# Real-Time Monitoring of Traffic Congestions

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***Abstract*— Alleviating the difficulty of congestion roads is quite a tough task; however such an alleviation can prevent many unwanted problems like employees late to work; deliveries do not arrive on time and many more. One of the main tactics to deal with the congested road difficulty is alerting the drivers about congested roads in real time, so the drivers will be able to evade these congested roads. This paper suggests examining road's images in real time so as to figure out which roads are congested and which roads are vacant. Moreover, the paper suggests combining the entire data into a full map showing each road's congestion intensity.**

***Keywords — Traffic Congestion, Discrete Cosine Transform, JPEG.***

## I. INTRODUCTION

Traffic congestions can be created because too many vehicles need to go through a road, but road traffic capacity is not enough for them. For that reason, traffic congestions are generated when there is a growth in the amount of vehicles or shrinkage in the road capacity.

A growth in the amount of vehicles can be produced if too many vehicles travel in a road to the same direction in the same time. Such a situation occurs for instance in the beginning of working days when many people travel to employment centers, or in the end of working days when these people return from the employment centers to their residences. Similarly, a mass event can instigate traffic congestions in the vicinity of this mass event.

Shrinkage in road traffic capacity can be generated by several occasions like vehicle accidents, police checkpoints or road constructions.

Unsurprisingly, the drivers are very concerned about the intensity of traffic congestions in their planned path [1,2]. This paper suggests employing a plain digital camera to trace the traffic congestions. Nearly each and every existing digital camera can create JPEG images. JPEG is a very usual technique for image compression. In addition, JPEG is broadly employed by electronic devices like scanners and digital cameras [3] over and above vehicle equipment like GPS and more [4].

JPEG format has various advantages that made it widespread like the potential of being decoded in parallel [5], the simplicity of adjustment of alternative compression techniques [ 6 ] and the possibility for uncomplicated and amenable hardware implementation from various producers [7,8].

Typically, images are compressed before storing because the difference in size between an uncompressed file and a compressed file is very significant. Moreover, the difference in eyesight between the uncompressed file and the compressed file is actually imperceptible. JPEG loses some data when it compresses an image, but this data loss is commonly absolutely invisible.

A naive tactic for dealing with compressed images would be first decompressing the image and just after that doing what we need to do on the uncompressed image. As an alternative, we would like to suggest a better tactic. In some cases, we can directly deal with the compressed image. This direct operation provides us two benefits:

1. A standard digital camera can be employed without any requirement to tweak the digital camera.
2. JPEG employs an algorithm that supposed to simulate the way a human eye sees, so JPEG will be able to take away the unnoticeable data from the image. Since the human eye is sensitive to changes and we mostly interested in changes, we can use this information that JPEG produces.

The rest of the paper is organized as follow: Section 2 explains how JPEG format can be used for monitoring traffic congestions; section 3 explains the experiments we have carried out while section 4 concludes the paper.

## II. MONITORING OF TRAFFIC CONGESTIONS

We choose the JPEG format because JPEG is a widespread image compression format and because it effectively detects changes in a picture. JPEG takes away some unnoticeable information when it compresses the image, so the decompressed image is different from the original image; however, the adjustments are normally imperceptible. The intensity of the changes can be opted for by means of attuning the compression parameters.

JPEG is very common in use n many applications mainly because of two essential motivations:

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1. JPEG stores full color information and allows choosing 8 or 12 bits for this information.
2. JPEG considerably diminishes the size of almost any image file. This diminution facilitates significant reduction of traffic on networks and alleviating of memory pressure [9].

JPEG is a widespread standard and many articles explaining its principles and implementations have been written e.g. [10,11,12].

JPEG transforms images into frequency space data using the DCT algorithm [13]. After this transformation, usually many of the coefficients have a low value between 0.5 to -0.5. These low values are rounded to zero. If a block has no changes or minor changes, most of the coefficients of this block will be rounded to zero. In such blocks, JPEG will be very efficient since it will compress the image into a very small file.

JPEG breaks any image into blocks of 8X8 pixels. The order of these blocks in the compressed file is line by line. Each line is compressed from left to right [14,15]. If there is a substantial change in the shade within a block of 8X8, most of the DCT coefficients' values will be higher. JPEG will compress such a block into many more bits than a block containing mostly zeros.

