

HISTOGRAM COMPARISON USING INTERSECTION METRIC APPLIED TO DIGITAL IMAGES ANALYSIS

Márcio Hosoya Name¹, Jonathan Rui de Lima², Fernanda Aline Boff², David de Souza Jaccoud Filho², Rosane Falate²

¹Universidade Federal do Paraná (UFPR) 83260-000 Matinhos – PR – Brasil

² Universidade Estadual de Ponta Grossa (UEPG) 84030-900 Ponta Grossa – PR – Brasil

name@ufpr.br, rlima.jonathan@hotmail.com, fernandaaboff@gmail.com, dj1002@uepg.br, rfalate@uepg.br

Abstract: *This paper reports the evaluation results of developed comparison histogram software using the intersection metric. The images used to support our conclusions are from The Amsterdam Library of Object Images, which contains image from objects under different orientations and illuminations. As related in the previous papers, the program indicates that: hue channel color is the least sensitive channel when considering the different object orientations; and the illumination influences all channels when any effective color-constancy algorithm was applied under variable light conditions. Therefore, the developed software seems to be compatible with literature and it is able to be applied in future researches.*

Keywords: *computer vision, histogram distance, ALOI, openCV*

1. Introduction

During the past decades, digital image processing and analysis, and computer vision have grown expressively and now constitute a leading technology in important areas such as broadcasting, robotics, manufacturing, medical imaging, biology, and material sciences and agriculture [1]-[3]. As a result, the number of people relying on this kind of systems will increase even more and different systems will be created in order to make the jobs of people more efficient.

Numerous spatial domain-processing techniques are based on histograms [4]. According to Gozalez and Woods [4], histograms are simple to calculate in software and also lend themselves to economic hardware implementations.

Histograms are obtained by counting the number of pixels with each color in an image. As a result, they are invariant to translation and rotation of pictures, and change slowly under adjustment of angle view, change in scale, and occlusion [5]. Although being invariable for the same image, histograms can differ markedly for different objects, which make it an excellent tool for identifying objects [5]. Due to that, methods to compare histograms and pictures have been created and used in different areas such as medicine and agriculture.

In 1991, Ballard and Swain used the intersection metric to determine histogram distances between images [5]. It is known that this metric does not need the accurate separation of the object under analysis from its background or of occluding items in the foreground. On the other hand, Jeffay and Zhang support that an effective color-constancy algorithm is needed when working under variable light conditions [6].

This work evaluates and proves the efficiency of our developed software which compares images and ranks them from the most to the less similar to the chosen base image grounded on the intersection technique. In order to carry out this comparison, images from a public database were used. Besides this Introduction Section, Section 2 shows technologies used to develop the software; Section 3 describes the image library, image characteristics and the ones chosen to be applied in this work. Section 4 presents a brief description of the intersection metric and the procedures to evaluate the software. Section 5 presents the obtained results, and finally, section 6 exhibits conclusions and futures perspectives.

2. Technologies

For the development of the software for digital image processing and computer vision application the OpenCV library (Open Source Computer Vision) was used [7]. This library was developed by Intel, written in language C / C ++ and currently supports Python Language [8]. However, to make the functions accessible by code in Java language it is necessary to use a plugin: the JavaCV [9]. This plugin implements several existing functions in OpenCV, which are accessed via JNI (Java Native Interface - Java native interface).

The JNI is an interface included in the JDK (Java Development Toolkit) to define native methods and embedded the Java Virtual Machine within native applications. Native methods are functions written in languages like C, C ++ and even Assembly, compiled into DLLs (Windows) or OS (Linux and Solaris) [10]. JNI serves as a bridge between Java and native part of an application, providing functionality for communication between the parties. Also included in JDK prototype tools for mapping methods and Java data types for C / C ++.

3. Materials

3.1 The Amsterdam Library of Object Images (ALOI)

To perform the experiment, three images from a database, which are available on the Internet at <http://staff.science.uva.nl/~aloi/>, were used. The Amsterdam Library of Objects Images (ALOI) is a set of images of different objects, recorded on a dark background and under supervised and predefined conditions, for scientific purposes [11]. The different sets are obtained by the systematically changing of view and illumination angle for each object, as well as the illumination color and captured wide-baseline stereo images.

Considering such database, the image set concerning view angle of each object has 72 elements, corresponding to a 5 degrees rotation angle for each one. The image set of illumination direction has 24 elements each one for a different configuration of

lights and camera recording. The set corresponding to illumination color has 12 elements, since the color temperature is successively increased from 2175K to 3075K.

The chosen images are in the highest resolution from ALOI with 768 x 576 pixels, 24 bits and PNG (Portable Network Graphics) extension.

