Software Framework for Testing JPEG Quantization Tables for Iris Recognition

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Abstract: - JPEG is most widely used image compression algorithm. The source of its superb compression ability are quantization tables which determine which frequency components of the DCT transform will be neglected. JPEG standard includes recommended quantization tables for general use. However, specialized applications may need different quantization tables. One such example is biometric iris recognition system where it does not matter whether the picture of iris looks good but can it be efficiently discriminated from other iris images. This paper describes software framework for testing JPEG quantization tables applied to iris recognition from digital images. It allows for easy testing and inclusion of different comparison modules.

Key-Words: - JPEG, Image compression, Quantization table, Biometrics, Iris recognition

1 Introduction

JPEG (Joint photographic experts group) compression algorithm was developed for image compression. It is not a fixed standard but a set of recommendations. The quantization is a main part where compression is archived. There are various ways of doing quantization since there is not a unique best way. Different types of quantization are appropriate for different types of images and different applications. It is possible to have different quantization in different regions of the image [1], specialized quantization matrixes for photos with human face [2], or even more specific, very low resolution human face image for mobile phone [3]. Quantization can be specifically adjusted to for recognition of iris in human eye for biometric purpose [4]. Quantization tables can also be designed to help separate images that have been processed by software from those that have not [5]. Some quantization tables are recommended with the JPEG standard. They are determined empirically and adjusted to human vision visual system, but research for alternatives continues [6].

A software system for experimenting with JPEG quantization is developed in C#. As an object-oriented system it is easy for maintenance and modifications and also has appropriate graphical user interface. Proposed methods of quantization tested with our software system facilitate rapid development of specific quantization tables for different types of images and different applications.

Iris recognition is one of the most successful biometric methods of identification. There is a lot of research in this area [1]. This paper describes a software framework with easy to use graphical user interface for testing different quantization tables and their effect to iris recognition from such compressed images.

The rest of this paper is organized as follows: in Section 2 the JPEG algorithm and its basic characteristics are described. Section 3 deals with the main topic of this paper: quantization and its various forms: threshold, a fixed number of coefficients and custom empirical matrixes for different applications, Section 4 is about iris recognition and appropriate algorithms and metrics and Section 5 describes our implementation of software framework for testing various quantization tables.

2 JPEG Image Compression

JPEG is most widely used standardized procedure for image compression. The name JPEG comes from the Joint Photographic Experts Group, which is the name of the association that proposed the standard. JPEG is designed for compression of color images as well as black and white or grayscale images. It is used for photographs and it is not very suitable for text and technical drawings.
The main problem with digital images is their size: typical photograph size today is of the order of tens of megabytes. In raster graphics, digital images are stored in a matrix of pixels and make the structure suitable for compression, since neighboring pixels are often identical or differ by a small value. Most standard format for bitmap graphics (e.g. GIF, PNG) support lossless compression methods, which are usually some variation of run-length encoding. The advantage of these methods is that compression and decompression are simple and fast, but they do not achieve high degree of compression. For example, run-length coding uses only similarity between pixels horizontally (horizontal coherence), and not vertically. Since every image is actually a 2-dimensional array of pixels, it can be viewed as a digital signal and methods for processing digital signals can be applied, including Fourier transform as an essential tool for signal processing.

JPEG compression is a very powerful lossy compression technique. It often can reduce the file size by factor of twenty or even fifty without apparent loss in image quality to the human eye. This is a huge saving since the lossless compression can achieve saving of memory space of barely 50%. JPEG compression is based on discrete cosine transform (DCT). DCT and inverse DCT used in decompression by itself do not induce any losses in the data, besides the fact that integer DCT does rounding of real value to the nearest integer.

JPEG uses the characteristic of the human eye that it sees less difference in the shades of colors than in the light intensity. Photos in full color achieve best compression ratios. Lower, but still good, is compression of images in shades of gray. Lowest compression is archived for simple drawings with sharp edges and the text, where even at low compression visible defects appear. User can choose the level of compression. For the higher level of compression files will be smaller but damaging of images becomes more pronounced. The main problem of JPEG compression algorithm is the fact that the damage resulting from the compression is permanent, and with successive editing of images, the losses accumulate.

