E-MEDI: A WEB-BASED E-TRAINING PLATFORM FOR BREAST IMAGING

I. Pratikakis, V. Virvilis, D. Kosmopoulos, S. Perantonis
IIT / NCSR "Demokritos", Athens, Greece

A. Damianakis, D. Tsatsos
Conceptum SA,12 Heyden str., 10434 Athens, Greece

Keywords: e-Training, Breast imaging, web-based learning.

Abstract: This paper concerns a Web-based e-Training platform that is dedicated to multimodal breast imaging. The assets of this platform are summarised in the following : (i) the efficient representation of the curriculum flow that will permit efficient training; (ii) efficient tagging of multimodal content appropriate for the completion of realistic cases and (iii) ubiquitous accessibility and platform independence via a web-based approach.

1 INTRODUCTION

The essence of a medical doctor's learning curriculum is the acquaintance with as many individual clinical cases as possible since the rate of success in diagnosis and treatment is directly proportional to the amount of this accumulated experience. This learning principle is directly applied to the field of radiology, where intensive training with medical images is required. Nowadays, the training in radiology at a European level is quite diverse both in curricula and quality due to the lack of appropriate content (tutorials and case-based learning material) as well as the lack of qualified trainers.

Furthermore, there is an increasing demand for recruiting personnel specialized in radiography which is proportional to the increase of produced imaging volumes. In Sweden, imaging volumes are increasing by 2% to 5% per year. The U.K. and Canada are both seeing demand for imaging growing by 5% (ESS, 2000). The demand isn't likely to fall. It is obvious that there is a gap which may be largely attributed to the deficiencies of the classic training methods described in the following.

The number and complexity of the radiographic imaging modalities have increased dramatically over time. The last decades have brought about tremendous innovation in the field with magnetic resonance imaging, mammography, electron beam computing tomography, positron emission tomography just to name a few. While the multimodal imagery helps the doctor in the diagnosis it also represents an administrative burden that renders the work of radiologists more complex, while the technical and IT skill demands become increasing and the underpinning knowledge base also expanding. The range of tasks radiologists have to perform has increased too. These rapid developments not only require a well-prepared work force but also rapidly adapting training programs.

The importance of critical thinking and professional judgement in professional practice is obvious. Especially the medical doctors that work in geographically isolated regions are not able to contact experienced professionals and lack in experience due to the fact that the cases they handle are very few compared to the ones handled in urban hospitals. The traditional training programmes are not applicable in these cases due to distance. The principle of distance learning has been the motivation factor for the increasing numbers of web environments dedicated to learning / training purposes, eg. (WebCT) (Blackboard) (TopClass) (LotusLS).

In this paper, we present a Web-based training environment that will facilitate accessibility and support platform independence as well as will help to bridge the gap between the availability of highly

Pratikakis I., Virvilis V., Kosmopoulos D., Perantonis S., Damianakis A. and Tsatsos D. (2007).
E-MEDI: A WEB-BASED E-TRAINING PLATFORM FOR BREAST IMAGING.
In *Proceedings of the Third International Conference on Web Information Systems and Technologies - Society, e-Business and e-Government / e-Learning*, pages 338-345
DOI: 10.5220/0001281003380345

trained/qualified radiology professionals and the current needs in Europe for medical doctor's training and lifelong learning curriculum.

Emphasis will be placed on (i) the efficient representation of the curriculum flow that will permit efficient training; (ii) the tagging of multimodal content appropriate for the completion of realistic cases; (iii) a web-based platform that permits ubiquitous accessibility and platform independence. Furthermore the actual tagging can be seen as a part of a strict protocol that helps the doctors file their data sorted in a hierarchical way by case, time and modality.

In this work, the focus is on breast imaging, but the results can be easily extended to imaging modalities of other anatomical objects like brain, heart, etc.

The paper will be structured as in the following. At Section 2, we will review existing relevant environments for which we will address their advantages and pitfalls. Section 3 is dedicated to the overall system architecture wherein a detailed description of the major components will be given. Finally, at Section 4, concluding remarks will be drawn.

