iccai
International Conference
Complexity in Acute Illness

10th International Conference on Complexity in Acute Illness (ICCAI)

September 8th-11th, 2011
Bonn, Germany

Biomedizinisches Zentrum
Universitätsklinikum Bonn

Scientific Program & Abstracts

Individualized Medicine -
From Data Deluge to Outcome Optimization

This event is supported by:

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Bonn, September 2011

Dear ICCAI 2011 participants,

in my role as organizer and chair of the Scientific Committee, I cordially welcome you at this 10th instantiation of the International Conference on Complexity in Acute Illness (ICCAI), an annual event initiated by the Society for Complexity in Acute Illness (SCAI).

While this event's focus has continuously changed and adapted as the SCAI membership and perspective evolved, the core idea of promoting the use of quantitative methodology at the intensive care bedside by bringing together quantitative scientists from mathematical, physical, and engineering backgrounds, experimentalists with biological backgrounds, and intensive care practitioners has remained unaltered.

As a result of fruitful interactions at past events, and in response to current developments in the quantitative data analysis field, we integrated, for the first time, a dedicated session on intensive care applications of machine learning and artificial intelligence methodologies.

Additionally, in support of SCAI's overarching goal, we have introduced a tutorial day, aiming to provide an in-depth introduction to a subset of relevant quantitative methodology to interested physicians and experimentalists, aiming to lower the entrance threshold for applying innovative methodology to clinically relevant data. Many thanks to the tutors, John Doyle and Gary An!

We also owe gratitude to our sponsors, both public (DFG, USAISR) and corporate (IBM, Immunetrics), as well as the Dpt. of Anesthesiology and Intensive Care Medicine, University of Bonn Medical Center, as the hosting institution. Without their generous support, this event would not have been possible.

Finally, I would like to thank all participants who have submitted abstracts. Reviving an old ICCAI tradition, selected contributions will be presented as oral presentations in the "Free Paper" sessions. Based on the excellent quality of the accepted abstracts, I am confident both "Free Paper" and poster sessions will provide stimulating input to all participants.

With my best wishes for a pleasant and instructive stay in Bonn, I remain sincerely,

Sven Zenker
Organizer, ICCAI 2011
On behalf of the ICCAI Scientific Committee and the SCAI board of directors

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For contributed abstracts, please refer to the published versions in the Journal of Critical Care (http://www.jccjournal.org)

ICCAI 2011

Organizer *Dr. Sven Zenker*
Co-Organizer *Dr. Edmund Neugebauer*

Scientific Committee

The organizers and

Dr. Mitchell Cohen
Dr. Andriy Batchinsky
Dr. Gilles Clermont
Dr. Andrew Seely
Dr. Gary An

Society for Complexity in Acute Illness (SCAI) board of directors

Yoram Vodovotz, President
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» **Combat Critical Care Engineering Task Area,**
Battlefield Health and Trauma Research Institute ,
San Antonio, Texas

Detailed Scientific Program

Reference numbers of abstracts, where available, are given in parentheses after the presentation title and can be found in the relevant later sections of this booklet.

Thursday, September 8th, 2011 (Tutorial Day)

9:00 – 12:00 Morning Session

Tutorial Track A: Introduction to control and dynamical systems (J. Doyle, Pasadena, CA, USA)

The morning tutorial will focus on a basic introduction to control and dynamics using case studies from physiology and biology. Topics will include state space models, simulation, stability analysis, feedback, transforms, input-output methods, nonlinear dynamics, bifurcations, notions of organized and disorganized complexity, and layered architectures. Case studies will include control systems involved in cell metabolism and signal transduction, human cardiovascular systems, and inflammation. Topics will be adjusted based on attendees background and interests, with the aim of bridging between their existing backgrounds and the afternoon tutorials on either agent based modeling or connecting models and data.

12:00 – 13:00 Lunch break

13:00 – 17:00 Afternoon Session

Tutorial Track A: Connecting data and models
J. Doyle, Pasadena, CA, USA

The afternoon tutorial will focus on comparing data and models, including methods from statistics, system identification, and machine learning. Some additional model methods may be reviewed here as needed. A particular focus will be on rigorous methods to analyze and model high variability phenomena, with case studies from cellular noise to heart rate variability. The complementary and contrasting use of both black-box and mechanistic models will be highlighted.

13:00 – 18:00

Tutorial Track B: Agent based modeling: An introduction
G. An, Chicago, IL, USA

Synopsis: Agent-based modeling is an object-oriented, discrete-event, rule-based method for creating computer simulations, and has been used extensively in the biomedical arena to represent a range of topic extending from cell signaling to epidemiology. This tutorial will introduce the basic concepts associated with agent-based modeling, with particular emphasis on its utility as a means of dynamic knowledge representation of biomedical systems. The tutorial will also include a hands on session where attendees with be taken step-by-step through the creation of a very basic but scalable agent-based model using the freeware toolkit NetLogo. Attendees should bring their own laptops for the session with NetLogo downloaded and installed (the package can be downloaded for free from http://ccl.northwestern.edu/netlogo/). During the tutorial session attendees with be guided through the development of a basic cell-level agent-based model, given the opportunity to expand upon the base model, and instructed on how to carry out simulation experiments.

13:00 - 13:45
Introduction to Agent-based modeling and its biomedical applications

13:45 - 15:30
Tutorial Part I: Getting started on a cell-based inflammation/infection agent-based model

15:30 - 16:00 Break

16:00 - 18:00
Tutorial Part II: Modification and customization of the base inflammation model and running simulation experiments

Friday, September 9th, 2011 (Day 1 Main Meeting)

8:30 - 9:00
Welcome and Introductory Remarks
Y. Vodovotz, S. Zenker, E. Neugebauer

9:00-10:00
Keynote Address
"More Data Than We Know What To Do With?" (I-1)
Dr. Stuart Russell, Berkeley, CA, USA

10:00 - 12:30
Session 1: Mechanistic modeling and model based control I
Session chairs: G. Clermont / S. Zenker

10:00 - 10:30
Uncertainty quantification for mechanistic models of physiological processes
J Stelling, Zürich, Switzerland

10:40 - 11:10
High throughput and multiscale patient - specific Systems Biology
S. Diamond, Philadelphia, PA, USA

11:20 - 11:50
Modeling of cardiovascular variability under time-varying loads: theory and experimental validation
J. Doyle, Pasadena, CA, USA

12:00 - 12:30
Pressure- and Work-Limited Neuroadaptive Control for Mechanical Ventilation of Critical Care Patients (I-2)
W. Haddad, Atlanta, GA, USA

12:30 - 13:30 Lunch

13:30 - 16:00

Session 2: Mechanistic modeling and model based control II

Session chairs: W. Haddad / J. Doyle

13:30- 14:00

Automatic control in medicine - how much is necessary, how much is wanted? (I-4)

S. Leonhardt, Aachen, Germany

14:10- 14:40

State-of-the-art numerical methods for optimal experimental design, online system identification, and model predictive control

J.P. Schlöder, Heidelberg, Germany

14:50- 15:20

The use of physiological models in ventilator control (I-5)

S. Rees, Aalborg, Denmark

15:30- 16:00

Model predictive control of a blood purification device

G. Clermont, Pittsburgh, PA, USA

16:00 - 16:30 Coffee Break

16:30 - 17:30 Free paper session I

Session chairs: T. Buchman / M. Cohen

Judges: The ICCAI Scientific Committee

(presentations 10 minutes + 2 minutes discussion each, for author details, refer to abstracts)

Petelczyc et al., Heart rate variability asymmetry in stochastic analysis (O-10)

Scheff et al., Multiscale Rhythmic Influences on Heart Rate Variability in Human Endotoxemia (O-5)

Clark et al., Acute uncoupling of heartbeat and respiration in neonatal respiratory decompensation (O-1)

Brown et al., The Short-term Fractal Exponent of Heart-Rate Variability Is Associated with Mortality in Severe Sepsis and Septic Shock (O-4)

Bravi et al., Development of a composite variability metric for clinical application. (O-3)

17:30 - 18:30 Poster Session 1:

Session chairs: G. An / A. Seely

Judges: The ICCAI Scientific Committee

(Posters P1-P9 will be presented and judged.)

