A SOFTWARE FOR LATERAL AND FRONTAL CEPHALOGRAM COMPUTERIZED ANALYSIS

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Abstract: Our study presents a software designed for lateral and frontal cephalogram analysis, in order to establish the orthodontic diagnosis. The program was created in Visual Studio, using MFC technology. The orthodontist has provided all the information needed to create the program (anthropometrical points, references planes, analysis of lateral and frontal cephalogram, diagnostic methods, normal values angles, normal values distances and results of diagnosis). Based on this information, the program was structured using C++ technology; we built the following separate classes: for image manipulation, for mathematical functions, for disc options, for multilanguage support, help, security, string manipulation. Using the analyses for frontal and lateral cephalogram the program establishes the diagnosis for several skeletal, alveolar and dental malocclusions, the type of facial and mandibular rotation and the facial asymmetries. The steps are the following: physician's selection, patient's selection, finding creation, analysis selection, finding's survey, results reading, diagnosis reading. The software main characteristics are: the possibility to create new analysis, the error correction and fast complete processing of cephalogram, the data confidentiality, the multilingual support, the multi-user support and low resources requirement. The software has a friendly interface with a lot of helpful functions and popup information's to guide through the application.

Introduction

In medicine area, artificial intelligence is successfully used in systems that provide medical assistance. These systems are required to improve the medical diagnostic or to enlarge the medical view of treatment.

In orthodontics, the case file has a lot of analysis needed to establish the diagnostic and treatment. The most used are the study of photographic and teleradiography images. The entire study takes a lot of time to be performed by a single individual. That is why, in most of the time, the physician only performs one or two analysis and then deduces the diagnostic based on these results. Beside this, the possibility of human error is very high (sometimes this can mislead to a different diagnostic or treatment).

Our study presents an original software, designed for lateral and frontal cephalogram analysis, in order to establish the orthodontic diagnosis.

Materials and Methods

The program was created in Visual Studio, using MFC technology. It supports the most used orthodontic analyses for frontal cephalogram (according to Ricketts, Grommos, Svanholt - Solow, Grayson and Hewitt) [1] and lateral cephalogram (according to Downs, Steiner, Tweed – Merrifield, Ricketts, Epker and Fish, Legan – Burstone and Holdaway) [2].

Internally, the software manages data using trees. For every physician the program has a tree (with the root consisting in physician's name and personal identification data). Every physician has some patients, and for every patient the program records every radiography image and its data (images data consist in the location of all the points that exist for that type of image). The type of image does not refer to the mathematical type (like jpeg or bitmap) but to the type that is to be seen by human eyes (like frontal image, lateral image) (Figure 1).

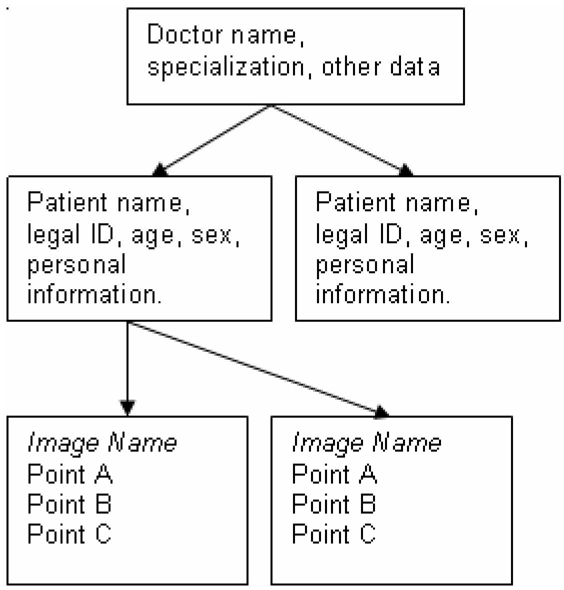

Figure 1: Database structure in memory

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The orthodontist has provided all the information needed to create the program (a list of anthropometrical points, skeletal points, alveolar points, dental points and soft tissue points, references planes, analysis of lateral and frontal cephalogram, diagnostic methods, normal values angles, normal values distances, results of diagnosis).

