CHAPTER 1 INTRODUCTION

1.1 Motivation

In the modernized society, digital cameras are more and more popular. A digital camera built inside everyone's cell phone is more and more popular. Many families would like owning a digital camera for recreation and capturing some memorial scenery. They motive us to develop a system which can detect the status of teeth at home and prescreen dental images for dentists.

We introduce contents of dental images.

Fig. 1.1.1 A dental image

In dental images, they are classified two types: tooth regions and non-tooth regions.

Tooth regions contain odontogenic (Teeth) structure and restorative structure. Restorative structure contains visible regions (e.g. amalgam(銀粉), metal crown, ...) and invisible (e.g. composite resin, porcelain material, ...).

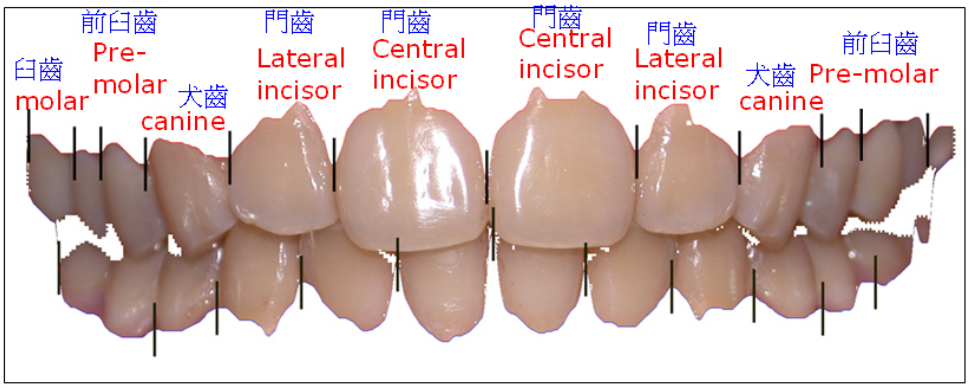

Fig. 1.1.2 Teeth structure

Non-tooth regions include soft tissue (gingiva and skin), lip retractor(擴張器), and other structure not belonging to teeth structure(e.g. an ornament).

We adopt FDI Two-Digit Notation to label its name of teeth. In the FDI (Fédération Dentaire Internationale) World Dental Federation ISO-3950 notation 1s are central incisors, 2s are laterals, 3s are canines, 4s are 1st premolars etc., up through 8s which are 3rd molars. The permanent teeth quadrants are designated 1 to 4 such that 1 is upper right, 2 is upper left, 3 is lower left and 4 is lower right, with the resulting tooth identification a two-digit combination of the quadrant and tooth (e.g. the upper right central incisor is 11 and the left is 21).

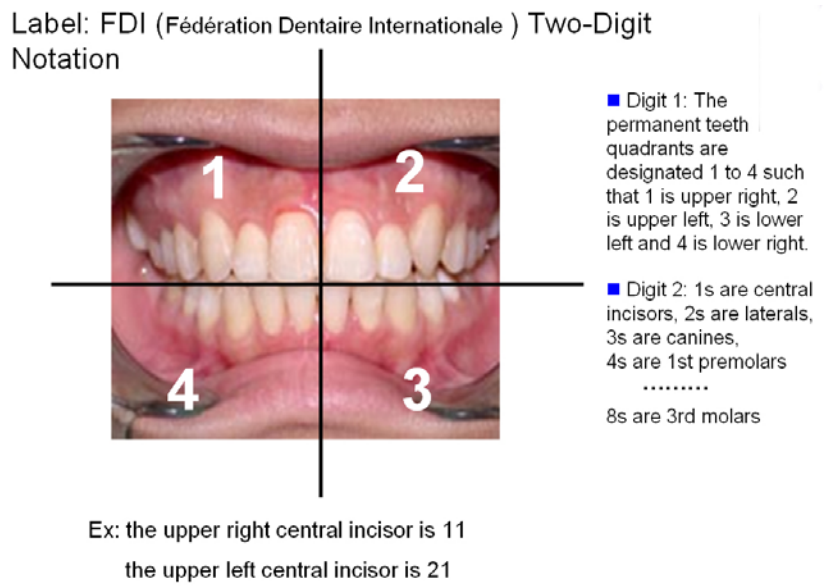

Fig. 1.1.3 FDI Two-Digit Notation

So the name of teeth can be defined as:

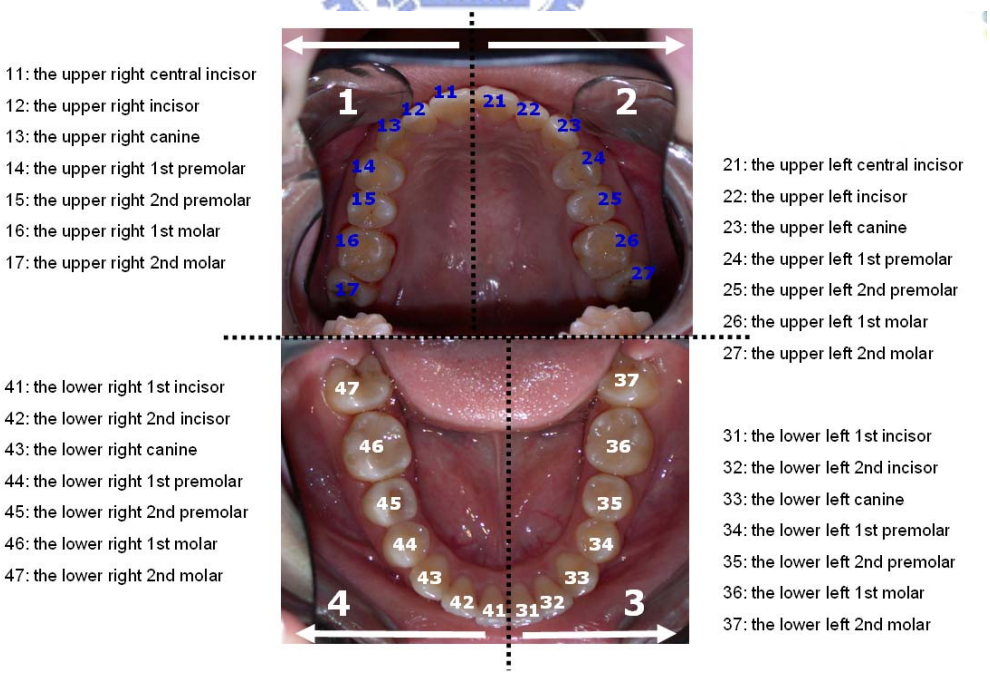

Fig. 1.1.4 FDI Two-Digit Notation (2)

1.2 Problem Definition

The problems that we want to solve in this study are listed as follows.

1.2.1 Extract tooth regions by removing non-tooth ones.

The major components, soft tissue and teeth, are neighbors. Colors of soft tissue differ from those of teeth. So we can distinguish soft tissue regions and tooth regions according to color information of soft tissue and those of teeth.

1.2.2 Tooth Segmentation

We have five kinds of experimental images.

Fig. 1.2.1 Experimental images

We can classify them as two types according to their arrangement of teeth.

The first type is line-aligned images which are the former three kinds of experimental images. The second type is parabola-aligned images which are the latter two kinds of ones. So we adopt different projection-based segmentation methods. We project them into different projection axis. For line-aligned images, we project them into a line axis. For parabola-aligned images, we project them into a parabola axis.

1.2.3 Tooth Classification

In our experiment, we classify status of teeth as normal teeth, missing teeth, and amalgam(銀粉). We use size feature and color feature of teeth to classify them. Other status of teeth such as decayed teeth, metal crown, and invisible restorative structure are left for future study. More features have to be used to classify them.

1.3 Related Works

Tooth segmentation in 3D images is proposed in digitized representation of a dental study model [1-3]. In 3D images, computer-aided design (CAD) and computer-aided manufacturing (CAM) in dentistry are examples of the introduction of computer technology to dentistry with successful clinical applications [4-5]. One such application is the automatic manufacturing of dental fillings such as crowns and inlays [4]. Computer-assisted design and fabrication of dental restorations have been proposed to speed production, eliminate labor-intensive steps, and provide consistent quality [5]. Presurgery simulation systems have been implemented for procedures such as tooth rearrangement and quantitative evaluation of 3D tooth movement [6]. Therefore, tooth segmentation is an important step in many automated and semi-automated computer-based system.

Digitized representation of a dental study model is an important component in computer-based algorithm for orthodontic procedures such as tooth rearrangement. Toshiaki Kondo, S. Hong, and Kelvin W. C. Foong [7-8] avoid the complexity of directly processing 3-D mesh data by proposing the idea of detecting features on two range images computed from the 3-D image. Tooth segmentation from Range images is another method to segment teeth [9-10]. Tooth segmentation in the upper view on

the maxilla and in the lower view on the mandible, the dental arch [8] plays an important role. Some studies refer to the detection of missing teeth [8, 11].

