- RESEARCH STATEMENT -

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Fellow, National Academy of Inventors (NAI)
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- National Academy of Inventors (NAI)

### Funding History ($30M over 25 years as PI or Co-PI)

<table>
<thead>
<tr>
<th>Grant</th>
<th>Description</th>
<th>Start</th>
<th>End</th>
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<td>NSF EPSCoR RII Track-2 FEC; OIA 1632891</td>
<td>Probing and Understanding the Brain: Micro and Macro Dynamics of Seizure and Memory Networks (PI)</td>
<td>09/16-08/20</td>
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<td>DoD STTR phase I AF17B-002-0016.</td>
<td>Real-time Enhanced Attention and Alertness via Closed-Loop Transcranial Stimulation (Co-PI)</td>
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<td>DoD (Concept grant)</td>
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<td>Cyberonics Inc.</td>
<td>Characterization of Novel Vagus Nerve Stimulation (VNS) Parameters’ Efficacy, Based on Desynchronization of Brain Dynamics, in Open and Closed-Loop Configurations: A Study in an Animal Model of Chronic Epilepsy (PI)</td>
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Iasemidis L. D., Ph.D.

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<th>Grant</th>
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**RESEARCH FOCUS**

I. Seizure Prediction and Control

**Goal:** Design and implement novel methodology and advanced signal processing techniques to monitor, process and model the electrical and magnetic activity recorded from the brain for the purpose of diagnosis, differential diagnosis, evaluation of treatment, timely warning and intervention to avert catastrophic state transitions like epileptic seizures. To interface the developed products with existing devices in biomedical industry used for monitoring and real-time timely intervention and treatment of the respective disorders, diseases and emergencies, for example via vagus nerve stimulation (VNS), deep brain stimulation (DBS), transcranial magnetic stimulation (TMS), in situ cooling of the brain or in situ administration of medication.

**Significance:** Abrupt disruptions of the normal electrical activity of the brain result into medical conditions that may require immediate treatment. About 1% of the world’s population develops epileptic seizures in a lifetime due to genetic or acquired insults to the brain. Epileptic seizures are manifestations of epilepsy, a devastating brain dynamical disorder. Of the world's ~70 million people with epilepsy, fully 1/3 have seizures that are not controlled by anti-convulsant medication. The field of seizure prediction, in which engineering technologies are used to decode brain signals and search for precursors of impending epileptic seizures, holds great promise to elucidate the dynamical mechanisms underlying the disorder, as well as to enable implantable devices to intervene in time to treat epilepsy. There is currently an explosion of interest in this field in academic centers and medical industry with clinical trials underway to test potential prediction and intervention devices for FDA approval. Therefore, development of algorithms and devices that, based on early detection of precursors to such apparently abrupt episodes, could issue in-time warnings and trigger on-demand interventions is of emerging importance. We are one of the leading research groups in the world in this effort. I first presented results on the predictability of epileptic seizures from analysis of the electroencephalogram (EEG) in 1988 [1]. Over the years, and through our publications and continuous support from NIH and the VA, we have developed the field of epileptic seizure prediction, that has flourished with the collaboration of Neurologists, Bioengineers and scientists from diverse areas like Physics, Mathematics, Chemistry and Statistics (see [2-3] for a review). Results from prospective, real-time, long-term (in the order of tens of minutes) prediction of epileptic seizures have been generated [4-8]. This research provides the answer to the question of “when to intervene”. However, answers to the questions of “how” and “where” to intervene are needed for complete control of these transitions in the brain, and constitute part of our ongoing research effort (real-time on-line seizure prediction and control schemes in computer simulations, animal models and patients), supported by NIH [9], NSF [10], Foundations [11], and
industry [12]. Subsequent implementation of the algorithms into implanted devices in the brain, controlling an actuator (e.g. electromagnetic stimulator or drug release device), is anticipated to provide the bioengineering solution to these medical crises (emergencies).

