Archimedes, Archive of Medical Images

http://www.cs.umd.edu/~hjs/escience.html

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Introduction

Breast cancer is one of the leading causes of death in women. Mammography is currently the most cost-effective method for early detection of breast cancer. Between ten to thirty percent of women with breast cancer have negative mammograms, and in about two-thirds of these cases the cancer is evident upon review. Computer aided detection (CAD) and pre-screening can be used to increase the effectiveness of radiologists to avoid these missed diagnoses. Alternative medical imaging approaches such as ultrasound or MRI could be more effective than mammography at detecting cancers or evaluating malignancy in certain types of women.
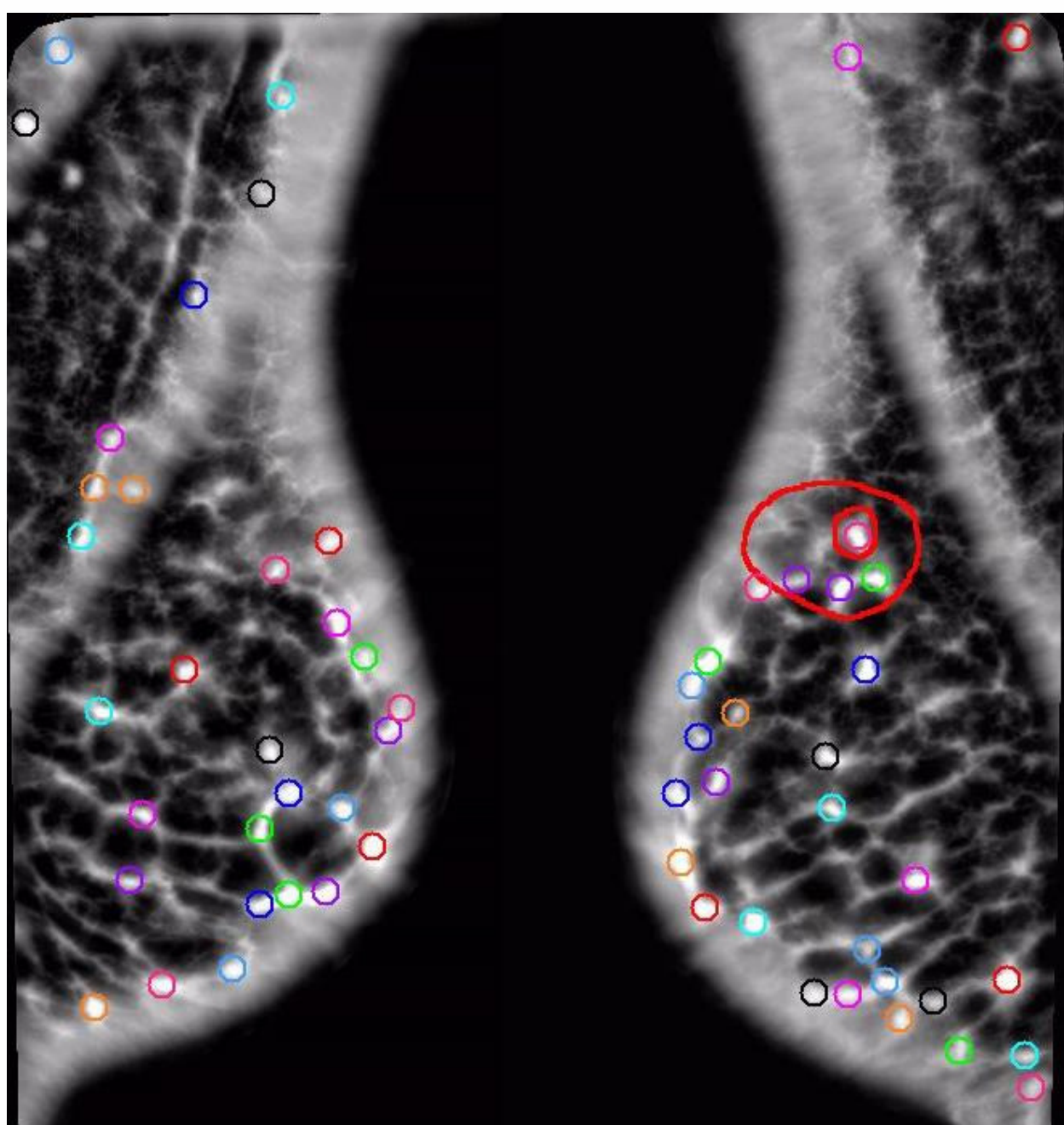
A large database of medical images with analysis is required to help train and test the CAD and pre-screening systems. A database with images from multiple technologies like mammograms, MRI, and ultrasound will also enable research into the effectiveness and usefulness of each technique at cancer screening and the determination of malignancy. We propose to create and store this database called Archimedes (an ARCHIve of MEDical imagES) using SQL Server and use it to provide doctors with a web-based query tool to access the data.

