

# CHAPTER 4 DETECTION OF MISSING TEETH AND AMALGAM

## 4.1 Detection of Missing Teeth

When missing teeth exist, there is a hole between two teeth as follows:

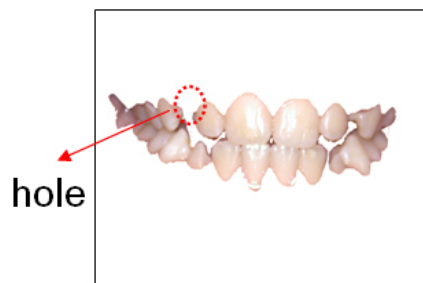


Fig. 4.1.1 Example of missing teeth

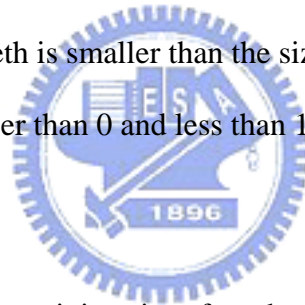
How do we know the existence of missing teeth? First task is to obtain the size of the teeth (Size Feature). Size feature can be gained from training.

We draw green lines to mark range of teeth in advance. We can obtain average sizes of teeth and minimum sizes of teeth from training teeth sizes. Our training samples are listed in Fig 4.1.2.



Fig. 4.1.2 Training samples of teeth sizes

How do we detect missing teeth? When size of holes is larger than size of teeth, missing teeth exist. We can decide the number of missing teeth according to holes sizes. The number of missing teeth is equal to size of holes divided by the size of teeth. Usually the size of missing teeth is smaller than the size of normal teeth. We can multiply a constant which larger than 0 and less than 1 to represent the size of a missing tooth such as



size of missing teeth =  $\alpha \times$  training size of teeth , where  $\alpha$  is the constant.

And the size of teeth is needed to be normalized. Therefore, we normalize size of a tooth according to the ratio of average size of teeth to training size of teeth. We multiply the ratio to adjust a size of teeth in each dental image. We can describe the method in a formula form.

$$\text{minimum size of teeth} = \text{minimum size of training teeth} \times \left( \frac{\text{average size of teeth}}{\text{average size of training teeth}} \right)$$

$$\text{size of missing teeth} = \alpha \times \text{minimum size of teeth} , \text{ where } \alpha = 0.4$$

## 4.2 Detection of Amalgam

Restorative comprises invisible and visible restorative. We interest in the visible restorative: amalgam. Color of amalgam is different from color of teeth or soft tissue. Therefore, we can use amalgam color feature to detect amalgam. Detection of amalgam requires choosing an appropriate color space. In our proposed method, we focus the discriminative ability for amalgam and non-amalgam color.

Obtain amalgam color feature from training samples of pre-selected regions of amalgam. Training samples are listed in Fig. 4.2.1.



Fig. 4.2.1 Training samples of amalgam

Through discussing in section 2.1, we skip selection of RGB color space. Here, we compare two color space, HSI and YCbCr color space. We list the distribution of amalgam regions and non-amalgam regions in H, S, I, Y, Cb, Cr in sequence from Fig. 4.2.2 to Fig. 4.2.7.

