The Computerized Establishing of Orthodontic Diagnosis through Radiographic Analysis

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Abstract: - Our study presents an original radiographic image processing application, designed to establish the orthodontic diagnosis. The application was written in Java. It requires JDK 1.5 and 10 Mb free on hard disk. All the data can be outputted in different formats (JPEG, GIF, PNG, HTML, RTF or PDF). It also supports multiple language tools (that can be added just as easily as the upgrades of the program). The software supports the most used orthodontic analysis for lateral and frontal cephalogram, orthopantomographies and wrist radiography. The orthodontist provides all the information needed to create the program, as well as the way of work, values interpretation and the way of taking the data. The software has a generic module and an intermediate language that allows it to understand almost any type of radiographic image. It contains several tools (distance measurements, image manipulation and colorimetric tools). All the images are ordered by categories, physicians and patients. Most of them are compressed and coded. The intermediate language support allows an easy upgrade of the program (adding new interpretation or improving old ones). The application has many advantages. It is useful in specialized clinics or universities, to establish different types of radiographic diagnosis.

Key-Words: -image processing, orthopantomography, cephalogram, computerized analysis

1 Introduction
The systems for medical decision assistance are usually designed in order to provide support in finding the right diagnosis and establishing the treatment plan, and therefore to improve the medical act quality.

The computerized applications in orthodontics have a quite long history worldwide, being generally oriented to the analysis of cranio-facial growth, using the cephalometric paths. During the last years new applications were developed, to establish the diagnosis and to make predictions regarding the growing of the facial massive. These applications have an accuracy similar to the human specialists in finding the right diagnosis and, besides this, they have the advantage to work much faster.

Another direction of computerized applications in orthodontics is represented by the automated identification of the anthropometric marks. The cephalometric image is first processed using a median filter, in order to detect the margins traced, then, using a rule-based algorithm, the contour is clearly defined, the positions are calculated and the radiologic anthropometric mark points are identified.

This information is used further to assist the treatment plan. The software evaluates the gravity of the dento-alveolar crowding in the frontal area and establishes, for example, if it is necessary to extract the premolars and to apply an orthodontic device – with an accuracy even better in some cases than the one of the human specialists.

Between the examples of such applications known in the world we can enumerate:
- OrisCeph Rx3 ([1]): designed in Italy, it is a complete tool for cephalometric analysis, with a graphic interface and advanced functions for the automatic insertion of anatomic structures, the real time update of the measures, the normogram and the orthodontic chart;
- CephX ([2]): designed in USA in cooperation with the Orthodontic Residency, it is a web-based service for ceph tracing, storing, viewing and sharing;
- FYITek ([3]): designed also in USA by For Your Imaging Technologies, it is an imaging system consisting of two modules: Dr. Ceph, the
program for cephalometric analysis with image morphing, which allows for the first time to superimpose the x-ray and photograph into one manipulable image which shows both hard and soft tissue, and Dr. View, an image capture and case presentation program which allows to customize the consultation for each patient;

- Facad ([5]): designed by the Swedish company Ilexis AB in co-operation with the maxillofacial unit at the University Hospital in Linköping, Sweden, it makes the cephalometric analysis as well as treatment simulations with soft tissue profile predictions.

In Romania there is a constant concern regarding the acquisition of such applications for medical decision assistance, but in many cases the prices are too high. The solution is to develop our own applications, but these are often only for internal use in hospitals or clinics, without commercial benefits. The main difficulty in developing such application is the fact that, in order to design them, multidisciplinary teams of specialists are necessary, from medical sciences as well as from the exact sciences (mathematics, physics and computer science).

Our study presents an original radiographic image processing application, designed to establish the orthodontic diagnosis.

The software offers the possibility of choosing the way to analyze and interpret quickly a radiographic image and it became very popular in our clinic because is free-of-charge, with all the menus in Romanian, being a very useful tool especially for our students.

