Table of Contents

Introduction 3
Research 3
People 4
Organization 6
Industry 6
Activities and Efforts 7
Future Activities 9
Conclusion 10
Acknowledgements 11
Contact Us 11

Edited by Julie Knoefel and Michael W. Berry

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Introduction

What began as a set of meetings involving various University of Tennessee (UT) faculty from several departments who envisioned a unified set of courses in machine learning, the Center for Intelligent Systems and Machine Learning (CISML) was formed in 2010. With funding from UT’s Office of Research, along with matching funds from affiliated faculty, affiliated academic departments, and the Science Alliance, CISML was formed to advance the theory and application of intelligent system and machine learning technology. As a component of the College of Engineering (COE), CISML is an organized research unit (ORU) and operates as its own cost center.

Led by Dr. Lynne Parker of the Electrical Engineering and Computer Science Department (EECS) for the first two years, CISML set a course for establishing a national and international leadership role in multiple technologies and systems that comprise the machine learning landscape. From its inception, the Center’s strategy has been to create and leverage active research collaborations of its research affiliates, comprised of university faculty, students, private industry, and national laboratory researchers, specifically from Oak Ridge National Laboratory (ORNL). By identifying and harnessing unique synergies amongst a diverse group of participants within the broad areas of intelligent systems, the Center seeks both to understand biological learning mechanisms and to design and develop computer-based systems that exhibit intelligent behavior, operate autonomously, and adapt to environmental changes.

Following the Center’s governance model of a rotating directorship, Dr. Michael W. Berry of the EECS department began his tenure as CISML’s director in 2012. Continuing the momentum generated by Dr. Parker, Dr. Berry is tasked with leading an immense collection of intellectual resources that is sure to help the Center reach its goal of becoming a world-wide leader in the intelligent systems community.

Research

With faculty and national laboratory research affiliates representing multiple discipline areas, CISML’s expertise is vast and wide ranging. Intelligent systems and machine learning cover an array of scholarly inquiry that incorporates mathematics, computer science, statistics, engineering, psychology, geography and many more. Such diversity allows the center to pursue multi-collaborator, multi-disciplinary research funding at both the national and local levels and to pursue funding opportunities not typically available by most research units.

- Automated reasoning
- Biologically-inspired intelligence
- Business intelligence and analytics
- Cognitive learning
- Collaborative/Distributed systems
- Complex system prognostics and diagnostics
- Data and text mining
- Deep machine learning
- Embodied intelligence
• Human infant perceptual and motor learning
• Image and video data analysis
• Information retrieval
• Knowledge discovery
• Medical diagnosis systems
• Pattern recognition
• Reinforcement learning
• Remote sensing
• Robotics
• Statistical modeling and model selection
• Systems biology
• Visual analytics

To that end, the diversity of research conducted by CISML opens the door to myriad opportunities for agency funding, much more than single discipline, single investigator initiatives. Relevant application areas for CISML efforts include energy and environmental monitoring, medical diagnostics, cognitive computing and robotic learning, intelligent transportation systems, and data mining and analytics.

People

As with most organizations, CISML's greatest assets are its people. Along with Director Dr. Michael W. Berry, CISML is lead by EECS Adjunct Professor and ORNL Group Leader Dr. Thomas Potok (CISML Associate Director) and Dr. John Goodall (CISML Assistant Director), an EECS Adjunct Professor and ORNL Team Leader and Research Scientist. In addition, as of December 2013, 17 faculty members from three colleges and eight departments comprise the UT component of CISML research affiliates. Rounding out CISML’s research team are nine research staff members from ORNL.

Helping the university achieve its mission of partnering with industry and government, as well as strengthening and expanding CISML’s research agenda, the center has developed a working partnership with Oak Ridge National Laboratory (ORNL). Sharing physical and intellectual resources with ORNL bolsters CISML’s opportunities for conducting cutting edge research and simultaneously facilitates UT’s effort to become a top 25 public research university.

