August 10-12, 2010

3rd International Symposium on Resilient Control Systems

ISRCS 2010

University of Idaho

Idaho State University

INL Idaho National Laboratory

IEEE

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Purpose of ISRCS 2010

The major purpose of this symposium is to communicate, discuss, and further develop these high level visions and ideas via community participation and to vet, modify, extend, and endorse particular concepts that will lead to research needs definitions. Desired product of the symposium is the publication of proceedings for these identified concepts that will set the stage for task group execution, identification and engagement of funding sponsors, and the identification of future research strategies and products.

Primary Topical Tracks and Chairs

There will be four tracks for this year's symposium, with control systems and control theory sessions included under these tracks:

Human Systems

Track Chair: Prof. Barrett Caldwell, Purdue University
Track Co-chair: Dr. David Gertman, Idaho National Laboratory

The human ability to quickly understand novel situations, employ heuristics and analogy can provide additional control system resilience. On the other hand there are situations in which we may have a general inability to reproducibly predict human behavior. This may be true in situations of fatigue or high stress or decision making under high levels of uncertainty. Bayesian methods provide one method by which to take into account evidence regarding human response, but this is one among many approaches. The literature in human reliability analysis provides an orientation regarding ergonomics, workload, complexity, training, experience, etc., which may be used to characterize and quantify human actions and decisions.

Digital technology, used to benefit control system interaction, can from the operators perspective, provide additional complexity. For example, more information can be presented to the human operator to base a response. However, the response could be completely automated, human manipulated, or a combination of both. The dependencies and rules for these complex interactions, or mixed initiative, are not necessarily well defined or clear. Resiliency results from understanding of this complexity, ensuring through human factor and design an error tolerant control system results that complements perception, fusion, and decision making.

Complex Control System Networks

Track Chair: Prof. YangQuan Chen, Utah State University
Track Co-chair: Prof. Charles Tolle, South Dakota School of Mines and Technology

As control systems become more decentralized, the ability to characterize interactions, performance and security becomes more critical to ensuring resilience. While more decentralization can provide additional reliability due to implicit redundancy and diversity, it may also provide more avenues or vectors to cyber attack. Therefore, the design of complex networks needs to consider all factors that influence resilience, and optimize for multiple considerations.

Global stability is often perceived as something that can be achieved by local minimization of all process unit operations, many of which are contained in a facility. However, there is no assurance that global stability can be achieved in this manner, and in addition, this philosophy maintains a reactionary control paradigm by its nature. However, considering the latencies in digital control systems, there is a tendency as well as a desire to provide faster responses when the feedback and response occur close to the point of interaction with the application. Therefore, it is suggested that a true global optimization coupled with a local interaction can achieve both the assurance of a global minima, and an acceptable response when designing control system architecture.

Cyber Awareness

Track Chair: Prof. Eugene Santos, Dartmouth College
Track Co-chair: Miles McQueen, Idaho National Laboratory

Because of the human element of a malicious actor, traditional methods of achieving reliability cannot be used to characterize cyber awareness and resilience. Dynamic mechanisms of probabilistic risk analysis that can link human reliability with the system state are still maturing. The intellectual level and background of the adversary makes stochastic methods unusable due to the variability of both the objective and the motives. In addition, the strength of the adversary is increased because the existing control system architecture is not random, and response characteristics are reproducible. Therefore, a resilient design can find strength in similar fashion by becoming atypical of normal control system architectural design, and appearing random in response and characteristics to the adversary.

Characterization of health or wellness from a cyber perspective is purely empirical, as prediction of the future is based on past events. While there are barriers in place to exclude known types of adversarial communication, state awareness cannot be assured because of the limited availability of diverse sensing. Determination of the actual cause of an abnormal event can only occur only after forensics are completed. Patterns or routines are analyzed and are used to provide comparisons to understand anomalies. However, while this understanding provides an interesting perspective, it may be very limited in predicting future behavior of the adversary.

Data Fusion

Track Chair: Prof. Devendra Garg, Duke University
Track Co-chair: Prof. Manish Kumar, University of Cincinnati

The nature of the various data types associated with proper operation or performance of critical infrastructure, including cyber and physical security, process efficiency and stability, and process compliancy is diverse. How these data are consumed to generate information will help determine whether appropriate judgments are made, whether by automated and/or human mechanisms. There are several issues that are addressed by data fusion, including the following ones:

- Reduction - The reduction of data to provide only that information necessary for the human or automation scheme to provide the appropriate response, i.e., to prevent a common issue of information overload.
- Identification - Validation and invalidation of causes for events, e.g., a process upset is due to a failed valve and not a cyber attack.
- Improved characterization and knowledge - Development of new information that helps to better characterize the process application, e.g., mining of process temperatures along with process flows provides a better interpretation of stability.

While many of the techniques required to perform data fusion are well known, application to the diverse types of data represented within the measures of performance provide a distinct challenge. This is nowhere more evident than the fusion of cyber and process data to not only indicate whether an event is cyber specific, whether due to an adversary or network problem, or actually represents a process upset. The effort to address this situation could be split into two parts: i) developing the appropriate data to characterize the cyber threat, and ii) combining the spatial and temporal aspects of both process and cyber data to confirm the cause of the process upset.

Tuesday, August 10 - *Tutorials and Workshops*

8:00 a.m.	**Registration**		
8:15 a.m.	Welcome and Opening Remarks Welcome: Craig Rieger Introductions & Logistics: Margie Jeffs (CHE 213)		
8:30 a.m.	Stream Computing for Data Fusion and Computational Intelligence Dr. Chitra Venkatramani, IBM (CHE 213)		
9:30 a.m.	**Morning Break**		
10:00 a.m.	**Session 1:**Tutorials & Workshops		
	Track 1: Data Fusion & Computation Intelligence (CHE 214) Dr. Mosoud Ghafari, *UC Prognostics and Health Management*	**Track 2: Human Systems & Complex Network Control Systems** (CHE 215) Prof. John Doyle, Caltech *Workshop on Universal Laws, Architectures, and Behaviors in Robust Evolvable Networks*	**Track 3: Human Systems & Cyber Awareness** (CHE 216) Prof. Eugene Santos, Dartmouth *Workshop on Formally Modeling the Human Element and Its Impact on Control Systems Resiliency*
11:30 a.m.	**Lunch Break** - No Host		
1:00 p.m.	**Session 2:**Tutorials & Workshops *(continued from Session 1)*		
	Track 1 (CHE 214)	**Track 2** (CHE 215)	**Track 3** (CHE 216)
2:30 p.m.	**Afternoon Break**		
3:00 p.m.	**Session 3:** Tutorials & Workshops *(continued from Session 2)*		
	Track 1 (CHE 214)	**Track 2** (CHE 215)	
4:30 p.m.	**Adjourn**		
6:00 p.m.	Symposium Chair Working Dinner *(special invitation only)* Sandpiper Restaurant 750 Lindsay Blvd. Idaho Falls, ID		

Wednesday, August 11 - *Paper Tracks*

8:15 a.m.	Opening Remarks Daily Agenda: Margie Jeffs (CHE 213)			
8:30 a.m.	Human Factor and Computational Intelligence in Resilient Control Systems Prof. Bogdan Wilamowski, Auburn (CHE 213))			
9:30 a.m.	**Morning Break**			
10:00 a.m.	**Session 1:** Track Papers			
	Track 1: Complex Networked Control Systems (CHE 213) Track Chair: Prof. YangQuan Chen, USU *Complex Networked Control Systems and Resilience*	**Track 2: Human Systems** (Auditorium) Track Chair: Mr. Pierre Le Bot, EDF *Open Symposium: The Mermos Human Reliability for Resilience*	**Track 3: Robotics & Computational Intelligence** (CHE 215) Track Chair: Prof. Sergiu-Dan Stan, TU Cluj-Napoca *Robotics & Mechatronics*	**Track 4: Data Fusion & Computation Intelligence** (CHE 216) Track Chair: Prof. Devendra Garg, Duke *Data Fusion Applications*
11:30 a.m.	Hosted Lunch **Keynote speaker: Dr. Floyd "Ben" Cole III, Special Projects, NSA** *The Paradox of Diversity: Fragility and Resiliency in the Network*			
1:00 p.m.	**Session 2:** Track Papers			
	Track 2: Human Systems (CHE 214) Mr. Pierre Le Bot, EDF *Model of Resilience in Situation (MRS)*	**Track 3: Robotics & Computational Intelligence** *(continued from Session 1)* (CHE 215)		
2:30 p.m.	**Afternoon Break**			
3:00 p.m.	**Session 3:**			
	Track 1: Complex Networked Control Systems (CHE 213) Mr. Johnathan Gray, INL *Industrial Perspective on Resilient Control Systems*	**Track 2: Human Systems** Roundtable (CHE 215)	**Track 3: Robotics & Computational Intelligence** (CHE 216)	
4:30 p.m.	**Adjourn**			
5:00 p.m.	**Load bus for Mountain River Ranch** (See program for more details)			
6:00 p.m.	**Hosted Social at Mountain River Ranch**			

