

A Method and Apparatus for Creating Medical Teaching Files From Image Archives

Filed of the Invention

The present invention relates to a method and apparatus for creating medical teaching files from image archives and refers particularly, though not exclusively, for use of such a method and apparatus for radiological teaching and information exchange using images retrieved from clinical archives.

Abbreviations and Acronyms

Throughout this specification the following abbreviations and acronyms shall have the following meanings:

ACR:	American College of Radiology;
DICOM:	Digital Imaging and Communications in Medicine. This is a standard medical imaging format and protocol;
GUI:	Graphical User Interface;
HTTP:	HyperText Transfer Protocol. This is an application-level protocol for distributed, collaborative, hypermedia information systems;
ID:	Identifier. An identifier is a string used to identify a patient, or a study, in the DICOM protocol;
JPEG:	Joint Photographic Experts Group. This is a popular image format (usually with file extension .jpg or .jpeg);
MIRC:	Medical Imaging Resource Center. This is a distributed medical imaging library and standard defined by RSNA. For the definition of RSNA see below;
MIRIP:	Medical Imaging Repository Interfacing with PACS. For the definition of PACS, see below. MIRIP is the name of the system utilizing the method and apparatus of the present invention;
PACS:	Picture Archiving and Communication System. The clinical image archive system;
RSNA:	Radiological Society of North America;
TF:	Teaching File, which is a document containing text and images that is useful for medical education;

UID: Unique Identifier, which is a number that uniquely identifies an object in the DICOM standard; and

XML: Extensible Markup Language as defined by the World Wide Web Consortium (W3C), to make it easy and straightforward to use on the Web: easy to define document types, easy to author and manage documents, and easy to transmit and share across the Web.

Background to the Invention

Medical (e.g. radiological) images are important building blocks for clinical support, teaching and research. In digital environments such as PACS, images may be manipulated and cross-referenced in a powerful and interactive fashion. As more hospitals adopt PACS, a scalable repository of case-based files will become a valuable tool for on-demand learning and exchange of data. However, a solution does not yet exist to interface such a repository with a clinical PACS. MIRC, which was developed in 2001 under the leadership of RSNA, is a standardized platform for exchanging image data.

No vendor of PACS systems presently provides a solution for creation of medical teaching files as a commercial option. Many teaching hospitals and universities have designed in-house solutions using a variety of formats. Recently, the RSNA has defined standards for MRIC. MIRC has the potential to be a worldwide set of standards defining teaching file and research data sets in the same fashion as DICOM has become the de facto standard for PACS.

Systems that can retrieve medical images and other information from PACS to compose radiological teaching files in a teaching file library, and share with other teaching file libraries using the MIRC protocols. are not yet available.

It is therefore the principal object of this present invention to provide a method and apparatus for creating teaching files from medical image archives.

Summary of the Invention

With the above and other objects in mind, the present invention provides a method for retrieving medical images from at least one imaging archive and creating at least one teaching file; the method including the steps of retrieving at least one medical image from the at least one image archive; storing the at least one medical image in a database; generating a database record for the

at least one teaching file; generating the teaching file; saving the teaching file into the database; and generating at least one index of the teaching files.

5 A searching mechanism for searching the teaching file may be provided; and when the at least one medical image is retrieved from the at least one clinical database, patient specific information related to the at least one medical image may be retrieved with the at least one medical image. The patient specific information may include sensitive information, the sensitive information being subjected to an anonymization process; the anonymization process preferably including replacing each item of the sensitive information with an anonymization code. The anonymization code may
10 include a randomly generated number, a prefix and a type. The prefix may be a short string of characters representing the creator of the sensitive information; and the type may represent a nature of the sensitive information.

15 A check may be first performed to determine if the item of sensitive information has previously been anonymized and the anonymization code previously generated; and, if yes, retrieving and using the previously generated anonymization code.

20 The sensitive information may include one or more of: patient's name, patient ID, other patient's names, other patient IDs, patient's birth name, patient's address, patient's telephone numbers, patient's mother's birth name, region of residence, country of residence, military rank, branch of service, patient comments, additional patient history, referring physician's name, referring physician's address, referring physician's telephone numbers, and all other person names.

25 Retrieval of the at least one medical image may be in batches or interactively. When retrieval is in batches, a plurality of medical images and information relative to the plurality of medical images is retrieved automatically using groups of patient identifiers or groups of study identifiers. The retrieval may be by a PACS accessor of an image server reading and retrieving the plurality of medical images from the at least one clinical image archive according to the patient identifiers or the study identifiers.

30 When the retrieval is interactive, the at least one clinical image archive may be queried using a graphic user interface and instructions are passed from the graphic user interface to a PACS accessor of an image server, the PACS accessor interrogating the at least one clinical image

archive, finds at least one medical image of interest, and retrieving the at least one medical image and information relative to the at least one medical images.

5 The at least one medical image may be received from the at least one clinical image archive, the image server then first storing the image in a temporary disk directory and validating the at least one image according to a DICOM standard; and, if the at least one image is not a valid DICOM image, the image server may discard the at least one image and check in the database for duplication.

10 If the at least one image already exists in the database, the image server may move the at least one image into a duplication directory. If the at least one image is not in the database, the image server preferably queries the at least one clinical image archive to retrieve relevant patient, study, series and image information, and merge the information with the at least one medical image; and store the information and the at least one medical image in the database.

15 The at least one medical image and information are preferably stored in the database and indexed by one or more of patient's name, patient ID, study ID, series ID and image ID.

20 The at least one medical image may be spanned to multiple storage media by determining when a current storage medium reaches its maximum capacity, finding a further storage medium with sufficient free space, and sending further medical images for storage to the further storage medium.

25 The present invention also provides apparatus for retrieving medical images from at least one image archive and creating at least one teaching file; the apparatus including a database, an image server, a MIRC server, a web server, and a graphic user interface for operation on a user's machine.

30 The database may be a relational database for storage of all required information, including database tables, database indexes, database scripts, and pointers to the medical images and teaching files. The image server may be for communicating with the at least one clinical image archive, querying and retrieving the at least one medical images, and patient data, study data, series data, and image-related information from the at least one medical image.

The MIRC server preferably provides MIRC compliant functions, including MIRC queries and MIRC storage; and the web server advantageously serves requests received from a user via the graphic user interface on a user's machine; the graphic user interface being for providing access functions and MIRC file editing functions.

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The image server may include a PACS accessor for querying and retrieving images from at least one image archive; a DICOM receiver for receiving the at least one medical image retrieved from the at least one image archive by the PACS accessor; and a DICOM anonymizer for anonymizing the at least one medical image received from the at least one image archive by the DICOM receiver.

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An MIRIP servlet may be provided in the web server to service requests from the graphic user interface; and the graphic user interface may includes an MIRIP client as a user interface able to run in a web browser or as a stand alone application on a user's machine.

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The MIRC server may include an MIRC storage for providing an MIRC teaching file storage service for the database and for the user's machine; and an MIRC query to provide queries as defined by the MIRC scheme.

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For both forms, the teaching file may be in accordance with the MIRC standard.

The present invention also provides a computer useable medium comprising a computer program code that is configured to cause a processor to execute one or more functions to perform the method described above.

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Description of the Drawings

In order that the present invention maybe better understood and readily put into practical effect there shall now be described by way of non-limitative example, a preferred embodiment of the present invention, the description being with reference to the accompanying illustrative drawings, in which:

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Figure 1 is a system block diagram that illustrates the main components of the apparatus of the present invention and that are used for performing the method of the present invention;

Figure 2 is an illustration in more detail showing the components of the apparatus of Figure 1;

Figure 3 is a system flowchart that illustrates the principal steps to create teaching files from clinical image archives;

Figure 4 is a flowchart of the batch image retrieval process as part of the first step of Figure 3 and illustrates the steps required to retrieve medical images from the clinical image archive;

5 Figure 5 is a flowchart of the third step of Figure 3 and illustrates the steps to anonymize one item of patient sensitive information in a DICOM file;

Figure 6 is a flowchart that illustrates the steps to anonymize all DICOM files in the database;

Figure 7 is a flowchart of the steps required to interactively input an ACR code; and

10 Figure 8 is a flowchart illustrating the steps of step 2 of Figure 3 when storing images in the database.

Description of Preferred Embodiment

To refer to Figure 1, the system consists of a database 1, an image server 2, a MIRC server 3, a web server 4, and a GUI 5 operating on a user's machine.

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The database 1 is a relational database. It stores all information for the system, including database tables, database indexes, and database scripts. It also stores the pointers to the physical files of the system. The image server 2 communicates with the clinical image archive, queries and retrieves medical images and patient data, study data, series data, and image-related information from them.

20 The MIRC 3 server provides MIRC compliant functions, including MIRC queries and MIRC storage.

The web server 4 serves various requests received from a user via the GUI 5 on a user's machine.

The GUI 5 provides functions to access the system, and also provides MIRC file editing functions.

25 A more detailed structure is illustrated in Figure 2. Here, the image server 2 includes a PACS accessor 6 that is used to query and retrieve images from the PACS 14; a DICOM receiver 7 that is used to receive the images retrieved from the PACS 14 by the PACS accessor 6; a DICOM anonymizer 8 that is used to anonymize the images received from the PACS 14 by the DICOM receiver 7; and Other Service 9 that includes PACS Ping (Echo), and so forth.

30 By anonymize (and its grammatical equivalents) it is meant that predetermined identification details of the patient, study, and so forth, are made anonymous so that a reader cannot determine the identity of the patient, study, or the like.

An MIRIP servlet 10 runs in the web server 4 to service requests from the GUI 5, and MIRIP client 11 is a user interface that can be run in a web browser or as a stand alone application on the user's machine.

- 5 MIRC storage 12 is part of the MIRC server 3 and provides an MIRC teaching file storage service for the database 1 and for a user's machine. MIRC query 13 is also part of the MIRC server 3 and provides queries as defined by the MIRC scheme.

The method is illustrated in Figure 3 and includes the steps:

- 10 1. retrieving medical images from the clinical image archive 14;
 2. storing the retrieved medical images in the database 1;
 3. anonymizing the patient information so that the user cannot obtain the patient information;
 4. generating the database record for the teaching file;
 5. generating the XML file;
 15 6. saving the XML file into the database 1;
 7. generating the indexes of the teaching files; and
 8. providing a searching mechanism.

Figure 4 illustrates the first step (1) of the method - retrieving medical images from the clinical
 20 image archive. The radiology department of a hospital generates a large number of medical images every day. Most images are in digital format, and are stored in the clinical image archive – PACS. Images are generally typical or atypical. But they may be particularly suitable for generating teaching files. Clinical image archives are for clinical purposes only and use a specific communication protocol named DICOM.

25 The method of the present invention can interface with the clinical image archive 14; and retrieve images and patient specific information. The retrieval process itself is in accordance with the DICOM protocol. The retrieval may be in batches or interactively. When in batches, medical images and information relative to those images can be retrieved automatically using groups of patient
 30 identifiers, or study identifiers. When interactive retrieval is required, the GUI 5 is able to query the clinical image archive 14 by categories, and user-selected studies may also be retrieved.

For batch retrieval, the user provides a file containing the patient ID or the study UID. The PACS
 35 accessor 6 of the image server 2 reads the file, and retrieves the corresponding medical images from the clinical image archive 14 according to the patient IDs. In the instance of one or more

studies being retrieved, the study UUIDs listed are used to locate and retrieve the required images. In both instances the required patient specific information is also retrieved with each image or study, as the case may be.

- 5 When retrieval is interactive, the user queries the clinical image archive 14 through the GUI 5. Instructions are passed from the GUI 5 on the user's terminal to the PACS accessor 6. The PACS accessor 6 interrogates the clinical image archive 14, finds the patient or study of interest, and retrieves the required images. The user can also work on a diagnostics imaging workstation, using the interface provided by the workstation, and send the retrieved images to the image server 2.
- 10 The process ends when all IDs have been processed.

- Figure 8 shows the process steps involved in storing images in the database 1. When the image server 2 receives an image from the clinical image archive 14, the image server 2 first stores the image in a temporary disk directory and then validates the image according to the DICOM standard.
- 15 If the image is not a valid DICOM image, it discards the image. Image server 2 then checks in the database 1 for duplication. If the image already exists in the database 1, image server 2 moves the image file into a duplication directory. If the image is not in database 1, the image server 2 queries the clinical image archive 14 to retrieve the relevant patient, study, series and image information, and merge the information with the information embedded in the incoming image file; and stores the
 - 20 information in the database 1.

- The retrieved medical images and patient information are stored in the database 1 for further processing. Other useful information may also be extracted from the images and stored in the database. This other information may be indexed by patient's name, patient ID, study ID, series ID
- 25 and image ID for the ease of searching.

- Since medical images are usually large in size, they take a large amount of disk space for storage. The image can be spanned to multiple storage media. When the current storage medium reaches its maximum capacity, a storage medium with sufficient free space is found and further images for
- 30 storage are sent to that storage medium.

To now refer to Figure 5, as patient-specific information retrieved from the clinical image archive 14 is very sensitive, it can only be referenced internally. It is not allowed to appear in teaching files, which may be published. Patient sensitive information can't be simply removed from the teaching

files. Sometimes it is required to refer back to the actual patient. So patient sensitive information needs to be made anonymous – or anonymized.

Whenever a whole study is received and stored in the database 1, the anonymizer 8 of image server 2 automatically starts to anonymize the images. The image server 2 keeps the correspondence relationship between the sensitive information and the anonymized code in the database 1. Image server 2 also provides a method to reveal the information before anonymization by looking up the database 1, but this method can only be used internally.

Sensitive information includes, but is not limited to, for example:

- Patient's name
- Patient ID
- Other patient's names
- Other patient IDs
- Patient's birth name
- Patient's address
- Patient's telephone numbers
- Patient's mother's birth name
- Region of residence
- Country of residence
- Military rank
- Branch of service
- Patient comments
- Additional patient history
- Referring physician's name
- Referring physician's address
- Referring physician's telephone numbers
- All other person names

An anonymization code may have the format of:

<Prefix> <Type> - <Number>

where, *prefix* is usually short alphabet characters or letters, which represents the creator of the anonymized information. Typically the acronym of the creating institute is used, for example, "BIL".

The *prefix* is generated during the initial set-up of the system

Type specifies the nature of the piece of anonymized information. Since patient name and ID are most frequently referenced, a "P" and a "D" may be used to represent them respectively. An "X" may be used to represent all other types of information. Further classification is also possible, for example, an "A" can be used to represent address information. Again, the *type* is created during the initial installation of the system.

Number is a random number generated by a number generator within the anonymizer 8 in image server 2. The *Number* is unique and serves to distinguish the anonymized code from other codes. For example, a code, "BILP-3388", represents a patient name, is created by an organization named "BIL".

The steps illustrated in Figure 5 are used to anonymize one item of patient sensitive information. For each item of patient sensitive information, the anonymizer 8 checks if this item of information has already been anonymized by looking up a look-up table in the records of the database 1. If yes, the already created anonymized code is used. Otherwise, anonymizer 8 generates a new random number. Anonymizer 8 then adds the prefix and type to the random number to form the anonymized code. The specific items of sensitive information are replaced with the anonymized code. The correspondence relationship between the sensitive information and the anonymized code is stored in the database 1 in a secure manner. It is normally only accessible to those having access to such information. Denial of access may be by use of one or more of known techniques including, but not limited to, a firewall, access level, passwords, PINs, members of an Intranet, and so forth.

Figure 6 shows the steps used to anonymize all images in one or more studies or other large cluster of images. Here, after retrieval of all images, all studies that need to be anonymized are determined. The studies all processed for anonymization one-by-one. The images within each study are processed for anonymization one-by-one. For each image, all patient-sensitive information is found and anonymized using the method described above in relation to Figure 5.

By using this anonymization method, no patient-sensitive information is disclosed to those not entitled to view the information, but the information required to be revealed to all users can be revealed to all users, and that information only able to be revealed to certain users having access to the information can be revealed to those users only.

To generate the database record for teaching file, useful information, such as patient name, ID, sex, age, race, etc, gathered from the above steps can be used to automatically generate a teaching-file database-record.

- 5 Significant images may also be selected and inserted into the teaching file database record. They can also be deleted and re-ordered. Author information and affiliation information may be retrieved automatically from the database and then inserted into the teaching file database record.

10 The GUI 5 allows entry of other necessary information such as copyright information, title, difficulty level, access permission, publishing date, reviewer, abstract, keywords, clinical findings, image findings, radiological codes, diagnosis, diagnosis groups, pathology of condition, imaging of condition, differential diagnosis, similar cases, references, and so forth.

