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p. 8

JPL Workshop: "A Decade of Neural Networks:
Practical Applications and Prospects"
May 11th-13th, 1994

Neural Networks: Application to Medical Imaging
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RESEARCH MISSION

•Development of computer assisted diagnostic (CAD) methods for improved diagnosis of medical images including digital x-ray sensors and tomographic imaging modalities.

•The CAD algorithms include advanced methods for adaptive nonlinear filters for image noise suppression, hybrid wavelet methods for feature segmentation and enhancement and high convergence neural networks for feature detection and VLSI implementation of NN for real time analysis. These methods are designed for fully automatic CAD methods that are operator, image and sensor independent for universal application for medical image analysis.

•Implementation of CAD methods on hospital based picture archiving computer systems (PACS) and information networks for central and remote diagnosis i.e. for cost effective health care delivery and standardization of diagnosis.

•Collaboration with defense and medical industry, NASA and Federal Laboratories in the area of dual use technology conversion from defense or aerospace to medicine .

SPECIFIC PROJECTS INVOLVING NEURAL NETWORKS

•Development of computer assisted diagnostic (CAD) methods for breast cancer screening using digital mammography. Projects include NN of different architecture tailored for each project:

1. Automatic detection of microcalcification
2. Detection of masses or parenchymal tissue distortion
3. Recognition of normal vs abnormal mammograms

•Development of nuclear medicine imaging methods for detection of beta particles used for antibody therapy or imaging of positron emitters.

1. Order statistic neural network for image resolution restoration based on systems physical response characteristics

•Development of MRI segmentation techniques using backpropagation and cascade correlation neural networks for tissue characterization.

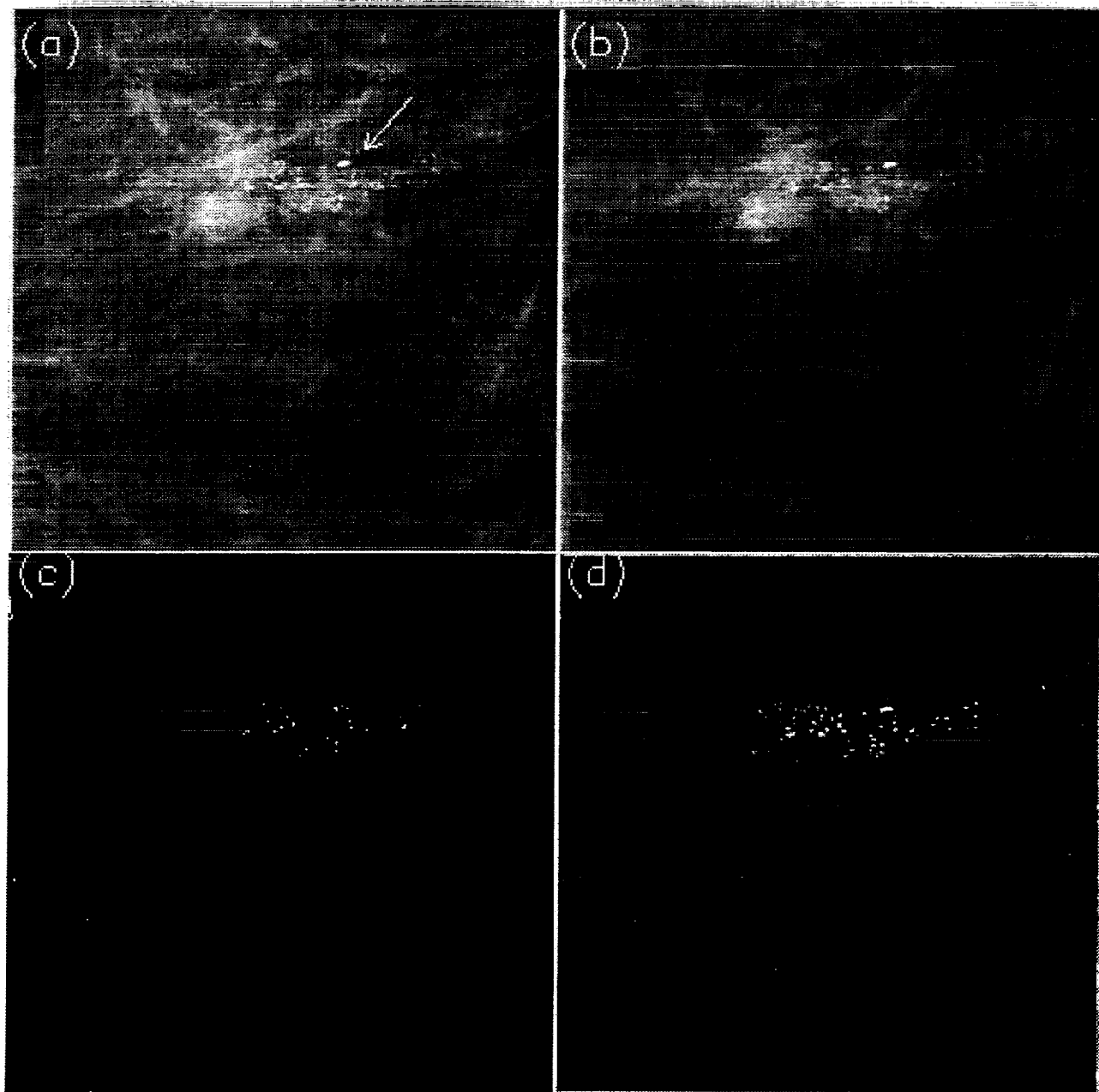1. Automatic segmentation of tumor volumes
2. Surgery simulation