Daily Agenda *Continued*

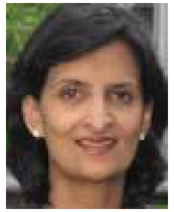
ISRCS 2010

Thursday, August 12 - *Panel Discussion*

8:15 a.m.	**Opening Remarks** Daily Agenda: Margie Jeffs
8:30 a.m.	**Time-Sensitive Complex Networked Control Systems.** Prof. Mo-Yuen Chow, NCSU (CHE 213)
9:30 p.m.	**Morning Break**
10:00 a.m.	**Panel Discussion** Complex Network Control Systems *Interdependences and the Role of the Human, both beneficial and malicious.* *What are the issues and how do we address them?* Led by Mr. Miles McQueen, INL (CHE 213)
11:50 p.m.	**Concluding Remarks** *Thanks and next year*

Friday, August 13 - *Yellowstone National Park Tour*

7:00 a.m.	**Meet at Fairfield Inn**
7:15 a.m.	**Meet at Hilton Garden Inn** *(Le Ritz and AmeriTel guests walk over)*
7:30 a.m.	**Drive to Yellowstone National Park**
9:30 a.m.	**Norris**
11:00 a.m.	**Canyon, Lunch**
12:30 p.m.	**Yellowstone Grand Canyon, Mud Volcano, Yellowstone Lake**
3:00 p.m.	**Old Faithful**
4:30 p.m.	**Midway Geyser Basin** *(if time allows)*
5:00 p.m.	**Depart back to Idaho Falls**



Stream Computing for Data Fusion and Computational Intelligence

Dr. Chitra Venkatramani, IBM

Abstract

As the world gets more and more instrumented and interconnected, the amount of data available from sensors monitoring various systems such as natural, man-made, and human systems, is increasing exponentially. The rate of growth of the volume, variety, and velocity of data poses many computational challenges to the process of extracting, predicting, and acting upon intelligence from the data. In this talk, we present our work on System S, a joint research program between IBM Research and the US Government. System S (recently commercialized as InfoSphere Streams) supports a programming model and a distributed, scalable, high-performance runtime platform to enable building of applications to process, correlate and explore large volumes of structured and unstructured data-in-motion. It supports extreme data-driven applications that are always in a state of overload -- there is too much work to do and too much data to save permanently. We present various real-world applications of stream computing to address problems of data-fusion, in various domains. We also discuss the positioning of stream-computing in the context of big-data analysis and fusion, on platforms such as Hadoop, that support the map-reduce paradigm. We will conclude the talk with related research activities currently underway in our lab.

Bio

Chitra Venkatramani is a Research Staff Member and manager of the Distributed Streaming Systems group at the IBM T.J. Watson Research Center. The focus of her team is on research related to System S, a software platform for large-scale, distributed stream processing. Her team explores issues in high-performance, large-scale distributed computing systems, including advanced computation and communication infrastructures, fault-tolerance, scheduling and resource management for data-intensive applications. Since obtaining her PhD in Computer Science from SUNY at Stony Brook in 1997, she has also been engaged in various projects around multimedia data streaming and content distribution at IBM's Watson labs. She holds numerous patents and publications and is also a recipient of IBM's Outstanding Technical Achievement award.

Human Factor and Computational Intelligence Limitations in Resilient Control Systems

Bogdan M. Wilamowski, Auburn

Abstract

Humans are very capable of solving many scientific and engineering problems, but during the solution process they have a tendency to make mistakes. For example, humans without computer aided tools, would not be able to design VLSI chips larger than 100 transistors. These imperfection of humans make them very unreliable elements in resilient control systems. There is a tendency of replacing humans with computers using artificial intelligence, expert systems, or methods of computational intelligence. The methods of computational intelligence can be most successful but they have to be used with great care. Limitations of fuzzy and neural networks are presented and it is shown how to avoid these limitations so resilient control systems can be developed. It turns out that often popular training algorithms are not capable of tuning neural network to proper accuracy without losing generalization abilities. As a consequence, such system of computational intelligence may not work properly for cases which were not used in training. The comparison of different neural network architectures is given and it is shown how to develop and train close to optimal topologies, so resilient control systems can be developed.

Bio

Bogdan M. Wilamowski received his MS in computer engineering in 1966, PhD in neural computing in 1970, and Dr. Habil. in integrated circuit design in 1977. He received the title of full professor from the President of Poland in 1987. He was the Director of the Institute of Electronics (1979-1981) and the Chair of the Solid State Electronics Department (1987-1989) at the Technical University of Gdansk. He was Professor at the University of Wyoming (1989-2000) From 2000 to 2003 he was Associate Director of Microelectronics Research and Telecommunication Institute at University of Idaho and he was Professor in Electrical and Computer Engineering Department and in Computer Science Department at the University of Idaho. Currently he is Director of ANMSTC – Alabama Nano/Micro Science and Technology Center and Alumna Professor of Electrical and Computer Engineering Department at Auburn University. Dr. Wilamowski was with the Communication Institute at Tohoku University, Japan (1968-1970) and he spent one year at the Semiconductor Research Institute, Sendai, Japan as a JSPS Fellow (1975-1976). He was a visiting scholar at Auburn University (1981-1982 and 1995-1996), and a visiting professor at the University of Arizona, Tucson (1982-1984). He is the author of 4 textbooks, more than 300 refereed publications, and has 27 patents. He was the major professor for about 130 graduate students. His main areas of interest are: semiconductor devices and sensors, mixed signal and analog signal processing, and computational intelligence.

Dr. Wilamowski was the Vice President of the IEEE Computational Intelligence Society (2000-2004) and the President of the IEEE Industrial Electronics Society (2004-2005). He served as an associate editor of IEEE Transactions on Neural Networks, IEEE Transactions on Education, IEEE Transactions on Industrial Electronics, Journal of Intelligent and Fuzzy Systems, and Journal of Computing, International Journal of Circuit Systems and IES Newsletter.

The Paradox of Diversity: Fragility and Resilience in the NETWORK

Dr. Ben Cole III

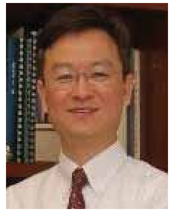
Abstract

The Global Information NETWORK is arguably the most complex system yet created by man. It is curious that a phenomenon which makes that NETWORK unstable, error prone, and subject to constant failure somewhere within its extent should also account for a significant part of its robustness and resiliency. We will discuss this non-intuitive fact in the light of the familiar biological metaphors which we have grown accustomed to use in describing the NETWORK. We will use those metaphors to suggest that there are lessons from biological evolution that can instruct us in our attempts to design parts of the NETWORK – what may be possible and what may not be.

Bio

Dr. Floyd B. Cole, III, DISL-7, is a Cryptologic Mathematician currently directs all Special Projects for the Research Directorate (RD) of NSA. In his present capacity, Dr. Cole often represents NSA on the Intelligence Community's interagency committees and intergovernmental working groups. He serves as the NSA representative on a number of advisory/evaluation boards for National Laboratories and FFRDC's.

Dr. Cole graduated from Davidson College, Davidson, NC in 1963 with a BS degree in Mathematics and English. He attended Rutgers University, New Brunswick, NJ, where he received a MS degree in 1965 and his Ph.D. in 1968, both in Mathematics. His doctoral dissertation was in a branch of mathematical logic known as Recursive Function Theory. While serving in the USAR, Dr. Cole completed the basic and advanced courses in intelligence and security as well as numerous other courses and seminars in strategic intelligence. Dr. Cole has taught for many colleges and universities. In 2007 Dr. Cole spent a sabbatical year as the Distinguished Visiting Professor of Mathematics at the US Military Academy, West Point, where he taught courses and facilitated engagement between the Academy and NSA. Currently, he is a faculty member at the University of Maryland teaching advanced courses in Mathematics and Computer Science at both the Baltimore County and College Park campuses. Dr. Cole regularly participates in the academic peer review process for government research grants. He is also an active participant in the NSA Mathematics Outreach Program through which he often speaks on mathematical topics to students at all levels from elementary through graduate school. He regularly attends meetings of the American Mathematical Society where he is actively involved in recruiting mathematical talent for NSA.



