

INTERACTIVE 3D ANIMATION FOR STATISTICS TEACHING

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Abstract — This paper describes an interactive and educational animation that will serve as support at the digital image classifier teaching based on virtual reality. This interactive animation shows the process of information acquisition over an image during its classification process. The system was developed in Java 3D with two versions: for student use and classroom use. In the first case, the student can use any operational system compatible with Java Virtual Machine. The classroom version was developed for VirtWall platform running on Linux.

Index Terms — Image classification, virtual education, virtual reality.

INTRODUCTION

Generally digital image classification uses multispectral wavelength band composed images to allow an easy identification of different classes. This way, pixels (picture elements) are represented in an abstract algebraic space whose dimension is dependent of the number of available wavelength bands denominated as feature space [2].

Due to the abstraction of mathematical and statistical concepts involved, were observed students difficulties to understand them during classes of digital image processing. One of the most difficult concepts for students to understand is the feature space idea. Basically this happens because sometimes the 2D space is not enough to represent the feature space. Additionally it demands from students, besides linear algebra, some ability to imagine and visualize a 3D space. So, it is not an easy task to teach statistical methods of image classification, that use wavelength bands composition to compose abstract and algebraic spaces, where image points or pixels can be spatially separated.

To help the visualization and the understanding of the abstract space used in image classification we developed an interactive animation based on virtual reality. The goal of this tool is to bring students near to the problem, immersing them in the feature space and allowing them to do an interactive study. This work was developed using the Java 3D language and improves the solution presented by [3], which also used an interactive visualization of the feature space and virtual reality concepts.

METHODOLOGY

Image Classification

Image Classification is divided in two major groups: unsupervised classification and supervised classification. In the first group the classes are divided or clustered automatically [5]. In these methods the algorithm by itself looks for classes in the images using grouping. This way it groups similar pixels or it separates different pixels. The user only needs to provide it the number of classes desired or some criterion to mathematically consider stable the group. The result of an image classification with this method is an image with unlabeled classes. This means that is not known any previous identification of the classes and they must be labeled by the user at the end of the process. The Hierarchic Clustering [4] is an example of a didactic unsupervised method. This algorithm begins with the supposition that each pixel is a grouping, so the distances between all the pixels are calculated and stored in a matrix of distances. In the following step, the closer neighboring points are united in new groupings. For each new grouping is calculated a center that will be the representative point of the class for new calculations of distance. The method ends when all pixels are united in a single grouping of points. Usually, the result is showed in a dendrogram and the user can decide with how many classes the image should have and to give labels to them.

However, the supervised classifiers are better than the unsupervised classifiers because they take into account training data provided by the user [9]. These classifiers use information contained inside the pixel for its own classification and require some previous knowledge about the classes [9], as the probability distribution for example [5]. They are interactive methods in which users provide the number of classes and the samples of areas previously known for each class. So, the algorithm must classify each image pixel from a discriminant function generated starting from user information. The K-NN classifier (K-Nearest Neighbor) is a non-parametric supervised classifier in which a pixel is associated to a class, depending on the K number of points that belong to that class [2] according to a distance criterion. The idea of classification is very simple and

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intuitive: to classify a point, initially the K nearest neighbors are taken and, inside this set, the most representative class is calculated. Due the fact that to compute the K-nearest neighbor for each point is very expensive, there is a faster variation of this algorithm. It selects points that are inside a hyper sphere with ray R and counts them. The main problem is that R is chosen empirically and can occur cases with hyper spheres without any point inside.

The main difficulty to teach both classifiers, supervised and unsupervised, is in the comprehension of the feature space and in the comprehension the distances in multi dimensional spaces.

Virtual Reality

Virtual Reality (VR) refers to real-time systems where users can that interact with a graphical environment, visualize and manipulate data in a three dimensional space with immersion sense [8]. The immersion is related to the sense of "be part" of the environment. The interaction is related to the computer capacity to detect the user actions and instantly modify the virtual world according them. Both immersion and interactivity influence the realism of the applications, but the realism also depends on the devices and platform used [8].