Fig. 1. (a) Section of digitized mammogram with a calcification cluster indicated by arrow
(b) Smoothed image using the AOSF.
(c) Calcification segmentation using a two-channel TSWT
(d) Calcification segmentation using a three-channel QMF; the morphology of the calcifications is better preserved supporting our proposed work.
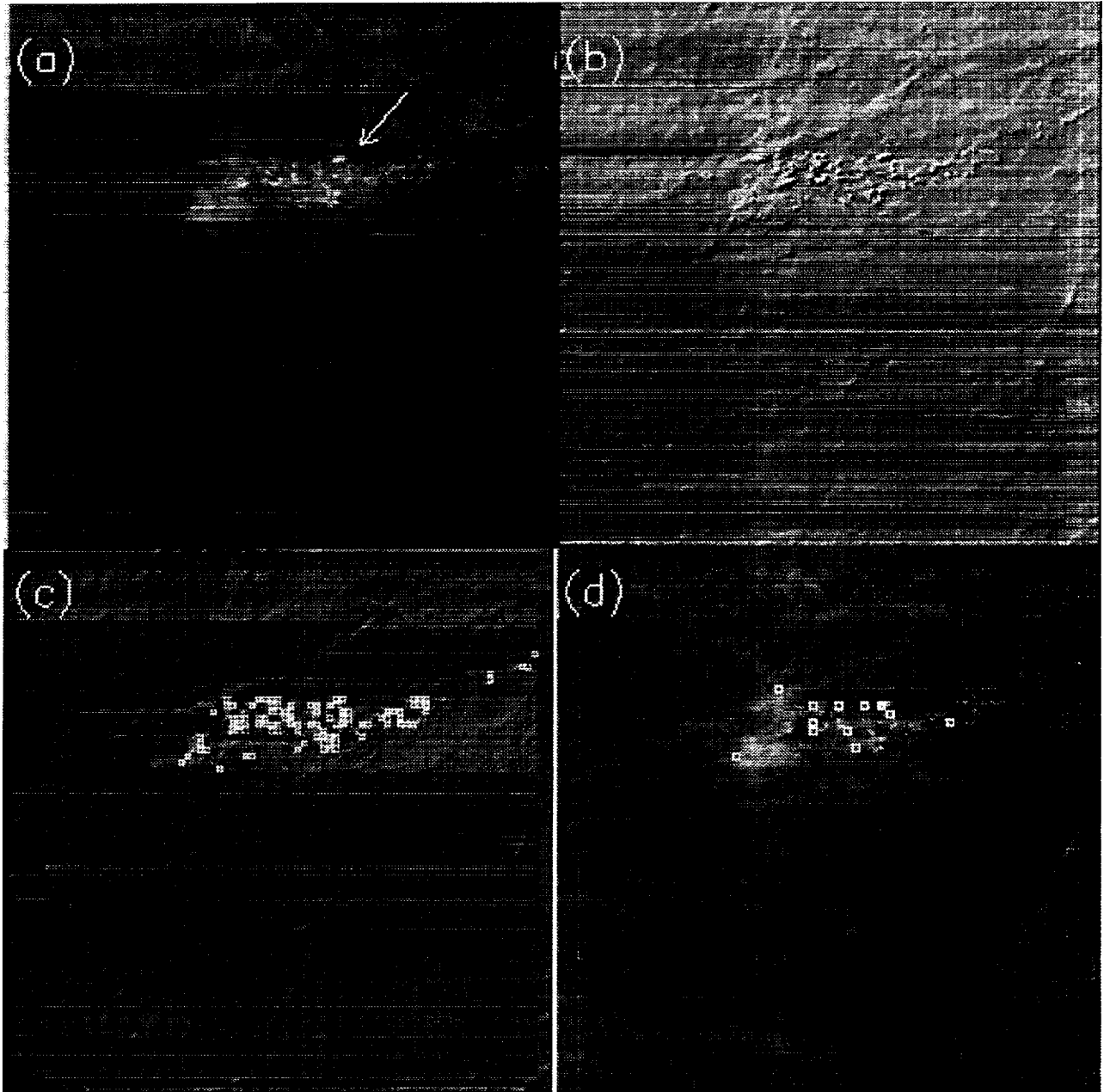
Fig. 2. (a) Section of digitized mammogram with a calcification cluster indicated by arrow