2 RELATED WORK

In the following, we review many of the existing e-learning systems related to radiology with particular emphasis to breast imaging.

In (Costaridou *et al.*, 1998), the potential of interactive multimedia and Internet technologies is investigated with respect to the implementation of a distance learning system in medical imaging. The system is built according to a client-server architecture, based on the Internet infrastructure, composed of server nodes conceptually modelled as World Wide Web (WWW) sites. Sites are implemented by integration and customization of available components. The system evolves around network-delivered interactive multimedia courses and network-based tutoring, which constitute its main learning features. This potential has been demonstrated by means of an implemented system, validated with digital image processing content, specifically image enhancement. Image enhancement methods are theoretically described and applied on mammograms. Emphasis is given in the interactive presentation of the effects of algorithm parameters on images. The system end-user access depends on available bandwidth, so high speed access can be achieved via LAN or local ISDN connections. In this system, the content from real clinical cases was not supported by all appropriate steps for a decision making from the medical doctor. Furthermore, it focused on mammograms only, limiting breast imaging in a single modality.

In the case of the MammoEd project (http:\\www.mammoed.com) which was developed by the University of Washington, the aim was to provide interactive, comprehensive teaching cases that could be easily accessed from any computer connected to the Internet and to provide general breast imaging education resource for radiology residents, attending physicians, students, clinicians, technologists, and patients. It was developed using teaching cases from daily clinical practice organized into a computerized database. The screen-film images were scanned. The student was prompted to click on the pertinent findings or to answer questions regarding the images. Each click rendered more images and questions with discussion of the correct and incorrect answers and management issues. Links were embedded to relate teaching files and references. Although, MammoEd system deals with clinical cases from the daily clinical practice supported by corresponding images that the trainee can manipulate with minimal interactivity, it does not support multimodal content and does not permit the trainee to exploit all steps required for the diagnosis of particular cases.

In January 2004 the Bavarian statutory Health Care Administration started recertification program for quality assurance and quality improvement in mammography reading (Riesmeir, 2004). The participating physicians are required to read 50 cases randomly selected from a larger collection. The mammography films were digitized using a high-quality CCD scanner (570 dpi, 4096 shades of grey) to be viewed on an appropriate display workstation. In addition to the workstation software, a 'home edition' operating on a standard PC window was developed, allowing physicians to practice the procedure at home and get used to working with the software. Based on this 'home edition' of the software, a CD-ROM with 35 cases for training was composed and distributed. Future releases of the home edition with more training cases will be in DVDs. A shortcoming of this effort is the lack of distance-based learning making the corresponding material restricted to being consulted at a particular place and consequently at particular time periods.

EURORAD (www.eurorad.org) is an e-learning initiative of the European Association of Radiology (EAR) that was officially launched at ECR 2001. It is the first and still the largest peer-reviewed Radiology teaching files database on the Internet, and offers free access to a wealth of medical information and imaging data, whose accuracy and quality have been validated by some of the most experienced Radiologists in Europe. In this approach, although we have a web-based learning environment, it cannot permit any interactive activities with the content itself.

In conclusion, it is clear from the above overview that a more comprehensive e-learning system for training is needed that firstly, will encapsulate all available breast imaging modalities (mammography, ultrasound, MRI), because contemporary medical students are taught to diagnose from a variety of modalities instead of individual image sources. This ensures decrease of uncertainties in difficult cases. The structure of such a multimodal e-learning system should be adaptable and customizable for any anatomical part (in contrast to a system that would involve different single modalities per body organ. Secondly, it is required that training should be based upon a system that will address all corresponding cases using real clinical examples constructed in a manner that will respect the procedure flow used in a daily clinical practice. Finally, it is imperative that such a system should be available for an ubiquitous trainee (anywhere, anytime, from any computer system), enabling accessibility, sharing and interoperability. The proposed e-MedI framework strives toward fulfilling the above requirements, for which a detailed description is given in the following Sections.