**Approach:** The foundation of this research is the application of systems and control theory to biological systems and signals. We have used advanced signal processing concepts, like spatio-temporal bifurcations and measures of complexity and stability profiles over time at critical brain sites automatically and adaptively selected by global optimization techniques, to quantify the human and animal brain’s intermittent transitions into and out of epileptic seizures. The generated results have led us to postulate and pursue **three novel hypotheses**. A process we have called “dynamical entrainment” characterizes the convergence of information and rate of information profiles of critical brain sites with the epileptogenic focus over time long before the occurrence of seizures, and it constitutes the basis of our **seizure prediction hypothesis**. Dynamical resetting (disentainment) of the brain sites occurs right after these seizures [13-14]. It is this observation (in rodents and humans) that has led us to the **brain resetting hypothesis** that may explain why seizures occur when they do, and provide some very important insight into schemes for seizure control and understanding of crises (e.g. we have shown that seizures that do not reset the brain may eventually lead to seizure clustering and status epilepticus). According to this hypothesis, seizures occur to reset the pathological situation of entrainment of the dynamics of normal sites with the epileptogenic focus. In this sense, the goal is not to fight seizures but the pathology of dynamics that precedes them. Counter-intuitively, seizures may then be seen as a defense mechanism of the brain, a last resort to counteract the pathology in its function. Accordingly, it is the pathology of the dynamics that develops prior to seizures than the seizures themselves a successful treatment for epilepsy should address. Experimentation with mathematical models of coupled nonlinear and chaotic oscillators [15-16] provided us with clues that we further pursued and tested on EEG data from experiments with rodents. A novel **control scheme** based upon stimulation of the brain by anti-epileptic drugs and/or electromagnetic stimuli at the onset of the dynamical entrainment, that is, long prior to a seizure, as well as upon the level of entrainment of the brain dynamics, has been devised and tested on cortical-cortical and thalamo-cortical neural population simulation models and rodent animal models with excellent results. We have called this new control scheme “**feedback decoupling control**”. The external feedback provided by an actuator disentrains the entrained brain dynamics very efficiently and effectively and “seizures” do not have to and do not occur [17-20].

**Future applications of this line of research** to the following areas are tested and some of them have been already validated: **a)** diagnose epilepsy from interictal periods in an outpatient setting (e.g. identification and localization of the epileptogenic focus [21-23]), **b)** provide differential diagnosis of epilepsy versus other diseases [24-25], **c)** evaluate the treatment of seizures by anti-epileptic drugs, especially in in the emergency room and intensive care unit in the case of **status epilepticus**, a life-threatening condition of epilepsy [26-27], **d)** develop **seizure susceptibility indices** that can help with monitoring the susceptibility of patients to seizures over time, so that patients can be warned on a regular basis to increase or decrease their medication, **e)** develop **biomarkers for SUDEP**, a deadly condition that occurs suddenly and unexpectedly for patients with epilepsy [28].

Publications: This research has enjoyed a lot of publicity in the local and national press (see above). To date, this research has cumulatively generated 46 journal papers, 27 book chapters, 29 conference papers and 83 abstracts of presentations; 5 patents have been awarded.

Patents: This research is protected by the following patents: Seizure warning and prediction (awarded 10/16/01 - US Patent and Trademark Office – No. 6,304,775); Multi-Dimensional Multi-Parameter Time Series Processing for Seizure Warning and Prediction (awarded 08/28/07 - US Patent and Trademark Office – No. 7,263,467); Optimization of Multi-dimensional Time Series Processing for seizure warning and prediction (awarded 05/13/08 - US Patent and Trademark Office – No. 7,373,199); Pacemaker for treating physiological system dysfunction (awarded 06/12/12 – US Patent and Trademark Office No. 8,197,395); System and Method for Identifying a Focal Area of Abnormal Network Interactions in the Brain (awarded 08/15/17 - US Patent and Trademark Office – No. 9,730,628).

Funding: This research has been funded over the years by NIH, VA, NSF, DARPA, not-for-profit organizations (Epilepsy Foundation of America, Whitaker Foundation, Science Foundation Arizona, CURE Foundation), for-profit organizations (Cyberonics Inc.) and seed grants from ASU [5].

References:
Iasemidis L. D., Ph.D.


