CURRICULUM VITAE

SHIH-CHUNG BENEDICT LO, PH.D.

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11355 Palatine Drive
Potomac, Maryland 20854
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Personal Data

Marital status: Married
Citizenship: US Citizen

Education

1971-1975   B.S. in Physics   National Cheng Kung University, Tainan Taiwan, R.O.C.

1980-1986   Ph.D. in BioMedical Physics   University of California, Los Angeles, California.

Professional Experience:

1986-1987   MRI & CT Scientist   Philips Medical Systems Inc., Shelton, Connecticut.
                                                Tomography Department: MRI & CT

1987-1992   Assistant Professor of Radiology Georgetown University Medical Center

(6/1987-12/1987   represented Georgetown University Medical Center as a Visiting Scientist working
                   at AT&T Bell Labs, 480 Red Hill Rd. Middletown NJ 07748)

1993- 1999   Associate Professor of Radiology Georgetown University Medical Center

2000-2012   Professor of Radiology   Georgetown University Medical Center
                  (Chief Scientist   Center for Imaging Science and Information Systems)

2006-   College Fellow, American Institute for Medical and Biological Engineering (AIMBE)

2007-2011   Adjunct Professor   Electrical Engineering and Computer Science
                                                Virginia Polytechnic Institute and State University

2012 -2014   Professor of Oncology   Georgetown University Medical Center,
(2015-   Retired and Adjunct)   Lombardi Comprehensive Cancer Center

2014 -   Adjunct Professor   Department of Physics
                                                Arlington Innovation Center: Health Research

Experience as Supervisor:

1995 – 2012   Radiology Department, Georgetown University Medical Center
Chief Scientist at Center for Imaging Science and Information Systems
Director, Division of Medical Imaging and Computer-aided diagnosis

Team members in this division include 1 clinical co-director, 1 assistant professor, 2 post-doctoral fellows, 1 staff member, and 2 - 5 graduate students.

Professional Societies

Member of American Association of Physicists in Medicine (AAPM)

Member of The Institute of Electrical and Electronics Engineering (IEEE)

Member of The Society of Optical Engineering (SPIE)

Invited Site Visits Sponsored by Industrial Partners:

1. AGFA HealthCare NV, Antwerp Belgium – Technical meeting on digital radiography and PACS (1991)
2. Konica Corp Tokyo Japan - Technical meeting on film digitization and image printing for PACS (1994)
3. Siemens Medical Solutions, Erlangan Germany – Technical meeting on CT CAD (2002)
4. GlaxoSmithKline Corp., Pennsylvania - Technical meeting on telemedicine (2004)
5. Riverain Medical, Miamisburg, OH - Technical meetings on lung cancer CAD (2005; 2007)
6. Accuray Inc., Sunnyvale CA - Technical meeting on real-time monitoring with computer-aided approach for fine-beam Gamma ray treatment (2006)
7. American GNC Corp, Simi Valley CA – Project development meeting on infra-red and transmission ultrasound for military medical applications (2008)
8. US Army Research Labs (Aberdeen Maryland) - Project communication meeting on the development of high-speed Tomosynthesis imaging (2012)
9. Swissray Headquarter - Medical Imaging, CAD, and beyond (2014)
10. LITE-ON Headquarter in Taipei, Taiwan - (1) Medical Imaging, Imaging Processing, (2) Future Lung Health Device (2016).

Invited Presentation (selected from more than 40):

1. "Development of PACS System" at Chinese Society of Radiology, Taipei, Taiwan, ROC, 1995.
2. "Computer-aided diagnosis and its clinical implications", Jaio-Tong University, Hsin-Chu, Taiwan, ROC, 1995.
3. "Computer-aided detection of breast cancer using convolution neural network system" at Department of Radiology, University of Virginia, 1997.
4. "Directional Edge Extraction for Registration of Temporal Chest Images" The 30th AIPR Workshop, Cosmos Club, Washington DC, Oct 10-12, 2001.

5. "Medical Imaging compression and transmission" at Telemedicine Workshop, GlaxoSmithKline (GSK) Company, PA, July, 2004.

6. "Computer-aided diagnosis methods and their potential clinical applications", National Cheng Kung University Medical Center, Tainan, Taiwan, ROC. May 16, 2005.

7. "Computer-aided Treatment of Cyberknife for Lung Cancer", Accuray, Sunnyvale, CA, August, 2006.

8. "PE-CMOS based ultrasound imaging systems", National BME conference, Taichung, Taiwan, ROC. Dec. 14, 2007,

9. "Next Generation Diagnostic Breast Imaging Using Digital Image Library and Networking Techniques" Era of Hope 2008 - Department of Defense Breast Cancer Research Program Meeting.

10. "State-of-Art Chest Radiography (dual-energy, tomosynthesis, rib-subtraction radiography) and their potential as lung cancer tools, Jia-Tong University Shanghai, China, Oct. 2010

11. "State-of-Art Chest Radiography (dual-energy, tomosynthesis, rib-subtraction radiography) and their potential as lung cancer screening tools, QingHua University, Beijing, China, Oct. 2010.

12. "Statistically Significantly Improved Nodule Detection in Rib Suppressed Chest Radiography: A Reader Study," Cancer Detection and Diagnostics Technologies for Global Health, NIH campus- Building 10, Bethesda, Maryland, August 22-23, 2011.

13. "Arc Cone-Beam Computerized Tomography – A Pilot Study of High-Speed Tomosynthesis," Army Material Labs, Aberdeen Maryland, March 12, 2012.

14. "Medical Imaging System Development & Clinical proposal for Screening Lung Cancer and Lung Disease in Taiwan – Part 1: Development of Tomosynthsis Systems" TECRO (The Pseudo-Embassy of Taiwan, ROC), Washington DC, May 22, 2014.

15. "Medical Imaging System Development & Clinical proposal for Screening Lung Cancer and Lung Disease in Taiwan – Part 2: Computerized Lung Radiography (Bone shadow removed chest radiography for lung cancer screening and lung diseases" TECRO (The Pseudo-Embassy of Taiwan, ROC), Washington DC, May 28, 2014.

16. "Clinical Reviews of Lung Cancer Screening – CT and Computerized Lung Radiography (Bone shadow removed chest radiography)" The First Hospital of Guangzhou Medical University, Guangzhou China, August 29, 2014.

17. "Medical Imaging System Development & Clinical proposal for Screening Lung Cancer and Lung Disease in Taiwan" School of Medicine and School of Science and Technology, Fujen University, Taipei, Taiwan ROC, September 3, 2014.

18. "Current and Upcoming Imaging Techniques: CXR, CT, Bone shadow removed chest radiography, and Tomosynthsis" Swissray Headquarter, September 7, 2014.

19. "Vessel Suppressed Thoracic CT and Lung Cancer CAD for LDCT Lung Cancer Screening" Ruijin Hospital, School of Medicine, Shanghai Jiao Tong University, China, September18, 2015.

20. "Vessel Suppressed CT for LDCT Lung Cancer Screening: Case Review with Pseudo-Video" Veteran General Hospital, Taipei, Taiwan, September 26, 2015.

21. "Vessel image suppressed thoracic CT - An innovative approach to screening lung cancer" Invited Speech for Radiology Grand Rounds, Georgetown University Medical Center , December 11, 2015.

22. "Apply Search Engine and AI to Medicine – From Advanced Technique to FDA Cleared Clinical System," Invited Speech at Google Campus (Verily Life Sciences), Mountain View CA, January 27, 2017.

23. "Vessel image suppressed thoracic CT - An innovative approach to screening lung cancer" Invited Speech, Zhang-Zhen Hospital, Shanghai, China April 25, 2017.

24. "Vessel image suppressed thoracic CT - An innovative approach to screening lung cancer" Invited Speech, Hwa-Dong Hospital, School of Medicine, Shanghai Fu-Dan University, China April 27, 2017.

25. "Vessel image suppressed thoracic CT - An innovative approach to screening lung cancer" Invited Speech, Ruijin Hospital, School of Medicine, Shanghai Jiao Tong University, China April 27, 2017.

26. "Vessel image suppressed thoracic CT - An innovative approach to screening lung cancer" Invited Speech, Yuan Rung Hospital, YuanLin, Taiwan, May 4, 2017.

27. "Vessel image suppressed thoracic CT - An innovative approach to screening lung cancer" Invited Speech, School of Medicine, FuJen University, Taiwan, May 5, 2017.

