Electronic Health Record: Facilitating the Coding Process

Harris G. Soteriades, Kleanthis Neokleous, George Tsouloupas, Antonis P. Jossif and Christos N. Schizas

***Abstract*—In this paper, we introduce an intelligent medical assistant tool that offers the ability to suggest appropriate medical diagnostic coding during the examination process through a friendly user interface. Furthermore the tool offers the capability to match medical coding definitions from one standard to another such as ICD 10 and SNOMED CT. The tool has three main functions: a) Easy Search, b) Coding Suggestion and c) Coding Interoperability.**

I. Introduction

ELECTRONIC Health Record (EHR) tools are rapidly evolving with increasing acceptance amongst the user community. The EHR systems are mainly used to offer assistance to health care professionals by providing an easy access to patient's medical records, review of their history and many other related functions that can offer helpful information that improves quality of care. The EHR offers many solutions to various problems such as for example the instant access to medical knowledge and information regarding patients' health status.

A key characteristic an EHR should provide is semantic, as well as technical, interoperability. This allows healthcare organizations, or health centers and individual doctors to easily exchange critical information regarding their patients [1, 2]. An important aspect of this information comprises the patient diagnoses, which are done using international coding standards such as ICD-10 and SNOMED [3, 4].

This paper focuses on the development of a tool that can guide the doctors in assigning the correct coding diagnoses to the patient through a friendly Graphical User Interface (GUI). The tool serves three main functions: a) Easy Search, b) Coding Suggestion functionality and c) Coding Interoperability. An important focus of our implementation is to create a tool that can be applied to any health center according to individual needs and provide a coding pattern that can start from one standard (e.g. ICD 10) and end up with to a matching secondary standard (e.g. SNOMED CT).

This article builds upon and is a continuation of previous work submitted to BIBE12 [5].

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II. Implementation Approach

The proposed tool is created based on a pediatric center's requirements which employs the FreeMed[6] open source EHR software. FreeMed has been in successful use for several years and offers a wide range of functionality but there is no advanced functionality for assigning a diagnosis code to a patient.

The main goal was to implement an add-on tool that can be attached to the patient's encounter and that will assist the doctor in assigning a coded diagnosis during the patient's examination. The coding standard used by the center, is the International Paediatric and Congenital Cardiac Code (IPCCC [7]. In figure 1 we provide a sample part of the IPCCC file structure in MS excel spreadsheet. The file directs the doctor where the particular codes are and in turn the doctor can go to the section and view the appropriate code.

Section	Description	go to
1	**Table of contents**	
	Broad generic terms for congenital heart disease	to 2
	Generic pathological cardiac and vascular terms	to 3
	Congenital heart defects in sequential segmental order	**to 5**
	Hereditary, fetal, neonatal & noncardiac abnormalities associated with heart disease	to 500
	Cardiothoracic acquired abnormalities and diseases	to 600
	Signs, Symptoms and Investigations of Heart Disease	to 740

Fig. 1. Part of the IPCCC spreadsheet. The user can check from the Contents and go to the specific Section and get the appropriate code.

III. Tool Implementation

A. FreeMed software

FreeMed is Open source software that employs the MySQL Database Management System (DBMS), PHP and JavaScript. The web-bases user interface can be accessed remotely over the Internet as well as the center's LAN, using any browser and is optimized for the Firefox web browser.

B. Database Creation

The first step was to incorporate the coding standards into the MySQL database. In order to be able to map the IPCCC to ICD-10 and ICD-10 to SNOMED CT standards, the database tables that describe the corresponding standards

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must be incorporated.

The IPCCC coding standard is imported into two tables. The first table holds the coding categories and the second holds the actual codes with their description and the ICD 10 mappings.

ICD-10 standard is imported into three tables. The first table holds the chapters, the second holds the blocks and the third holds the actual codes [3].

SNOMED CT system is imported into four tables. One holds the concepts, the second holds the descriptions, the third holds the relationships and the fourth holds the mappings between ICD 10 and SNOMED CT [8].

