstract

GPS devices typically make use of images that are excessively large to be stored as a Bit Map, so the images are always compressed. The widespread compression technique is JPEG; however JPEG has a disadvantage – JPEG assumes that the average color of beginning of each blocks line is commonly similar to the average color of end of its preceding blocks line. Almost always this assumption is wrong for GPS images. This paper proposes a method to adjust JPEG order of compression to an improved order that is more suitable for GPS images.

Keywords: Image Compression, JPEG, GPS

1. Introduction

The JPEG committee was established in 1986 by the CCITT and ISO Standards organizations with the aim of creating universal standards for image compression [1]. The committee finalized the standard by early 1991 and latter the standard was approved as an International Standards Organization (ISO). Initially, JPEG targeted achieving a 15:1 average compression ratio; however, currently JPEG achieves even better compression ratios. Some real-time, full-motion and video applications also used JPEG [2-3].

Many GPS applications use maps stored in small squares format [4]. With the aim of reducing transmitted data [5], these small squares are stored in the well known JPEG format [6]. The aim of this paper is presenting a better layout for the JPEG order of operation with the purpose of yielding a better compression result [7].

JPEG compression algorithm performs these operations:

At first, it transforms the image color into a suitable color space. The most common procedure is the converting into YUV components. These components are interleaved together within the compressed data. The ratio between these components is usually not one to one. The Y components will usually have a four times weight. The human eye is less sensitive to the frequency of chrominance information than to the frequency of luminance information which is represented by the Y component in the YUV format. Hence, the Y component gets a higher weight [8]. *i.e.* the order is 4 Y blocks, one U block, one V block and then over and over again Y blocks, one U block, one V block; whereas each block contain 8X8 pixels.

JPEG employs Chroma subsampling which is a technique of encoding images by using less resolution for chrominance information than for luminance information, taking advantage of the human eye's lower sensitiveness for color differences than for luminance differences. JPEG supports the obvious 4:1:1 chroma subsampling which denotes the color resolution is quartered, compared to the luminance information *i.e.* for each sampled element as in figure 1, there is 4 numbers for luminance and just one number for chrominance [9]; however the default chroma subsampling of JPEG is 4:2:0 which denotes the horizontal sampling is doubled compared to 4:1:1, but as the U and V components are only sampled on each alternate line.

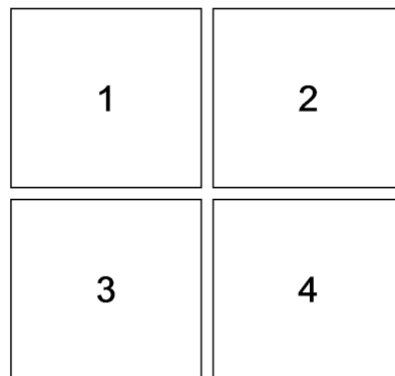


Figure 1. One JPEG Sampled Element

JPEG allows samples of 8 bits or 12 bits. In the original JPEG all values contained by the same source image must have the same precision. The values are shifted from unsigned integers with range $[0, 2^p-1]$ to signed integers with range $[-2^{p-1}, 2^{p-1}-1]$, by reducing 2^{p-1} from the original values, where p can be either 8 or 12 [10]. These biased values are then sent to the next step.

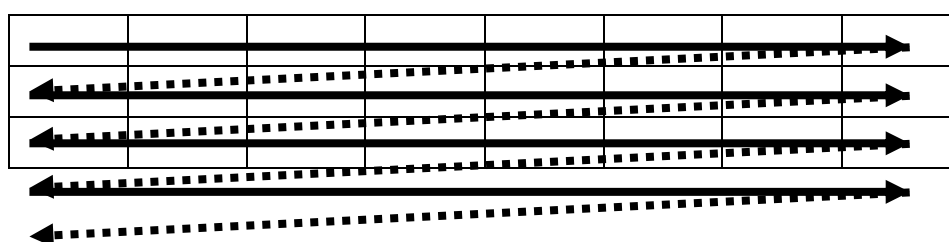
The order of the blocks is line by line and each line is read from left to right. After the group into blocks, JPEG transforms each block through a Forward Discrete Cosine Transform (FDCT) [11]. The DCT gives a frequency map, with 8×8 or 64 elements. The transformation keeps the low frequency information which a human eye is sensitive to [12].

Subsequently a quantization is done. In each block, each of the 64 coefficients is divided by a separate "quantization coefficient". The quantization coefficients are set according to the desired image quality. In point of fact, the image creator decides about a quality level (which is a number amongst 1 to 100) and according to this number the quantization coefficients are set. There is no standard method how to translate this quality level number into the quantization coefficients, so the quantization coefficients themselves are stored in the compressed image. The results of the division are rounded to integers. This step loses some information because of the rounding. Furthermore, it can be noted that even if the quantization coefficient is 1, some information will be lost, because more often than not the DCT coefficients are real numbers.

