database, data security,
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THE PROPOSED SYSTEM FOR ORTHODONTIC SURGERY

The article presents the project of system for computer aided orthodontic diagnosis. The system consists of four modules for data integration, data storage (database), data visualization and edition, and data analysis. The aim of the system is to collect all the necessary data, to present it to the physician, and to help in the analysis of the head deformation. In the database are stored patients data, physicians data (also used for user authentification), and image descriptions with links to the images. Images are analyzed – the analysis gives parameters of the head models, landmarks, and information about the skull deformation. All the kinds of images (2 & 3D, volumetric data and point cloud) should be visualized, if it is necessary – simultaneously.

1. THE OUTLINE OF THE PROJECT

The aim of the system is to give to the physician the coherent tool for acquisition, integration, processing, storage, edition and visualisation of 3D representation (input data and model) of the human head. The system should be useful for orthodoncy, plastic surgery, and oncology. The coherent and specialized system shall be easy to use.

In the projected system can be distinguished some modules (see fig. 1):

- The data integration module, used for integration of the data from varied sensors, and from varied positions of the sensor. The acquired data should be registered (arranged in the same co-ordinates).
- The database. The system store not only images, but also the patients data (demographic data, description of disease, etc.). The personal data should be protected.

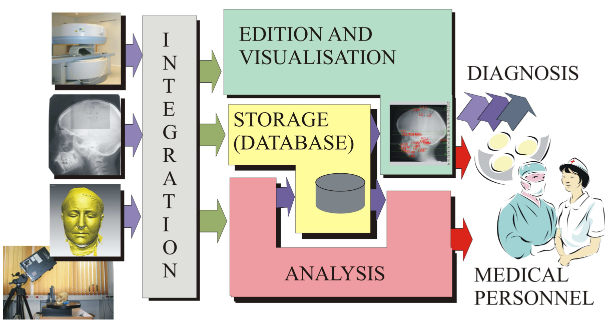

Fig.1 The schema of the system.

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- The module for data analysis is used for many tasks in the system: finding landmarks, and parameters of the active, deformable model of the head; data classification, data searching in the database; the statistical shape models.
- The edition and visualization module (with 3D interfaces, such as 3D monitors, google (HMD), etc.) shall meet requirements of the medical practice.

The details of the modules are presented below.

3. THE DATA INTEGRATION MODULE

The data for the system comes from different sources: MR, CT, RTG, and laser scanner. In the case of RTG and laser scans, there is a need for many measurements (e.g. 8 laser scans for one model [11, 6]) to build the model of the head. The individual images should be registered [4] (i.e. put in the same coordinate system) and integrated, before the model is built.

An additional reason for initial data registration is the demand of visualization of different images (3D volumetric images, 3D point clouds, and 2D images) at the same time.

The data registration contains two stages: initial, approximate registration (made by human operator, or by using the shape or color invariants); and exact registration (chiefly done by ICP algorithm [1]). While the algorithms for exact registration are well know (although they need to improve efficiency), there is a need for the algorithms for initial, approximate, automatic registration.

The criterion for registration is an additional problem. There are two main criteria – optimal superposition (Prokrust’s method) and edge superposition. For some tasks the first is better, for the other – the second, the choice depends on user.

4. THE DATABASE AND DATA SECURITY

In the database are stored the patients data (demographic data, diseases description, etc.), physician data, and image data (image location, parameters, etc.).

There are four classes of information in respect of data security:

- public data (image data including landmarks, etc.);
- data accessible only for procedures (the birth date and image acquisition date);
- personal data, accessible only for users with passwords;
- data used for user authentification (passwords, user names).

The personal data are protected using the Triple-DES algorithm [8] (key has 168 bits) with one byte shift for each stage of coding.

The first step of authentification procedure (see fig. 2) is the search of the username in the database. In the database are stored not the real usernames, but the digests produced by SHA algorithm [8], so the SHA digest of the username is compared with the information stored in the database (1). In the second step (2) the SHA digest of the password is compared with the SHA digest of password in the database. In the third step the SHA digest of the password and user id (to avoid possible similarity of passwords in database) gives the key to decrypt internal key of the database (3). The internal key is used to the decrypt the personal data in the database (4).

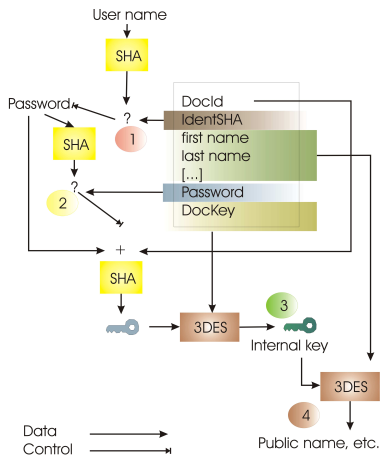

Fig. 2. Scheme of authentification procedure.