C. *Easy Search functionality*

Based on a number of interviews from the medical center's doctors, it has been clearly established that the doctors' main concern is to have easy access to IPCCC coding during an examination, in order to select the appropriate code for the patient. To this end, we included the easy search functionality. The functionality accepts the doctor's input in a search-input area and outputs the matching cases from the IPCCC coding standard.

For this functionality the PHP and jQuery/JavaScript were used. Two PHP classes were created. The "coding" class that represents the codes as an object and the "dbconnect" that can be used to connect with the database. Additionally the "findlike" page was created that holds the search results and the "jQuery.autocomplete" mechanism which will be responsible to accept the users input and automatically bring the matched results back. For the development of the above functionalities, we extended and modified open-source tools [9] with appropriate extensions based on the doctors' requirements.

In figure 2 we can observe that the user can enter a number of characters in the html input area. The autocomplete function will automatically be triggered and call the findlike page. The findlike page will then call the dbconnect class to query through the database with the input characters, cast the results as coding type and will return them back to findlike page. The results will finally be added to an array of type "coding" and presented back to the user as a list of possible matching results in respect to the input characters.

D. *Coding Suggestion functionality*

In order to facilitate the doctor's coding assignment, we added functionality to read text from the doctor's notes (such as the physical examination free-text field) and convert to medical semantics. In turn, the proposed medical semantics will be queried through the database and bring back the matching coding suggestions. To extract the medical semantics we used the MetaMap tool. The tool is widely available and can map biomedical text to the UMLS Metathesaurus and extract medical terms [10].

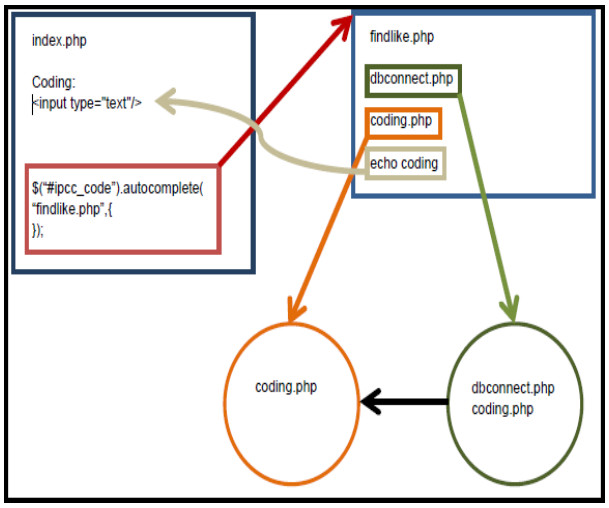

Fig. 2. Graphical representation of the Easy Search functionality

This functionality was created in JAVA and jQuery/JavaScript. Connection with the database is handled through a "DB_connect" class. Also created is the "Code" class that will represent the coding as an object and the "Coding_Sugest" class that will use the MetaMap methods. Additionally the "Show_Suggestions" java servlet is created which handles the POST event.

As can be seen in figure 3, the physical examination text is passed on to the Show_Suggestions servlet as a parameter. The parameter then passes to the coding_sugest class which in turn will call the MetaMap methods to extract the medical terms and semantics from the text. The medical terminology is then sent back to the servlet and passed to the DB_connect so as to query the database and get back the results. The results will be treated as code objects and returned back to the Show_Suggestions servlet as a list. Finally both the medical terms and the coding suggestions are returned back to the user as a selectable list.