Finally, JPEG uses a Huffman compression method with the aim of reducing the size of the data. JPEG encodes the reduced coefficients using Huffman codes (Arithmetic coding [13-15] is also supported, but it is not commonly used). There are also other compression algorithms that fit JPEG, but are not officially supported [14].

2. Improved JPEG Based GPS Picture Compression

As was mentioned above the blocks of JPEG are stored line by line. So, the first block of line no. $N+1$ is stored after the last block of line no. N . Accordingly, the order of the block is as depicted in Figure 2:



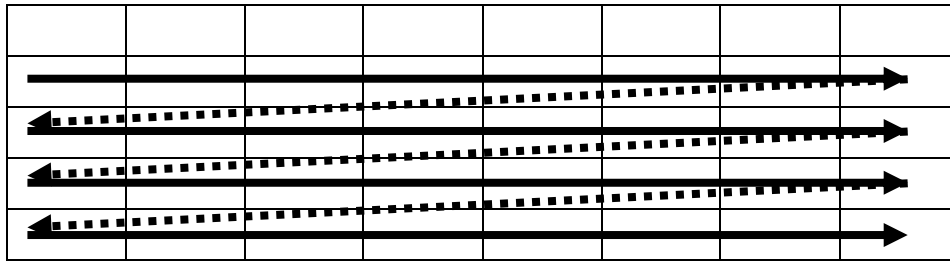


Figure 2. The Order of the Lines in JPEG Image

The first value of each block is "DC" [15]. DC is the average intense of the block multiplied by 8. It should be noted that DC is not stored as a plain value; rather it is stored as the difference between the current DC value and the previous DC value [16-17]. Usually, the DC values of adjacent blocks is similar [18-19], so it is commonsensical to store the difference which is a smaller number instead of the original number [20-22]; however the difference between the last DC in a line and the first DC in the next line is not always small because there are not DC values of adjacent blocks.

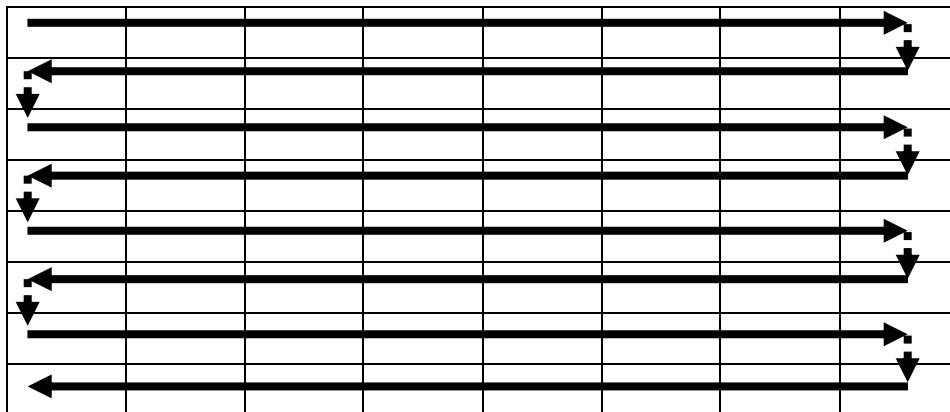


Figure 3. New Order Line for JPEG Images

The average colors of the beginning of the lines are typically quite similar and sometime are even equal. Likewise, the average colors of the end of the lines are also typically quite similar and sometime are even equal. The probability for the average colors of the beginning and the average colors of the end of the lines to be dissimilar is significantly higher [21-22]. For that reason, we suggest to change the order of the blocks in JPEG images to the order in Figure 3. In that way JPEG will always go through adjacent blocks and the probability of having similar DC values will become much higher; therefore the compression will be improved.

3. Experiments Results

Figure 4 is a GPS map [23] of a region in Israel. Each line of the image's blocks is of 16 pixels height. Each block is 8X8 pixels, but since for each four Y block there are only one U block and one V block each four pixels of U, just one pixel is actually stored and its value is the average of the four pixels [24]. The same is for V block. So for each 16X16 block of pixels there are four Y blocks, one U block and one V block.

In Figure 5 we can see the first and the second 16 pixels lines of the image. The average DC values of the last blocks of the first line and the average DC values of first block of the second line are shown in Table 1.

