CHAPTER 4
IDENTIFICATION OF ORIGINAL DIAMONDS FROM CUBIC ZIRCONIA USING THRESHOLDING & HISTOGRAM

4.1 Introduction

The ultimate aim in a large number of image processing applications is to extract important features from image data, from which a description, interpretation, or understanding of the scene can be provided by the machine [54]. Image analysis deals with the techniques for extracting information from an image. The first step in image analysis is to segment the image. Segmentation subdivides an image into its constituent parts or objects [53]. Segmentation technique basically divides the spatial domain, on which the image is defined, into ‘meaningful’ parts or regions. This meaningful region may be a complete object or may be a part of it. The level to which this subdivision is carried depends on the problem being solved. An image contains various regions corresponding to different objects or their parts in the scene. The pixels comprising a region receive information from points of corresponding object or its part. Since different objects or different parts of the same object have different characteristics (e.g. reflectance of material, surface orientation and texture), feature values recorded at pixels belonging to various regions should be different [1]. Hence, to differentiate / identify original diamonds from CZ, based on their optical properties, thresholding, which is one form of segmentation, is used.

Image thresholding enjoys a central position in applications of image segmentation [71]. The key and most difficult step in most image analysis procedures is the thresholding or segmentation step used to separate the image into features and background. This process is usually performed manually, which leaves plenty of room for operator differences and inconsistency, but allows the subtle power of human vision to decide what 'should' be included as features to be measured. Having the image histogram displayed to show the threshold settings in relationship to the brightness values, and then showing the selected pixels on the image immediately to show the effect of changes in settings, are both vital tools for the human while adjusting the settings. Simple brightness thresholding can be performed using the built-in Photoshop Threshold function (select Image -> Adjustments -> Threshold).
This displays a histogram of the image with a single sliding marker that can be moved to separate the brightness values to be displayed as black and white, while the image shows the result [72].

As the objective of the present work is identification of original diamonds from CZ, their difference in the optical properties need to be studied using thresholding. If the threshold is too high, important edges may be missed. If the threshold is too low, noise may be mistaken for a genuine edge. The specific threshold value plays a very important role in the outcome of the segmentation. Hence, threshold selection is very important. Obviously, one method of doing this is to always threshold about 128, the middle point in the histogram. This value was used to threshold several diamond images. As the result proved to be satisfactory when compared to other values, the threshold value used in this work is a constant which equals the value, 128. By using this value, the process of distinguishing original diamonds from Cubic Zirconia was found to be easier. Therefore, to the color image of the diamonds acquired Image>Adjustments>Threshold is applied, without making any tonal corrections, and the number of pixels with gray-level zero is found using the Histogram. It can be realized that there exists significant difference in the number of pixels with gray-level zero, between the original diamond and the CZ images after applying thresholding. In some cases, the CZ image is found to vanish completely. This is totally due to the light properties of the two gemstones, and mainly due to the property called the “read through effect”. As it is well known that diamonds show more brilliance than CZ and CZ shows more fire than diamonds, to perform this action, the table view or the pavilion view images are not used and only culet view images are used.

The images of diamonds that seem to be of same size to the naked eye are considered for testing, in this method. The thresholding and histogram concepts are thus applied for the identification of original diamonds from Cubic Zirconia when the gemstones of both these varieties are found to be of same size when viewed with the naked eye. For the purpose of illustration, in this Chapter four gemstones are considered, of which three seem to be of same size to the naked eye.

There are several ways to distinguish original diamonds from its imitations using regular Gem Tools and everyday items. While distinguishing original diamonds from its imitators may seem hard at first, it is often surprisingly easy. The most commonly utilized Diamond simulant is Cubic Zirconia. No relation to natural
Zircon, CZ as it is known, makes a fairly convincing Diamond simulant. Although discovered in the 1930's, CZ first entered the market in the 1970's. This gem simulant quickly generated concern within the Jewelry and Diamond industries. Unwarranted pessimism said CZ would ruin the industry, as it was just too difficult for jewelers to tell the difference. However, the optical properties of Diamond and Cubic Zirconia are different. One of the reasons for the beauty of Diamonds is their remarkable power of reflection. A well-proportioned Round Brilliant Cut Diamond returns all the light that enters it back through the table facet. In other words, no light at all “leaks” out of the back of the Diamond. Conversely, a Round Brilliant Cut Cubic Zirconia, with its lesser powers of reflection, experiences loss of light or “leakage” through the back. This loss results in diminished brilliance and beauty. Initially this loss of brilliance and light sounds negative, but it is actually a powerful ally for a person who has no expensive space age equipment. These differences can be exploited through a simple test that distinguishes between Diamond and Cubic Zirconia using nothing more complicated than a pen and a piece of paper. A normal household black pen with a thin nib is taken and a 5cm long straight line is drawn on a white piece of paper and placed down on a table. Then a Round Cut Cubic Zirconia and a Round Cut Diamond are placed side-by-side, table facets down, directly over the pen line. By looking down from above through the back of the two gems, the differences can be seen as in the figures 4.1 and 4.2.

The above test’s diagnostic accuracy is largely experiential. While Diamonds that are not ideally cut may allow some of the pen image to leak through the back, the strength and width of the image seen will be markedly different to those seen in CZ. Brilliance is white light reflected up through the top of a diamond, and diamonds are more brilliant than CZ. CZ have a plastic like look/appearance and because of its low refractive index compared to original diamonds, there is leakage of light, and also suffers from the ‘read through effect’. Hence, it is sufficient to consider only the table (top of the diamond) area of the diamond image for the study. This area matches to 75% of the image from the centre for all the images. Therefore, this selection is performed as the first and foremost step for every image either original diamond or CZ, and new images are then processed.
Figure 4.1 Very visible through the back of this Cubic Zirconia is the pen line. The leakage of light due to its lesser powers of reflection, allows the image of the pen line to become clearly visible. [6]

Figure 4.2 The back of the Diamond allows none or very little of the pen line image to reach the eye. A well-proportioned Round Brilliant Cut Diamond shows no image whatsoever.