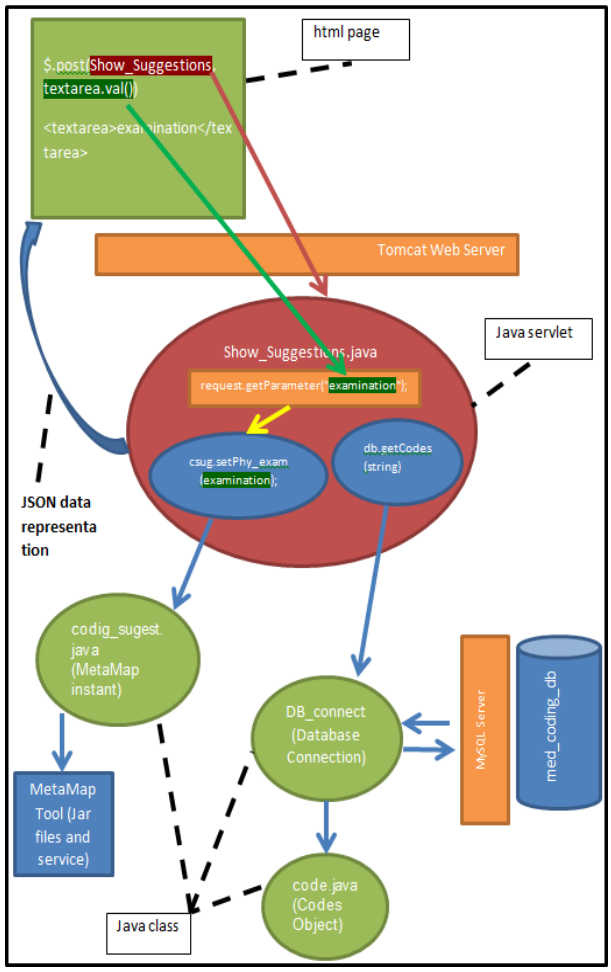

Fig. 3. Graphical representation of the Coding Suggestion functionality.

E. *Coding interoperability functionality*

When the doctor chooses an IPCCC coding the code can be matched with an ICD-10 coding standard. The matching of the two standards exists, for most of the IPCCC codes, in the IPCCC table. For example in one record of the IPCCC code there is a column ICD10_code which indicates the matched ICD 10 code. In this case the doctor can only see the matching between the codes and cannot see the ICD 10 description for the matched ICD 10 code because this option is not included. For this reason we are using the ICD-10 categories table to display the matched description. The ICD-10 code will be matched with the SNOMED CT code, if it exists, and the tool will display the matching pattern from IPCCC to ICD-10 and back to SNOMED CT to the doctor.

For the matching scheme a new PHP page was created that gets the IPCCC code as a parameter and holds the results of the matched ICD 10 and SNOMED CT codes.

The illustration in figure 4 shows that the IPCCC code is passed to the icd10_check.php page. In turn, the dbconnect class queries the database to get the matching ICD 10 code and description based on the IPCCC code. At the same time

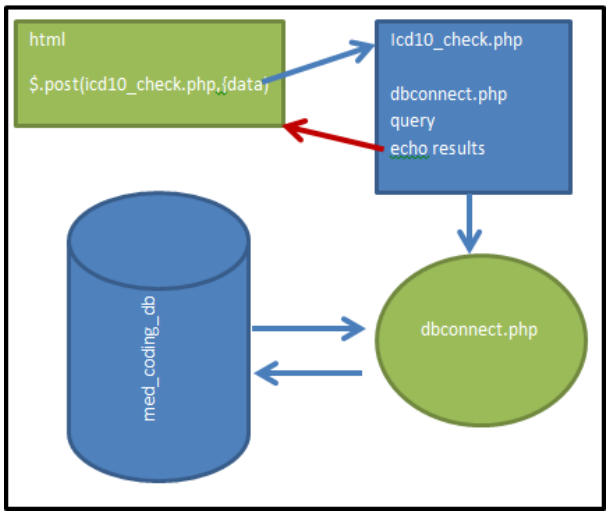

Fig. 4. Graphical representation of the Coding interoperability functionality.

the ICD-10 code is matched to the SNOMED CT code and description; this is based on the matching scheme that exists in the SNOMED and ICD-10 mappings table.