2 Problem Formulation

The cephalogram analysis has the purpose to identify the relations between some selected radiologic anthropometric points, identified through specific coordinates. The relations are evaluated in sagittal and vertical plan, between the following major components of the cranio-facial complex: the skull and the skull’s base, the maxilla and mandible skeletal components, and the alveolar process and the dentition – maxillary and mandibulary. The relations between these morpho-functional units are correlated with the aspect of the soft components of the facial profile.

The computerized analysis principle consists in comparing the values measured on the patient’s cephalogram with the standard values of the normal reference group; the differences found are emphasized, being relevant in establishing the diagnosis of dento-maxillar anomaly.

In order to create the software for analysis and diagnosis, the orthodontist had the following working strategy:

1. Establishing and defining the radiologic anthropometric points, skeletal, alveolar and dental, median and paramedian, used in all the analysis;
2. Establishing and defining the reference plans;
3. Establishing the normal and pathological values of the angular methods, used to find the final diagnosis;
4. Establishing the normal and pathological values of the metric methods used to measure the cranio-facial morphological methods;
5. Establishing the angular and metric values which define the types of facial and mandibular rotation;
6. Presenting the working procedure and the interpretation of the angular and metric values for each method of cephalometric analysis used to establish the final diagnosis;
7. Establishing the data acquisition and processing procedures.

The software of diagnosis and analysis was developed based on this information, and it uses the following classes structure:

1. Classes for image processing (save, open and print), the double buffer technique, zoom (at any percentage), tools to modify the image’s clarity (fade, contrast, light), etc;
2. Classes for mathematical operations (using analytic geometry formula): the distance between two points, the angle between three points, the angle between two planes, the mathematical equation of a plane using two points, the intersection point and the angle between two planes, the perpendicular through a point to a plane, the tangent in a point, the distance between two parallel planes, collinear points;
3. Classes using databases, to store the patients list, the radiographies list, the anthropometric radiologic points for each patient (and the data of their recording) and other characteristics of the patients: name, surname, sex, date of birth and race (Caucasian, Black or Asian) – all these characteristics are relevant for the diagnosis accuracy;
4. Classes for multilanguage support, to assure the using of selected language in data recording, diagnosis finding, print and help;

5. Classes for Help (contain a virtual class as object, used to derive the classes for Multilanguage support) – assure the explaining of orthodontics notions necessary to understand the diagnosis as well as other information to assist the user in finding the final diagnosis;

6. Classes for security (assure the data and program confidentiality). The program can be used in multi-user mode, each user having his password and no access to the other users’ data. The data can be encrypted, and for their decryption the owner password is required. There is also a privileged user, defined as “administrator”, but he also cannot access the other users data;

7. Classes to create new individualized analysis: the user can add new points (name, location characteristics) and the software will calculate the new information required using these points as well as the old implicit ones; for these new analysis there is no help menu, which is provided only for the standard analysis;

8. Classes to zip (to compress the bitmap images, for their saving or transport);

9. Classes for mouse, which allow to create different images for the mouse: standard images (hand, arrow, magnifier) and images of the point which will be marked (arrow and the short name of the point);

10. Classes to work with strings (format, parsing, spaces deleting, conversion to numbers).

3 Problem Solution

The application was written in Java (which makes it compatible with most of the systems). It requires Java JSDK 1.5 installed and at least 10 Mb free on hard disk (for local storage). All the data can be outputted in different formats (JPEG, GIF, PNG, HTML, Rich Text Format or PDF). It also supports multiple language tools (that can be added just as easily as the upgrades of the program).

The software supports the most used orthodontic analysis for lateral and frontal cephalogram, orthopantomographies and wrist radiography. The orthodontist provides all the information needed to create the program: a list of anthropometrical points, skeletal points, alveolar points, dental points, facial types, and types of mandible rotation, angles, planes, as well as the way of work, values interpretation and the way of taking the data [5, 6 and 7].

The main purpose was to design an application that can be easily adapted to new radiographic technologies, maintaining the standard format for radiographic analysis. That is why the software is created using a pluggable architecture build around a logical language use internally to describe the logical elements of radiographic images and the technical details for analysis. The software can interpret almost any kind of radiography, as long as a description language exists.

