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Research Article

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Establishment of the database of standard crown

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ABSTRACT

Standard crown database is an important part of CAD packages for a complete denture CAD/CAM system. Standard crown model is the geometrical model base of standard teeth database. In this study, based on the standard model of dental resin, the surface model of crown was created by using reverse engineering technology and denture feature modeling technology. These technologies meet the CAD/CAM system requirements. The process includes data acquisition, data processing and model reconstruction, and then a CAD model was generated. In this paper, the standard crown CAD model of Asians 28 permanent teeth was developed, based on this model E-R model of standard crown database was created, it provides model basis for developing denture CAD/CAM system with China's own intellectual property.

Key words: Denture; surface modeling; database

INTRODUCTION

In the late 1980s, the fixed denture CAD/CAM system was introduced into the oral prosthesis clinic, a significant technological revolution of Oral Prosthesis field was initiated. In order to quickly and accurately recovery the anatomy and physiological morphology of the defect teeth, and making the proper restorations e.g. inlays, crowns, bridges, conventional treatment of hand-carved physical models was replaced by digital models in fixed denture CAD/CAM systems, and the design was conducted directly in the CAD software. The surface shape of dental is complex, especially occlusal surface is undulating valley and ridge ditch intricate, which could not be represented by the simple geometric models. Therefore, it is a key issue for denture CAD/CAM system to get the surface morphology of the teeth to meet the clinical requirements [1-5].

The traditional lost wax method was applied in Duret system [6], which based on occlusal contact principle of mandibular teeth, and a man-machine interactive technology was proposed to build the occlusal surface. A large number of reference points need to be adjusted for the technology. Furthermore, the design process was tedious and not easy to be operated by the doctor. Some fixed denture CAD/CAM system developers proposed the establishment of teeth model database, which can provide better tooth surface reference model for prosthesis design. Cicero system [7] contains a complex teeth model database, the developer VanderZe proposed deformation parameters of the same name tooth. However, this system has high operating skills of CAD software for the users and is difficult to promote. Based on the surface morphology of the tooth structure, the geometry deformable models were proposed in the Cerec system [8]. Teeth database technology of Hint-Els system is still not perfect, needs further study. Recent years, many studies have been conducted by Chinese scholars in the field of technology. A three-dimensional graphics database of artificial teeth was established by school of stomatology, Peking University [9]. The overall geometric transformation of standard crown was initially realized. Determination of the local variation and the amount of movement need to be further improved. The purpose of this study is to develop CAD/CAM system with China's

independent intellectual property rights, which can be used in oral rehabilitation and computer-aided design and production.

The database is an important part of the denture CAD/CAM technology, which was responsible for the management of denture CAD/CAM systems large amounts of data, including information definitions and data exchange functions e.g. standard dental models, different races, different ages, different teeth. In order to easily use the database, the basic feature properties of database are the size and morphology properties of standard teeth, information integration of database can be completed using based on the features.

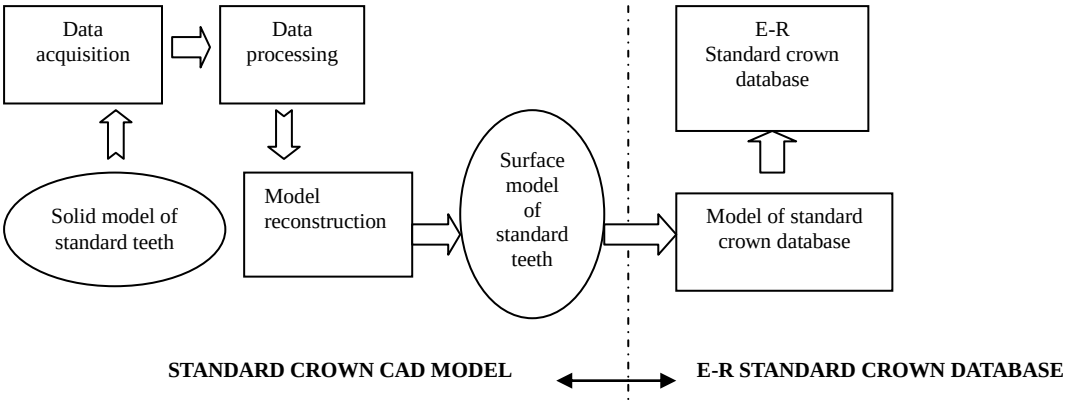


Fig. 1: Standard crown cad model

In the process of the establishment of a database, the main task is to feature modeling of standard crown geometric model. The modeling process (Fig. 1) includes data acquisition, data processing, the geometric model reconstruction and surface modeling. Any step will affect the accuracy of the model, thus affecting the model size and morphology features. In this study, the process of establishing the database, modeling of Chinese was regarded as the important step, and then the database was managed according to the standard teeth information features.