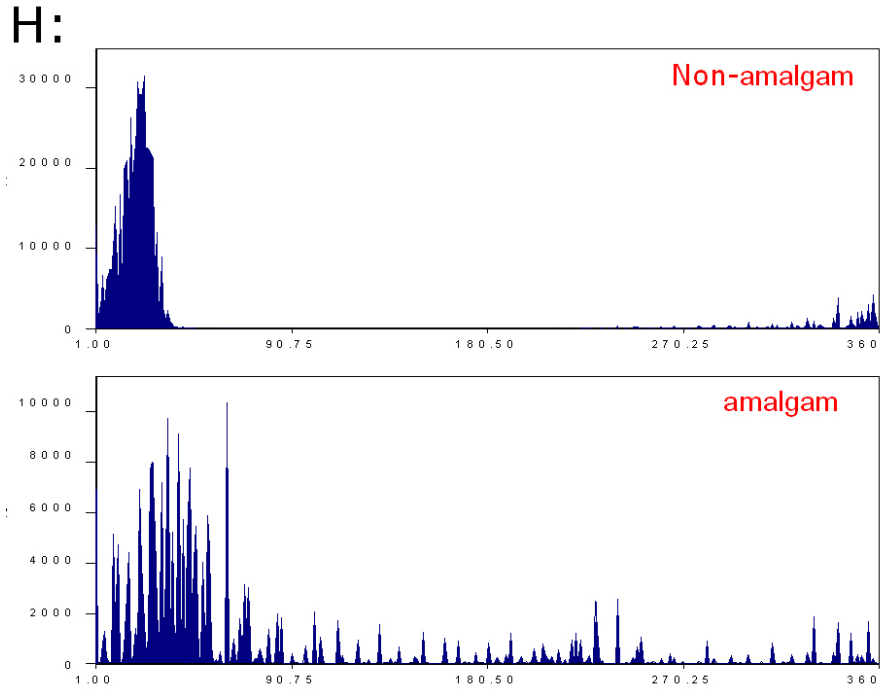


Fig. 4.2.2 Distribution of amalgam regions and non-amalgam regions in H

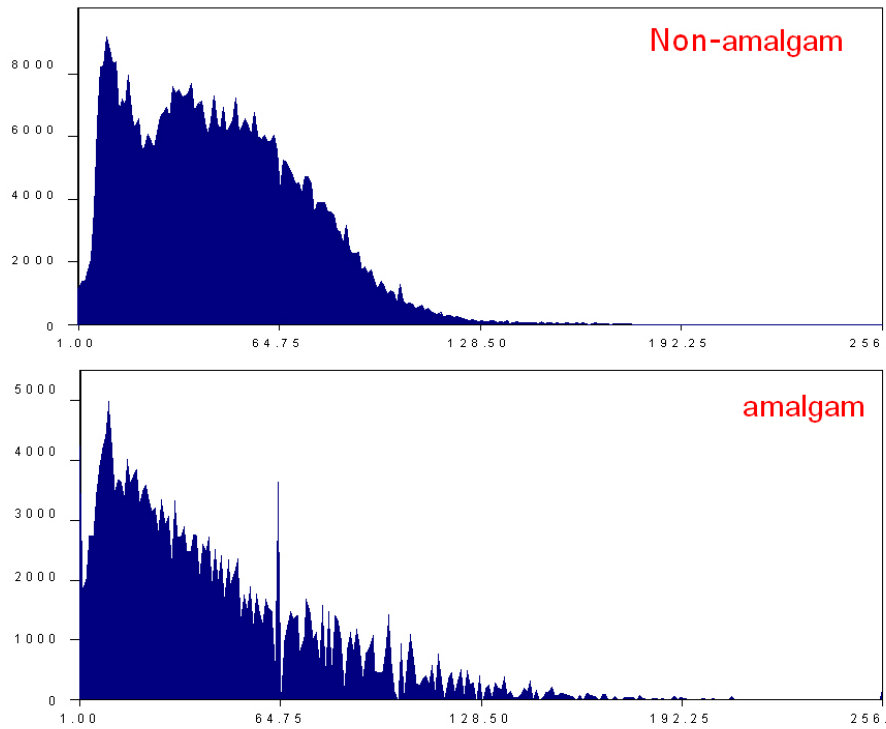


Fig. 4.2.3 Distribution of amalgam regions and non-amalgam regions in S

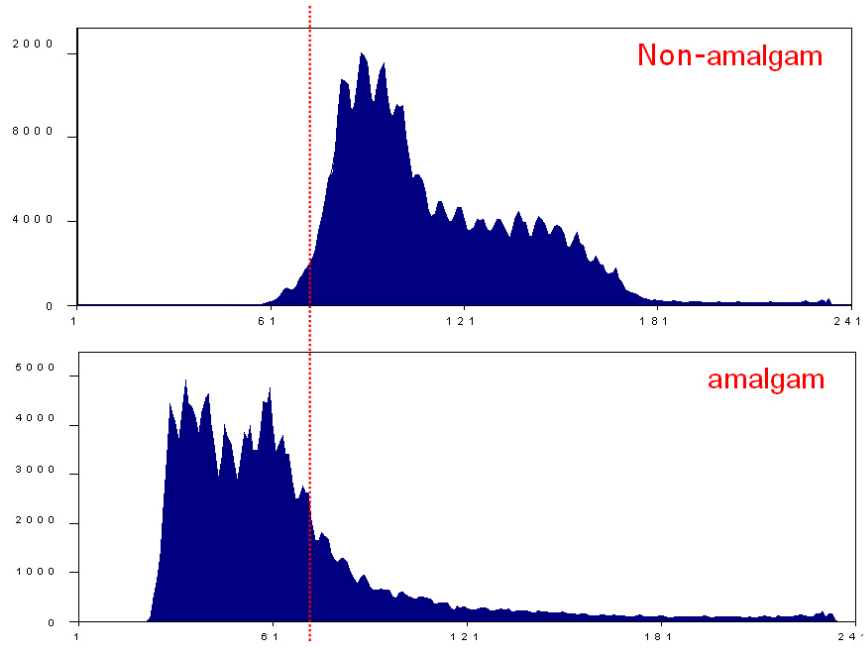


Fig. 4.2.4 Distribution of amalgam regions and non-amalgam regions in I

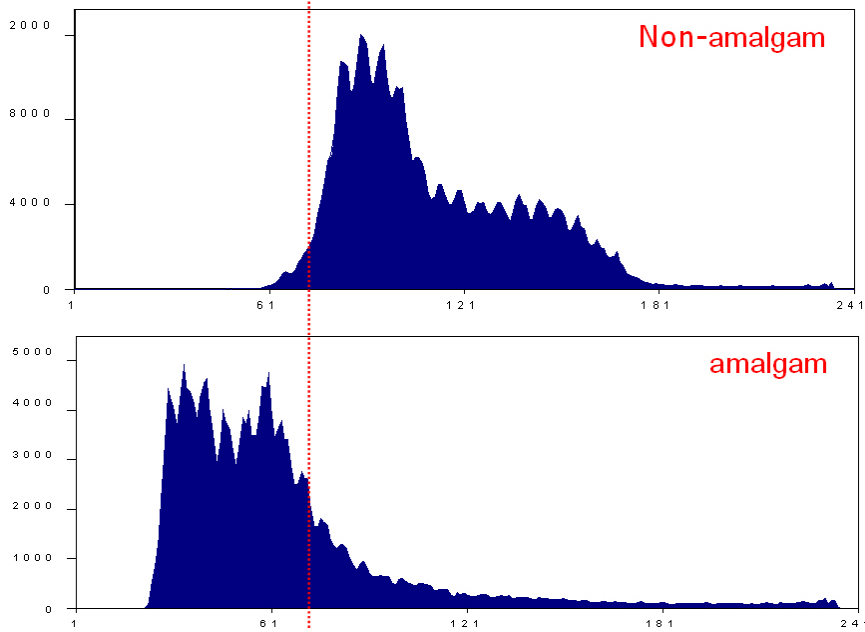


Fig. 4.2.5 Distribution of amalgam regions and non-amalgam regions in Y

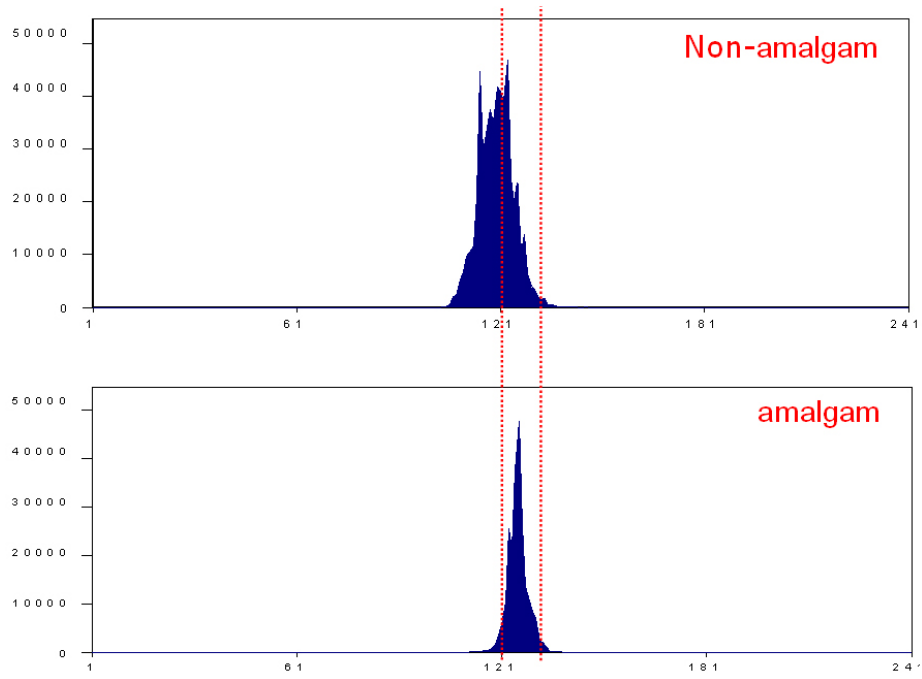


Fig. 4.2.6 Distribution of amalgam regions and non-amalgam regions in Cb

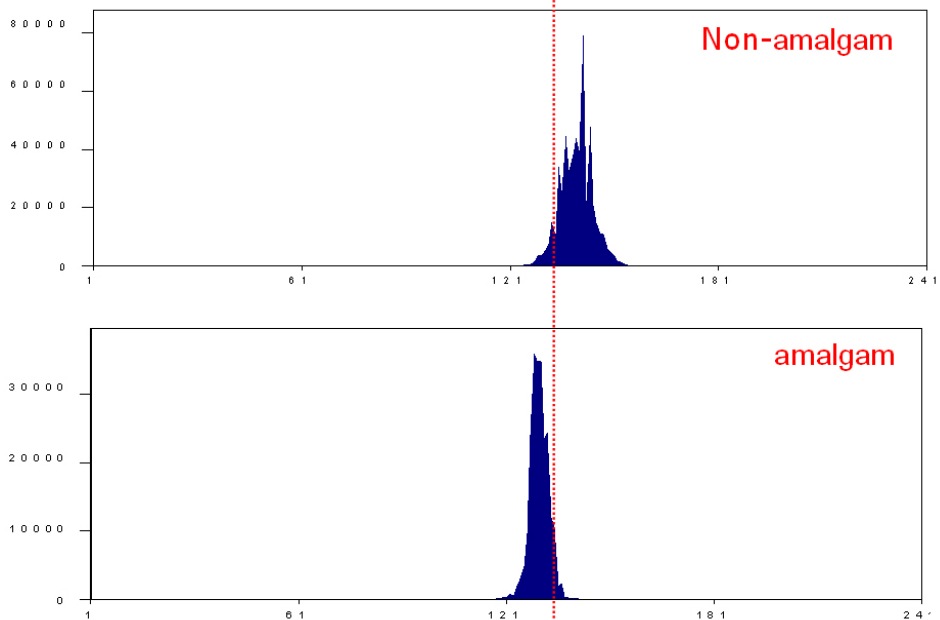


Fig. 4.2.7 Distribution of amalgam regions and non-amalgam regions in Cr