18:30 – 19:30 Break

transfer to dinner location (pick-up at conference site and Dorint hotel)

19:30 Festive dinner at Godesburg Bonn

Saturday, September 10, 2011 (Day 2, Main Meeting)

9:00 - 11:30

Session 3: Machine learning and Artificial Intelligence Approaches to Critical Care Data

Session chairs: S. Russell / J. Stelling

9:00 - 9:20
"Failure to rescue" concept in clinical diagnostic alerts (I-6)
V. Herasevich, Minnesota, USA

9:30 - 9:50
Real-time prediction of an anesthetic monitor index using machine learning (I-7)
G. Bontempi, Brussels, Belgium

9:55 - 10:15
Prognostic methods in the ICU: the role of pattern and subgroup discovery (I-8)
A. Abu-Hanna, Amsterdam, Netherlands

10:20 - 10:40
Dimension reduction in the analysis of high dimensional bioassay data (I-9)
Y. Vodovotz, Pittsburgh, PA, USA

10:45- 11:05
Redefining physiology: Physiologic state identification and transition propensity using multivariate ICU informatics
M. Cohen, SanFrancisco, USA

11:10- 11:30 Predictive data mining in routine clinical data: possible applications (I-10)
G Meyfroidt, Leuven, Belgium

11:30 - 12:30 Free paper session II

Session chairs: Y. Vodovotz / A. Batchinsky
Judges: The ICCAI Scientific Committee
(presentations 10 minutes + 2 minutes discussion each, for author details, refer to abstracts)

Rusin et al., Distributed Cluster Computing system for recording and processing physiological data in the ICU (O-8)

Podziemski et al., Lienard-Type Dynamical System Models for the simulation of the Human Heart Atrium (O-9)

Enright et al., Individualised Patient Models Combining Mathematical Models and Real-Time Clinical Data (O-2)

Tambuyzer et al., Dynamic algorithms of biomarkers for monitoring infection/inflammation processes in pigs (O-6)

Song et al., Understanding pathophysiologic mechanisms in severe sepsis using an ensemble of neutrophil kinetic based systemic inflammation model (O-7)

12:30 - 13:30 Lunch Break

13:30 - 15:30

Session 4: Physiological Signals and Nonlinear Time Series Analysis I

Session chairs: A. Batchinsky / P. Norris

13:30- 13:55

Kalman filtering for artifact detection and reduction in multimodal monitoring data (I-11)

G. Clifford , Oxford, UK

13:55 - 14:20

Low frequency oscillations of the intracranial pressure signal in acute traumatic brain injury - relationship between spectral energy, phase and autoregulation.

A. Stefanovska, Lancaster, UK

14:20- 14:45

Generic Decision Support Architectures in the ICU: Burn Decision Support

J. Salinas, Ft. Sam Houston, TX, USA

14:45- 15:10

Taking multiorgan variability quantification to the bedside - a multicenter clinical trial

A. Seely, Ottawa, Canada

15:10 – 15:35

Mortality reduction by heart rate characteristic monitoring in very low birth weight neonates: a randomized trial. (I-18)

R. Moorman, Charlottesville, VA, USA

15:35 - 16:00 Coffee Break

16:00 - 18:00

Session 5: Physiological Signals and Nonlinear Time Series Analysis II

Session chairs: T. Buchman / A. Seely

16:00 - 16:30

Identifying rare clinical events in complex physiological time series. (I-12)

P. Norris, Nashville, TN, USA

16:30 - 16:45

Artemis: Real-Time Streaming Analytics for Intensive Care Units - an academic perspective (I-13)

C. McGregor, Toronto, Canada

16:45 - 17:00

Artemis: Real-Time Streaming Analytics for Intensive Care Units - an industrial perspective (I-14)

D. M. Sow, Hawthorne, NY, USA

17:00 - 17:30

Robust signal extraction from complex physiological monitoring timeseries (I-15)

M. Imhoff, Bochum, Germany

17:30- 18:00
Data Acquisition and Analysis of Physiological Signals in Pediatrics: Investigations and Challenges (I-16)
J. Fackler,

18:00 - 19:00 Poster Session II:
Session chairs: M. Cohen / P. Norris
Judges: The ICCAI Scientific Committee
(Posters P10-P17 will be presented and judged.)

19:30 – 21:00 Buffet dinner and announcement of prizes

Sunday, September 11th, 2011 (Day 3 Main Meeting)

09:00 - 10:20
Session 6: Moving the frontier: future perspectives
Session chairs: G. Clermont / Y. Vodovotz

09:00 - 09:20
Mathematical Abstraction and Formalism in Biology: How far can we go? (I-17)
G. An, Chicago, IL, USA

09:20 – 09:40
Medical decision support of the future: Integrated real-time physiological monitoring and automated data analysis in the ICU
A. Batchinsky, San Antonio, TX, USA

09:40- 10:00
Moving from bench to bedside: the role of industrial partners
S. Chang, Pittsburgh, PA, USA

10:00 - 10:20
Turning new methodology into patient benefit: challenges and opportunities
T. Buchman, Atlanta, GA, USA

10:20 - 10:45 Closing remarks, adjournment of scientific meeting

10:45 – 11:00 Coffee break

11:00-12:00 SCAI Business meeting (SCAI members only)

Abstracts

Abstracts Invited Presentations

I-1 More Data Than We Know What To Do With?

Dr. Stuart Russell, Computer Science Division, Berkeley, CA, USA

"Decisions are made at every moment in the ICU. What if the decision-maker had access to all relevant data for every such decision? The relevant data include everything from this patient's current physiological readings to the results of drug trials done years before. Machine learning can bring all these data to bear in a usable form. Of the many tools in the machine learning toolbox, model-based methods hold the greatest promise. In the not-too-distant future they may be able to support accurate real-time diagnosis and the synthesis of complex intervention strategies. On the other hand, no matter how much data we have, uncertainty -- and with it the need for continuous observation -- will be unavoidable and must be embraced by technology."

I-2 Pressure- and Work-Limited Neuroadaptive Control for Mechanical Ventilation of Critical Care Patients

Wassim Haddad, Georgia Institute of Technology

Objectives: In this work, we present a neuroadaptive control architecture to control lung volume and minute ventilation with input pressure constraints that also accounts for spontaneous breathing by the patient.

Methods: Specifically, we develop a pressure- and work-limited neuroadaptive controller for mechanical ventilation based on a nonlinear multi-compartmental lung model. The control framework does not rely on any averaged data and is designed to automatically adjust the input pressure to the patient's physiological characteristics capturing lung resistance and compliance modeling uncertainty. Moreover, the controller accounts for input pressure constraints as well as work of breathing constraints. Finally, the effect of spontaneous breathing is incorporated within the lung model and the control framework.

Results: It is shown that the delivered air volume using nominal controllers significantly exceeds the desired values in the absence of adaptation, whereas satisfactory tracking of the desired air volume is achieved with adaptation. Failure to adequately regulate the mode and parameters of ventilatory support can result in failure to oxygenate, failure to achieve adequate lung expansion, or overexpansion of the lung resulting in lung tissue rupture. These problems oftentimes occur when open-loop volume-control or pressure control is employed, or when averaged respiratory data is used to choose the parameters for a closed-loop ventilation control algorithm. In contrast, the proposed neuroadaptive control algorithm avoids reliance on average respiratory data and achieves system performance without excessive reliance on system model parameters.

Conclusions: Acute respiratory failure due to infection, trauma, and major surgery is one of the most common problems encountered in intensive care units and mechanical ventilation is the mainstay of supportive therapy for such patients. In particular, mechanical ventilation of a patient with respiratory failure is a critical life-saving procedure performed in the intensive care unit. Failure to adequately regulate the mode and parameters of ventilatory support can result in failure to oxygenate, failure to achieve adequate lung expansion, or overexpansion of the lung resulting in lung tissue rupture. In this research, we developed a neuroadaptive control algorithm for mechanical ventilation to control lung volume and minute ventilation. The adaptive controller accounts for input pressure constraints as well as work of breathing constraints in the face of lung resistance and compliance model uncertainty.

I-3 High throughput and multiscale patient-specific Systems Biology

Scott L. Diamond, PhD, Director, Penn Center for Molecular Discovery University of Pennsylvania

Predicting tissue function based upon an individual's unique cells requires a multiscale Systems Biology approach to understand the coupling of intracellular signaling with spatiotemporal gradients of extracellular biochemicals controlled by convective-diffusive transport. During thrombotic or hemostatic episodes, platelets bind collagen and release ADP and thromboxane A2 (TXA2) to facilitate the recruitment of additional platelets to a growing deposit that distorts the flow field. Using high throughput experimentation, we obtained a large set of platelet calcium responses to combinatorial activators in order to train a neural network (NN) model of platelet activation for several individuals. Each NN model was then embedded into a kinetic Monte Carlo/finite element/lattice Boltzmann simulation of stochastic platelet deposition under flow. Simulations predicted the unique clot buildup dynamics for each donor and responses to various pharmacological inhibitors (measured in microfluidic assays). Consistent with measurement and simulation, one donor displayed a gain of function phenotype, while another donor was distinguished by combined aspirin-resistance and U46619-insensitivity, consistent with a thromboxane receptor mutation. In silico representations of an individual's platelet phenotype allows prediction of blood function, essential to prioritizing patient-specific cardiovascular risk and drug response or to identify unsuspected gene mutations.