DATA ACQUISITION

Obtaining data information of oral tissue morphology is the most basic and critical technologies for the various systems. There are two measurement methods i.e. intraoral and extraoral method. The traditional method e.g. impression taking, pouring model can be replaced by intraoral method and extraoral method can be conducted indirectly measuring the teeth information from the plaster model.

The measurement technique can generally be divided into two categories: contact and non-contact. In this paper, asians teeth standard model will be created. In order to obtain high accuracy and avoid occlusion caused by reflective measurement data, PICZA PIX-30 three-dimensional solid-contact scanners was used, the accuracy up to 0.025mm (Fig. 2).

When obtaining the crown surface data, in order to facilitate subsequent processing, development and applications, the shape of the teeth and position in the scanner were especially considered, the planning of measuring sequential was the focus. Standard crown surface consists of five surfaces: facial and buccal, lingual, mesial, distal, occlusal. Occlusal is the most complex surface, which is connected with the other four surfaces. First, the occlusal was scanned. The most common feature area will be obtained when reconstruction data and easily search the same feature point. In the remaining four surfaces, the buccal surface features is obvious, and has more common feature area with occlusal, which will be scanned subsequently, and then following mesial, lingual, distal will be scanned.

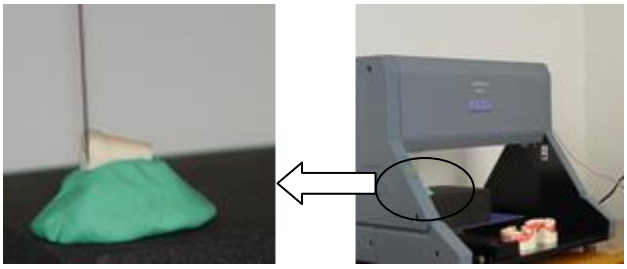
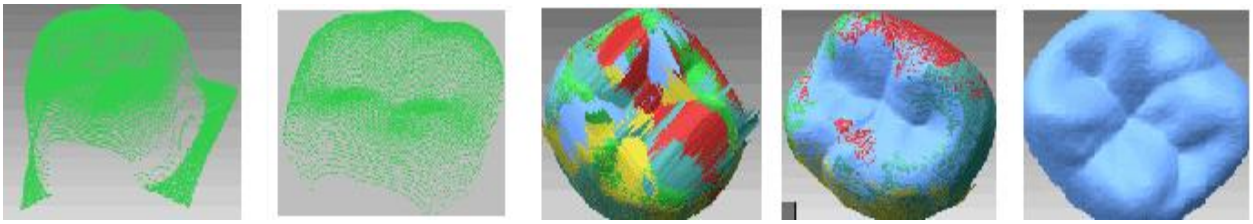


Fig. 2: Data scan



a **b** **c** **d** **e**

Fig. 3: Data processing a) original point cloud; b) remove noise; c) positioning before combination; d) multi-view combination; e) data Fusion

DATA PROCESSING

After scanning resin model, the model data of each shell is stored in the computer as point cloud of multiple angles (Fig. 3a). Data preprocessing is mainly to remove noise data (Fig. 3b) and redundant data. Multi-view combination is based on a fixed visual shell to adjust the coordinates, i. e. this process can calculate the exact position of each shell using the common geometrical characteristics (Fig. 3c,d,e). After the multi-view combination, data fusion can be done by overlying or subtracting the data value.

During the measurement, the number of collection points is generally large, and data fusion will be huge after multi-view piecing, which make data reduction becomes inevitable. Sampling and chord difference are commonly used in reducing. In the sampling method, if the scanning direction along mesh or array of point cloud, point can be reduced along mesh or scanning direction; if multiple unordered point cloud, removal of the neighbor point can be adopted. Two parameters of the maximum deviation and maximum spacing of points were used to reduce the point cloud in chord difference. Point cloud is unordered in this article, so chord difference was used to reduce the point (Fig. 4).