Time-Sensitive Complex Networked Control Systems

Professor Mo-Yuen Chow, NCSU

Abstract

Complex networked control systems have been gaining popularity due to their high potential in widespread applications for national critical infrastructure and are becoming realizable due to the rapid advancements in embedded systems and communication technologies. However, with the network-in-the-loop control constraints, the large-scale deployment of heterogeneous devices in the system, the constant demands of higher performance, the increasing requirements on security and resilience features, and more uncertain and wider operating conditions, many grand challenges await for complex networked control systems.

In this presentation, the speaker will share some of his viewpoints on time-sensitive complex networked control systems, their challenges, and potential tools. We will use a Smart Grid, which is the modernization of the power grid with more reliable, effective, efficient, and resilient features, as an illustration of a typical national critical infrastructure for complex networked control system applications. Achieving the goal requires the development of power electronics for advanced devices and components, the evolution of techniques to integrate into the grid, and the analysis and design of advanced communication, coordination and control systems. In this presentation, we will first provide an overview of the time sensitive complex networked control systems and the smart grid concept. Then we will share our experiences on several complex networked control systems related to Smart Grid related research projects at the FREEDM Center (Future Renewable Electric Energy Delivery and Management) at North Carolina State University. Finally, we will highlight several lessons that we have learned, and will share our perspectives on future time-sensitive complex networked control systems research and applications.

Bio

Mo-Yuen Chow earned his degree in Electrical and Computer Engineering from the University of Wisconsin-Madison (B.S., 1982); and Cornell University (M. Eng., 1983; Ph.D., 1987). Dr. Chow joined the Department of Electrical and Computer Engineering at North Carolina State University as an Assistant Professor in 1987, an Associate Professor in 1993, and a Professor since 1999. Dr. Chow is also a Zhejiang University Changjiang Professor.

Dr. Chow's research focuses on fault detection, diagnosis and prognosis, time-sensitive distributed control systems, and computational intelligence. He has been applying his research to areas such as smart grids, power distribution systems, transportation systems, batteries, motors, robotics and mechatronics. Dr. Chow has established the Advanced Diagnosis and Control Laboratory (ADAC) at NC State University. He has published one book, several book chapters, and over one hundred journal and conference articles related to his research work. He is an IEEE Fellow and the Editor-in-Chief of IEEE Transactions on Industrial Electronics. He has received the IEEE Region-3 Joseph M. Biedenbach Outstanding Engineering Educator Award, the IEEE ENCS Outstanding Engineering Educator Award, and the IEEE ENCS Service Award.

Mr. Pierre Le Bot

"Overview of the MERMOS Human Reliability Method" (Open Lecture)

MERMOS ("Méthode d'Evaluation de la Réalisations des Missions Opérateur pour la Sûreté) is a second-generation human reliability method developed by EDF for use in ensuring the safety of French reactors. It is unique among human reliability modeling methods in its heavy emphasis on defining the organizational context behind human errors and using simulator data to inform quantification. In this open lecture, the lead developer of MERMOS, Mr. Pierre Le Bot of EDF R&D, will give a brief introduction to the method and its application across the French nuclear industry.

"Model of Resilience in Situation (MRS)"

In this lecture, Mr. Pierre Le Bot will outline the Model of Resilience in Situation (MRS), which proposes a theoretical modeling of resilience for engineering risky systems. The MRS framework bridges research on human reliability analysis and resilience engineering, ensuring the proper link between risk analysis and accident prevention and mitigation. The MRS also provides a crucial bridge between resilience for hardware systems, contextual factors, and human resilience.

Bio

Pierre Le Bot has extensive experience in nuclear power plant safety engineering in general and in accident prevention and mitigation in particular.He has been an expert researcher in human reliability analysis for EDF's R&D since 1993. First, he contributed to the human data collection from observations on simulators for HRA (human reliability analysis) method development and application. Then he led the development of MERMOS (méthode d'evaluation de la réalisations des missions opérateur pour la sûreté), currently being implemented at EDF. A former graduate in sociology from the Institute of Political Sciences (IEP, Institut d'Etudes Politiques), Pierre Le Bot is currently focusing his research on the impact of organizations on human reliability. Recently he has developed the Model of Resilience in Situation, which proposes a theoretical modeling of resilience for engineering of risky systems.

Track 1- Data Fusion & Computation Intelligence

Tutorial on Prognostics and Health Management

Chair: Jay Lee, NSF Center for Intelligent Maintenance Systems, University of Cincinnati
Co-chair: Masoud Ghaffari, NSF Center for Intelligent Maintenance Systems, University of Cincinnati

Prognostics and Health Management (PHM) is defined as "systems engineering discipline focusing on detection, prediction, and management of the health and status of complex engineered systems."

These sessions will provide an overview of PHM, commonly used algorithms and a systematic methodology, a number of case studies, and the future direction. It will also discuss how PHM relates to Resilient Control Systems, Engineering Immune Systems, and other systems engineering concepts related to management of complex engineering systems.

Track 2- Human Systems & Complex Network Control Systems

Workshop on Universal Laws, Architectures, and Behaviors of Robust, Evolvable Networks.

John Doyle, Caltech

This talk will review recent progress on developing a unified theory for complex networks involving three elements: hard limits on achievable robust performance (laws), the organizing principles that succeed or fail in achieving them (architectures and protocols), and the resulting high variability data and "robust yet fragile" behavior observed in real systems (behavior, data).

Biological systems are robust and evolvable in the face of even large changes in environment and system components, yet can simultaneously be extremely fragile to other small perturbations. Such universally robust yet fragile (RYF) complexity is found wherever we look. The amazing evolution of microbes into humans (robustness of lineages on long timescales) is punctuated by mass extinctions (extreme fragility). Diabetes, obesity, cancer, and autoimmune diseases are side-effects of biological control and compensatory mechanisms so robust as to normally go unnoticed. RYF complexity is not confined to biology. The complexity of modern institutions and technologies is exploding, but in ways that remain largely hidden. They facilitate robustness and accelerate evolution, but enable catastrophes on a scale unimaginable without them (from network and market crashes to war, epidemics, and global warming). Understanding RYF means understanding architecture — the most universal, high-level, persistent elements of organization — and protocols. Protocols define how diverse modules interact, and architecture defines how sets of protocols are organized.

Insights into the laws, architecture, and organizational principles of networked systems can be drawn from three converging research themes. 1) With molecular biology's description of components and growing attention to systems biology, the organizational principles of biological networks are becoming increasingly apparent. Biologists are articulating richly detailed explanations of biological complexity, robustness, and evolvability that point to universal principles and architectures. This talk will connect these insights with the role of layering, protocols, and feedback control in structuring complex multiscale modularity, and contrast strikingly with many popular mainstream "theories" that ignore biological functionality and evolution. 2) Advanced technology's complexity is now approaching biology's. While the components differ, there is striking convergence at the network level. New theories of the Internet and related networking technologies have led to test and deployment of new protocols, and suggest a fundamental rethinking of network architecture, including those involved in finance and economics. We will particularly focus on problems with TCP/IP and ideas for new Internet architectures that are more secure and robust. 3) A new mathematical framework for the study of complex networks suggests that this apparent network-level evolutionary convergence within/between biology/technology is not accidental, but follows necessarily from the universal system requirements to be efficient, adaptive, evolvable, and robust to perturbations in their environment and component parts. The universal hard limits on systems and their components have until recently been studied separately in fragmented domains of control, communication, computation, physics, and chemistry, but a unified theory is needed and appears feasible.

Track 3- Human Systems & Cyber Awareness

Workshop on Formally Modeling the Human Element and Its Impact on Control Systems Resiliency

Chair: Eugene Santos, Jr., Dartmouth College
Co-chair: Annarita Giani, University of California

The focus of this session is on modeling the human element found within many complex control systems. In particular, we are interested in how to formally model humans as necessary to address resilience. Topics for discussion include hybrid modeling approaches and mixed-initiative complex systems. Game-theoretic approaches, information assurance (misinformation, deception, etc.) as it affects the human element, and information reliability and impact on the system due to the human are more specific foci. Elements of networked mixed human-machine control systems are also potential directions of discussion.