After comparing the above diagram, Y and Cr channels in YCbCr color space have the discriminative ability to distinguish between amalgam and non-amalgam. But only I channel in HSI color space do. YCbCr color space have more information than HSI color space, since two channels in YCbCr can be used but only one in HSI. Y and I are similar. Therefore, we adopt YCbCr color space to detect the amalgam from a tooth.

Due to some overlapping area of amalgam regions and non-amalgam regions, we can detect amalgam correctly and cannot mistake *non-amalgam* as *amalgam*. In experiment, only using Cr can detect status-amalgam correctly but it also raise error rate of mistaking other status as amalgam. So we decide to use Cr and Y to decide amalgam or non- amalgam.

Detect the amalgam of a pixel in a tooth region. We can regard as two classes: amalgam and non-amalgam. They have two kinds of probability distribution. So we can use Bayesian Decision Rule to decide what class they belong to. The Bayesian Decision Rule is:

$$P(\text{amalgam} / X) = \frac{P(\text{amalgam})P(X/\text{amalgam})}{P(X)}$$

$$P(\text{non-amalgam} / X) = \frac{P(\text{non - amalgam})P(X/\text{non - amalgam})}{P(X)}$$

$$\begin{cases} Cost_{\text{amalgam}} \times P(\text{amalgam} / X) > Cost_{\text{non-amalgam}} \times P(\text{non-amalgam}/X) \Rightarrow \text{status} = \text{amalgam} \\ Cost_{\text{amalgam}} \times P(\text{amalgam} / X) < Cost_{\text{non-amalgam}} \times P(\text{non-amalgam}/X) \Rightarrow \text{status} = \text{non - amalgam} \end{cases}$$