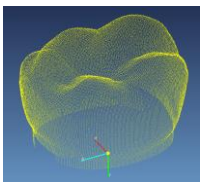
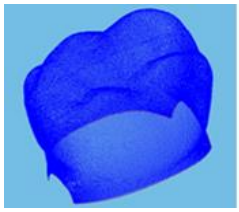


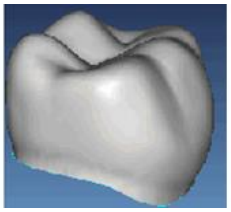
Fig. 4: Data reduction

MODEL RECONSTRUCTION

When fitting surface from point cloud, reasonable choice of parameters directly determines the quality and fitting accuracy of the generated surface. The main parameters are surface order, control points, other fitting parameters. The higher the order of the surface, the less internal node fitting for obtaining the same desired effect, and with increasing the order of the surface, the computational complexity is increased, the surface will easily produce oscillations. Control points: the number of control points depends the expressed details of the entity, the more control points, the more detail expression. But the number of control points is determined also depends on other factors, the more is not the better. Besides control points, there are three the fitting parameters can effect on the quality of fitting, i.e. tension, smoothness and standard deviation of data noise. a) Tension can be considered to control the accuracy of the fitting, the greater the tension, the higher the accuracy. b) Smoothness is the degree of control of the entity curvature, the greater the value, the better the smoothness of spline. c) Standard error indicates accuracy of the scanned data, in the fitting surface, the situation of data points were selected by the program according to the value of the data. A smaller value indicates more credible data. Spline is similar accuracy of interpolation to fit the surface. These three parameters are mutually restricting, for example, it is necessary to reduce the accuracy requirements to get a better smoothness.

In order to obtain better accuracy and adequacy of the data for follow-up work, the accuracy will be considered preferentially when selecting parameters. Based on computing capacity and the difficulty of control, fourth order surface was selected in the study, control points of u and v are 200. Tension should be large as possible, and smoothing will be small, so that the standard deviation is close to the scanning errors(Fig. 5).





a **b** **c**

Fig. 5: Different expression of surface fitted from point cloud
a) network; b) solid rendering ; c) cutting Surfaces

Fig. 6: Standard crown model

The surface model of standard crown was basically established by the above processed steps, each tooth model was constructed in accordance with the above procedure, the Chinese standard crown model of the right proportion of 28 teeth was obtained (Fig. 6), the information management of different tooth was conducted in accordance with location, thus the Chinese standard crowns database was established.

E-R STANDARD CROWN DATABASE

A set of standard crown model should be provided to the designers and manufacturers of the teeth shape when developing the system. Modify and re-design of modelling is based on the standard crown model in design process, the efficiency of geometric modeling can be greatly improved. Therefore, when doctors and denture prosthesis designers need to design a tooth, they can be very convenient to search the corresponding standard tooth in the system, and obtain reliable surface models of crown and the corresponding medical features. It is one of the goals of establishing standards crowns database.

Two types of data stored in the Asian adult permanent teeth standard database; surface model standard crown; medical feature points of standard teeth and feature points in the position of crown surface

SURFACE MODEL OF STANDARD CROWN

The entity is the primary entity in standard teeth database and the model basis for subsequent design and modeling. There are two methods can be used to store geometric elements in a database, one method is a file system, which can store data and modeling, this method is used by most systems, however, the representation is not linked to the structure of the database. Another method is the geometric shape can be directly represented in the database. The former approach has shortcomings, but it is mature, and can be saved with other document formats using the unified relationship model. The second method is more difficult, but it is the fundamental way. Project database was used in data management of CAD/CAM system. The method of this system depends entirely on modeling method of the overall structure of the system.

Medical feature points of standard teeth and feature points in the position of crown surface

As an object of the study, tooth has its own feature points and feature parameters the geometric model should be provided in standard library, and the key feature points of the tooth should be provided as well. This will be helpful to reasonably modify for the standard model in the design process. Feature point of the crown can be classified in accordance with the position of teeth (Table 1).