Table 1. DC Values

	Last DC of First line	First DC of Second line	Difference
Y	236	204	-32
U	122	156	34
V	130	108	-22

As can be easily seen the average colors of the beginning of the lines is usually very similar and sometime is even identical. The likelihood for the average colors of the beginning and the end of the lines to be similar is to a great extent lower [25-26]. In particular, the differences between the average colors of the beginning of the lines in Figure 4 for Y, U and V are all zero *i.e.* they are totally identical. The DC values of Y, U, V in the end of line 2 are specified in Table 2: 237, 125, 127, accordingly the differences between the average colors of the end of the lines in Figure 4 for Y is 1, for U is 3 and for V is -3.

In view of the fact that the DC values are stored as the differences between the current value and the previous value, we should focus on the differences. When there is no difference, according to [27], it will be indicated by JPEG by the sequence 00 which is a two bits string. A difference of 1 will be indicated by 0101 (4 bits), a difference of 3 will be indicated by 01111 (5 bits) and a difference of -3 will be indicated by 01100 (5 bits).

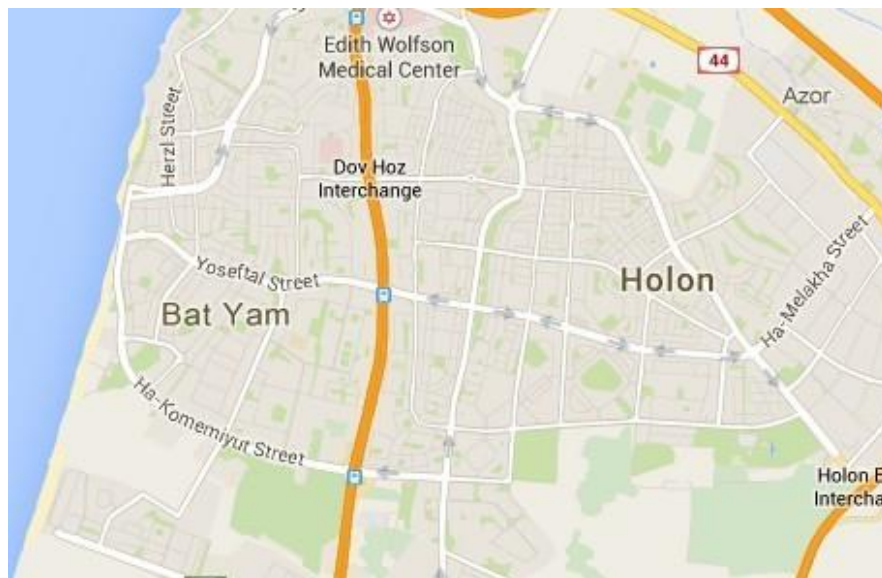


Figure 4. Example of GPS Map



Figure 5. Two First Lines of 16 Pixels

On the other hand, in the original scheme of JPEG, -32 will be indicated by the string 1110011111 and 34 will be indicated by 1110100010 which are both 10 bits strings. -22 will be indicated by a slightly shorter bit string – 11001001 which is just 8 bits, but still a longer string than the bit strings that represent the differences between the last DCs of the first line and the last DCs of the second line.

Table 2. DC Values

	Last DC of First line	Last DC of Second line	Difference
Y	236	237	1
U	122	125	3
V	130	127	-3

For that reason, we suggest to change the order of the blocks in JPEG images to the order in Figure 3. In the example of Figure 5 this will result in 14 bits (4+5+5 bits) instead of 28 bits (10+10+8 bits) in the original scheme of JPEG. That is reduction of 50%.

With the new suggested order the difference between the DCs of adjacent lines will be significantly smaller and the image will be compressed better. The changes between the DC values will be much more gradual; therefore the values of the differences will be much smaller resulting in smaller bit sequences for the code-words that the compressed data is consisting of.

The previous example in this section contained a sea; however, the differences in GPS images are not just because of water bodies. Yet another example is given herein below in Figure 6. This additional example contains green areas in the right side of the image and because of these areas, here again the differences between the DCs of the end of the first line and the DCs of the beginning of the second line are much higher than the differences between the DCs of the end of the first line and the DCs of the end of the second line.

Actually, this image has an interesting feature - The DCs of the end of the first line and the DCs of the end of the second line are exactly the same. In an arbitrary not adjacent blocks this can hardly ever happen; however, when the blocks are adjacent, the chance for such a case becomes quite good.