Based on these information, the program was structured using C++ technology [3] – we implemented the following classes: a class for image manipulation (zoom, double buffer), a class for mathematical calculation, a class for disc options (database's saving, opening, a.s.o.), a class for multilanguage support, help, security, and string manipulation.

All the computations made by the program are based on the point locations and a set of rules (mainly the software can compute angles, distances and ratios and can compare these values with the standard ones). Of course, the rules that are used for computations are based on analytical geometry for 2D images. The rules are different for every type of image. The standard values are relative, being dependant by the type of populations; that is why the user can modify these values to reflect his current situations. Anyway, the user can not modify the significations of these values, and the way in which the software makes the diagnostic (mostly because this could create errors). The only necessary data for the software is the location of the points (not all the points are required in order to complete an analysis). The software keeps track of all the points registered and determines the analyses that can be performed based on these points. Although the scale process can reduce the quality of the image, the program makes all the computations using the real size image (so that the result has minimum errors). It also has a special routine that tries to determine if a rule (such as an angle computation) can lead to an error or not. In such cases the program can correct these errors, by enlarging the picture in order to obtain better results. All these things are not directly visible, but there are necessary in order to obtain a fair evaluation of the patients. The software can assist the user when he locates points, but their final position is set by the user. That is why it is necessary that only an orthodontic physician or a specialist physician to use the software.

Results

Using these analyses for frontal and lateral cephalogram, the program can establish the diagnosis for several skeletal, alveolar, soft tissues and dental malocclusions, the type of facial and mandibular rotation and the facial asymmetries.

The software has a friendly interface with a lot of helpful functions and popup information for guiding through the application. Almost every aspect of the software (from language to colors and fonts can be changed and adjusted according to user's preferences).

The main window consists in a list with all the patients and their characteristics (Figure 1). On can add new users or new images for the current user (using twain, clipboard or from local drive). The image is assigned to the current date. There is a notebook attached for every patient where on can add specific information about that patient. We can also view a quick diagnostic for an image (Figure 2).

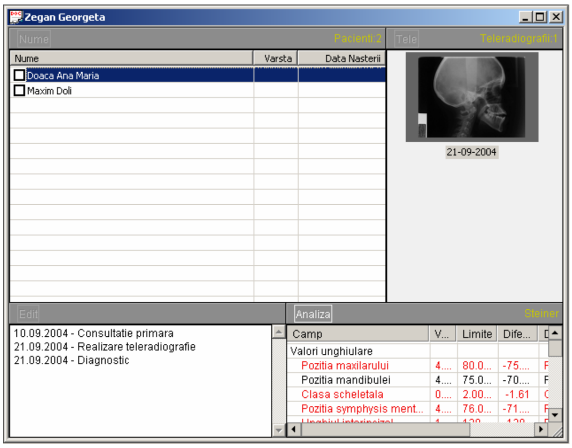

Figure 2: General data. List of patients

On the image window, the user has to set a lot of anthropometric points (not all of them are used for specific analysis). The other elements (like planes, angles, distances, reports) are created using those points. Of course, the program has several tools that can help you to locate exactly every point location (including an example window). Some tools are used to compute angles or distances (other than the ones within the current analysis). We can also use these tools to create perpendicular, tangent or parallel planes (that are required for the construction of some anthropometrical points). All the points are classified in three categories (bone points, soft tissue points and dental points). For each kind of point there is a filter that can accentuate the image where that point lies (Figure 3).

