MARTIN MARIETTA

PHOTONICS: From Target Recognition to Lesion Detection

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Photonics: From Target Recognition to Lesion Detection

Martin Marietta Corporation and Rose Health Care Systems
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Introduction -- Since 1989, Martin Marietta has invested in the development of an innovative concept for robust real-time pattern recognition for any two-dimensional sensor. This concept has been tested in simulation, and in laboratory and field hardware for a number of DoD and commercial uses from automatic target recognition to manufacturing inspection. We have now joined Rose Health Care Systems in developing its use for medical diagnostics.

The Concept -- The concept is based on determining regions of interest by using optical Fourier bandpassing as a scene segmentation technique, enhancing those regions using wavelet filters, passing the enhanced regions to a neural network for analysis and initial pattern identification, and following this initial identification with confirmation by optical correlation. The optical scene segmentation and pattern confirmation are performed by the same optical module. The neural network is a recursive error minimization network with a small number of connections and nodes that rapidly converges to a global minimum.

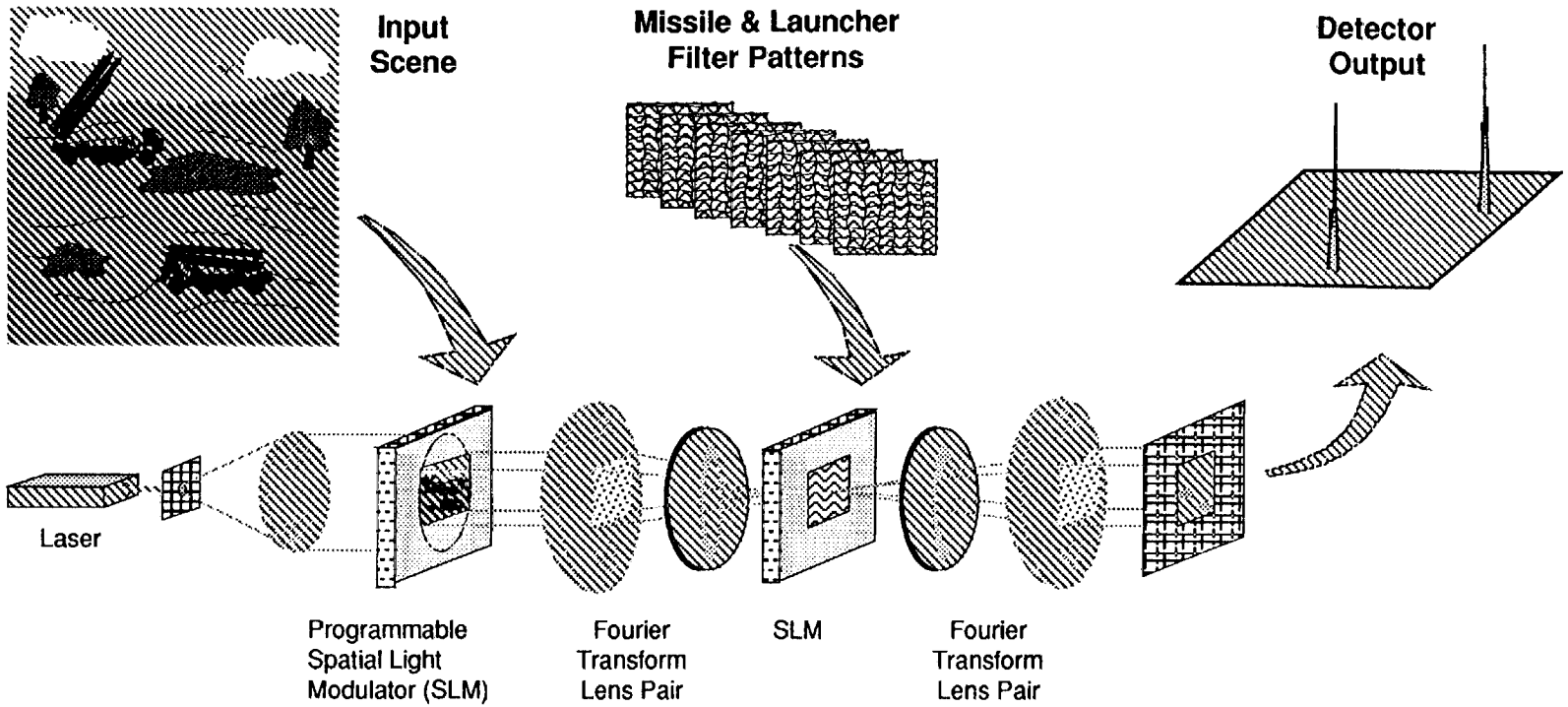
A Specific National Need -- The specific commercial application for which this Defense technology is proposed is a medical diagnostics demonstration in analyzing screening mammograms. Breast cancer is an ever-increasing problem that is striking women at younger and younger ages. Recent statistics indicate that one in eight women will experience breast cancer in their lifetimes--an increase from one in twelve a few years ago. One of the most effective tools in the fight against breast cancer is early detection through the use of mammography. In 1990, 17 million screening mammogram sets were generated. Based on National Cancer Institute and American Cancer Society recommendations, 44 million sets should have been processed. While there are several barriers to greater mammography participation, one barrier is cost. Radiologist reading fees alone for screening mammograms amounted to $652 million in 1990 and are expected to grow to $1 billion by 1996. Statistics also show that early detection of breast cancer not only saves lives, but significantly reduces the cost of the ensuing

