EVALUATION OF DEVELOPED SOFTWARE FOR CALCULATING HISTOGRAM INTERSECTION DISTANCES

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Abstract: This paper presents the results obtained using a developed software implementing the histogram intersection metric to compare images of three different objects under different situations. The images were obtained from the website of Amsterdam Library of Object Images and were divided into two sets: changes on viewpoints of the objects and changes on illumination colors. The histogram intersection distances varied from 0.723 to 1.000, when occurs changes in the viewpoints, and from 0.505 to 1.000, when happens changes in illumination colors. These results are expected since the rotation of objects with symmetric shape slightly modifies the histogram distribution. On the other hand, in the case of illumination color changes, bigger variations are predictable since it directly alters the values of pixels.

Keywords: Illumination; Orientation; Color space; Similarity; ALOI

1. INTRODUCTION

Visual analysis, recognition and object classification are important tasks in various areas, either by inspection of a product, for the purpose of quality control, or by comparing an object with a default. Agriculture, medicine, security and manufacture are some areas that utilize these tools [1]-[5].

Histogram comparison techniques are widely applied on the image processing field. In these techniques, an image is described as a histogram which represents the frequency distribution of each color in the image [6]. Histograms are largely explored in the last few years for finding similarity and classification of objects, and for image segmentation [7]-[10]. Histograms are chosen due to its invariance on rotation, translation, occlusion and change in scale [11].

There are several metrics to calculate the distance or difference between histograms [8], [11]. In the case of the intersection metric, it measures how much an image is similar to other even without an accurate separation between the object and the background [11].

This paper evaluates if the developed software is able to reproduce the characteristics expected from the comparisons between images using the intersection metric. For this, images from The Amsterdam Library of Object Images (ALOI) with changes in the viewpoint and the illumination colors were used.

Besides this Introduction Section, Section 2 describes the materials used on this work and the reasons for their choices; Section 3 explains the methods used and gives the description of the experimental setup; Section 4 shows and explains the results obtained

with the experiments and finally, on Section 5, there is the conclusion about this work and some future perspectives.

2. MATERIALS

2.1 The Amsterdam Library of Object Images (ALOI)

The Amsterdam Library of Object Images (ALOI) is a library composed of images from one-thousand small objects with variation on their viewing angle, illumination direction and illumination color. Its purpose is to create a database of images that follow the same properties and capture patterns so that can be used in scientific researches [12]. The images were obtained in front of a dark background with controlled conditions. In the case of changes in the viewpoint of objects, the angle was altered 5 degrees between each capture, totalizing 72 images for each object. In the case of variations in illumination color, the temperature of the color changed from 2175K to 3075K [12].

2.2 Images

The objects were chosen by their shapes and colors, being two of them symmetric and one asymmetric, Figure 1. The first and second objects, object 35 and object 809, are respectively symmetric and asymmetric, and completely white. The third object (object 115) is a wooden chess pawn. These object characteristics were chosen to evaluate if the intersection metric of histogram comparison was correctly implemented in the software. We have chosen to keep the number of object of the ALOI library along this paper.

Figure 1 presents images of the three objects related before when the viewpoint angle was 0, 45 and 90 degrees.

Angle (°)	Object 35	Object 115	Object 809
0			
45			
90			

Figure 1 - Object images for viewpoint angles of 0º, 45º and 90º.

The second set of images was chosen to evaluate how much the illumination influences on the intersection metric. More precisely, when illumination color temperature varies

from 2175 K to 3075 K. Figure 2 shows images of the three objects related before for illumination color temperatures of 2175, 2625, and 3075K.

Temperature (K)	Object 35	Object 115	Object 809
2175			
2625			
3075			

Figure 2 - Object images for illumination color temperature of 2175, 2625, and 3075 K.

3. Methods

3.1 Intersection Metric

Equation 1 calculates the intersection metric between two images *I* and *M*, where I_j and M_j are respectively the number of pixels with the color *j* on the image histograms of *I* and *M* and *j* represents one of *n* colors of R, G and B channels [11].

$$H(I,M) = \frac{\sum_{j=1}^{n} min(I_j, M_j)}{\sum_{j=1}^{n} M_j} \qquad (1)$$

To execute the equation 1, the algorithm passes through each of histograms *H(I)* and *H(M)* and evaluates how many pixels of them are equal. After that, this quantity is normalized by the size of the base image *M*, which results in a value between 0 and 1 [11].

3.2 Experimental Setup

The algorithm was developed in Java using Netbeans 7.1.2 which is an Oracle free platform. For the experiments, it was used a computer with an Intel i5, 2.40 GHz, 4.0 GB of RAM and Windows 2008 Server R2 operating system.

After downloading the images from http://staff.science.uva.nl/~aloi/, they were divided into categories depending on the parameter variation they suffered on the moment they were photographed. A base image was chosen for each object of the set and then, all the other images of the same object in the set were compared with it using the intersection method. In the case of viewpoint changes set, the base images used were the ones where rotation angle was zero degrees. In the case of temperature illumination change set, we have chosen as base images the ones with illumination color temperature of 3075K.

4. Results and discussion

Figure 3 shows the obtained results from the histogram distances using the intersection metric when images from the viewpoint changes set were used. Lines are only a visual guide.

