A proposal of a digital cephalogram standard using DICOM

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Abstract

An important aspect of distributed data management is the structure of the managed information, which is the basis for a semantic approach of information and ensures extensibility, interoperability and adaptability in collaborative environments. This document describes how to use DICOM to store and transfer digital cephalograms in collaborative orthodontics systems. Current efforts of digitizing decaying longitudinal cephalometric studies can find immediate applications of this project.

1. Introduction

Currently, valuable cephalogram film series belonging to studies performed during the first half of the 20th century, are starting to decay. The studies are composed of images of patients who where voluntarily x-rayed periodically (sometimes even with implanted artificial landmarks) in order to research cranial growth and development. Today, such studies would be impossible, which makes the preservation of these films a high priority project. The American Association of Orthodontics Foundation (AAOF) aims to create a digital database of these studies. However, for the database to be useful, it must be compatible with various computer software programs, possibly in a standard format. To date, no informatics standards have been proposed or adopted by the orthodontic profession, although the American Dental Association's Standards Committee for Dental Informatics (ADA SCDI) is currently working on one [7, 4].

Cephalograms are more than a simple radiograph of the skull. They are used for craniofacial growth studies as well as for orthodontic treatment planning and must be accompanied with information which can guarantee their accuracy. DICOM (Digital Imaging and Communications in Medicine)[9] contains enough definitions to unambiguously store all cephalogram metadata. Currently most medical equipment which deal with images, can interpret the DICOM format making it a perfect match for this project. The widespread use of DICOM in the medical field will greatly facilitate the integration of the cephalometric images with existing software, a basic principle of standards development, since a well developed standard that remains unimplemented, is of no or little use.

In 1993 and 2003 Hans [2, 3] worked on and published a study that defined the minimal resolution parameters needed for a digital cephalogram to be clinically acceptable. Two years later, Magni recovered the effort and produced a poster-board [8], an article [7], and a Master's Thesis[6]. The work provided a method for the development of a standard for the electronic orthodontic patient record, as well as a draft for a digital cephalogram standard, and a small implementation of it[5] in JAVA.

As of today, there are two major applications for a standard for digital cephalograms:

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1. Working Group 11.6 at ADA SCDI which is working on the orthodontic electronic patient record, directly relies on digital cephalograms.

2. The AAOF, offering a grant for the preservation of legacy orthodontic records, could use a standard for digital cephalograms to insure its durability and compatibility of its records.

2. Digital cephalograms and DICOM

While DICOM can handle all necessities required by digital cephalograms, cephalograms are nowhere explicitly mentioned in the normative DICOM documentation. The summary of the results of our research is presented below as a list of information elements which necessarily need to accompany all digital cephalograms.

Cephalogram pair Lateral and postero-anterior cephalograms are related by making use of the *Referenced Image Sequence* (0008,1140), which is part of the *Image SOP Instance Reference Macro*.

Patient demographics This should be stored in the patient information entity modules as defined by DICOM in C.7.1.1, C.7.1.2 and C.7.1.3 [9, PS 3.3].

Radiographic magnification This can be encoded within a DICOM DX IOD making use of the *DX Positioning Module* [9, PS 3.3 - Page 631]. The module contains three useful attributes: *Estimated Radiographic Magnification Factor* (0018,1114), *Distance Source to Patient* (0018,1111) and *Distance Source to Detector* (0018,1110). By making use of either the first, or a combination of the last two attributes, magnification information can be accurately preserved along with the image.

Head orientation DICOM provides a way to store the angles at which the patient is oriented with respect to the detector and beam in the *DX Positioning Module* (C.8.11.5) defined in [9, PS 3.3, C.8.11.5]. This field already accounts for standard beam directions. Arbitrary angles should be stored using the *Positioner Primary Angle* (0018,1510) and *Positioner Secondary Angle* (0018,1511) attributes.

Image distortion It is not within DICOM's scope to directly address the distortion caused by digitization [10]. Nonetheless DICOM does allow for associating fiducials to an image, which, in turn, can be used to verify image distortion by making use of the *Spatial Fiducials* IOD. The details of the usage of these elements should be part of an ADA SCDI technical report.

Resolution This information can be correctly stored using the *Image Pixel Module* (C.7.6.3). Minimum resolution requirements should be mandatory for cephalograms to be used for clinical purposes, yet not be necessary for presentation purposes.

Conformance specifications Digital cephalogram can conform to the specifications in two ways: by simply guaranteeing that the image is properly encoded, or by guaranteeing the clinical usefulness of the image. In DICOM terms, these would be named "FOR PRESENTATION" and "FOR PROCESSING" respectively.

3. Providing results with `dcm4ceph`

An open source software package (`dcm4ceph`) was developed to produce digital cephalograms stored in DICOM according to the suggestions presented in this paper. It is based on the `dcm4che` 2.0.7 [1] open source project. `dcm4ceph` is a wrapper for various `dcm4che` classes and methods to represent the appropriate DICOM objects and attributes. It even provides classes to take care of image distortion issues discussed above. The software comes with a utility program, called `dcm2ceph`, which reads a cephalogram image, its metadata and a configuration file and outputs a DICOM cephalogram object. More information can be found on the internet at http://dcm4ceph.antoniomagni.org

4. Conclusions

In order to successfully address distributed data management and interoperability between orthodontic software, the full electronic orthodontic patient record must be standardized such that software vendors will be able to, by simply implementing such standard, easily import and export patient record. Digital cephalograms are an important part of the patient record, yet no standards exists for their storage. This paper discusses the necessities of digital cephalograms, and how they could be satisfied by making use of DICOM.

The collaboration with various U.S. institutions for the preservation project funded by the AAOF guarantees that, in the near future, this work will be implemented and validated by experimental results.

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