Use of such a tool will allow doctors to improve the effectiveness of CAD and prescreening systems by building and testing better diagnosis criteria. Doctors will be also able to compare the effectiveness of various medical imaging technologies on this database, as well as find cases similar to a current patient thereby improving the accuracy of the diagnosis. We have developed a pictorial query specification system for this tool that enables users to specify queries by identifying the desired shapes or characteristics and specifying the spatial relationship between them using distance and direction.

Incorporating our spatial pictorial query searching techniques into the database would provide greater flexibility and power thereby allowing doctors to query the images by content and hence search for similar structures or groups of features in cases. For example, such a capability would permit a doctor to find the percentage of similar cases that were malignant, thereby helping recommend biopsy procedures. Most importantly, with such a capability, doctors could also define their own feature sets in an attempt to improve on the cancer detection methods like CAD and pre-screening by enabling them to diagnose patients by searching for similar feature sets. Thus what we are trying to provide, in part, is a means for doctors to perform exploratory data analysis where they do not need to rely on predefined diagnosis methods. Alternatively, through the pictorial query specification method, doctors will have more freedom to test out hypotheses and provide better care for their patients.

The image above is the left and right breasts of a patient with a large and obvious cancer outlined in red, but the texture is very similar to the normal tissue. Thus shape is very important, as well as a comparison of the left to right breasts.

The main interface provides users with a menu of tools to manage patients and options for a multi-faceted image search based on image features or patient data.

User Interface of Archimedes

The graphical user interface is arranged into four major sub frames: Search Results, Search, Notes, and Data.

Search Results: Shows the image results by thumbnail and associated data as determined from the patient key. It also displays the patient's name and age as well as the number of images in the associated set and a quantitative measure of the effectiveness of the match.

Notes: The text field which returns the patient information specific to the image being viewed. It allows the doctor the ability to make and save notes (termed annotation) specific to the image for future reference.

Search: Contains all the search options available to the user. Currently, the user may search by one of two different methods: 1) Shape-based search, where the user can search by a number of pre-defined shapes, and 2) Text search of the patient information or image annotations. Additional search capabilities are still in development.

View Image: Shows the currently active image as well as associated patient data. Patient data is only available to authorized doctors, while images can be made public. Users can see thumbnails of the previous and next images in the set, and can move through the images associated with a patient by set and by image.

Mammograms of the left and right breasts, MLO view. The tiny multi-colored circles are shape features, while the thicker red lines are the hand-drawn annotation of a cancer by a radiologist. The shape features cluster in and around the cancer, but there are many false-positives. Combining multiple shape features with a spatial query could reduce the number of false-positives. Additionally, comparing the left and right breast features in a spatial query could also improve the performance, as could a distance query which would pick out the clustering of shape features.

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Search results are returned as a set of thumbnails along with minimal patient information. Selecting a thumbnail from the search results provides users a full size view of the image with detailed patient information, doctors annotations and overlays.

Functionality of Archimedes

Shape Based Search
The shape-based search capability of Archimedes enables users to search for predefined and user-defined shapes within medical images. This ability is useful for doctors who would like to locate existing information on a specific shape of a tumor. Doctors are provided the flexibility of searching on the basis of existing, pre-defined shapes or by drawing their own user-defined shapes that will subsequently be added to the list of pre-defined shapes.

Spatial Search
The spatial search capability of Archimedes provides users with the ability to determine the relative positions between two shapes on an image. The user can either use pre-defined shapes for this search, or create a user-defined shape that will be added to the list of pre-defined shapes. Doctors can use this function to determine the relative spatial positions of shapes or tumors on a patient and use that information as reference in diagnosing current patients.