28. "Vessel image suppressed thoracic CT - An innovative approach to screening lung cancer" Invited Speech, ShengZhen Medical and Health Academy, ZhengZhen, China May 9, 2017.

29. "Convolutional Properties and their Applications in a Neural Networks Setting – Data Correlation Learning or Deep Learning?", Computer Assisted Radiology & Surgery International Conference & Exhibition, Berlin, Germany June 20-June 23, 2018.

30. "Deep Learning Convolutional Neural Network Techniques and Their Applications in Biomedical Sciences –
 A successful example in lung imaging" CBA Annual Meeting, Med-Immune, Gaithersburg, Maryland, June 9th, 2018.

31. "Convolutional Neural Networks and Its Successful Applications in Medical Imaging" 2018 New Medicine and Technology Hengqin Talent Summit Forum, Hengqin Zhuhai, Guangdong, China Sep 1, 2018.

Public Services

Reviewer for IEEE Transaction on Medical Imaging (89-).

Reviewer for IEEE Transaction on Circuit System (95).

Reviewer for grant application, Diagnostic Radiology Special Study Section NCI/NIH (1990-2002).

Reviewer for the TAP project at University of Maryland, College Park (90).

Reviewer for Medical Physics Journal (91-).

Reviewer for Journal of Digital Imaging (92).

Reviewer for Academic Radiology (96).

Reviewer for Journal of Electrical Imaging (92).

Committee member for the workshop of Digital Medical Imaging sponsor by NLM, NSM and NIAM of NIH (93)

Reviewer for both Preliminary and Full Proposals of the Breast Cancer Research Program, State of California, 1995.

Reviewer for an NIH PO1 Study Section (Site visit) 1996

Reviewer for the Breast Cancer Research Program, Army Medical Commander, 1995 - 1999.

Program Chairman of The Workshop of Computer-Aided Diagnosis in Medical Imaging, Washington, D.C. 1994

Program Co-Chairman of Biomedical Applications in The World of Congress of Neural Networks **(**WCNN), 1995 and 1996

Program Committee Member of Image Processing Section, SPIE Medical Imaging, 1995 - 2006.

Program Committee Member of Computer-Aided Detection Section, SPIE Medical Imaging, 2006 - 2010.

FDA/CDRH Panel Reviewer for a GS-14 Scientist Promotion to GS-15 [2007].

American Association Physicists in Medicine (Computer Aided Detection in Diagnostic Imaging (CAD) Subcommittee) 2008-2010

Panel member invited by NIH CSR Mock Review at 2008 SPIE conference as a part of NIH grant review process presentation.

Reviewer: NIH BMIT/MEDI (ZRG1 SBIB-V) Grant Review Study Section, March 2008.

Reviewer: NIH BMIT/MEDI (ZRG1 SBIB-P 04 M) Grant Review Study Section, Oct. 2009.

Reviewer: NIH BMIT/MEDI (ZRG1 SBIB-V (55) R) Grant Review Study Section, June. 2010.

Reviewer: NIH BMIT-B Grant Review Study Sections, Oct. 2011 and Feb. 2013.

Consulting Services

1. Technical Consultant for Deus Technologies, LLC Rockville, MD   [1998 – 2004]
   Development of a computer-aided diagnosis system for the detection of lung cancer in chest radiography.

2. Technical Consultant for Riverain Technologies, Rockville, MD & Miamisburg, OH [2004 – present]
Development of computer-aided function and diagnosis systems for the detection of lung cancer in chest radiography and thoracic CT.

3. Technical Consultant for Imperium Inc., Silver Spring, MD [1999 – 2010]
Development of high-resolution speckle-free real-time C-scan ultrasound imaging systems for medical applications.

4. Technical Consultant for Intelligent Automation Inc. Rockville, MD [2011 – 2013]
Development of a high-resolution high-speed tomosynthesis prototype for dual-use in military material examination and medical applications.

5. Technical Consultant for Shenzhen Capital Health & Medical Academy. Shenzhen, China [2017 Spring] Medical device development and establishment of medical engineering education.

6. Consultant for TaiHao Medical Inc., Taipei, Taiwan [Aug. 2017 - present]
Development of computer-aided detection and diagnosis systems for breast ultrasound [handheld & Automatic full breast US scanner]

Record of Research Grants and Contracts: (For those Dr. Lo serves as PI)

Grant Sponsor: The Whitaker Foundation
Title of the project: Image Data Compression for Clinical Digital Radiography
Duration: 1/1/92 - 12/31/94
PI: S.C. Lo, Ph.D. - 25% (Total direct costs: $180,000)

Grant Sponsor: National Institute of Health / National Cancer Institute (5 R01CA59763-01)
Title of the project: Optimization of DCT Type Image Compression
Duration: 9/30/92 - 9/29/95
PI: S.B. Lo, Ph.D. - 50% (Total direct costs: $210,000)

Grant Sponsor: The US Army (Grant # DAMD17-93-J-3007)
Title of the project: Implementation of Computer Assisted Breast Cancer Diagnosis
Duration: 1/1/93 - 12/31/96
PI: S.B. Lo, Ph.D. - 20% (Total direct costs: $300,000 for GU)
PI-Univ. of Michigan: H.P. Chan, Ph.D. - 25%

Grant Sponsor: The American Cancer Society (Grant # EDT 93)
Title of the project: An "Expert-Trained" System for Lung Nodule Detection
Duration: 1/1/95 - 12/31/96
PI: S.B. Lo, Ph.D. - 20% (Total direct costs: $160,000)

Contract Sponsor: NIH/NLM
Title of the project: Segmentation of Cervical and Lumbar Spines in Radiographs
Duration: 6/1/98 - 2/28/99
PI-   M.T. Freedman, MD and S.B. Lo, Ph.D. (Total direct costs: $12,000)

Contract Sponsor: Deus Technologies, LLC
Title of the project: Pilot study of computer-aided diagnosis for lung cancer in chest radiography

Duration:	8/1/99 - 5/31/99
PI:	S.B. Lo, Ph.D. and M.T., Freedman, MD (Total direct costs: $50,000)
	A budget of $30,000 is available for other research

Grant Sponsor:	The American Cancer Society (Grant # RPG-95-034-03-EDT)
Title of the project:	An "Expert-Trained" System for Lung Nodule Detection (2nd phase project)
Duration:	1/1/97 - 12/31/99
PI:	S.B. Lo, Ph.D. (Total direct costs: $200,000)

Contract Sponsor:	CDC
Title of the project:	Digitization and Archival of NHANES II.
Duration:	11/1/97 - 10/30/98
PI-	S.B. Lo, Ph.D. - 10% (Total direct costs: $41,000)
	A budget of $41,000 is available for other research

Contract Sponsor:	Eli Lilly and Company
Title of the project:	Mammography imaging segmentation and quality assurance analysis
Duration:	1997 - 1998
PI-	Seong Ki Mun, Ph.D. and S.B. Lo, Ph.D. ($100,000)

Grant Sponsor:	The US Army
Title of the project:	Computer-Aided Diagnosis and Feature-Guided Compression Systems in Mammography. [Demonstration project]
Duration:	11/1/96 - 10/30/2001
PI-	H.P. Chan, Ph.D.(Univ. of Michigan, Ann Arbor) - 20%
PI-Georgetown:	S.B. Lo, Ph.D. (Total budget: $425,000 for GU [$280,000 for direct])

Grant Sponsor:	The US Army
Title of the project:	Development of Computer-Aided Diagnostic System for the Detection of Lung Cancer In helical CT.
Duration:	11/15/99 - 11/14/2001
PI:	S.B. Lo, Ph.D. (Total direct costs: $165,000)

Grant Sponsor:	National Institute of Health / National Cancer Institute (1 R01CA74458-01)
Title of the project:	Image Pattern Based Image Compression for Radiology
Duration:	4/7/98 - 3/31/2002
PI:	S.B. Lo, Ph.D. (Total direct costs: $340,000)

Contract Sponsor:	Deus Technologies, LLC
Title of the project:	Clinical trial of computer-aided diagnosis for lung cancer in chest radiography
Duration:	6/1/99 - 6/30/2002
PI:	S.B. Lo, Ph.D. and M.T., Freedman, MD (Total direct costs: $300,000)
	Most of budget was saved as a part of GD account.

Grant Sponsor:	The US Army
Title of the project:	Combine clinic, sonographic, and elatographic features for prostate cancer detection.
Duration:	11/15/99 - 5/14/2002
PI:	Brian Garra, M.D. (Univ. of Vermont)
PI-Georgetown:	S.B. Lo, Ph.D. (Total direct costs: $30,000 for GU)

Grant Sponsor: The US Army BCRP (DAMD 17-01-1-0267)
Title of the project: "A Partnership Training Program in Breast Cancer Diagnosis: Concept Development
                       of the Next Generation Diagnostic Breast Imaging Using Digital Image Library and
                       Networking Techniques."
Duration: 09/01/01 – 08/31/05
PI: S.B. Lo, Ph.D. (Total direct costs for GU: $230,000)

Grant Sponsor: NIH/NCI (SBIR Phases I) [Joint project with Deus/Riverain]
Title of the project: "Computer-Aided Detection of Lung Cancer for Temporal Chest Radiography"
Duration: 5/01/02 - 4/30/04
PI: S.B. Lo, Ph.D. (Total direct costs for GU: $66,000)

Grant Sponsor: NIH/NCI (SBIR Phases II) [Joint project with Deus/Riverain]
Title of the project: "Computer-Aided Detection of Lung Cancer in Thoracic CT"
Duration: 8/01/02 - 7/31/04
PI: S.B. Lo, Ph.D. (Total direct costs for GU: $150,000)

Grant Sponsor: NIH/NIBIB (R21R33) – CA91803-01
Title of the project: "Speckle-Free Transmission Ultrasound for Breast Imaging"
Duration: 5/01/02 - 4/30/04 for R21;   5/01/04 - 4/30/08 for R33
PI: S.B. Lo, Ph.D. (Total direct costs for GU: $110,000 (R21); ~$800,000 (R33))

Grant Sponsor: Army MRMC (SBIR Phases I & II)
Title of the project: "Ultrasound C-Scan Image of Bone Fractures" [Joint project with Imperium Inc.]
Duration: 11/01/06 - 4/30/07 for Phase I;   11/01/07 - 8/30/09 for Phase II
PI: Seong Ki. Mun, Ph.D. and S.B. Lo, Ph.D. (Total direct costs for GU: $270,000)

Grant Sponsor: NIH/NCI (R21R33) – CA102960
Title of the project: "New Century Breast Cancer Diagnosis System (image library with intelligent system)
Duration: 9/01/05 - 8/30/07 for R21;   9/01/07 - 8/30/10 for R33
PI: S.B. Lo, Ph.D. (Total direct costs for GU: $200,000 (R21); ~$800,000 (R33))

Contract Sponsor: Riverain Medical contract to Georgetown University Medical Center
Title of the project: Clinical trial of computer-aided diagnosis for lung cancer in chest radiography
Duration: 8/1/2004 – 12/31/2013
                       A total of 11 studies have been performed for lung cancer screening trail.
                       (Total direct cost budget: ~$1,100,000)
PI: S.B. Lo, Ph.D. and M.T., Freedman, MD for 4 studies
                       M.T., Freedman, MD and S.B. Lo, Ph.D. for the recent 7 studies

Contract Sponsor: Riverain Medical contracts to Virginia Tech
Title of the project: Evaluation of ClearRead-CT-Insight for Assisting Radiologist in Lung Cancer
                       Detection on Thoracic CT Images
Duration: 2/15/2015 – 9/30/2016
                       Total budget: $360,000)
PI: S.B. Lo, Ph.D. and M.T., Freedman, MD

Teaching Activities

Advisor for Post-doctoral fellow:
   (1) Lisa Kinnard   2005 - 2006   Department of Electrical Engineering,
                                     Howard University, Washington, DC
   (Dr. Kinnard is currently with US Army Medical Research and Material Command (MRMC) Fort Detrick, Maryland. She is responsible for a part of Coordination of Breast Cancer Research Programs)

Co-Advisor for Post-doctoral fellow:
   (1) Yue (Joseph) Wang (1995 -1996)
       (Dr. Wang is Grant A. Dove Professor of Electrical and Computer Engineering, Virginia Tech – National Capital Region Campus.)

   (2) Akira Hasegawa (1994 -1998)
       (Dr. Hasegawa currently is Director, Medical Research at Fujifilm Medical Systems, SF, CA, USA)

Ph.D. dissertation co-advisor for:
   (1) Ji Chan 1990-1991   Department of Electrical Engineering, University of Michigan, Ann Arbor
       Topic: "The Effective of Data Compression on Image Quality in High Resolution Digital
              Chest Radiography"

   (2) Jessie Lin 1992 -1994 Department of Electrical Engineering, University of Maryland, College Park.
       Topic: "Convolution Neural Network Architecture with Application for Lung Nodule
              Detection in Digital Chest Radiography"
       (Dr. Lin is with Fuji Medical Imaging Processing Lab)

   (3) Huai Li 1993 -1997   Department of Electrical Engineering, University of Maryland,
                                                                      College Park.
       Topic: "Model-Based Image Processing Techniques for Computer-Aided Diagnosis of Breast Cancer
              in Digital Mammography "
       (Dr. Li currently is with Bioinformatics Unit, Research Resources Branch, National Institute on
              Aging, National Institutes of Health)

   (4) Jason Xuan   1995-1996
       (Dr. Xuan is an associated Professor of Electrical and Computer Engineering, at Virginia Tech –
       National Capital Region Campus)

   (5) Jose Jerez   1997- 1998   Department of Computer Sciences, E.T.S.I. Informatica,
                                    Campus Universitario de Teatinos, Malaga, Spain

   (6) Zuyi Wang   1999 - 2000   Department of Electrical Engineering,
                                   The Catholic University of America, Washington, DC

   (7) Hui Zhao   1999 - 2003   Department of Electrical Engineering,
                                  The Catholic University of America, Washington, DC
       Topic: Detection of Lung Cancer via Temporal Chest Image Subtraction
       (Dr. Zhao is with Carestream Health. He is the Chief of Computer-aided diagnosis Lab)

   (8) Lisa Kinnard   2000 - 2005   Department of Electrical Engineering,
                                    Howard University, Washington, DC
       Topic: Detection of Mammographic Masses using Likelihood Analysis and Fuzzification Methods

(9) <u>Chu-Chuan Liu</u> 2001 - 2008 Department of Electrical Engineering,
Virginia Tech – Northern Campus, VA
Topic: Localized Computed Tomography of Transmission Ultrasound

(10) <u>Yimo Tao</u>   2006 -2012   Department of Electrical Engineering and Computer Science,
Virginia Tech – National Capital Region Campus, VA
Topic: Content-based mammography retrieval for breast cancer diagnosis
(Mr. Tao is current with Microsoft Health Solution Group)

Master thesis co-advisor for:
(1) Shu-Jen Huang 1992-1993   Department of Electronic Engineering, Taiwan Institute of
Technology
Topic: "Strip Integral verse Line integral in Maximum Likelihood SPECT Reconstruction"

(2) Andrzej Delegacz   1998-2001   Department of Electrical Engineering,
The Catholic University of America, Washington, DC

Developed Research and Commercial Software Packages:

(1) Simulation and teaching package in basic physics of MRI scanning and reconstruction.

(2) A part of the Cardiac Package and the sodium research pulse sequence program for Gyroscan Systems (Philips MR machines).

(3) Sodium MRI pulse sequence programs for Varian 4.7 T System.

(4) Research package for CT projection, reprojection and reconstruction in three different geometry systems (i.e. parallel beam, equi-angular, and equally spaced detectors). This package has been distributed to four research institutes by their request - UCSF; University of Washington at Seattle; Naval Research, D.C.; and Taiwan Institute of Technology.

(5) Research package for medical image compression (error-free and irreversible compression). Various research approaches using cosine transform and wavelet transform are implemented for radiological applications.

(6) Research package for lung nodule detection using matched filter technique. This package has been distributed to three research institutes for evaluation - AGFA-Gavaert; University of Luvan in Belgian; and UCSF (executable files only). A part of this development will be selectively adapted by a commercial system under negotiation.

(7) Research package for the detection of microcalcifications and masses in mammography using wavelet filter and convolution neural network.

(8) Research package for the detection of lung nodules in helical thoracic CT.

(9) Research package for the simulation of tomosynthesis 3-D image reconstruction.

