The Labial Teeth and Gingiva Photographic Image Database LTG-IDB

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Abstract. This article describes the initial version of the labial teeth and gingiva photographic image database (LTG-IDB), developed at the Color Imaging Lab at the Optics Department of the University of Granada in Spain. The database currently contains 90 photographic digital still images from 27 subjects. Images are available in several sets that differ by resolution, file format and image scene type. This leads to a total of 405 images occupying about 7GB of memory. Images of this database could for instance be used as benchmark for image segmentation tasks. The acquisition process discussed here is applicable for many kinds of visual monitoring or illustration tasks of oral cavities in the field of dentistry. We render this database publicly available under a creative common license, which allows others the usage of this image data and to build upon our work.

Keywords: Imaging systems; Digital image processing; Image analysis; Creative commons

1 Introduction

An image database is a collection of images with some inherit meaning, usually for a specific application [1]. In many cases, image databases are very important for the scientific community, for instance as tool for illustration of certain visual aspects or objects (e.g. medical images [2,3]), or as benchmark for image processing applications (e.g. image segmentation or image retrieval performance evaluation [4]).

The creation of a digital still image database from labial teeth and gingiva photographic images (LTG images) has been conceived as part of a project at the Color Imaging Lab at the Optics Department of the University of Granada (Spain) in summer 2010. The project aimed at the development of color image processing techniques for the detection and analysis of gingival inflammatory processes on photographic LTG images. Initially, the project sought to obtain images of labial teeth and gingiva of a group of healthy subjects. These images were intended to be used as benchmark for performance evaluation of image processing techniques

employed at the Color Imaging Lab. However, the project team made out a lack of publicly available images of labial teeth and gingiva and hence initiated the creation of the image database described here.

We suggest the LTG-IDB as a contribution for researchers working in the field of medical image analysis, in particular related to dentistry. The strengths of this database are the fixed, well-defined and well known parameters of image acquisition. In addition, the variety of analytical and methodological applications shall be highlighted, as this database includes raw images, as well as pre-processed JPEG and TIFF images and is published under a creative common license. To the knowledge of the authors, up to this date no comparable image database with photographic images is publicly available. Most available collections of dental images seem to serve the purpose of visualizing different kinds of oral pathologies, rather than allowing image analysis to be performed [2,3].

Images in this database are available in raw image format (which is the unprocessed sensor data of the camera in a specific vendor dependent data format, in this case the *Canon raw image format cr2*), as well as JPEG and TIFF. JPEG is an image file format for lossy or lossless compressed image information, according to a coding standard established by a joint ISO/CCITT committee (the *Joint Photographic Expert Group*) [5]. TIFF, which stands for *'Tagged Image File Format'*, is a file format that offers the possibility of storing lossless image information [6]. The database can be accessed by the public via the web-page of the Color Imaging Lab of the University of Granada [7].

The rest of the article is organized as follows: Section 2 describes the experimental set-up for image acquisition as well as applied camera parameter settings. Section 3 gives an overview of the content of the image database, i.e. demographic data, number of subjects and number of images. Further, possible applications for images of this database are discussed in section 4. The article concludes with remarks on future work and acknowledgements.

2 Experimental Set-Up

A Canon EOS 7D digital single-lens reflex color camera [8] was used in combination with a Canon EFS 18-135 mm standard zoom lens [9] for the image acquisition. In addition, a circular polarization filter was used in front of the camera lens and a linear polarization filter in front of the internal camera flash (see Figure 1 (1,2)). The transmission axis of the polarization filters were set to be perpendicular, in order to minimize specular reflection in the images. An illustration of the basic scene set-up can be found in Figure 1 (1).

We used a tripod with the camera and another tripod to keep the head of subjects approximately constant during the image acquisition process (see Figure 1 (1,3)). The distance between the front plane of the lens and the subjects chin was kept constant on 34 cm. Specific camera parameter settings can be found

Fig. 1. Experimental set-up and image acquisition: basic scene set-up (1), camera with polarization filters (2), image acquisition (3)

from Table 1. To achieve images from labial teeth and gingiva with minimal occlusion by cheeks and lips, a standard mouth opener for dentistry was used.

Note: An *image acquisition how-to* document, as well as other descriptive documents on the experimental set-up can be downloaded from the homepage of the Color Imaging Lab of the University of Granada [7] or requested from the authors.

