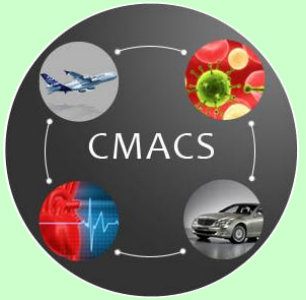
# Computational Modeling and Analysis For Complex Systems
## NSF Expedition in Computing

# Knowledge Transfer




**Scott A. Smolka,**

**CMACS Deputy Director**

**Stony Brook University**

**2nd Year Review Meeting, Carnegie Mellon University**

**November 3, 2011**

Carnegie Mellon

# Knowledge Transfer Domains

- Education
- Industry
- Academia
- Broader public

# Knowledge Transfer Mechanisms

- Education and Industry Workshops
- Academic Courses
- CMACS Seminar Series
- Invited Talks & Tutorials
- CMACS Web site
- Publications Repository
- Open-Source Tools Repository

# NSF-CMACS Annual Workshop Series

- Innovative educational program centered around annual workshops series which seeks to develop scientific interest & skills of students from urban, minority-serving institutions
  - **It would not have even been possible** without CMACS
- Each a **highly intensive 3-week workshop** held at Lehman College (part of CUNY) in the Bronx

**Nancy Griffeth**:
CMACS Educational Program Director
**Flavio Fenton**
**Andre Platzer**
Program Co-Director

# Jan 2011: Workshop on Atrial Fibrillation

- **Student co-authored** paper published in *Advances in Physiology Education*

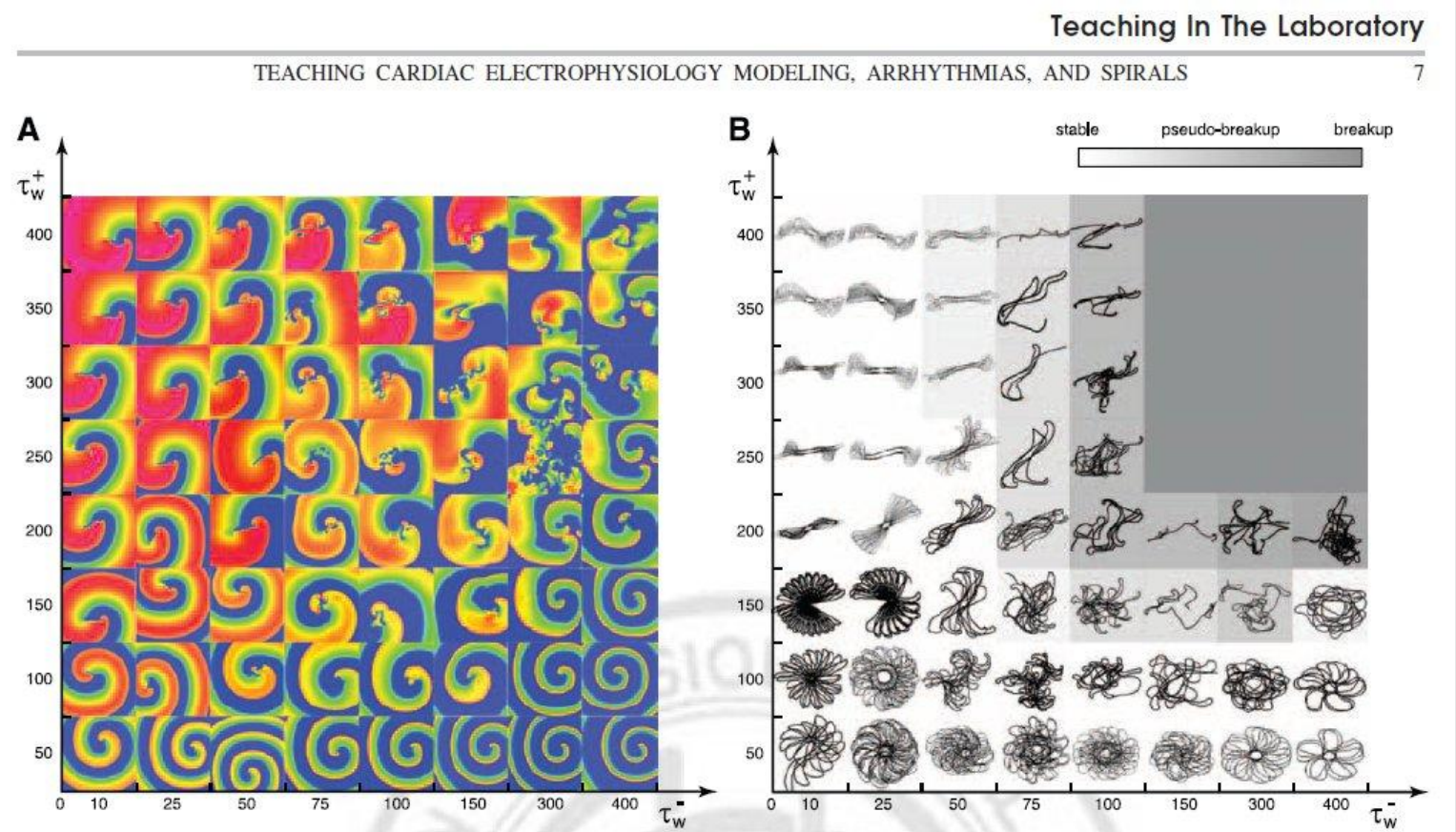



Fig. 5. Spiral wave snapshots (*A*) and tip trajectories (*B*) for combinations of the following parameters: the time constant to inactivate the slow inward $Ca^{2+}$ current ($\tau_w^+$) and the time constant to recover from the inactivation of the slow inward $Ca^{2+}$ current ($\tau_w^-$). Instability is promoted by increasing the values of both parameters, leading to quasi-breakup or full breakup (gray shaded regions in the tip trajectory plot). See text for details.

# Jan 2012: Workshop on Cellular Signaling Pathways

LEHMAN COLLEGE

80 Celebrating 80 Years of Excellence

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*Information For...*

- Prospective Students
- Current Students
- Faculty and Staff
- Alumni and Friends

CMACS

Computational Modeling and Analysis for Complex Systems

- 2012
  - Main
  - Pre-Workshop Materials
  - Staff
  - Lectures and Readings
  - Downloads and Manuals
