Modeling Applications in Bio-processing and Food Quality/Safety Evaluation

Overview

Because of increased global competition, food companies must respond rapidly to consumers' changing needs of more nutritious food that is safe. Mathematical modeling can be used to decrease the experimental effort, time, and cost of modified or new process design. Static, linear modeling methods were successfully developed in the last century, but are insufficient for modeling dynamic processes, where the product temperature, moisture, shear rate, pH, viscosity, and thermal properties may all change simultaneously. Much modeling is done on small-sample model systems in laboratories. Application of these models to commercial, dynamic systems is difficult and rarely done. Very little development of methods to estimate model parameters using dynamic data has been done. An exception is in Dr. Dolan's lab, where both research and teaching on dynamic methods is ongoing.

This course presents the foundation for a) designing equipment for processing fluid foods, and b) modeling food quality and food safety attributes during both static and dynamic conditions. Introduction to rheology, reaction kinetics, and microbial growth and inactivation models, are presented. The basics of using MATLAB coding are taught. The differences between the forward and inverse problems are highlighted. The focus of this course is on the inverse problem. The use of explicit models, for static conditions, and differential models, for dynamic conditions is shown. Matrix formulations for linear and nonlinear parameter estimation problems are given. Scaled sensitivity coefficients are derived and shown to be useful to determine whether model parameters can be estimated, and which parameters will be most accurate. A variety of example problems in designing bio-processing pipelines, and microbial inactivation and growth will be used. Although the course examples are focused on food, the principles can be applied to any biomaterial.

Objectives

- Learn how to use food rheological data to design fluid food processing equipment;
- Determine whether a model is linear or nonlinear with respect to each parameter and determine when to use a forward or an inverse problem, and what the difference is;
- Solve numerically the forward problem of coupled ODEs or single PDEs with a time and a space variable;
- Estimate parameters by Ordinary Least Squares in systems of coupled ODEs, a single PDE, or in explicit equations;
- Compute all statistical results for parameters and the dependent variable;

Modules	**August 14, 2017** *(Module A: Food Rheology)* Lecture 1: 1 hrs: KDD Introduction to rheology, apparent viscosity, fluid foods flow characteristics as they relate food quality. Lecture 2: 1 hrs: KDD Concentric cylinder viscometry, mixer viscometry, laminar flow assumption, and non-Newtonian fluids characteristics. Tutorial 1: 2 hrs: KDD Problem solving session with examples: Analyzing fluid food data from concentric cylinder and mixer viscometer. **August 16, 2017** *(Module B: Modeling and Parameter Estimation)* Lecture 3: 1 hrs: KDD Introduction to models and to MATLAB software. Difference between forward and inverse problem and applications to parameters estimation. Lecture 4: 1hrs: DSS Assessment of food quality attributes (bioactive compounds and physical prperties) Tutorial 2: 2 hrs: KDD Solving boundary values (BV) problems using finite-difference method(forward problem). **August 17, 2017***(Module B: Modeling and Parameter Estimation)* Lecture 5:1 hrs: KDD Linear versus Nonlinear models and introduction to parameter estimation, linear regression. Lecture 6: 1hrs: DSS Sorption isotherms for agro-waste processing into value-added byproducts Tutorial 3: 2 hrs: DSS Innovative techniques for determining antioxidants and other bioactive compounds **August 18, 2017** *(Module B: Modeling and Parameter Estimation)* Lecture 7:1 hrs: KDD Methods used for nonlinear regression and plotting Scaled Sensitivity Coefficients (SSCs).

	Lecture 8:1 hrs: KDD Review of matrices and numerical solution to initial-value problems (Runge-Kutta methods) and adaptive methods and stiff systems—using ode45 Tutorial 4: 2 hrs: DSS Response surface methodology (RSM) for food products quality and safety optimazation **August 19, 2017** *(Module B: Modeling and Parameter Estimation)* Lecture 9: 1 hrs: KDD How to solve inverse problems and using instructor's code template for parameter estimation using nonlinear regression. Lecture 10: 1 hrs: KDD How to solve inverse problems and using instructor's code template for parameter estimation using nonlinear regression. Tutorial 5: 2 hrs: KDD Problem solving session with examples: MATLAB examples of solving exponential decay model with explicit and differential method. *Course Assessment/Exam: August 21, 2017* **Number of participants for the course will be limited to fifty.**
You Should Attend If…	▪ Student at all levels (BSc/MSc/MTech/PhD) of Food Technology ▪ Faculty from reputed food science institutions. ▪ Researchers /Post-docs/ Research Associates from Universities, Govt and R&D laboratories.
Fees	The participation fees for taking the course is as follows: **Participants from abroad:** US $200 **Industry:** Rs 2000/- **Academic Institutions in India:** BSc students: Rs. 500/- MSc/MTech students: Rs. 1000/- PhD students: Rs. 1500/- Faculty members: Rs. 2000/- The above fee includes all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, free internet facility. The participants will be provided with accommodation on payment basis.

The Faculty

Kirk Dolan's degrees are in Agricultural Engineering from U. FL (B.S.), U. CA Davis (M.S.), and MSU (Ph.D.) He worked for Pharmaceutical & Food Specialists (San Jose, CA) from 1993-1999 as their representative in China and in the Asian region. He has been a faculty member at MSU since 2000, and has joint appointments in Department of Food Science & Human Nutrition (lead), and Department of Biosystems & Agricultural Engineering. His has appointments in research, teaching, and extension. His research is on modeling effects of thermal processing on safety and quality of foods, and on inverse problems and parameter estimation. His research group is a leading user of MATLAB with COMSOL for parameter estimation. The group has developed new statistical analysis and computational methods for food researchers.

Prof Dalbir Singh Sogi received his Bachelor degree from PAU Ludhiana, Master from CFTRI Mysore and Doctorate from GNDU, Amritsar. He joined Department of Food Science and Technology, GNDU, Amritsar in 1993. He visited The Hebrew University of Jerusalem, Rehovot, Israel. He was awarded Fulbright Fellow at Michigan State University, East Lansing, USA. His areas of interest are waste management, plant proteins and plant pigments.

Course Coordinator

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