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TITLE: A Partnership Training Program in Breast Cancer Diagnosis: Concept Development of the Next Generation Diagnostic Breast Imaging Using Digital Image Library and Networking Techniques

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| 14. ABSTRACT In this partnership training program, experts from Georgetown and Howard Universities participated in training through seminars, specialized tutorials and workshops. Further, we developed a large digitized mammography database of African-American patients. The database was made accessible through the web to support breast cancer research. We have accomplished the objectives of this 4-year project and have reached our goal. As a result, a large number of Howard faculty investigators and students, both undergraduate and graduate, have been trained for breast cancer research. Under this program, one Ph.D. student and three Masters students have successfully completed their theses and obtained their degrees from Howard University; four graduate students have entered the Ph.D. degree program of the ECE Department; and half a dozen of undergraduate students have successfully completed their degree work. More than a dozen academic papers have been published in both international journals and at international conferences based on the research activities of this partnership program. We have also developed a large-scale mammography database featuring Africa-American patients and a mammography research website, among other major achievements listed in this final report. | | | | | | |
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Abstract

In this partnership training program between Howard University and Georgetown University, our goal was to train faculty and students in breast cancer imaging, digital image database library techniques and network communication strategy. Experts from Georgetown University and Howard University participated in training through seminars, specialized tutorials and workshops. They provided the faculty investigators and students with opportunities to discuss and to broaden their knowledge in breast cancer, imaging, database library and networking. The first goal was to provide investigators at Howard with basic and updated breast imaging techniques as well as background knowledge in breast cancer diagnosis. Further, we developed a large digitized mammography database of African-American patients. The database was made accessible through the web to support breast cancer research. The optimal goal of this program was to equip Howard investigators with sufficient knowledge and tools in breast cancer and breast imaging that can lead them to conduct cutting edge research in the field. In Summary, the program objectives were:

1. Offering breast image and breast cancer related lectures and seminars
2. Preparation of training materials including breast images and case reports
3. Concept development in breast imaging research
4. Development of competitive research grants

We have accomplished the above objectives in this 4-year project and have reached our goal. As a result, a large number of Howard faculty investigators and students, both undergraduate and graduate, have been trained for breast cancer research. Specifically, during this partnership program, six students received IRB training, passed the NIH Human Subject Examination, and received their certificates. Ten students received trainings in breast imaging and working on specific training/research topics such as Advanced imaging enhancement technique for extracting breast cancer features, Display functions, Mammogram database, DICOM, Networking, and Database design and functions. Under this program, one Ph.D. student and three Masters students have successfully completed their theses and obtained their degrees from Howard University; four graduate students have entered the Ph.D. degree program of the ECE Department; and half a dozen of undergraduate students have successfully completed their degree work. More than a dozen academic papers have been published in both international journals and at international conferences based on the research activities of this partnership program. We have also developed a large-scale mammography database featuring Africa-American patients and a mammography research website, among other major achievements listed in this final report.

Introduction

This program was a collaboration between participants from the Howard University in the Department of Electrical Engineering, the Department of Systems and Computer Sciences, the Department of Radiology and the Cancer Center; and collaborating investigators from the Georgetown University Image Science and Information Systems (ISIS) Center. The training program consisted of three major components, namely: start up, training and research development stages. During the start up stage, the Howard faculty members were trained in breast cancer imaging. The faculty members have developed a unique database whose patients are African-American women. The database was made available online to the Howard University and to the investigators involved in breast cancer research and in training communities at large. They have also participated in an internship given by the Howard Radiology Department in an effort for them to understand the breast cancer screening and diagnosis viewing and related procedure as well as to observe breast cancer patterns on mammograms, ultrasound, and MRI images.

The Georgetown University investigators and the clinical members of the Howard University Hospital have offered a series of lectures and workshops on topics such as Breast Anatomy, Physics and Instrumentation of Mammography, Breast Ultrasound, Breast MRI, State-of-the-Art Ultrasound Instrumentation, Cancer Biology and Physiology, Breast Cancer Oncology and Management, and High-Performance Software Display Workstation for Breast Cancer Research.

Figure 1 shows the organization of this partnership training program.