3 E-TRAINING FRAMEWORK

The e-MedI architecture as it is shown in Figure 1 is based on a client-server 3-tier architecture that consists of the following core elements: (i) Learning Management System (LMS); (ii) Visual Authoring Tool; (iii) Trainee's interactive e-training environment and (iv) Keyword-guided Clinical Case search tool.

3.1 LMS

The LMS is by definition a complex administrative system used to deliver electronic content in the form of lessons and to organize people who are attend these lessons. In the proposed framework, we have used a proprietary LMS. Specifically, the Lotus LMS was chosen for a multitude of reasons such as portability, compatibility, standard compliance and feature completeness. Lotus LMS is written in Java, which ensures, up to a certain degree, multiplatform portability. Lotus provides LMS for several popular and enterprise class platforms, thus actively supporting the generic aspect of the learning platform. Furthermore, LMS supports several databases, both free and commercially available, as its storage backend.

For a public access system such as a virtual school authentication is an essential feature. However, modern computing often requires authentication more than one time. This situation quickly becomes cumbersome encouraging people to by pass security using weak passwords, sharing accounts etc. Lotus LMS supports Single Sign On (SSO) which enables the user to be authenticated only once in order to access any service offered.

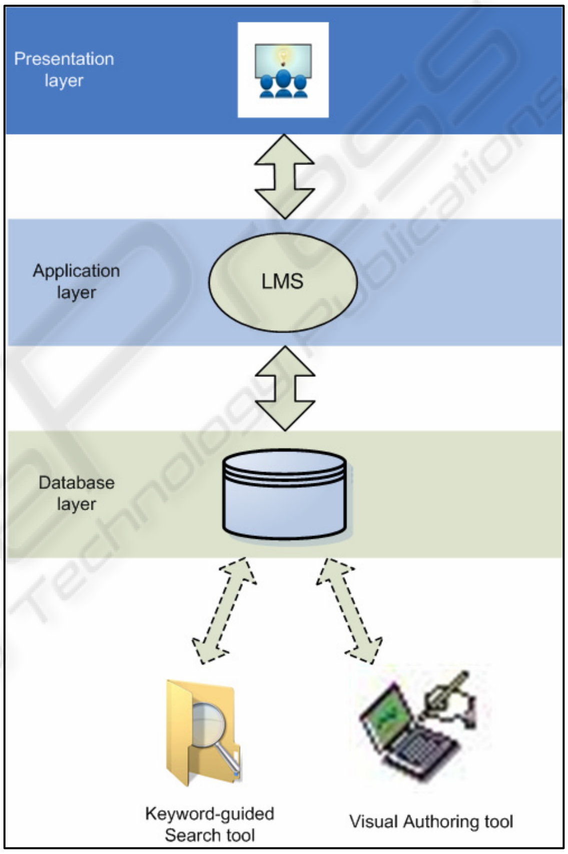

Figure 1: e-MedI e-training platform architecture.

LMS scales its support from simple seminars lessons up to curriculum lessons sets. Although e-MedI does use currently only a small percentage of the full LMS feature set, this setup allows future expansion.

Finally, Lotus LMS does support SCORM (Sharable Content Object Reference Model) (LTSC), the widely accepted standard for e-lessons, thus making possible to take advantage of the multitude of SCORM tools available in the market and in the Free Software world, and avoid a potential future vendor lock-in.

3.2 Visual Authoring Tool

The Visual Authoring Tool is written in Java in order to maximize portability and to take advantage of future and current technologies like Java Web Start (JWS) which drive the remote execution technologies. The Authoring Tool is a custom software made to facilitate the creation of Test cases for breast imaging, but it can be adapted to other types of pathology.

The main motivation factor that guided the Authoring Tool development has been that the Doctor's (teacher's) time is extremely valuable. With the Authoring Tool, an experienced author is allowed to construct a simple test case in about a time period that ranges from 3 minutes, for a simple case, to 10 minutes for the most complex one.

In order to achieve this level of productivity and user friendliness the specifications of the Authoring Tool were crafted by an iterative process. The key point was that we collected a series of feedback from a team of doctors from different countries, namely Ireland, Belgium and Cyprus. In this way, experience was gathered from users that are familiar from different medical systems and procedures. This knowledge is embodied into the Authoring Tool.