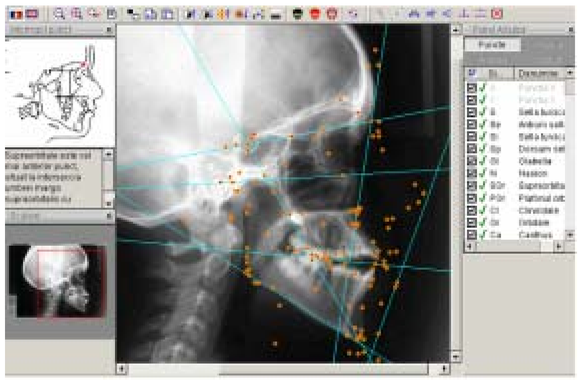

Figure 3: Image window. Point locations.

The main characteristics of this software are its compatibility and flexibility. Compatibility is achieved through a multilanguage support and a minimal resource set needed (the beta version contains only two languages – Romanian and English – based on a dictionary). Other languages will be inserted in the final release. The program is very easy to use (most operations can be done by mouse work and every anthropometrical point contains on-screen explications). Another feature of this software is that the user can manually change or add new information

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such as analysis, points, and planes, to the database. The final version will provide most of the standard orthodontic analysis. All the data are stored compressed (using a zip-like tool). The multi-user support allows to this software to be simultaneously used by different peoples (for example, a few physicians that work in the same clinic), and also provides mechanisms for data security.

All the data can be saved in different formats for full compatibility (like FoxPro databases, text files, Rich Text Format files, Bitmap images, HTML pages). Printing and twain support are also available. All the images are stored on the local disk, among with all the information about the patient (Figure 4).

Figure 4: Bitmap radiographic image

The software contains several image processing tools (such as contrast, brightness, flipping) and some advanced functions, like soft tissue or bones accentuation. It also contains a colorimetric tool to measure the exposure of the tissues to the X-Ray. All these filters are used for a better enhancement of the image (mainly to reveal soft tissue) (Figures 5, 6 and 7).

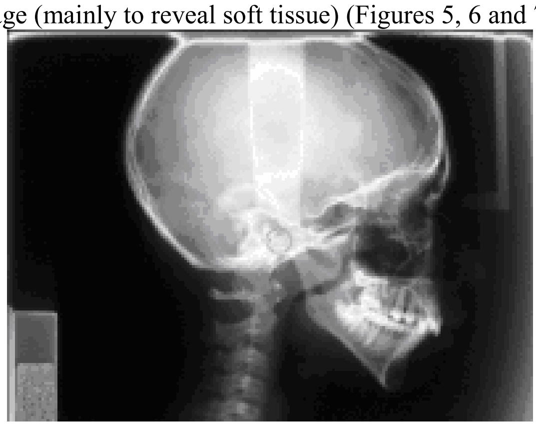

Figure 5: Bone accentuation

Figure 6: Soft tissue accentuation

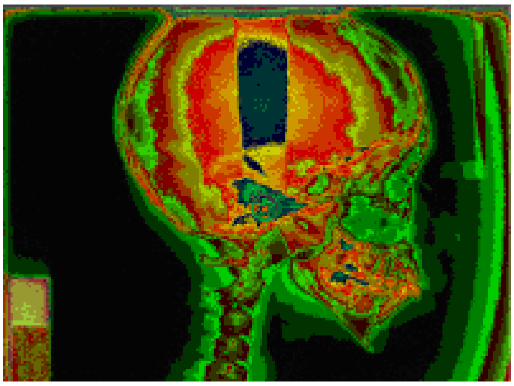

Figure 7: Colorimetric accentuation

The software can perform also an image representation of the current analysis (using distances, angles and planes). The image representation and the table representation of the analysis represent the final diagnosis (which can be printed or saved in different formats). This kind of representation offers to the physician all the information that he requires in order to prescribe the treatment. The table representation has an integrated help (which shows the signification of each measurement and specifies the elements useful to establish the case's treatment) (Figures 8, 9 and 10).