As expected, a small variation on histogram distances was obtained for the symmetric objects (object 35 and object 115) since its sides are similar and follow the same characteristics, Figure 3(a) and Figure 3(b). Additionally, object 35 had the smallest variation because its material has the same shape and color characteristics in all over the object. The case for object 115 is different, since the wood does not have a constant color distribution. Nevertheless, its symmetrical shape has maintained its results above 90% of similarity.
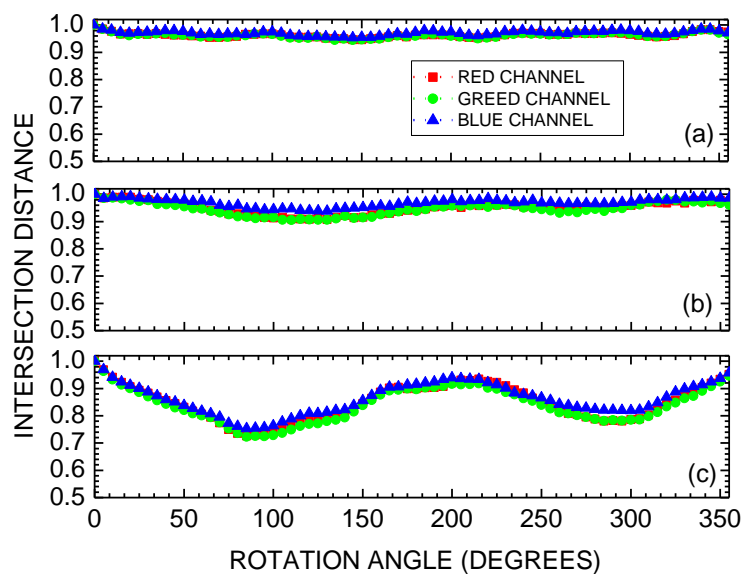
Figure 3: Intersection distance results for viewpoint changes set: (a) object 35, (b) object 115, and (c) object 809.

On the other hand, for the asymmetric object, object 809, Figure 3 (c), the variation on intersection distance is bigger, about 0.28 from the maximum. It is more expressive due to the fact that the sides of this object do not have a pattern and are independent from each other. More precisely, the object 809 is oval, so the amount of pixels with the same color decreases as the photographed face of the object gets thinner. Same way, the biggest the photographed side, the higher is the intersection between the images, since the base image is a lateral photograph of the object and the colors are the same.

Figure 4 presents the results of object 35, object 115, and object 809, when the color temperature illumination is changed. Lines are only a visual guide.
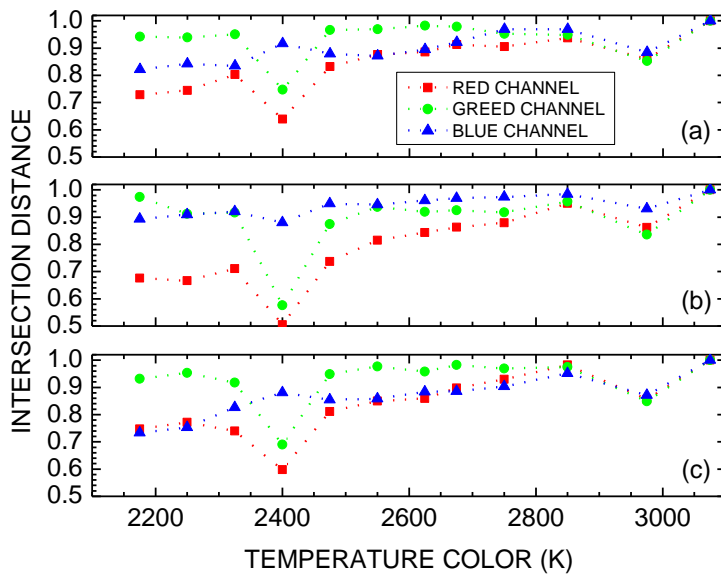
Figure 4: Intersection distance results for illumination color temperature set: (a) object 35, (b) object 115, and (c) object 809.

Changes on the illumination color are expected to generate more variation in the histogram distances obtained with intersection metric than the rotation of objects. It is because color is directly related with histogram distribution. Figure 4 also shows that the RBG channels independently varied; being the red the most variable. However, all channels have changed according the object considered.

The distance differences between objects, in the illumination color set, are also expected. Different object materials and colors respond optically different to the incident color, considering the light absorption, transmission and reflection issues of an object [14]. Because of this difference on the response of each object for different incident color, Swain and Ballard (1991) proposed a constancy color algorithm.

In summary, the software algorithm developed with the histogram intersection metric fulfills its purpose since our results agree with the literature. It is known that the intersection method is supposed to maintain the results even under small variations on background or on the viewpoint of the objects [11]. As we obtained, the evaluation of the objects under different viewpoints do not vary expressively, particularly for the symmetric ones. When one considers the illumination color changes, Swain and Ballard (1991) supports that the intersection metric needs a color constancy method to get it robust to changes on illumination that affects the image. If this method is not applied, it is expected a considerable variation on the results because the intersection metric considers the color of pixels to make the comparison. Therefore, for the illumination color temperature set, where there are color changes, the difference between the histograms of the images increases, and this is what happened in our results.

5. CONCLUSIONS AND FUTURE PERSPECTIVES

This paper presents the results obtained from comparison of images with the histogram intersection metric. The images are from the ALOI library and were divided into two sets, corresponding to the variations they suffered during their acquisition. Each set was chosen to generate results that could validate the software efficiency. The results are the expected and the objective was accomplished, showing that the developed software can

be used to compare images and find their similarity using the histogram intersection metric.

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