3.2 Selection of Images

Since we want to validate the developed system, and we know from [5] that the Intersection metric is less sensitive to changes on angle of view and more sensitive to color changes [6], from the one-thousand small objects available at ALOI, we chose two of them, one symmetric and another asymmetric. They have similar color and correspond respectively to object numbers 35 and 809 of the ALOI. Some images of them are in the Figure 1, from the left to right column.

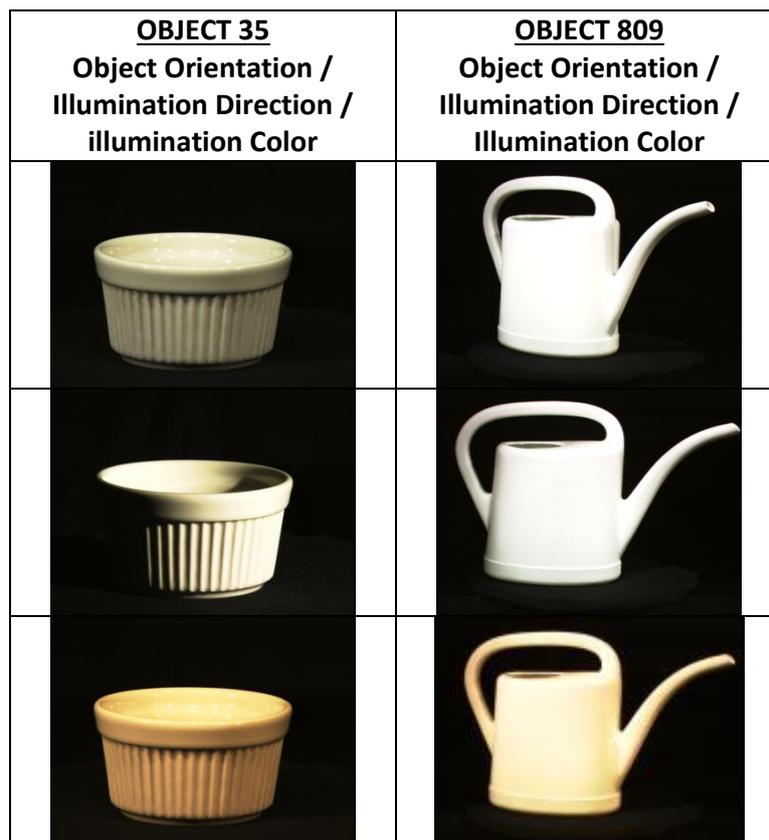


Figure 01 – Three changes for object: rotation, illumination direction and illumination color.

4. Methods

4.1 Histogram intersection metric

The metric for comparison of histogram intersection is given by equation [12]:

$$d(H_1, H_2) = \sum_I \min(H_1(I), H_2(I))$$

Where H corresponds to the image histogram, I is the total number of colors in the color space of the image, and d is the histogram distances between images.

4.2 Test

From the related images in section 3.2, we started testing the software for comparison of histograms through intersection metric. The system was developed using the Netbeans platform free of Oracle 7.1.2, OpenCV version 2.4.0, and also javacv 0.1 (Java plugin for OpenCV), running on an Intel i5 2.40 GHz, 4.0 GB of RAM and Operating System Windows 2008 Server R2.

All tests were made after converting the color space from RGB to HSV, separating the three channels of the image (Hue, Saturation and Value) and normalizing them. These steps are standard and necessary for a correct comparison between images.

The base or reference images chosen to be compared to others from their set (object orientation, illumination direction and illumination color) are the ones which filename finished with `_r0.png`, `_l1c1.png`, and `_i110.png`, respectively. After that, the comparison was made one class at a time.

5. Results and discussions

Figure 2 shows the main screen of the developed system for histogram comparison between images. To compare the histogram of images, first of all is needed to select which image you want to be used to compare with others, the reference image. Such file is selected in the “select reference image” field.