II. Probing and Understanding the Brain: Micro and Macro Dynamics of Seizure and Memory Networks

**Goal:** In this project, we seek transformative advances in long-term probing and understanding of the brain’s function, in particular the elucidation of the molecular and neurophysiological underpinnings of transitions of brain networks from normal states into crises (e.g. seizures) and the impairment of brain’s higher function (e.g. memory). This Focused EPSCoR Collaborations (FEC) project, supported by NSF’s research infrastructure improvement program, is exceptionally well aligned with NSF’s “Understanding the Brain” initiative focusing on neuroscience and cognitive science, and supports the BRAIN initiative announced by the White House in April 2013. The project is leveraged by the complementary expertise of a consortium of senior and junior investigators in academic and medical settings we have now called NeuroNEM (Neuronal Networks in Epilepsy and Memory), and the complementary resources offered by three partnering institutions: Louisiana Tech University (LA Tech) in Ruston, LA; University of Arkansas for Medical Sciences (UAMS) in Little Rock, AR; and University of Alabama (UAB) in Birmingham, AL. Across all three sites, a total of 18 senior and junior faculty, 6 research faculty, 4 postdoctoral fellows, 10 graduate students, 10 undergraduate students and 40 REU students participate in this project. The project leadership team benefits from a nationally respected team of two external evaluators and one strategic planner/team builder, two consultants at Barrow Neurological Institute, Phoenix Arizona and Cleveland Clinic, Cleveland Ohio, and services of a world renowned Science Advisory Board (Dr. Jose Principe from U. Florida, Dr. Emery Brown from Harvard University, Dr. Nitish Thakor from Johns Hopkins U. and Dr. Bin He from Carnegie Mellon U.).

**Significance:** Epilepsy has been called a window to brain function because a) it impairs different brain functions depending on the location of the epileptogenic focus and its network, and b) it provides a unique opportunity to study the impaired brain’s function over time and space. Despite decades of research into ictogenesis (seizure generation), a common mechanism of the epileptic networks that leads to seizures has yet to emerge. One reason is the short-term study of seizures development (*temporal dimension*), for example, over a few minutes prior, within and after seizure onsets or by sparse sampling of the intervals between seizures (interictal periods). A second reason is the identification of the relevant networks to record from and subsequently analyze (*spatial dimension*). A third reason is inadequacy of the recording methods employed, in vitro or in vivo (*typically unimodal*). A fourth reason is the inadequacy of the employed mathematical methods for analysis of the generated data. In this project, we seek to elucidate seizure generation by establishing a framework that would concurrently address the above shortcomings in innovative ways.

Completion of the scientific goals of the project would significantly advance the state-of-the-art in probing the brain at multiple levels at once and the mathematical study of spontaneous brain transitions to crises, as well as contribute to novel applications in epilepsy. First, the capability to localize the epileptogenic focus and its network interictally, either invasively (iEEG) or noninvasively (MEG), and objectively identify its overlap with higher brain function (memory) networks, will find direct applications to the diagnosis, prognosis and treatment (e.g. surgical intervention) in epilepsy. Second, we expect the developed mathematical algorithms and models to contribute to the development of more reliable prediction of seizures and timely administration of new pharmacological or...
electromagnetic treatments (responsive neuromodulation). Third, these tools could also assist with prediction of transitions in dynamical disorders other than epilepsy (e.g. strokes, migraines, heart attacks and fibrillations). Fourth, the developed monitoring tools of brain function may be utilized to evaluate over time the progression of the disease as well as the treatment's effectiveness. Fifth, the developed novel multimodal recording technology (new electrode materials, configurations and electrochemistry) may lead to significant improvements in implants' life, an Achilles heel in chronic neurochemical monitoring.

Research Approach: The research involves recording and analysis of long-term (days to months) intracranial electro-encephalographic (iEEG) and electrochemical recordings, long-term optical imaging and short-term magnetoencephalographic (MEG) recordings from the brains of 100 rats and 80 patients with epilepsy. In our human studies we employ iEEG and MEG to identify epileptic and memory networks from interictal periods, monitor their dynamical behavior, study their transition to seizures, and investigate the impairment of memory function typically observed in patients with epilepsy. In our animal studies we seek to obtain a more fundamental understanding of the transition to seizures by probing the brain concurrently with novel intracranial electrochemical electrodes to capture neurotransmitter release over time, and optical imaging to capture cell network changes in the epileptogenic focus over time. Novel mathematical methods are applied to the acquired longitudinal signals for mapping the underlying epileptic and memory neural networks and prediction of the transitions to seizures and memory impairment. This multiscale and multimodal project will establish for the first time a bridge between the electrophysiological and neurochemical domains of brain dynamics, and contribute to understanding and control of intermittent crises of brain function.

