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Orthodontic Treatment Simulation Using Image Processing Techniques

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ABSTRACT: Orthodontics deals with the study and treatment of malocclusions (improper bites). The processes involved in orthodontic treatment can be automated to reduce a lot of human effort. However this benefit comes at a significant cost. In such a scenario, a goal is to see if we could try and provide the core function of the orthodontic treatment, i.e. Cephalometric Analysis, in a more economical alternative.

This paper proposes an interactive tool that works on dental X-ray images and allows the user to plot certain structural landmarks of the head known as reference points onto the X-ray. These points can then be used to plot planes which facilitate certain linear and angular measurements. These measurements can be observed and analyzed to give a diagnosis of any deformity in the patient's occlusion. Using image processing techniques, a user can conveniently perform Cephalometric Analysis in an orderly, sequential manner.

KEYWORDS: Orthodontics, Cephalometrics, Simulation, Landmarks, Malocclusions

I. INTRODUCTION

Most orthodontists work on a trial and error basis, estimating an "ideal" loading condition that can lead to a precise and aimed tooth movement. Hence the actual outcome in practice is not guaranteed. Therefore, the orthodontist and patient have a strong need for a method which enables them to visualize, using realistic pictures of the expected teeth positioning to circumvent unexpectedly situations that eventually may occur in practice.

The main goal of the application is to perform the process of Cephalometric Analysis effectively. Cephalometric Analysis is the first and most important step in the orthodontic treatment. This activity alone takes anywhere between three to four hours to complete when done manually in the traditional way (i.e. using a tracing paper) and can be a tiresome. The economic advantage of tool will allow newly established orthodontic ventures to acquire and use it, thereby reducing a lot of human effort.

Also, dentistry students specializing in the field of orthodontics will be able to exploit the functionalities of this application to experiment and learn the procedure for diagnosis of patient's deformity and generation of a treatment plan. Thus it could be an effective learning aid. Again, the economical advantage of system will enable institutions to provide the application to their students as part of the educational infrastructure without creating an overhead in its expenditure.

II. LITERATURE REVIEW

Orthodontics is concerned with the study and treatment of malocclusions (improper bites), which may be a result of tooth irregularity, disproportionate jaw relationships, or both[3]. Orthodontic treatment can focus on dental displacement only, or can deal with the control and modification of facial growth. Orthodontic treatment is generally carried out for purely aesthetic reasons with regard to improve the general appearance of patients' teeth. For an Orthodontic treatment, the dentist must first perform diagnosis and generate a treatment plan.

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To do this, first and foremost the Orthodontist has to perform Cephalometric Analysis. Cephalometric analysis[1] is the study of dental and skeletal relationship in the head. It depends on cephalometric radiography to study relationships between bony and soft tissue landmarks and can be used for diagnosis of facial growth abnormalities prior to treatment. Thus the assessment of cranio-facial structure is an important part of orthodontic diagnosis and treatment. X-rays play a major role in cephalometrics. In fact the term cephalometrics is used to describe the analysis and measurements made on cephalometric radiograms also known as cephalograms. There are two types of cephalograms:
Lateral: provides a lateral view of the skull and
Frontal: provides an antero-posterior view of the skull.

The following are some of the applications of cephalometrics in orthodontics.

- Cephalometrics helps in orthodontic diagnosis by enabling the study of the skeletal, dental and soft tissue structures of the cranio-facial region.
- It helps in classification of the skeletal and dental abnormalities and also helps in determining facial types.
- Cephalometrics helps in planning treatment for a patient.
- It helps kin evaluation of the treatment results by quantifying changes brought about by the treatment etc.

In this respect, automatic cephalometric analysis is one of the main goals, to be reached in orthodontics in the near future. Accordingly, several efforts have been made to automate assessment of cephalometric analysis.

III. PROPOSED ALGORITHM

Cephalometric analysis of lateral radiography of the head is an important tool in orthodontics. Manually locating specific landmarks is a tedious, time consuming and error prone task. It consists of placing a sheet of acetate over the cephalometric radiograph, tracing salient features, identifying landmarks, and measuring distances and angles between landmark locations.

A computer-aided approach is proposed here. This approach aims at automating the procedure mentioned above. A X-ray film is digitized. The system allows the orthodontics to plot landmarks directly on the screen and provide the measurements. An application provides the user with the functionality to:

1. Load the image
2. Provide basic enhancement
3. Perform reference point (landmark) identification
4. Perform reference plane identification
5. Perform cephalometric analysis (measurements)
6. Store the results in an excel sheet

In this work, the process of cephalometric analysis is semi-automated, wherein landmarks needed for detecting skeletal abnormalities are marked on the screen by the user and measurements are obtained.

IV. CEPHALOMETRIC LANDMARKS

Cephalometrics makes use of certain landmarks or points on the skull, which are used for quantitative analysis and measurements (Fig 1). These landmarks represent actual anatomic structures of the skull and are obtained secondarily from anatomic structures in a cephalogram. The landmarks should also permit valid quantitative measurements of lines and angles projected from them.