Special Presenters:

- Marco Carvalho - Institute for Human-Machine Cognition (IHMC)
- Joao Hespanha - University of Californica, Santa Barbara
- LtCol Brett J. Borghetti - Air Force Institute of Technology, WPAFB, OH
- Neil Rowe - NPS
- George Cybenko - Dartmouth

Primary Tracks

Track 1 - Complex Control System Networks

Track Chair: Prof. YangQuan Chen, Utah State University
Track Co-Chair: Prof. Charles Tolle, South Dakota School of Mines and Technology
Understanding how control systems become more decentralized and their ability to characterize interactions, performance and security while ensuring resilience.

Speakers:

- Venkat Venkatasubramanian, Purdue
- YangQuan Chen, USU
- Craig Rieger, INL
- Saurabh Amin, UC Berkeley

Track 2 - Human Systems

Track Chair: Prof. Barrett Caldwell, Purdue University
Track Co-Chair: Dr. David Gertman, Idaho National Laboratory
Human reliability analysis that provides information on ergonomics, workload, complexity, training, and experience which may be used to characterize and quantify human actions and decisions.

Speakers:

- Ron Boring, INL
- David Gertman, INL
- Johanna Oxstrand, INL
- Barrett Caldwell, Purdue
- Pierre Le Bot, EDF

Track 4 - Data Fusion

Track Chair: Prof. Devendra Garg, Duke University
Track Co-Chair: Prof. Manish Kumar, University of Cincinnati
Various data types associated with proper operation or performance of critical infrastructure, including cyber and physical security, process efficiency and stability, and process compliancy.

Speakers:

- Denis Vollmer, INL
- Omid Fatemieh, University of Illinoise at UC
- Devendra Garg, Duke University
- Manish Kumar, University of Cincinnati

Special Sessions

Track 3 - Robotics and Computational Intelligence

Robotics and Mechatronics

Chair: Prof. Milos Manic, University of Idaho;
Dr. Sergiu-Dan Stan, TU Cluj-Napoca
Mechatronics is the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes. It relates to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control.

Presenters:

- Dr. Sergiu-Dan Stan
- Dr. faridoon shabani
- Mr. Viorel Gheorghe
- Mr. Adam Csapo

Resilient (Vehicle) Coordination Over Sensing & Communication Networks

Chair: Dr. Nicholas Kottenstette, ISIS, Vanderbilt University
Numerous examples studying (vehicle) coordination problems such as those which address effective (vehicle) deployment and rendezvous problems abound in the literature. Typically, these problems either: i) assume communication of individual sensor information (such as position and/or velocity) over networks in order to maintain coordination (spacing) amongst subsystems (neighbors) or ii) assume that each subsystem (vehicle) can sense relative (position and/or velocity) measurements amongst their immediate neighbors. Papers which rely on communication networks can typically achieve faster convergence rates than those which rely on only local sensing information. However the decentralized approaches which rely on local sensing information are not prone to networked attacks. Attacks on communication networks can include: i) standard denial of service (DOS) attacks which introduce time delay and data loss; or ii) more sophisticated man in the middle (MITM) attacks; for example. MITM attacks are considerably worrisome because they can negate sensor information and potentially destabilize the entire system. Resilient (vehicle) coordination is\ concerned with: i) specifically identifying types of attacks which can adversely affect given group coordination control problems (DOS, MITM) ii) clearly identifying how performance will degrade (system becomes unstable, collisions occur, etc.) iii) identifying potential countermeasures and control structures (combine networked control solutions with decentralized control approaches) which can better withstand a given attack/ system fault iv) developing improved network attack/ fault detection algorithms.

Presenters:

- Mr. Ryan Bradetich
- Dr. Nicholas Kottenstette
- Prof. Semyon Meerkov, University of Michigan
- Mike McCourt and Panos Antsaklis, University of Notre Dame

Industrial Perspective on Resilient Control Systems

Chair: Mr. Jonathan Gray, INL

To provide perspective on the needs for resilience in next generation control systems from vendors and/or owner, this session will present a selection of topics researched or of interest to the end user community. This session is invitation only, but those interested in participating can contact the session chair as indicated below.

Presenters:

- Dr. Dong Wei
- Dr. Alvaro Cardenas
- Prof. Subramaniam Ganesan

Track 2: Human Systems

Special Presentation

Roundtable: Reconciling Resilience and Reliability

Chair: Dr. Ronald Boring & Dr. David Gertman, INL

The purpose of this session is to discuss the similarities and differences between human reliability analysis and resilience engineering. These two fields share many roots but have emerged with different methods and different goals. What are the methods and goals of each field? Can the two fields reconcile their differences? Are there strong differences between them? What is the relationship of both fields to other areas like human factors, safety culture, and high reliability organizations? The presenters will briefly provide their position statements, followed by a roundtable discussion of these perspectives.

"Overview of the MERMOS Human Reliability Method" (Open Lecture)

Mr. Pierre Le Bot

MERMOS ("Méthode d'Evaluation de la Réalisations des Missions Opérateur pour la Sûreté) is a second-generation human reliability method developed by EDF for use in ensuring the safety of French reactors. It is unique among human reliability modeling methods in its heavy emphasis on defining the organizational context behind human errors and using simulator data to inform quantification. In this open lecture, the lead developer of MERMOS, Mr. Pierre Le Bot of EDF R&D, will give a brief introduction to the method and its application across the French nuclear industry.

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In this lecture, Mr. Pierre Le Bot will outline the Model of Resilience in Situation (MRS), which proposes a theoretical modeling of resilience for engineering risky systems. The MRS framework bridges research on human reliability analysis and resilience engineering, ensuring the proper link between risk analysis and accident prevention and mitigation. The MRS also provides a crucial bridge between resilience for hardware systems, contextual factors, and human resilience.

Panel Discussion: Complex Network Control System Interdependencies and the Role of the Human, Both Beneficial and Malicious: What are the issues and how do we address them?

The proficiency of the human in operating and maintaining control systems is a traditional research area within the field of human reliability. To partially address the dependence on human reliability, automation has often been implemented as a means to provide reproducible responses while minimizing human interaction. While this has been beneficial in many aspects, the underlying design basis is still dependent upon determinations made by one or more individuals. If the operating conditions vary outside those in which the automation was based, then the automation may not behave as desired. As the interconnections grow between control systems, initiated to address desires such as improving efficiency of operation, the complexity and potential for error also grows. Add the complexity of a potential malicious actor, and a different type of complexity is created.

The desire in this case is not to understand the human to maximize benefit, but instead to defeat intrusions. Traditionally the primary methods used in cyber security to defeat intrusions have not been focused on modeling the malicious actors or the defenders, so there may be opportunity for progress to be made.

The purpose of this session, therefore, is to discuss the human aspects of control system interdependencies and promising approaches to understanding and using these diverse aspects.

Panelists:

- Mr. Miles McQueen, INL
- Prof. Barrett Caldwell, Purdue
- Prof. YangQuan Chen, USU
- Prof. Mo-Yuen Chow, NCSU
- Prof. Eugene Santos, Dartmouth,
- Dr. Marco Carvalho - Institute for Human-Machine Cognition (IHMC)
- Prof. Paul Oman (University of Idaho)

A Resilience-Reliability Crosswalk

By Ronald L. Boring and David I. Gertman

There has been strong interest in the new and emerging field called resilience engineering. This field has been quick to align itself with many existing safety disciplines, but it has also distanced itself from the field of human reliability analysis. To date, the discussion has been somewhat one-sided, with much discussion about the new insights afforded by resilience engineering. This paper presents an attempt to address resilience engineering from the perspective of human reliability analysis (HRA). It is argued that HRA shares much in common with resilience engineering and that, in fact, it can help strengthen nascent ideas in resilience engineering. This paper seeks to clarify and ultimately refute the arguments that have served to divide HRA and resilience engineering.

Towards Resilient Multicore Architectures for Real-time Controls

By Ryan Bradetich

The DOD community is interested in new computer architectures to host Multi-Level Secure (MLS) command and control systems. These systems must be secure and resilient, not unlike hardened real-time control systems used in critical infrastructures. Thus, analyses of multi-core architecture security has relevance to both future MLS systems and resilient real-time controls. In this paper we discuss how Smart Grid features will complicate real-time controls, and suggest that resilient multi-core systems may offer a solution to the increased complexity of our critical infrastructure control systems, if those architectures can be suitably hardened. We showcase two vulnerabilities in the Cell Broadband Engine and show how those vulnerabilities can be mitigated using changes to the Linux kernel. Similar problems can been found in the Intel Nehalem architecture and the Free-scale P4080 architecture. We conclude that multi-core architectures are only suitable for MLS and resilient real-time controls if, and only if, designers pay close attention to mitigating the inherent firmware and software vulnerabilities.