According [1], a VR system can be classified as passive, exploratory or interactive. A passive VR system provides to the user an automatic exploration and does not allow any interference. On the other hand the exploratory VR systems allow the user interaction during the exploration. Finally, an interactive VR system allows an interactive exploration with virtual entities reacting in response of user interactions.

Stereoscopy

In computer graphics there are techniques used to generate and visualize computer images with depth, the same way that we observe the images in real world. The stereoscopy is a technique used to generate a pair of images from a same scene: left image and right image. Each of these two images will be observed by a different eye [10] to form a single 3D image perceived by the observer.

In VR systems the stereoscopic view is generally obtained using three different methods: anaglyph, intermittent light and polarized light. In the anaglyph method the images are presented in complementary colors (usually red and green or red and blue) and the user wears glasses with colored filters. The intermittent light method presents each image alternately for each eye and uses the fact that an image remains from 1/20 to 1/8 seconds in the brain. This way, the observer did not notice the images alternation and perceives a single 3D image from each scene. In the polarized light method, polarized filters are used to make that each scene be projected in orthogonal plans. The user wears polarized glasses, each lens corresponding to each plan of projection, and visualizes only one of the images

projected. The stereoscopic view comes from the fusion of the images.

Java 3D

Java 3D is a Java API (application program interface) to write programs that exhibit and allow interaction with 3D graphic images [11]. The Java 3D API is a standard extension of the Java 2 language. It determines a hierarchy of Java classes to creation and manipulation of 3D geometries and determines structures to render these geometries. This way, Java 3D determines functions to create images, visualizations, animations and interactions for applications [6]. The programmer works with high-level constructors to create and manipulate 3D objects. These objects are inserted in a virtual world that is processed.

The Java API is designed with flexibility to creation of virtual worlds with a large variety of types. Java 3D programs can be written to be executed as a single application or inside a browser window. It also can use low-level instructions for hardware acceleration with OpenGL and Direct3D. Because Java 3D is based on Java it runs on any platform with Java Virtual Machine installed [12].

VirtWall

The VirtWall [7] is a visualization platform that allows real-time interactions based on VR techniques. The images are presented in a large screen, as it was a big wall. The main feature is the stereoscopic and colored projection of the images that makes them jump outside the screen, what offers the sensation that they are positioned in space with real colors. For this, the users must wear special glasses. The images can be seen by multiple observers what allows individual or collective analysis of the objects visualized. Besides that, users can control the point of view and move the objects in the space using a mouse or even the keyboard. The platform has as advantage the low cost and the use of public domain programs, as Linux. These tools provide the development of reliable and high performance systems for Virtual Reality, comparable to commercial systems of high cost.

IMPLEMENTATION AND RESULTS

The system was developed using the Java 3D API. It presents two versions. The first one is for individual use for students in a single PC. It works in any operational system running the Java Virtual Machine and presents the 3D scene with anaglyphs.

The second version uses intermittent light and was developed to be used in classes and runs in the VirtWall [7]. In this version the teacher and the students can visualize and interact with the animation. As in similar immersive systems, the animation control and the interaction can be executed by only one person. Generally this person is the teacher.

The animation is composed by two virtual worlds and the interaction is possible by the use of a mouse. Initially, the animation presents an RGB composition image. The image rotates (Figure 1) to reveal the points being collected to the classification (Figure 2). This way, the first sequence describes the samples of the classes being collected from image. The samples jump out of the image (Figure 3) and go to the feature space: that is the place where the classifier will work (Figure 4). The samples will constitute the algebraic space.