The Authoring Tool creates Test Cases that consist of consecutive stages. Each stage is associated with one or more visual content object (2D, 3D images and 2D+t sequences) . Each visual content object is the acquisition output of one of the available modalities (Mammogram, Ultrasound, MRI).

At program startup, the Authoring Tool presents to the author the opportunity to select and continue editing an already existing case. If the author selects a new case then he is prompted to select available visual content objects from each modality. The author is required to locate and describe the findings the student is expected to identify in the image. The description stage is supported via selection menus (combo boxes), and boolean check boxes whenever needed (Figure 2).

When the author has finished with the description that is related to a particular visual content object eg. a 2D image, it is prompted for

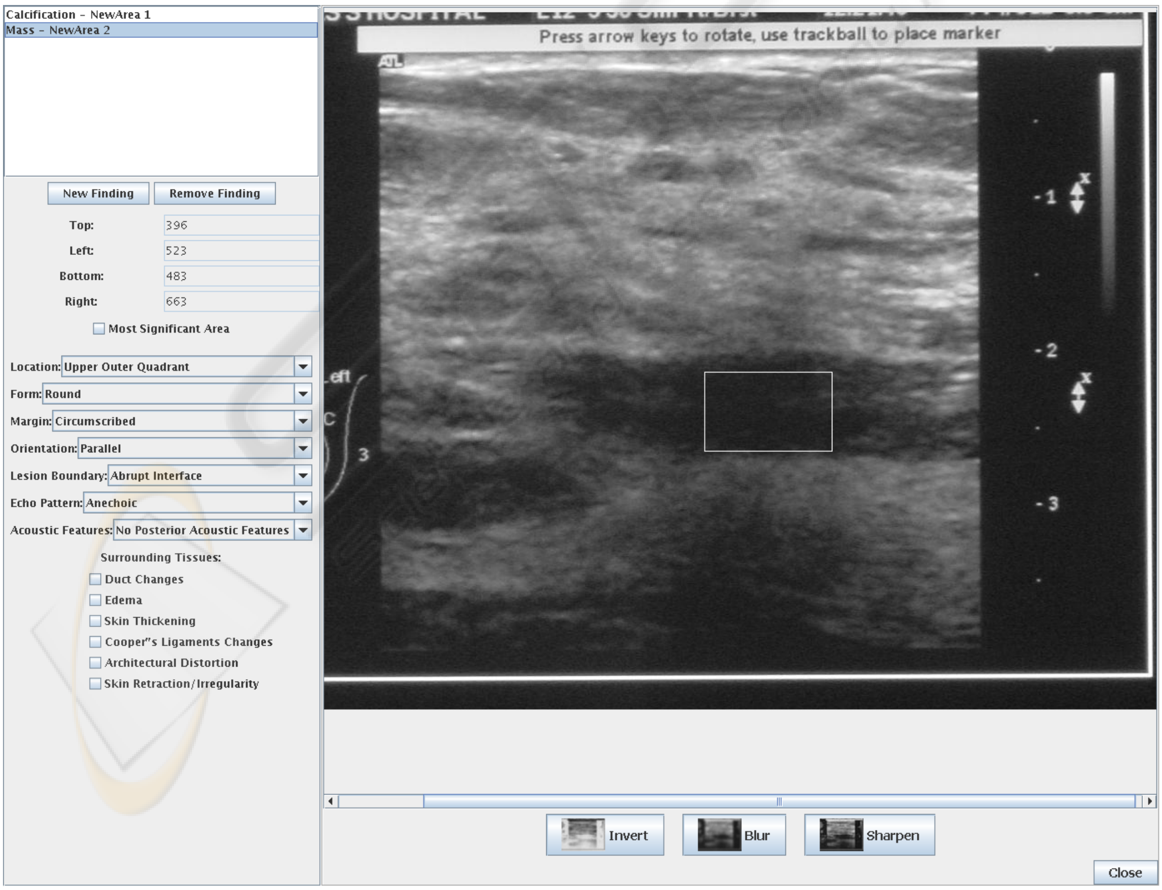

Figure 2: An instance of the e-MedI Visual Authoring Tool environment.

another one. When finishes all visual content objects, it is prompted for a new stage. *Stages* are data points in patient's time line. Upon finishing all the desired stages, the author is prompted to fill a small text field representing comment's about the specific patient in free text form, such as age or other important clinical data.