At the user level, the software consists in a local interface for security reasons (a way to limit the access to data and to create local users (physicians) which manage the patients, by adding, deleting or modifying them). Any user can also modify the general settings, in order to adapt the program for his/her personal needs.

The internal structures are kept locally, encrypted and compressed (using a zip like library, and 128b encrypting algorithm). Data is kept separately for each physician (a physician cannot access other physicians information). There is also a software administrator, which has some more facilities (he can create/delete a new physician, he can add a new plugging - a language interpretation for a new type of radiography), but he also cannot modify the personal records of another physicians.

The interface is simple and powerful. It groups the elements so that they can be easily used and understood. Tool tips are available for most of the components. In some cases, tool tip info is a
technical detail for a local element (this facility is required by the medical personal that uses the software). The software has a multilanguage interface (almost any component and help can be easily translated). Initial implementation had four languages (Romanian, English, French and German), but, since language component is also pluggable, other languages can be easily added. The only difference from other components is that the language components require some internal modifications and can be added only by the software designers (Figure 1).

The software’s interface contains also a lot of helpful functions and popup information to guide through the application. The steps are mainly the following: the physician’s selection, the patient’s selection, finding’s creation, the analysis selection, finding’s survey, results reading and diagnosis reading.

Using the analyses of frontal and lateral cephalogram the program establishes the diagnosis for several skeletal, alveolar and dental malocclusions, the type of facial and mandible rotation and the facial asymmetries (Figure 2).

Other important tools are zooming, color/palette modification, image processing tools, distance and angles computing. Conversing mechanisms are also availed in different kinds of external formats (Figures 3 and 4).

Image reading can be done from local storage, network, twain sources, etc. (Figures 5 and 6).

A full description of internal representation of the data and logical analysis for radiographic image exists within the help of the program. Nevertheless, it’s not recommended to create a new interpretation for images if internal language is not perfectly understood.
The general database comes with several analysis, that can be easily changed rather than to create a brand new one. All information can be easily exported and imported from different computers.

4 Conclusion

Using Java we obtain some significant advantages (platform independency, pluggable architecture, portability). The software uses different fast algorithms for image processing, and it complements some slow Java functions [8].

The radiography processing is a necessary complementary exam for the orthodontic diagnosis. The lateral cephalogram establishes the skeletal alveolar and dental disorders in sagittal and vertical plane. There are multiple methods to analyze this cephalogram. The physician can choose between them according to the ethnic group, the type of treatment or the type of malocclusion [9].

The frontal cephalogram establishes the disorders in development in transversal and vertical plane. The frontal cephalogram is recommended in facial asymmetries. The asymmetry diagnosis is established based on different measures [10].

The orthopantomography is necessary to estimate the size of permanent teeth before eruption. The dental age is computed using the dental buds and their degree of mineralization.

Wrist radiography is required to determine the growth stage, the bone age, and the skeletal growth. The final diagnosis for this radiography is made after establishing the wrist bones maturation [11].

The orthodontic diagnosis requires a lot of mathematical calculations (differences, ratios), and the use of some special ratings according with the tissues structure. The cephalogram contains complete information about all structures (bones, dental, soft tissues), on all the three spatial axes – but this amount of data is rarely used entirely in diagnosis finding. Our software, instead, makes it possible and allows establishing a full radiographic diagnosis which can be related to the clinical diagnosis.

Human errors usually appear during the radiographic execution and processing. The most often met errors are generated by the misplacing of the anthropometrical points, which leads to wrong values of the measured angles and distances. These difficulties can also lead to a fallacious orthodontic diagnosis, and automatically, to errors in treatment planning.

Our software provides for this purpose the zoom tool and the tools for bone structure and soft tissues emphasizing, helpful to eliminate the errors generated by the anthropometrical points misplacing.

The software has many advantages. It was created to help the orthodontist and it is useful in clinics or universities to establish different types of radiographic diagnosis.

References: