MacRad: A Case-Based Retrieval System For Radiology Image Resources

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For reference purposes, radiologists need access to an image resource that provides a significant number of solved case problems and offers searches based on combinations of radiologic findings. Our goal is to capture the expertise of specialists in radiology and codify that knowledge in the form of radiology cases. The overall goal is to develop a radiology image retrieval system that would use a case-based reasoning paradigm to allow radiologists with different levels of expertise to formulate image content-based queries when searching for reference images.

We have compiled a case-based retrieval system, MacRad, that is structured around descriptors for radiology image findings. MacRad is implemented as a part of a relational database with an image archive.

Case representation: The case in our database is referred to as an example that presents a particular abnormality pertaining to a specific body location. The case is defined based on the diagnosis, the location of the anatomical lesion, and the age group. The diagnosis for a case is represented as a list of features that lead to a particular outcome. A set of images is related to each case. Images are grouped according to the modality. Each image in the library is indexed according to its radiologic content.

Case indexing: MacRad encodes image content using verbal descriptors for the domain-specific logic that underlies the image findings. We structured an index for coding image content as a hierarchical image description index using the relational format. We use a semantic hierarchy in which higher level interpretations incorporate lower level findings - basic observations. Findings have assigned an importance value. This index of radiologic findings facilitates multilevel query formulation according to the user's level of experience.

Case retrieval: At present, image retrieval in MacRad is accomplished through template matching with backtracking. Database records are retrieved based on a sum of features in the input case that matches cases in the library. The important features are considered in the first order and determine the minimum range of the match. The order of case presentation is based on the differential diagnosis lists stored in the decision table and the number of matched features. The decision table uses two diagnostic cues (age of the patient and location of the lesion) and the judgment of neuroradiology experts regarding the probability of a given diagnosis. The system uses rules to control the backtracking for incomplete matches and to generate lists of diagnostic hypotheses. Rules are embedded within the database structure.

Case adaptation: MacRad offers tools for adapting the retrieved case, but the process of adaptation is left to the user. Adaptation tools include: discussion text files attached to particular cases, lists of differential diagnoses that represent pathologies which may be confused with particular cases, diagnosis field for a case provides a keyword to the radiology information resource that allows retrieval of textbook-like documents describing a particular pathology with exemplar images.

Functions: We are using MacRad in a multi-user configuration that is accessible through the radiology department network (4D Server and 4D Client, ACI US, Cupertino, CA). 4th Dimension-81 can be used as client/server front end tool not only for the 4D Server but also when connecting to other SQL databases. Each user may connect to an image database located on a server from his/her own Macintosh. MacRad has three functions. 1) MacRad provides a case-based retrieval system for a radiology case resource. MacRad is a part of the larger project called Radiology Resource and Review - R3. MacRad allows retrieval of images from R3 based on the radiologic features. Whereas, R3 provides textual and pictorial reference source for case adaptation purposes used in MacRad. 2) MacRad provides teaching applications with an access to a case library to allow the use of feature-coded cases for instruction. 3) MacRad functions as a diagnosis support tool. MacRad helps the user reach a diagnosis by providing images from proven cases that match the description of a specific case being evaluated with a list of differential diagnoses. Relevant images and a textual description are produced for comparison to the case in question based on the search criteria defined by the user. The user may browse through retrieved cases, zoom images, make a correlation between different procedures, or access textual information as needed. At present, MacRad's indexing system is used to encode 300 cases with 3,000 images that present intracranial masses on skull X-rays, CTs, MRIs, and angiograms.

Summary: We envision that MacRad will become part of the picture archiving and communication system (PACS) and teleradiology environment. Testing of the indexing and retrieval system in clinical settings will determine whether the system design has the potential to make MacRad a welcome addition to daily diagnostic practice in radiology. Future research will involve automated indexing of image findings and assessment of the system's impact on practice of radiology.