香港浸會大學
HONG KONG BAPTIST UNIVERSITY

Centre for Mathematical Imaging and Vision
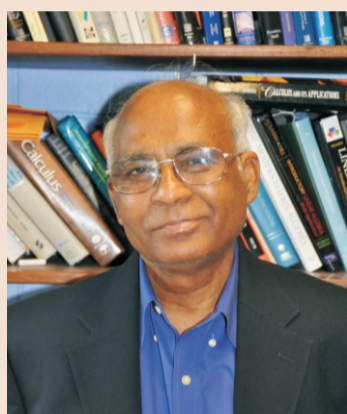**Department of Mathematics**

Science Distinguished Lecture Series

Computational and Optimization Methods for Quadratic Inverse Eigenvalue Problems Arising in Mechanical Vibration and Structural Dynamics: Linking Mathematics to Industry

Professor Biswa Nath Datta

IEEE Fellow
Distinguished Research Professor, Northern Illinois University

Date: **22 January 2015 (Thursday)**
Time: **5:00 pm - 6:00 pm** (Preceded by Reception at 4:30 pm)
Venue: **SCT909 Science Tower, Ho Sin Hang Campus, Hong Kong Baptist University**

Abstract

The Quadratic Eigenvalue Problem is to find eigenvalues and eigenvectors of a quadratic matrix pencil of the form $P(\lambda) = M\lambda^2 + C\lambda + K$, where the matrices M, C, and K are square matrices. Unfortunately, the problem has not been widely studied because of the intrinsic difficulties with solving the problem in a numerically effective way. Indeed, the state-of-the-art computational techniques are capable of computing only a few extremal eigenvalues and eigenvectors, especially if the matrices are large and sparse, which is often the case in practical applications. The inverse quadratic eigenvalue problem, on the other hand, refers to constructing the matrices M, C, and K, given the complete or partial spectrum and the associated eigenvectors. The inverse quadratic eigenvalue problem is equally important and arises in a wide variety of engineering applications, including mechanical vibrations, aerospace engineering, design of space structures, structural dynamics, etc. Of special practical importance is to construct the coefficient matrices from the knowledge of only partial spectrum and the associated eigenvectors. The greatest computational challenge is to solve the partial quadratic inverse eigenvalue problem using the small number of eigenvalues and eigenvectors which are all that are computable using the state-of-the-art techniques. Furthermore, computational techniques must be able to take advantage of the exploitable physical properties, such as the symmetry, positive definiteness, sparsity, etc., which are computational assets for solution of large and sparse problems.

This talk will deal with two special quadratic inverse eigenvalue problems that arise in mechanical vibration and structural dynamics. The first one, Quadratic Partial Eigenvalue Assignment Problem (QPEVAP), arises in controlling dangerous vibrations in mechanical structures. Mathematically, the problem is to find two control feedback matrices such that a small amount of the eigenvalues of the associated quadratic eigenvalue problem, which are responsible for dangerous vibrations, are reassigned to suitably chosen ones while keeping the remaining large number of eigenvalues and eigenvectors unchanged. Additionally, for robust and economic control design, these feedback matrices must be found in such a way that they have the norms as small as possible and the condition number of the modified quadratic inverse problem is minimized. These considerations give rise to two nonlinear unconstrained optimization problems, known respectively, as Robust Quadratic Partial Eigenvalue Assignment Problem (RQPEVAP) and Minimum Norm Quadratic Partial Eigenvalue Assignment Problem (MNQPEVAP). The other one, the Finite Element Model Updating Problem (FEMUP), arising in the design and analysis of structural dynamics, refers to updating an analytical finite element model so that a set of measured eigenvalues and eigenvectors from a real-life structure are reproduced and the physical and structural properties of the original model are preserved. A properly updated model can be used in confidence for future designs and constructions. Another major application of FEMUP is the damage detections in structures. Solution of FEMUP also give rises to several constrained nonlinear optimization problems. I will give an overview of the recent developments on computational methods for these difficult nonlinear optimization problems and discuss directions of future research with some open problems for future research. The talk is interdisciplinary in nature and will be of interests to computational and applied mathematicians, and control and vibration engineers and optimization experts.

✦ ✦ ✦ **All are welcome** ✦ ✦ ✦

For enquires please contact Ms. Claudia Chui, 3411 2348.
http://www.math.hkbu.edu.hk/