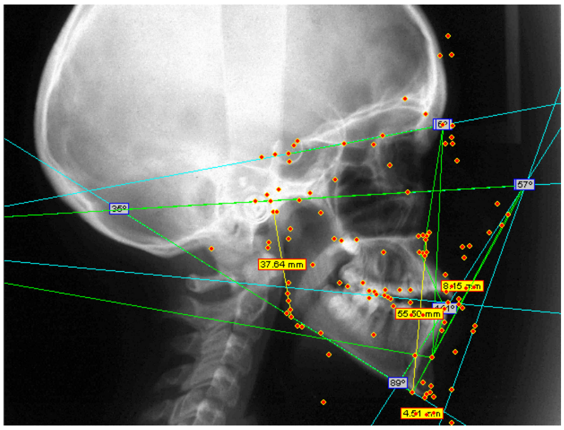

Figure 8: Tweed Analysis of the lateral cephalogram

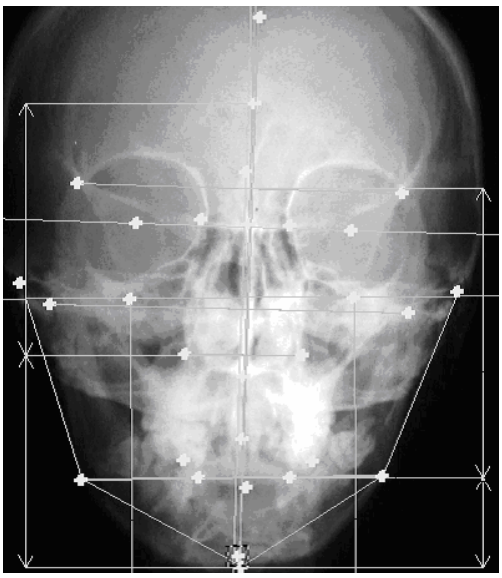

Figure 9: Ricketts Analysis of the frontal cephalogram

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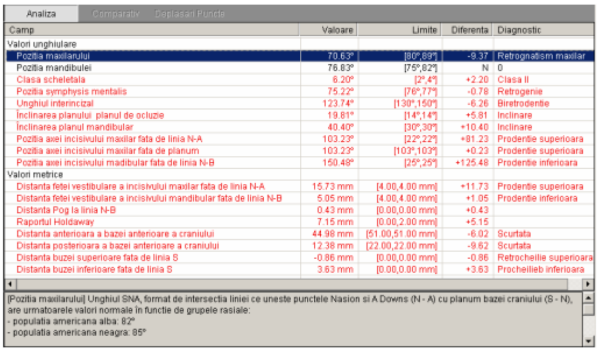

Figure 10: A complete analyze of a patient (the fields marked with red represent abnormal values)

All the anthropometrical points are inserted by the orthodontist using the imaging tools and some mathematic tools (like tangents, perpendiculars, parallels, bisectors). All these function, together with the zoom tool and the on-screen definition and location, reduce the human errors. The most computations are made using double variables (24 bytes), which mean that the errors are practically inexistent. We can also measure any distance or angle directly on the image and convert the result in the measurement unit we want (for distances there are available the millimeters, centimeters and inches, and for angles there are the degrees).

The software saves all the information stored immediately, so that the data loosing in case of system malfunctions is minimal. There is also the possibility to create all kinds of backups (for all the data, for images only, for patients only). We can also configure all the program colors and fonts (for each user). There is not a limit for the number of users or the number of patients (the only limit that applies is set by the disk space). The software itself doesn't need much space (2-3 Mbytes are enough for a full installation).

One other powerful feature of this software is that it can compare different analysis or can compute point migrations for the same patient. In other words, if a patient has two different cephalographic images (one for the beginning of the treatment and another one after the treatment end), those two images can be compared to establish whether or not the treatment was successful (Figure 11).