Since e-MedI is a multilingual system and despite the fact the Authoring Tool is currently only in English the resulting Test case is multilingual with the exception of the free text comment mentioned above which has to be entered for all currently supported languages (English, French, Greek).

Finally, it is worth mentioning that the Authoring Tool gives an essential assistance to the tutors by supporting image filters such as inversion, blurring and sharpening that are routinely used by the medical doctors during an examination.

3.2.1 Training Flow

A novel feature of the e-MedI e-training platform relies upon the creation of a training flow that assimilates the real situation in a clinical environment and guides the interaction between the trainee and the system during training. The training flow depends on the selected modality, as it is displayed in both the image properties panels and the associated findings panels. For example in a Mammogram image it is not possible to detect ‘nipple retraction’, so this specific option does not exist. This way the Author faces only the relevant choices, thus accelerating the process of content creation. Examples of the availability of findings with respect to the modality can be shown at Figures 6-7.

In the following, the produced XML document that depicts the training flow is discussed. After the XML preamble (header) that states that the encoding is Unicode, each XML file fully describes a clinical case. For each case, a short free text with the patient's history is available along with a case follow up for future reference. The case follow up can be associated with a small image for a better overview without actually digging into the case.

The XML format described so far is like this :

```
<?xml version="1.0" encoding="UTF-8"?>
<case>
 <general>
     <history>
     <caseFollowUp>
         <img>
```

Since each case may have multiple stages these are described in the data section of the XML file.

```
 <data>
     <stage>
     <stage>
     <stage>
     <stage>
         <image>
         <image>
         <image>
         ...
         <action>
         <help>
         <significance>
     <closeCase>
```

closeCase represents the final diagnosis and the suggested course of action.

For example:

```
<closeCase>breastComposition="heterogeneously dense" score="4: suspicious abnormality" followUp="biopsy"></closeCase>
```

Each stage may have multiple images and each image may have more than one finding. In each stage it is possible for the author to specify further action (e.g. request ultrasound) and give little guidance to the trainees in the form of popup windows (<help> tag)

Each area of the image has only one finding.

```
<stage>
    <image>
        <area>
        <associatedFindings>
        <implant>
    <image>
    <image>
```

The Image node has the following tags :

<file>: image filename
<label>: window title
<display>: left, right or both breasts
<modality>: mammo, ultrasound or MRI.

In the area tag the ROI coordinates are stored along with the finding's type e.g. calcification. The associated finding tag holds the options that are displayed in the above figures and they are modality specific.

Finally, the program gives the opportunity to classify a finding as implant in order to avoid further evaluation.

3.3 Interactive e-Training Environment

The presentation tier is the layer of user interaction. Its focus is on efficient user interface design and accessibility throughout the training process. The UI tier can reside on the user's desktop, on an Intranet, or on the Internet.