Basic steps of JPEG sequential encoding are forward DCT, quantization and entropy coding (where a variation of run-length encoding appears).
The JPEG2000 standard supports lossy and lossless compression of single-component (e.g., grayscale) and multicomponent (e.g., color) imagery. In addition to this basic compression functionality, numerous other features are provided. Due to its excellent coding performance and many attractive features, JPEG2000 has a very large potential application base. Other compression algorithms are also used [7].

In this paper we will limit our attention to JPEG algorithm since for such uniform application as human iris recognition we do not need additional features of JPEG 2000.

3 Quantization Tables

Quantization is the main source of compression, but also a reason for information loss. Highly useful feature of the JPEG process is that varying levels of image compression and quality are obtainable through selection of quantization tables. As a result, the quality ratio can be tailored to suit different needs. Each of the coefficients in the 8x8 DCT matrix is divided by a weight taken from a quantization table and less important DCT coefficients are wiped out. If all the weights are 1, the transformation does not do any compression.

The JPEG still image compression standard allows use of custom quantization tables when image material with special properties is subject to compression. Example is iris imagery [4] which have different properties compared to common arbitrary images, and a pleasant viewing experience as being the aim in designing the default tables, might not deliver optimal matching results in the context of biometric recognition (e.g. sharp edges required for exact matching could appear appealing to human observers).

Table 1 shows the JPEG recommended quantization table for brightness component, which is contained in the information annex of the JPEG standard.

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Table 1: Quantization matrix Q_{50}

It is a quality level 50 quantization matrix which renders both high compression and excellent decompressed image quality.

The user can to decide on quality levels different from 50, ranging from 1 to 100, where 1 gives the poorest image quality and highest compression, while 100 gives the best quality and lowest compression.

For compression levels higher than 50, the standard quantization matrix is multiplied by \((100\text{-quality level})/50\). For a quality level less than 50, the standard quantization matrix is multiplied by \(50/\text{quality level}\). For quality levels above 50 the elements of quantization table are proportionally decreased and by dividing by smaller numbers more AC coefficients will survive. Opposite is true for the case when quality level is less than 50.

It is important to notice that resulting image quality can be very sensitive to small changes in the quality parameter. Figures 4, 5 and 6 show original image and image compressed to 95% and 97% of AC coefficients neglected.

Figure 4: Original image “Lena”

Figure 5: Quality 15%, 95% of zeros
The difference in compression for the last two images is neglectable, but the difference in image quality is quite noticeable. This shows that it is important to have good testing environment for any specialized application since it is important to detect such points of sharp image quality deterioration.

4 Iris Recognition

Biometrics attempts to solve the problem of uniquely identifying human beings by measuring a person’s intrinsic psychological or physical traits and using those measurements for future comparison and recognition [8], [9]. It has been successfully used for recording and comparing fingerprints, faces, DNA, gait, voice, retina, iris and other traits.

To be useful it must fulfill a few conditions to a satisfactory degree, such as being automated to allow large scale applications and concentrating on a highly unique trait which is not easily misrepresented or altered, either intentionally or by passage of time. We can gauge the effectiveness of a biometric system by its speed, rates of false positive and negative detections, ease and comfort of use, intrusiveness to subjects, resistance to tampering and the ability to work in suboptimal conditions and with suboptimal inputs with a satisfactory low degradation in accuracy.

Iris of an individual’s eye is a good candidate for biometrics for several reasons. The intricate random patterns it exhibits are determined during gestation, remain stable throughout the majority of a person’s life and are highly unique, even among genetically identical twins. The eye is a well-protected organ so there is a relatively low risk of iris pattern damage or destruction compared to some other human traits. Recording an iris pattern does not require physical contact so it is less intrusive than other methods.

Experience has shown that a system for iris recognition can be implemented is such a way that it can perform millions of match comparisons per second and yet exhibit very low to negligible false or missed matches.