Thrust Area 1: Electrical Activity (EEG) (Animal & Human Brain) LA Tech, UAB, UAMS
Thrust Area 2: Magnetic Activity (MEG) (Human Brain) UAB, LA Tech
Thrust Area 3: Neurochemistry & Optical Signals (Animal Brain) LA Tech
Thrust Area 4: Memory Function (EEG & MEG) (Human Brain) UAMS, UAB, LA Tech

Project Research Roadmap

The research program is organized in four synergistic thrust areas (TA) with focus areas (FAs) within each TA that address different aspects of the theme of each TA. Within thrust area 1 (TA1), we investigate the dynamics of the electrical activity (iEEG) of the brain before, during, and after crises (seizures) in humans...
and animals. The recording of long-term brain electrical activity in the case of animals is accomplished by conventional (commercially available) as well as novel (in house manufactured) microelectrodes implanted stereotaxically and, in the case of humans, with the assistance of state-of-the-art robotic systems. The magnetic activity (MEG) of the human brain is recorded and analyzed within thrust area 2 (TA2).

Long-term recording of neurotransmitter (glutamate, GABA and dopamine) activity at critical sites in the animal brain is achieved by conventional and in-house developed novel neurochemical microelectrodes within thrust area 3 (TA3). Also in TA3, recently developed novel optical imaging techniques are applied to visualize and evaluate changes in the cellular network (neurons, astrocytes, interneurons and their interconnections) that may occur due to crises occurrence over long time intervals (months). Finally, in TA3, we mathematically analyze our concurrent long-term in vivo recordings of macroscopic (iEEG) and microscopic (neurochemical) signals from the animal epileptic brain towards the development of more reliable and with a longer horizon seizure prediction algorithms. In thrust area 4 (TA4), we investigate the effect the pathology of brain networks may have on higher brain functions. Impairment of different types of memory processes (acquisition, retention and recall) and their MEG and iEEG signature networks in patients with epilepsy constitute the target of these investigations.


Publications: This research has also enjoyed a lot of publicity in the local and national press. To date, it has generated 3 published journal papers, 4 journal papers under review, and 8 conference presentations.


Funding: This research is currently funded by a $6M grant from NSF’s Experimental Program to Stimulate Competitive Research (EPSCoR) as part of its Research Infrastructure Improvement (RII Track-2) Focused EPSCoR Collaborations (FEC) through the Office of Integrative Activities (OIA) grant number 1632891.

RESEARCH IN OTHER AREAS

i) Crises in other than epilepsy dynamical disorders

Brain dynamical disorders other than epilepsy exist and may also be characterized by intermittent neurophysiologic transitions from normal to abnormal states (e.g. stroke, narcolepsy, migraine attacks, abrupt changes in anesthesia, depression). Also, catastrophic cardiovascular transitions (e.g. heart attacks, fibrillation attacks) exist, and every year about 1.1 million Americans suffer a heart attack, out of which 460,000 are fatal. In both areas, the overall goal will be to explore the utility of similar approaches to the ones we have used in epilepsy to further characterize and understand the dynamical mechanisms underlying the involved dynamical transitions, and to possibly develop and test novel and more effective approaches than the existing ones in the diagnostic, prediction and treatment (intervention / control) domains. Our preliminary results about development of biomarkers from the study of brain-heart-respiration interactions in SUDEP, supported by our ongoing grant from CURE (see below) point to this direction.

ii) Genomic Signal Processing

This has been an emerging field for signal processing. We expect that insights and advanced techniques developed from processing of brain signals would be helpful in the analysis of DNA signals. Towards this goal, in 2002, I started a collaboration with Dr. Spanias (Electrical Engineering, ASU) and TGen Inc. (Phoenix) for the application of modern signal processing techniques to the identification of exons and introns of genes in long DNA sequences from prokaryotic and eukaryotic cells. As a result of this collaboration, a MS thesis, a conference proceedings paper, and a journal paper were produced (see below). Entropy-based methods from information theory and nonlinear dynamics (Kolmogorov entropy, Transfer entropy, Lyapunov exponents and Cross-Lyapunov exponents), that are used to characterize our EEG signals, can be implemented to provide enhanced similarity measures between different DNA segments. Along these lines, we envision a project on autism and epilepsy that will involve autistic patients with epilepsy. We expect to investigate the existence of any relation between EEG dynamics of the epileptic brain (e.g. via measures of susceptibility to seizures) to DNA abnormalities found by traditional genome analysis in those patients.