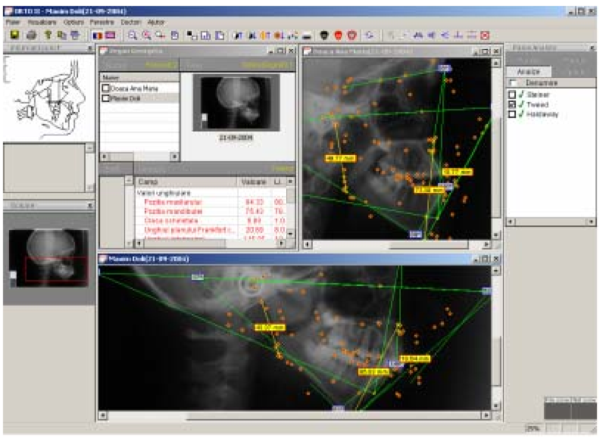

Figure 11: Direct compare between two teleradiographic images from the same patient

The software can also estimate the migration of the anthropometrical points and even predict the growing after some time. Those growing predictions are made using the existing information (if the patient follows a different orthodontic treatment the growing prediction will change to reveal the result of the treatment). To create a valid prediction, we need at least two cephalografic images (from different periods of growing).

Discussion

The cephalogram is a necessary complementary exam for the orthodontic diagnosis. The lateral cephalogram establishes the skeletal alveolar and dental disorders in sagital and vertical plane. The frontal cephalogram establishes the disorders in development in transversal and vertical plane.

The teleradiographic orthodontic diagnosis requires a lot of mathematical calculations (differences, ratios), and the using of some special ratings according with the tissues structure. The para-clinical analysis of models, photos and panoramic views usually lead to incomplete diagnostics, because there are based only on certain structures which are studied. The cephalograms contain complete information about all the 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 possible this thing and allows to establish a full para-clinic diagnosis which can be coroborated with the clinical diagnosis.

The human errors usually appear during the cephalograms 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 in this purpose the zoom tool and the tools for bone structures and soft tissues emphasizing, helpful to eliminate the errors generated by the anthropometrical points misplacing.

The large amount of analysis existent in the specialized literature [4] for each type of cephalogram requires from the orthodontist to spend a lot of time for cephalograms processing and diagnosis establishing. In many cases, the cephalographic diagnosis establishing demands to repeat the processing or to reiterate the analysis for the same initial case. Besides this case, during the treatment it is also necessary to make several cephalographic examinations, at least at the treatment beginning and end, in order to compare the images and the therapeutically results.

The necessity of cephalograms using is also imposed in the cases that requires a surgical – orthodontic treatment. In such situations the cephalograms are used to make the computerized set-ups, made before the orthognathic surgical intervention. The cephalogram - made measures precision (at millimeters level) is essential in such cases, to eliminate any surgical error.

Between the software's useful characteristics we can also emphasize the possibility to create new analysis, the error correction and the fast complete processing of lateral and frontal cephalograms, the mechanisms for data confidentiality, multilanguage support, multi-user support and low resource requirement.

This software can be also used as a learning tool for the beginners, useful to study many types of cephalographic analysis.

Although those are its main functions, the software is also capable to analyze other types of radiographic or photographic images as well. There is also a possibility to extend the software, by adding any kind of images (radiographic or simple images), among with a set of points and local analysis. This feature makes the software very reliable and flexible.

The using of OOP/C++ technologies makes the program capable to extend its features, every time when it is necessary. Implementing the software in Visual C++ allows the full usage of disk, memory and video resources in Windows systems [5].

We propose this program, as a solution for fast and individual analysis of lateral and frontal cephalogram images.

A Java release is also available for use on multiple platform systems. All the main functions from Visual Studio were imported in the Java version. The Java version also has particular settings for OpenGL (on machines that support this).

Conclusions

The software has many advantages. It was created to be used for helping the orthodontist and we hope that it will become a working instrument used in specialist polyclinics or universities to establish orthodontic diagnostic.

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