REGISTRATION BETWEEN 3D OBJECT AND VIDEO IMAGE FOR BRACKETS ALIGNMENT ON DENTAL CAST

Yootthana Mahitdhiharn\(^1\), Chanjira Sinthanayothin\(^2\)

\(^1\)Department of Computer Engineering, Faculty of Engineering, Chulalongkorn University
\(^2\)National Electronics and Computer Technology Center (NECTEC), NSTDA, Thailand

**ABSTRACT**

This paper presents the technique for registration between 3D object and video image for aided orthodontics application, which helps dentist to have more accurate brackets alignment on dental cast. This paper gives the development and features of the registration technique that allow the user to place the bracket to the real cast follow to the computerized orthodontics planning. The program will track the right position of the 3D object model to match the video image in order to transfer the brackets position from the 3D model to the real dental cast. During the placement of the brackets on real dental cast, the user is allowed to see the correctness of aligned brackets position in color. The results of the registration between 3D model and video image show effectiveness of the brackets aligned on the real cast from using this technique.

**1. INTRODUCTION**

Nowadays, many people become more interested in orthodontic. Since orthodontic has to be done precisely by the dentist, especially in the part of bracket placement; many methods are invented for more accuracy. Also computer programs become significant solution. Some commercial products are also available in the present such as OrthoCAD \([1]\), a product of Cadent Inc., developed for computer-aided treatment, 3Dxer \([2]\), the product by Dimennex Digital Lab has been used for orthodontics analysis, e-model \([3]\), from Geodigm Corp is another 3D digital model service for orthodontics diagnostic. Also AlignBracket3D \([4]\), the software developed by Thai researchers. However, apart from 3D orthodontics planning, the location of the brackets need to be transferred to the real cast or the patients. Normally, it is available in the form of brackets guide \([5]\) which need the rapid prototyping (RP) machine for constructing which is costly. Therefore, the technique for transfer the location of brackets from computerized planning to the real dental cast has been developed, which will give an accurate placement of the brackets on the cast. By using only video camera, the cost also can be afforded by general dentists as well.

**2. METHODOLOGY**

The overview of system starts with the system receive video image of real dental cast from video camera, which is connected to the computer, for performing registration technique with 3D model. The result from this technique will give user a guided image for brackets placement to the real dental cast. The relation of each component above is shown in figure 1.

![Figure 1. System Overview](image)

Therefore, images from two sources were applied, i.e., video image, and 3D model. In this project, the 3D model with the brackets alignment is first performed and planned by AlignBracket3D \([4]\), then saved all files in STL file format and re-open again in our project. The image of real dental cast from video camera is shown in figure 2(a), and image of 3D model is shown in figure 2(b) respectively.

(a) Image from video capture
Then the guided image for brackets placement is performed by combine 2 images between real dental cast and 3D model. As the users concern in placing brackets to real dental cast, therefore there is a transparency tool for setting the guided image as shown in figure 3. The first image of figure 3 shows the image of 3D model while the last image shows video image with the position of the brackets. Other images show an appearance in between the 3D model and video image depend on transparency tool. The Equation (1) can be applied for transparency tool.

\[ f(x) = k \, g(x) + (1-k) \, h(x) \]  

Where \( f(x) \) is the intensity in guide image, \( g(x) \) is intensity from the video image and \( h(x) \) is the intensity from 3D model image, and \( k \) is the transparency level.

![Figure 3. Guided images with different transparency level.](image)

2.1 Teeth Model Tracking

In teeth model tracking procedure, we have to know whether the 3D model location is accurate compares with the video image. Therefore, three steps have been developed as follows:

2.1.1. Image Subtraction

We begin with finding the part of both 3D model image and video image, which contains teeth by using threshold segmentation technique. Start with real dental cast, which is bright color, so we segment it with its specific color and replace with the white background. In the case that initial threshold value does not appropriate, users can define the threshold value using track bar. From this method we can get image of teeth from video source as shown in figure 4.