iii) Stroke Rehabilitation/Assistive Technology

Patients who suffer strokes and Parkinson’s disease must undergo extensive physical therapy to relearn use of their limbs. This project was conducted at the Arizona State University. To assist patients with their physical therapy a cutting-edge computerized Mixed Reality Rehabilitation system was utilized in conjunction with recording and analysis of EEG from the subject’s brain for objective evaluation of the therapy and to propose future improvements in the therapy itself. Patients engaged with audiovisual scenes, enabling them to practice physical movements that expedite their recovery. They were positioned in front of a video screen and a set of sound speakers. Sensory equipment tracked their movements in real time and connected them to interactive images and sounds. For instance, patients learned to move their arms efficiently while they were trying to make puzzle-like images converge on the screen.
The image convergence was accompanied by an interactive music composition that helped patients improve the timing of their movement. The system’s digital and physical aspects were algorithmically adapted to each individual patient’s needs and progress. The future goal was to get the Mixed Reality Rehabilitation system into an adaptable, portable low-cost platform that patients can use in their homes. The home system will give the patients freedom to continue their rehabilitation training on their own on a daily basis, between sessions with trained medical professionals. Trained professionals also will be able to remotely monitor a patient’s work with the home system. This can help reduce the number of trips a patient needs to take to a hospital for physical therapy. Not all patients have ready access or transportation to rehabilitation facilities at hospitals, clinics and medical centers to help them recover quickly. This research was at the leading edge of employing virtual-reality technology in medical rehabilitation.


Funding: This research was supported by NSF’s Integrative Graduate Education and Research Traineeship Program (IGERT) on Experiential Media: “Analysis of EEG for evaluation of rehabilitation in stroke patients” (09/05-09/12).

**iv) Traumatic Brain Injury (TBI)**

A great percentage of patients who have suffered severe traumatic brain injury (TBI) develop epilepsy over time. The diagnosis of such a possibility beforehand is extremely difficult and usually delays the treatment with anti-epileptic drug therapy for a long time, probably enough to render it ineffective. Based on nonlinear dynamical analysis of EEG, we have developed specific measures of seizure susceptibility that we will apply to the EEG recorded regularly from patients and rodents after TBI. These measures will be used to predict the development of post-traumatic epilepsy in specific individuals. Identification of those candidates long before the appearance of any clinical symptoms will allow for a timely intervention and treatment, and probably early seizure control and therapy.

Funding: This research was supported by the DoD grant: “A new quantitative EEG technique for prediction of post-traumatic epilepsy (PTE) in individual subjects after traumatic brain injury (TBI)” (Dept. of Defense - Concept grant).

**v) Normal Brain**

Normal brain does not experience seizures without external stimulation. According to our findings from the epileptic brain, and since seizures do not occur spontaneously in the normal brain, the normal brain itself should be able to reset any observed entrainment of dynamics fast and without need of any seizure occurrences. It is very reasonable to assume that communication inside the normal brain occurs via instantaneous dynamical synchronization (or dynamical entrainment) of pertinent cortical sites (this synchronization should last for a very short time so that the involved sites can then participate in other tasks). We hypothesize that this can occur only if the feedback circuits for desynchronization of dynamics of the involved sites do operate properly. We will be able to test this hypothesis within the framework of the recent grant we were awarded from DoD (see below). We expect that analysis of EEG in normal subjects would reveal entrainment of their brain dynamics accompanied by fast disentrainment. Taken together, these results would signify that the degree of resetting for the normal brain would be much higher than the epileptic one.

Funding: Real-time Enhanced Attention and Alertness via Closed-Loop Transcranial Stimulation (10/17-07/18), Phase I, DoD STTR grant with Teledyne Scientific, Universal Technology Corporation (UTC), and Advanced Brain Monitoring (ABM), AF17B-002-0016.
INFRASTRUCTURE

A. THE BRAIN DYNAMICS LABORATORY (BDL)

A research recording and computational facility for investigations in the dynamics of electrical (EEG) and magnetic (MEG) signals recorded from the surface or interior of the human and animal brain, as well as from simulations of coupled, spatially extended physical systems. The Lab is also used as a resource in the teaching of undergraduate and graduate courses in biomedical signal processing. The recording facility of the Lab is located on the 1st floor of the Biomedical Engineering Building (BMEB) and consists of two separate rooms: one room (400 sq. ft.) is used for EEG recording and cognition experiments with human subjects and the other one (200 sq. ft.) for recording from rodents. The computational facility of BDL (800 sq. ft.) is hosted on the recently renovated 3rd floor of BMEB. The BMEB is a 52,000-square foot building completed 10 years ago that houses core facilities, research labs, two classrooms, meeting rooms and faculty offices.

