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A collaborative platform for consensus sessions in pathology over Internet

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Abstract

The design of valid databases in pathology faces the problem of diagnostic disagreement between pathologists. Organizing consensus sessions between experts to reduce the variability is a difficult task. The TRIDEM platform addresses the issue to organize consensus sessions in pathology over the Internet. In this paper, we present the basis to achieve such collaborative platform. On the one hand, the platform integrates the functionalities of the IDEM consensus module that alleviates the consensus task by presenting to pathologists preliminary computed consensus through ergonomic interfaces (automatic step). On the other hand, a set of lightweight interaction tools such as vocal annotations are implemented to ease the communication between experts as they discuss a case (interactive step). The architecture of the TRIDEM platform is based on a Java-Server-Page web server that communicate with the ObjectStore PSE/PRO database used for the object storage. The HTML pages generated by the web server run Java applets to perform the different steps (automatic and interactive) of the consensus. The current limitations of the platform is to only handle a synchronous process. Moreover, improvements like re-writing the consensus workflow with a protocol such as BPML are already forecast.

Keywords:

Decision making (Consensus); Internet; Computer Systems ; Telepathology

1. Introduction

Diagnosis in pathology is based on the subjective interpretation of histological images. The design of valid databases is a key issue in this domain, in particular for educational and quality assurance purposes, and faces the problem of diagnostic disagreement between pathologists. Such disagreement is mostly due to the lack of reproducibility in identifying, localizing and labeling relevant morphological features in images corresponding to diagnostic criteria [1]. In a previous study, we showed that IDEM software contributes to relevant indexing of images. Unambiguous descriptions of morphological features are built by pathologists using both labeling functions and a glossary of the domain [2]. Since determining relevant image features is often complicated by contradictory opinions, the IDEM environment comprises also a consensus module to build multi-expert case-descriptions. The consensus module evaluates image description variation among experts and allows them to reach consensus and to standardize descriptions [3].

Reaching consensus is, however, often hampered by the organisational difficulties of ensuring that several, often very busy, pathologists can meet to derive consensus. Several European and French projects or institutions are already underway to facilitate communication among pathology experts over the Internet [4][5][6][7]. Nevertheless, two issues remain largely unresolved to conduct consensus sessions over the Internet. These are

firstly, to provide appropriate digital images of pathological cases, and secondly, to automatically compare pathologists' descriptions and diagnoses of each case.

The TRIDEM "telepathology & retrieval of images and diagnosis from examples in medecine" project is part of the IDEM framework and addresses the two previous issues. It aims at developing a computerized environment to enable expert pathologists to conduct consensus sessions using teleslides over the Internet in order to build consensual and validated cases. It is based on the IDEM consensus module.

In a first section, we present the objectives of the TRIDEM project and focus on the technical issues to be solved. The next section gives an overview of computerized collaborative tools. The two next sections describe the implementation of these tools in the domain of pathology. The first prototype of the TRIDEM platform is presented next and discussed.

2. Context : the TRIDEM project

In agreement with ADICAP ("Association pour le Développement de l'Informatique en Cytologie et Anatomie Pathologique"), the TRIDEM project aims to supply to pathologists consensual databases of multimedia medical reference cases over Internet and to measure the impact of the TRIDEM server on the reduction of the diagnostic variability. The originality of the project is to provide an integrated architecture with the following features:

- automated microscopes are connected to the platform such that a virtual navigation into teleslides with different enlargement factors is possible,
- annotated and validated medical cases are available for hospital local network and any hosted PACS (Picture Archiving and Communication System) through the DICOM standard support,
- consensual cases are generated within the platform through teleconsensus sessions over the internet.

The present work specifically deals with the last aspect.

3. Backgrounds

3.1. Overview of the internet protocol

Over the past decade, the internet became a privileged communication channel between all computerized systems that need to exchange data with their environment: from the smallest ones like cellular phones or electronic organizers to the heaviest enterprise servers, all of these systems now support the Internet communication protocol (HTTP). HTTP (Hyper Text Transfer Protocol), initially designed to publish HTML pages, is now used as a backbone between servers and databases handling database transactions and client/server connections [8]. Because of the slow throughput for data transmission often encountered in some area on the internet, we decided not to use high bandwidth consuming resources, like video broadcasting, nor video streaming of web cam inputs, and not to go beyond the scope of handling the virtual slide navigation, which is quite resource consuming.