When examining a picture of congested road vs. a picture of vacant road, the main issue will be to find the amount of the vehicles. Our algorithm uses the JPEG compression that splits the image into blocks of 8X8. Next the algorithm examines the compressed file size. The algorithm takes a close picture of each road segment. If the picture entire size is exceeding a certain threshold, the algorithm will consider this road segment as a congested segment.

If there are doubts what the threshold value is supposed to be, we can analyze the probability density function (PDF) of the block with the aim of choosing the best value. In a straightforward pictures, the PDF can be mono-modal and the inflection point value can be chosen [16,17].

JPEG is a decent algorithm that does its job well and is very common in use. This motivated us to select this algorithm. There may perhaps be additional useful algorithms, but employing those uncommon algorithms requires us pushing a new standard which is not advisable.

Figure 1 shows how JPEG compresses a block containg a substantial change vs. a block without changes. The image of Figure 1 was compressed in grayscale baseline JPEG format with quality of 75%. The image is a picture of 1000X1000 pixels most of them are white except of the black rectangle. Table 1 details the values of the JPEG block containing the upper right corner of the black rectangle. The rectangle boundaries are not aligned to the 8X8 blocks of JPEG.

DC value is the average of 8X8 block values. JPEG does not store in the compressed file the DC values themselves, but rather it stores the value variance between the previous block DC value and the current block DC value [18,19]. If a block contains only black or white pixels, there will be no variance in the DC values. Such a block is treated very efficiently by JPEG and will be encoded only by six bits:

0, 0,1,0,1,0.

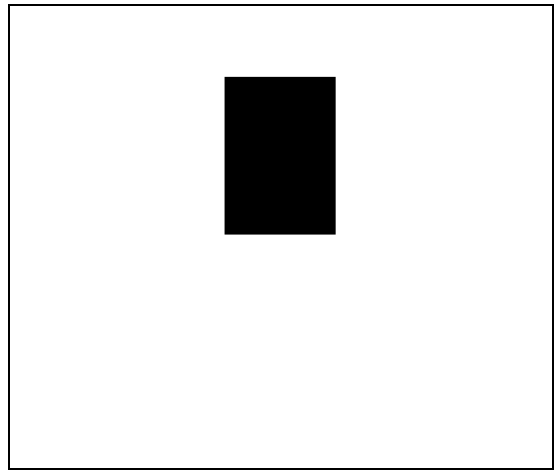

**Fig. 1.** Sample image showing how JPEG can be used for edge detection.

The 00 in the beginning of the six bits sequence indicates that there is no variance between the previous block's DC value and the current block's DC value. The 1010 in the end of the six bits sequence indicates an end of the block (EOB).

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -12 | 18 | -8 | -2 | 3 | -1 | -1 | 1 |
| 22 | -25 | 8 | 2 | -3 | 0 | 1 | -1 |
| -18 | 20 | -7 | -2 | 2 | 0 | -1 | 1 |
| 16 | 14 | 4 | 1 | -1 | 0 | 1 | 1 |
| -11 | 10 | -2 | -1 | 0 | -1 | -1 | 0 |
| 6 | -5 | 1 | -3 | 0 | 0 | 0 | 0 |
| -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0 |
| 1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 1.** JPEG compression for a block with a substantial change.

A block that includes a substantial change from one color to another will be transformed into a wide range of frequency values. Such block values can be seen in Table 1. Therefore, in this case the threshold that marks out the edges is discernible [20,21,22].

243 bits are needed in JPEG baseline format so as to compress the values of table 1. The dissimilarity between 243 bits that are required for this block and the six bits that has

been required to the smooth blocks is clearly distinct. We suggest examining block's length in order to detect edges of vehicles [23,24]. If there are many vehicle edges in one picture, it will indicate that the image contains many vehicles and the road is congested.

## III. Experiments

We tested our algorithm on many road segments. We examined whether the algorithm works as expected and it is able to recognize which road segments are congested and which road segments are vacant. Obviously, smooth blocks and blocks with substantial changes like the blocks of Figure 1 do not exist in real pictures of road segments; however, we still have accomplished to realize in most of the road segments our system has checked up, the approximately intense of the congestion.