Equipment.

Data acquisition: The animal EEG recording facility of BDL allows for individual housing and free range of motion video/EEG monitoring for up to 8 rats. It includes low light video cameras, video multiplexers, commutator wiring systems and Plexiglas cages. The available System 3, Tucker-Davis Technologies, Inc. EEG recording system, with Z-Series RZ5D Processor, PZ5 Low Impedance Preamplifier, PO5e Optical Gigabit High Speed Interface, and Synapse Software, provides 8 isolated amplifiers and allows for continuous and simultaneous recordings from up to 8 rats and a total of 128 channels at high sampling rate per channel (50KHz). It includes head stages, 8 commutators, analog-to-digital converter, digital filters and workstation. Notably, it can place time stamps working with different recording modalities, e.g. EEG and electrochemical sensing and optical image data. The facility is in close proximity to 3 small animal surgery core facilities of BMEB for implantation of intracranial EEG electrodes, and the animal behavioral testing lab with Morris Water Maze equipment. The human EEG recording facility of BDL is equipped with two clinical grade 26 channel EEG machines by Nihon Kohden and one evoked potential dense EEG system by EGI (Model: 2009-0035).

Rat Epilepsy Monitoring Unit (EMU): (a) Plexiglass cage with commutator wiring systems allowing free range of motion and free access to food and water within the cage during 3-month EEG monitoring. (b) Close-up view of rat head-piece for intracranial EEG recording.
A happy graduate student at BDL with EEG recording and analysis via GPDC (Generalized Partial Directed Coherence)

Analysis of MEG

Data storage and communication power: For temporary data storage we use a Synology Network Attached Storage (NAS) disk station with four drives of 10 TB each. It is configured with Mirror RAID (so the usable space is 20TB). For permanent storage there is a custom-made Microway 4U high performance computer server / data server with 128 GB memory, Intel Xeon E5-2690 v4 Broadwel-EP processor (CPU), speed of 2.60 GHz and fourteen cores. The 4U size chassis has space for 60 bays. We currently use 32 bays with 8TB hard drives (total of 256 TB disk space) at RAID 60 configuration. It is connected to a 10 GB dual internet port and mapped to the user computers at remote sites through secure file transfer protocol (sftp). Four 10 Gbit/sec small form-factor pluggable (SFP) long range optical transceivers are used to connect to the network.

Computation Power: The computational facility has dedicated computing power with five 2.53 GHz Quad-core Intel Xeon E5630 (Dell; 12GB DDR3 memory, 320GB hard drive) and five 2.2 GHz Dodeca-core E5-2650v4 (Microway Xeon WhisperStations; 128GB DDR4 memory, 4TB Raid and 525 GB SSD hard drive, GeForce GT 730 CUDA cores 384 graphic card) computer stations in a Gigabit LAN configuration, with ultra-fast Internet connection and protected by firewall. Laplink software provides the capability to dial-in and work from remote locations. There are presently 1 digital camera, 2 color laser printers and 15 large digital media storage units (external hard drives with capacities 500GB-2TB). The Lab has access to the Louisiana Optical Network Initiative (LONI). The LONI is a statewide environment that integrates and aggregates Louisiana’s considerable strength that is distributed across its universities and industries. It provides 2 high performance computing clusters interconnected via the LONI fiber backbone and dedicated to furthering the efforts of researchers throughout Louisiana.

Software. The computational algorithms include conventional signal processing techniques and software (ARMA and linear filters, principal components, time-frequency and wavelet transforms, Kalman filtering, independent component analysis / blind source decomposition), as well as novel ones developed in house (machine learning, global optimization, nonlinear modeling, measures of stability and complexity, network directional connectivity analysis and centrality measures from graph theory, Gabor entropy, Multivariate Matching Pursuit decomposition). Python, MATLAB, Mathematica, MathCad, Labview, C/C++, Fortran are the programming languages currently used. The Lab has been particularly successful in the modeling, prediction and control of epileptic seizures, as well as in the development of novel measures of nonlinear dynamics to quantify and decode the information transfer in the brain.

