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Basic Concepts in the Methodology of Mathematical Modeling

The objective of this course is to introduce the student to important concepts and methods needed for developing complex models of physiological control mechanisms at the organ and system level. In particular, parameter estimation will be a primary focus. A key issue in such research is that models that have sufficient complexity to allow for new insights about complex interactions often leads to the problem that such models contain many parameters but data for identification is limited. This is certainly an issue for models intended for application in the clinical setting where non-invasive testing generates only a restrictive set of data. Furthermore, the inter-individual variation in a physiological system's inventory of control responses adds further complication to model application for diagnosis and treatment design. These problems represent an important challenge to current research and shape, to a large extent, the approach to model design.

Topics for this module include:

1. Key concepts in model design and the validation of the design;
2. How control issues enter the model design;
3. Approaches to linear and nonlinear control design:
   (a) Optimal control;
   (b) Receding horizon control;
4. The need for innovative methods of parameter estimation and the definition of the mathematical setting;
5. An application: cardiovascular modeling;
6. Numerical issues and problems in model implementation.

References

[1] J. J. Batzel, F. Kappel, D. Schneditz and H.T. Tran, *Cardiovascular and Respiratory Systems: Modeling, Analysis and Control*, SIAM Frontiers in Applied Math, SIAM, Philadelphia, 2006.

[2] F. S. Grodins, *Control Theory and Biological Systems*, Columbia University Press, 1963.

[3] K. Thomaseth and C. Cobelli. Generalized sensitivity functions in physiological system identification., *Ann Biomed Eng.*, **27(5)** (1999), 607–616.