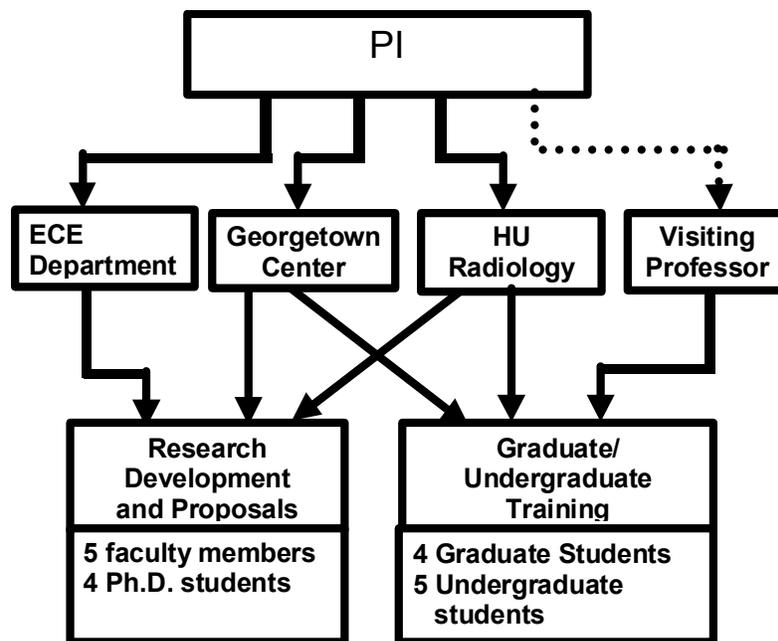


Figure 1. The organization of the partnership training program at Howard University (Department of Electrical Engineering)

2. Training and Research Activities

2.1. Lecture Series

Year 1: (Total 10 lectures were provided to the faculty members and students)

A. A Mammography SoftCopy Display Workstation for Breast Cancer Research - By Dr. Jerry Gaskil (January 15, 2002)

B. Program plan and Mammography Physics and Image Requirements (part 1) – By Dr. S-C. Ben Lo (January 29, 2002)

C. Mammography Physics and Image Requirements (part 2) – By Dr. S-C. Ben Lo (February 12, 2002)

D. Ultrasound Instrumentation - By Mr. Terry Correll of Philips/ATL (February 22, 2002)

E. Cancer Biology and Physiology - By Dr. Theodore Bremner (February 26, 2002)

F. Genetic Bases of Cancer - By Dr. Theodore Bremner (March 12, 2002)

G. Human Breast Anatomy - By Dr. Matthew T. Freedman (March 26, 2002)

H. Physics in Breast Ultrasound - By Dr. S-C. Ben Lo and Ms. Anita Sarcone (April 9, 2002)

I. Detection and Classification of Breast Cancer – By Ms. Lisa Kinnard (April 16, 2002)

J. Nuclear Magnetic Resonance Image - By Dr. Paul C. Wang (April 23, 2002)

Year2: (Total 11 lectures were provided to the faculty members and students)

A-D: Medical Diagnostics
Radiological Diagnosis I
Radiological Diagnosis II
Image Perception and Diagnosis
Perception and ROC Study
Matthew Freedman, MD, *Weeks of 1/13 & 1/20*

E. Transmission Ultrasound
Speaker: Peter N. T. Wells, PhD, DSc, MD *honoris*. (February 24, 2003)
Editor-in-Chief *Ultrasound in Medicine and Biology*

G. Detection of Microcalcifications on Mammograms (April 8, 2003)

H. Detection of Masses on Mammograms (April 15, 2003)

I. Mammography Physics and Image Requirements – By Dr. S-C. Ben Lo (April 21, 2002)

J. Visiting Radiology Department GUMC – By Dr. S-C. Ben Lo (April 28, 2002)

K. Installation and Preliminary of Kodak LS-85 digitizer - By RadInfo (August 15, 2003)

L. Kodak LS-85 Digitizer Functions and Training Sections for Mammogram
- By RadInfo (August 29, 2003)

Year 3: (Total 6 lectures and 1 workshop were provided to the faculty members and students at Howard University)