treatment as well. Our goal is to reduce screening mammogram fees to increase participation, to aid radiologists in finding a higher percentage of cancerous lesions, and to detect these lesions at least a year earlier than is generally possible with current techniques.

The On-going Effort -- Martin Marietta and Rose Health Care Systems are conducting demonstrations of the concept for mammogram processing. These demonstrations use an optical processor simulator to detect and identify spiculated lesions -- one of three types of potentially cancerous lesions commonly detectable in the human breast, and will be extended to detect the other lesions as well. The effort will then conduct a full proof of concept through simulation and hybrid digital/optical hardware for all three lesion types, prepare a system operational concept, develop a total system prototype for evaluation tests, and prepare for FDA clinical trials and manufacturing readiness. The Martin Marietta/Rose mammogram analysis system has the potential to significantly reduce total mammography costs, while improving the quality of care by ultimately functioning as a radiologist's aid as well as an automatic prescreener or a "second opinion" system. Mammography is only the first of a number of applications to medical diagnostics for which this technology could be key. We expect to expand its use to the analysis of chest imagery, pap smears and other similar image and cytological diagnostics.

The Team -- The team is composed of Martin Marietta Photonic Systems as system developer and team administrator and Rose Health Care Systems as partner and key medical advisor on radiology and operational concepts. Optics and neural network experts from the University of Colorado, the University of Dayton Research Institute, and Tactical Technical Solutions, Inc., are providing technical support in pattern processing. Two nationally-known radiologists provide additional expertise in mammogram analysis techniques, and the Eastern Cooperative Oncology Group, a group of over 3000 cancer research professionals, provides guidance on this and other diagnostic areas for which these techniques apply. Several local suppliers provide assistance in the human-machine interface for medical diagnostic workstations, in clinical evaluation requirements and techniques, and in system packaging.