Table 1. Camera settings

Parameter	**Setting**
zoom position index	*135mm*
image stabilizer	*ON*
autofocus	*ON*
shutter speed	*1/60 sec*
aperture value	*5.00 EV*
ISO speed rating	*400*
exposure compensation	*OFF*
flash exposure compensation	*+1 stop*
auto lightning optimizer	*OFF*
auto focus area selection	*upper central part of the image*
image recording quality	*RAW 18M 5184* x *3456,* *JPG L18M 5184* x *3456*

3 Properties of the LTG Image Database

To create the image database, 27 subjects with normal oral health condition were recruited for two successive imaging sessions on two different days in July 2010 at the Optics Department of the University of Granada. Composition of the group was as follows: 37% of the subjects were female (10 out of 27), 63% male (17 out of 27). Their age spanned form the youngest subject of 19 years

to the oldest subject of 61 years,whereas the average age was 34 years. 85% of the participants were Europeans (23 out of 27, 18 from Spain, the others from Ukraine, Denmark, Romania, Italy and Germany), 11% form Columbia the other 4% from China, Pakistan and India.

The database consists of raw- and preprocessed images in different sets with varying image format and image resolution, as well as image scene type. Table 2 illustrates properties for different image sets, including the number of available images, image resolution and the image scene type. The first image scene type is illustrated in Figure 2 (upper left), the second scene type in Figure 2 (lower left). Figure 2 (right) illustrates data samples, plotted in RGB color space, corresponding to *teeth* and *not-teeth* regions from the image in Figure 2 (lower left).

Table 2. Image set properties

Set	**#-Images**	**Format**	**Resolution**	**Scene Type**
Set 1	*45*	*raw*	*5202* x *3456*	*1*
Set 2	*45*	*raw*	*5202* x *3456*	*1*
Set 3	*45*	*JPEG*	*5202* x *3456*	*1*
Set 4	*45*	*JPEG*	*5202* x *3456*	*1*
Set 5	*45*	*TIFF*	*5202* x *3456*	*1*
Set 6	*45*	*TIFF*	*5202* x *3456*	*1*
Set 7	*45*	*TIFF*	*ca. 600* x *700*	*2*
Set 8	*45*	*TIFF*	*ca. 600* x *700*	*2*
Set 9	*45*	*TIFF*	*ca. 600* x *700*	*2*

Set 1 and *Set 2* consist of the original raw images. Images of *Set 2* have been acquired from each subject after drying the oral cavity with a blast of air. Drying the oral cavity is a useful approach to reduce specular reflections in labial teeth and gingiva images. Such reflections are partly induced by subjects saliva [10]. Images of *Set 1* are acquired without drying the oral cavity prior to acquisition. *Set 3* and *Set 4* consist of automatic white balanced versions of images from *Set 1* and *Set 2* in JPEG file format. *Set 5* and *Set 6* consists of the same images as included in *Set 1* and *Set 2*, but manual white balanced with a white patch algorithm [10,11] according to a gray reference patch that was included in the image scene for individual images. These images are in TIFF file format. The white balance is performed to maintain color properties amongst acquired images as constant as possible. By means of this approach, we intend to account for unavoidable changes in lightning of the scene or the spectral properties of the light source. This is important for the analysis of color properties in images of successive acquisition over a long period of time, when performed on a single-subject basis. Further, *Set 7* accumulates the same images than *Set 6*, but in a cropped and resized version. Cropping has been performed in such a way to

include the visible part of the upper and lower incisors and canine teeth, as well as corresponding gingival areas, for each individual image. *Set 8* and *Set 9* consist of images from *Set 7*, manually segmented into two regions corresponding to *teeth* and *non-teeth*.

What we describe here as manual segmentation is our definition of the best expected result (*or: ground-truth*) for segmentation of a given region in an image, obtained manually by an expert (*the first author*). Accordingly, this data suffers from an inevitable subjectivity, induced by the expert observer. Therefore, the authors of this article suggest careful evaluation of applicability of such *ground-truth* data for user-specific applications, especially for possible segmentation evaluation tasks.