In the present form of the database there is no search algorithm, that uses the shape information. Such function should be very useful for the search of pathological deformations of skull. The known methods for shape comparison are proposed for matching shapes of different classes of the objects (for example, to distinguish a human from a car [3, 5, 7]), but not for comparison of similar and only slightly deformed shapes. The parameters of skull model (built analogically to the active appearance models [2]), and landmarks (pointed by user and by the active models [10]) shall be used to find such deformations.

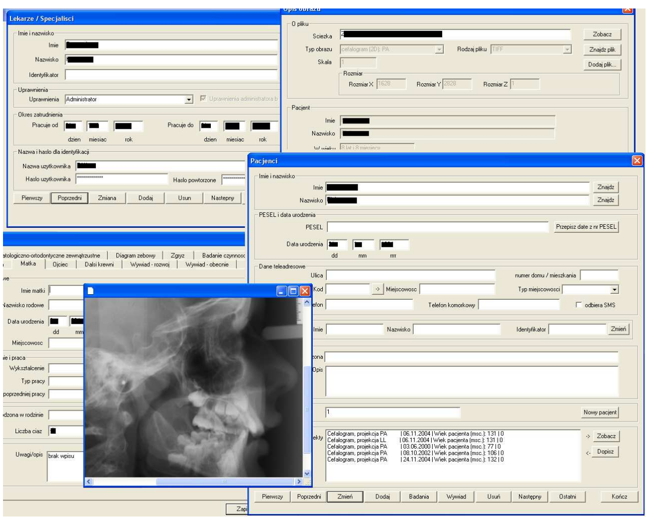

Fig.5. The dialog windows of the database.

5. EDITION AND VISUALISATION

The data for the system belongs to some classes: MRI – 3D volumetric images; CT – 3D volumetric images; laser scans – 3D point clouds (meshes); RTG – 2D images.

All the images should be visualized at the same time to compare results, and to point interesting regions in the images. The applications used at present (RapidForm, Matlab) visualize only one kind of images in one window. The additional problem is caused by the interface mainly designed for engineering (not for medical problems).

Proposed 3D editor uses medical projections of the skull, enable physician to see any chosen surfaces (especially isosurfaces extracted from CT and MRI [3]). The functionality shall allow the visualization for patients (morphing and warping).

Medical images are in fact still presented in 2D – as a slices, or reconstruction. The 3D output devices (as googles and 3D monitors) improve the understanding of medical images, that are still presented in 2D – as a slices, or reconstructions.

6. THE DATA ANLYSIS

The proposed system incorporates the modules for data analysis, previously developed in ITAI PAS [9, 11]. The combination of the data analysis module and database allows to calculate mean models of the skull for given bone age, and made other statistical analysis of population. The analysis module calculates the parameters of active skull model and landmarks – the same parameters are used in shape matching and stored in the database. The analysis of the skull deformation gives also information’s about the pathological deformations and treatment.

7. SUMMARY

At present the system consists of database and some applications that may be executed from the database application with the given images (using paths stored in the database). The integration of the system is a task still shall be carried out.

BIBLIOGRAPHY

[1] P. J. Besl, N. D. McKay, A method for registration of 3-d shapes, IEEE Trans. Pat. Anal. and Mach. Intel. 14(2), pp 239-256, Feb 1992.

[2] T. Cootes, C. Taylor, Constrained active appearance models, In Proceedings of IEEE International Conference on Computer Vision, vol. 1, pp. 748–754, 2001.

[3] T. Funkhouser, M. Kazhdan, P. Shilane, P. Min, W. Kiefer, A. Tal, S. Rusinkiewicz, D. Dobkin, Modeling by Example, ACM Transactions on Graphics (SIGGRAPH 2004), Los Angeles, CA, August 2004.
[4] J.V. Hajnal, D.L.G. Hill, D. J. Hawkes, Medical Image Registration, CRC, 2001.
[5] M. Kazhdan, T. Funkhouser, S. Rusinkiewicz, Shape Matching and Anisotropy, ACM Transactions on Graphics (SIGGRAPH 2004), Los Angeles, CA, August 2004.
[6] L. Luchowski, K. Skabek, A. Tomaka, M. Tarnawski, 3D head surface scanning techniques for orthodontics, Journal of Medical Informatics & Technologies, vol. 9, pp. 123-130, 2005.
[7] R. Osada, T. Funkhouser, B. Chazelle, D. Dobkin, Matching 3D Models with Shape Distribution, Shape Modeling International, Genova, Italy, May 2001.
[8] B. Schneider, Kryptografia dla praktyków, WNT, 1995.
[9] A. Tomaka, Detekcja i opis deformacji struktur na podstawie sekwencji obrazów cyfrowych, Praca Doktorska, Gliwice, 2001.
[10] A. Tomaka, P. Kowalski, B. Liśniewska-Machorowska, Landmarks Identification Using Active Appearance Model, Archiwum Informatyki Teoretycznej i Stosowanej, vol. 17, nr 4/2005.
[11] A. Tomaka, B. Liśniewska-Machorowska, The application of 3D surfaces scanning in the facial features analysis, Journal of Medical Informatics & Technologies, pp. 233-240, 2005.