(10) Research package for searching optimal wavelet using wavelet convolutional neural networks (WL-CNN)

(11) Research packages for convolutional neural networks (CNN), wavelet CNN (WL-CNN), multiple circular path CNN (MCP-CNN), transfromation-identical CNN with symmetric operators (TI-CNN-1),

Transfromation-identical CNN with symmetric operations (TI-CNN-2), and 4 types of geared rotation-identical CNN (GRI/SSK-CNN, GRI/SNK-CNN, GRI/GSK-CNN, and GRI-/GNK-CNN).

Publications

Referred Papers:
1. Lo, S.B. and Huang, H.K., "Radiological Image Compression: Full-Frame Bit-Allocation Technique," RADIOLOGY, Vol. 155, June 1985, pp. 811-817.

2. Lo, S.B. and Huang, H.K., "Compression of Radiological Images with 512, 1024 and 2048 Matrices," RADIOLOGY, Vol. 161, Nov. 1986, pp. 519-525.

3. Lo, S.B., Taira, R.K., Mankovich, N.J., Huang, H.K. and Takeuchi, H., "Performance Characteristics of a Laser Scanner/Printer System for Radiological Imaging," J. Computerized Radiology, Vol. 10, No. 5, Oct. 1986, pp. 227-237.

4. Huang, H.K., Lo, S.B., Ho, B.K. and Lou, S.L., "Radiological Image Compression Using Error-Free an Irreversible Compression and Reconstruction in 2-Dimensional Direct Cosine Transform Coding Techniques," J. Optical Society of America. May 1987, pp. 984-992.

5. Lo, S.B., "Strip and Line Path Integrals with Square Pixel Matrix - A Unified Theory for Computational CT Projections," IEEE Trans. Medical Imaging, Vol 7, No. 4, Dec. 1988, pp. 355-363.

6. Lo, S.B., Krasner, B.H., and Mun, S.K., "Noise Impact on Error-Free Image Compression," IEEE, Trans. Medical Imaging, Vol. 9, No. 2, June 1990, pp. 202-206.

7. Lo, S.B., Gaskill, J.W., Mun, S.K., and Krasner, B.H., "Contrast Information of Digital Imaging in Film Digitizer and Display Monitor," J. of Digital Imaging, Vol. 3, No. 2, May, 1990, pp. 119-123.

8. Horii, S.B., Mun, S.M., Levine, B., Lo, S.B., Garra, B.S., Zeman R.K., et al. "PACS Clinical Experience at Georgetown University," Computerized Medical Imaging and Graphics, Vol. 15, No. 3, 1991, pp. 183-190.

9. Lo, S.B., Shen, E., Mun, S.K., and Chen, J., "A Method for Splitting Digital Value in Radiological Image Compression," Medical Physics, vol 18, No. 5, 1991, pp. 939-946.

10. Lo, SC.B, Krasner B, Mun S.K., Major B, "Image data compression for PACS", Adm Radiol., 1991, 10(9): 35-8, 40.

11. Lo, S.B., Lou, S.L., and Mun, S.K., "Projection Domain Compensation of Missing Angles for Fan-Beam CT Reconstruction", Computerized Medical Imaging and Graphics. Vol. 16, No. 4, 1992, pp. 259-269.

12. Lo, S.B., Freedman, M.T., Krasner, B.H., Mun, S.K., "Automatic Lung Nodule Detection Using Profile Matching and Back-Propagation Neural Network Techniques" J. of Digital Imaging, Vol. 6, No. 1, 1993, pp. 48-54.

13. Krasner, B.H., Lo, S.B., and Mun, S.K., Vector Quantization Distortion of Medical Ultrasound Features. J. of Digital Imaging 1993, Vol. 6(3):164-171.

14. Wu, Y.C., Freedman, M.T., Hasegawa, A., Zuurbier, R.A., Lo, S.B., and Mun, S.K., "Classification of Microcalcifications in Radiographs Of Pathological Specimen for the Diagnosis of Breast Cancer," Academic Radiology, 1995. Vol. 2, pp. 199-204.

15. Chan, H.P., Lo, S.B., Sahiner, B., Lam, K.L., and Helvie, M.A., Computer-Aided Diagnosis of Mammographic Microcalcifications: Pattern Recognition with an Artificial Neural Network, Medical Physics, 1995, vol. 22, No. 10, pp. 1555-1567.

16. Lo, S.B., Lou, S.L., Lin, J.S., Freedman, M.T., Chien, M.V., and Mun, S.K., Artificial Convolution Neural Network Techniques and Applications to Lung Nodule Detection, IEEE Trans. Med. Imag., 1995, vol. 14, No. 4, pp. 711-718.

17. Lo, S.B., Chan, H.P., Lin, J.S., Li, H., Freedman, M.T., and Mun, S.K., Artificial Convolution Neural Network for Medical Image Pattern Recognition, Neural Networks, 1995, Vol. 8, No. 7/8, pp. 1201-1214.

18. Lin, J.S., Lo, S.B., Hasegawa, A., Freedman, M.T., and Mun, S.K., Reduction of False Positives in Lung Nodule Detection using a Two-Level Neural Classification, IEEE Trans. Med. Imag., April, 1996, vol. 15, No. 2, pp.216-227.

19. Chan H.P., Lo, S.B., Niklason, L.T., Ikeda, D.M., and Lam, K.L., Image Compression in Digital Mammography: Effects on Computerized Detection of Subtle Microcalcifications, Medical Physics, 1996, Vol. 23, No. 8, pp. 1325-1336.

20. Lo, S.B., Lin, J.S., Li, H., Hasegawa, A., Freedman, M.T., and Mun, S.K., "Detection of Clustered Microcalcifications Using Fuzzy Modeling and Convolution Neural Network," SPIE Proceedings, Medical Imaging on Image Processing," (Peer elected paper for inclusion in a special issue), SPIE Med. Imag., 1996, Vol. 2710, pp. 8-15.

21. Freedman, M.T., Lo, S.B., Artz, D.S., and Mun, S.K., "Classification of False-Positive Findings on Computer-Aided Detection of Breast Microcalcifications," (Peer elected paper for inclusion in a special issue), SPIE Med. Imag., 1997. vol. 3034, pp.853-859

22. Wang, Y., Adali, T., and Lo, S.B., Automatic Threshold Selection using Histogram Quantization," J. of Biomedical Optics, 1997, Vol. 2, No. 2, pp.211-217.

23. Li, H., Liu, K.J., and Lo, S.B., Fractal Modeling and Segmentation for the Enhancement of Microcalcifications in Digital Mammograms, IEEE Trans. Med. Imag., 1997, Vol. 16. pp. 785-798.

24. Lo, S.B., Lin, J.S., Freedman, M.T., and Mun, S.K., Application Of Artificial Neural Networks To Medical Image Pattern Recognition: Detection of Clustered Microcalcifications on Mammograms and Lung Cancer on Chest Radiographs," J. of VLSI in Sign. Proc., Vol. 18, 1998, pp. 263-274.

25. Hasegawa, A., Lo, S.B., Lin, J.S., Freedman, M.T., and Mun, S.K., A Shift-Invariant Neural Network for the Lung Field Segmentation in Chest Radiography," J. of VLSI in Sign. Proc., Vol. 18, 1998, pp. 241-250.

26. Freedman M., San Martin J., O'Gorman J., Eckert S., Lipman M.E., Lo S.B., Wall E.L. and Zeng J., "Digitized mammography: a clinical trial of postmenopausal women randomly assigned to receive

raloxifene, estrogen, or placebo", Journal of the National Cancer Institute, Vol. 93, No. 1, 2001, pp. 51-56.

27. Li H., Wang Y., Liu K.J.R., Lo SB, and Freedman M.T., ``Computerized Radiographic Mass Detection -- Part I: Lesion Site Selection by Morphological Enhancement and Contextual Segmentation,'' IEEE Trans. on Medical Imaging, Vol. 20, No. 4, April. 2001, pp. 289-301.

28. Li H., Wang Y., Liu K.J.R., Lo SB, and Freedman M.T., `` Computerized Radiographic Mass Detection -- Part II: Decision Support by Featured Database Visualization and Modular Neural Networks,'' IEEE Trans. on Medical Imaging, Vol. 20, No. 4, April. 2001, pp. 302-313.

29. Lo S-CB, Li H, Wang Y, Lisa Kinnard, and Freedman M.T., "A Multiple Circular Path Convolution Neural Network System for Detection of Mammographic Masses," IEEE Trans. on Medical Imaging, vol. 21, No. 2, 2002, pp. 150-158.

