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Gray level co-occurrence and random forest algorithm-based gender determination with maxillary tooth plaster images

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ABSTRACT

Gender is one of the intrinsic properties of identity, with performance enhancement reducing the cluster when a search is performed. Teeth have durable and resistant structure, and as such are important sources of identification in disasters (accident, fire, etc.). In this study, gender determination is accomplished by maxillary tooth plaster models of 40 people (20 males and 20 females). The images of tooth plaster models are taken with a lighting mechanism set-up. A gray level co-occurrence matrix of the image with segmentation is formed and classified via a Random Forest (RF) algorithm by extracting pertinent features of the matrix. Automatic gender determination has a 90% success rate, with an applicable system to determine gender from maxillary tooth plaster images.

1. Introduction

Teeth are important for breaking down food and chewing, as well as producing correct sounds while talking, providing development of supportive tissues by simultaneously protecting them, and determining identity information about a person. Teeth have durable, resistant features, and can protect their own structure despite catastrophes thus being helpful in identification in forensic and archeology science. Gender is one of the properties of identity, even while improvements can be made by reduction in the cluster when a search is being performed.

In the literature, it has been seen that teeth have differences depending on gender. Parekh et al. [1] stated that the width of the canine arch in males was significantly larger than that of females. In the study of Hasanreisoğlu et al. [2], it was indicated that the size of the central incisors and canines in males was wider than those of females. It was concluded by Forster et al. [3] that the width of the dental arch was related to gender and vertical morphology of the face. In the study of Louly et al. [4], when the dental arch was investigated in a population of Brazilian children, it was found that males had more maxillary depth. In another study by Olmez and Doğan [5], it was discovered that the dental arch of males had more depth and width when compared to females. Horvath et al. [6] found the correlation between maxillary anterior form and gender in 3D data indicated that the maxillary anterior had differences according to gender. In the study of Shin [7], eighteen properties of Principle Component Analysis of maxillary tooth plaster models were classified according to k Nearest Neighbors (kNN) and its algorithm, with a 76% success rate.

When the literature was further investigated, gender determination from teeth can be seen by manual measurements in forensic science and dentistry. However, in the computer sciences, there are inadequate studies on this subject. The purpose of this study is to identify gender determination with features extracted automatically from maxillary tooth plaster model images, without requiring manual measurement. The main contributions of our study to the literature are as follows:

- Automatic segmentation was carried out with image processing methods, with features being extracted automatically. Rapid gender determination was performed with this fully automatic designed system.
- This study is multi-disciplinary, one in which there are benefits in dentistry, forensic science, and computer sciences.
- Size of teeth vary from one population to another. Our proposed method is an automatic system in which every population can adapt to it.

The manuscript is organized as follows: materials and methods

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used for the proposed system are discussed in the second part. The experimental results are presented in the third part. Finally, the manuscript is finalized with focused remarks.

2. Materials and methods

To perform fully automated gender determination from maxillary tooth plaster model images of individuals, a system is designed where steps can be seen in Fig. 1.

In the first stage of the system, the segmentation process is handled by standard image. Gray Level Co-occurrence Matrix (GLCM) of segmented image is formed, with specific features extracted from this matrix. The extracted features are classified by the RF algorithm, at which point gender determination is performed.

2.1. Image acquisition process

The first stage of the proposed automated system is the process of image acquisition. In order to get a standard image without shading, a lighting mechanism is used. The maxillary tooth plaster model images of individuals are used, and then a standard image is obtained for each model.

As shown in Fig. 2, the top inner part of the mechanism is equipped with light sources in the shape of a cube, in order to absorb light from every direction; next, a camera is fixed on top to take a picture. Thus, standard tooth plasters are taken without any shade. All images are taken under identical conditions. In addition, the models are trimmed by making a pedestal for the underside of the model to eliminate problems in the model caused by the angular displacement of teeth. The models were placed parallel to the floor in order to see the dental arch and teeth with a complete steep-angle of the camera. Thus, different perspectives are prevented in the plaster model, as all of them are used with the same angle. Ruler and angle measurement cards are placed under the model to display them at the same level.

2.2. Segmentation process

After taking images of each maxillary tooth plaster model by using the lighting mechanism to get standard images, the image segmentation process begins.

