IRMA Code II

A New Concept for Classification of Medical Images

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Abstract. Content-based image retrieval (CBIR) provides novel options to access large repositories of medical images. Thus, there are new opportunities for storing, querying and reporting especially within the field of digital radiology. This, however, requires a revisit of nomenclatures for image classification. The Digital Imaging and Communication in Medicine (DICOM), for instance, defines only about 20, partly overlapping terms for coding the body region. In 2002, the Image Retrieval in Medical Applications (IRMA) project has proposed a mono-hierarchic, multi-axial coding scheme. Although the initial concept of the IRMA Code was designed for later expansion, the appliance of the terminology in the practice of scientific projects discovered several weak points. In this paper, based on a systematic analysis and the comparison with other relevant medical ontologies such as the Lexicon for Uniform Indexing and Retrieval of Radiology Information Resources (RadLex), we accordingly propose axes for medical equipment, findings and body positioning as well as additional flags for age, body part, ethnicity, gender, image quality and scanned film. The IRMA Code II may be used in the Cross Language Evaluation Campaign (CLEF) annotation tasks as a database of classified images to evaluate visual information retrieval systems.

1 Introduction

The Image Retrieval in Medical Applications (IRMA) project aims at providing a flexible framework for content-based image retrieval (CBIR) applications in medicine. The IRMA classification scheme is based upon a mono-hierarchic multi-axial coding system, which includes four axes with three to four positions (0-9 and a-z). "0" for "unspecified" describes the end of a path of an axis [1]. The four axes contain:

- T (technical) = image modality
- D (directional) = body orientations
- A (anatomical) = body region
- B (biological) = biological system examined.

Table 1. Medical terminologies and their aims [4, 5, 6, 7]. DICOM: Digital Imaging and Communications in Medicine; ICD-10: International Classification of Diseases; MeSH: Medical Subject Headings; RadLex: Lexicon for Uniform Indexing and Retrieval of Radiology Information Ressources; SNOMED CT: Systematized Nomenclature of Medicine Clinical Terms; TNM: Tumor-Nodule-Metastasis Staging; UMLS: Unified Medical Language System

	DICOM	ICD-10	IRMA	MeSH	RadLex	SNOMED	TNM	UMLS
Diagnosis coding		✓					✓	
Literature indexing				✓	✓	✓		✓
Semantic linking				✓	✓	✓		✓
Neoplasia staging							✓	
Radiology reports	✓			✓	✓	✓		
Image classification	✓		✓			✓		
Image retrieval	✓		✓		✓	✓		
Image storage	✓		✓	✓				
CBIR			✓		✓			

The code supports a unique labeling of images and was used in the ImageCLEF annotation tasks, which present a part of the Cross Language Evaluation Campaign (CLEF) [2, 3]. The goal of this project is to provide evaluation of different visual information retrieval systems. However, the appliance of the terminology in the practice of scientific research discovered several weak points:

- pathologies are not enclosed,
- additional parameters such as gender or age are absent,
- missing differentiation between right and left side of the body,
- the defined depth of the hierarchy is not sufficient in parts, e.g. radiographs of single epiphyses of the hand,
- ambiguities due to inconsistencies between is-part-of relations within deeper levels of the hierarchy, for instance the sacrum can be classified as a part of the chord and as well under the term pelvis,
- no coding options for images from the field of genetics and biology (in the course of increasing overlap between bioinformatics and medicine).

In the past years, new ontologies for medical imaging have been developed and substituted existing schemes in research as well as clinical practice (Tab. 1). For instance, the RadLex nomenclature proposed by the Radiological Association of North America (RSNA) provides the radiologist a unified language to organize and retrieve images, imaging reports, and medical records [4]. Furthermore, there are upcoming semantic data platforms such as the LinkedLife Data (http://www.linkedlifedata.com) resource released by the Large Knowledge Collider (LarKC). This is a European project aiming to build a knowledge framework for linking and retrieving large biomedical knowledge databases (currently 26 different ontologies). Taking this into account, the IRMA code is revisited.

2 Material and methods

Designing a new concept for the IRMA code is composed of the following steps:

1. Coding of a provided database of radiological images,
2. Searching images of specific classes determined by the tree structure,
3. Collecting shortcomings within the consisting scheme,
4. Drafting a new basic structure in relation to other medical terminologies,
5. Adjusting the initial version to the new concept, and
6. Evaluating the new version of the IRMA code.

The difficulties, which appeared in the course of manually labeling of new images served to create a defined list of shortcomings.

In order to enhance specific classes of the image database we used the Picture Archiving and Communication System (PACS) database of the Department of Diagnostic and Interventional Radiology of the University Hospital Aachen as well as the medical image search engine called American Roentgen Ray Society (ARRS) GoldMiner® [8].

Based upon experiences gained and shortcomings collected the designing of the new framework includes a revision of the existing main axes. Testing and evaluating the new IRMA classification will be the application within the tasks of the Cross Language Evaluation Campaign (CLEF) and thereby a comparison to former results of this usage [2]. Besides, we plan to implement a mapping between the new IRMA Code and RadLex.