A. Program plan and Mammography Physics and Image Requirements (part 1)
– By Dr. S-C. Ben Lo (January 20, 2004)

B. Program plan and Mammography Physics and Image Requirements (part 2)
– By Dr. S-C. Ben Lo (February 3, 2004)

C. Nuclear Magnetic Resonance Image - By Dr. Paul C. Wang (February 17, 2004)

D. Genetic Bases of Cancer - By Dr. Theodore Bremner (March 2, 2004)

E. Mammographic Microcalcifications: - By Dr. S-C. Ben Lo (March 23, 2004)

F. Detection and Classification of Breast Cancer- By Dr. S-C. Ben Lo (April 16, 2004)

G. Grant applications and review (May 21, 2004)

A mini-workshop (last 3 hours) – By Dr. S-C. Ben Lo, Dr. Chouikha and Dr. Jianchao Zeng

Year 4: The partnership program moved on to a more research oriented direction

A. Biweekly meeting and progress report – coordinated by Dr. Chouikha and Dr. Lo

B. Medical Imaging Course – offered mainly by Dr. Jianchao Zeng (Since Fall Semester of 2004)

Part 1. Signals and digital images

Part 2. Introduction to medical imaging

Part 3. Medical image processing and analysis

2.2. Digitization of Film-based Mammograms and Development of a Mammography Database

Goal of the project:

The ultimate goal of this phase of the Breast Cancer Training Project was to produce a database of digitized mammograms that were taken from Africa American patients.

Project Advisors: Dr. Ahmed Jendubi, Dr. Paul Wang, and Dr. Jiancho Zeng

Students: Ms. S. Ross, Ms. O Ejeofodomi, Mr. O. Juma, Mr. L. Debo, Mr. Monyenye.

Description of Tasks

Part A – Initial training instruction

1. Write a report describing mammography
 - Define mammography
 - Describe how mammography works
 - Forms of abnormalities (calcifications vs. masses)
 - Describe malignant and benign image features
 - Describe clinical mammographic procedures
 - Define breast density and its role in breast cancer diagnosis
2. Compile a list of helpful digital mammography tutorial web sites
3. Compile a list of digital mammography database web sites
 - Select the most well organized database and identify items that would prove to be useful to researchers who would like to use the Howard University database (e.g. – ethnicity, shape description of abnormalities, pathology of abnormalities, et cetera)
4. Study various lossless compression methods in an effort to determine the best method for compressing the database images
5. Determine a naming scheme for the digitized images
6. Determine the best method (e.g. – excel spreadsheet) for recording image data (filename, film size, pathology)
7. Digitize mammograms provided by the Howard University Hospital (HUH)

Part B – Procedure and Tasks

1. Digitized two hundred sixty (260) cancer cases (~2000 images).
Resolution: 50 microns [4,000x5,000x2bytes (i.e., 40Mbytes/image)]
Types: CC and MLO
Number of images: typically 4 – 10 images per case.
2. For each patient (i.e. for each case), we have gathered all information as listed by the radiologist and tabulated it for inclusion in the Mammography Database.
3. Copy all data to external hard disks and CDs.

Result of the project.

By the end of year 4, we have digitized 260 breast cancer cases [~2000 images]. A preliminary work of establishing mammography database (image and text) featuring Africa American patients has completed. A journal paper reflecting this work is now in press by the Journal of Digital Imaging.

2.3. D-Viewer and User Interface for Displaying Mammograms

Project leaders: Dr. Jendoubi

We have developed a research workstation for mammography. The initial system interface is shown in Figure 2 and its detailed system components are given below.

The '*D-Viewer*' has been able to cater for the important functions that this imaging software will eventually possess. It serves as a training and research tool:

1. Image display.
2. C-Sharp(C#) programming language.
3. Image processing and functions.
4. Annotation, markup and cropping on mammogram.