  - Student Exercises and Projects
- + 2011
- + 2010

## 2012 NSF-CMACS Workshop on Cellular Signaling Pathways

» Workshop Application Form [PDF]

**Workshop Dates: January 4, 2012 - January 24, 2012**

**Workshop Location:** Carman Room 118, Lehman College

See also 2010 Workshop on Cellular Signalling Pathways and 2011 Workshop on Atrial Fibrillation

Are you interested in how cells work? Would you like to know how do they decide to grow. to move. to split. or to die? Do you like working with high-performance computers? Would you like a career in biology, medicine, computer science, or math, or even a career combining all of these fields? Does discovering new things excite you?

Every winter Lehman College holds an NSF-sponsored workshop on modeling complex systems, for undergraduate students. The students attending the workshop use and

**Quick Links**

Read about CMACS

Main CMACS Website

# Engaging the Industry

CMACS **Embedded Systems Industry** Workshop - 10/20/11,CMU

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CMACS **Embedded Systems Industry** Workshop - 10/20/11,CMU

| | |
|---|---|
| 09:00 | *Welcome and Workshop Overview* – B. Krogh |
| 09:10 | *Recent Advances in Verification Technologies* (4x20)<br>09:10 Rance Cleaveland – Software verification/testing<br>09:30 Patrick Cousot – Abstract interpretation<br>09:50 Matthias Althoff – Reachability analysis<br>10:10 Andre Platzer – Theorem proving for dynamic systems |
| 10:30 | *Break* |
| 10:40 | *Applications of Verification the Automotive Industry* (2x25)<br>10:40 Verification Challenges in Automotive Embedded Systems - Bill Milam (Ford)<br>11:05 Toyota's Direction - Ken Butts (Toyota) |
| 11:30 | *Applications of Verification in the Aircraft Industry* (1x30)<br>11:30 Verification of Avionics Systems - Steve Miller (Rockwell-Collins) |
| 12:00 | Lunch – *Perspectives from tool vendors* (2x15)<br>12:15 National Instruments - Jeff Jensen (National Instruments)<br>12:30 Simulink Design Verifier 2.0 - Denizhan Alparslan (MathWorks) |
| 12:45 | Discussion 1: *Impediments to the Use of Verification in Industry*<br>Moderator: Rance Cleaveland; Scribe: Bruce Krogh |

# Sample Academic Courses

- **Edmund Clarke**
  - Abstract interpretation added to model-checking courses at CMU
- **Patrick Cousot**
  - *Program semantics, analysis, and verification by abstract interpretation* course at NYU
- **Nancy Griffeth**
  - *Simulation and Modeling of Biological Systems*, new course at Lehman College based on NSF CMACS winter workshops
  - New minor in *Quantitative and Systems Biology* is in approval process at Lehman College

# CMACS Seminar series at CMU

- **35 speakers** (so far) from top US and European institutions

| | | |
|---|---|---|
| 12/10/2010,<br>2:00 PM<br>**GHC-6501** | Ufuk Topcu<br>California Institute of Technology, Department of Computing and Mathematical Sciences<br>**Synthesis of Embedded Control Software** PDF slides | |
| 12/03/2010,<br>2:00 PM<br>**GHC-6501** | Christel Baier, Professor<br>Technische Universität Dresden, Germany<br>**On Model Checking Techniques for Randomized Distributed Systems** PDF slides | |
| 11/19/2010,<br>2:00 PM<br>**GHC-6501** | Mahesh Viswanathan, Associate Professor<br>Department of Computer Science University of Illinois, Urbana-Champaign<br>**Approximating Hybrid Systems** PDF slides | |
| 11/12/2010<br>2:00 PM<br>**GHC-6501** | Alessio Lomuscio<br>Department of Computing, Imperial College, London, UK<br>**Verification of multi-agent systems** | |

# Sample Invited Talks

- **Matthias Althoff** (CMACS **postdoc**)
  - *Worst-Case Deviations of Planned Trajectories for High-Speed Mobile Robots*. Robotics: Science and Systems (RSS) Workshop, Los Angeles, CA, 2011
- **Edmund Clarke**
  - *Model Checking and the Curse of Dimensionality*. Computing in the 21st Century Conference, Beijing, China, 2011
  - *Statistical Model Checking for Cyber-Physical Systems*. Symposium on Automated Technology for Verification and Analysis (ATVA), Taiwan, 2011
- **Rance Cleaveland**
  - *Automatic Requirements Extraction from Test Cases*. Runtime Verification (RV) 2010, Malta

# Sample Invited Talks (contd.)

- **Steve Marcus**
  - *A Model Reference Adaptive Search Method for Global Optimization.* Symposium in Honor of Professor Onesimo Hernandez-Lerma, 2011, San Luis Potosi, Mexico
- **Paolo Zuliani** (CMACS **postdoc**)
  - *Computational Modeling and Analysis of Signaling Pathways*. 2nd TriSys Workshop, Tokyo, Japan
  - *Verification Issues for Stochastic Hybrid Systems*. Workshop on Modeling and Verification of Uncertain Hybrid Systems, CPSWeek 2010, Stockholm, Sweden

# Sample Tutorials

- **Edmund Clarke**
  - *Model Checking and the Curse of Dimensionality*. LASER Summer School on Software Engineering, 2011, Elba, Italy
- **Patrick Cousot**
  - *Abstract interpretation based tool construction for software verification*. LASER Summer School on Software Engineering, 2011, Elba, Italy
- **James Faeder**, *BioNetGen tutorials*:
  - q-bio 2010 & 2011, Santa Fe, NM
  - 12th International Conference on Systems Biology (ICSB) 2010, Edinburgh, UK

# Sample Tutorials (contd.)

- **Flavio Fenton**
  - *Caos, espirales y la dinámica del corazón*. XII Escuela de Otono en Biologia Matematica y VI Encuentro Nacional de Biologia Matematica, Pachuca, **Mexico**, 2010
- **Klaus Havelund**
  - *Internal versus External DSLs for Trace Analysis*. Runtime Verification (RV) 2011, San Francisco, CA
  - *Runtime Verification*. Software Engineering and Formal Methods (SEFM) 2011, Montevideo, Uruguay

# CMACS Website

- **http://cmacs.cs.cmu.edu**

# Publications Repository

Papers distributed by email

## Publications

**Please click on the paper's title to request a paper.**

### 2012

Coordinate ascent for penalized semiparametric regression on high-dimensional panel count data. T.T. Wu and X. He. In Computational Statistics and Data Analysis, Volume 56, Issue 1, 1 January 2012, Pages 25 - 33.