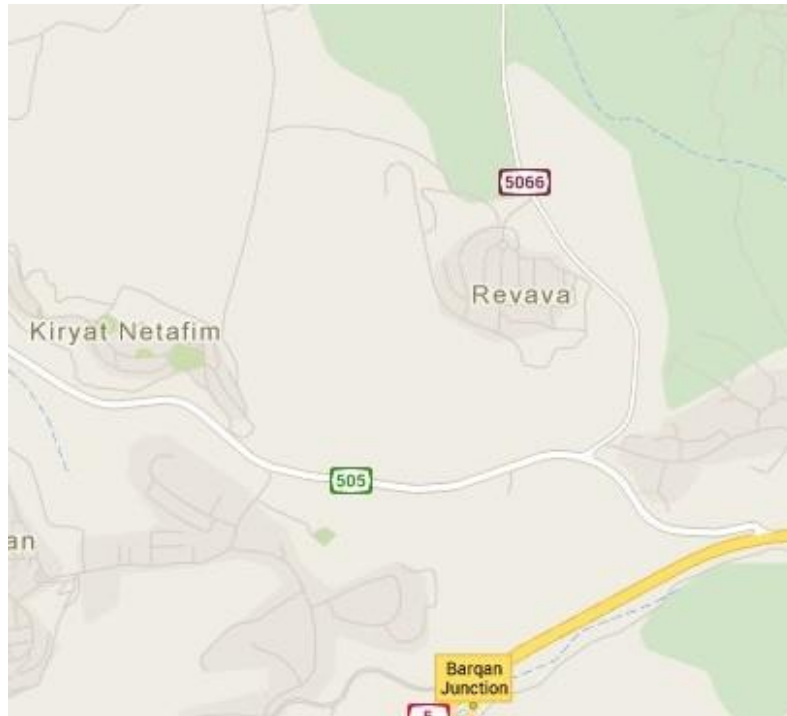


Figure 6. Yet another Example of GPS Map

Similarly to Figure 4, Figure 6 is a GPS map of a region in Israel whereas each line of the image's blocks is of 16 pixels height. The DC values of the end of the first line and DC values of the beginning of the second line and the differences between them are specified in Table 3.

These values will be indicated by these code-words: 20 will be indicated by the string 11010100 (8 bits), 5 will be indicated by 100101 (6 bits) and 10 will be indicated by 1011010 (7 bits) which is in total 21 bits.

On the other hand, when there is no difference, it will be indicated by JPEG by the sequence 00 which is a two bits string; therefore, for 3 DCs the total needed bits is just 6 bits which is a reduction of 71.43%.



Figure 7. Two First Lines of 16 Pixels

Table 3. DCValues

	Last DC of First line	First DC of Second line	Difference
Y	218	238	20
U	117	122	5
V	120	130	10

Table 4. DC Values

	Last DC of First line	Last DC of Second line	Difference
Y	218	218	0
U	117	117	0
V	120	120	0

4. Satellite Images

Satellite images [28] usually have the same characteristic *i.e.* the possibility of the average colors of the beginning and the average colors end of the lines to be similar is extensively lower than the possibility of the average colors of adjacent blocks to be similar [29].

However, there is a noteworthy difference between satellite images and map images. Maps images typically make use of brighter colors whereas satellite images typically make use of both bright and dark colors [30]. This attribute to some extent reduces the possibility of the Y component differences to be large.



Figure 8. Example of Satellite Image

Figure 8 is a good example for this attribute. The DC values of the end of the first line and DC values of the beginning of the second line and the differences between them are specified in Table 5. The difference between the DC values of the Y components is frequently very large as it is in this example. When the difference is calculated between the Y components of adjacent blocks, such a difference will hardly ever occur.

In this example the code-words for these values will be: 102 will be indicated by the string 111101100110 (12 bits), -4 will be indicated by 100011 (6 bits) and 10 will be indicated by 1011010 (7 bits) which is in total 25 bits.

When the order of the blocks is that the last block of the second line comes after the last block of the first line, the difference between the Y components is still relatively not so small, but it is not as large as the difference between the Y components in the original order.

The actual numbers for the new suggested order for this example are specified in Table 6 and they will be: 20 will be indicated by the string 11010100 (8 bits), 1 will be indicated by 0101 (4 bits) and -3 will be indicated by 01100 (5 bits) which is in total 17 bits and a reduction of 32%.



Figure 9. Two First Lines of 16 Pixels

Table 5. DC Values

	Last DC of First line	First DC of Second line	Difference
Y	62	167	102
U	121	117	-4
V	125	135	10

Table 6. DC Values

	Last DC of First line	Last DC of Second line	Difference
Y	62	82	20
U	121	122	1
V	125	122	-3

5. Conclusions

GPS memory complicatedness [31-32] makes compression essential [33-34]. A technique of compression for JPEG based GPS picture with a higher compression ratio has been introduced. This paper has shown that JPEG's supposition that the average color of beginning of each blocks line is quite similar to the average color of end of its preceding blocks line is incorrect for most of GPS images. The change of the block order of JPEG compression algorithm can facilitate a reduction in the compressed file. The results are encouraging. The difference between the values of each blocks line can be dramatically decreased and as a result a much small compressed images can be obtained.

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