30. Kinnard L, Lo S-CB, Wang P, Freedman MT, Chouikha M, "Automatic Segmentation Of Mammographic Masses Using Fuzzy Shadow and Maximum-Likelihood Analysis," IEEE International Symposium on Biomedical Imaging Macro to Nano, 2002, pp. 241-244. (July 7-10, Washington DC), [peer reviewed article]

31. Lo S-CB, Li H, Freedman M, "Optimization of Wavelet Decomposition for Image Compression and Feature Preservation, IEEE Trans. Med. Imaging, vol. 22 No. 9, 2003, pp. 1141-1151.

32. Helvie M, Hadjiiski R, Makariou E, Chan HP, Petrick N, Sahiner B, Lo SCB, Freedman MT, et al, Sensitivity of noncommercial computer-aided detection system for mammographic breast cancer detection: Pilot clinical trial." RADIOLOGY 231 (1): 208-214 APR 2004.

33. Kinnard L, Lo S-C. B., Makariou E., Osicka T., Wang P., Freedman M.T., Chouikha M., "Changes of likelihood function for delineation of mammographic masses." IEEE International Symposium on Biomedical Imaging Macro to Nano, 2004, [peer reviewed article, accepted for presentation and publication]

34. Kinnard L, Lo SCB, Makariou E, Osicka T, Wang P, Freedman MT, Chouikha M, "Steepest changes of a probability-based cost function for delineation of mammographic masses: A validation study," Med. Phy. Vol. 31(10), 2004, p.2796-2810. (This paper has also been selected and included in October 2004 issue of Virtual Journal of Biological Physics Research. Only two papers in Medical Physics are selected at this time.)

35. Ross S, Ejofodomi O, Jendoubi A, Chouikha M, Lo S-C.B, Wang P, and Zeng J, "A Mammography Database and View System for the African American Patients,", J of digital Imaging. March 2008; 2191) 18-26.

36. Chu-Chuan Liu, Lo S-C.B., Freedman, M.T., Lasser M.E., Wang Y., "Modeling Forward Ultrasound Scattering in a Projection Imaging System using PE-CMOS Sensor Array," IEEE Trans. Med. Imaging., 2009.

37. Liu C-C, Lo S-C B, Freedman MT, Lesser ME, Kula J, Sarcone A, and Wang Y,"PE-CMOS based C-scan ultrasound for foreign object detection in soft tissue", Frontiers in Bioscience, vol. E2, pp. 241-249, 2010.

38. Tao Y, Lo S-CB, Freedman MT, Makariou R, and Xuan J, "Multi-level Learning-based Segmentation of Ill-defined and Spiculated Masses in Mammograms," Medical Physics, vol. 37(11), pp.5993-6002, 2010.

39. Freedman MT, Lo S-C B, Seibel J, and Bromley CM, "Lung Nodules: Improved detection with software that suppresses the rib and clavicle on chest radiographs," RADIOLOGY, 260(1): 265-273, July 2011.

40. Huo Z, Summers RM, Paquerault S, Lo J, Hoffmerster J, Armato SG, Freedman MT, Lin J, Lo S-CB Petrick N, Sahiner B, Fryd D, Yoshida H, and Chan HP, "Quality assurance and training procedures for computer-aided detection and diagnosis systems in clinical use", Medical Physics, Vol 40:7, 2013.

41. Lo S-CB, Freedman MT, Gills LB, White CS, Mun SK, "Computer Assisted Detection of Lung Nodules on CT with a Computerized Pulmonary Vessel Suppressed Function," American Journal of Roentgenology (AJR) 2018; vol. 210: 480-487.

42. Lo S-CB, Freedman MT, Mun SK, "Early Development of Convolutional Neural Networks and Related Techniques - A Review (Invited and submitted to 'Radiological Physics and Technology')

Proceedings and Book Chapters
P1. Lo, S.B. and Huang, H.K., "Error-Free and Irreversible Radiological Image Compression." SPIE Proc. Vol. 536, PACS III, 1985, pp. 170-177.

P2. Stewart, B.K., Lo, S.B. and Huang, H.K., "Gray Level Dynamic Range in Magnetic Resonance Imaging." SPIE Proc. Vol. 626, Medicine XIV/PACS IV, 1986. pp. 189-195.

P3. Huang H.K. (Some Contributions from Mankovich, N.J., Papin, P., Lo, S.B., Chuang, K.S., Taira, R.K., Stewart, B.K. and Cho, P.) "Elements of Digital Radiology - A Professional Handbook and Guide." Prentices-Hall Inc. Englewood Cliffs, NJ. 1987.

P4. Mun, S.K., Benson, H.R., Lo, S.B., Levine, B., Braudes, R., Elliot, L.P., Gore, T., and Mallon-Ingeholm M.L., "Development and Technology Assessment of a Comprehensive Image Management and Communication Network." Med. Inform., Vol. 13, No. 4, 1988, pp. 315-322.

P5. Lo, S.B., and Mun, S.K., "Data Compression for a Radiology Image Display System with Visual Directory." SPIE Proc. Vol. 914, Medical Imaging II, 1988, pp. 1203-1208.

P6. Lo, S.B., Krasner, B.H., and Mun, S.K., "Impact of Noise on Radiological Image Compression." SPIE Proc. Vol. 1092, Medical Imaging III, 1989, pp. 224-250.

P7. Lo, S.B., Gaskill, J.W., Krasner, B.H., and Mun, S.K., "Image Information in Film Digitization and Display Monitor - Implication for Teleradiology." SPIE Proc. Vol. 1093, Medical Imaging III, 1989, 252-258.

P8. Lo, S.B., Horii, S., Mun, S.K., Braudes, R., and Garra, BS., "Development of Pictorial Directory Workstation for Rapid Image Presentation." SPIE Proc. Vol. 1091, Medical Imaging III, 1989, pp. 234-239.

P9. Lo, S.B., Shen, E., and Mun, S.K., "An Image Splitting and Remapping Method for Radiological Image Compression." SPIE Proc. vol. 1232, Med. Imag. IV, 1990. pp. 312-321.

P10. Lo, S.B. and Lou, S.L., "Reprojection in the Projection Domain for Limit-View Fan-Beam CT Reconstruction, IEEE Symp. on Nuc. Science and Medical Imaging." 1990, pp. 1498-1512.

P11. Lo, S.B., Krasner, B.H., Mun, S.K., and Horii, S.C., "The Full-Frame Entropy Encoding for Radiological Image Compression." SPIE Proc. Med. Img. V, vol. 1444, 1991, pp. 265-277.

P12. Lo, S.B., Freedman, M.T, and Mun, S.K., "Display Characteristics and Image Transformation in Film and CRT Monitor." Proc. of IMAC 1991, Kyoto, Japan, pp. 342-347.

P13. Freedman, M.T., Lo, S.B., Nelson, M., and Mun, S.K., "Tests of the AGFA Phosphor Plate Imaging System in Chest Images." Proc. of IMAC 1991, Kyoto, Japan, pp. 425-429.

P14. Horii SC, Mun SK, Levine B, Lo S-CB, Krasner B, Fielding, "Technical Barriers in the Realization of PACS: Network Operation", Proc. of IMAC 1991, Kyoto, Japan , pp. 42-47.

P15. Horii SC, Mun SK, Elliott LP, Lo S-CB, Garra BS, Zeman RK, Freedman MT et al, "PACS Clinical Experience at Georgetown University," Proc. of IMAC 1991, Kyoto, Japan , pp. 149-153.

P16. Lo, S.B., Krasner, B.H., Mun, S.K., and Majors, B., "Image Data Compression for PACS." Admins. Radio. Vol. 10, No. 9, 1991, pp. 35-40.

P17. Lo, S.B., Krasner, B.H., Mun, S.K., and Horii, S.C., "A Hybrid Coding for Split Gray Value for Radiological Image Compression." SPIE Proc. Medical Imaging VI, vol. 1652, 1992, pp. 194-202.

P18. Lo, S.B., Freedman, M.T., Lin, J.S., Krasner, B.H., and Mun, S.K., "Computer-Assisted Diagnosis for Lung Nodule Detection using a Neural Network Technique." SPIE Proc. Medical Imaging VI, vol. 1653, 1992, pp. 572-580.

P19. Freedman, M.T., Lo, S.B., Nelson, M.C., Reagan, K., Horii, S.C., and Mun, S.K., "Test of Radiology Performance in Interpreting Bedside Chest Examinations On a Workstation." SPIE Proc. Medical Imaging VI, vol. 1652, 1992, pp. 142-158.