Fractional Calculus, Delay Dynamics and Networked Control Systems

By Yang Quan Chen

In networked control systems (NCS), the spiky nature of the random delays makes us wonder about the benefits we can expect if the spikiness, or what we call delay dynamics are considered in the NCS controller design. It turns out that the spikiness of the network induced random delays can be better characterized by the so-called -stable processes, or processes with fractional lower-order statistics (FLOS) which are linked to fractional calculus. Many real dynamic systems are better characterized using a non-integer order dynamic model based on fractional calculus or, differentiation or integration of non-integer order. Traditional calculus is based on integer order differentiation and integration. The concept of fractional calculus has tremendous potential to change the way we see, model, and control the nature around us. Denying fractional derivatives is like saying that zero, fractional, or irrational numbers do not exist. This article proposes a transformative research idea to link fractional calculus, delay dynamics and NCSs. Specifically, fractional order modeling of delay dynamics will be used to better characterize the dynamic delay behavior. Then, a fractional order controller will be designed based on the fractional order delay dynamic model. Initial evidence confirmed that, incorporating delay dynamics in the controller design offers improved NCS control performance. Index Terms—Fractional Calculus, Delay Dynamics, Networked Control Systems.

Towards a Numerically Tractable Model for the Auditory Substitution of Tactile Percepts

By Adam Csapo

We refer to channels of communication that link the user to information systems as cognitive communication channels. One especially interesting research topic related to cognitive communication channels deals with a special application called sensory substitution, when information is conveyed through a channel other than the one that is normally used for the given application. Our goal is to develop engineering systems for the remote teleoperation of robots using sensory substitution to convey feedback information in meaningful ways. Such applications could help reduce the cognitive load for the user on the one hand, and help alleviate the effect of control instabilities and hidden parameters on the other. A large part of our research deals with how to provide information on tactile percepts - otherwise inaccessible to the remote user - through sound. In this paper, we present one possible mapping between tactile percepts and auditory parameters. Through a set of controlled experiments, we show that the parameters used are meaningful and the sounds can at some level be learned by users as a substitute for tactile perception. Analyzing the error statistics of the experiments, we argue that it would be worthwhile to create a system in which the sound parameters could be locally tuned to enhance performance on a user-per-user basis. To this end, we convert the analytical descriptions of our sounds into an HOSVD-based tensor product model form. In order to be able to apply a wide range of mathematical analysis tools - such as principal component analysis and user performance-oriented adaptivity - we demonstrate that it is possible to convert our models into such canonical forms.

Design and Control of a Novel Type of Actuator for the Isoglide T3R1 Parallel Robot

By R. C. Donca

This paper deals with a new type of actuator which can be used for the driving of an Isoglide T3R1 Parallel Robot. The proposed machine is a linear transverse flux motor operating based on the variable reluctance principle. The topology of the motor is presented. A 3D finite element method analysis is carried out on a small dimension structure, evidencing the flux density distribution and the developed tangential and normal forces. The control strategies of this motor are approached. Experimental setup is presented in the final part of the paper.

Low Cost and Secure Smart Meter Communications using the TV White Spaces

By Omid Fatemieh

We investigate the use of white spaces in the TV spectrum for Advanced Meter Infrastructure (AMI) communications. We provide a design for using white spaces for AMI and show its benefits in terms of bandwidth, deployment, and cost. We also discuss ongoing work on applying machine learning classification techniques to improve the attack resilience of spectrum data fusion in the proposed architecture.

Mobile Sensor Frame Mapping via Vision and Laser Scan Matching

By Devendra P. Garg

Cooperative mobile robots must have knowledge of their positions relative to the group in which they operate. Commonly used on-board sensors such as laser rangefinders may be used to detect and track other robots with high precision. However, limited feature recognition and susceptibility to occlusion relethermnduces the efficacy of this solution alone. Matching multiple robots' laser scans can overcome some of these issues, but it requires extensive memory usage and large communication bandwidth. Overhead imaging systems may also be utilized, although sensor nonlinearities, field of view restrictions, and data latency limit such usage to some extent. In this paper, a data fusion method is proposed for dynamically evaluating a mobile robot's position by matching laser scan data to overhead image data.

Rolling Robot with Radial Extending Legs

By Viorel Gheorghe

The paper presents the construction of a rolling robot able to move in the horizontal plane due to an original structure of a regular dodecahedron shape with twelve extending legs disposed in a radial manner in the centers of its faces. A mathematical model is developed and the robot functioning is simulated. Simulation results were validated by preliminary testing. A control algorithm developed by the authors takes advantage of the symmetric shape of the robot and allows recovering from perturbations, thus increasing the resilience of the robotic system.

Discrete-Time IDA-Passivity Based Control of Coupled Tank Processes Subject To Actuator Saturation

By Nicholas Kottenstette

Interconnection damping assignment passivity based control (IDA-PBC) is an emerging control design method which allows an engineer to systematically design an advanced controller for complex non-linear systems. As a result specific gain ranges can be determined which can prevent an operator (adversary) from accidentally (maliciously) setting control gains which could potentially destabilize the system. However in order to generate the controller the engineer will have to resort to using symbolic numerical solvers in order to complete the design. This can be both a cumbersome and error-prone task which can be automated. We present initial results of a tool which simplifies IDA-PBC. In addition many fluid control problems posses tight operating regions in which pumps degrade over time. As a result actuator saturation may occur for given set-point profiles which will lead to integrator wind-up and more oscillatory behavior. We provide a non-linear anti-windup control-law which greatly improves system resilience to such degradation. Finally we demonstrate that IDA-PBC works reasonably well for moderately large sampling times by simply applying the bilinear transform to approximate any additional (non-linear) integral control terms.

Notional Examples and Benchmark Aspects of a Resilient Control System

By Craig G. Rieger

Digital control system technology has pervaded most industries, leading to improvements in the efficiency and reliability of the associated operations. However, the ease of distributing and connecting related control systems for the purposes of increasing performance has resulted in interdependencies that can lead to unexpected conditions. Even with less complex designs, operators and engineers alike are often left with competing goals that are difficult to resolve. A fundamental reason for this dichotomy is that responsibilities lie with different disciplines, and operations are hosted on separate control systems. In addition, with the rising awareness of cyber security and diverse human interactions with control systems, an understanding of human actions from a malicious and benevolent standpoint is necessary. Resilience considers the multiple facets of requirements that drive the performance of control systems in a holistic fashion, whether they are security or stability, stability or efficiency, human interactions or complex interdependencies. As will be shown by example, current research philosophies lack the depth or the focus on the control system application to satisfy these requirements, such as graceful degradation of hierarchical control while under cyber attack. A resilient control system promises to purposefully consider these diverse requirements, developing an adaptive capacity to complex events that can lead to failure of traditional control system designs.

A Resilient H∞ Control Design for Swarm Formation Control of Multi-Agent systems: A Decentralized Adaptive Fuzzy Approach

By Faridoon Shabani

In this paper, a decentralized adaptive control scheme for multi-agent formation control is proposed. This control method is based on artificial potential functions integrated with adaptive fuzzy H1 technique. We consider fully actuated mobile agents with partially unknown models, where an adaptive fuzzy logic system is used to approximate the unknown system dynamics. The H1 control theory is used to attenuate the adaptive fuzzy approximation error to a prescribed level. Therefore the agents motion is forced to obey the dynamics defined by the simple inter-agent artificial potential functions. Stability proof is given using Lyapunov functions, which shows the resilience behavior of controller with respect to disturbances and system uncertainties. Finally, Simulation results are demonstrated for a multi-agent formation problem of a group of six agents, illustrating the effective attenuation of fuzzy logic approximation error.

RNEDE: Resilient Network Design Environment

By Venkat Venkatasubramanian

Modern living is more and more dependent on the intricate web of critical infrastructure systems. The failure or damage of such systems can cause huge disruptions. Traditional design of this web of critical infrastructure systems was based on the principles of functionality and reliability. However, it is increasingly being realized that such design objectives are not sufficient. Threats, disruptions and faults often compromise the network, taking away the benefits of an efficient and reliable design. Thus, traditional network design parameters must be combined with self-healing mechanisms to obtain a resilient design of the network. In this paper, we present RNEDEa resilient network design environment that that not only optimizes the network for performance but tolerates fluctuations in its structure that result from external threats and disruptions. The environment evaluates a set of remedial actions to bring a compromised network to an optimal level of functionality. The environment includes a visualizer that enables the network administrator to be aware of the current state of the network and the suggested remedial actions at all times.

