Computer Aided Detection of Dental Implant Crown Defects

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A dental implant is an artificial tooth root that is placed into to hold a replacement tooth or bridge. Crown is the apparent part of the dental implant. Detection of crown defects is important for health of the patient before the surgery. In this study, a computer aided detection system developed to analyze tooth dental implant crown digital images to detect defects. The developed system detects various implant defects such as fractures, cracks, dents, spots and roughness. Micro fractures are detected using morphologic operations by the system. Dents and spots are also detected using this image processing techniques. Textural analysis can be performed on digital images to detect different roughness and porosity areas on dental implant. The developed system prevents waste of time and decreases costs. Using the system also will increase patients’ satisfaction.

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1. Introduction

Biomaterials are materials that are identified as including living systems systematically and pharmacologically [1]. Biomaterials are also commonly used in dentistry. Biomaterials are developed over time in the field of the dentistry. Metal-based materials are replaced with ceramic types due to biocompatibility and corrosion [2]. There are significant challenges in the monitoring and displaying of biomaterials tissues and structures. For this reason, various imaging techniques are developed to struggle these challenges [3]. Digital photography is the most inexpensive imaging method. Besides of the its cost, receiving image and transmitting to a computer is easy, rapid and no need too much experience. In the near future, imaging is exactly digitized with regards to contemporary prosthesis techniques. The development of digital technology will play an important role in the monitoring the movement of the jaw, prosthesis manufacturing and dental education. Digital image processing, pattern analysis and artificial intelligence techniques have application areas such as prosthesis odontotherapy, orthodontia and oral surgery that are increasing day by day. Some companies are making efforts to develop new hardware and software in these areas [4].

The aim of this study is developing a computer aided detection (CAD) system to detect defects that can be occurred in dental prosthesis produced for patients by using image processing techniques. In this study, irregularities such as spots, cracks, fractures on dentures and also problems that can affect the quality of the usage are detected by image processing techniques. Detection of such defects by an expert is a difficult process. For this reason, the detection of these defects by the developed system improves the quality of the production.

2. Materials and method

Developed CAD system consists of three phases. In the preprocessing phase, RGB images are converted to gray level images and enhanced. In the segmentation phase, images are separated into meaningful regions for detection. In the detection phase, defects of the tooth image are detected and labeled. Block diagram of the CAD system is presented in Fig. 1.

Fig. 1. Block diagram of the developed system.

2.1. Preprocessing phase

Digital camera images of the dental crown images are true color RGB images. In preprocessing phase, RGB images are converted to gray level intensity images. The obtained dental crown images are digital true color RGB images. In order to use some image processing techniques more effectively, these images are converted to gray-level images. Thus, only the luminance effect appears on the images while the effects of hue and saturation are eliminated.

2.2. Segmentation phase

The term image segmentation refers to the partition of an image into a set of regions. Aim of the segmentation is for the regions to represent meaningful areas of
the image. The regions might be sets of border pixels grouped into such structures as line segments or circular segments. Regions may also be defined as groups of pixels having both a border and a particular shape such as a circle or polygon [5]. Image segmentation is the process of separating target regions in a digital image from others. These targeted areas, which are meaningful for the purpose of image processing application, can be geometric shapes such as line, circle, polygon, or structures without a certain shape. The pixel values between these two threshold values constitute the regions of interest, in which defects may be present [5–7]. An original image matrix and thresholded image matrix with minimum threshold value 100, maximum threshold value 180 are shown in Fig. 2a,b. Then, thresholded images are converted into binary images.

\[ G^{-1} \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \text{Co}(i, j)(i - j)^2; \]  

(1)

\[ G^{-1} \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \text{Co}(i, j) \log(\text{Co}(i, j)); \]  

(2)

\[ G^{-1} \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \frac{1}{1 + |i - j|^2} \text{Co}(i, j); \]  

(3)

\[ G^{-1} \sum_{i=0}^{G-1} \frac{(\text{Co}(i, j))^2}{1 + |i - j|}. \]  

(4)

In the equations, \( G \) represents row and column number of the GLCM, \( i \) and \( j \) represent row and column indices,
Co(i, j) represents an element of the GLCM. Areal rates of different type areas are calculated according to correlation results. The regions with similar textural characteristics are marked with the same color.

2.3. Detection phase

After preprocessing and segmentation phase, dental implant crown defects can be detected. Detection phase of the developed system is able to detect different types of defects such as cracks, fractures, dents, and spots. For fractures and cracks detection, morphologic structure elements are used. Morphologic dilation method is used to detect dents. Blue color band separation and connected component labeling methods are used for spot detection.

2.4. Experiments with the CAD system

Thirty different digital dental implant crown images have been used in experiments. These images includes fractures, cracks, dents, spots, and surface problems. The experimental results showed that the CAD system is successful on crack, fracture, dent, and spot detection. Also the CAD system detects different surface characteristics and color differences using semi-automatic textural analysis. The CAD system was unable to distinguish similar color differences when full automatic textural analysis was performed.

3. Results and discussion

Developed system is successful on detection of dental implant crown defects. Cracks, fractures, dents, spots and surface problems are detected by developed system. Steps of a fracture detection are presented in Fig. 7. Detection of a dent process is shown in Fig. 8. In Fig. 9, spot detection process steps are presented.
4. Conclusion

In this study, a CAD system is developed to detect surface defects of dental implant crowns. Crack, fracture, dent, and spot defects of crown surfaces can be detected easily before the implementation. The system also detects surface problems using textural analysis. The ability of the system to work on digital photography images reduces costs. By using the system, waste of time can be prevented and implementation costs are decreased. In addition, patient’s satisfaction can be increased.

References