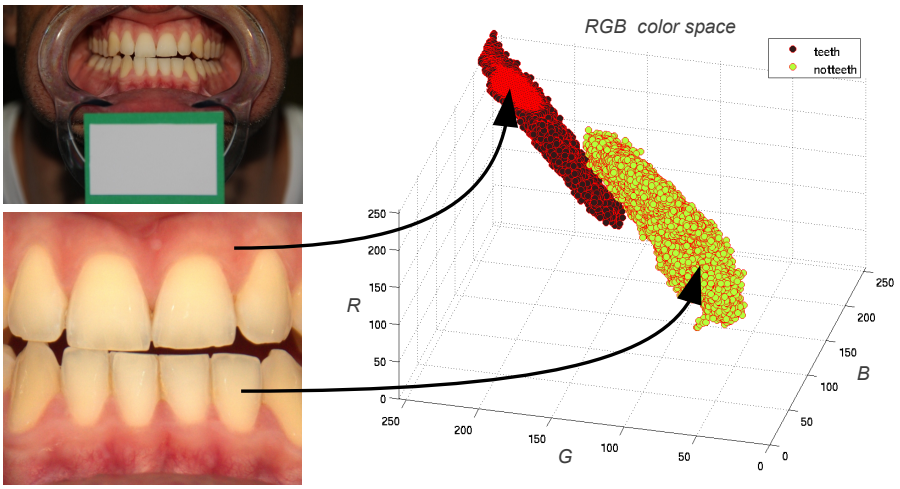

Fig. 2. Sample image of scene type 1 (upper left), sample image of scene type 2 (lower left), illustration of color samples from *teeth* and *non-teeth* regions in RGB color space (right)

The database is published under the *Creative Common Attribution Non-Commercial Share Alike* license, of which legalcode can be found at [12]. Such a license allows to share (copy, distribute and transmit work) and to adapt the licensed work under following restrictions: *this work must be attributed by full citation of this article. It may not be used for commercial purposes, unless otherwise agreed on in consensus with the authors. If this work is altered, transformed, or further work builds upon it, it must be distributed under the same or similar license.*

It should be mentioned that for protection of privacy of participants of the

imaging sessions, meta-data tags on the images related to date and time of image acquisition have been removed. In addition, images are assigned a number in random fashion as file name.

4 Possible Applications for the Database and the Proposed Image Acquisition Method

The scope of possible applications of the LTG image database is quite wide, due to the well-defined image acquisition process and its fixed parametrization. One possible application is its usage as a benchmark for medical image segmentation- or classification algorithms of labial teeth and gingiva images. For the task of *teeth/non-teeth* segmentation, already available ground-truth data can be utilized for performance evaluations. Furthermore, already acquired images could serve for educational purposes in dentistry fields, as they illustrate nicely the variations inherit in teeth- and gingival colors for subjects with normal oral health, as well as the variations of tooth shapes of different subjects.

The image acquisition method proposed here is generally applicable for photographic image capturing of labial parts of oral cavities in the field of dentistry. Capturing such images may be useful for instance to visualize an oral pathology to a patient and for documentation of current states of oral pathologies. Further, long-term monitoring and direct visual comparison of medical states of oral pathologies on the basis of individual subjects can be applied. Even though colorimetric values of the pixels in the images are in device dependent RGB color space of the camera, certain analyses of color properties in images acquired with the proposed acquisition method are possible. One such application could be to monitor changes in gingival or teeth colors on the basis of individual subjects over a long period of time.

5 Future Work

Our method for image acquisition has intentionally been developed to account for experimental conditions in non-laboratory facilities, like dental surgery. Apparently, the current acquisition set-up requires the photographer to carefully observe parameters like the subjects head pose or distance between the subject and the camera. We are currently working on a new image acquisition set-up which includes a chin- and forehead rest to simplify the image acquisition process for the photographer as well as for the subject. Such a device serves to reduce the effect of possible head movements between successive image acquisitions. In addition, we intend to use standard dentistry cotton pads, placed between the canine teeth of subjects during image acquisition in order to enforce a separation of maxilla and mandible. This approach shall prevent any occlusion of the lower incisors by the upper incisors.

Finally, the LTG image database at its current state only consists of images from 27 subjects with normal oral health state. We intend to expand the database

with images from additional subjects with normal oral health, as well as images from subjects with ongoing gingival inflammation processes.

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Fig. 3. Sample images from image set 3, scene type 1

Fig. 4. Sample images from image set 7, scene type 2

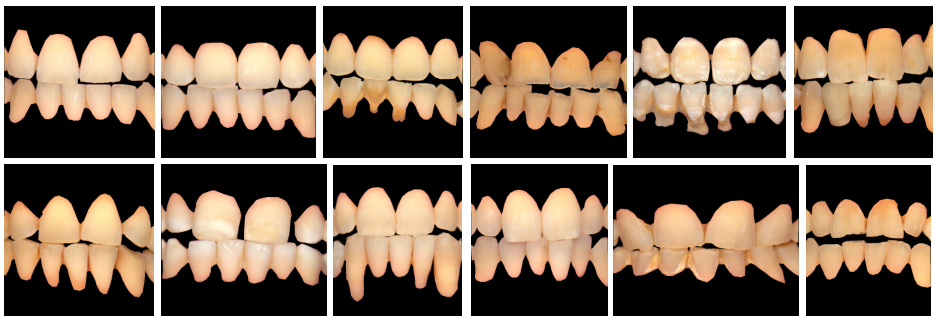

Fig. 5. Sample images from image set 8, scene type 2 (ground-truth teeth).