Iris recognition works by comparing an input biometric template of an iris pattern with a database of previously acquired templates and reporting if a match is found. Patterns are extracted from an image of the iris and described mathematically to form a template and facilitate quick and accurate comparisons.

Image acquisition can be done from ever more increasing distances from a subject and is made less susceptible to suboptimal conditions such as a person or the eye itself moving while recorded. This is an improvement over the more commonly used “stop-and-stare” interface. Preprocessing methods can be used to improve on common issues with input images, such as obstruction by eyelashes, eyewear or glare, movement, off center gaze, pupil dilation variations, uncommon eye appearance and others caused by either the technique used or a medical condition.

The first working automated iris recognition system has been implemented and patented in the early nineties by John Daugman, a Cambridge researcher. It was shown to be reliable and effective by many studies and overall superior to other biometric technologies such as fingerprint, speech or face recognition. Due to the original implementation being encumbered by patents it is a worthwhile effort to research an open-source platform for iris recognition with the aim of verifying existing study results and improving the performance of known implementations.

Standard iris recognition process consists of number of steps. The pattern extraction begins with segmentation which is a process of isolating the actual iris region from the surrounding sclera and pupil areas. This can be accomplished by approximating with concentric circles or by using more sophisticated approaches that do not assume the shape and position of different areas of the eye. Segmentation can be challenging if there is much occlusion of the iris or due to poor lighting conditions during the image acquisition stage. Near infra-red lighting can be used to minimize reflections and increase the contrast between the pupil and a darkly pigmented iris. If included non-iris data can severely deteriorate the quality of the biometric template so the segmentation process is considered critical.

To be comparable biometric templates of the iris must be normalized to a fixed size because of
variations in physical area of the iris due to pupil dilation, changes in distance to the image acquisition apparatus and head and eye position.

To acquire an accurate template only the most distinguishing features of the iris need to be recognized and extracted. Samples are filtered to discard variations produced by lighting or equipment and thus improve the template usability over time. It is also important to determine a matching metric such that one can later distinguish if a new template is indeed made from the same iris as a previously extracted template or from a different iris.

In [4] some custom quantization tables for iris recognition are proposed. In Table 2 an increasing large number of high frequencies are suppressed by dividing the coefficients by 255, coefficients not affected are quantized as defined in the default Q-table.

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Table 2: Quantization matrix Q-12

In the matrix Q-16, only the 6 leading coefficients are quantized in the regular manner, the rest is severely quantized. The rationale behind the selection of these matrices is to investigate the importance of medium frequency information in iris recognition (high frequency information is assumed not to be useful in any case)

5 Software Framework

A framework is a special kind of software library that is similar to an application program interface (API) in the class of packages that make possible faster development of applications. Big difference is that, while an API consists of a set of functions that user calls, a framework consists of a hierarchy of abstract classes. The user only defines suitable derived classes that implement the virtual functions of the abstract classes. Frameworks are characterized by using the inverse control mechanism for the communication with the user code: the functions of the framework call the user-defined functions and not the other way round. The framework thus provides full control structures for the invariant part of the algorithms and the user only supplies the problem-specific details.

We implemented our software framework in C# under MS Visual Studio 2010. We used iris images from CASIA-IrisV4 database from http://www.cbsr.ia.ac.cn/english/Databases.asp, specifically we used CASIA-Iris-Interval subset. Examples of the original iris image and compressed image are in Figures 7 and 8.


In [4] different quantization tables were investigated. We wanted to be able to test different resolutions of original images as well as different degrees of compression [12]. We are also able to...
easily include modules that will use different metrics for image distance.

6 Conclusion
Software system is developed that facilitates, through user-friendly graphical interface, access to all internal parameters of the JPEG compression recommendations. Since quantization process is most important and critical step in JPEG image compression, besides changes in parameters, different ways of handling quantization are incorporated. There is a lot of research in the area of custom quantization tables that are appropriate for very specialized types of images and applications and this system allows for testing them.

Further development of this software system will include more possibilities for new ways of generating and testing custom quantization tables.

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