3 Results

The IRMA classification should be unique, clearly arranged and expandable. Especially in regard to the properties uniqueness and expandability it is necessary to modify the basic structure.

3.1 Additional axes

Equipment In image retrieval, the code must reflect the optical appearance of the image. This is majorly determined by artificial objects, such as prostheses, osteosynthetics or electrodes. By means of this axis, images in lower quality and, for instance, an upper ankle joint with plate and screws can be differed from regular images (Fig. 1). Furthermore, one can search the archive for images with special medical implements, for example a tube for respiratory assistance.

Findings So far, pathologies and findings are not modeled within the IRMA code, and the bio-system axis was misused to classify mammograms according to the Breast Imaging Reporting and Data System (BI-RADS) codes. Thus, this axis should be extended by general terms like calcification, necrosis and neoplasias as they can be found in classifications like the Tumor-Node-Metastasis

Fig. 1. Radiographs with equipment and artifacts: (left) Right ankle joint including plate and screws, (middle) Right hand with a ring on the finger, (right) Sagittal view of a chest showing a cardiac pacemaker probe.

(TNM)-classification of Malignant Tumours, which is published by the International Union Against Cancer (UICC). In addition, this axis links the clinical process and thereby confirmed main diagnoses, similar to the International Classification of Diseases (ICD 10) [5]. Particularly with regard to the upcoming projects of computer-aided diagnosis as published by Doi [9] it is necessary to have a particular axis for findings.

Configuration Similar to artificial objects which are superimposed to the image, patient positioning could impact the entire appearance of the image bitmap. For instance, the fingers of a hand may be closed or spread, and the patient may sit, stand, or lay down. So far, this is partly covered in the direction axis resulting in ambiguous codes.

3.2 Resulting basic structure

The IRMA Code II consists of seven axes each of them with three positions for refinement. For reasons of consistency we adjusted the already existing class titles. In order to illustrate the new coding options there is presented an example of a radiography showing a shoulder after operation with associated codes (Fig. 2). The seven main axes are defined as follows:

- A (anatomy) = body region
- B (bio-system) = general system of the body
- C (configuration) = positioning of the body
- D (direction) = body orientation in the room
- E (equipment) = specific objects and visible equipment (e.g., electrode)
- F (finding) = type of visual observation and/or pathological process
- G (generation) = imaging technique.

3.3 Additional flags

In the previous version of the coding scheme there existed terms (flags) independent of the mono-hierarchic system which gave option to mark images in view of image quality and pathology. In IRMA Code II, pathology is modeled

as self standing axis. The image quality coding flag remains and was extended by additional options. According to the RadLex terminology modeling "patient identifiers" [4] we integrated flags for age, gender and ethnical group. For instance, coding of age classes – not to be confused with the chronological age, determined by date of birth and date of examination – is important with respect to computer-assisted bone age assessment from plain radiography.

In summary, we suggest the following additional flags, which may be notated in IRMA Code II as an additional axis H of six position:

- Age (0: unspecified; 1: $[0 - 0.5[$ years, 2: $[0.5 - 1[$ years, 3: $[1 - 2[$, etc.);
- Body part (0: unspecified; 1: right; 2: left; 3: both; 4: none);
- Ethnicity (0: unspecified; 1: african-american; 2: asian; 3: caucasian; etc.);
- Gender (0: unspecified; 1: female; 2: male; 3: intersexual);
- Image quality (0: unspecified; 1: poor; 2: acceptable, 3: good, 4: best);
- Scanned film (0: unspecified; 1: true; 2: false).

In IRMA Code I, the "scanned film" feature was set within the axis of imaging technique and complicated it by necessity of a fourth position, which is removed in IRMA Code II unifoming the axis.

Fig. 2. IRMA II = 463-700-100-120-110-110-111-l13231. The IRMA Code III in form of AAA-BBB-CCC-DDD-EEE-FFF-GGG-HHHHHH is composed of:
A: upper extremity, upper arm, unspecified
B: musculo-sceletal system, unspecified, unspecified
C: elevation, angle < 45-degree, unspecified
D: coronal, anteroposterior, unspecified
E: metal, fixateur externe, unspecified
F: fracture, humerus shaft, unspecified
G: x-ray, plain radiography, overview image
H: Age: l (30-35 years); Body part: right; Ethnicity: Caucasian; Gender: male; Quality: good; Scanned film: true

4 Discussion

As a result of those modifications, IRMA II now has parallels to following axes of RadLex: Examination type, Technique, Exam quality, Image location, Anatomic location and Findings [4]. Concerning the suggested modifications of the basic structure, it has to be figured out to what extend the subclasses can be implemented especially within the axes for (F) findings and (E) equipment. However, the chance of simplifying the axis will also be taken. Fir instance, IRMA Code I definitions for "bregmaticosubmental" or "submentobregmaticofrontal" direction my be replaced by simpler terms. This means that we have to discuss the depth

(number of positions) and the hierarchical linking between the subdivisions. Furthermore, mapping the IRMA II classification to other ontologies, for instance RadLex, must be established in order to evaluate and adjust IRMA II to future semantic requirements.

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