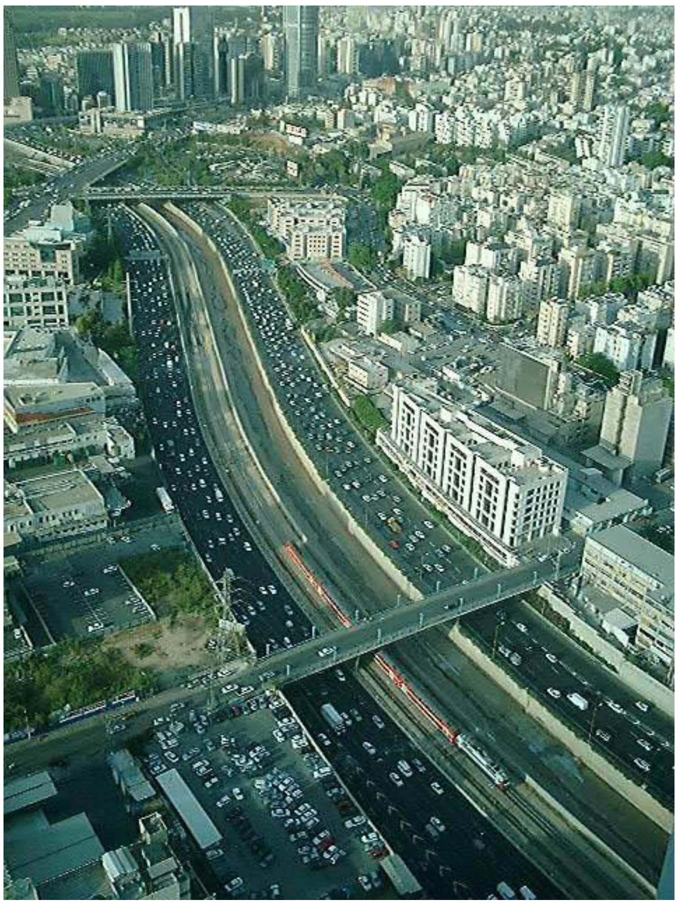

**Fig. 3.** Ntivey Ayalon in a congested mode

Figure 2 shows the most congested road in Israel in the city off Tel Aviv – Netivey Ayalon (road no. 20). The traffic in this picture is backed-up and because the image contains many vehicles and many changes, our system classified it as a congested road.

Figure 3 shows the same road as figure 2 shows; however the picture was taken in another time when the traffic was quite sparse. This picture has more smooth blocks with fewer changes. Therefore, the picture has been compressed into a smaller file and the system has succeeded to recognize that traffic was sparse.

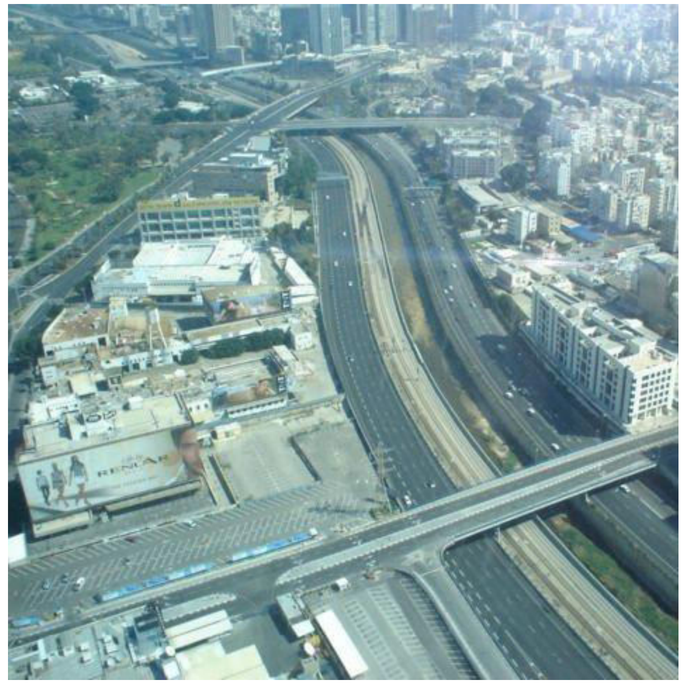

**Fig. 2.** Ntivey Ayalon in a vacant mode

We employed a Nikon D5300 digital camera [25] with resolution of 24.2 MP. Pictures that have been compressed into more than 5.7MB typically indicated a congested road; whereas Pictures that have been compressed into less than 4.2MB typically indicated vacant roads. The sizes between 4.2MB to 5.7MB were uncertain.