A transcriptome analysis by lasso penalized Cox regression for pancreatic cancer survival. T.T. Wu, H. Gong, and E.M. Clarke. In Journal of Bioinformatics and Computational Biology. To appear.

### 2011

Linear Absolute Value Relation Analysis. L. Chen, A. Miné, J. Wang, P. Cousot. In ESOP 2011: Proceedings of the 20th European Symposium on Programming, LNCS 6602, pp. 156-175, 2011.

The Reduced Product of Abstract Domains and the Combination of Decision Procedures. P. Cousot, R. Cousot, L. Mauborgne. In FOSSACS 2011: 14th International Conference on the Foundations of Software Science and Computational Structures, LNCS 6604, pp. 456-472, 2011.

A parametric segmentation functor for fully automatic and scalable array content analysis. P. Cousot, R. Cousot, F. Logozzo. In POPL 2011: Proceedings of the 38th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages, pp. 105-118, 2011.

Precondition Inference from Intermittent Assertions and Application to Contracts on Collections. P. Cousot, R. Cousot, F. Logozzo. In VMCAI 2011: 12th International Conference on Verification, Model Checking, and Abstract Interpretation, LNCS 6538, pp. 150-168, 2011.

Runtime Verification with State Estimation. S.D. Stoller, E. Bartocci, J. Seyster, R. Grosu, K. Havelund, S.A. Smolka, and E. Zadok. In RV'11: Proceedings of the 2nd International Conference on Runtime Verification, Springer LNCS. To appear. (**Best Paper Award**)

# Tools Developed in CMACS

| Tool | Authors | Description |
|---|---|---|
| **GPU-based Cardiac Simulator** | Ezio Bartocci, Elizabeth Cherry, Flavio Fenton | Simulation of cardiac models in real time |
| **GPU-based Curvature Analysis** | Abhishek Murthy, Ezio Bartocci , Radu Grosu | Fast and accurate curvature estimation of cardiac excitation waves |
| **Java Applet for Optical Mapping Experiments** | Flavio Fenton, Alessio Gizzi, Elizabeth Cherry | Visualization of data obtained from optical mapping experiments |
| **OpenGL-based Cardiac Simulator** | Ezio Bartocci, Flavio Fenton | Online simulation of cardiac models |
| **Statistical Model Checking and BioNetGen** | Anvesh Komuravelli, Paolo Zuliani, et. al. | Combination of Statistical Model Checking and rule based modeling |
| **Statistical Model Checking and BooleanNet** | Paolo Zuliani, Natasa Miskov-Zivanov, et. al. | Combination of Statistical Model Checking and probabilistic Boolean networks |