Personnel / Collaborators. BDL employees currently include 1 postdoctoral fellow, 4 PhD graduate students, 1 MS graduate student and 4 undergraduate students from the departments of Biomedical Engineering, Computer Science and Mathematics. BDL enjoys a national and international reputation in epilepsy research and collaborates with brain researchers regionally, nationally and internationally. We currently collaborate very closely with the Laboratory for Translational Research at Barrow Neurological Institute (BNI) in Phoenix, AZ (Dr. David Treiman, Neurology). We also collaborate with Drs. Sandip Pati, Jerzy Szaflarski, Roy Martin and Timothy Gawne at the U. of Alabama, Birmingham, Neurology, Clinical Psychology and Physics.
departments for the analysis of EEG signals recorded at their Epilepsy Monitoring Unit (EMU) with multiple (up to 128) depth (intracranial) EEG electrodes, and of MEG signals recorded with 300 MEG sensors in their MEG unit from epilepsy patients in the resting state and during memory experiments. We collaborate with Drs. Linda Larson-Prior, Jennifer Kleiner Fausett and Jennifer Gess in the department of Psychiatry at the U. Arkansas in the analysis of EEG under similar conditions. We also collaborate with Drs. Hai Sun, Charles Fox and Ed Glasscock at our closest medical school, Louisiana State University’s in Shreveport, in the areas of depth of anaesthesia, sudden and unexpected death in epilepsy (SUDEP), and neurosurgery. We have an ongoing close collaboration with Dr. Andreas Alexopoulos and Dr. Balu Krishnan (Neurology) at Cleveland Clinic on epilepsy and MEG. International collaborators include investigators in Greece, Czech Republic, Austria, Holland, Belgium, China and India (see more details on BDL’s collaborators in my CV).
The Center for Biomedical Engineering and Rehabilitation Science (CBERS) was established in 1985 and since then has been identified as a Center of Excellence at Louisiana Tech University by the Louisiana State Legislature, and more recently by the University of Louisiana System in a review of all its colleges and universities. The Center exists to develop and promote fundamental and translational biomedical research, develop intellectual property, strong ties with biotechnology and medical industry, and strengthen the educational experience and potential of our engineering and science students in biosciences. Through its mission and vision, CBERS is bound to make a significant contribution to the economic development of the State of Louisiana.

The Center has its own facilities (research space and equipment) in the Biomedical Engineering Building (BMEB). More than 30 faculty members across departments at Louisiana Tech are CBERS members as well as 7 faculty members are adjunct members from outside campus (e.g. Louisiana State University’s medical school in Shreveport and the University of Louisiana at Monroe). CBERS members come from different disciplines and schools, for example, Biomedical Engineering, Electrical Engineering, Mechanical Engineering, Chemical Engineering, Biology, Statistics, Physics, Computer Science, and are actively involved in biomedical research. The Center’s budget includes the operational budget as well as undergraduate and graduate student research awards, reimbursement for student presentations at conferences, sponsoring of events, organization of conferences. An important function of CBERS is fundraising for biomedical research at Louisiana Tech.

The Center is actively engaged in all major fields of biomedical research across all disciplines of engineering and science. CBERS faculty are internationally acclaimed for the interdisciplinary biomedical research they conduct in the broad fields of Neural Engineering and Neuroscience, BioMEMS and Nanobiotechnology. Research laboratories to further support and enhance these efforts have been built in the thrust areas of biosignal and bioimage acquisition and processing, computer modeling and neural networks, biosensors, drug delivery, cell culture and tissue engineering, cancer detection, stem cells and gene technology. The Center promotes faculty’s entrepreneurial activities and has established and continues to pursue research partnerships with academic institutions, medical centers and industry regionally, nationally and internationally. CBERS research sponsors include the Whitaker Foundation, State of Louisiana, NSF, NIH, AFOSR, VA, and the US Department of Education.

CBERS is housed in the 50,000 sq. ft. Biomedical Engineering Building (BMEB). The building encompasses staff and administrative offices, lecture halls and teaching laboratories, core and individual faculty research laboratories with a wide range of state-of-the-art and clinical-grade equipment. A 5,500sqft of electronically controlled access space at BMEB is dedicated to first class animal research facilities with three surgical suites, animal housing, autoclave and storage rooms, as well as tissue and bacterial culture laboratories with CO2 incubators, biological safety II cabinets and filtered air transfer hoods.

Last but not least, CBERS provides unique opportunities for faculty and students throughout the university to participate in a multitude of related educational and research outreach activities and programs the Center organizes. For more information on the Center’s activities, visit www.latech.edu/coes/cbers.