Distance Search
The distance search capability of Archimedes enables users to determine the distance between two shapes within an image. The user can either use pre-defined shapes for this search, or create a user-defined shape that will be added to the list of pre-defined shapes. Doctors can use this function to determine the distance between shapes or tumors on an image and use this information as reference in diagnosing current patients.
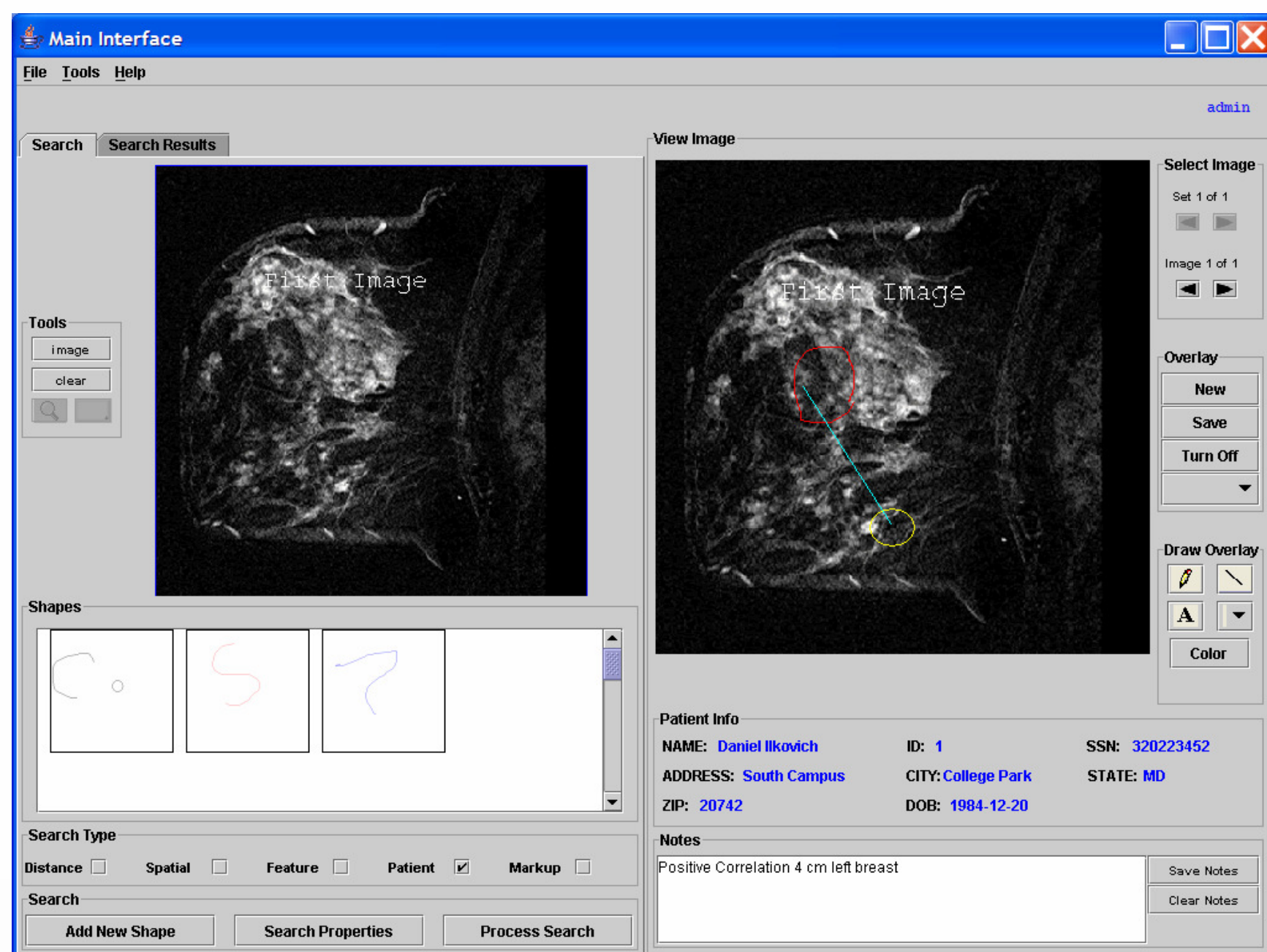
Annotate Images
The user is given the ability to associate plain text notes with a particular image. By clicking on the image, the user can also see a full-screen view of the image. Below the full-size image, the editable text box allows users to write notes pertaining to (i.e., annotate) that particular image. Multiple users are allowed to annotate the same image at the same time because they each make changes on a new overlay. If the user wishes to clear annotations, this is possible by clicking on the Clear Notes button located below the Save Notes button.

Textual Search
The user can perform a textual search on annotated images. The bottom portion of the Search Options screen enables the user to enter text into a text field that is then used to query all existing annotated images. Queries return images as the result of the search.

Overlay Image Features
Overlay Image features provide the user a virtual marker to highlight selected regions in an image. This tool allows the user to annotate a portion of the image to be highlighted with vector and pencil tools. On the overlay, the user can enter his or her annotations and use a save button to associate the annotations with the highlighted regions.

Selecting an image allows users to view detailed patient information, as well as annotate the image with text and multiple overlays which can be drawn using a mouse.

ARCHIMEDES
ARCHIVE OF MEDICAL IMAGES