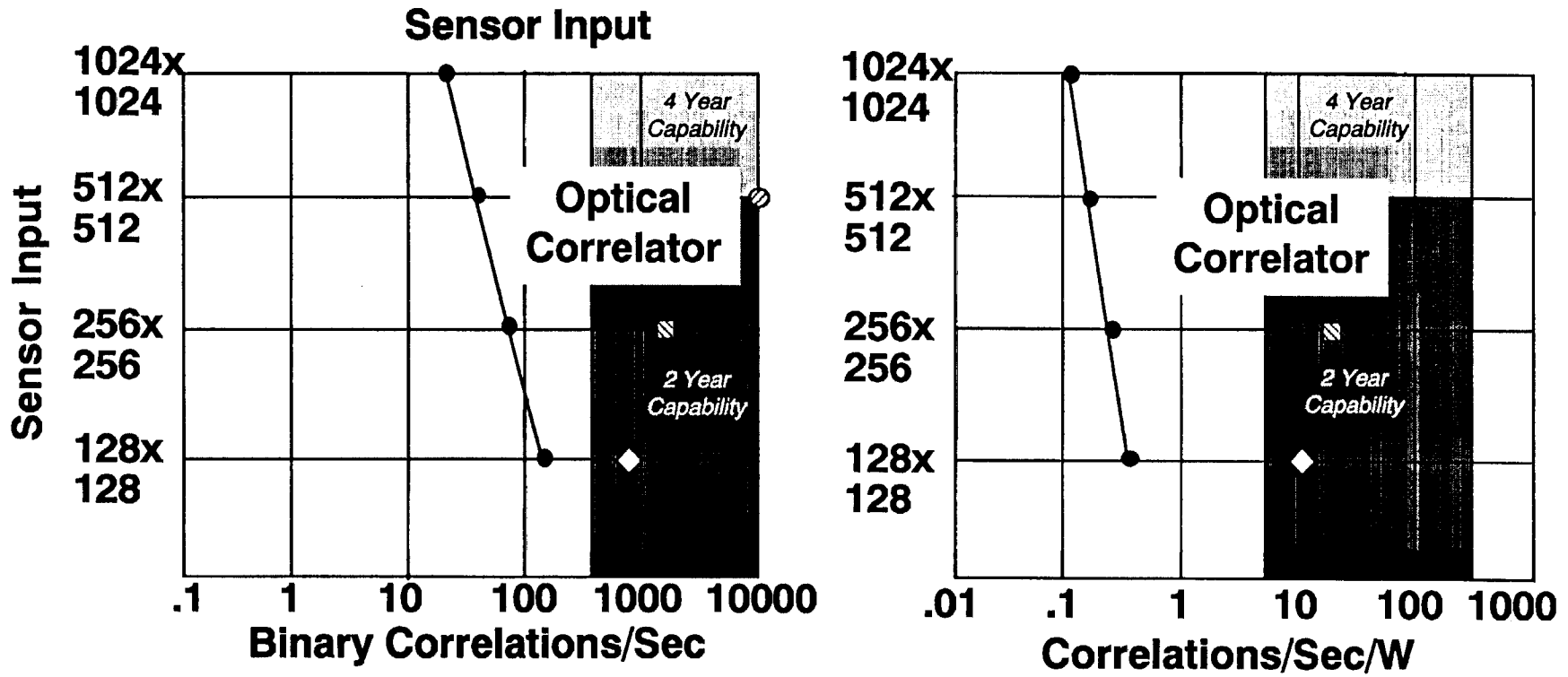
Optical Pattern Recognition



- Inherently Massively Parallel (Entire Frame Simultaneously)
- Excellent Discrimination, Low False Alarm Rates
- Low Power, Light Weight, Small Volume
- Frame Rate Essentially Independent of Sensor Resolution