*Orange - Afib, Pink - PC, Blue – cross-cutting Impact, Green - Educational*

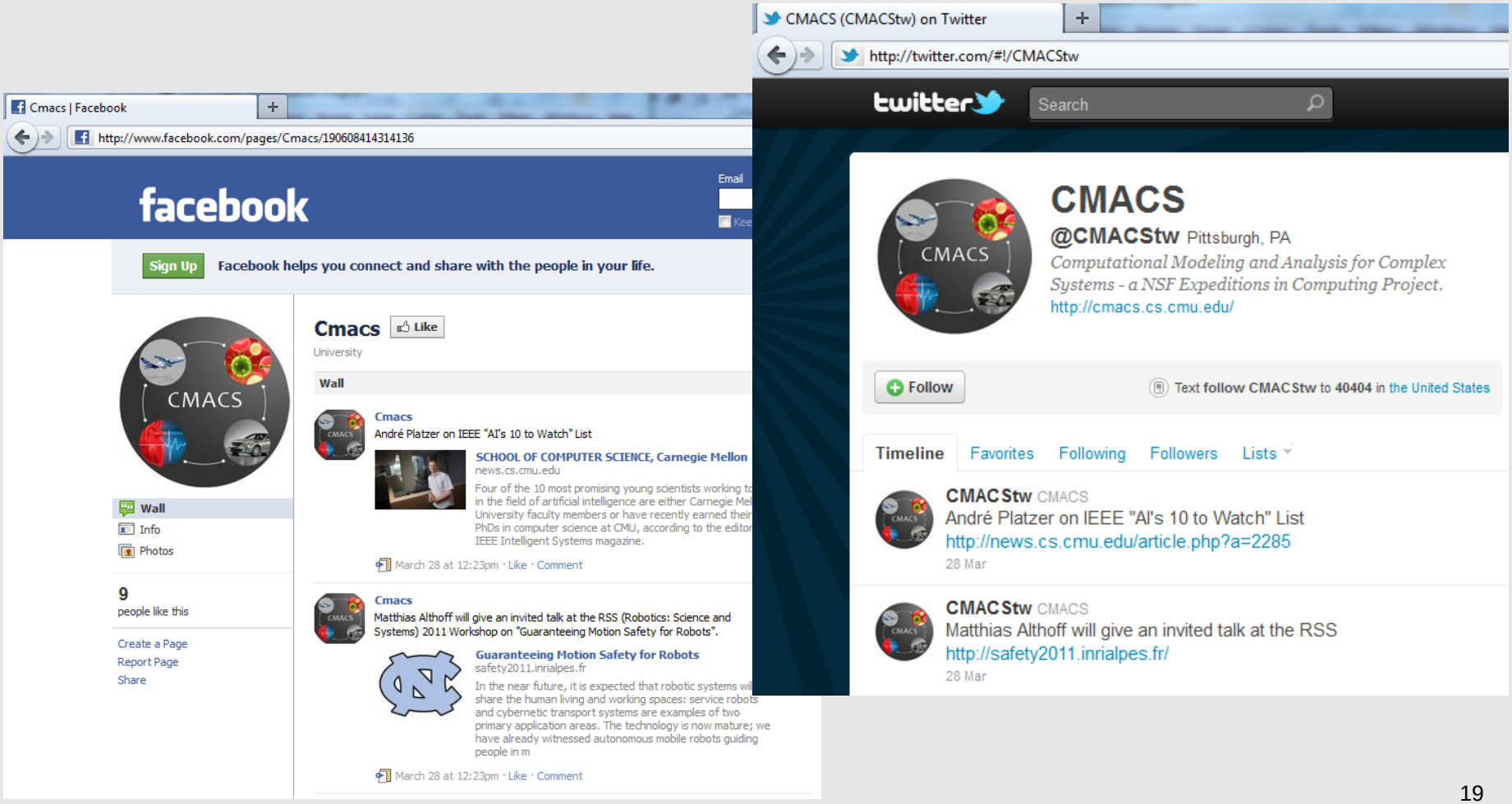
# Tools Developed in CMACS

| Tool | Authors | Description |
|---|---|---|
| **SpaceRover** | Ezio Bartocci, Radu Grosu | Improved reachability analysis by combining RoverGene and Space Ex |
| **Optimal Hybridization Algorithm** | Radu Grosu, Ezio Bartocci | Linearization of non-linear dynamics for constructing Hybrid Automata |
| **KeYmaera** | Andre Platzer and Jan-David Quesel | Theorem prover for hybrid systems |
| **Cuda-based lab experiments** | Ezio Bartocci | Undergraduate lab experiments on parameter analysis of cardiac models |

*Orange - Afib, Pink - PC, Blue – cross-cutting Impact, Green - Educational*

# CMACS and the Social Networks

- CMACS is on **Facebook** and **Twitter**



# Societal Benefits

- Better understanding of **cancer**
- New and better treatments for **cardiac arrhythmias**
- Safer **cars**
- More reliable **avionics software**
- New generation of **CMACS-inspired researchers**