15 An ACR coding system may be used in the teaching file record. An ACR code has the following format:

`<aaaa> . <pppp>`

where `<aaaa>` is the anatomy part, and `<pppp>` is the pathology part. They are digits from 0 to 9.

20 As shown in Figure 7, the user is guided to input the ACR code step by step, or digit by digit. At each step, the system prompts the user with only the possible digits at the current position, and the text of corresponding meanings. As illustrated, the user inputs the anatomy codes first, and then any sub-anatomy codes. After completion of the anatomy code, the user is prompted to enter the pathology code, then sub-pathology code.

25 Based on the database record generated above, a teaching file complying with the MIRC scheme may be created. This may be in XML or other suitable format. The teaching file can also be previewed while editing, and it can be reloaded for modification.

30 An image inserted into a teaching file has two forms: a thumbnail, and a full image. The images may be in JPEG format, DICOM format, or other suitable format.

The case record and the XML file together with their images (thumbnails and full images) may be stored in the database for later access. Access may include indexing, searching and retrieving.

The teaching files stored in the database may be indexed under various categories for searching purpose. These indexes may include title, abstract, keywords, authors, affiliations, contacts, patient information, radiological codes, image format, image compression status, image modality, anatomic location, and so forth.

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Internet-based searching mechanisms may be provided. There may be two types of searching mechanisms, including internal searching and external searching. Internal searching is available to those members of staff of the medical facility who have access to patient records. As such, for internal searching, patient sensitive information may be revealed. For external searching, no patient-sensitive information is revealed as it is anonymized.

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Whilst there has been described in the foregoing, description a preferred embodiment of the present invention, it will be understood by those skilled in the technology that many variations or modifications in details of design, construction or operation maybe made without departing from the present invention.

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The present invention extends to all features disclosed both individually and in all possible permutations and combinations.

1. A method for retrieving medical images from at least one imaging archive and creating at least one teaching file; the method comprising:
directly retrieving at least one medical image from the at least one image archive;

5 storing the at least one medical image in a database;
generating a database record for the at least one teaching file;
generating the teaching file using the at least one medical image and additional information input by a user, the teaching file being compliant with at least one predetermined schema;

10 saving the teaching file into the database;
generating at least one index of the teaching files; and
automatically anonymising patient identification data when the at least one medical image is retrieved from the at least one image archive.

2. A method as claimed in claim 1, wherein a searching mechanism
15 for searching the teaching file is provided.

3. A method as claimed in claim 1, wherein when the at least one medical image is retrieved from the at least one clinical database, patient-specific information related to the at least one medical image is retrieved with the at least one medical image.

20 4. A method as claimed in claim 3, wherein the patient-specific information includes sensitive information, the sensitive information being subjected to an anonymization process.

5. A method as claimed in claim 4, wherein the anonymization process includes the steps of replacing each item of the sensitive information with an
25 anonymization code.

6. A method as claimed in claim 5, wherein the anonymization code includes a randomly generated number, a prefix and a type.

7. A method as claimed in claim 6, wherein the prefix is a short string of characters representing the creator of the sensitive information; and the type represents
5 nature of the sensitive information.

8. A method as claimed in claim 6, wherein a check is first performed to determine if the item of sensitive information has previously been anonymized and the anonymization code previously generated; and, if yes, retrieving and using the previously generated anonymization code.

10 9. A method as claimed in claim 4, wherein the sensitive information includes one or more items selected from the group consisting of: patient's name, patient ID, other patient's names, other patient IDs, patient's birth name, patient's address, patient's telephone numbers, patient's mother's birth name, region of residence, country of residence, military rank, branch of service, patient comments, additional patient
15 history, referring physician's name, referring physician's address, referring physician's telephone numbers, and all other person names.

10. A method as claimed in claim 1, wherein retrieval of the at least one medical image is in batches or interactive.

11. A method as claimed in claim 10, wherein when retrieval is in
20 batches, a plurality of medical images and information relative to the plurality of medical images is retrieved automatically using groups of patient identifiers.

12. A method as claimed in claim 10, wherein when retrieval is in batches a plurality of medical images and information relative to the plurality of medical images is retrieved automatically using groups of study identifiers.