P20. Krasner, B.H., Lo, S.B., Garra, B., and Mun, S.K., "Effect of Vector Quantization on Ultrasound Tissue Characterization" SPIE Proc. Med. Imag. VI, vol. 1652, 1992, pp. 360-373.

P21. Lo, S.B., Lin, J.S., Freedman, M.T., and Mun, S.K., "Computer-Assisted Diagnosis of Lung Nodule Detection using Artificial Convolution Neural Network" SPIE Proc. Med. Imag. VII, vol. 1898, 1993, pp. 859-869.

P22. Lo, S.B., Krasner, B.H., and Mun, S.K., "Gain of Irreversible over Error-Free Compression in Radiological Imaging" SPIE Proc. Med. Imag. VII, vol. 1899, 1993, pp. 292-297.

P23. Dawkins T.A., Freedman M., Lo, S-C. B., Mun, S.K., "High Resolution (35 micron) CCD Based Film Digitizer for Mammography," SPIE Proc. Medical Imaging VI, vol. 1897, 1993, pp. 511-517.

P24. Lo, S.B., Lin, J.S., Freedman, M.T., and Mun, S.K., "Application of Artificial Neural Network to Medical Image Pattern Recognition," WCNN, INNS Press, 1994, Vol. I, pp. 37-42.

P25. Lo, S.B., Kim, M.B., Li, H., Krasner, B.H., Freedman, M.T., and Mun, S.K., "Radiological Image Compression: Image Characteristics and Clinical Consideration," SPIE Proceedings, Medical Imaging 1994, vol. 2164, pp. 276-281.

P26. Lo, S.B., Chien, M., Jong, S., Li, H., Freedman, M.T., and Mun, S.K., "Extraction of Rounded and Line Objects for the Improvement of Medical Image Pattern Recognition," IEEE/MIC Proceedings, Nov. 1994.

P27. Hasegawa, A., Lo, S.B., Freedman, M.T., Mun, S.K., "Convolution Neural Network Based Detection of Lung Structures," SPIE Proceedings, Medical Imaging 1994, vol. 2167, pp. 654-662.

P28. Wu, YC, Lo S.B., Freedman M.T., Hasegawa A., Zuurbier R.A., and Mun, S.K., "Classification of microcalcifications in Radiographs of Pathological Specimen for the Diagnosis of Breast Cancer [CNN]," SPIE Proceedings, Medical Imaging 1994, vol. 2167, pp.630-641.

P29. Krasner, B.H., Lo SC.B , Mun, S.K., "Narrow bandwidth spectral analysis of the textures of interstitial lung diseases [CNN]," SPIE Proceedings, Medical Imaging 1994, vol. 2167, pp.778-785 .

P30. Lin, J.S., Lo SC.B , Freedman M.T., Mun, S.K., Application of artificial neural networks for reducing false positives in lung nodule detection on digital chest radiographs [FFNN]," SPIE Proceedings, Medical Imaging 1995, vol. 2434, pp. 563-570.

P31. Lin, J.S., Ligomenides P.A., Lo SC.B , Mun, S.K., "A hybrid neural-digital computer-aided diagnosis system for lung nodule detection on digitized chest radiographs [CNN]," 7th Annual IEEE Symp on Comp based Med Syst, 1994, pp. 207-212.

P32. Lin, J.S., Ligomenides P.A., Lo SC.B, Hasegawa, A., Freedman M.T., Mun, S.K., "An application of convolution neural networks: reducing false-positives in lung nodule detection," IEEE Nucl Sci Symp and Med Imag Conf,(Oct 1994), 1995, pp, 1842-1846

P33. Lo, S.B., Li, H., Krasner, B.H., Freedman, M.T., and Mun, S.K., "Wavelet and Full-Frame DCT Compression in Digital Radiography," SPIE Proceedings, Medical Imaging 1995, vol. 2431, pp. 195-202.

P34. Lo, S.B., Lin, J.S., Li, H., Freedman, M.T., and Mun, S.K., "Performance Characteristics of Ultra High-Resolution CCD Film Scanners," SPIE Proceedings, Medical Imaging 1995, vol. 2432, pp. 470-475.

P35. Lo, S.B., Li, H., Lin, J.S., Hasegawa, A., Wu, Y.C., Freedman, M.T., and Mun, S.K., "Artificial Visual Neural Network with Wavelet Kernels for Disease Pattern Recognition," SPIE Proceedings, Medical Imaging 1995, vol. 2434, pp. 579-588.

P36. Lo, S.B., Li, H., Lin, J.S., Hasegawa, A., Wu, Y.C., Freedman, M.T., and Mun, S.K., "Wavelet-Based Convolution Neural Network for Pattern Recognition," WCNN, INNS Press, 1995, pp. II-838 - 843.

P37. Lo, S.B., Li H., Krasner, B.H., Freedman, M.T., and Mun, S.K.," A contour coding and Full-frame compression of discrete wavelet and cosine transforms, Proc IEEE ICIP 1995, 9-15.

P38. Lin, J.S., Lo SC.B , Freedman M.T., Mun, S.K., "Application of artificial neural networks for reducing false positives in lung nodule detection on digital chest radiographs," SPIE Proceedings, Medical Imaging 1995, vol. 2434, pp. 563-570.

P39. Freedman M.T., Steller D.E., Jafroudi H, Lo, S.B., ... Mun S.K., "Digital mammography: Tradeoffs between 50 and 100 micron pixel size*," S*PIE Proceedings, Medical Imaging 1995, vol. 2432, p. 114-125.

P40. Freedman M.T., Steller D.E., Jafroudi H, Lo, S.B., ... Mun S.K., "Digital mammography: The effects of decrease exposure*," S*PIE Proceedings, Medical Imaging 1995, vol. 2432, pp. 488-500.

P41. Lo, S.B., Lin, J.S., Li, H., Hasegawa, A., Freedman, M.T., and Mun, S.K., "Detection of Clustered Microcalcifications Using Fuzzy Modeling and Convolution Neural Network," SPIE Proceedings, Medical Imaging on Image Processing, 1996, Vol. 2710, pp. 8-15.

P42. Lo, S.B., Li, H., Wang, Y., Freedman, M.T., and Mun, S.K., "On Optimization of Orthonormal Wavelet Decomposition: Data Accuracy, Feature Preservation, and Compression," SPIE Proceedings, Medical Imaging on Image Display, 1996, Vol. 2707, pp. 201-214.

P43. Lo, S.B., Li, H., Wang, Y., "Optimization of Wavelet Decomposition through Neural Network Search," WCNN, INNS Press, 1996, pp. 278 - 283.

P44. Jafroudi, H., Lo, S.B., "Dual-Energy Mammography - A Feasibility Study," SPIE Proceedings, Physics of Medical Imaging, 1996, Vol. 2708, pp. 278-293.

P45. Li, H., Liu, K.J., and Lo, S.B., "Enhancement of microcalcifications on mammograms using a fractal modeling approach", Proc. 18th Annual Int. Conf. of IEEE EMBS, 147, 1996.

P46. Lin, J.S., Lo, S.B., Li, H., Freedman, M.T., and Mun, S.K,. "Region-based enhancement on digital chest radiographs', Proc. ICASSP, IV:2211, 1996.

P47. Li, H., Freedman, MT, Wang, Y., Lo, S.B. and Mun, S.K., "Mammographic image segmentation using combined morphological filtering and contextual Bayesian labeling", Proc. 15th Southern Biomed. Eng. Conf., 412, 1996.

P48. Li, H., Lo, S.B., Wang, Y., Freedman, M.T., and Mun, S.K., "Detection of masses on mammograms using advanced segmentation techniques and an HMOE classifier", Proc. 3rd Int. Workshop on Digital mammography, 397, 1996.

P49. Li, H., Liu, K.J., Wang, Y., and Lo, S.B., "Morphological filtering and stochastic modeling-based segmentation of masses on mammographic images", Proc. IEEE Nuclear Science Symp. and Med. Imag. Conf., 1996.

P50. Li, H., Liu, K.J., and Lo, S.B., "Fractal modeling of mammograms and enhancement of microcalcifications", Proc. IEEE Nuclear Science Symp. and Med. Imag. Conf., 1996.

P51. Li, H., Liu, K.J., Wang, Y., and Lo, S.B., "Nonlinear filtering enhancement and histogram modeling segmentation of masses for digital mammograms", Proc. 18th Annual Int. Conf. of IEEE EMBS, 145, 1996.