Oversight of the Center is provided by an Internal Advisory Board comprised of associate deans in charge of research from each college represented by CISML faculty. This board provides overall guidance and direction to the Center director and is currently comprised of Dr. William M. Dunne of COE, Dr. Christine Boake of the College of Arts & Sciences, and Dr. Tom Ladd from the College of Business Administration.
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<th>People</th>
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<tr>
<td><strong>Dr. Itamar Arel/UTK</strong></td>
<td>Dr. Jacob Barhen/ ORNL</td>
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<td>Electrical Engineering and Computer Science</td>
<td>Center for Engineering Advanced Science Research</td>
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<td><strong>Dr. Michael Berry/UTK</strong></td>
<td>Dr. Hamparsum Bozdogan/UTK</td>
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<td>CISML Director</td>
<td>Statistics, Operations, and Management Science</td>
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<td>Electrical Engineering and Computer Science</td>
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<td><strong>Dr. Qing Cao/UTK</strong></td>
<td>Dr. Subhadeep Chakraborty/UTK</td>
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<td>Electrical Engineering and Computer Science</td>
<td>Mechanical, Aerospace, and Biomedical Engineering</td>
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<td>Dr. Erik Ferragut/ORNL</td>
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<td>Psychology</td>
<td>Cyber and Information Security Research</td>
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<td><strong>Dr. Shaun Gleason/ ORNL</strong></td>
<td>Dr. John Goodall/ORNL</td>
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<td>Computational Science and Engineering Division</td>
<td>CISML Assistant Director</td>
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<td><strong>Dr. Wesley Hines/UTK</strong></td>
<td>Cyber and Information Security Research</td>
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<td>Nuclear Engineering</td>
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<td><strong>Dr. Asad Khattak/ UTK</strong></td>
<td>Dr. Bruce MacLennan/ UTK</td>
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<td>Civil and Environmental Engineering</td>
<td>Electrical Engineering and Computer Science</td>
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<td><strong>Dr. Lynne Parker/UTK</strong></td>
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<td>Electrical Engineering and Computer Science</td>
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<td><strong>Dr. Vladimir Protopopescu/ORNL</strong></td>
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<td>Center for Engineering Advanced Science Research</td>
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<td><strong>Dr. Eric Ragan/ORNL</strong></td>
<td>Dr. Fernando Schwartz /UTK</td>
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<td>Dr. Chad Steed/ORNL</td>
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<td>Geography</td>
<td>Computational Data Analytics Group</td>
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<td><strong>Dr. Wenjun Zhou/UTK</strong></td>
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Guided by a set of bylaws that were created and approved by the voting members of CISML’s faculty (who comprise the Executive Board), the center has established a governance model predicated on shared decision making and streamlined administration. The chart above illustrates CISML’s organizational structure.

### Industry

As part of its operational and funding framework, CISML instituted a model of corporate sponsorship in order to partner with external business entities for collaborative research opportunities as well as to diversify operational revenue. By partnering with industry, CISML is able to strategically foster relationships that allow our faculty to introduce timely, real world problems into the classroom, which directly connects students and these organizations for problem solving, and contributes to business and economic development. In return, organizations get to directly participate in teaching and research agendas while simultaneously exposing internship and employment opportunities to students.
Over the past year, the Center partnered with five outstanding organizations forging strong working relationships. We gratefully acknowledge these organizations below for their support in 2013.

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<th>Catalyst Repository Systems</th>
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<td>Huron Legal</td>
<td>Chicago, IL</td>
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<td>Intel</td>
<td>Santa Clara, CA</td>
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<td>Link Analytics</td>
<td>Atlanta, GA</td>
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<td>M-CAM</td>
<td>Charlottesville, VA</td>
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Activities and Efforts

2013 was a busy year for CISML. In its third full year, the Center experienced many changes and much growth.

Dr. John Goodall, one of the Center's Oak Ridge National Laboratory (ORNL) affiliates assumed the role of CISML Assistant Director. Dr. Goodall along with Drs. Eric Ragan and Erik Ferragut of ORNL were all approved as adjunct faculty members of the EECS Department in 2013.

"CISML has opened opportunities for collaboration between UTK and ORNL that brings together researchers, professors, and students from a variety of backgrounds to tackle difficult data analysis problem."

Dr. John Goodall, CISML Assistant Director

New Faculty and Lab Affiliates

The Center added faculty from three different departments during the calendar year, further strengthening the diversity of our intellectual resources. The following were welcomed into the Center in 2013:

- Dr. Subhadeep Chakraborty (Mechanical, Aerospace, and Biomedical Engineering)
- Dr. Asad Khattak (Civil & Environmental Engineering)
- Dr. Fernando Schwartz (Mathematics)

Joining the Center from ORNL as national laboratory affiliates were:

- Dr. Erik Ferragut
- Dr. Shaun Gleason
- Dr. Eric Ragan
- Dr. Kenneth Tobin

Seminar Series

The Center's seminar series continued with many speakers from diverse backgrounds, including UT visitors and faculty, which led to numerous new collaborations and several new proposal submissions. CISML seminars have become an integral component of the Center, creating new ideas and new avenues of scholarship. Below are titles of some of the presentations made by various faculty and visiting researchers at our seminars during 2013, representing the myriad research endeavors in which we participated or were requested to participate.
Industry Affiliations

Engaging industry is not only part of the Center's mission, but it's also part of our operating model. One of the benefits of partnering with CISML is our ability to provide quality interns who work with our industry affiliates and are exposed to real-world problems working with industry professionals.

Two of the Center's PhD students served internships over the summer where they gained invaluable insight working in the private sector, while applying the knowledge and skill obtained from their machine learning courses.

In early 2013, the Center hosted its third annual Industry Affiliate Workshop. The theme of the workshop was Bring Your Own Idea/Interest (BYOI) in which the affiliates were asked to bring a text/data mining problem or issue they're interested in that the Center can help them with. Representatives from all three CISML-based affiliate groups (faculty, industry, and lab) gave presentations at the meeting.

As previously mentioned, engaging industry affiliates in mutually beneficial ways is important to the Center. In addition to attending the workshop and hosting interns, Center industry affiliates also engaged in the university's machine learning curricula. Center director Dr. Berry incorporated industry challenge problems into his fall class, Introduction to Data Mining. Industry affiliates M-CAM and Link Analytics each provided problems involving real-world data.