Flamm MH, et al. J. Chem. Phys 134:034905 (2011)
Chatterjee MS, et al. PLoS Comp. Biol. 6:e1000950 (2010)
Chatterjee MS, et al. Nature Biotechnology 28:727 (2010)

I-4 Automatic Control in Medicine - how much is necessary, how much is wanted?

Steffen Leonhardt , Director, MedIT, Aachen, Germany

Feedback control is a fundamental principle in nature that, if implemented the right way, tends to stabilize dynamic systems. Also, today various fields of technology, from robots and cars to modern production systems, strongly utilize feedback control to improve the dynamic behaviour. In fact, automation and control are key concepts to deal with complexity.
In medicine, therapeutic concepts tend to become more complex as well, due to increasing amounts of standarized clinical protocols, new sensing modalities and a tendency towards more and more computerization. In the future, we are expecting more and older multimorbid patients and less staff to care for them, due to the demographic changes in aging societies. This all points towards more automation in medicine.
But a very important question is not answered yet: how much automation is useful, safe and acceptable for our societies? The talk will provide selected examples to stimulate discussion.

I-5 The INVENT project - Using mathematical models in selecting appropriate mechanical ventilation.

Steven Rees, Associate Professor, Center for model-based medical decision support (MMDS), Aalborg University, Denmark

This presentation will describe the INtelligent VENTilator project (INVENT), the goal of which is to build, evaluate and integrate into clinical practice, a model-based decision support system

for control of mechanical ventilation. Models included in INVENT will be presented including those of pulmonary gas exchange, and acid-base status of blood along with decision-theoretic penalty functions for balancing the competing goals of mechanical ventilation. The level of model complexity to enable patient specific tuning will be discussed and examples will be given of patients cases to illustrate the potential of model-based decision support in this field. In addition, examples will be shown of how models often lead to new ideas, scientific projects and commercial applications. These examples will include a system for measuring pulmonary gas exchange and a system for mathematical arterialisation of the acid-base and oxygen status of peripheral venous blood; removing the need for painful arterial punctures.

I-6 "Failure to rescue" concept in clinical diagnostic alerts

Vitaly Herasevich, Assistant Professor of Medicine, Department of Anesthesiology, Multidisciplinary Epidemiology and Translational Research in Intensive Care (METRIC), Mayo Clinic

The expansion of electronic medical records (EMR) provides an unprecedented opportunity to use syndrome surveillance technology for the development of "smart alarms" or sniffers that improve the safety of critically ill hospitalized patients. Preliminary studies which use rule-based alerts and/or computer-generated messages directed at clinicians demonstrate a decrease in patient length of hospital stay and decreased response time before the physician institutes appropriate treatment. However the timeliness of an intervention depends critically not only on syndrome pattern recognition but vigilant follow up of a system's delivery of care. Unfortunately, failure-to-recognize and failure-to-rescue errors are a common and extremely important cause of morbidity and mortality in the ICU. Monitoring for errors of this type is a task that requires a degree of vigilance in addition to pattern detection. The ICU electronic environment contains many markers of human agents' actions and these may be used to detect errors of omission. During this presentation, speaker will address "Failure to rescue" concept in clinical diagnostic alerts and also will outline the problem of information overload from unnecessary multiple clinical alerts while presenting some key potential steps to address this issue.

I-7 Real-time prediction of an anesthetic monitor index using machine learning

Gianluca Bontempi, ULB Machine Learning Group, Brussels, Belgium

Anaesthesiologists control the level of consciousness of a patient undergoing surgery by appropriately dosing hypnotic drugs on the basis of the information provided by monitoring devices. The bispectral index (BIS) monitor provides a dimensionless quantity derived from the electroencephalogram, which quantifies the level of awareness of the patient. This presentation discusses the use of machine learning techniques
to implement a predictive model of the BIS based on the variation of the hypnotic drugs. Such a model learned from a database of recorded operations can aid real-time decision
making during the course of an operation. In order to deal with inter-individual variability, the proposed model takes into account patient physiology as well as the reactions of the patient during the early phases of the operation. Two models of the bispectral index behavior are assessed and compared in this work: a linear predictor and a local learning predictor. These prediction

models were software implemented and their accuracies were assessed by a computerized cross-validation study and were tested in real situations.

I-8 Prognostic methods in the ICU: the role of pattern and subgroup discovery

Ameen Abu-Hanna, Department of Medical Informatics, Academic Medical Center, University of Amsterdam, The Netherlands

This talk will address three important uses of prediction models in the Intensive Care Unit (ICU), with focus on mortality prediction. I will review our work on using prediction models for benchmarking ICUs, in which model predictions of an ICU¹s outcomes are compared to the ICU¹s actual outcomes. I will demonstrate how changes over time in the performance of these models impact the assessment of quality of care of ICUs. Next I will explain how discovered frequent patterns in organ functioning status can be used to provide daily predictions to help make treatment decisions for individual patients. I will show how these predictions compare to those made by ICU nurses and physicians. Finally I will present applications of subgroup discovery algorithms for identifying ³interesting² patient subgroups that behave markedly differently than the rest. I will reveal a condition in which a simple classification tree algorithm performs better than an algorithm specifically designed for sub-group discovery. The talk will provide promising future research directions in prognostic modeling.

I-9 Dimension reduction in the analysis of high dimensional bioassay data

Yoram Vodovotz, Departments of Surgery, Immunology, Computational and Systems Biology, Bioengineering, Clinical and Translational Science, and Communications Science and Disorders, University of Pittsburgh, Pittsburgh, PA
Center for Inflammation and Regenerative Modeling, McGowan Institute for Regenerative Medicine, Pittsburgh, PA

Like many biological processes, inflammation and its various manifestations in disease are multidimensional. The advent of multiplexed platforms for gathering biological data, while providing an unprecedented level of detailed information about complex biological systems such as the inflammatory response, has paradoxically also flooded investigators with data they are unable to use in the reductionist, linear paradigm of hypothesis generation and testing. Herein, we discuss the use of dimensionality reduction techniques as standalone methods with both mechanistic and translational applications in trauma/hemorrhage, traumatic brain injury, and sepsis. We also describe the incorporation of these techniques into mechanistic simulations of the acute inflammatory response, and the use of such simulations within a paradigm of Translational Systems Biology.

I-10 Predictive data mining in routine clinical data: possible applications.

G Meyfroidt, Leuven, Belgium

Computerization in healthcare in general, and in the intensive care unit (ICU) in particular, is on the rise. This leads to large patient databases, with specific properties. There seems to be a reluctance to use these databases for research purposes, often related to fact that they contain large amounts of unvalidated data. Machine learning techniques are able to examine large databases in an automatic way, to extract knowledge. Although the number of potential applications for these techniques in medicine is large, few medical doctors are familiar with their methodology, advantages and pitfalls. Early work demonstrates that the ability of machine learning techniques to build robust and reliable prognostic models and preliminary early warning systems. An overview of this work will be presented.

I-11 Kalman filtering for artifact detection and reduction in multimodal monitoring data

G. Clifford , Oxford, UK

Noise contaminates biomedical recordings frequently, disrupting patient care and leading to distrust and confusion. As many as 95% of critical events requring human intervention are false. In part this is due to the lack of intelligent interaction between physiological parameter streams. We present a method to analyse events which discovers relevant features in multiple physiologic streams and fuses them together with signal quality indices. An example application of neonatal apnea is described which demonstrates that 89% of false alarms in an unseen test set can be supressed.