Table 1: Feature point of the crown

Tooth type	The number of feature points	Feature point position
upper incisor	4	incisal edge; mesial marginal ridge; distal marginal ridge; lingual fossa
upper canine	6	dental cusp; mesial cusp ridge; distal cusp ridge; mesial marginal ridge; distal marginal ridge; lingual axial ridge
upper bicuspid	7	buccal cusp; lingual cusp; buccal cusp triangular ridge; lingual cusp triangular ridge; mesial marginal ridge; distal marginal ridge; central groove
upper molars	10	mesial buccal cusp; distal buccal cusp; mesial lingual cusp; distal lingual cusp; mesial marginal ridge; distal marginal ridge; oblique ridge; buccal groove; lingual groove; central fossa
lower incisor	4	incisal edge; mesial marginal ridge; distal marginal ridge; lingual fossa
lower canine	4	dental cusp; mesial cusp ridge; distal cusp ridge; buccal axial ridge
lower bicuspid	7	buccal cusp; lingual cusp; buccal cusp triangular ridge; lingual cusp triangular ridge; mesial marginal ridge; distal marginal ridge; transverse ridge
lower molars	11	mesial buccal cusp; distal buccal cusp; mesial lingual cusp; distal lingual cusp; mesial marginal ridge; distal marginal ridge; distal cusp; buccal groove; lingual groove; mesial buccal groove; central fossa

The position of the feature point listed in the table is the position of medical terminology. The feature position can

be parameterized relative to the coordinate value of the surface model of the standard tooth in the development. Only parameters of feature point can be changed and it doesn't affect the overall topology.

DETERMINE THE PROPERTIES OF THE ENTITY

The entity set of standard crown surface models includes tooth code, tooth type and surface model (Fig. 7). The entity set of standard crown feature point should include tooth type, the number of feature points and position of feature points

ANALYSIS OF THE CONNECTION BETWEEN THE ENTITIES

One to one contact (1:1) has two entity sets A and B, then if it is one to one contact between entity set A and entity set B: for each entity in A set of entities, at most one (or may not) corresponding entity can be found in entity B, and vice versa.

One to many contact (1: n) if each entity in set A has one, more than one corresponding entities can be found in set B; while for each entity in set B, at most one corresponding entity can be found in set A.

Many to many contact (m: n), each entity in set A, one or more corresponding entity can be found in set B, and vice versa.

Fig. 7: Standard crown database of solid model

One to many contact (1: n) was used in the study, each entity in entity set of feature points of standard crown has one or more corresponding entity in entity set of surface model of standard teeth. For each entity in entity set of surface model of standard teeth has one corresponding entity at most can be found in entity set of feature points of standard crown.

DETERMINE THE CONNECTION BETWEEN THE ENTITIES

The feature points entity of standard crown in entity set of the crown model of standard crown surface models includes feature points of corresponding tooth type E-R model of the standard crown database is shown Fig. 8.

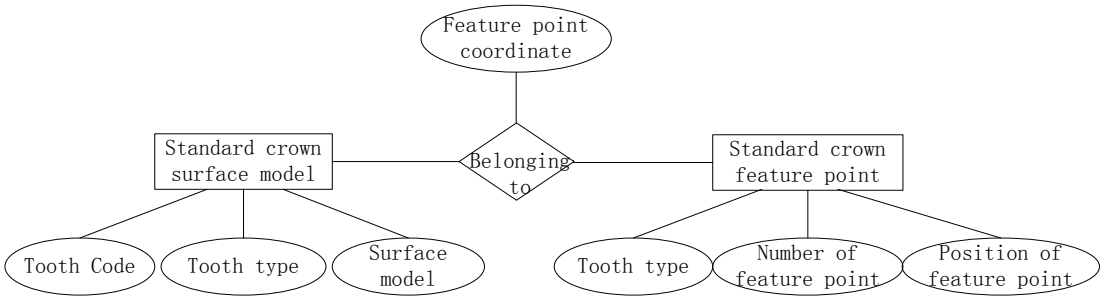


Fig. 8: E-R model of standard crown database

CONCLUSION

In this paper, the standard crown CAD model of Asians 28 permanent teeth was created. Furthermore, the E-R model database of standard teeth was developed. The CAD model was created by using reverse engineering technology includes data acquisition, data processing, model reconstruction and surface generation. Data management of denture CAD/CAM system and establishment method of standard teeth database were proposed. After analyzing the data management system, the feature points of standard teeth will be added to the standard database, and the E-R model of standard teeth database will be established. In this paper, the establishment of standard crown database provides a data basis for the development CAD / CAM systems.

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