SEMINAR NOTICE

Department of Electrical and Systems Engineering

DETECTION AND LOCALIZATION OF PARTICLE-EMITTING SOURCES WITH COMPOUND-EYE INSPIRED DETECTOR ARRAYS

by

Zhi Liu

Center for Sensor Signal and Information Processing

We develop methods to detect and localize particle-emitting sources using detector arrays that are inspired by biological compound eyes. The sources of interest may be optical, nuclear, or cosmic; they emit particles such as visible photons, neutrons, protons, or charged particles. Our results may have wide applications to artificial vision, which can be important in robotics (robot vision) or medicine (e.g., artificial eyes for the blind); security, where the detection of nuclear materials is needed; or astronomy. This dissertation consists of three parts. First, we detect a far-field particle source using two directional detector arrays: cubic and spherical. We propose a mean-difference test (MDT) detector, analyze its statistical performance, and show that the MDT has a number of advantages over the generalized likelihood-ratio test (GLRT). Second, we localize the source by proposing a novel biologically inspired detector array, whose configuration generalizes the compound eye of insects. This array combines the advantages of compound eyes (e.g., large field-of-view) and human eyes (e.g., high angular resolution). We derive a rigorous mathematical model for the array by defining a set of basis concepts and assumptions, proposing a basis function presentation for the array's transfer function, and optimizing that basis. We then analyze the array performance by computing the Cramer-Rao bound (CRB) on the error in estimating the source direction. We also derive lower bounds on the mean-square angular error (MSAE) of the source localization and investigate the MSAE of two source-direction estimators. Third, we derive a statistical angular resolution limit (ARL) on resolving two closely spaced point sources in a three-dimensional frame, error in estimating the source direction. We also derive lower bounds on the mean-square angular error (MSAE) of the source localization and investigate the MSAE of two source-direction estimators. Third, we derive a statistical angular resolution limit (ARL) on resolving two closely spaced point sources in a three-dimensional frame, which is applicable to various measurement models (e.g., radar, sonar, or astronomy). Using the asymptotic analysis of the GLRT, we derive the ARL with constraints on the probabilities of false alarm and detection. Our results give explicit analytical expression for the ARL that is proportional to the square root of the CRB on the angular source separation, or equivalently to the lower bound on the MSAE.

DATE:	Tuesday, February 20, 2007
TIME:	3:00 p.m.
PLACE:	Room 305, Bryan Hall

Research advisor:
Arye Nehorai

This seminar is in partial fulfillment
of the Doctor of Science Degree

Washington University in St. Louis
SCHOOL OF ENGINEERING & APPLIED SCIENCE