Meta analysis of the colour images in the Visible Human Dataset anatomy repository

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Abstract

The about 15000 multimodal bio-images US National Library of Medicine Visible Human Dataset (VHD) is a remarkable piece of raw digital anatomical knowledge. For its best use, among major problems waiting for effective solutions we have the automatic segmentation of significant anatomical structures within images. Methods to apply depend strongly on image characteristics. The amount of memory necessary to manage each VHD image, the detailed anatomical structures contained in a single image, the aim to keep limited the computational time, all of them are problems to solve. We investigate approaches able to obtain appreciable results.

Keywords:
Digital image analysis; Visible Human Dataset; Digital anatomy; Colorimetric characterization

1. Introduction

The Visible Human Dataset (VHD) consists of digital images of two cadavers, a male and a female. Male and Female dataset contains over one thousand of digital magnetic resonance (MR) images, about two thousand computed tomography (CT) images, and colour pictures of anatomic serial sections – over than 3700 images for the Male and over than 5000 images for the Female \cite{1}, \cite{2}.

One of the top problems regarding any anatomic image is the contouring of significant body parts or other relevant anatomic structures present in the image. For such a purpose, a number of different and complementary algorithmic approaches may be considered \cite{3},\cite{4},\cite{5},\cite{6},\cite{7}. For their effective application, the availability of preliminarily quantitative characterizations of the images can help in targeting better the contouring task. Sets of three red, green and blue intensity histograms for each VHD colour image, stored on a server and made accessible like the VHD images themselves, represent a potentially useful resource to many developers working on the VHD raw data.

In this study we describe an histogram-based colorimetric characterization of the VHD 24-bit colour images. Such characterization is performed keeping limited the computational
time besides the high resolution of the considered VHD images. A tool, we developed to display simultaneously in a web page up to five hundred histograms of a single colour component of a user defined set of images, is also described.

2. Materials and methods

The axial section anatomic colour images of the Visible Human Male are 1871 spaced at 1.00 mm intervals from head to toes. Each of these images is composed by 2048 x 1216 pixels, with each pixel constituted by 24 bits of colours – a byte for each red, green and blue component - and with square pixel size of 0.33 mm. Each image takes 7.2 megabytes, thus the whole set of images occupies approximately 13 gigabytes. Recently, the seventy millimetre film taken during the original data collection phase has been digitized at a resolution of 4096 x 2700 pixels, 24 bits of colours [1], and square pixel size of 0.144 mm. Also these images are spaced at 1.00 mm intervals from head to toes and are 1871. Such images are referred as “higher resolution images” and takes about 32 megabytes each. The whole higher resolution dataset requires about 60 gigabytes.

The axial section anatomic colour images of the Visible Human Female were obtained at 0.33 mm intervals - instead of 1.00 mm intervals – from head to toes. Also these images are composed by 2048 x 1216 pixels with each pixel constituted by 24 bits of colours and a square pixel size of 0.33 mm. Female body is 1734 mm long, so into female dataset there are over 5,000 anatomic images. Female dataset is around 40 gigabytes in size.

As any colour image, each VHD colour image can be represented according to a colour model. A colour model is a specification of a coordinate system and a subspace, within that system, where each colour is represented by a single point. The Red-Green-Blue (RGB) colour space can be represented geometrically in a three-dimensional orthogonal coordinate system by a cube. The cube has a vertex in the coordinate system origin. Each axis represents one of the three usually called primary colours Red, Green and Blue [8]. Each pixel of an RGB image can be represented in that cube as a vector whose components are the red, green and blue pixel intensities, respectively.

From each VHD colour image, we obtained three histograms, one for each colour component. A histogram is a discrete function representing the number of pixels (vertical axis) for each possible colour level (horizontal axis).

To perform colorimetric characterization, i.e. colour histogram construction, of the VHD colour images, we used the algorithm shown in Figure 1. The first step was downloading the colour image raw files from the VHD Milano Mirror Site FTP server [9].

Figure 1 shows colour histogram construction algorithm.