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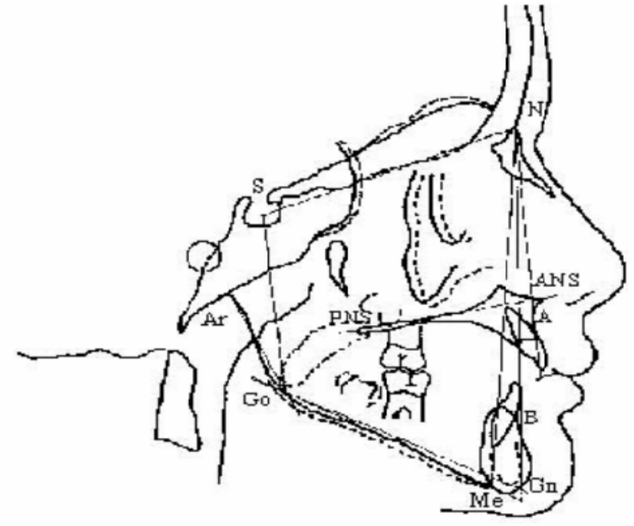

Fig. 1 Cephalometric Landmarks

Some of the landmarks[5] used in this work are:

Nasion (N): The most anterior point midway between the frontal and nasal bones on the fronto-nasal suture.

Sella (S): The point representing the midpoint of the pituitary fossa or sella turcica. It is a constructed point in the mid- sagittal plane.

Gonion (Go): A constructed point, the intersection of the lines tangent to the posterior margin of the ascending ramus and the mandibular base.

Menton (Me): According to krogman and sassouni, Menton is the most caudal point in the outline of the symphysis; it is regarded as the lowest point of the mandible and corresponds to the anthropological gnathion.

Point A, subspinale (A): The deepest midline point in the curved bony outline from the base to the alveolar process of the maxilla, i.e. at the deepest point between the anterior nasal spine and prosthion. In anthropology, it is known as subspinale.

Point B, supramentale (B): Most anterior part of the mandibular base. It is the most posterior point in the outer contour of the mandibular alveolar process, in the median plane. In anthropology, it is known as supramentale, between infradentale and pogonion.

V. SIMULATION RESULTS

The proposed system consists of the Cephalometric Analysis module. (Fig. 2)

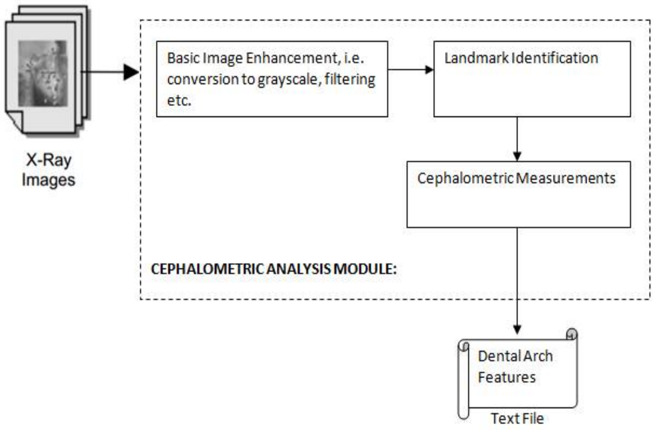

Fig. 2 The main architecture of the system

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The Cephalometric Analysis module is responsible for the mouth measurements of the patient. The output of this module is stored as a excel sheet (Fig. 4).

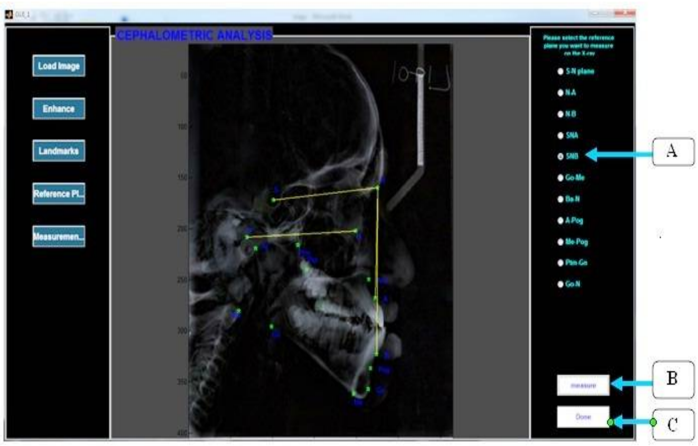

Fig 3: Performing Measurement

	A	B	C
1	Parameters	Referred Values	Patient Values
2	S-N Lengh	78+/-2	76.4562
3	N-A length	70+/-5	64.2483
4	N-B	90+/5	88.3425
5	SNA	82+/-4	83.2874
6	SNB	80+/-3	85.9716

Fig 4. Cepahlometric analysis report

The above table displays the stored values for the patient's dental analysis. The labeled point A shows the angle SNA value in degrees for a patient. Similarly all values are stored in the spreadsheet file and easy to retrieve.

VI. CONCLUSION

In this work, the process of landmark identification is semi-automated. The cephalometric measurements are dependent on the specificity of this process. Hence the performance efficiency of this model is based on the expertise of the user in identifying the landmarks.

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