

UVA Center for Biomathematical Technology
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Overview

The University of Virginia's Center for Biomathematical Technology intends to participate with both the research and education missions of the university. Our recent objectives have focused on the emerging role of biomathematics in biomedical research, as well as clinical practice.

We define biomathematics as (i) modeling, to recreate and thus describe and simulate, biological processes and phenomena; (ii) functionally and/or mechanistically parameterizing and thus testing hypotheses about physiological processes through computer-based experimentation; (iii) not restricted to considering only population data, but can and does consider individually-based data and phenomena; and (iv) employing a broad range of mathematical methodologies, including nonlinear methods, network modeling, and dynamical (temporal) approaches.

After discussions with then UVA Vice President for Research and Public Service, Gene Block, the biomath center was established at the University of Virginia in August of 1999, albeit with the clear understanding that revenue generation be the responsibility of the center by way of solicitation of intramural and/or extramural sources of funding. We are beginning to experience success in our pursuit of funding to support the activities of the biomath center.

Rationale

Recent technological advances provide easy access to enormous volumes of increasingly complex data in the biomedical research setting. As such, increasingly complex quantitative methods are being developed and employed by the life sciences. In particular, there is recognition of the growing needs for custom quantitative and computational strategies (e.g., UVA's NSF Center for Biological Timing; the Center for Behavioral Medicine Research in association with the Department of Psychiatric Medicine; and the Department of Internal Medicine's Division of Endocrinology and Metabolism in association with UVA's General Clinical Research Center).

Successful development and implementation of custom biomedical analytical and interpretive computer-based tools requires participation by individuals with interdisciplinary skills that span the boundary between the life sciences and the quantitative & computational sciences. Individuals who speak both languages are needed for this role, those with comfortable familiarity with both bioscience and the quantitative & computational sciences. With the correct complement of training and experience, we have been quite successful over the past decade and more in applying non-standard expertise to a broad diversity of biologic, biomedical, and psychophysiology problems.

Biomathematics has had a diverse impact on biomedicine at UVA as demonstrated by our long-standing relationships with a variety of bioscience research projects:

- Diabetes management and control
 - Prediction of severe hypoglycemia
 - Artificial pancreas development
 - ADHD/EEG objective diagnostics
 - Temporally complex biological dynamics
 - Endocrine regulatory physiology
 - Endocrine decline with aging
 - Infertility, hormones, and remedial therapy
 - State-of-the-art hormone assay analysis
 - Dynamic physiological network modeling
 - Advanced analysis of hormone pulsatility
 - Analysis of biological/circadian rhythms
 - Shiftwork schedules/worker health & safety
 - Optimal individualized cancer therapies
 - Chronomodulated treatment of cancer
 - Epilepsy interfaced with circadian biology
 - Automated seizure prediction – EEG S/W
 - Novel analysis of saltatory growth patterns
 - Automated sleep apnea ID/characterization
 - Sepsis prediction in premature infants
 - Circadian patterning and cardiac pathology
 - Driving simulation experimentation/research
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Professional Expertise of Participants

Michael L. Johnson, Ph.D. is Professor of Pharmacology and Internal Medicine (Division of Endocrinology and Metabolism) and the biomathematician for the UVA General Clinical Research Center. He has a Ph.D. in biophysics with a specialty in modeling of biological processes. Johnson has authored more than 280 publications and edited 8 books, the majority of which involve mathematical modeling of biological processes (particularly numerical computer methods and quantitative neuroendocrinology).

Boris P. Kovatchev, Ph.D. is Associate Professor of Psychiatric Medicine and Health Evaluation Sciences, has a Ph.D. in probability and statistics, and has 10 years experience in biomathematics. He has had continuous NIH funding since 1996 exclusively dedicated to biomathematical modeling for diabetes research. He has (i) developed the low blood glucose index, the best predictor to date of severe hypoglycemia, (ii) created the theory of risk analysis of blood glucose data, (iii) developed new computational tools for assessment of behavioral irregularity associated with type 1 diabetes and for assessment of long-term diabetes control, and (iv) successfully developed a remarkably accurate deterministic model of insulin-glucose dynamics. Two patent disclosures have been filed and licensed by industry leaders in the area of diabetes management.

Martin Straume, Ph.D. is Associate Professor of Research in the Division of Endocrinology and Metabolism in the Department of Internal Medicine. He is also the biomathematician of the NSF Center for Biological Timing at UVA. He has a decade of experience with biomathematics applied to circadian rhythms research, with clinical and basic research in epilepsy and cancer therapy, with analysis and interpretation of time series of gene expression arrays, has worked closely with Kovatchev on blood glucose prediction and control in diabetes, and collaborates with Johnson on analysis of hormone pulsatility, network dynamic modeling and regulation, and endocrine decline with aging and disease.