I-12 Detecting Rare Clinical Events in Complex Physiological Time Series

Patrick R. Norris, Ph.D., Vanderbilt University Medical Center, Nashville, Tennessee USA

Analysis of complex variability in biological signals has provided new insight into the pathophysiology of critical illness. Reduced heart rate complexity, for example, has been associated with poor outcomes in trauma patients and other critically ill populations. However, these and similar findings have yet to inform specific critical caredecisionsin a widespread, meaningful way. Successfulapplication requires improved understanding of physiologic mechanisms responsible for altered biosignal complexity,the ability to measure these changes in the course of routine patient monitoring, and associated evidence-based protocols for modifying patient care.
Monitoring hemodynamic complexity to predict specific adverse clinical events underscores these challenges in defining mechanisms, making measurements, and modifying care. Mechanistically, heart rate or other hemodynamic signal complexity are affected by diverse factors, including evolving myocardial infarct, hemorrhage, infection, certain medications, and mechanical ventilator settings. Sufficiently detailed models of these factors, and the mechanisms by which they alter complexity in signals of interest, are needed to ensure specificity for particular events. Complexity measurements of known accuracy and precision must be available to clinicians at the point care, and efficiently presented in a format immediately useful for decision-making. Finally, evidence-based protocols, based on proven utility of complexity over other measurements, are required if care is to be modified.
This presentation will describe an approach to selecting appropriate clinical events, modeling

relevant mechanisms, identifying suitable measurements of complexity, and, potentially,modifying care of critically ill trauma patients. Selected clinical events, both potentially confounding events and those requiring provider attention, have been linked to the SIMON (Signal Interpretation and Monitoring) database, a large repository of continuously-captured hemodynamic signalsincluding more than two years of EKG waveform capture. Patterns of heart rate complexity surrounding these events will be presented and discussed, with critical appraisal of the clinical value of these measurements to predict rare adverse clinical events, and next steps to rigorously evaluate their potential in the course of patient care.

I-13 Artemis: Real-Time Streaming Analytics for Intensive Care Units - an academic perspective

Carolyn McGregor, Canada Research Chair in Health Informatics. Professor, Director of Research, Faculty of Business and IT. Cross appointed with Faculty of Health Sciences University of Ontario Institute of Technology (UOIT)

Critical care units internationally boast state of the art medical equipment that constantly monitor vital organs. However, they are at a critical crossroad where their ability to gather this information has outpaced their ability to aggregate and interpret in a clinically meaningful way. Recent medical research has reported that conditions such as late onset neonatal sepsis, pneumothorax, intraventricular haemorrhage, and periventricular leukomalacia, appear to exhibit early pathophysiological indicators in physiological data. However research in this domain has been limited to either patient centric, diagnosis centric or physiological stream centric approaches with a heavy emphasis on retrospective analysis and minimal translation to real-time monitoring. This research presents Artemis, a framework for concurrent multi-patient, multi- diagnosis and multi-stream (ie multidimensional) temporal analysis in real time for clinical management and historically for clinical research. The real-time component utilizes new stream processing approaches while the clinical research utilizes new approaches to data mining more suited to the analysis of physiological stream behaviours and within the healthcare context. Critical care patients in rural, remote and some urban healthcare facilities do not have the same level of access to intensivist support as patients in higher care level urban critical care units (CCUs). The provision of clinical decision support tools, in a cost effective way to all CCUs has the potential to reduce mortality and morbidity rates, reduce critical care patient transportation between CCUs and in so doing reduce healthcare costs. This research also presents Artemis Cloud, a cloud computing based Software-as-a-Service and Data-as-a-Service approach for the provision of remote real-time patient monitoring and support for clinical research. This research is demonstrated using a neonatal intensive care unit case study.

I-14 Artemis: Real-Time Streaming Analytics for Intensive Care Units - an industrial perspective

Daby M. Sow [1,2]
Additional Contributors: Alina Beygelzimer [1], Alain Biem[1], Marion Blount [1], Tim Dinger [1], Maria Ebling [1], Gang Luo [1], Michael Schmidt [2], Deepak Turaga[1]
[1] IBM T. J. Watson Research Center, Hawthorne, NY, USA; [2] Columbia University, New York, NY, USA

For each patient, critical care physicians are confronted with hundreds of disjoint variables collected by patient monitors and general clinical information systems. To cope with this data overload, clinicians need assistance to: 1) gather and pool together patient data from disparate devices

and clinical information systems; 2) automatically analyze the data in a timely manner to extract clinically relevant information; and 3) efficiently interface with the data and the analytics to make quick accurate clinical decisions. Our research addresses these problems with the design of the Online Healthcare Analytics infrastructure (a.k.a. Artemis), and its extensions for exploration. OHA is a framework for real-time analysis in intensive care leveraging IBM InfoSphere Streams (Streams), a state-of-the-art stream computing platform that we developed at IBM Research.
From a data integration perspective, OHA is designed to interface with an open set of devices and clinical information management systems through well defined adaptation mechanisms. A tight integration with the Excel Medical BedMasterEX system is enabled with appropriate adapters to acquire physiologic data from patient monitors.
From an analytical perspective, OHA has been initially designed to operate in an open loop configuration where analysts specify explicitly real-time analytics for the detection of specific patterns in patient data. Physicians and researchers at SickKids, Toronto and at the University of Ontario Institute of Technology are leveraging OHA in this configuration to collect data, mine them externally and test clinical hypotheses to come up with new ways to detect nosocomial infections in neonatal ICUs. Recently, we have been extending OHA with exploration capabilities and have designed an Exploration Platform for Intensive Care (EPIC). EPIC is a closed loop extension of OHA. It provides assistance to analysts in the exploration of patient data, to accelerate the discovery of interesting patterns in streaming data. While working with the Columbia Medical Center Neuro-ICU, we are developing EPIC for application to the early detection of complications like delayed cerebral ischemia.
Users interact with EPIC and OHA at different levels of abstraction. At the lowest level, analysts program real-time analytics in the Stream Processing Language (SPL), a generic programming language for the specification of streaming analytics. At higher levels of abstraction analytics can be composed from pre-defined analytical SPL building blocks, shielding domain experts from SPL programming and allowing them to quickly compose and deploy streaming analytics.

I-15 Robust signal extraction from complex physiological monitoring time series

*Roland Fried, Matthias Borowski, Ursula Gather, Michael Imhoff**
Department of Statistics, TU Dortmund University, Germany
** Department for Medical Informatics, Biometrics and Epidemiology, Ruhr-University Bochum, Germany*

Introduction: The disease state of the critically ill is described by complex data from multiple sources. For the clinician the challenge is to distinguish clinically relevant changes from noise and artifacts. In this contribution we will give an overview and present some examples of robust statistical signal extraction methods.

Requirements and methods: Algorithms for use in clinical real-time environments have to be robust against artifacts and missing values as well as efficient and fast. Online use demands instantaneous updates with every new incoming value. Many different univariate and multivariate algorithms have been proposed for use in such situations, including median filters, Kalman filters, different robust filters, graphical models, multivariate regression as well as approaches from artificial intelligence. While some of these approaches showed promising results, none has gained universal acceptance or even commercial implementation.

Examples from vital signs monitoring: Robust regression techniques represent one approach to signal extraction. Repeated median regression seems to be the best choice for intensive care

monitoring because of the quality of signal extraction and the favorable computational demands. We expanded this approach to multivariate time series using an adaptive online trimmed repeated median least squares filter. In intensive care monitoring data the univariate filters can eliminate a major percentage of false positive alarms without compromising alarm sensitivity in a clinically relevant manner.

Conclusions: Recognizing true failure in the critically ill requires fast and reliable interpretation of complex data with high sensitivity and specificity. Currently commercially available methods are often inadequate for this task. Statistical research has made new univariate and multivariate alarm algorithms available that can provide better and more robust alarm detection.

I-16 Data Acquisition and Analysis of Physiological Signals in Pediatrics: Investigations and Challenges

Jim Fackler, Baltimore MD, USA

About 10 years ago, Brahm Goldstein reported a system for physiological data collection and lamented in his introduction that, “Current bedside monitoring techniques have remained relatively unchanged over the past 20 yrs…” Adam Seiver in an accompanying editorial lamented, “Biological systems have resisted mathematical treatment.” In 2011, Adam is no longer correct; unfortunately, Brahm’s words still ring true.

Collecting digital data fromall devices at the bedside of acutely ill children (and here, adults are nothing more than grown children) must be as plug-and-play as are data feeds from consumer products. Emerging international standards for an Integrated Clinical Environment will be discussed and need to be supported.

Once collected, there is a need to unify the distributed and captured heterogeneous data. The data architecture must be secure, scalable and best implemented with open-source components. An update on the Virtual PICU initiative will be presented and needs to be supported and expanded.

With the data, the primary low-hanging-fruit for which mathematical treatments should be focused is support of a fundamental critical care cognitive task – pattern recognition and the aggregation of partial mental models into complete mental models. Preliminary work describing cognitive task analysis in critical care will be discusses. Further, preliminary work on a novel application of natural language processing will be presented to the discovery of patterns in physiological data.