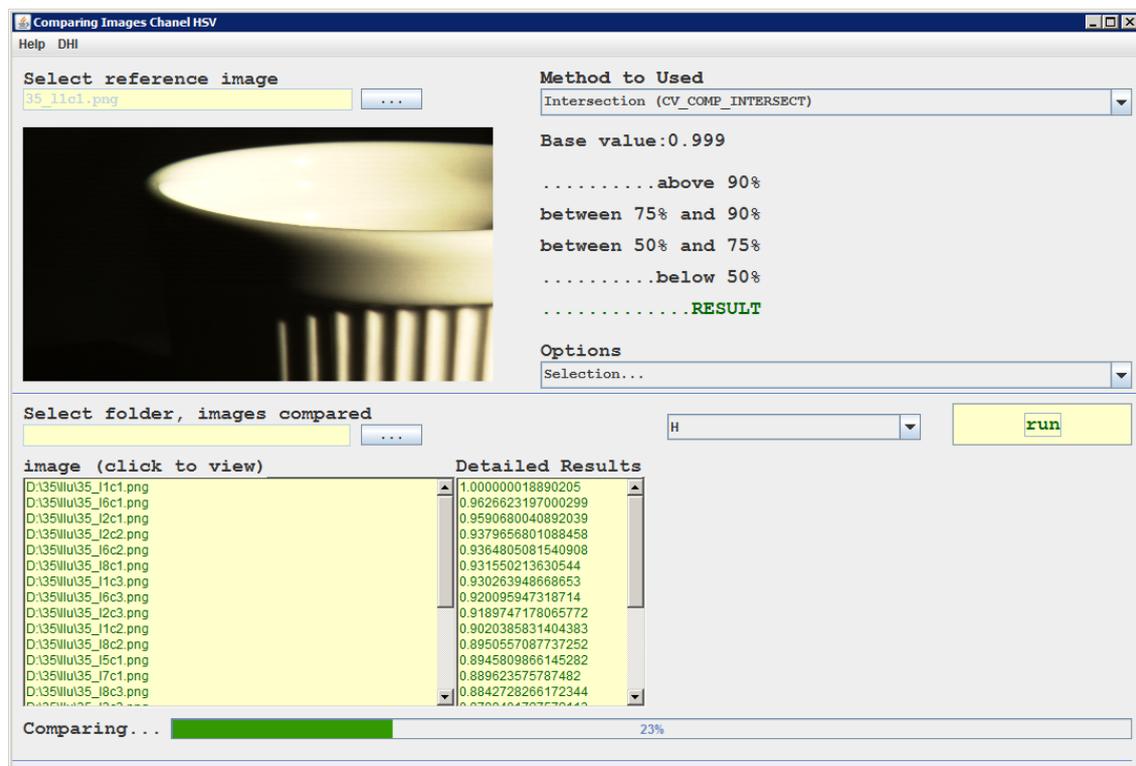


Figure 02 – Three changes for object orientation, illumination direction and illumination color.

After that, the system was elaborated to compare the selected image with all files from a selected directory, which was indicated in the field “select folder, images compared.” Then, one chooses the metric to be used to compare the histograms, in our case, intersection. The next command is indicate with channel one wants to compare. In the case of Figure 2, it was picked the channel H, from HSV space color. Finally, one clicks at “run” button, to generate the comparison. The results are then presented with green letters in field “detailed results.” In the following, it is presented the obtained results for histogram comparison between images using the developed system.

Figures 3(a) and 3 (b) respectively show the obtained distances when object 35 and 809 of ALOI suffer incremental rotations. The dot lines are just visual guide.

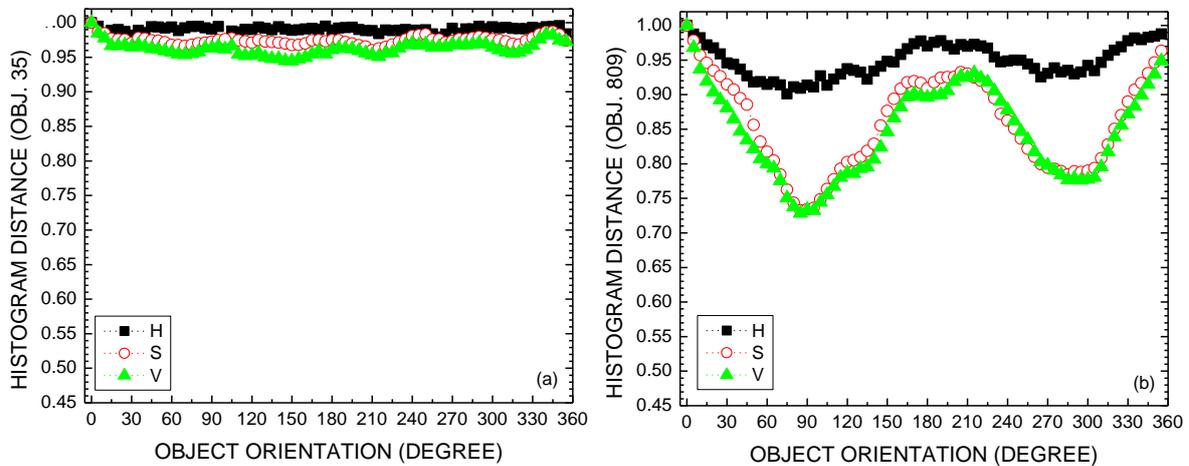


Figure 03 – Histogram distances when the object is successively rotated: (a) object 35 and (b) object 809.