IV. Problems during implementation

A. *SNOMED CT Tables hold a vast amount of records*

Our starting goal was to create a coding matching path from IPCCC to SNOMED CT. In this case the doctor, at first, would have entered the SNOMED CT code manually and for future aspect the pattern will be indicated automatically by the system to the doctor. One problem that we have encountered during this implementation was the large amount of data that the SNOMED CT tables hold. The number of those records can come up to one and a half million and more. The load imposed on the system while querying these records was quite heavy and it took a long time to display results, leading to unacceptable latency.

Instead we've decided to use the matching pattern from IPCCC to ICD 10 that existed in the IPCCC tables and subsequently find the matching ICD 10 and SNOMED CT pattern that exists in the SNOMED CT mappings table.

B. *ICD 10 and SNOMED CT code matching issue*

Some of the IPCCC codes do not have an actual match with an ICD-10 code. In this case the return values would be empty. For this reason, we have provided the option to the doctor to change it to the one that is more appropriate.

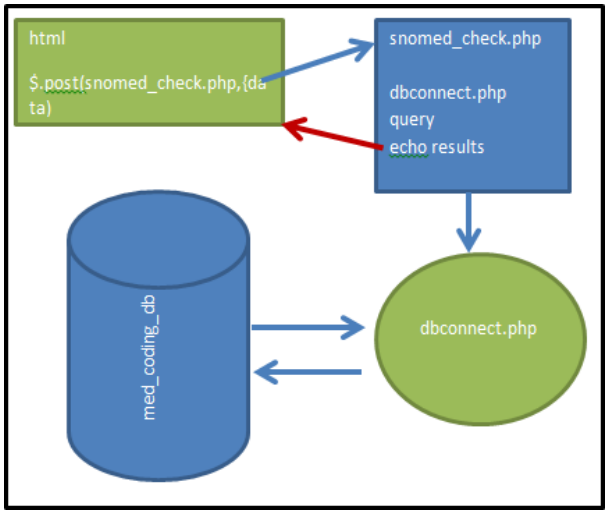

Fig. 5. Graphical representation of the Coding interoperability functionality with the ICD 10 change option .

Figure 5 shows the addition of the "snomed_check.php" page which gives the ability to the doctor to change the ICD 10 coding. The option works the same way as the interoperability functionality but in this case the matching scheme is done only from the ICD-10 to SNOMED CT.

C. *Mapping between IPCCC and ICD-10 issue*

IPCCC coding was created and is dedicated for paediatric cardiology and congenital heart diseases and provides very high granularity. Due to this fact the existing mapping between IPCCC and ICD-10, that has only a limited number of codes for this discipline, does not and cannot have matching for all the IPCCC codes. For this reason there are a lot of IPCCC codes that map to the same ICD-10 code and some others do not have a map between them. In this case the matching path from IPCCC to ICD-10 is being done with a more generic ICD-10 code and then the path from ICD-10 to SNOMED CT is being again matched with the ICD-10 generic code potentially leaving behind important characteristics of the diagnosis. This is an issue that the coding system specialists should take into consideration.

V. Conclusion

An add-on tool has been created that can be attached to the FreeMed EHR software and can help the doctor assign diagnosis codes to the patients of the center. With the introduced tool, the physicians of the center have direct unencumbered access to the different coding systems, as they are able to query through the database instantaneously and find details for a code or other information required.

Once the codes are assigned to the patient, useful electronic reports can be created that can provide important information to the doctors that is the result of appropriate and complete coding. For example doctors can monitor patients that suffer from the same disease, the patients' treatment, disease that occurred in a certain period of time and many more information that can lead to more complete and accurate results. This useful information is for the benefit of both, the doctor's and the patients.

Additionally with the appropriate adjustments the tool itself can be applied to any other medical center as a standalone application. As a continuation of this work we plan to study the user acceptance and also time saved by using this tool. Additionally we plan to investigate whether this may limit the need for dedicated coders

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