13. A method as claimed in claim 11, wherein the retrieval is by a PACS accessor of an image server reading and retrieving the plurality of medical images from the at least one clinical image archive according to the patient identifiers.

14. A method as claimed in claim 12, wherein the retrieval is by a
5 PACS accessor of an image processor reading and retrieving the plurality of medical images from the at least one clinical image archive using the study identifiers.

15. A method as claimed in 10, wherein when retrieval is interactive, the at least one clinical image archive is queried using a graphic user interface and instructions are passed from the graphic user interface to a PACS accessor of an image
10 server, the PACS accessor interrogating the at least one clinical image archive, finding at least one medical image of interest, and retrieving the at least one medical image and information relative to the at least one medical images.

16. A method as claimed in claim 13, wherein the at least one medical image is received from the at least one clinical image archive, the image server first
15 storing the image in a temporary disk directory and validating the at least one image according to a DICOM standard; and, if the at least one image is not a valid DICOM image, the image server discarding the at least one image and checking in the database for duplication.

17. A method as claimed in claim 16, wherein if the at least one image
20 already exists in the database, the image server moves the at least one image into a duplication directory.

18. A method as claimed in claim 16, wherein if the at least one image is not in the database, the image server queries the at least one clinical image archive to retrieve relevant patient, study, series and image information, and merges the information

with the at least one medical image; and stores the information and the at least one medical image in the database.

19. A method as claimed in claim 18, wherein the at least one medical image and information are stored in the database and indexed by one or more selected
5 form the group consisting of: patient's name, patient ID, study ID, series ID and image ID.

20. A method as claimed in claim 1, wherein the at least one medical image is spanned to multiple storage media by determining when a current storage medium reaches its maximum capacity, finding a further storage medium with sufficient
10 free space and are sending further medical images for storage to the further storage medium.

21. A method as claimed in claim 1, wherein the at least one teaching file is in accordance with a Medical Imaging Resource Centre standard.

22. Apparatus for retrieving medical images from at least one image
15 archive and creating at least one teaching file; the apparatus comprising a database, an image server, a MIRC server, a web server, and a graphic user interface for operation on a user's machine.

23. Apparatus as claimed in claim 22, wherein the database is a relational database for storage of all required information, including database tables,
20 database indexes, database scripts, and pointers to the medical images and teaching files.

24. Apparatus as claimed in claim 22, wherein the image server is for communicating with the at least one clinical image archive, querying and retrieving the at least one medical images, and patient data, study data, series data, and image-related information from the at least one medical image.

25. Apparatus as claimed in claim 22, wherein the MIRC server provides MIRC compliant functions, including MIRC queries and MIRC storage.

26. Apparatus as claimed in claim 22, wherein the web server serves requests received from a user via the graphic user interface on a user's machine; the
5 graphic user interface being for providing access functions and MIRC file editing functions.

27. Apparatus as claimed in claim 22, wherein the image server includes a PACS accessor for querying and retrieving images from at least one image archive.

10 28. Apparatus as claimed in claim 27, wherein the image server includes a DICOM receiver for receiving the at least one medical image retrieved from the at least one image archive by the PACS accessor.

29. Apparatus as claimed in claim 28, wherein the image server further includes a DICOM anonymizer for anonymizing the at least one medical image received
15 from the at least one image archive by the DICOM receiver.

30. Apparatus as claimed in claim 22, wherein an MIRIP servlet is provided in the web server to service requests from the graphic user interface.

31. Apparatus as claimed in claim 22, wherein the graphic user interface includes an MIRIP client as a user interface able to run in a web browser or as a
20 stand alone application on a user's machine.

32. Apparatus as claimed in claim 22, wherein the MIRC server includes an MIRC storage for providing an MIRC teaching file storage service for the database and for the user's machine.

33. Apparatus as claimed in claim 22, wherein the MIRC server includes an MIRC query to provide queries as defined by the MIRC scheme.

34. Apparatus as claimed in claim 22, wherein the at least one teaching file is in accordance with a Medical Imaging Resource Centre standard.

5 35. Computer useable medium comprising a computer program code that is configured to cause a processor to execute one or more functions to perform the method of claim 1.