Secondly, general principles about how pathologists use to communicate and discuss to validate a medical case in a consensus session were investigated. It appears that pathologists need to easily and quickly discuss with the other members of the panel: the specific objective is therefore to implement a set of lightweight interaction tools in order to allow efficient communication among the expert panels.

3.2. Overview of computerized collaborative tools

Computerized collaborative tools are used in domains where people have to interact like, for instance, the enterprise. The simplest tools only allow file sharing, electronic mailbox or diary management. However, new kinds of tools appear more and more in the enterprise context [9]:

- *instant messaging*, or *chat discussion*, allow people to virtually meet them, and exchange issues when they have to talk together [10].
- *threaded discussions* allow people to join and feed with their own knowledge a specific topic that is pointed out by a group,
- *document annotations* allow people to create short text annotations on documents (mostly text document) [11],
- *life cycle document management* and *content management based servers* : packed together, these two systems allow to focus on the collaborative process for creating and publishing "validated" documents.

The open source community also offers a successful example of a collaborative environment of scattered workers producing reliable products [12]. Collaborative tools used by this community can be classified in few categories:

- tools that enable the versioning and the evolution of the pieces of code (management of concurrent access, version numbering, rollbacks to a previous state, etc.) [13],
- tools that enable the navigation in the source code with cross-reference of the used programming language elements [14],
- tools that enable the track and the follow-up of collected software bugs : who has found the bug, when, in which context (hardware platforms, software context), what is the workflow associated to the bug (creation, validation, duplication of other bugs, resolution, etc.), what is the patch procedures to apply, etc [15].
- tools that enable forum based discussion among the developers to address main issues: generally implemented as web servers additional modules.

What can be learned from the enterprise context and the free software communities is that the task of elaborating a validated, efficient and state-of-the-art rated piece of work, in a collaborative and distributed context, can be reach by the use of the relevant computerized tools.

4. Material : specifications of the consensus

4.1. The entities of the consensus

The specific problems that arise in pathology consensus sessions are slightly different from those found in the enterprise context or in the free software development context. The entities involved in the consensus are the image interpretations given by the experts for a same case. These interpretations rely on the identification and the localization of relevant morphological features (MF) in the medical images. Each MF is composed of:

- a label which is the semantic signature of the MF. Labels are chosen from a glossary of the domain,
- one or more regions of interest (ROI) in images which are the topographic signature of the MF. ROI are drawn manually by the experts using drawing tools.

The aim of the consensus is to create an unique interpretation of the case in terms of a set of consensual MF. The main issue is therefore to cluster the initial MF (from the different interpretations) in classes. Each class represents a consensual MF characterized by a consensual label and one or more consensual ROI.

4.2. The automatic phase of the consensus

The elaboration of the consensus in the TRIDEM environment is a two step procedure. During the first, automatic, phase, the system computes a consensus based on the 2 by 2 comparison of each MF of the initial set. The comparison of two MFs involves a semantic agreement between the labels and a topographic agreement between the ROI [2]. Each set of MF in both semantic and topographic agreements constitute a preliminary consensual MF.

4.3. The collaborative phase of the consensus

The second phase of the consensus is an interactive phase: in order to validate or modify the results of the automatic phase, each preliminary consensual MF is submitted to the expert panel. Collaborative tools are useful at this stage of the consensus.

5. Method : consensus with collaborative tools

5.1. Modelization of the overall consensus survey

In the current step or our work, the consensus is specified as a synchronous process. In the traditional (non computerized) organization, the whole expert panel studies the set of cases one by one and gives a decision regarding a case in conjunction. It does not mean that all the expert descriptions must be done at the same time, but the consensus process itself demands a synchronous scheduling to operate.