JPEG standard has a quality factor which is used to create two quantization tables - one for the luminance (brightness) information and the second for the chrominance (color) information. Any application that complies with IJG (Independent JPEG Group) produce quantization tables according to the IJG specification; however, there are many other applications employing various quantization tables.

In our system, we have employed IJG quantization tables. We obviously have chosen the highest quality factor (100%), in an attempt to obtain the best distinguishableness. A quality factor of 100% in IJG stipulates that all the quantization table is filled with ones that is to say the frequency coefficients are actually not divided.

There are some circumstances which were uncertain for our system. When there is a jam in one lane, the system will have many changes in one side of the picture; whereas the other part has almost no change. Such situations are typically happens in the turn right lane. Figure 4 is an example for such a situation. The picture size is pretty similar to a picture of a minor congestion; however it is very difficult to realize just by the JPEG compressed picture size which picture contains a minor congested road and which picture contains a road with one congested lane.

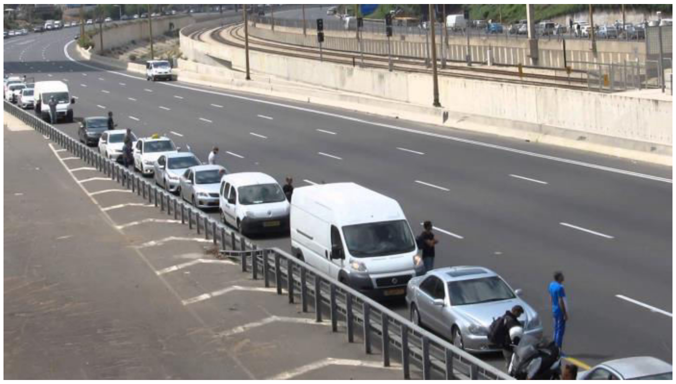

**Fig 4.** Jam in right turn lane.

Flooded roads are another situation of a difficult distinction for our system. When a vehicle splashes water on the road, it will make the system consider the vehicle larger than its real dimensions. Figure 5 contains such incident. Even so, this misinterpretation of our system is actually not harmful, because as a matter of fact such splashes by some means truly occupy a slice of the road since commonly drivers prefer not to go through such splashes as they are afraid the water will restrict their ability to see.

**Fig 5.** Vehicle splashes water in a flooded road.

False alarms are one major problem in many systems and our system is no exception. Figure 6 shows a situation when a false alarm has been generated. Figure 6 contains hail that a human eye can be straightforwardly observe; however, this hail made our system presuming that the road in this picture is congested; whereas as a matter of fact this road was almost vacant. Similarly, Light snow can generate such false alarms; heavy snow however will not be a problem because such a snow will make the entire road white and therefore the changes in the picture will not be substantial and as a result the picture will be compressed into a small file.

**Fig 6.** Road with hail

## IV. Conclusions and Future work

JPEG employs DCT which compresses better picture blocks that do not contain substantial changes. When there is a picture block with substantial changes, JPEG compresses it into a much larger file. If there are many picture blocks containing substantial changes, the file size of the compressed picture will be considerably larger. Consequently, if a road segment picture has been compressed into is a large file, a computer system can figure out that this road segment is probably congested.

Congestion traffic map is employed by many applications like Waze [26] or Google Traffic [27]. Because of these applications, improving systems for traffic congestion detection is an emerging research area [28]. Most of these applications employ cellular phones [29]; however, in this paper we suggested to employ a digital camera that can generate JPEG images in order to find roads with traffic congestions and create a congestion traffic map.

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