![Figure 4. Teeth image from video capture.](image)

Then we compare the above segmented image to the 3D model image by counting pixels which both images show the teeth region. The ratio of the counted pixels will be used to compare the accuracy of matching locations.

2.1.2. Adapted Random Tracking

Next, the 3D model has been randomly moved in twelve directions around the object both translation and rotation. Equation (2) and (3) are used for translation and rotation in \( x, y, z \) directions both forward and backward respectively.

\[
\begin{align*}
x' & = x - R_x \\
y' & = y - R_y \\
z' & = z - R_z
\end{align*}
\]  

Therefore, the technique used in this research is required two main procedures:

(i) Teeth model tracking and
(ii) Brackets detection

![Figure 5. Teeth image from video capture with brackets.](image)
Where \( Rx, Ry, Rz \) are the translation distance in \( X, Y \) and \( Z \) directions.

Rotation

\[
\begin{align*}
X\text{-Axis Rotation} & : x' = x, y' = y \cos \Theta - z \sin \Theta, z' = y \sin \Theta + z \cos \Theta \\
Y\text{-Axis Rotation} & : x' = z \sin \Theta + x \cos \Theta, y' = y, z' = x \cos \Theta - y \sin \Theta \\
Z\text{-Axis Rotation} & : x' = x \cos \Theta - y \sin \Theta, y' = x \sin \Theta + y \cos \Theta, z' = z
\end{align*}
\]

Where \( \Theta \) is the rotation angle.

After random movement, the result of movement has been calculated with the image subtraction method above. Bad movement will be cancelled and the movement will not show to the users. Otherwise good movement will be shown, and program will try move the 3D object in the same direction. Therefore, the huge movement which contains few directions and less random will be done. Since variance of video image is expected; that makes accuracy for any location tracking not stable. Thus, it has to be threshold value that makes the accuracy coefficient fixed at the highest rate, until the non-matching value is decrease. From this method, the 3D model will stay in the best findable location as long as the real dental cast is not moved. The tracking sequence between 3D model and video image can be shown in figure 5.

2.1.3. Rotation Test

In some cases, the 3D model is still not in the right location, but it will not move anymore. This can happen when the 3D model fits to the video image, but it is not in a right angle as shown in figure 6. To solve this problem, we force the program to rotate in higher angle than in randomly rotate, when the 3D model stays still for a period of time. If desired movement is just rotation, then the 3D model will be in more precise location.

2.2. Brackets Detection

Bracket detection procedure is used to show the users whether the real brackets on the real dental cast is well-aligned. Well-positioned brackets will turn into red as shown in figure 7.

The method that we use to define whether the brackets are in position is threshold segmentation. We assume that the pixel, which has difference between each primary color less than fifteen is bracket. However, if the brackets’ color is similar to the background, the result of segmented image might be wrong as can be seen in figure 8 (a). This effect may cause undesirable result in the case that 3D model location is out of the real dental cast location as in figure 8 (b).
The result on aligning brackets to real dental cast by using this program is shown in figure 9(a) figure 9(b) shows 3D model brackets alignment which is used to align in the real dental cast as a comparison to the result.

4. DISCUSSIONS & CONCLUSION

The program works fine in normal situation with less tracking. However, some tracking takes long time for users to wait, usually with rotation. Threshold segmentation results might not be effective on both teeth and bracket segmentation in some cases. However, this problem can be solved by choosing the background in color that differs from both dental cast and brackets. However, the program should be improved in tracking techniques that may put some cases to deal with other solutions instead of random. One important problem in developing this program is the speed of the program because the users have to wait for each task to continue its work. Nevertheless, this program has met the ordinary need, and it could help the users to place the brackets in the right positions. This program will help orthodontists to have more comfortable and accuracy in their job. Also auto tracking model could handle problem that caused by dental cast slip while implanting bracket as well. Because the 3D model can moved follow to the real dental cast for changing location. Then the precise of brackets alignment will be shown in color separately for each bracket. However, some mistakes might happen, but it can be avoided by manually place the bracket one by one.

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REFERENCES