The image of the plaster model was examined in R (Red), G (Green), and B (Blue) color channels to distinguish them from background images. It was observed that the plaster model in the image had distinctive features in the B color channel than the background. First, the colored image was a transformed binary image according to the B channel threshold level. Dilation, erosion, and median filters were applied to delete background noise after transforming the binary image format. As shown in Fig. 3, plaster images were cleaned from background noise. The plaster model was segmented by cropping area that obtained from the above process. The segmented plaster image was transformed into a gray level image for features with GLCM. Converting the gray level does not cause any loss of information, in that color information in a plaster model image does not determine gender.

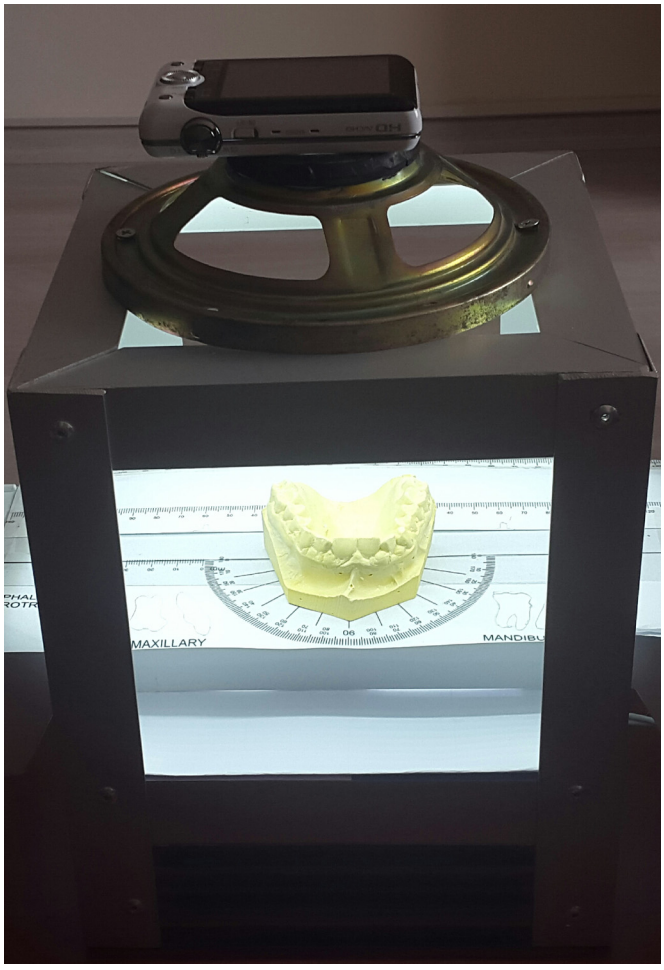

Fig. 2. Lighting mechanism and image acquisition process.

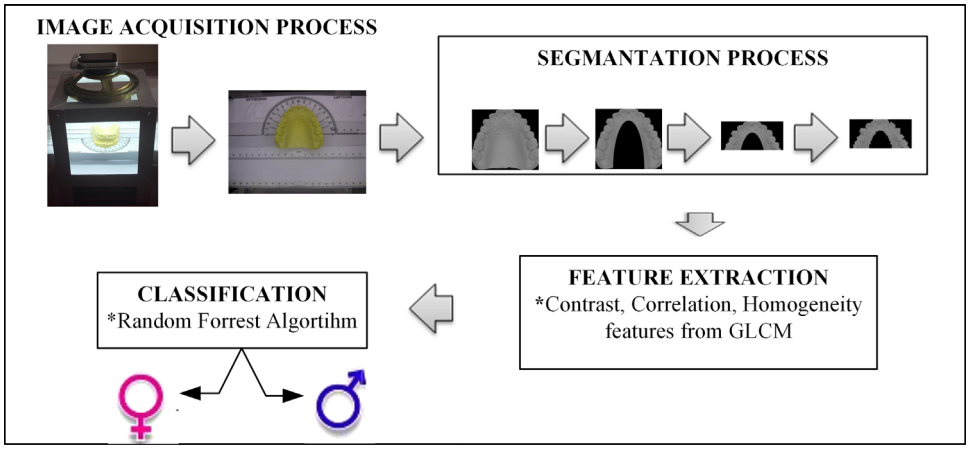

Fig. 1. Applied steps.