![Figure 1](image)

Figure 1- Algorithm to perform colorimetric characterization of VHD colour anatomic images.
The second step was obtaining three monochrome 8 bit images from each 24 bit colour image. We have extracted single colour components from the higher resolution images of the Visible Human Male dataset.

The third step was histogram calculation and storing. Each single colour component of an image was considered in order to obtain the three red, green, and blue intensity histograms, one for each primary colour.

Histograms were stored on hard disk in two formats: binary to be read quickly by other programs, and in eXtended Mark-up Language (XML) format. Binary format was obtained storing sequentially in a file the number of pixels for each intensity level. The XML format was obtained storing in a file into XML tags the number of pixels for each intensity level. For each image six files – three in binary and three in XML format – for a total of 48 KBytes were generated.

In order to display the generated histograms we have developed a web visualization tool. It is able to visualize single colour component histograms in a 3D Cartesian coordinate system. In this system the section identification number increases along the x-axis, the colour intensity increases along the y-axis, and the number of pixel increases along the z-axis.

We used different hardware platform: a laptop computer with x86 architecture, 1.4 GHz CPU, and 256 MByte of RAM memory, and 40 Gabyte of hard disk; a desktop PC with 733 MHz CPU, 512 MByte of RAM memory, and 80 Gabyte of hard disk; a workstation with 1.4 GHz CPU, with 256 MByte of RAM memory, and 60 Gabyte of hard disk. All these computers were connected to a Mega Ethernet LAN, with 1 Gigabps backbone. The computers we used for image processing, the laptop, had GNU/Linux operative system, while the other two computers used to storing VHD images and show results had MS Windows 2000 operating system. We used Samba [10] in order to allow Linux to use Windows resources. We have implemented algorithms in C++ programming language, into Debian GNU/Linux environment, and we used dynamic memory allocation and garbage collector features to maintain computational time limited.

3. Results

Intended as a meta analysis service for developers of applications based on the VHD data, we calculated histograms of the red, green and blue components of all the VHD colour images. We have maintained the original colour image name in the dataset to naming histograms. Thus, the generic histogram is labelled by a tag containing the section number, the gender (male or female), the colour component (red, green, or blue). For example, a_vm1281.raw_r_ist indicates the red colour component histogram of the a_vm1281.raw male image; 1300.rgb_b_ist indicates the blue colour component histogram of the 1300.rgb high resolution image of the male; avf1432a.raw_g_ist indicates the green colour component histogram of the avf1432a.raw female image.

The time needed to perform the second and the third steps of the colorimetric characterization algorithm explained above, varied from 15 to 30 seconds per image. The memory occupation of each histogram file was of 1 KByte in binary format, and of 15 Kbytes in XML format.

The only considered subset of VHD colour images generated an amount of about 26800 histograms. To allow a manageable access and view of such a number of histograms, we developed a visualization tool. It let the user to choose a single section image or a sequence of section images by selecting the first and the last section of the sequence and the
browsing step. The histogram sequence is axonometrically represented. The choice between a single colour component or the full set of the three R, G, B colour components is also allowed.

In Figure 2 are shown colour histograms of the red, green and blue component, of two hundreds VHD Male higher resolution images: from section 1701 to section 1900, with one image step.

Besides the “still-histograms” visualization tool, we are developing a “rotatory-histograms” tool for the visual catching of valleys and peaks on piled histograms. This could help the developers in discovering thresholds for the proper tuning of their algorithms. More features are under evaluation.

4. Conclusion

At this time, we have performed colorimetric characterization, by means of colour histograms, of all the VHD colour images. Users can view them via web interface, accessing the VHD Milano Mirror Site® web site [9] using visualization tool we have developed. Histograms are also available on as binary file to download from the VHD Milano Mirror Site®. This web service is devoted mainly to developers.

Figure 2 shows colour component histograms.

Figure 2 – Colour component histograms for two hundred section images, from the 1701 to the 1900 section with step 1, of the Visible Human Male higher resolution dataset. Z-axis values have been limited to 300 thousand pixels.
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6. References


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