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This proposed training program is planned for undergraduates majoring in electrical engineering, medicine science or radiology. The program was designed as following: They were guided to visit the clinical site of related devices for mammography, the biopsy process for patients with suspicious breast tumor in Moffitt cancer center. They visited the process of film-screen image converting and transmitting and display of processed medical images in the laboratory of Digital Medical Imaging Program (DMIP) in the cancer research institute. It helped trainees to set up perceptive understanding on mammography for breast cancer diagnosis. The trainees were given a series of lectures on the basic principle of mammography, medical imaging, image processing, CAD methods, generation of databases and truth files, evaluation of CAD methods by means of lecture and seminars. The purpose was to teach trainees to have basic theory and technique on the breast cancer study. Trainees practiced on development of CAD modules and completed small scale projects related to CAD modules for breast cancer under mentors' direction. They submitted scientific report before the end of training program.

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Annual Report:

Development, Optimization and Evaluation of CAD System for Breast Cancer

Introduction:

Mammography plays an important role in the diagnosis of breast cancer. The problem with diagnosis of mass and microcalcifications is that different radiologists read mammograms differently Due to their different levels of skill and experience. It brings about the increase of medical image processing. Computer Assisted Diagnosis (CAD) for breast cancer detection becomes essential and second opinion for the diagnosis of breast cancer. CAD is a computer program that helps the radiologist make a judgment that what the likelihood of cancer is for a mass. In a study done with CAD, the radiologist's reading can get better and they are able to detect more cancers and avoid unnecessary benign biopsies. We believe that the development of CAD system will be a powerful tool in the evaluation of breast cancer appearing as mass and microcalcifications. In order to attract and train undergraduates who have interests and potentially become excellent researcher on the breast cancer study, we designed this undergraduate training program. This proposed training program is planned for undergraduates majoring in electrical engineering, medicine science or radiology. The program was designed as following: They were guided to visit the clinical site of related devices for mammography, the biopsy process for patients with suspicious breast tumor in Moffitt cancer center. They visited the process of film-screen image converting and transmitting and display of processed medical images in the laboratory of Digital Medical Imaging Program (DMIP) in the cancer research institute. It helped trainees to set up perceptive understanding on mammography for breast cancer diagnosis. The trainees were given a series of lectures on the basic principle of mammography, medical imaging, image processing, CAD methods, generation of databases and truth files, evaluation of CAD methods by means of lecture and seminars. The purpose was to teach trainees to have basic theory and technique on the breast cancer study. Trainees practiced on development of CAD modules and completed small scale projects related to CAD modules for breast cancer under mentors' direction. They submitted scientific report before the end of training program.

BODY OF REPORT

The training program is designed as three stages: visiting, lecturing, practicing and doing projects.

(1). Visiting

In order to get a basic understanding of mammography and the role of medical image in the breast cancer diagnosis, the trainees will be scheduled to visit the Moffitt cancer center, where they will see the clinical implementation of X-ray mammography or direct digital mammography devices to learn the process of mammography. In addition, they will observe the biopsy method for the patient who is diagnosed with suspicious tumor based on their images. Noticing the pain that the patients suffer from during the biopsy, the trainees will get a deep impression about how important correct diagnosis of breast cancer based on the mammography for patients is. The undergraduates will visit the laboratory of DMIP to learn the conversion process of the film-screening image into a digital one, the generation of medical image database, the display of medical image on computer, and medical image processing. It will give trainees the understanding that CAD methods for mass and MCCs detection are helpful for breast cancer diagnosis.

(2). Lecturing

A series of lectures or seminars by mentors and other scientists in breast cancer study are planned for training undergraduates for them to obtain thorough understanding of mammography and find more interest in the study of CAD for breast cancer, which includes:

(a) General introduction of the development of mammography, emphasizing on its importance in the future and on the diagnosis of breast cancer.

(b) The features of breast tumor, the behaviors of mass and microcalcification clusters (MCCs) on X-ray images, the difference between benign and malignant tumor.

(c) The generation of image database and truth files.

(d) Basic principle of medical image, including film-screen mammography and direct digital mammography.

(e) Basic theory of image processing, including: enhancement, segmentation, feature extraction, selection and classification.

(f) Basic principle of pattern recognition and feature classification.

(g) The development of CAD methods for breast cancer detection. The emphasis will be placed on the detection of mass and MCCs with this technology.

(3). Practicing

In this training stage, undergraduates will be divided into three groups with different subjects based on their major and their interests. Students majoring in Electrical Engineering or Computer Science will mainly be divided into two groups: one group for development and optimization of CAD methods for mass/MCCs detection; another one for evaluation of CAD system with retrospective study. Trainees in medical science or radiology including some students in computer science will create one group to generate image databases and truth files.