The UML (Unified Modelling Language) language [16] was used to model the different actors, their interactions with the system and the objects that should be implemented to perform the consensus. The most important UML use cases were:

1. "to define the moderator" : who is the "project leader" of the consensus survey
2. "to define the purpose of the consensus survey" : what is the medical issue (abstract, keywords, bibliographical references, etc.), what is the material (the slides and the images) that will be described, etc ?
3. "to define the expert panel that will work during the consensus sessions" : experts may be associated to a particular consensus survey according to their domains, their grade (senior, junior) etc.
4. "to define the domain knowledge model" : the glossary that will be used to label the MF and the similarity tables used to compare 2 labels of the glossary.
5. "to manage the image descriptions by the expert panel" : to create MF with their associated labels and ROI.
6. "to define the time scheduling for the whole consensus survey".
7. "to manage a consensus session" : for a given case, to start a comparison of the MF described by the connected experts, and to establish a consensual description, to store/retrieve a session which is not completed, etc.

5.2. Supported tools for the consensus session

The interactive phase is directed by the moderator who is responsible for its correct scheduling during the consensus session.

The work of the pathologists is mostly based on the image re-analysis : the preliminary consensual MF are iteratively discussed by the panel and displayed on the web navigators of all connected pathologists. For each MF of the initial set, the pathologist must answer the following question: "is this submitted MF belonging to the preliminary consensual MF under consideration ?"

The answer of the pathologist is twofold : 1) to validate/invalidate the semantic agreement (the label) of the new MF and 2) to validate/invalidate the topographic agreement (the ROIs) of the new MF. To do this, the pathologist first points to the displayed label and choose "validate" or "invalidate" in a first pop-up menu, and second points to each ROI and choose "validate" or "invalidate" in a second pop-up menu.

Before sending his answers to the moderator, the pathologist can check the opinion of the other members of the panel by listening short vocal annotations made during the survey of the status of the new MF by other pathologists. He can also record new vocal annotations to send his opinion concerning the submitted MF. Vocal annotations are sent to the server by one pathologist during the session, and the server makes them available for the other pathologists.

6. Realization of a first TRIDEM platform

The architecture of the TRIDEM platform is based on a Java-Server-Page web server that communicates with the ObjectStore PSE/PRO database. In this JSP architecture, the web server generates HTML pages which are sent to the web navigators. These pages run Java applets to perform the different steps of the consensus. When an applet has to communicate with the server, it creates a new socket (tcp/ip) channel to send and receive data. Requests are implemented as remote invocations of JSP pages in the server. Moreover, to reflect a change in the server to the connected pathologists (for example when a new vocal annotation has been received and should be transmitted to all users), a dedicated java thread in each client applet is responsible for regularly polling the server to get new available data.

7. Conclusion

In this paper we present the TRIDEM consensus platform that allows a panel of experts to derive a consensus over the internet. The consensus sessions are very straightforward for the pathologist who has both a visual control of his/her actions (with the elements to consider displayed on images) and a control of the opinion of all the panel members (with the vocal annotations). We think that the vocal annotations are of great efficiency, because during the consensus sessions, pathologist could not spend time with keyboard typing and it is not easy to read a text annotation and in the very same time looking at the medical image to make up his mind

But the platform suffers from several limitations. The current architecture is somewhat restricting, especially in the workflow management: the sequence of the modelized consensus session is very basic, and may be not fitted to specific organizations. This does not questions the methods used to reach the consensus but it raises the issue that consensus sessions may be differently organized (in an asynchronous manner, for instance). The consensus should be parameterized as a collection of rules, which could be executed by a generic engine. The BPML (Business Process Modeling Language) language seems to be of

great relevancy to perform this task. We think of re-writing the consensus workflow with a protocol such as BPML and to execute it in the TRIDEM platform with BPML engines such as the IBM BPWS engine. Secondly, if we examine in detail the role of the moderator, we think that it could be helped by an "intelligent" module: an agent module could automate most of the moderator tasks like 1) automatically send relevant MF to the pathologists for submission or 2) automatically compute a consensual result from all of the pathologists decisions.

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