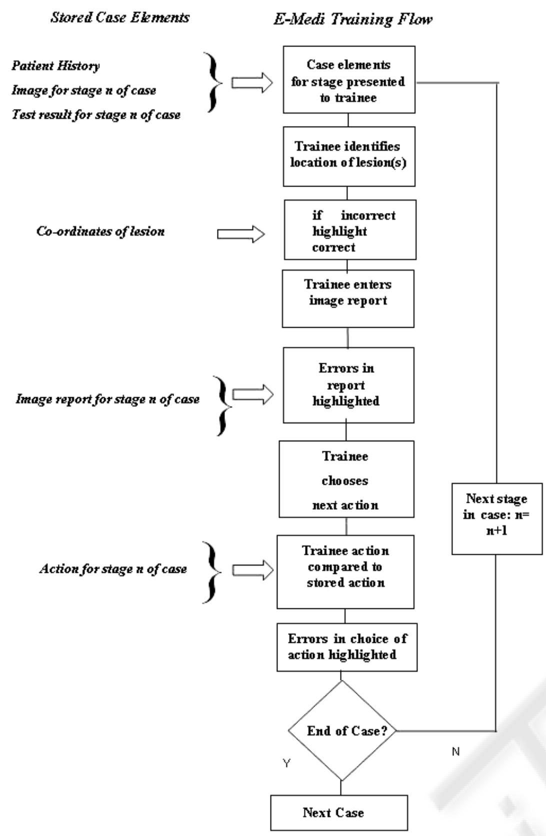

Figure 3: Core interaction between the trainee and e-MedI for a single case.

The proposed core aspects of e-MedI as experienced by the trainee during interaction are presented in Figure 3. This flowchart shows the core interaction between the trainee and e-MedI for a single case. Outside of this core, additional functionality will exist to manage case selection, presentation and entry of cases into e-MedI. For example, additional functionality could be envisaged to filter cases into categories (eg. ‘easy’ to ‘difficult’), alter the appearance of the user interface, or provide the trainee with scores and tutorials.

The data are not be revealed in their entirety to the trainee at the outset but in *stages*. A stage is the data that is available to the trainee at any given point between decision nodes in the decision tree. For example at the first stage, only the patient data and clinical breast exam results may be available. On selecting the correct action for this history, the images and/or test results associated with the next stage are displayed. Note that several views (images taken at different orientations) will typically exist for a single examination. Where more than one image exists for a given examination, images may need to be presented as thumbnails or equivalent. The trainee will then click on regions of the image(s) to identify suspect lesions. The chosen locations will be crosschecked with the stored lesion coordinates for that image.

The trainee then enters a report for the current image using a report data entry table, which displays a range of standard image features such as “mass”, “mass margins”, “mass density” etc. Each feature has standard descriptors. For example the standard descriptors of the margins of a mass in a mammogram are “circumscribed’, “microlobulated”, “obscured”, “indistinct” or “speculated”. Each descriptor will be associated with a checkbox in the report entry table. If the trainee believes the margins of the mass identified are best described by “circumscribed”, then they will check the box associated with this descriptor. Errors between the report entered by the trainee and the stored report can be highlighted. The trainee must then select the next action required from a predefined list. For example possible actions include “carry out ultrasound” and “carry out spot compression mammogram”, “score BiRads” or “Biopsy”. Actions can be selected using an on-screen push button, dropdown list or similar. Other than scoring BiRads, any non-imaging action will in general close the case. An important feature is that several different image modalities may be available at the same screen providing the trainee the opportunity to diagnose simulating the real diagnosis procedures. This can be shown via a snapshot of the interactive e-training environment at Figure 4.

3.4 Keyword-based Clinical Case Search Tool

The e-MedI database holds all available visual content along with their corresponding descriptors. The keyword-based clinical case search tool allows searching through keywords with the aim to assist the user in finding visual content instances eg. 2D images that have specific features in order to further improve training in a particular case diagnosis. For example if the user has in a mammogram that may have a ‘ruptured implant’ and wants to verify the diagnosis, he/she can use this feature as keyword to retrieve all relevant visual content.

Searching is realised by querying with different granularity. An example is shown at Figure 5. First, the user of the system selects what type of image wants to search eg. Mammogram, Ultrasound or MRI. After that, based on the selected modality, the user selects among all the modality-specific descriptors those that are needed for the particular