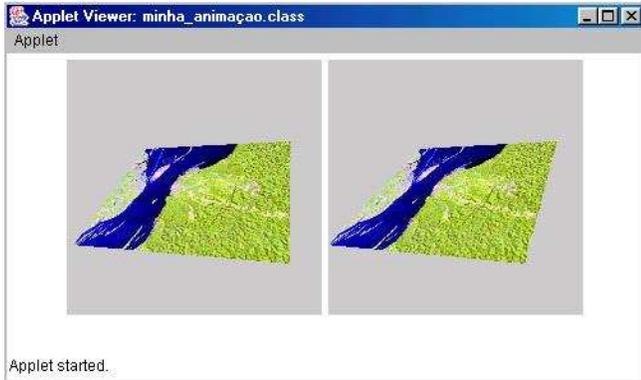


FIGURA. 1

SEQUENCE OF ANIMATION SHOWING RGB COMPOSITION IMAGE AND ITS ROTATION.

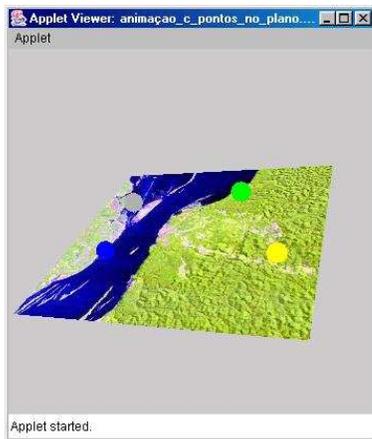


FIGURA. 2

SAMPLES OF THE IMAGE CLASSES BEING COLLECTED.

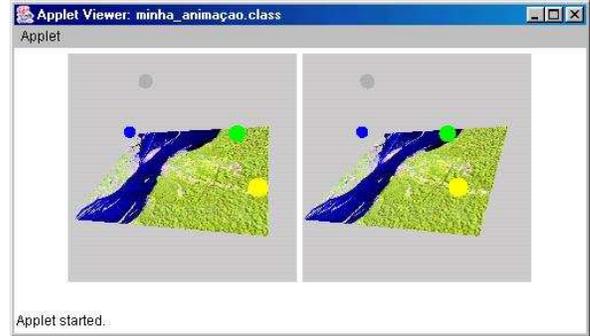


FIGURA. 3

SAMPLES JUMP OUT OF THE IMAGE.

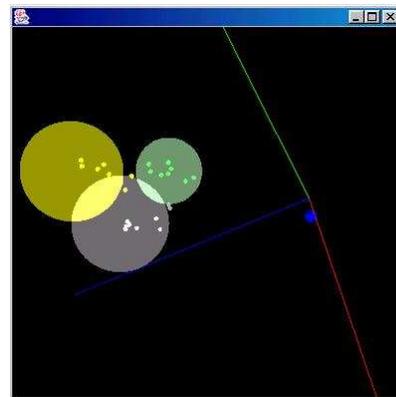


FIGURA. 4

FEATURE SPACE VIEW ON DESKTOP.

The second sequence presents the image classification according one of two classifiers: the Hierarchic Clustering unsupervised classifier or the K-NN supervised classifier. Figure 4 shows the classifier running in PC desktop and Figure 5 shows the same running in VirtWall [7].