Mechatronic design, kinematics analysis of a 3 DOF medical parallel robot

By Dan Verdes

Robots are one of the most representative fields in mechatronics, this article presents the development process of a mechatronic system, taking into account 3 DOF parallel robots, pointing out the integration of the elements and showing the challenges needed to be faced for the interfaces between the robot modules and the GUI (Graphical User Interface). The interface uses virtual reality to provide the user with an interactive 3D graphical representation of the parallel robot.

A Distance Measure Comparison to Improve Crowding in Multi-Modal Problems.

By D. Todd Vollmer

Solving multi-modal optimization problems are of interest to researchers solving real world problems in areas such as control systems and power engineering tasks. Extensions of simple Genetic Algorithms, particularly types of crowding, have been developed to help solve these types of problems. This paper examines the performance of two distance measures, Mahalanobis and Euclidean, exercised in the processing of two different crowding type implementations against five minimization functions. Within the context of the experiments, empirical evidence shows that the statistical based Mahalanobis distance measure when used in Deterministic Crowding produces equivalent results to a Euclidean measure. In the case of Restricted Tournament selection, use of Mahalanobis found on average 40% more of the global optima, maintained a 35% higher peak count and produced an average final best fitness value that is 3 times better.

Resilient Industrial Control System (RICS): Concepts, Formulation, Metrics, and Insights

By Dong Wei

To monitor and control industrial machinery and processes, industrial control systems play an important role in daily life. Resilient control is a new topic of control technologies which studies how to maintain acceptable level of operation or service in face of undesirable incidents. This emerging technology, applied to industrial control systems, can provide a certain degree of protection for critical infrastructure, such as electric power generation, transmission and distribution, oil and gas production, water treatment. This paper proposes a 3-layer system model and resilience curve, discusses the concept and presents definition, properties and some insights of resilient industrial control systems. The metrics to estimate resilience quantitatively is disclosed. The general approaches to build, operate and improve a resilience industrial control system are proposed as well. Cyber attack resilient power grid automation system is discussed to illustrate the proposed approaches.

Anti-swing control for an overhead crane with intelligent compensation

By Wen Yu

This paper proposes a novel anti-swing control strategy for an overhead crane. The controller includes both position regulation and anti-swing control. Since the crane model is not exactly known, an intelligent technique-fuzzy systemi is used to compensate friction, gravity as well as the coupling between position and anti-swing control. Real-time experiments are presented comparing this new stable anti-swing PD control strategy with regular crane controllers.

Resilience Engineering: Fancy Talk for Safety Culture: A Nordic Perspective on Resilience Engineering

By Johanna Oxstrand

Safety culture is an umbrella term covering related fields, such as human factor analysis, human reliability analysis, and human performance tools. As a whole, the goal is to increase the utilities' ability to handle anticipated as well as unexpected events. Recently, resilience engineering – with much the same goals – has gained popularity in the nuclear industry. In this paper we explore the similarities between safety culture and resilience engineering.

Indirect Adaptive Interval Type-2 Fuzzy Output Feedback Controller for Mimo Nonlinear Systems: A Resilient Approach

By Faridoon Shabani

This paper proposes an adaptive robust fuzzy controller for the tracking problem of a class of uncertain nonlinear MIMO systems. The control signal is comprised of two parts. One part is an adaptive fuzzy controller which approximates the system unknown functions using an interval type-2 fuzzy approximator. The other part is an $H\infty$ based controller that is applied to attenuate the effect of disturbance and approximation error. Moreover, it is assumed that only output variables are measurable. Hence a state observer is carried out to estimate the system states. To illustrate the effectiveness and resilience behavior of the proposed controller, simulation results for a two-degrees of freedom robotic manipulator are presented.

Fast and Totally Nonlinear Set Membership Filtering; Application to Control a 5-DOF Robot Manipulator

By Faridoon Shabani

Control of a robot manipulator to follow the desired path is a growing need in today industry, especially for manipulators with more than two links which are capable of miscellaneous motions in space. This paper is thoroughly concerned with the issue, taking in mind the necessity of estimation or filtering states from noises. Abstractly saying, the control used is a feedback-feedforward one while the states are estimated by a fast totally nonlinear version of the so-called set membership filtering algorithm.

Achieving resilience in critical infrastructures: A case study for a nuclear power plant cooling loop

By Venkat Venkatasubramanian

Engineered systems are increasingly equipped with sensing and actuating equipment making the operation ans supervisiry task increasingly difficult to handle by means of human interaction alone. In particular, the detection, identification and accommodation of abnormal, potentially harmful, events has been a longstanding challenge. Many scientists in different scientific areas have attacked this problem which has resulted in a plethora of techniques for both Fault Detection and Identification (FDI) and advanced control, each with their strengths and weaknesses. Because of the diverse nature of adopted theory and paradigms and because of a historical separation of FDI specialists and control theoreticians, it remains a challenge to establish automated systems able to handle exceptional events with minimal human intervention. As such, a project has been set up to enable full integration of diverse FDI methods as well as optimal coupling of FDI modules and control modules in the closed-loop supervisory control system. In this contribution, we introduce the basic paradigms of our approach, a strategic plan to achieve this goal as well as some preliminary results.

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Idaho Falls, ID 83404
208.529.6111

CHE 213 - All Group Meetings

CHE 211 - Break Room and Poster Session

Day 1, August 10:

CHE 214 - Data Fusion and Computation Intelligence

CHE 215 - Human Systems & Complex Network Control Systems

CHE 216 - Human Systems and Cyber Awareness

Day 2, August 11:

CHE 213 - Complex Networked Control Systems

CHE 214 - Human Systems

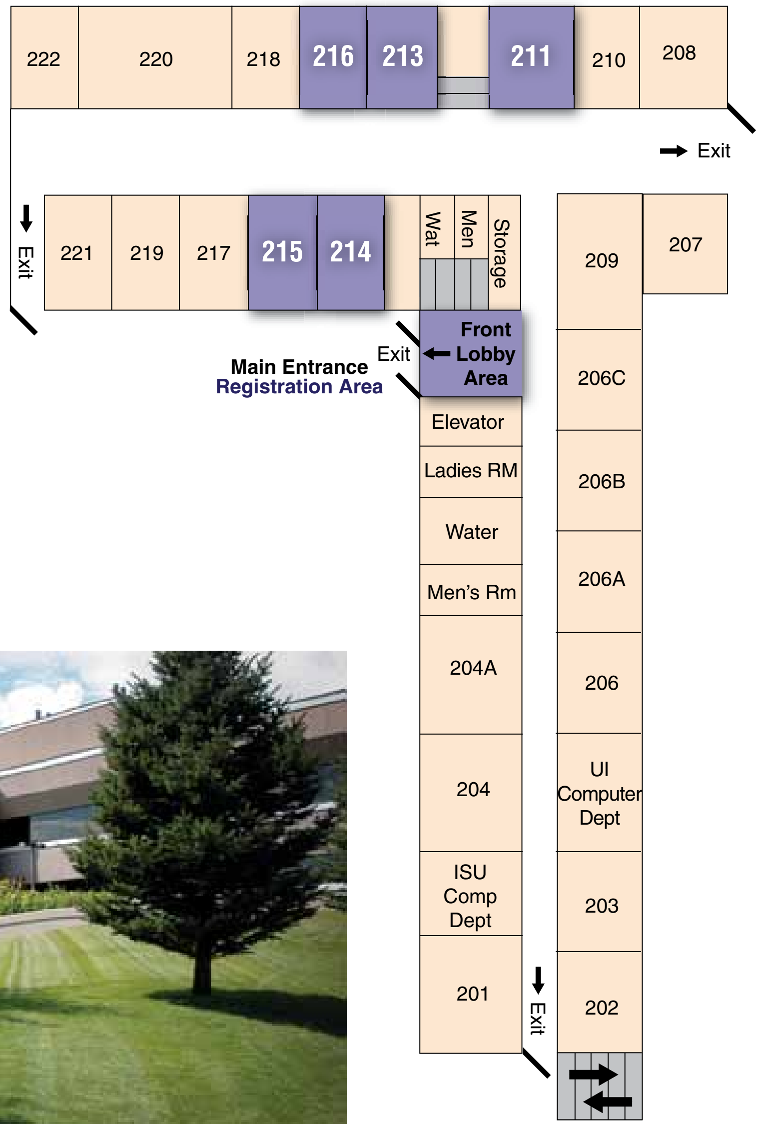
CHE 215 - Robotics and Computational Intelligence

CHE 216 - Data Fusion & Computation Intelligence

Day 3, August 12:

CHE 213 - Panel Discussion

Main Level 2



Yellowstone Tour Information

Yellowstone Tour

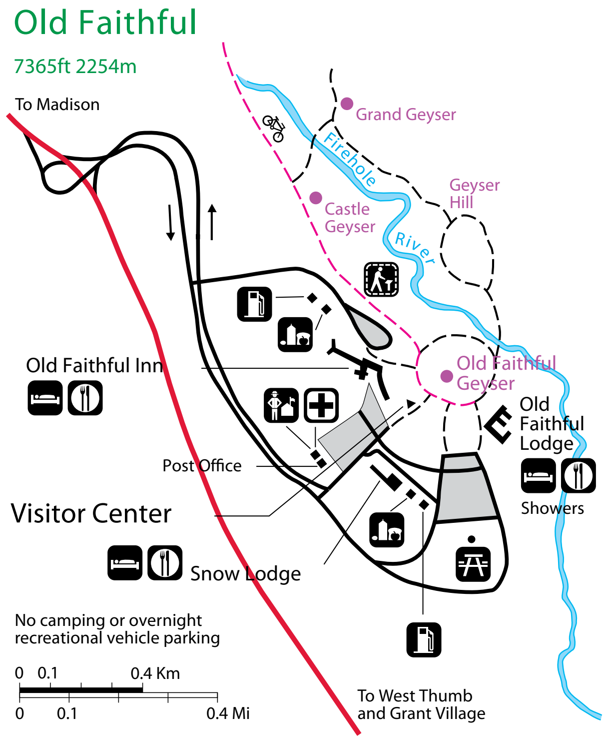
The guided Lower Loop Tour is a day-long trek that travels the lower portion of Yellowstone National Park's famous figure "8" road system.

Tour highlights include Old Faithful and Upper Geyser Basin, the bubbling mud pots of Fountain Paint Pots, the striking colors of the Grand Canyon of the Yellowstone with the 308-foot Lower Falls, and Yellowstone Lake, the largest alpine lake in North America. Stops typically include walking 1/2 to one mile around boardwalks and developed areas.

Walking times and distances may vary depending on the group's preferences. There also may be stops for wildlife viewing and other smaller features.

Recommended Items

- Backpack
- Sunscreen
- Chap Stick
- Camera
- Light jacket/sweatshirt
- Walking Shoes
- Hat
- Sunglasses
- Sack Lunch or Money for Lunch
  (There will be restaurants available at the lunch stop)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Geyser Hill
Castle Geyser
River
Old Faithful Inn
Old Faithful Geyser
Old Faithful Lodge
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Snow Lodge
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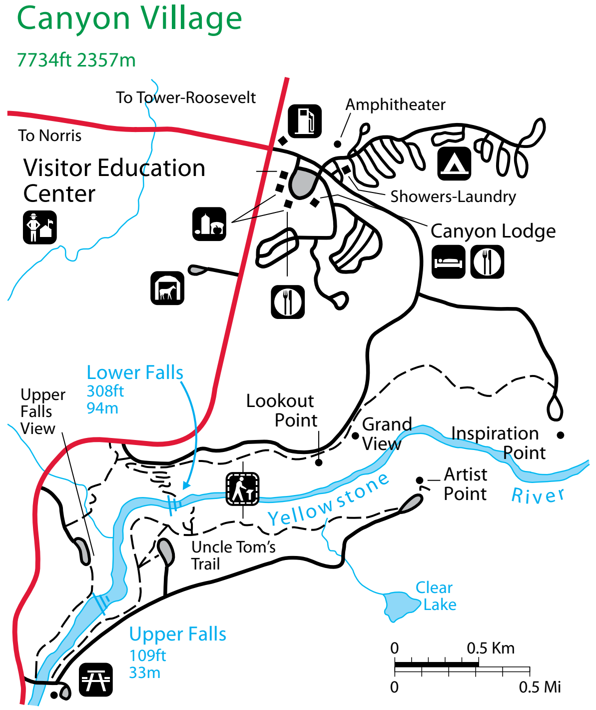
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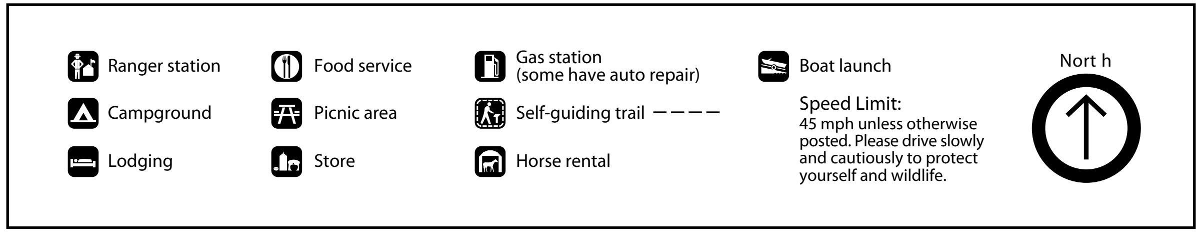
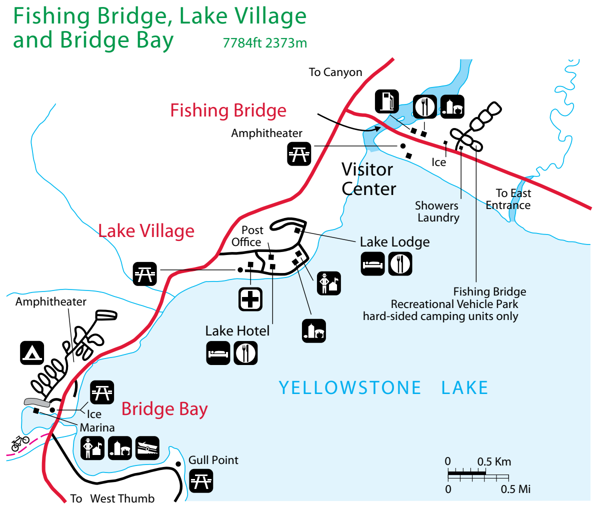

Ranger station
Campground
Lodging
Food service
Picnic area
Store
Gas station (some have auto repair)
Self-guiding trail
Horse rental
Boat launch
Speed Limit:
45 mph unless otherwise posted. Please drive slowly and cautiously to protect yourself and wildlife.
Nort h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Fishing Bridge
Amphitheater
Visitor Center
Ice
Showers Laundry
To East Entrance
Lake Village
Post Office
Lake Lodge
Amphitheater
Fishing Bridge Recreational Vehicle Park hard-sided camping units only
Lake Hotel
YELLOWSTONE LAKE
Bridge Bay
Ice
Marina
Gull Point
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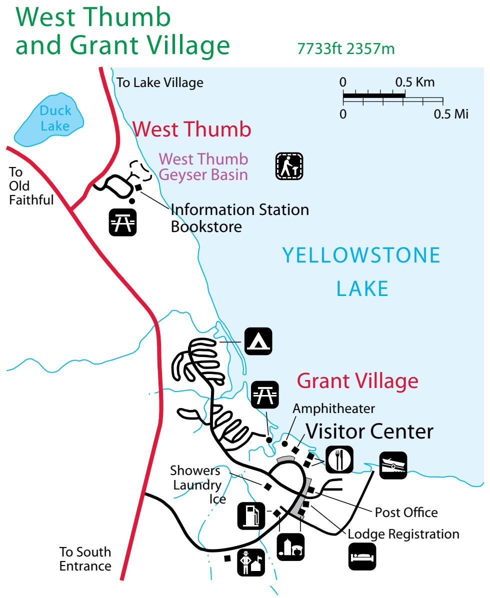
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West Thumb Geyser Basin
To Old Faithful
Information Station Bookstore
YELLOWSTONE LAKE
Grant Village
Amphitheater
Visitor Center
Showers Laundry Ice
Post Office
Lodge Registration
To South Entrance

About Idaho Falls

While retaining its small-town charm, Idaho Falls boasts some of the most beautiful scenery in the West. With an abundance of outdoor recreational opportunities and cultural events at their fingertips, citizens of Idaho Falls are proud to have been ranked 8th in the nation for “hottest small city to live” by Inc. Magazine.

While largely agricultural, Idaho Falls has, among its many highlights, a booming economy with high job-growth rate and the 3rd lowest unemployment rate in the nation. Idaho Falls is the second largest city in Idaho, with a population of 52,730 and an area population of about 125,000. Idaho Falls truly is a great place to live, work, and visit.