I-17 Mathematical Abstraction and Formalism in Biology: How far can we go?

Gary An, Department of Surgery, University of Chicago

There are both potential rewards and pitfalls to attempts at formal descriptions of biological systems. The rewards are obvious: as a science almost entirely grounded on empiricism, biological knowledge does not lend itself to the scalable analysis that is a primary benefit of theory. Each biological system becomes a subject of essentially unique study, only very weakly linked to other "similar" systems through poorly characterized analogy. The establishment of a formal description of biological systems would greatly enhance the ability to generate and utilize bio-

logical knowledge, and usher in a modern age of biological investigation. However, there are significant limitations to existent attempts at creating biological formalisms, such as Rosen's M-R systems and topological analyses. While effective in terms of description, they are lack the ability to instantiate the essential dynamics of biology, and therefore do not provide a means of translating insight gained through their use to overcome the relative empirical uniqueness of biological systems. They lack in utility to map back onto the individual instances of the biological systems they purport to represent in a way that obviates such a high degree of empirical description that essentially renders them superfluous. Attempts of formal descriptions of biology need to remain, counter intuitively, grounded in the physical substance of biology, and the primary generative forces associated with biology, namely evolution and its relationship with the Second Law of Thermodynamics.

I-18 Mortality reduction by heart rate characteristic monitoring in very low birth weight neonates: a randomized trial

Randall Moorman [1] , Waldemar Carlo [2] , John Kattwinkel , Robert Schelonka [2] , Peter Porcelli [3] , Christina Navarrete , Eduardo Bancalari , Judy Aschner [5] , Whit Walker [6] , George Stukenborg [1] , Douglas Lake [1] , Michael O'Shea [3]
[1]University of Virginia; [2]University of Alabama-Birmingham; [3]Wake Forest University; [4]University of Miami; [5]Vanderbilt University; [6]Greenville (SC) Regional Hospital

Objectives: Late-onset neonatal sepsis is a common and serious illness among very low birth weight infants. Prior to clinical signs, abnormal heart rate characteristics of reduced variability and transient decelerations can appear, and we previously developed and validated algorithms to detect them. Here, we tested the hypothesis that heart rate characteristics monitoring improves neonatal outcomes.

Methods: This was a two-group, parallel, individually randomized controlled clinical trial of 3003 very low birth weight infants in 9 tertiary care U.S. Neonatal Intensive Care Units. In one group, heart rate characteristics monitoring results were displayed; in the other, results were masked. The primary outcome was number of days alive and ventilator-free in the 120 days after randomization. Secondary outcomes were mortality, number of ventilator days, NICU stay and antibiotic use. Heart rate characteristics monitoring uses linear (standard deviation, sample asymmetry) and non-linear (sample entropy) measures of heart rate in a logistic regression expression to estimate the fold-increase in risk of neonatal sepsis in the next 24 hours. These measures were developed to detect the signature abnormality of heart rate control – reduced variability and transient decelerations – that precedes clinical signs of illness.

Results: Infants whose heart rate characteristics monitoring results were displayed demonstrated a reduction in mortality from 10.2% to 8.1% (HR = 0.78, 95% CI = 0.61 to 0.99, P = 0.04, number needed to monitor to save one life = 48) and there was a trend toward increased days alive and ventilator-free (95.9 of 120 days compared to 93.6 in controls, P = 0.08). Although more blood cultures for suspicion of sepsis were drawn in the infants whose heart rate characteristics monitoring results were displayed (1.8 per month compared to 1.6, P=0.05), the incidence of sepsis (23.9% and 25.5%, P=0.34) and days on antibiotics (15.7 and 15.0, P=0.31) were not different. As expected, mortality was concentrated in infants with birth weight <1000g where the benefit was greater (HR=0.74, 95% CI 0.57 to 0.95, P=0.02, number needed to monitor to save one life = 23). The mortality benefit was further concentrated in infants who had an episode of sepsis, where the 30-day mortality fell from 16% to 10% (p=0.01).

Conclusions: Heart rate characteristics monitoring reduces mortality in very low birth weight infants. This is the largest randomized trial in premature infants, and the first demonstration that real-time dynamical monitoring has an impact on patient outcomes.

Faculty

Ameen Abu-Hanna
Institution: University of Amsterdam
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City: Amsterdam
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Talk Title: Prognostic methods in the ICU: the role of pattern and subgroup discovery

Professor Ameen Abu-Hanna's research interests lie in statistical machine learning, especially in the context of developing and validating prognostic models, and in decision support systems in health care. His background is in Computer Engineering (BSc), Computer Science (MSc) and Artificial Intelligence (PhD). He is a former president of the European Society of AI in Medicine and is currently heading the department of Medical Informatics at the Academic Medical Center at the University of Amsterdam.

Gary An
Institution: University of Chicago
Department: Dpt. Of Surgery
City: Chicago, IL
Country: USA
Website:

Talk Title: Mathematical Abstraction and Formalism in Biology: How far can we go?

Dr. Gary An is a graduate of the University of Miami, Florida School of Medicine, and did his surgical residency at Cook County Hospital/University of Illinois, Chicago. He is currently an Associate Professor of Surgery at the University of Chicago, and is the Co-director of the Surgical Intensive Care Unit. He previously worked as a Trauma Surgeon at Cook County Hospital from 1997 to 2003, was the Director of the Burn Intensive Care Unit at Cook County Hospital from 2003-2006, and was a Trauma/Critical Care Surgeon at Northwestern Memorial Hospital in Chicago, IL from 2006 to July of 2010. He has worked on the application of complex systems analysis to sepsis and inflammation since 1999, using primarily agent based modeling to create mechanistic models of various aspects of the acute inflammatory response. He is a founding member of the Society of Complexity in Acute Illness (SCAI). He is a faculty member of the Center for Inflammation and Regenerative Modeling at the McGowan Institute of Regenerative Medicine at the University of Pittsburgh. He is very active in the agent based modeling community, participating in the Swarm simulation community since 1999. He is the current president of the Swarm Development Group, and was the host of the Group's annual meetings from 2008-2010,. He is currently working on the use of agent-based models as a means of dynamic knowledge representation to integrate multiple scales of biological phenomenon. His research involves bioinformatics/ontology development to facilitate mechanism-based computer simulation/agent-based modeling, investigation of mathematical descriptions of fundamental aspects of biological systems and high-performance/parallel computing architectures for agent-based models.

Andriy Batchinsky
Institution: U.S. Army
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Talk Title: Real time Assessment of Systems Level Complexity in the ICU: How Well is the patient?

Gianluca Bontempi
Institution: Université Libre de Bruxelles
Department: Département d'Informatique
City: Brussels
Country: Belgium
Website: http://www.ulb.ac.be/di/map/gbonte/

Talk Title: Real-time prediction of an anesthetic monitor index using machine learning

Gianluca Bontempi graduated with honors in Electronic Engineering (Politecnico of Milan, Italy) and obtained his PhD in Applied Sciences (ULB, Brussels, Belgium). He took part to research projects in academy and private companies all over Europe. His interests cover data mining, machine learning, bioinformatics, time series prediction and simulation. He is author of more than 100 scientific publications. He is also co-author of software for data mining and prediction which was awarded in two international competitions. From January 2002 he is Gianluca Bontempi graduated with honors in Electronic Engineering (Politecnico of Milan, Italy) and obtained his PhD in Applied Sciences (ULB, Brussels, Belgium). He took part to research projects in academy and private companies all over Europe. His interests cover data mining, machine learning, bioinformatics, time series prediction and simulation. He is author of more than 100 scientific publications. He is also co-author of software for data mining and prediction which was awarded in two international competitions. From January 2002 he is Professor and Head of the Machine Learning Group of ULB.