(4). Projects

A series of small-scale projects are designed for trainees by mentors that are related to the mentors' current research topics. These can be done by students under supervision of relevant mentor.

(1). Investigate the development of image preprocessing modules: It is the first and important stage in image processing. Several methods for this module have been developed with different algorithms, some of them the student has studied. We are trying to develop new adaptive image preprocessing modules. The trainees will take part in parts of this research project to learn about the development of contemporary CAD preprocessing methods. They performed comparison test among current developed methods through computer programming for different image databases. After finishing the work, the trainees wrote a report about the performance comparison of the CAD module with different image databases. During training, the trainees were encouraged to propose their own methods for this module and to do related computer programming.

(2). Generation of image databases and truth files: databases of film-screening mammography have been configured and are being expanded, the databases for direct digital mammography have been developed. The trainees generated databases for different kinds of images under the direction of mentors and research assistants. They learnt to construct the truth files for image databases. The student was required to submit reports about the constructed image database and related truth files.

(3). Development of Adaptive CAD module for false positive (FP) reduction: Sensitivity and false positive rate are two factors that greatly affect the clinical trial of CAD modules. For a long time, these two performance factors of CAD system were not suitable for the clinical use. Efforts are placed on searching an ideal method that can obtain high sensitivity and keep low false positive rate. The trainees worked on the investigation of the current literature. In our medical imaging Lab., a new kind of adaptive CAD system for false positive reduction has been developed. The trainees assisted the mentor to test the performance of developed CAD methods. The students submitted a report on the performance of new module for FP reduction.

(4). Evaluation of CAD system for breast cancer study: so many CAD systems for mass and MCCs detection have been developed, which need retrospective study and clinical analysis. It is suitable to do this evaluation study. Following the guidance of mentors, the trainee performed retrospective analysis on current CAD modules using the data sets developed through the Department of Defense Breast Cancer Research Program (BCRP) grant to the University of South Florida (USF) (http://marathon.csee.usf.edu/Mammography/ Database.html) for film

screening mammography or the databases developed by themselves for digital mammography. Being familiar with evaluation method for retrospective study, the students presented evaluation reports for different CAD systems.

(5). The research project involves three parts. ***The first part*** is for initial optimization of each module performed using standard signal processing criteria, analysis of simulated images and comparison of segmented images of mass area to ground truth files. The adaptive techniques are used to improve image preprocessing CAD modules. ***The second part*** is focused on a novel, fully automatic and highly efficient method for CAD system full optimization based on the clinical objective. The objective function is built from a set of 2000 case mammograms that will contain: 200 mammograms with no lesion (normals), 1800 mammograms with masses of irregular, circumscribed, microlobulated, obscured, ill-defined and spiculated as defined in BI-RADS. ***In the third part,*** is to design a statistic test to validate the optimized algorithm model. This statistical method is the Hypothesis Testing with the Null Hypothesis (NH) of that the two parameter settings of the CAD system have the same performance. The students submitted a report on the above study.

Key Research Accomplishments

(1). Well done the project of "development and optimization of CAD modules". We have developed lots of CAD modules. At first, the trainees were given the detailed process for CAD module development, then they were given a designated projects that is related to mentors' current research work, the trainees were asked to complete the project under the mentors' direction. It helped them get thorough understanding of development of CAD modules. Moreover, what they are assigned to do is closely related to the modern development of CAD modules for breast cancer detection. This helped them pursue careers in breast cancer.

(2). Well done the generation of medical image databases and truth files: The trainees were directed by mentor to collect different images and related information, convert film-screening images to digital format with digitizer, and construct medical image databases for both film-screening and direct digital mammography. The students studied the feature of mass and MCCs under the direction of mentors.

(3). Well done the evaluation of CAD modules: so many CAD systems for mass and MCCs detection have been developed. They need retrospective analysis with testing databases, which is a suitable study for the trainees.

Reportable Outcome

Conference Abstract:

Wei Qian, Xuejun Sun and Robert Clark, " Research Project Design for Summer Training Program on CAD System" Technical Program for the U.S. Army Medical Research and

Materiel Command's (USAMRMC) Era of Hope 2002 DoD Breast Cancer Research Program Meeting, Orlando, Florida, September 25-28, 2002.

Conclusions

The long-term aim of this program is to encourage undergraduates pursuing the careers on breast cancer study, and to attract their interests on the development of CAD methods for diagnosis of breast cancer. The main objectives of this training program are:

1. Learning the basic principles of mammography and image processing, mastering basic methodologies for imaging breast cancer detection.
2. Stimulating trainees' interests on breast cancer study, encouraging students to pursue their academic career on the breast cancer study.

The trained undergraduates are planned to track their future careers to see the achievement of training program.