The decision boundary determined by the Bayesian rule when  $Cost_{\text{amalgam}} = Cost_{\text{non-amalgam}}$ .

$$P(\text{amalgam} / X) = P(\text{non-amalgam} / X)$$

Note that  $P(X / \text{amalgam})$ ,  $P(X / \text{non- amalgam})$ ,  $P(\text{amalgam})$  and  $P(\text{non- amalgam})$  are constant. In general,  $P(\text{non- amalgam})$  is larger than or equal to  $P(\text{amalgam})$  in a dental image. According to Bayesian test for *minimum cost*, mistaking *amalgam* as *non- amalgam* is larger cost, i.e.  $Cost_{\text{amalgam}} > Cost_{\text{non-amalgam}}$ . Therefore, we select the cost.

Let  $Cost_{\text{non-amalgam}} * P(\text{non- amalgam}) = Cost_{\text{amalgam}} * P(\text{amalgam})$  in order to decrease the cost of mistaking *amalgam* as *non- amalgam*. So comparing  $P(\text{amalgam} / X)$  and  $P(\text{non- amalgam} / X)$  can be reduced to compare  $P(X / \text{amalgam})$  and  $P(X / \text{non- amalgam})$ .



Using a Bayesian Decision Rule, we can select a threshold value  $t$ . In our experiments, we select threshold value,  $threshold_{Cr} = 134$  and  $threshold_Y = 76$ .

Therefore, we can obtain that

$$\begin{cases} \text{if } Cr(i,j) \geq threshold_{Cr}, \text{ then assign } (i,j) \text{ to amalgam} \Rightarrow status_{cr} = 1 \\ \text{else assign to teeth} \Rightarrow status_{cr} = 0 \end{cases}$$

$$\begin{cases} \text{if } Y(i,j) \geq threshold_Y, \text{ then assign } (i,j) \text{ to amalgam} \Rightarrow status_Y = 1 \\ \text{else assign to teeth} \Rightarrow status_Y = 0 \end{cases}$$

if pixel  $(i,j)$  of which  $status_{Cr} = 1 \cap status_Y = 1$ , then assign the pixel : status = amalgm  
else assign to status = non - amalgm

We can judge if a tooth is amalgam by the rule.



$$if \left\{ \begin{array}{l} \text{number of pixel is amalgam} > N \\ \text{or} \\ \frac{\text{regions of pixel is amalgam}}{\text{regions of the tooth}} > R \end{array} \right. \Rightarrow \text{detect the status of the tooth is amalgam}$$

here, we set  $R = 0.2$ ,  $N = 500$

The result of amalgam detection is shown in Fig. 4.2.8.

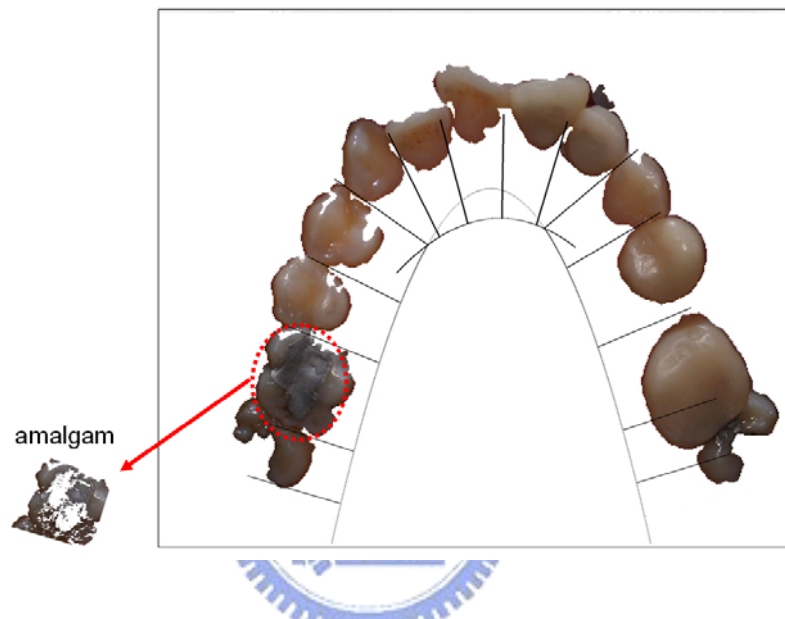


Fig. 4.2.8 Detect amalgam