(b) Enhanced image using the AMNF–TSWT filter (linear operation); the extent of the cluster is better defined.

(c) Calcification detection indicated by squares using the enhanced image as input to the ANN.

(d) Calcification detection indicated by squares using the unprocessed image as input to the ANN; several FN detections are observed.
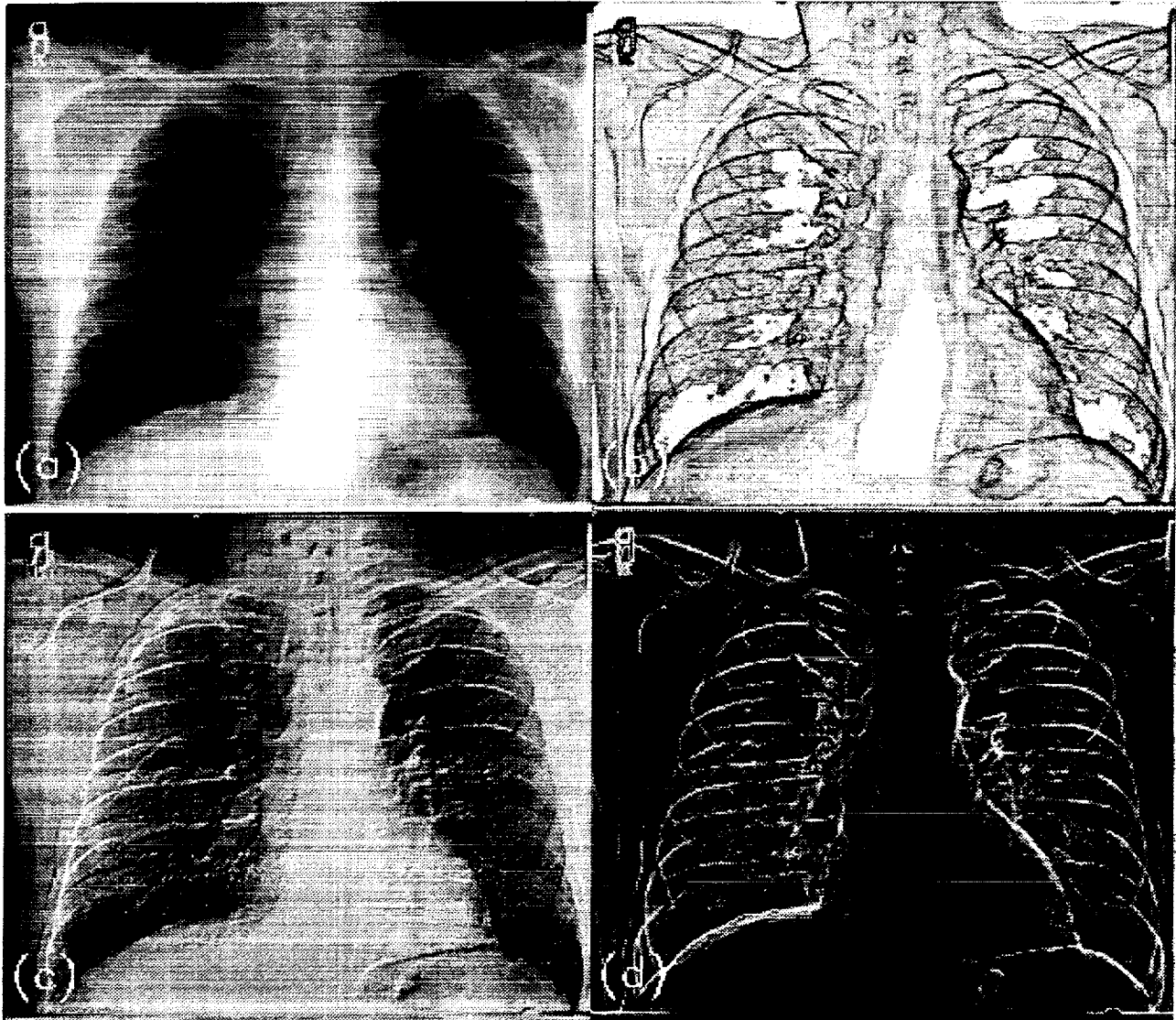
Fig. 3. (a) Digitized unprocessed chest x-ray.
   (b) Enhancement by adaptive multistage nonlinear filter
       with an order statistic operation.
   (c) Enhancement by adaptive multistage nonlinear filter
       with a linear operation.
   (d) Processing by a tree-structured nonlinear filter
       and a dispersion edge detector.

CURRENT COLLABORATORS:
FEDERAL/INDUSTRY

1. NASA Jet Propulsion Laboratory (JPL), Pasadena, California. Neuroprocessing and Analogue Computing Devices (NACD).
    Topic: Real time analysis of digital mammograms using VLSI implementation of NNs.

2. NASA Ames. Search for extraterrestrial intelligence (SETI), Moffett Field, California. High Resolution Microwave Survey Project.
    Topic: Detection of weak signals in digital mammograms for microcalcification and tumor detection.

3. DOD. Navy Surface Warfare Center (NSWC), Dahlgren, Virginia. Advanced Computations Technology Group.
    Topic: Pattern Recognition methods in digital mammography for identification of suspicious areas.

4. E-Systems. Garland Division, Dallas, Texas. Information Technology Systems.
    Topic: Algorithm design and real time parameter optimization in digital mammography.

5. Fischer Imaging, Denver, Colorado & Nanoptics, Gainesville, Florida.
    Topic: High resolution direct x-ray digital detection.

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●Li HD, Kallergi M, Clark RA, Jain VK and Clarke LP. Markov random field model for tumor detection in digital mammography. *IEEE Trans. in Med. Imag.* (submitted for publication Jan. 1993).

●Priebe CE, Solka JL, Lorey RA, Rogers GW, Poston WL, Kallergi M, Qian W, Clarke LP and Clark RA, 1993. The application of fractal analysis to mammographic tissue classification. *Cancer Letters* (submitted).

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