5. Segmentation of breast lesions.

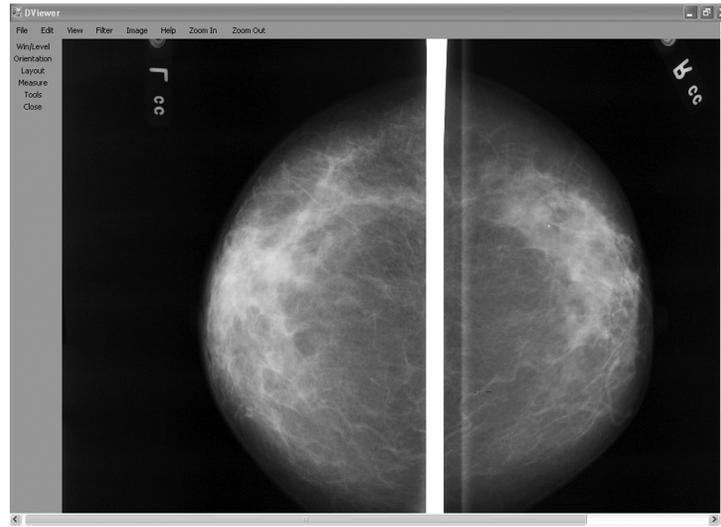


Figure 2 D-Viewer Interface

2.4 Development of Breast Cancer Research & Training Website

Project leaders: Drs. Chouikha, Jendoubi, Zeng, Humphries

Intended project goal: To perform collaborative and computer assisted diagnosis

System component:

- DB: Howard University Radiology Department (> 200 African-American Cases) (not all the same)
- Data: Case history (> 3000 images)
- Web Interface (Figure 3)
- Grid Based Repository (Figure 4)

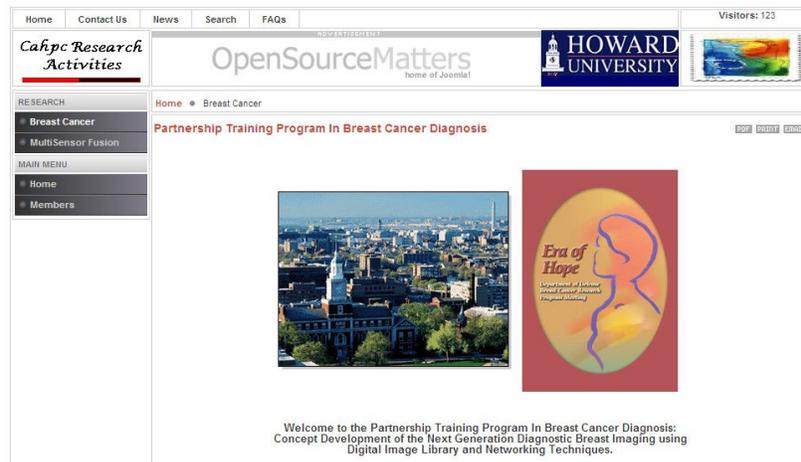


Figure 3 Website Front Page

Additional functional development for the mammography web

Collaboration with the Center for Applied High Performance Computing (CAHPC), the University of Maryland and the QuaTeams, Inc. High-resolution mammograms and advanced algorithms must be accessible for them to be useful. To that end we have designed and are in the process of implementing a new end-to-end system that leverages our existing database and research technologies along with advances in technologies from high performance computing, and Grid or Cyber-infrastructure (Figure 4). The purpose is to make the cases in the database and our technologies accessible to researchers and students over the network via an intuitive web-accessible locate data and services that may be distributed over "the grid" and span organizational boundaries. The prototype was designed around proven cyber-infrastructure technologies such as the Globus Grid toolkit and the San Diego Supercomputing Center's Storage Resource Broker (SRB). The initial version includes an interactive client that provides the ability to sign and annotate mammograms and to request and receive "consults" from radiologists, researchers, instructors, or even expert systems and to find additional cases. Additional functionality is planned to include security certificates, content-based retrieval, and the ability to visualize pathology slides.