Research Proposals

Three new multi-investigator proposals totaling more than $5 million were submitted, involving nine Center faculty affiliates. These proposals, involving Intel Corporation, the National Science Foundation (NSF), and the Defense Advanced Research Project Agency (DARPA), largely resulted from collaborations and synergies fostered by the Center and its wide range of machine learning expertise.
Special Colloquium

CISML hosted a Special Colloquium on Health Engineering. Dr. Marco Santello from Arizona State University joined us in October 2013 to share his research on *Neural Control of the hand: Interactions between feedback and feedforward mechanisms*.

Research Assistantship Program

**GRAMS** (Graduate Research Assistantship Program), supported by funding from ORNL and the Science Alliance, was just the type of program to contribute to the college's growth and play an integral role in helping the university reach its ultimate goal of becoming a top 25 public research institution.

Four students benefitted from the GRAMS program this year:

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<tr>
<td>Spring 2013</td>
<td>Collin Bell</td>
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<tr>
<td>Spring /Fall 2013</td>
<td>Josh Pyle</td>
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<td>Fall 2013</td>
<td>Jacob Shelton and Jacob Lambert</td>
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Future Activities

Bolstered by the momentum generated from the Center's success and growth, CISML actively continues to build on its brand and reputation for creating new and unique research synergies amongst a diverse group of scholars.

- **New Faculty Affiliates**

Additional faculty from around the university has a greater potential to both strengthen and expand CISML's pool of funding sources, both internal and external. Broadening our expertise and exploring opportunities for new synergies will better enable the Center to leverage the immense scholarly talent on the UT campus while also exposing our research agenda to a wider audience and potentially more students.

- **New Industry Affiliates**

As industry continues to identify new applications for machine learning technologies, it is expected that organizations will increasingly look to academia for intellectual resources. The Center is prepared to engage with more industry partners and is already in discussion with several new entities that have expressed interest in the industry affiliate program.

- **New Proposals**

Identifying new multi-investigator synergies remains one of the many goals of the Center for the next year. Correspondingly, the expectation is for new synergies to result in new proposals.
• GRAMS Expansion

Originally created to provide assistantships for EECS students, discussions are underway to expand the program to include students from other departments across campus, such as mathematics, information science, and physics. Supporting the universities goal of fostering collaborations with ORNL, expanding GRAMS has the potential to greatly increase UT and ORNL engagement. A consequence of creating new opportunities for grad students is the added benefit to the university of attracting more and brighter students.

• Seed Funds

A key component of most successful funding proposals is preliminary evidence that new research ideas will actually work. This typically comes in the form of preliminary research that gives an early indication that the planned research direction should be fruitful. Thus, CISML aims to provide seed money for CISML faculty, available on a competitive basis, to support students who can develop new research ideas and obtain early results that can strengthen new research proposals. After receiving seed money grants, the expectation is that the CISML faculty will submit research proposal(s) (within one year).

Conclusion

A core objective for forming CISML was to improve individual research capabilities through collaboration. While it is clear that CISML affiliates all have an interest in related topics in intelligent systems and machine learning, a key predictor of future center success is our ability to identify the unique opportunities and synergies in which CISML research can be exceptional, and can be a cause for increased national and international recognition. We have been successful in identifying several areas in which the combined expertise of multiple center faculty has led to new research directions, new application domains, and improved potential outcomes.

"CISML's unique combination of intellectual resources has facilitated our ability to create ongoing collaborations both across campus and between UT and ORNL. Leveraging this exceptional talent, we are determined to expand the frontiers of machine learning and make UT a real competitor on the national stage and abroad."

Dr. Michael W. Berry, CISML Director

The Center is well positioned to continue building upon its amazing success in such a short period of time. Unification of a vibrant machine learning community on the UT campus has been a goal of the Center since day one. Meeting that goal and leveraging the momentum of collaborative efforts will continue to propel the Center into the future.

Moving forward, the Center plans to further identify and build upon unique, multi-investigator competencies to increase our research impact. Opportunities across the spectrum of research, teaching, and industry engagement are endless.

As the national research agenda continues to evolve, CISML’s research portfolio will grow and will exemplify our exceptional assembly of talent. Our contributions to machine learning and intelligent systems teaching and research will inevitably help propel the university toward its goal of becoming a top 25 public research university and will make unique contributions to our local and state economies.
Acknowledgements

In addition to our industry affiliates, CISML would like to acknowledge the following for their support of the Center and for helping us build a solid foundation:

- CISML Advisory Board
- Science Alliance
- UT College of Arts and Science
- UT College of Business Administration
- UT College of Engineering
- UT Office of Research

The Center would also like to recognize the following academic departments for their support:

- Civil and Environmental Engineering (CEE)
- Electrical Engineering and Computer Science (EECS)
- Geography
- Mathematics
- Mechanical, Aerospace, and Biomedical Engineering (MABE)
- Nuclear Engineering
- Psychology
- Statistics, Operations, and Management Science (SOMS)

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