4.2 Application of Digital Image Processing Method – Thresholding & Histogram

The following figure (figure 4.3) is a culet view image of an original diamond. The process of applying thresholding to this image is explained below.

Figure 4.3 Digital image of original diamond with scanned girdle diameter 1.48 inches.

Figure 4.4 Image showing 75% (from the centre) of the image in figure 4.3.

Figure 4.4 is the image showing 75% (from the centre) of the culet view image in figure 4.3 which is 1.11 inch in diameter. This area is selected using the elliptical marquee tool in Photoshop.
The images below (figures 4.13, 4.14, 4.15 and 4.16) show 75% of the culet view images of Diamond1, Diamond2, Diamond3 and Diamond4, chosen from the centre of the image (approximately), and are called Diamond1new, Diamond2new, Diamond3new and Diamond4new respectively.

As all images are acquired under similar illumination conditions, and in order to maintain the originality of the acquired images, no color adjustments are applied to them. Instead, the concept of thresholding is applied to them as such. The threshold value is fixed as 128. The thresholded images (figures 4.17, 4.19, 4.21 and 4.23) and their respective histograms (figures 4.18, 4.20, 4.22 and 4.24) are shown side by side below.
and height = 3 inches, with a resolution of 200 pixels/inch. Hence, the total number of pixels in the image is 360000. The number of pixels at level zero in the thresholded image of each of the diamonds are shown in the following table (table 4.1).

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Culet view of the Diamond</th>
<th>Figure Number [75% of the culet view image of the Diamond (taken from centre)]</th>
<th>Figure Number after Thresholding.</th>
<th>Number of pixels at level 0 after Thresholding.</th>
<th>Actual Diameter of the Diamond (millimeters) / Scanned Diameter in inches.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Diamond1 [Figure 4.9]</td>
<td>4.13 [Diamond1new]</td>
<td>4.17</td>
<td>2111 [from Histogram in Figure 4.18]</td>
<td>2.8448 mm / 1.12 inches</td>
</tr>
<tr>
<td>2.</td>
<td>Diamond2 [Figure 4.10]</td>
<td>4.14 [Diamond2new]</td>
<td>4.19</td>
<td>2974 [from Histogram in Figure 4.20]</td>
<td>2.7686 mm / 1.09 inches</td>
</tr>
<tr>
<td>3.</td>
<td>Diamond3 [Figure 4.11]</td>
<td>4.15 [Diamond3new]</td>
<td>4.21</td>
<td>0 [from Histogram in Figure 4.22]</td>
<td>2.794 mm / 1.1 inches</td>
</tr>
<tr>
<td>4.</td>
<td>Diamond4 [Figure 4.12]</td>
<td>4.16 [Diamond4new]</td>
<td>4.23</td>
<td>1502 [from Histogram in Figure 4.24]</td>
<td>6.5024 mm / 2.56 inches</td>
</tr>
</tbody>
</table>

Table 4.1 Table showing the number of pixels at level 0 in the thresholded images of the diamonds, considering only 75% of the culet view image (taken from the centre) of the diamond.

The number of (black pixels) pixels at level zero in each image obtained by the application of Thresholding and Inverting imply the number of pixels with intensity/gray-level value less than 128, as the threshold value has been fixed to be 128. From table 4.1 it is found that even though the diamonds Diamond1, Diamond2 and Diamond3 are more or less of the same diameter with very small difference, the number of (black pixels) pixels at level zero in the thresholded image of Diamond1new and Diamond2new are greater than 2000, but it is nil (zero) in the case of Diamond3new, which shows that there are zero number of pixels at level zero (that is, there are no pixels at level less than 128 in Diamond3new image). For Diamond4new, the number of pixels at zero level in the thresholded image is found to
be 1502. But Diamond4 has a diameter approximately twice greater than that of the other three stones, but the number of zero level pixels is very less compared to Diamond1 and Diamond2. This difference is due to the optical properties and ‘read through effect’ of CZ. Hence, it can be concluded that Diamond1 and Diamond2 are Original Diamonds, whereas Diamond3 and Diamond4 are Cubic Zirconia. This method of differentiating original diamond from CZ will work in a most efficient manner when two gemstones that seem to be similar size and dimensions to the human vision (unaided or naked eye) are considered. When more number of stones need to be compared, the volume calculation method may be used first, and later the result may be verified or confirmed using the thresholding method.

Summary

<table>
<thead>
<tr>
<th>Diamond1</th>
<th>Original Diamond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamond2</td>
<td>Original Diamond</td>
</tr>
<tr>
<td>Diamond3</td>
<td>CZ</td>
</tr>
<tr>
<td>Diamond4</td>
<td>CZ</td>
</tr>
</tbody>
</table>

The method described above was tried with several samples, and found successful.

4.4 Conclusion

Thus, to differentiate/identify original diamonds from CZ, based on their optical properties, thresholding, which is one form of segmentation, is used. The systematic method of identifying Original diamond from Cubic Zirconia by the usage of ‘thresholding’ and ‘histogram’ concept has been clearly explained in this chapter. Thresholding proves to be a reasonable tool in the identification of original diamond from Cubic Zirconia when both these gemstones seem to be of same dimensions to the human eye (unaided or naked eye), than the conventional method of using a 10X loupe by the jewelers. This method is not only simple and systematic, but also affordable.