# Fuselage Safety Apparatus

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**Abstract**

*This paper proposes a simple way to monitor the fuselage in flight to quickly diagnose whether there is a defect in a certain part of the fuselage. The proposed device not only diagnoses whether there is a defect but also informs about the exact location of the defect. This device increases the safety of the flight and helps the pilot to decide on an immediate emergency landing if a defect is discovered in the plane's fuselage.*

**Keywords:** JPEG, Fuselage, Digital Camera.

## 1. Introduction

Monitoring of the fuselage's condition is tremendously crucial [1]. It is suggested using an ordinary digital camera to locate the damaged part. Nearly all digital cameras can produce JPEG pictures. JPEG is a very common method for image compression and it is also extensively used by electronic devices like scanners and digital cameras [2].

JPEG images have many advantages like the ability of being decoded in parallel [3], the straightforwardness of adaptation for new compression methods and the capability of flexible implementation for hardware from different vendors. The wide use of JPEG is because of two fundamental reasons: storing full color information and reducing the size of image files, so as to avoid high traffic on the network and avoiding memory pressure. When there is a good algorithm that is very common in the market and does a good job, it seems to be the commonsensical choice. There might be some other good algorithms, but using those algorithms means you have to push a new standard which can be a very hard task.

Images are often stored in a compressed standard. A naive approach for image processing on compressed images would be to decompress the image and then running the image processing algorithm on the original image data. Instead, for some image operations, we can act on the compressed data directly. This gives us two benefits: first, we can use the standard digital cameras without a need to adjust the digital camera; second, the signal processing used by JPEG can let us use the frequency information embedded in the compressed data.

## 2. Detection of Fuselage Defective Parts

The JPEG standard [4] is based on the DCT paradigm [5]. The DCT changes the picture into frequency space. The frequency coefficients, which are very low magnitude, are rounded to zero. When most of the coefficients in a block are zero or very low magnitude: The compression algorithm will give a very short bits sequence for such a block. Zero sequences are treated very efficiently by JPEG compression and the results will be only few bytes.

Unlike text compression method that usually use Lempel-Ziv methods [6], the last step of JPEG encodes the reduced coefficients using either Huffman or Arithmetic coding. There are also other compression algorithms that fit JPEG, but are not officially supported [7]. When there is a drastic change in a block of 8X8, the value of many frequency coefficients will be high. Such a sequence will be compressed into many more bits. JPEG's standard stipulates that the block's size will be 8X8 pixels, but the algorithm will be obviously good for other small NXN pixels size too.

When looking for the contour of an object, the goal will be to locate the object's border. The idea is to break the compressed file into its original blocks, then look in the compressed file for long bit sequences. The blocks which are compressed into long bit sequences, are presumed to be the object's border. In our implementation we took a simpler approach. We take pictures of the fuselage. We actually take a close picture of each part of the fuselage. If the entire size of a picture is above a certain threshold, we will consider this part of the fuselage as a damaged part. If we have no idea what the threshold value should be, we can examine the probability density function (PDF) [8] of the block representation to select a suitable value. In the uncomplicated case the PDF should be mono-modal and we set the value in the inflection point.

We made an example of a fully white image with a black square. The image was compressed in grayscale baseline JPEG format with 75% quality with a high-resolution picture of 1000X1000 pixels. The size of the black square was 200X200 pixels and the square is not aligned relative to JPEG's 8X8 blocks.

The JPEG file reports the difference of magnitude between the DC's coefficients of a previous block relative to the current block. In the case of a white or black area there are no changes in the coefficients' magnitudes. This type of block is encoded as six bits by the JPEG standard: 0,0,1,0,1,0. The "00" reflects that there are no differences between the values of the previous and the current block's DC coefficients, and "1010" symbolizes the end of the block. However, in order to compress the block which contains the upper left corner of the black square in JPEG standard, 243 bits are needed. The difference between 6 to 243 is obviously significant. A block which encodes a sharp change from white to black is represented by a wide range of frequency coefficients. It is easy to select a threshold that delimits the edges of the shape from the rest of the image [9,10,11].

By using three parameters the length of the block, its magnitude and the number of consecutive blocks the threshold can extract the contour with a range of scalar values [12,13]. The extra parameters allow more control over the resulting mechanism.

## 3. Experiments

We examined our technique on some damaged fuselages and tried to check whether we succeed to locate the damaged part. Clearly, obvious cases like in Figure 4 do not exist in real fuselages, but we still succeed to find most of the damaged parts by taking many picture of it in all of its parts. We used an Olympus FE-170 digital camera with resolution of 2112X2816. The Images with no damage in the fuselage produced images in size of less than 1.3MB; whereas images in size of more than 1.5MB usually had damage in the fuselage. Many of the fuselage damages are clear. It appears that many wildlife strike aircrafts and in such cases the damage is usually quite large. Since the establishment of the Federal Aviation Administration's (FAA) National Wildlife Strike Database at 1990, 99,411 reported wildlife strikes to airplanes have been reported [14].

The result of these strikes causes more than 200 human lives lost worldwide as well as financial losses (direct and indirect) of at least $1.2 billion annually to civil aviation worldwide. Particularly, more than $625 million of financial losses annually just in the United States [15]. This is more than the loss for the aviation industry caused by various terror groups [16]. However, sometimes there are smaller damages. One major reason for smaller damages is hail [17]. At July 14, 2011, More than 100 flights have been called off at Denver International Airport after hail damaged about 40 aircrafts and stranded about 1,000 passengers overnight. The damages were usually not large. There also some other small objects that sometime soar over airports and can cause tiny damages.Actually, there are seasons that there more such accidents [18]. Usually the months of Aug-Oct have the highest priority of having such damages. As a matter of fact, the use of our system for large and clear damages is less important, although sometimes a cabin crew member under stress can need a help even such cases; however when a small and indistinguishable damage can make lower the pressure in the cabin and locating it without delay can be an imperative.

There are also cases where our system has produced false alarms. A plain dirt made the system assuming that the fuselage is damaged; whereas this fuselage was actually undamaged.

The quality factor of JPEG is used to produce two quantization tables - one for the luminance (brightness) information and the other for the chrominance (color) information. Applications that support IJG (Independent JPEG Group) produce quantization tables according to the IJG specification; however, many other applications employ different quantization tables. At this paper we have used IJG quantization tables. Actually, in our system, we obviously preferred the highest quality factor (100%), so as to get the best distinguishableness, which means in IJG that the entire quantization table is filled with 1s i.e. the frequency coefficients are not divided.

## 4. Conclusions and Future Work

Defected fuselage is tremendously hazardous and can cause many loss of life. Computerized inspection of plane's fuselage is critical and vital as was noted in [19]. Damage detection of vulnerable structures has been explored by many researchers in different engineering disciplines. Various detection methods have been developed and successfully applied to different types of structures [20]. In addition, various damage scenarios and circumstances have been researched [21]. This method can be also effective for data collection for the flight data recorder. Using this device the flight data recorder will be able to know about the size and the location of the damage during the flight time [22]. We also consider developing more sophisticated algorithm that can not only identify damaged fuselage, but also identify various kinds of damages. Looking at existing machine-vision [23] and machine-learning algorithms [24] may help in significantly extending the suggested method.

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