As it can be seen, the histogram distance results obtained for objects with different rotations and for each channel of HSV space color are different for symmetric and asymmetric objects. This is an expected result since when symmetric object has successive rotations the frontal view does not change, so its digital image might be the same for all angles. In the case of object 35, the maximum histogram distances for channels H, S, and V, are respectively 0.979, 0.960, and 0.945. One can see in the Figure 3(a) that channel H is the least susceptible channel to object rotation changes.

On the other hand, an asymmetric object has different frontal views for each rotation angle; therefore, the digital images in such case are dissimilar. This is verified in the Figure 3(b), where different object orientations represent different geometries or images of the object and so its related histogram. The maximum histogram distances of object 809 for channels H, S, and V, are respectively 0.901, 0.733, and 0.728. Once again, the channel H is the least susceptible channel to object rotation changes.

Figures 4(a) and 4(b) respectively show the obtained distances when object 35 and 809 of ALOI suffer different illuminations. The dot lines are just visual guide. The results for the histogram distances obtained for different object illuminations and for each channel of HSV space color indicates that every channel suffers influence by the illumination, Figure 4.

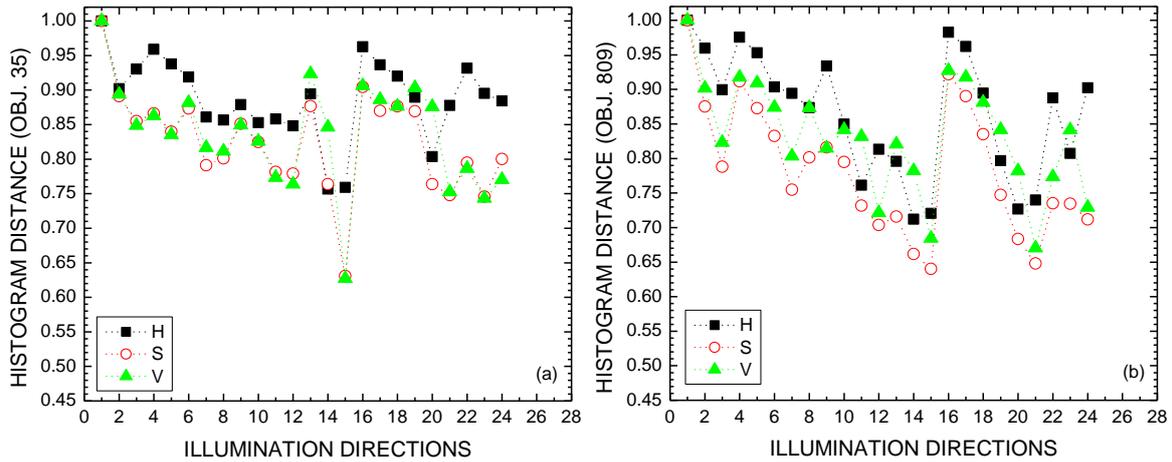


Figure 04 – Histogram distances when the object is under different illuminations: (a) object 35 and (b) object 809.

For the object 35, the maximum histogram distances considering channels H, S, and V, are respectively 0.757, 0.631, and 0.627, and for the object 809 these distances are respectively 0.712, 0.640, and 0.670. Once we obtained similar maximum values in each channel even with different objects, it seems that the illumination direction equally affects all HSV channels of an image. It is also interesting to note that the S and V channels are more influenced in this test and are both related to lighting. This result agrees with Jeffay and Zhang [6], who affirm that an effective color-constancy algorithm is needed when the light conditions are variable on the objects where intersection metric is used, and we do not used such algorithm.

Figures 5(a) and 5(b) respectively show the obtained distances when object 35 and 809 of ALOI receives different illumination color. The dot lines are just visual guide.