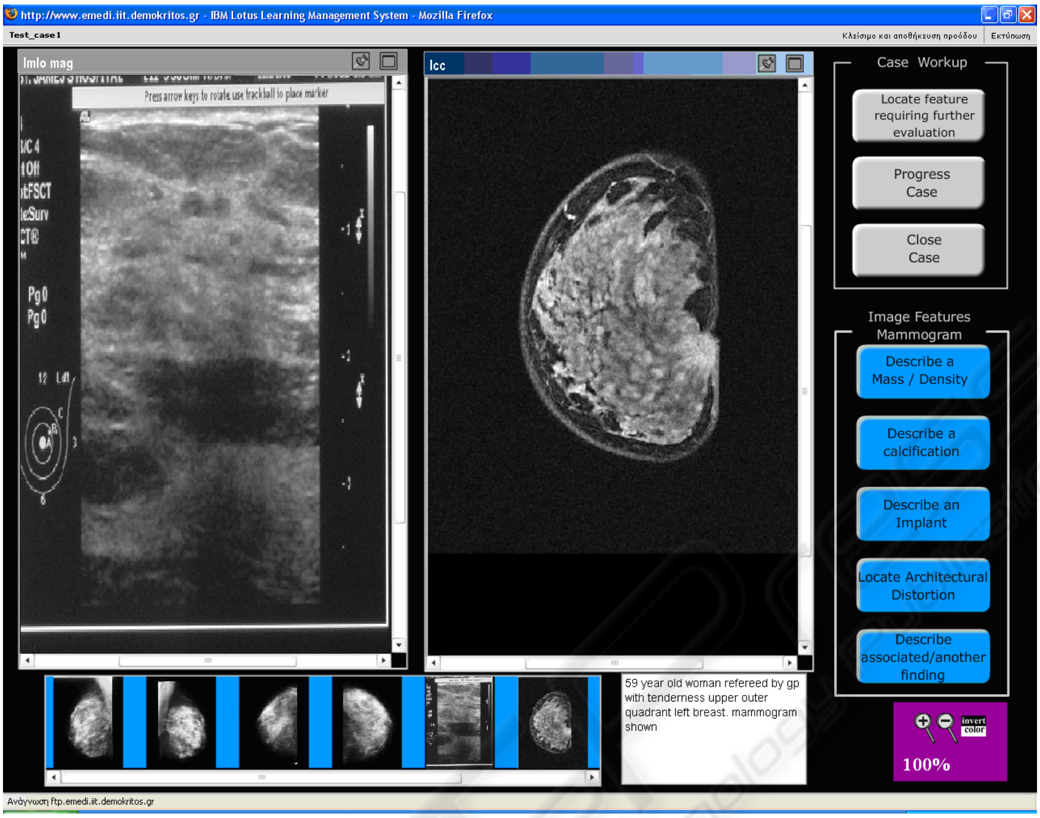

Figure 4: A snapshot of the interactive e-training environment.

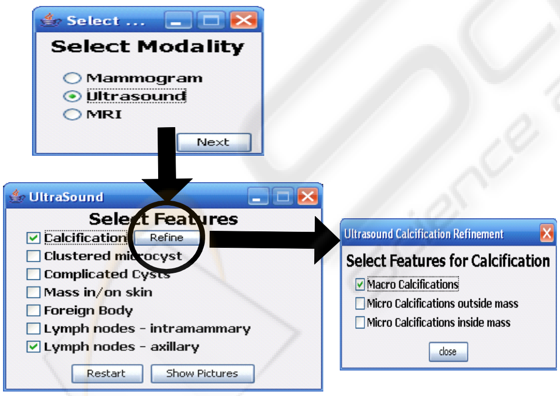

Figure 5: Example of a refined query.

image the user searches for. Some descriptors are further refined by clicking on the button refine next to it.

4 CONCLUDING REMARKS

The proposed platform for e-training on breast imaging draws its importance from the underlying principle that a fruitful training process has to assimilate and subsequently follow a training flow which corresponds to a valid step-by-step process followed in a real clinical routine setting. This principle is realised via e-MedI through mainly an authoring tool that supports the creation of the realistic flow as well as an interactive environment that is both user friendly and enables the acquaintance of the trainee with the training flow process. e-MedI can support an ubiquitous trainee due to its web-based design providing the students useable skills that they can directly apply in the real world. In our immediate future plans, we will apply to corresponding authorities all over Europe that support Continuous Medical Education certificates to consider e-MedI as the means of accreditation on breast imaging.

