CMACS: Wrap-Up
Steve Marcus
CMACS Deputy Director
University of Maryland
http://cmacs.cs.cmu.edu/

2nd Year Review Meeting, Carnegie Mellon University
November 3, 2011
Our Goals

- **Scientific:** Develop Next-Generation Model Checking and Abstract Interpretation – MCAI 2.0

- **Societal:** Apply MCAI 2.0 to Challenge Problems in complex biological and embedded systems

- **Education & Outreach:** Build a program that
  - supports CMACS’ vision of research and knowledge transfer
  - serves as a primary recruitment mechanism for students, especially those from under-represented groups
Challenge Problems

**Systems Biology**
- Pancreatic Cancer
- Atrial Fibrillation

**Embedded Systems**
- Distributed Automotive Control
- Aerospace Flight Software
Uniqueness, Synergies, and Impact

- Unique in bringing together MCAI with controls, embedded systems, systems biology, medicine

- A very strong team of researchers with diverse backgrounds, working closely and learning from each other → unique and promising approaches to these major societal problems

  - Important: real, ongoing, and deep interactions, across fields and across institutions: ECE/CS, CMU/NYU, CMU/UMD, SB/JPL, SB/Cornell, CMU/Pitt
Impact

- On undergraduates (e.g., workshops)
- On graduate students (e.g., in interdisciplinary research)
- On industry (e.g., industry workshops/input)
- On scientific fields (publications, tutorials)
- On how researchers think about problems (key publications)
- On the challenge problem areas (innovative new approaches and tools)
- On how we teach (new courses)
Significant Achievements & Impacts

- New computational methods for cancer
- New computational methods for cardiac dynamics
- New automated modeling and verification techniques for complex embedded systems
- Highly successful 2010 and 2011 Undergraduate Workshops on Pancreatic Cancer and Atrial Fibrillation for students from urban, minority-serving institutions
  - Beautiful examples of integration research and education
Cross-Cutting Research Themes

- Model Checking
- Abstract Interpretation
- Modeling, Control and Analysis of Hybrid Systems
- Stochastic and Statistical Models
CMACS: Whole >> [Sum of Parts]

- Many breakthroughs due to **new, cross-institutional, cross-disciplinary collaborations**
- Typical example: Atrial Fibrillation Research

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<tr>
<th>Stony Brook</th>
<th>Cornell/RIT</th>
<th>NYU</th>
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<td>Bartocci (Computer Sci)</td>
<td>Cherry (Biomedical)</td>
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<td>Fenton (Physics)</td>
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<td>Smolka (Computer Sci)</td>
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CMACS: Whole >> [Sum of Parts]

- Another example: Pancreatic Cancer Research

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<th>CMU</th>
<th>Pitt</th>
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<tr>
<td>Clarke (Computer Sci)</td>
<td>Faeder (Sys. Biol.)</td>
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- Translational Genomics Research Institute
  - Rich Posner and Daniel Von Hoff
Value-Added as an Expedition

- Deep integration of MC + AI is enabling fundamental breakthroughs in modeling, analysis, and verification of complex systems
- Unique societal benefits
- We are inspiring new and under-represented groups of students to choose careers in computer science and related fields
- CMACS Research Plan & Challenge Problems require critical mass and visibility that cannot be achieved with piece-meal efforts
- Our research is inherently cross-disciplinary: CPs require large teams involving both domain scientists, computer scientists, and engineers
- Integration of research, education, and outreach. New courses. Research and education opportunities for undergraduates as well as graduates.
Looking Forward

- First two years
  - Exciting new discoveries
  - Building strong interdisciplinary foundations
    - Technical
    - Educational
    - Human
Looking Forward (contd.)

Research

- Continue, further develop challenge problem areas
  - More realistic cancer models, tight connections to new pancreatic cancer data; e.g., multi-cellular / multi-pathway models
  - MC & AI to developed more reduced order heart models that allow analysis & control
  - Distributed embedded control, using integrated methods

- Continue, further develop research in cross-cutting areas
  - Stochastic models, analysis
  - Compositional modeling, reasoning
  - Hybrid systems
  - Interplay between model checking, theorem proving
Looking Forward (contd.)

- **Research**
  - Deepening integration of MC and AI
    - Model approximation / simplification
    - Automatic generation of abstracted models, depending on properties being checked
  - More & wider cross-institutional & cross-disciplinary **collaborations**; e.g.
    - apply UMD classification & dimension-reduction technology to NYU cancer models
    - apply CMU statistical model checking to SB+Cornell 2D & 3D cardiac models
Looking Forward (contd.)

- Educational
  - More winter workshops at Lehman
  - REU experiences at CMU
  - Curricular efforts
    - Further development of course materials and modules for education at all levels
    - Programs of study in complex systems science and engineering

- Outreach and knowledge transfer
  - Specialized workshops for industrialists / scientists
  - Annual advisory-board meetings
  - Special conference sessions / journal volumes