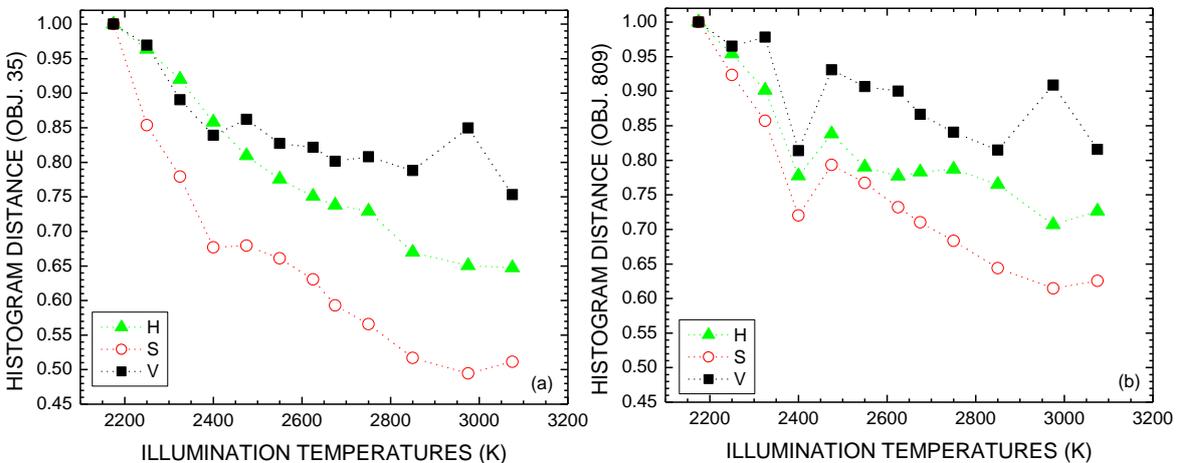


Figure 05 – Histogram distances when the object is under different temperature color illuminations: (a) object 35 and (b) object 809.

The results of intersection obtained for different temperatures show that all channels H, S and V are influenced by color illumination. In the case of object 35, the maximum histogram distances for channels H, S, and V, are respectively 0.647, 0.494, and 0.753; and for the object 809 these distances are respectively 0.707, 0.615, and 0.814. It can be seen that the changes on color illumination mainly affects in the saturation channel.

6. Conclusions and Future Perspectives

This paper presents the results of the developed software based on the intersection metric to compare histograms of digital images. ALOI image database was used since they offer images from objects under different object orientation, illumination direction and illumination color. As expected and verified with the software, symmetric and asymmetric objects present different results when object are successively rotated. This occurs because the front image of asymmetric object changes with rotation. Furthermore, we acquired similar maximum values of histogram distance in each channel with different objects under different illumination directions, which indicates that illumination direction equally affects all HSV channels of an image. Moreover, the changes on color illumination of objects mainly affects in the saturation channel. These results agree with specialized literature. Therefore, according to the results, we notice the efficiency and effectiveness of our software what makes future studies and improvements possible.

References

- [1] Pitas, Ioannis. *Digital Image Processing Algorithms and Applications* (2000). John Wiley & Sons.
- [2] De Gouveia, Lilian T., Senger, Luciano J. (2011). Texture analysis of mineral aggregates using entropy. *Iberoamerican Journal of Applied Computing*, v. 1, n. 1, pp. 33-41.
- [3] Moreno, T. E. W, et all. (2011) Image analysis of soybean leaf diseases using metadata. *Iberoamerican Journal of Applied Computing*, v. 1, n. 2, pp. 56-64.
- [4] Gonzalez, Rafael C.; Woods, R. E. (2002) *Digital Image Processing*. Prentice-Hall, Inc.
- [5] Swain, M. J.; Ballard, D. H. (1991) Color Indexing. *International Journal of Computer Vision*, vol. 7, no. 1, pp. 11-32, 1991.
- [6] Jeffay, Kevin; Zhang, Hong Jiang. (2002) *Readings in Multimedia Computing and Networking*. Morgan Kaufmann.
- [7] Marengoni, M., Stringhini, S. (2009) *Revista de Informática Teórica e Aplicada*. v. 16, n. 1, 2009.
- [8] Heidemann, G. Z. *Aplicando Diversas Técnicas de Realidade Aumentada no Desenvolvimento de um Jogo*. Universidade do Vale do Itajaí. Itajaí, SC. 2011.

- [9] Audet, S. JavaCV. 2010. Disponível em <<http://code.google.com/p/javacv/>> . Acesso em 30 Jul 2012.
- [10] Alves, G. D. Trabalho de Formatura Supervisionado. 2004. Disponível em: <<http://www.linux.ime.usp.br/~cef/mac499-04/monografias/givanildo/jni.html>>. Acesso em 31 Jul 2012.
- [11] J. M. Geusebroek, G. J. Burghouts, and A. W. M. Smeulders. (2005) The Amsterdam library of object images, *Int. J. Comput. Vision*, 61(1), 103-112.
- [12] Histogram Comparison – OpenCV 2.4.0 Documentation. Disponível em: <http://docs.opencv.org/2.4/doc/tutorials/imgproc/histograms/histogram_comparison/histogram_comparison.html>. Acesso em: 30 jul 2012.