

Feature Curves Based Cephalometric Superimposition

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Abstract

The analysis of the spatial changes of the craniofacial structures for orthodontic treatment or surgery always relies on the superimposition of cephalometric tracings taken at different times. The errors in the manual measurement of superimposition may be arisen from the bad cephalogram quality, the facial growth, and the orthodontist's experience. In this paper, the computerized superimposition is developed for alleviating the problems mentioned above. This procedure contains three parts: 1. To digitize and calibrate the cephalogram through the CCD camera; 2. To extract the feature curves for the cranial base using the best oriental edge detector and Hough transform, and for the mandible using the Laplacian of Gaussian and grouping; and 3. To automate the superimposition based on the clinically available procedure and finally to display the associated results. The complete procedure typically takes 5 to 6 minutes of computation. The precision for the cranial base superimposition is about 0.312cm, and the mandible about 0.605cm. The difference between the superimpositions of the proposed system and the manual measurement is about 0.95cm in the cranial base, 0.98cm in the maxillary, and 1.26cm in the mandible.

Keywords: Feature curve matching, Cephalometric superimposition, Landmark, Image processing

Introduction

Cephalogram usually plays the key role in cephalometric diagnosis and superimposition. In general, orthodontists manually locate the landmarks and trace their associated feature curves and lines on the tracing paper (Fig. 1(b)) attached on the cephalogram (Fig. 1(a)). Landmarks on the cephalogram are defined according to the anatomical features [26] for clinical reference. The associated data for the cephalometric analysis is then measured and computed. This manual procedure is very tedious and time-consuming. Moreover, the accuracy of measurements is heavily dependent on the factors such as the film quality and orthodontist's experience.

Spatial changes of craniofacial structures are the basic information for the orthodontic treatment and surgery. They are measured by superimposition of cephalometric tracings taken at pre- and post-treatment, or pre- and post-surgery. It usually takes about 5 to 10 minutes to plot a tracing paper, and 20 to 30 minutes for superimposition in cephalometrics. From the cephalometric analysis, the orthodontists can understand the general view of growth changes and the effect of treatment. Superimposition is a procedure to match two cephalograms with the same features, relative landmarks, or anatomical

structures. Some difficulties may be encountered in the cephalometric superimposition, especially for the growing young patients. In the growing skulls, the various bones may move apart from each other at different rates. The landmarks adjacent to the growth locations will then move farther from the growth sites. Therefore, same feature curves and anatomical structures may not be easily found and matched. The parts for cephalometric superimposition are generally divided into three areas as follows.

Cranial base superimposition

To evaluate facial changes, the anatomic structures for registration must be relatively stable over the time of orthodontic treatment or surgery. The cranial base region grows rapidly in early postnatal life and reaches 90% of its final size by 4 to 5 years of age [1]. So the cranial area is considered as a satisfactory reference for the cephalometric registration. For examples, there are two methods of superimposition on the cranial base [2]. One is the superimposition on the best fit of the anterior cranial base anatomy as shown in Fig. 2(a), and the other is superimposition on Sella-nasion(SN).

Maxillary base superimposition

Maxillary superimposition is done along the palatal plane from ANS to PNS registered at ANS [3]. It may also superimpose on the palatal plane but register at the pterygomandibular fissure. The method of the best fit on the

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