Optical -- Electronic Correlation Comparison

Photonic Systems



◇ TOPS Martin Marietta Compact Correlator

▧ 1994 Martin Marietta Compact Correlator

● Typical Electronic Parallel Processor

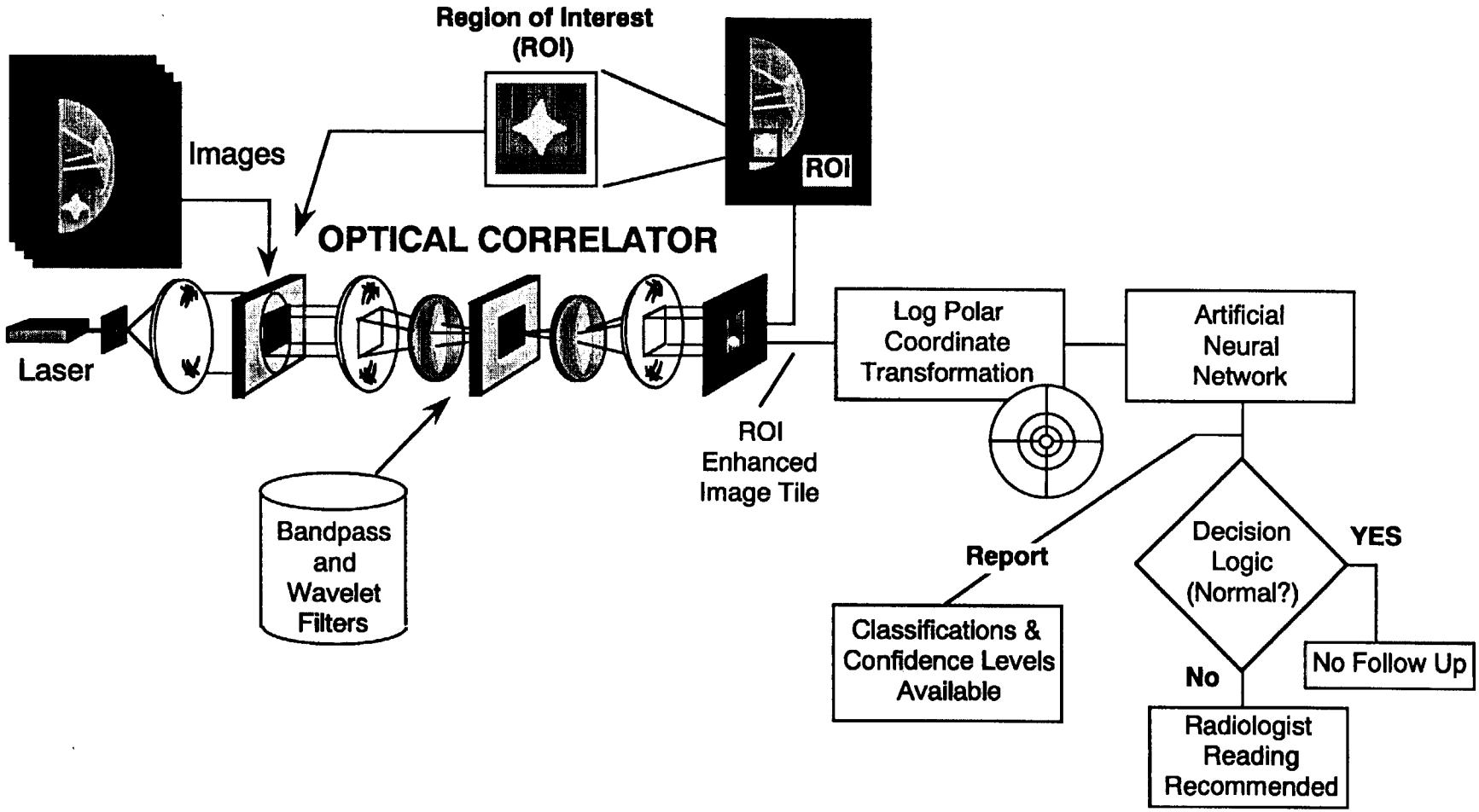
⊘ Approximate Teraflop Throughput

Breast Cancer Detection

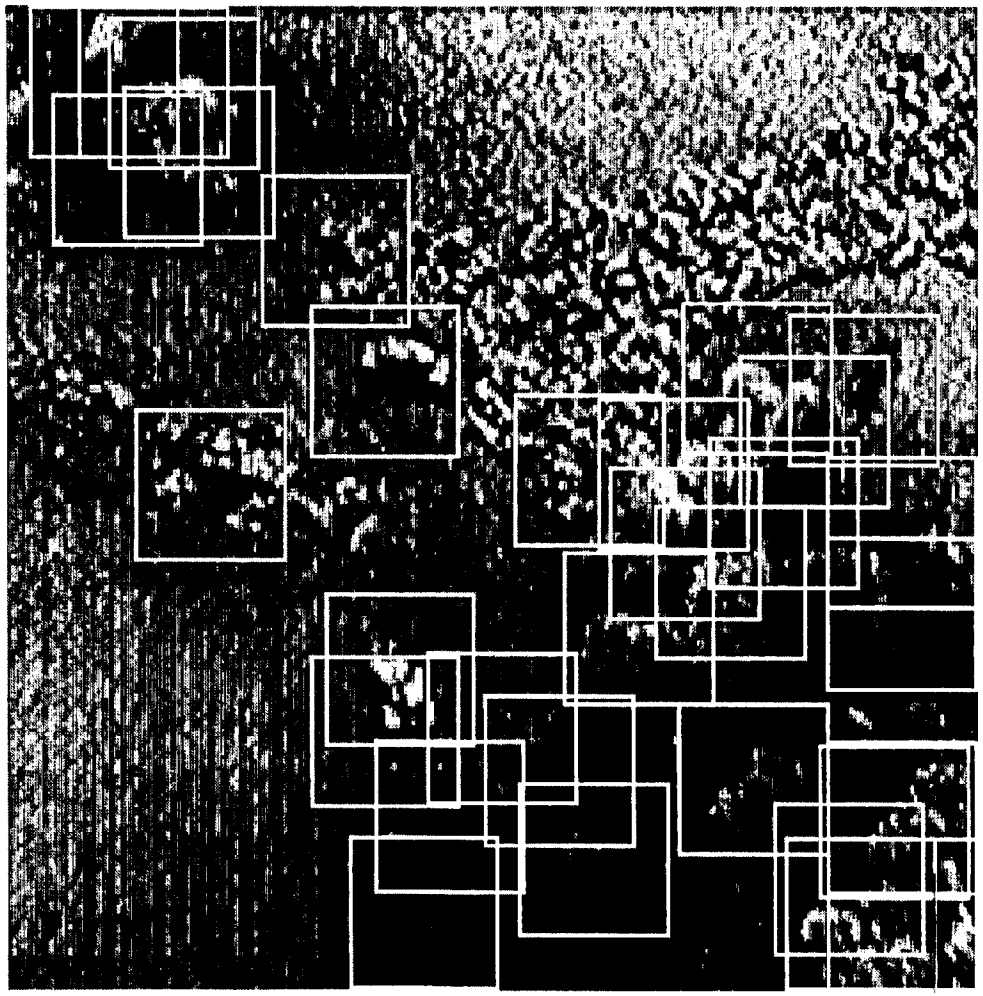
- **Breast Cancer**
  - ~200,000 Cases per year
  - ~50,000 Deaths per year
  - 21 million Screening Mammogram Sets (USA, 1992)
- **Detection**
  - Screening (Mammography and *Interpretation*)
    - » Mammograms (X-ray films)
  - Diagnostics
    - » Alternate Views (X-ray films)
    - » Ultrasound
    - » Biopsy
- **Screening Leads to**
  - Early Detection - Prior to Palpable State
  - Less Radical and Costly Cures
  - Higher Chance of Survival