P52. Lo, S.B., Xuan, J., Li, H., Wang, Y., Freedman, M.T., and Mun, S.K., "Dyadic Decomposition: A Unified Perspective on Predictive, Subband, and Wavelet Transforms", SPIE Proceedings on Medical Imaging, 1997, vol. 3031, pp. 286-301.

P53. Li, H., Lo, S.B., Wang, Y., Freedman, M.T., and Mun, S.K., "Mammographic Mass Detection by Stochastic Modeling and a Multi-Modular Neural Network, SPIE Proceedings on Medical Imaging 1997, vol. 3034, pp. 480-490.

P54. Li, H., Liu, K.J., Lo, S.B., Wang, Y., "Stochastic Model and Probabilistic Decision-Based Classifier for Mass Detection in Digital Mammography", IEEE Proc Intern Conf Img Proc 1997, vol. 3, pp. 539-542

P55. Freedman, M.T., Lo, S.B., Artz, D.S., and Mun, S.K., "Classification of False-Positive Findings on Computer-Aided Detection of Breast Microcalcifications," SPIE Proceedings on Medical Imaging 1997, vol. 3034, pp.853-859.

P56. Lo, S.B., Li, H., Hasegawa, A., Wang, Y.J., Freedman, M.T., Mun, S.K., "Detection of Mammographic Masses Using Sector Features with a Multiple Circular Path Neural Network," SPIE Proceedings on Medical Imaging 1998, vol. 3338, pp. 1205-1214.

P57. Lo, S.B., Freedman, M.T., Lin J.S., Xu X.W., Delegacz A., "Feature Analysis of Lung Nodules Using Sector Geometry and Multiple Circular Path Neural Network," SPIE Proceedings on Medical Imaging 1999, vol. 3661, pp.1596-1606.

P58. Delegacz A.M., Lo S.B., Choi J.J. Xei H.C., Freedman M.T., and Mun S.K. "Three-Dimensional Visualization System as an Aid for Lung Cancer Diagnosis ", SPIE Proc. Med. Imag, Vol. 3976, 2000.

P59. Wang Y.J., Wang Z, Luo L, Lo S.B., and Freedman M.T., "Clinical Decision Support System: Visual Mapping of Featured Database, SPIE Proc. Med. Imag, Vol. 3979, 2000.

P60. Lo SC.B., Rich D., Lasser M.E., Kula J., Zhao H., Lasser R., and Freedman M.T., "A C-Scan Transmission Ultrasound Based on a Hybrid Microelectronic Sensor Array and Its Physical Performance," SPIE Proc. Med. Img. Vol. 4325, pp. 89-95, 2001.

P61. Zhao, H., Lo, S.B., Freedman, M.T., Mun, S.K.., "Automatic Temporal Subtraction of Chest Radiograph and its Enhancement for Lung Cancer," SPIE, Med. Imaging, 2001, Vol. 4322, pp.1867-1872.

P62. Freedman M.T., Osicka T., Lo S.B., Lure F., Xu X.W., Lin J., Zhang R., "Methods for identifying changes in radiologists' behavioral operating-point of sensitivity trade-offs within an ROC study of the use of computer-aided detection of lung cancer," SPIE Med. Imag., vol. 4324, 2001

P63. Delegacz A.M., Lo S.B., Xei H.C., Freedman M.T., and Mun S.K. " Features Extraction, Analysis, 3D Visualization of Lung Local Region in Volumetric CT Images" SPIE Med. Imag., 2001, vol. 4319, pp.76-81

P64. Lo, S.B., Makariou, E., Chan H.P., Freedman, M.T., Dorfman D.D., and Berbaum K., "Integer Wavelet Compression Guided by a Computer-Aided Detection System in Mammography", SPIE, Med. Imaging, Vol. 4322, 2001, pp.643-648.

P65. Freedman M.T., Lo S.B., Lure F., Xu X.W., Lin J., Osicka T., Zhao H., Zhang R., "Computer-Aided Detection of Lung Cancer on Chest Radiographs: Algorithm Performance Versus Radiologist's Performance by Size of cancer" SPIE Med. Imag., vol. 4319, 2001 .

P66. Zhao H., Lo S.B., Freedman M.T., "Directional Edge Registration for Temporal Chest Image Subtraction" IEEE Applied Imagery Pattern Recognition, The 30th Workshop (Oct. 10-12, 2001 Washington DC), 2001, pp. 32-36.

P67. 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 [CP-CNN]," SPIE Med. Imag. 2002, Vol. 4684, 733-741.

P68. Zhao H., Lo S-C. B., Freedman M.T., Wang Y, "Enhanced Lung Cancer Detection in Temporal Subtraction Chest Radiography Using Directional Edge Filtering Techniques," SPIE Med. Imag. 2002, Vol. 4684, 698-703.

P69. Freedman M.T., Osika T., Lo S-C. B., Xu X., Lure Y-M.F., Lin J-Y.J. and Zhao H., "Computer-Aided Diagnosis of Lung Cancer on Chest Radiographs: Effect of machine CAD false positive locations on radiologists' decisions," SPIE Med. Imag. Vol. 4684. pp. 1311-1319, 2002, [Received CUM CAUDE Award in Imaging Processing Section]

P70. Lo S-C.B, Hsu L-Y, Freedman M.T., Lure Y-M.F., Zhao H. "Classification of Lung Nodules in Diagnostic CT: An Approach Based on 3-D Vascular Features, Nodule Density Distributions, and Shape Features", SPIE Medical Imaging 2003, Vol. 5032

P71. Freedman M.T., Lo S-C.B., Honda C., Makariou E., Sisney G., Pien E., Hiromu O, Akira I., and Shimada F., "Phase Contrast Digital Mammography Using Molybdenum X-Ray: Clinical Implications in Detectability Improvement", SPIE Medical Imaging 2003, Vol. 5030

P72. Kinnard L., Lo S.-C. B., Wang P., Freedman M.T., Chouikha M., " Separation of malignant and benign masses using image and segmentation features", Proceedings of the SPIE Medical Imaging Conference, Vol. 5032, February, 2003.

P73. Osaka T., Freedman M.T., Lo SB, Zhang R., "Computer aided detection of lung cancer on chest radiographs: Differences in the interpretation time of radiologists showing vs. not showing improvement with CAD", SPIE Medical Imaging 2003, Vol. 5032

P74. Liu CC, Lo S-C. B., Freedman M.T., Rich D., Kula J., Lasser R., Lasser M.E., Zeng J., Ro D., "Projection Ultrasound and Ultrasound CT using A PE-CMOS Sensor: A Preliminary Study," Proceedings of the SPIE Medical Imaging Conference, Vol. 5373, pp. 61-69, 2004.

P75. Lo S-C.B., Lin J-S., Hsu L-Y, Lure Y-M.F., Freedman M.T., Li R., Zhao H., "Enhancement of Lung Nodule Detection in Temporal CT: An approach based on 3-D volume registration." Proceedings of the SPIE Medical Imaging Conference, 2004, Vol. 5370, pp. 1139- 1144.

P76. Freedman MT., Osicka T., Lo S-C.B., Lure Y-M.F, Xu X., Lin J., Zhao H., Zhang R "Computer-aided detection of lung cancer on chest radiographs: effect of machine CAD true positive/false negative detections on radiologists' confidence level" Proceedings of the SPIE Medical Imaging Conference, Vol. 5372, pp. 185- 191, 2004.

P77. Freedman, M.T. Lo S-C.B., Lure Y-M.F, Zhao, H., Lin J.S., Yeh, H.M., " Computer-aided detection of Severe Acute Respiratory Syndrome (SARS) on chest radiography," CARS Conference, June 2004,1268:908-910

P.78. Kinnard L., Lo S-C. B., Makariou E., Osica, T., Wang P., Freedman M.T., Chouikha M., "Likelihood Function Analysis for Segmentation of Mammographic Masses for Various Margin Groups", IEEE Intern Symp on Biomedical Imaging: Nano to Macro, 2004, pp.113-116.

P.79. Osaka T., Freedman M.T., Lo SB,   Lure F., Xu X., Lin J.S., Zhang R., Zhao H., " Computer aided detection of lung cancer in the absence of the cancer on chest radiographs: Effect of the computer aided detection on radiologists' performance on cancer-free cases", SPIE Medical Imaging 2004, Vol. 5749

P80. Lo S-C.B., Liu C.C, Freedman M.T., Kula K., Lasser B., Lasser M.E., Wang Y., "Transmission and Reflective Ultrasound Images using PE-CMOS Sensor Array," vol. 5750, pp. 69-78, 2005.