Directions to Mountain River Ranch

From University Place: (Inset Map on right - X)

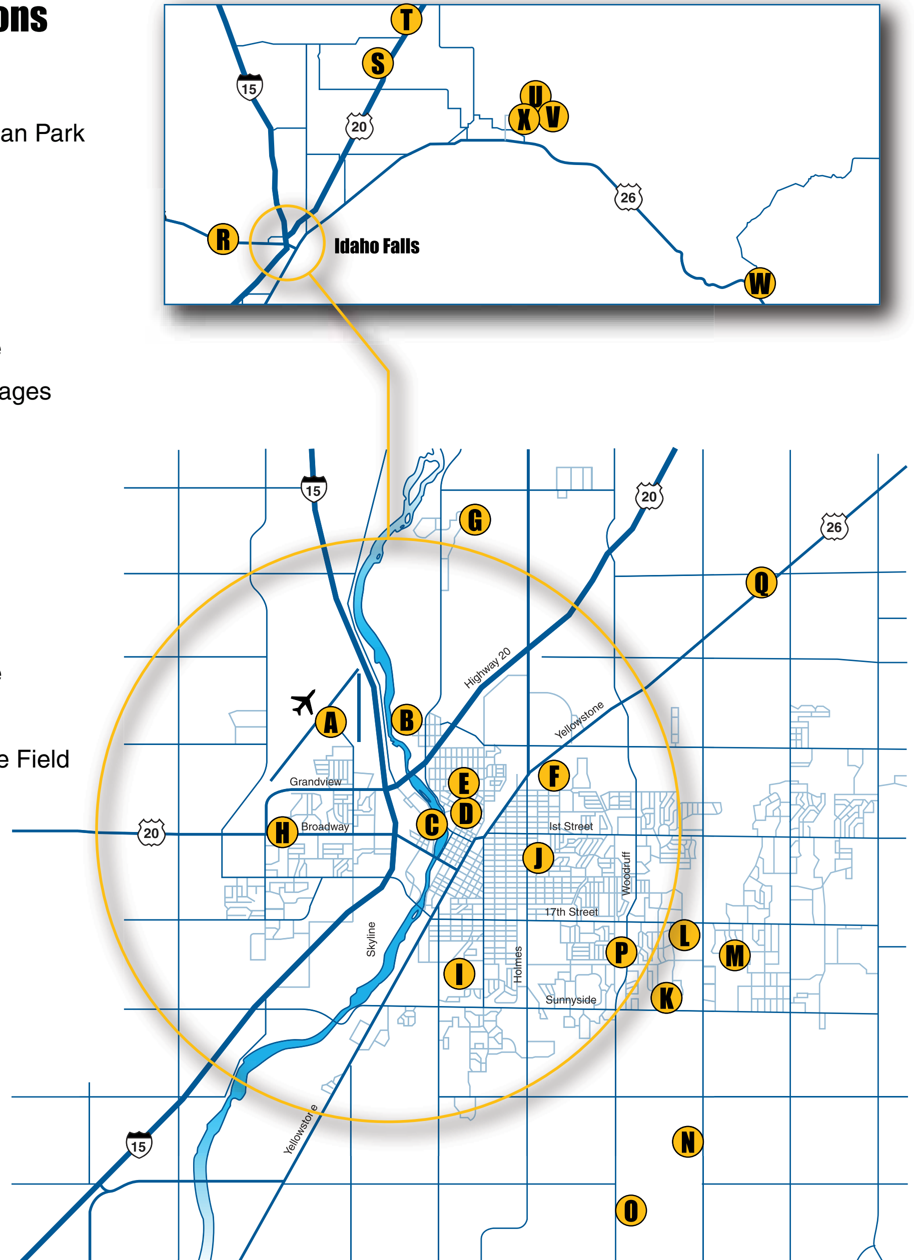
- Take left onto Science Center Drive
- Take a left on N. Yellowstone Highway (US-26 E)
- Follow Highway 26 17.3 miles
- Take a left on N 160 E
- Take a right on Poplar Loop (E 100 N)
- Take a sharp right on N 5050 E
- Mountain River Ranch will be on the right

Idaho Falls Attractions

- A Airport
- B University Place / Freeman Park
- C Snake River Greenbelt
- D Historic Downtown
- E Idaho Falls Chuckars
- F Pinecrest Golf Course
- G Sage Lakes Golf Course
- H Field of Green Batting Cages
- I Tautphus Park Zoo
- J Idaho Falls Mustangs
- K Eastern Idaho Regional Medical Center
- L Grand Teton Mall
- M Ammon
- N Sand Creek Golf Course
- O Sandy Downs
- P G&H Paintball and Game Field
- Q Snake River BMX

Inset Map

- R Noise Park
- S Riot Zone
- T Yellowstone Bear World
- U Heise Hot Springs
- V Kelly Canyon
- W Swan Valley
- X Mountain River Ranch



Local Attractions

Museum of Idaho
General Admission- $6
200 N Eastern Ave. (208) 522-1400
Open Mon-Tues 9am-8pm~ Wed-Sat 9am –5pm

Tautphaus Park Zoo
2725 Carnival Way
Idaho Falls, ID
(208) 612-8552
Adults $4, Children $2

Local Golf Courses:
Pinecrest (208) 612-8485
Sage Lakes (208) 612-8115
Sand Creek (208) 612-8535

10-50 Miles Away

Heise Hot Springs
5116 E. Heise Rd.
Ririe, ID 83443
(208) 538-7312
Adults, $6; Children under 11, $3

Yellowstone Bear World
Located 5 Miles
South of Rexburg, Idaho
on U.S. Hwy 20
(208) 359-9968
Adults: $13.95

Hell's Half Acre National Landmark
I-15 between Blackfoot and Idaho Falls

Teton Flood Museum
51 N. Center Rexburg, ID $2

50-100 Miles Away

Yellowstone National Park
Visitor's Center
Yellowstone National Park, WY 82190
(307) 344-7381

Lava Hot Springs Resort
430 E. Main St.
Lava Hot Springs, ID 83246
Phone: (800) 423-8597

Mesa Falls
In Targhee National Forest
Highway 47
Ashton, ID 83420
(208) 652-7442
Fees: $5 per car
Guided tours available

Harriman State Park
Highway 20
Island Park, ID 83429
(208) 558-7368
Fees: $4 per vehicle
Trails, hiking, fly-fishing

Craters of the Moon National Monument
Highway 20 Arco, ID 83213 (208) 527-3257

Grand Teton National Park
Northwestern Wyoming (307) 739-3300

For more information on area attractions visit: Visitors Information at www.inl.gov

Idaho Falls Restaurants

Grill/Pub

Brownstone Pub and Brewery
455 River Parkway (208) 535-0310

Chili's Grill and Bar
620 N Utah Ave. (208) 552-2577

Applebee's Bar and Gill
635 N Utah Ave (208) 528-8985

Mexican

Jalisco's
325 River Parkway (208) 612-2021

Pachanga's Mexican Restaurant
552 N Capital Ave (208) 522-1976

American

The Snakebite
401 Park Ave. (208) 525-2522

Sandpiper Steak and Seafood House
750 Lindsay Boulevard (208) 524-3344

Outback Steakhouse
970 Lindsay Boulevard (208) 523-9301

Jakers
851 Lindsay Boulevard (208) 524-5240

Smitty's
645 W. Broadway (208) 523-6450

Famous Dave's
245 Houston Circle (208) 523-1712

Italian

Olive Garden
1305 W. Broadway (208) 227-0545

International/Fine Dining

Collage
445 A Street (208) 524-0875

Rutabaga's
415 River Parkway (208) 529-3990

Vino Rosso
439 A Street (208) 525-8466

Whitewater Grill/ Wasabi Japanese Grill
355 River Parkway (208) 523-3355

Asian

Happy's Chinese
549 Park Avenue (208) 522-2091

Ming's
376 Shoup Ave. (208) 523-5707

Thai House
366 Shoup Ave. (208) 529-2754

Community Events

Community Night Out - *Family Activities and Music*
August 11, 2010
6:00 pm (East Greenbelt on Memorial Drive)

EIRMC Snake River Concert - *Swing Shift -Soulful Jazz*
August 11, 2010
7:00 pm (East Greenbelt between D&E Streets)

The Snake River Roaring Youth Jam - *Art Festival*
August 11,12,13 & 14, 2010
10:00 am - 4:00 pm (Greenbelt)

Samba Fogo! - *Live dancing to Brazilian Drumming*
August 12,13 & 14, 2010
7:00 pm (Colonial Theater)

Notes

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ISRCS 2010

09-GA50094