Screening Mammogram Analysis Concept

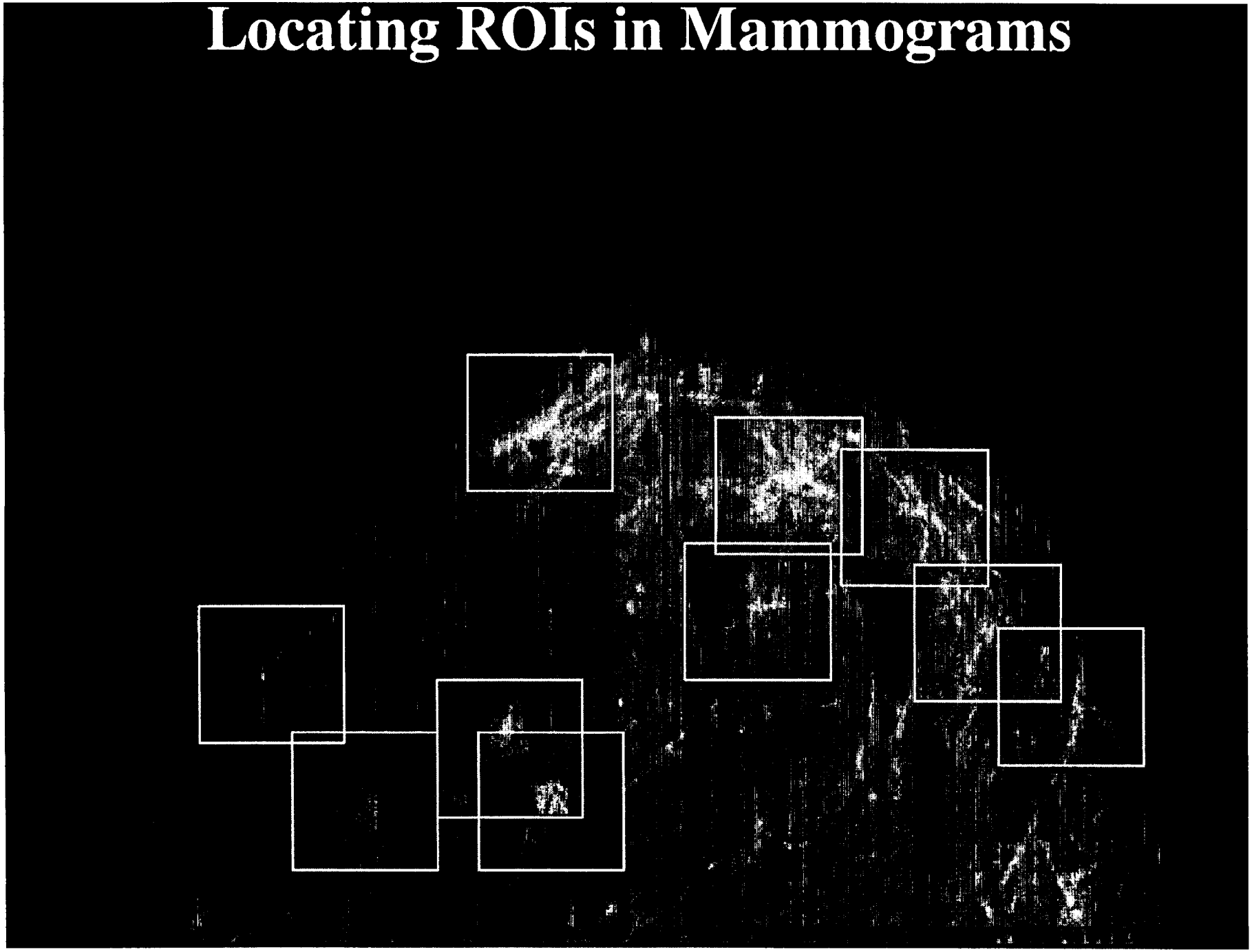
Photonic Systems



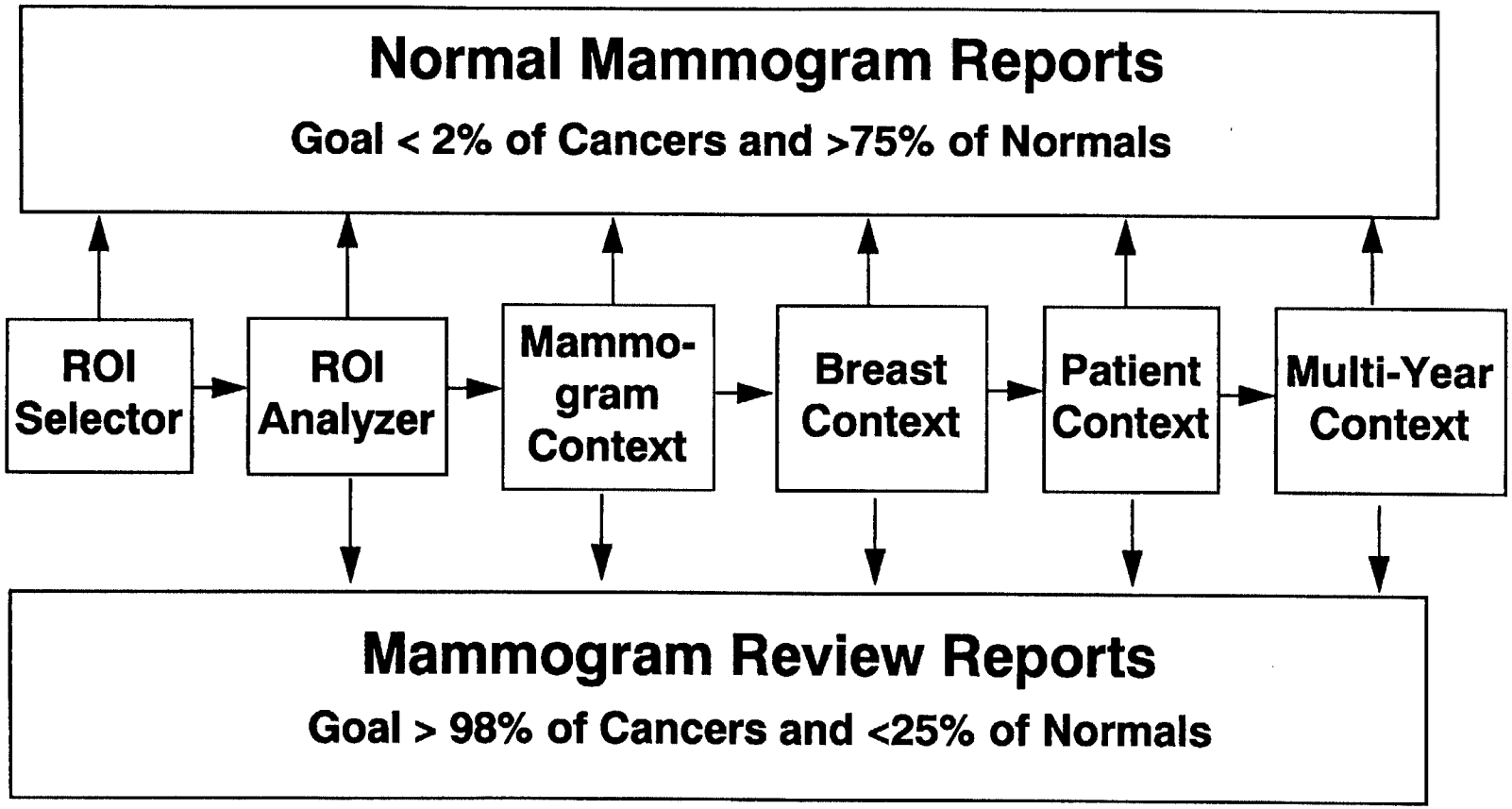
Locating ROIs for ATR



Locating ROIs in Mammograms



System Approach



ROSE HEALTH CARE SYSTEM/MARTIN MARIETTA

Automated Mammogram Screening Project

"If we have the technology sophisticated enough to direct missiles to target thousands of miles away, then we ought to work to have technology sophisticated enough to detect every fatal lump in a woman's breast."

Hillary Clinton
July 19, 1993