P81. Liu C.C., Lo S-C.B., Freedman M.T., Lasser M.E., Lasser B., Kula J., Wang Y., Hsieh T., Sarcone A., "Investigation of foreign objects in soft-tissue using a PE-CMOS ultrasound system: a preliminary study." SPIE Proc. vol. 6147:176-182; 2006.

P82. Lo S-C.B., Freedman M.T., Kinnard L., Makariou E., "Mammographic CADx System using an imaging library and an intelligent agent: A pattern marching approach." SPIE Proc. Vol. 6144: 1829-1834, 2006.

P83. Liu, C.C., Lo, S-C.B., Freedman, M.T., Wang, Y., Rich, D., Kula, J., Lasser, B., Lasser, M.E., "Transmission Ultrasound Computed Tomography Using A PE-CMOS Sensor Array: A Preliminary Animal Study", IEEE International Symposium on Biomedical Imaging (ISBI), pp. 908-911, 2006.

P84. Liu, C.C., Lo, S-C.B., Freedman, M.T., Lasser, M.E., Lasser, B., Kula, J., Wang, Y., "Quantitative Ultrasound Images Generated by a PE-CMOS Sensor Array: Scatter Modeling and Image Restoration." SPIE Proc. vol. 6513, #25; 2007.

P85. Tao, Y., Lo,S-CB, Freedman, M.T., Xuan, J., "A Preliminary Study of Content-based Mammographic Masses Retrieval." SPIE Proc. Vol. 6514 #71, 2007.

P86. Lo, S-CB, Liu, C.C., Freedman, M.T., Lasser, M.E., Lasser, B., Kula, J., Wang, Y., "Projection-Reflection Ultrasound Images using PE-CMOS Sensor: A Preliminary Bone Fracture Study." SPIE Proc. vol. 6920, #4; 2008.

P87. Tao, Y., Lo, S-C.B, Freedman, M.T., Erini, M., Xuan, J., "Automatic Categorization of Mammographic Masses Using BI-RADS as a Guidance." SPIE Proc. Vol. 6915 #77, 2008.

P88. Lo, S-C.B., Liu, C.C., Freedman, M.T., Mun, S.K., Lasser, M.E,. Lasser, B., et al., "PE-CMOS Based C-Mode Ultrasound: Signal Acquisition and Time Gating." SPIE Proc. vol. 7265; 2009.

P89. Wong, K.H., Lo, S-C.B., Lin, CF, Lasser, B., and Mu,n S.K., "Imaging components for robotic casualty evaluation system, IEEE Eng in Med and Bio, P. 467-470, 2009.

P90. Tao, Y, Lo, S-C.B., Freedman, M.T., Xuan, J., "Joint Segmentation and Spiculation Detection for Ill-defined and Spiculated Mammographic Masses," SPIE Medical Imaging, Vol. 7624, #6, 2010.

P91. Tao, Y, Lo, S-C.B, Hadjiski, L., Chan, H.P., Freedman, M.T., "BI-RADS Guided Mammographic Mass Retrieval", SPIE Proc., Vol. 7963, 79632H, 2011.

P92. Lo, S-C.B. and Freedman, M.T., "Changes of Nodule Detection After Radiologists Read Bone Opacity Suppressed Chest Radiography." SPIE Medical Imaging, 2012, Vol. 8315, 2S.

P93. Lo, S-C.B. and Freedman, M.T., "Image Reconstruction of Arc Cone-Beam CT with Reprojection: A preliminary study and its potential applications", SPIE Med Imaging, 2013, Vol. 8668 (# 109).

P94. Freedman, M.T. and Lo, S-C.B., "CAD Successes and Failures", SPIE Med Imaging, 2014, CAD Panel Session.

P95. Freedman, M.T., Lo, S-C.B., "Effective Use of Computer-Aided Diagnose in Clinical Practice: Effective Use of Lung Computer-Aided Diagnosis in Clinical Practice," RCC33B [Computer-Aided Diagnosis], RSNA Nov 29, 2016, Chicago

P96. Lo, S-C.B., Freedman, M.T., Gillis, L.B., and White, C.S. "A Retrospective Lung Cancer Screening Study with and without a Computer-Aided LDCT System Consisting of Vessel Suppression Function and CADe Marks", RSNA: Chest - Lung Cancer Screening (SST03-06), 2016.

P97. Lo, S-C.B., Freedman, M.T., Mun, S.M., " The Application of A Vessel Suppressed Function Incorporated with Lung Opacity Analysis for the Significant Increase of Nodule Detectability in CT", 2017 CARS conference (June 20-24, 2017; Barcelona, Spain).

P98. Lo, S-C.B., Freedman, M.T., Mun, S.M., "Convolutional Properties and their Applications in a Neural Networks Setting – Data Correlation Learning or Deep Learning?", 2018 CARS conference, (June 20-June 23, 2018; Berlin, Germany)

P99. Lo, S-C.B., Freedman, M.T., Mun, S.M., Gu, S., "Transformationally Identical and Invariant Convolutional Neural Networks through Symmetric Element Operators," June 2018
arXiv preprint arXiv:1806.03636

P100. Lo, S-C.B., Freedman, M.T., Mun, S.M., "Transformationally Identical and Invariant Convolutional Neural Networks by Combining Symmetric Operations or Input Vectors," July 2018
arXiv preprint arXiv:1807.11156

P101. Lo, S-C.B., Freedman, M.T., Mun, S.M., Chan H.P., "Geared Rotationally Identical and Invariant Convolutional Neural Network Systems," August 2018
arXiv preprint arXiv:1808.01280

Special Program and Program Development – Serving as Program Director
1. "The First International Symposium on Computer-Aided Diagnosis in Medical Imaging" held at Leavy Conference Center, Georgetown University Medical Center; July 5-6, 1994

Symposium Chair: S-C Benedict Lo, Ph.D.; Co-Chair: Matthew Freedman, MD, MBA

Objective of CADx Symposium: To present current research results, discuss areas for further research, and explore the clinical use of computer-aided technique.

Totally 26 speakers and more than 80 participants participated in the Symposium.

2. Facilitating "Army Breast Cancer Research and Training Partnership Program" at Electrical Engineering Department and Radiology Department, Howard University, Washington, DC. [Spring 2002- Spring 2005]

Partnership Program Director: S-C Benedict Lo, Ph.D.
  (1) Coordination of lecture series (10 lectures) in breast imaging and breast cancer biology.
  (2) Development of mammography database featuring Africa-American women.(A total of 830 cases of mammograms were digitized and stored in a database)
  (3) Development of mammography workstation (System: workstation with 2 high-resolution monitors; Software: display software developed by faculty members and students at Howard University)
  (4) Development of identification algorithm for localization of breast lesions in CC and MLO view mammograms. (all developed by faculty members and students at Howard University and reported on publications)
  (5) Two Ph.D. level research projects were grown out from this program

Totally 6 faculty members, 8 graduate students, and more than 30 students involved in the research/training partnership program,

3. Academic and Industrial Collaboration on Lung Cancer CADx Targeting Clinical Applications
Program Director at ISIS Center: S-C Benedict Lo, Ph.D. and Matthew Freedman, MD

Achievements: Publishing more than 20 papers in the field of CADx. Developing technical break-through algorithm that can remove bone/rib shadow on any chest radiograph without distracting image of soft-tissue. Training 3 graduate students who all received their doctoral degrees. GU team received 2 major grants and 1 related contract; Deus team received 2 SBIR grants. Riverain team received 8 amended PMA and 4 510(K) approvals associated with lung cancer CADx from FDA.

4. Academic and Industrial Collaboration on New Medical Ultrasound Development using A Newly Invented CMOS Ultrasound Sensor Array (1999-2013)
Program Director at ISIS Center: S-C Benedict Lo, Ph.D. and Matthew Freedman, MD

Achievements: publishing more than 20 papers in the field of ultrasound. Training 2 graduate students who received their doctoral degrees. GU team received 2 major grants and 2 related contracts; Imperium team received 3 grants. A dedicated transmission ultrasound mammography system was developed and showed that the system can reveal different types of breast lesions and can identify whether the lesion has speculation or not. A transmission/reflection ultrasound prototype was fabricated and showed that the system can reveal bone fracture as small as 0.5 mm.