Timothy Buchman
Institution: Emory University
Department: Emory Center for Critical Care
City: Atlanta, GA
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Website:

Talk Title: Turning new methodology into patient benefit: challenges and opportunities

Steven Chang
Institution: Immunetrics Inc.
Department: CEO
City: Pittsburgh, PA
Country: USA
Website:

Talk Title: Moving from bench to bedside: the role of industrial partners

Gilles Clermont
Institution: University of Pittsburgh
Department: Department of Critical Care Medicine
City: Pittsburgh, PA
Country: USA
Website:

Talk Title: Model predictive control of a blood purification device

Gari Clifford
Institution: University of Oxford
Department: Institute of Biomedical Engineering
City: Oxford
Country: UK
Website: http://alum.mit.edu/www/gari

Talk Title: Kalman filtering for artifact detection and reduction in multimodal monitoring data

Dr. Clifford trained in Theoretical Physics and subsequently in Artificial Intelligence (AI) and Biomedical Engineering at the University of Oxford, UK. From 2003 to 2009 he was with the Laboratory for Computational Physiology at the Harvard-MIT Division of Health Sciences where he was a Principal Research Scientist and the engineering manager of a R01 NIH-funded research program, "Integrating Data, Models, and Reasoning in Critical Care", and a significant contributor to the well-known Physionet Research Resource. In 2009 Dr Clifford returned to the Department of Engineering Science at Oxford where he is the Associate Director of the Centre for Doctoral Training in Healthcare Innovation, a major UK government-funded center for teaching translational biomedical engineering, and a University Lecturer. Dr Clifford retains associate research positions at MIT and Harvard, where he has several ongoing research programs in fetal, neonatal and sleep medicine as well as intelligent telemedicine, which he is in the process of moving to Oxford. Dr Clifford has been working in the area of cardiovascular signal processing and data fusion for over 10 years. Dr Clifford is co-founder of Sana, a generalized mHealth platform for delivering remote diagnostic screening which recently won Vodaphone's mHealth Alliance Award. His work also recently won the Martin Black Prize from the Institute of Physics for work on data fusion and signal quality in the ICU. Dr Clifford has been the Scientific Advisor for several international hardware and software companies, is a Senior Member of the IEEE and has also worked in industry on the design and production of several CE- and FDA-approved medical devices. Dr Clifford is also on the editorial and international advisory board of several journals and resources, including Physiological Measurement, BioMedical Engineering Online and PhysioNet.

Mitchell Cohen
Institution: University of California at San Francisco
Department: Dpt. Of Surgery
City: San Francisco, CA
Country: USA
Website:

Talk Title: Redefining physiology: Physiologic state identification and transition propensity using multivariate ICU informatics

Scott Diamond
Institution: University of Pennsylvania
Department: Penn Center for Molecular Discovery
City: Philadelphia, PA
Country: USA
Website: http://www.seas.upenn.edu/~diamond

Talk Title: Model driven discovery of complex biological mechanisms: towards a mechanistic understanding of coagulation

Scott L. Diamond (B.S. Cornell University, Ph.D. Rice University) holds the Arthur E. Humphrey Chair of Chemical and Biomolecular Engineering and is the founding director of the Penn Center for Molecular Discovery. He researches Therapeutic Technologies in several key areas: mechanobiology, blood clot dissolving therapies, blood systems biology, drug discovery, and gene therapy. His laboratory has produced over 140 publications and patents. He has served on advisory committees to NSF, NIH, NASA, and the American Heart Association. He is the recipient of the NSF National Young Investigator Award, the NIH FIRST Award, the AHA Established Investigator Award, and the AIChE Allan P. Colburn Award. He is an elected fellow of the Biomedical Engineering Society. Currently, Dr. Diamond is the Director of the Penn Biotechnology Masters Program, one of the largest in the country with more than 130 students. Dr. Diamond also serves as Associate Director of the Institute for Medicine and Engineering.

John Doyle
Institution: California Institute of Technology
Department: Control and Dynamical Systems, Electrical Engineering
City: Pasadena, CA
Country: USA
Website: http://www.cds.caltech.edu/~doyle

Talk Title: Modeling of cardiovascular variability under time-varying loads: theory and experimental validation

John Doyle is the John G Braun Professor of Control and Dynamical Systems, Electrical Engineer, and BioEngineering at Caltech. He has a BS and MS in EE, MIT (1977), and a PhD, Math, UC Berkeley (1984). Current research interests are in theoretical foundations for complex networks in engineering and biology, focusing on architecture, and for multiscale physics. Early work was in the mathematics of robust control, including LQG robustness, (structured) singular value analysis,

H-infinity plus recent extensions to nonlinear and hybrid systems. His research group has collaborated in many software projects, including the Robust Control Toolbox (muTools), SOSTOOLS, SBML (Systems Biology Markup Language), and FAST (Fast AQM, Scalable TCP). Prize paper awards include the IEEE Baker, the IEEE Automatic Control Transactions Axelby (twice), and best conference papers in ACM Sigcomm and AACC American Control Conference. Individual awards include the AACC Eckman, and the IEEE Control Systems Field and Centennial Outstanding Young Engineer Awards. He has held national and world records and championships in various sports.

Jim Fackler
Institution: Johns Hopkins University School of Medicine
Department: Department of Anesthesiology and Critical Care Medicine
City:
Country: USA
Website:

Talk Title:

Jim Fackler M.D. is an Associate Professor of Anesthesiology and Critical Care Medicine within the Johns Hopkins University School of Medicine and practices primarily pediatric critical care medicine as well as pediatric anesthesiology. Dr. Fackler received his medical degree from Rush Medical College in Illinois. He trained in pediatrics, pediatric critical care, and pediatric anesthesiology at the Johns Hopkins Hospital in Baltimore. He was on the faculty of the Harvard Medical School at the Children's Hospital Boston for about 10 years thereafter and before returning to his current faculty position at Hopkins. While at Children's he assisted in the founding of the Children's Hospital Informatics Program.
Academic interests remain device integration. He and others hold a U.S. patent for "Smart Plug, a universal medial device interface". He continues to contribute to the Medical Device "Plug-and-Play" (MD PnP) Interoperability Program from within CIMIT (housed at MIT). He is a founding Board Member of the Virtual PICU. With medical device and physiological data he is mentoring Masters and PhD students in data visualization, pattern recognition and guideline adherence.
Dr. Fackler worked for the Cerner Corporation from 2002 to 2006 and left the position of Vice President to return to academic medicine. He was responsible there for the development and deployment of the critical care solution suite. He is a co-Founder of Oak Clinical Systems which is a start up company focused on the implementation of a personally controlled health record with a problem-based organization. He also has a part-time executive role for Cardiopulmonary Corporation, which is a vendor neutral medical device agnostic data integration, analytical and alarm management company.

Roland Fried
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Talk Title: Robust signal extraction from complex physiological monitoring timeseries

Ursula Gather
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Talk Title: Robust signal extraction from complex physiological monitoring timeseries

Brahm Goldstein
Institution: Ikaria Inc.
Department: Translational Science
City: Clinton, NJ
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Website:

Talk Title: Data Acquisition and Analysis of Physiological Signals in Pediatrics: Investigations and Challenges

Dr. Brahm Goldstein is Senior Medical Director, Translational Science, at Ikaria, Inc., Clinton, NJ. He is the Treasurer and on the Board of Directors for the Society for Complexity in Acute Illness. Dr. Goldstein graduated from the State University of New York Upstate Medical Center, Syracuse, NY in 1981 and completed his residency at University of California, Los Angeles, CA with subsequent fellowships in pediatric cardiology at The Children's Hospital, Boston, MA and pediatric critical care at Massachusetts General Hospital, Boston, MA. He served as an Instructor in Pediatrics at the Massachusetts General Hospital and Harvard Medical School until 1989. Dr. Goldstein was recruited to Oregon Health & Science University (OHSU) in 1994 from the University of Rochester Medical Center at Rochester, NY where he was Chief, Division of Pediatric Critical Care and Medical Director of the Pediatric Intensive Care Unit at Doernbecher Children's Hospital. He also served as Medical Director, Doernbecher Children's Hospital and Associate Medical Director, OHSU Hospitals and Clinics from 2000-2006. In 2007, Dr. Goldstein received a Master's degree in clinical research at OHSU. Dr. Goldstein has been Professor of Pediatrics at the University of Medicine and Dentistry of New Jersey since 2006. Dr. Goldstein serves on the editorial board of many leading medical and scientific publications. He has served on advisory boards for companies including Baxter Healthcare, Eli Lilly, Xoma, and Wyeth-Ayerst and was a founding scientist for ProteoGenix. Since 2008, he has been the Industry Representative on the Pediatric Advisory Committee, US Food and Drug Administration. Dr. Goldstein's areas of clinical and research expertise include: pediatric critical care, sepsis, traumatic brain injury and complex systems analysis of biomedical signals.