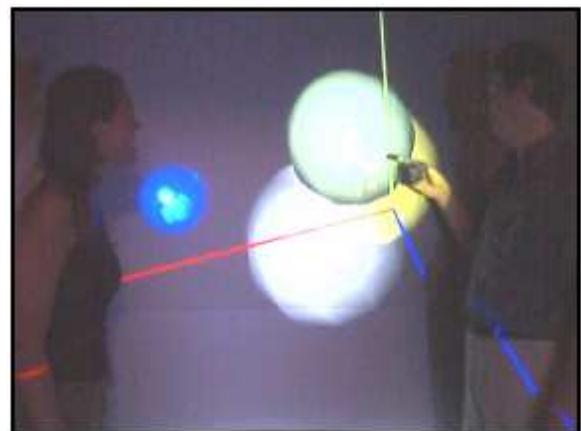


FIGURA. 5

FEATURE SPACE AND K-NN CLASSIFIER RUNNING IN THE VIRTWALL

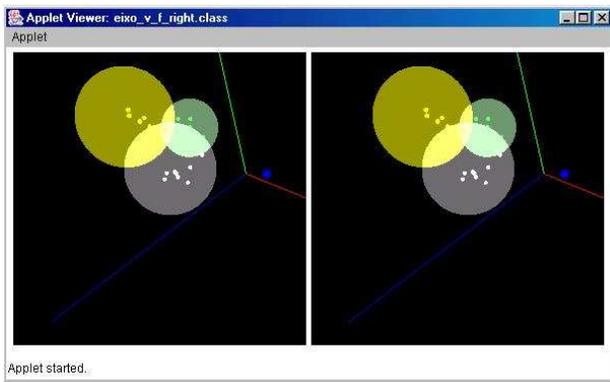


FIGURA. 6

FEATURE SPACE AND K-NN CLASSIFIER RUNNING IN STEREO MODE.

The stereoscopic version of this system is available only for VirtWall [7]. Figure 6 shows the feature space and K-NN classifier running in stereo mode in two separated windows. Stereoscopic version used on VirtWall is better to approximate students to subject in study.

CONCLUSIONS

This paper presents an interactive and educational animation that will serve as support at the digital image classifier teaching based on virtual reality. That animation shows the process of information acquisition over an image, the formation of feature space and classification process.

To help the student, two versions are implemented: the first one for student's use and the second one for classroom use. Both of them are programming in the JAVA language, which is compatible with any operational system that runs Java Virtual Machine (Linux, UNIX or Windows). The classroom version runs on Linux operating system with visualization on VirtWall.

As future works, we intend to add audio to improve the learning through the interactive and educational animation.

REFERENCES

- [1] Burdea and Coiffet. *Virtual Reality Technology*. Wiley-Interscience, 2003.
- [2] Duda, R. O. and Hart, P. E., *Pattern Classification and Scene Analysis*. New York: John Wiley and Sons, 1973.
- [3] Gnecco, B.B., Cabral, M.C., Moraes, R.M., Machado, L.S., An Immersive and Interactive Environment to Support Image Classification Teaching. *Annals of 4th SBC Symposium on Virtual Reality*, Florianópolis - Brazil, 2001. Proceedings. SBC, 2001. p.291-301. [in Portuguese]
- [4] Jia, X. and Richards, J. A., *Remote Sensing Digital Image Analysis: An Introduction*, Springer Verlag, 3rd ed, 1999.
- [5] Johnson, R.A. and Wichern, D.W.; *Applied Multivariate Statistical Analysis*. Prentice-Hall Inc., 1982.
- [6] Manssour, I. H. Java 3D. [on-line] <http://www.inf.pucrs.br/~manssour/Java3D/> .December, 2003. [in Portuguese]
- [7] Moraes, R. M.; Machado, L. S.; e Souza, A. C. M., VirtWall: A Concept of Low-Cost Virtual Wall for Immersion in Virtual Reality, *Proceedings 6th Symposium on Virtual Reality*. Ribeirão Preto, Brazil, 2003, pp. 383 – 385.
- [8] Netto, A. V. , Machado L. S., Oliveira, M. C. F. *Virtual Reality – Concepts and Applications*. Visual Books. 2002. [in Portuguese]
- [9] Saebo, H.V.; Braten, K.; Hjort, N.L.; Llewlynn, B. and Mohn, E.; *Contextual Classification of Remotely Sensed Data : Statistical Methods and Development of a System*, Norwegian Computing Center. Oslo, 1985.
- [10] Stereographics, [on-line] <http://www.stereographics.com/homepagecomp/frame-prod.html>. Access in Jan/ 2002.
- [11] Sun Microsystems. *Java 3D API Tutorial*. [on-line] <http://java.sun.com/developer/onlineTraining/java3d/>. Access in Jan/2004.
- [12] The Sun Center of Excellence for Visual Genomics. [on-line] http://www.visualgenomics.ca/PDF_files/whitepaper.pdf. Access in Jun/2004.