ACKNOWLEDGEMENTS

This research was supported by the EC Leonardo da Vinci programme "E-MedI-Virtual School on Medical Imaging and E-Learning Framewrok" under contract 2004-EL/2004/B/F/PP-148269.

REFERENCES

Costaridou, L., *et al.*, 1998. Distance Learning in Mammographic Digital Image Processing, *The British Journal of Radiology,* 71(842):167-74.

Riesmeir, J., 2004. Experiences with a workstation Prototype for softcopy Reading within the Bavarian Mammography Re-certificating Program, *Acad Radiol*, 11: 407-418

LTSC, Learning Technologies Standardization Committee (http://ltsc.ieee.org)

WebCT, (http://www.webct.com)

Blackboard, (http://www.blackboard.com)

TopClass, (http://www.wbtsystems.com/)

Lotus LS, (http://www.lotus.com/home.nsf)

ESS, 2000. Employers skill survey. Case study: Health and social care, Department of education and employment, Nottingham, UK.

Diagnostic imaging, http://www.diagnosticimaging.com

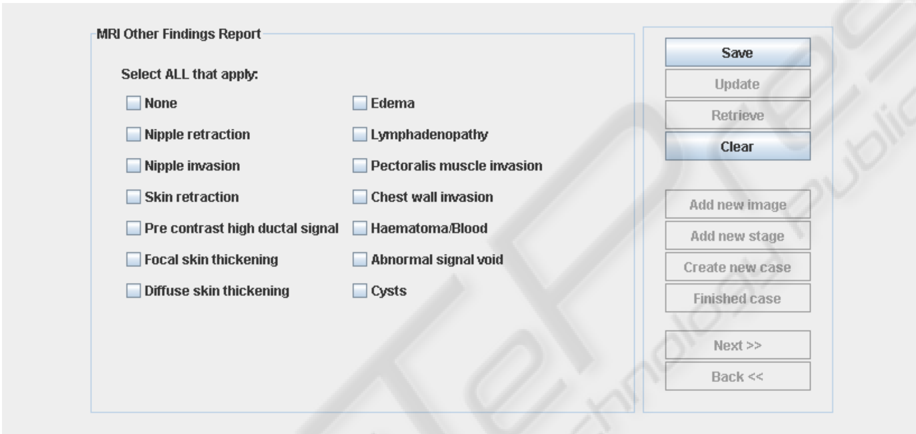

Figure 6: Valid findings for MRI.

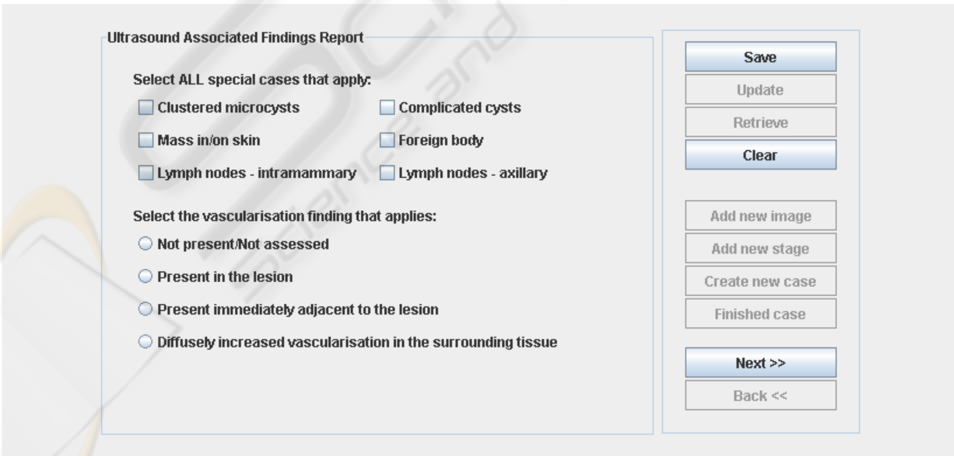

Figure 7: Valid findings for Ultrasound.