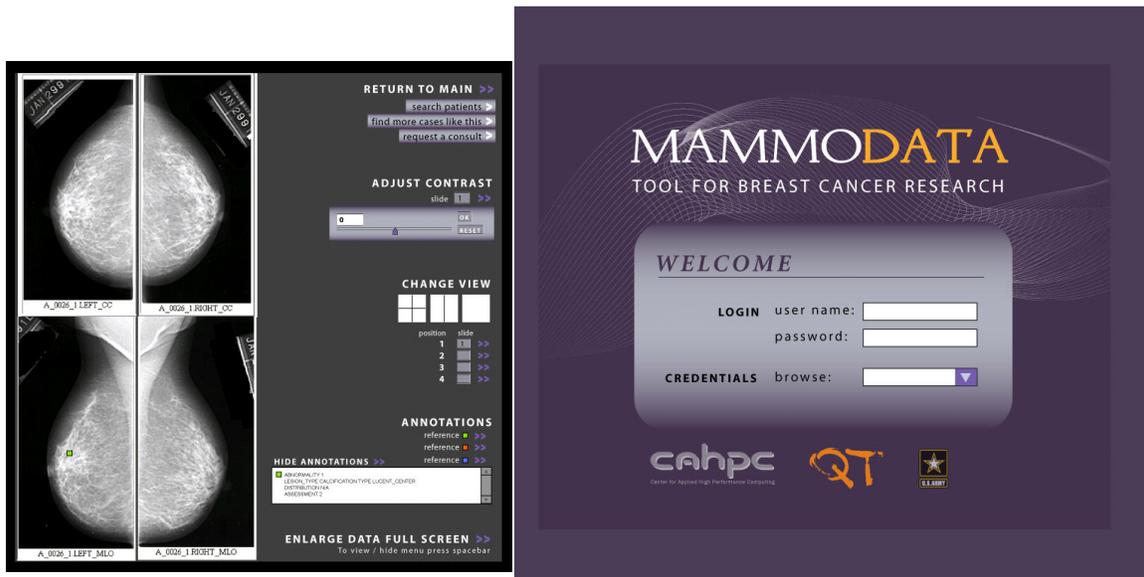


Figure 4. The Mammodata System

2.5 Multi-Component Image Feature Analysis of Breast Imaging

Project leaders: Dr. Chouikha, Dr. Lo

Student: Mona Elshinawy

Project goal: Design a proper filter bank to enhance the mammography mass features

Results of the project:

1. Development of the filter bank using AM-FM modeling technique for mammography mass feature extraction.
2. Development of a needle diagram based on AM-FM modeling technique. This method potentially provides a new research avenue for the analysis of breast lesions.

3. Other related activities:

In year 4 and the no-cost extension period, the partnership team has taken on the following additional actions:

- a. Contacted NIH/NIBIB training program division and visited the division in the winter of 2005. The director of NIBIB training program division and two additional members briefed us the procedure and potential in getting NIH training grant.
- b. Participated in HBCU/ MI Partnership Training Award Reverse Site Visit, April 12-23, 2006.
- Sponsored by Army Breast Cancer research Program
Nine Army HBCU/MI awardee sites were invited to participate in the meeting and to report the progress of the individual project.
- c. During this training program, the ECE Department has represented Howard University and worked with other 3 Universities in Washington District of Columbia in a biomedical engineering consortium – WABME: Washington Academy of Biomedical Engineering (Georgetown University, Howard University, George Washington University, and Catholic University of America). Numerous research meetings and workshops have been organized by WABME.

4. Major Accomplishments

- Provided lecture series in breast imaging and cancer biology (all in graduate level) for the faculty and students in the Electrical and Computer Engineering Department, Howard University.
- Completed the mammography digitization project and developed a mammography database featuring Africa-American patients.
- Established a mammography research workstation.
- Established a mammography research website.
- Four faculty level members and 10 students actively involved in the training/research project. Additional 20 students participated in the seminar and courses. Specifically, six students received IRB training, passed NIH Human Subject Examination, and received their certificates. Ten students received the training in breast imaging and working on specific training/research topics such as: Advanced Imaging Enhancement Technique for extracting breast cancer features, Display functions, Mammogram database, DICOM, Networking, and Database design and functions. One student worked on a mentored research project and received her MS degree. Her thesis is entitled “Using Gabor Filters Bank on Mammograms: The First Stage of The AM-FM Modeling Technique.” One additional student completed summer internship at Georgetown ISIS center working on mammography image processing.

5. Reportable Outcomes

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2. Kinnard L., Lo S-C. B., Wang P., Freedman M.T., Chouikha M, "Separation of Malignant and Benign Masses using a Maximum-Likelihood Analysis and Neural Networks," SPIE Med. Imag. Vol. 4684, 733-741, 2002.
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12. Shani Ross, O.tega Ejofodomi, Ahmed Jendoubi, Mohamed Chouikha, Ben Lo, Paul Wang, Lisa Kinnard, and Jianchao Zeng, "A Mammography Database and View System for African American Patients", in press by Journal of Digital Imaging, December 2006.