Wassim Haddad
Institution: Georgia Institute of Technology
Department: School of Aerospace Engineering
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Talk Title: Multistability, Bifurcations, and Biological Neural Networks: A Synaptic Drive

Firing Model for Cerebral Cortex Transition in the Induction of General Anesthesia

Wassim M. Haddad received the B.S., M.S., and Ph.D. degrees in mechanical engineering from Florida Institute of Technology, Melbourne, FL in 1983, 1984, and 1987, respectively, with specialization in dynamical systems and control. From 1987 to 1994 he served as a consultant for the Structural Controls Group of the Government Aerospace Systems Division, Harris Corporation, Melbourne, FL. In 1988 he joined the faculty of the Mechanical and Aerospace Engineering Department at Florida Institute of Technology, where he founded and developed the Systems and Control Option within the graduate program. Since 1994 he has been a member of the faculty in the School of Aerospace Engineering at Georgia Institute of Technology where he holds the rank of Professor and Chair of the Flight Mechanics and Control Discipline. Dr. Haddad's research contributions in linear and nonlinear dynamical systems and control are documented in over 520 archival journal and conference publications. He is a coauthor of the books Hierarchical Nonlinear Switching Control Design with Applications to Propulsion Systems (Springer-Verlag, 2000), Thermodynamics: A Dynamical Systems Approach (Princeton University Press, 2005), Impulsive and Hybrid Dynamical Systems: Stability, Dissipativity, and Control (Princeton University Press, 2006), Nonlinear Dynamical Systems and Control: A Lyapunov-Based Approach (Princeton University Press, 2008), Nonnegative and Compartmental Dynamical Systems (Princeton University Press, 2010), and Stability and Control of Large-Scale Systems (Princeton University Press, 2011). His recent research is concentrated on nonlinear robust and adaptive control, nonlinear dynamical system theory, large-scale systems, hierarchical nonlinear switching control, analysis and control of nonlinear impulsive and hybrid systems, adaptive and neuroadaptive control, system thermodynamics, thermodynamic modeling of mechanical and aerospace systems, network systems, expert systems, nonlinear analysis and control for biological and physiological systems, and active control for clinical pharmacology. Dr. Haddad is an NSF Presidential Faculty Fellow, a member of the Academy of Nonlinear Sciences, and an IEEE Fellow.

Vitaly Herasevich

Institution:	Multidisciplinary Epidemiology and Translational Research in Intensive Care (METRIC), Mayo Clinic
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Talk Title: "Failure to rescue" concept in clinical diagnostic alerts

Michael Imhoff

Institution:	University of Bochum
Department:	School of Medicine
City:	Bochum
Country:	Germany
Website:	

Talk Title: Robust signal extraction from complex physiological monitoring timeseries

Board certified in surgery and intensive care medicine. Research areas include trauma surgery, intensive care medicine, patient monitoring, clinical data management, artificial intelligence in medicine and health economics, leading to over 300 publications and scientific presentations. Dr. Imhoff is a professor in Medical Informatics and Statistics at the Medical School of the Ruhr-University Bochum, Germany, and currently chairman of the Section Patient Monitoring of the German Association of Biomedical Engineering (DGBMT). He is member of the editorial boards of and a reviewer for several international journals. Medical school: University of Bochum and Munster, Germany; PhD, Ruhr University, Bochum, Germany. 1991 Recipient of the Lederle Prize for Research. Dr. Imhoff is the managing director of Boston MedTech Advisors Europe GmbH with office in Dortmund, Germany.

Steffen Leonhardt
Institution: RWTH Aachen
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Talk Title: Automatic control in medicine - how much is necessary, how much is wanted?

Steffen Leonhardt, M.D., Ph.D., holds a M.S. in Computer Engineering from SUNY at Buffalo, Buffalo, NY, USA, a Dipl.-Ing. and a Ph.D. in Control Engineering from TU Darmstadt, Darmstadt, Germany and a M.D. from Johann Wolfgang Goethe-University, Frankfurt, Germany. After 5 years R&D management experience working for Dräger Medical AG, Lübeck, Germany, he was appointed full professor and director of the Philips Chair for Medical Information Technology at RWTH Aachen University in 2003. Research interests include: measurement technologies, especially contact-free, for medicine, wearable medical devices for supporting patients at home (personal health care), concepts of feedback control in medicine.

Carolyn McGregor
Institution: University of Ontario
Department: Institute of Technology
City: Oshawa
Country: Canada
Website:

Talk Title: Artemis: Real-Time Streaming Analytics for Intensive Care Units - an academic perspective

Geert Meyfroidt
Institution: Katholieke Universiteit Leuven
Department: Intensive Care Medicine
City: Leuven
Country: Belgium
Website: http://www.kuleuven.be/cv/u0058374e.htm

Talk Title: Predictive data mining in routine clinical data: possible applications

Geert Meyfroidt graduated as a MD in 1996, has a board certification in anesthesiology and intensive care medicine, and is clinically active as "adjunct-kliniekhoofd" (vice head of clinics) at the department of intensive care medicine of the university hospitals Leuven. In 2010, he finished his PhD, entitled, "Computerized data management in the intensive care unit: predictive modeling, time series analysis, and opportunities for support of care". He performs research at the department of acute medical sciences of the KULeuven. Data mining and mathematical modeling to develop early warning systems and outcome prediction models for critically ill patients are his main research field, with a special interest in brain trauma and brain damaged patients. He is involved in the foundation of multicenter patient databases with high resolution and high quality patient data. Other research projects include computerized decision support systems, tight blood glucose control and mathematical characteristics of the blood glucose signal, and sedation and delirium in critically ill patients.

Edmund Neugebauer
Institution: University of Witten-Herdecke
Department: Institute for Surgical Research
City: Cologne
Country: Germany
Website:

Talk Title:

Edmund A. M. Neugebauer Born: Nov.18, 1949 in Kleinalmerode (Hessia) Current Position: Professor and Chairman of Surgical Research, Director: Institute for Research in Operative Medicine (IFOM) Faculty of Health, University Witten/Herdecke, Campus Köln (Cologne), Dean for Research, Faculty of Health,University Witten/Herdecke Education • Studies as Chemical Engineer, University Aachen (1971 – 1974) • Position as Chemical Engineer, Chemie Grünenthal (1974 – 1975), .1975 change to University Marburg/Hessia, Studies in Chemistry,Diploma Chemistry 1979 • PhD in Chemistry/ Biochemistry 1982 • Start of Education in Experimental/Theoretical Surgery (Prof. Lorenz),Institute of Theoretical Surgery • Vice Chairman Institute of Theoretical Surgery 1983, Team leader shock 1982 • Study of Medicine 1982 - 1988 at University Marburg (cand. med.) • Habilitation (Assistant Professor) Nov. 1988 • 1989 change to University of Cologne, Head of Biochemical and Experimental Department, Surgical Clinic II, University of Cologne • Full Professor of Experimental Surgery, University Cologne 1995 • 2004 offer of University Cologne as Chairman of Surgical Research (declined) • 2005 offer of University Witten/Herdecke as Chairman of Surgical Research and Director of the Institute for Research in Operative Medicine (accepted) Funding German Research Council (DFG), Ministry of Research and Education (BMBF), Foundations and Industry by a total of 750.000 - 1 Mio. Euro/ year Scientific Achievements 750 scientific publications, more than 250 original articles, Editor of 10 scientific books,Lectures > 650 Awards • Diefenbach bust for excellence in science in Traumatology by the German Society of Traumatology (DGU) (2005) • Prof. hc. of Southern Medical School, Kanton (China) (2005) • Rudolph-Zenker Prize of the German Surgical Society (2004) • Müller-Osten Prize of the German Association of Surgery (2001) • Singapore Totalisator Board, Visiting Professor, National University of Singapore (2000) • Scientific award for Research in Surgical Intensive Care of the German Surgical Society (1992) I have been one of the founding members of SCAI(first president) and organized several international ICCAI congresses as well as the International Shock congress of the IFSS in 2008 in Cologne, Germany, and continue to serve this organization and its development as vice president.

Patrick Norris
Institution: Vanderbilt University
Department: Department of Surgery
City: Nashville, TN
Country: USA
Website: https://medschool.mc.vanderbilt.edu/facultydata/php_files/show_faculty.php?id3=16458

Talk Title: Identifying rare clinical events in complex physiological time series.

Dr. Patrick Norris is an Assistant Professor of Surgery in the Vanderbilt University School of Medicine. He earned his Ph.D. in Biomedical Engineering from Vanderbilt University in 2006 in the study of heart rate variability (HRV) and other metrics of physiological complexity in trauma patients. He has designed and implemented continuous physiological data capture and decision support systems including SIMON (Signal Interpretation and MONitoring), which has been applied to the discovery, refinement, and validation of HRV and other prototype new vital signs. The system's modular architecture offers a high degree of reliability and scalability for dense physiologic data capture, processing, and decision support tasks, and it has been in use continuously since 1998 in the Vanderbilt trauma intensive care unit (ICU). In addition to his ongoing research in patient monitoring, critical care decision support, and physiological complexity, Dr. Norris collaborates on a variety of other projects aimed at identifying genetic, metabolic, and immunologic predictors of outcomes in surgical critical care.