Except research in 3D images, some researches about tooth segmentation focus on X-ray image [12-14]. We survey other studies applied in other field [15-16]. Less research studies address the problem on detecting in digital color dental images captured by a digital camera. We propose another method of tooth segmentation in digital dental images captured by a digital camera instead of 3-D images. To segment teeth in color images, the color information has been extensively utilized to improve the system performance and accuracy.

1.4 Assumptions

In order to concentrate on the methods for solving our proposed problems, we make the following assumptions.

1.4.1 The kinds of input images are known.

We have known the kinds of input images in advance. We can use the relative method to extract, segment, and detect teeth.

1.4.2 Teeth in a dental image may have limited tilt.

We limit tilt of teeth in a dental image.

1.5 System Flow

Our proposed system consists of extraction of teeth, segmentation of ones, and detection of missing teeth and amalgam. The system flow diagram is shown in Fig. 1.5.1. The main modules of our system are described as follows:

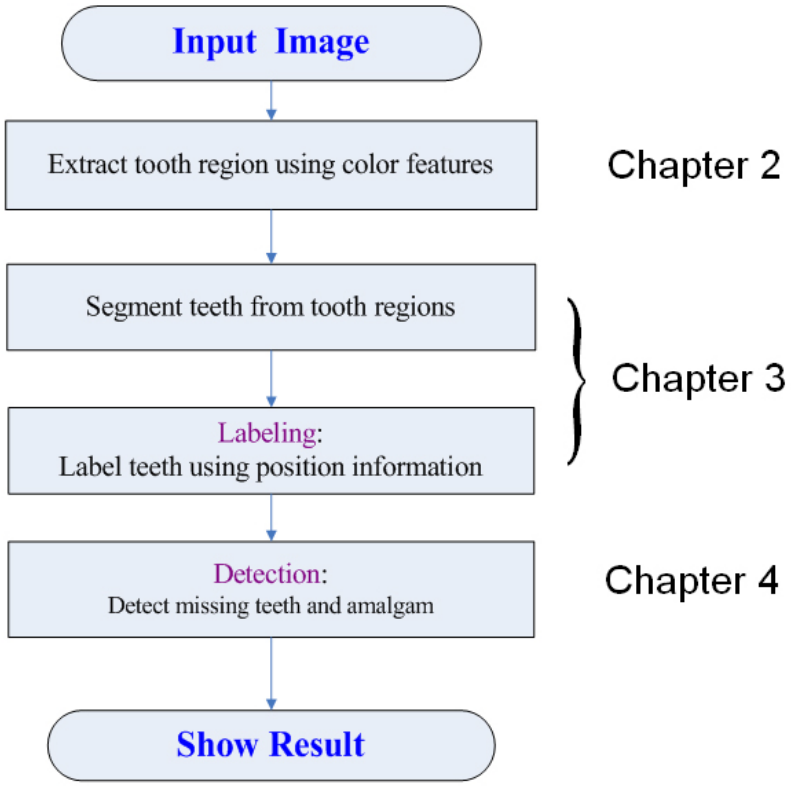

Fig. 1.5.1 System flow

1.5.1 Extract tooth region using color features

We collect samples of tooth and soft tissue. Analyze the discriminative ability of three different color spaces by using a statistical method. And adopt a dynamic threshold to help us to extract regions of teeth. There are two types of arrangement of

teeth. We use different methods according to arrangement of teeth.

1.5.2 Segment teeth from tooth regions

The system segments teeth from tooth regions. We have two methods for different arrangement of teeth. We project them into different projection axis. For line-aligned images, we project them into a line axis. For parabola-aligned images, we project them into a parabola axis. The parabola axis is combination of two parabolas.

1.5.3 Label teeth using position information

After segmentation, we label teeth by using position information.

1.5.4 Detect missing teeth and amalgam

We detect the existence of missing teeth according to size feature. We use Bayesian decision rule to detect amalgam according to amalgam color feature.

1.6 Thesis organization

My thesis consists of six chapters. Extracting tooth region by color features is described in chapter 2. Segmenting teeth from tooth regions is stated in chapter 3. Chapter 4 states how to detect missing teeth and amalgam. Experimental results and

analyses are presented in chapter 5. Finally, chapter 6 presents conclusions and suggestions for future works.