Steven Rees
Institution: Aalborg University
Department: Center for Model-based Medical Decision Support
City: Aalborg
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Website:

Talk Title: The use of physiological models in ventilator control

Stuart Russell
Institution: University of California
Department: Computer Science Division
City: Berkeley, CA
Country: USA
Website: http://www.cs.berkeley.edu/~russell/

Talk Title: Dynamic Bayesian Networks for artifact detection in monitoring data

Stuart Russell was born in Portsmouth, England in 1962. He received his B.A. with first-class honours in physics from Oxford University in 1982, and his Ph.D. in computer science from Stanford in 1986. He then joined the faculty of the University of California at Berkeley, where he is Professor (and formerly Chair) of Electrical Engineering and Computer Sciences and holder of the Smith-Zadeh Chair in Engineering. He is also an Adjunct Professor of Neurological Surgery at UC San Francisco. He has received many awards including the 1995 Computers and Thought Award (the premier research award in artificial intelligence) and the 2005 ACM Karlstrom Outstanding Educator Award (the premier award for education and mentoring in computer science). He has published over 150 papers on a

wide range of topics in artificial intelligence; his current research interests also include computational physiology and global nuclear monitoring. His textbook, "Artificial Intelligence: A Modern Approach" (with Peter Norvig, Prentice Hall, 1995, 2003, 2010) has been adopted by approximately 1200 universities in 109 countries and translated into 13 languages.

Jose Salinas
Institution: US Army
Department: Battlefield Health and Trauma Research Institute
City: Ft. Sam Houston, TX
Country: USA
Website:

Talk Title: Medical decision support of the future: Integrated real-time physiological monitoring and automated data analysis

PhD, Manager Combat Critical Care Engineering Task Area

Johannes Schloeder
Institution: University of Heidelberg
Department: Interdisciplinary Center for Scientific Computing
City: Heidelberg
Country: Germany
Website: http://www.iwr.uni-heidelberg.de/~Johannes.Schloeder/

Talk Title: State-of-the-art numerical methods for optimal experimental design, online system identification, and model predictive control

Andrew Seely
Institution: University of Ottawa
Department: Division of Thoracic Surgery & Critical Care Medicine
City: Ottawa
Country: Canada
Website:

Talk Title: Taking multiorgan variability quantification to the beside - a multicenter clinical trial

Daby Sow

Institution: IBM
Department: T. J. Watson Research Center

City: Hawthorne, NY
Country: USA
Website:

Talk Title: Artemis: Real-Time Streaming Analytics for Intensive Care Units - an industrial perspective

Aneta Stefanovska

Institution: University of Lancaster
Department: Department of Physics
City: Lancaster
Country: UK
Website: http://www.physics.lancs.ac.uk/research/nbmphysics/stefanovska.htm

Talk Title: Low frequency oscillations of the intracranial pressure signal in acute traumatic brain injury - relationship between spectral energy, phase and autoregulation.

Aneta Stefanovska holds the Chair of Biomedical Physics in the Physics Department at Lancaster University, UK. She graduated from the University of Ljubljana and worked on her PhD project both in Stuttgart, Germany, where under the supervision of Hermann Haken she embraced the use of synergetics in treating thermodynamically open systems, and in Ljubljana, Slovenia, where under the supervision of the late Prof Lojze Vodovnik she embraced the role of biocybernetics and careful measurements/ recordings in treating living systems. She completed her PhD in 1992 and headed the Nonlinear Dynamics and Synergetics Group at the Faculty of Electrical Engineering, University of Ljubljana from 1993 to 2006, when she moved to Lancaster. Her main interests are the physics of thermodynamically open, nonautonomous systems, the physics of life, biological oscillators and the role of oscillatory dynamics in maintaining life, as well as changes in the interactions between oscillatory processes as a cause/ consequence of an impaired state of health. She has more than 200 publications, co-authored with physicists, mathematicians, engineers, clinicians and biological scientists.

Joerg Stelling

Institution: ETH Zurich
Department: Department of Biosystems Science and Engineering
City: Basel/Zurich
Country: Switzerland
Website: http://www.csb.ethz.ch/people/joergs

Talk Title: Uncertainty quantification for mechanistic models of physiological processes

Jörg Stelling is currently an Associate Professor for Computational Systems Biology at the Department of Biosystems Science and Engineering of ETH Zurich (since 2008). Prior to this, the obtained a PhD in Engineering from University of Stuttgart, before he moved to the Department of Computer Science of ETH Zurich as an Assistant Professor for Bioinformatics in 2005. His research interests include methods and model development for complex biological systems, including systems identification, model discrimination, and systems design. More specifically, the group develops computational methods for studying and designing complex networks that establish cellular functions to elucidate their operating and design principles. All projects involve close collaborations with experimental biologists and computer / systems scientists.

Yoram Vodovotz
Institution: University of Pittsburgh
Department: Department of Surgery
City: Pittsburgh, PA
Country: USA
Website: http://www.mirm.pitt.edu/cirm

Talk Title: Dimension reduction in the analysis of high dimensional bioassay data

Yoram Vodovotz, Ph.D., is a Professor of Surgery, Immunology, Computational and Systems Biology, Clinical and Translational Science, and Communication Science and Disorders at the University of Pittsburgh. He is currently the President of the Society for Complexity in Acute Illness. His research interests include the biology of acute inflammation in shock states, chronic inflammatory diseases, wound healing, malaria, and restenosis. His work utilizes mathematical modeling to unify and gain insight into the biological interactions that characterize these inflammatory conditions. As the Director of the Center for Inflammation and Regenerative Modeling (CIRM; www.mirm.pitt.edu/cirm) at the University of Pittsburgh's McGowan Institute for Regenerative Medicine, he has been involved in the mathematical modeling of acute inflammatory states (e.g. septic or hemorrhagic shock, wound healing), including cellular and physiological elements, as part of a large, interdisciplinary collaborative team. He is also a co-founder of Immunetrics, Inc., a company that is commercializing this mathematical modeling work.

Christopher White
Institution: US Army
Department: Battlefield Health and Trauma Research Institute
City: Ft. Sam Houston, TX
Country: USA
Website:

Talk Title: Analysis of respiratory complexity for decision support during spontaneous breathing trials

LtCOL, Manager Clinical Trials Task Area

Sven Zenker
Institution: University of Bonn Medical Center
Department: Dpt. of Anesthesiology and Intensive Care Medicine
City: Bonn
Country: Germany
Website: http://www.amp.uni-bonn.de

Program overview

Thursday, Sep. 8, 2011 "Tutorial Day"

9:00 -12:00 Morning Session
Tutorial Track A - Part 1
Machine learning methods
System identification and control

12:00 - 13:00 Lunch Break

13:00 - 17:00 Afternoon Session
Tutorial Track A - Part 2
Connecting data and models

13:00 - 18:00
Tutorial Track B
Agent based modeling: An Introduction
» Introduction to agent-based modeling and its biomedical applications
» Part 1: Getting started on a cell-based inflammation/infection agent-based model
» Part 2: Modification and customization of the base inflammation model and running simulation experiments

Friday, Sep. 9, 2011

8:30 - 9:00 **Welcome & introductory remarks**

9:00 - 10:00 KeyNote Address
More Data Then We Know What To Do With?

10:00 - 12:30 Session 1
Mechanistic modeling and model based control I

12:30 - 13:30 **Lunch Break**

13:30 - 16:00 Session 2
Mechanistic modeling and model based control II

16:30 - 17:30 **Free Paper Session 1**

17:30 - 18:30 **Poster Session 1**

19:30
Festive dinner at Godesburg Bonn

Saturday, Sep. 10, 2011

9:00 - 11:30 Session 3
Machine learning and Artificial Intelligence Approaches to Critical Care Data

11:30 - 12:30 **Free Paper Session 2**

12:30 - 13:30 **Lunch Break**

13:30 - 15:30 Session 4
Physiological Signals and Nonlinear Time series Analysis II

18:00 - 19:00 **Poster Session 2**

19:30 - 21:00
Buffet dinner and announcement of poster and presentation prizes

Sunday, Sep. 11, 2011

9:00 - 10:20 Session 6
Moving the frontier: future perspectives

10:20 - 10:45 **Closing remarks, adjournment of scientific meeting**

10:45 - 11:00 **Coffee Break**

11:00 -12:00 **SCAI Business meeting**
(SCAI members only)