

# Understanding the Brain via a Hybrid Data Science & Neuroscience Research Traineeship Program

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## Description of the problem to be addressed, including its importance to the state of Alabama and how it is generalizable to other states, the U.S. and the world:

Understanding the human brain is critical to many fields in Medical and Human-Behavioral Sciences. Neuroscientists strive to understand the intricacies of the brains of patients suffering from neural, cognitive and physical disorders/impairments in order to create medical innovations that can improve patients' quality of life. At the same time, human-behavioral scientists are faced with the need to understand the neurological phenomena that govern people's behaviors when performing day-to-day tasks, such as driving, browsing the web or operating a computer, in order to improve user experience, safety and online security/privacy. Unfortunately, neuroscientists usually do not have formal training to fully automate their methodologies and data collection procedures and to analyze the large-and-complex neural datasets, while behavioral scientists typically lack formal background in cognitive and neuroscientific principles that limit their capability to design their experiments based on such principles and interpret the resulting neurological data. This situation significantly hampers the scientific advancement in both medical and human-centered computing fields.

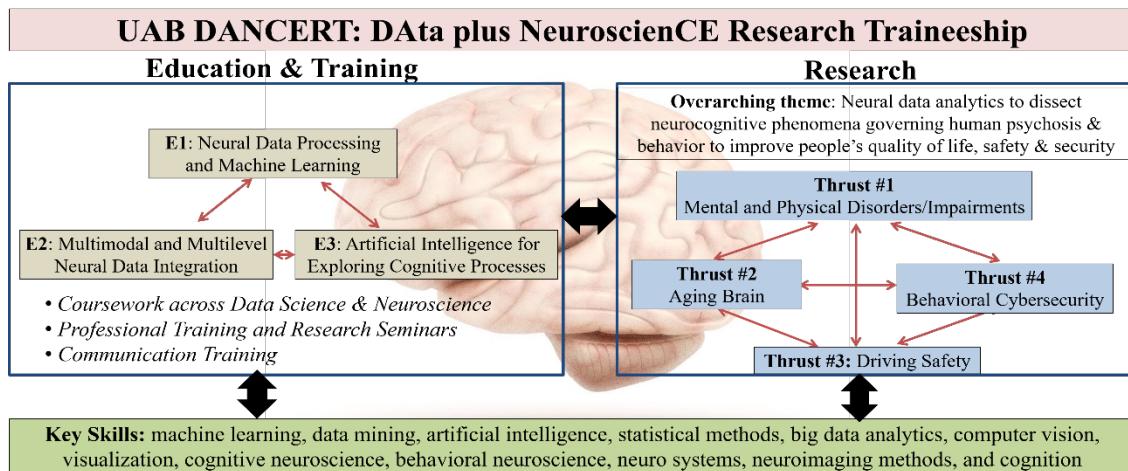


Figure 1: A high level depiction of the proposed program

This UAB “grand challenge” proposal launches DANCERT (Figure 1), a unique research traineeship program that will prepare a scientific workforce which is *fully-equipped to simultaneously handle the neuroscience and data science challenges* towards a rapid advancement in medical and human-behavioral computing domains. On one end, the program will formally train students pursuing traditional neuroscience and related degrees in fundamental data science topics including *data mining, big data analytics and machine learning*, and on the other end, it will formally train students pursuing data/computer science degrees in fundamental neuroscience topics including *cognitive and behavioral neuroscience, neuro systems and neuroimaging methods*. This cross-pollination of expertise from both fields will harness the data revolution and enable the participants to solve their respective research problems in a principled, systematic and self-sustained manner. *The program builds on UAB’s well-established strengths in medical science*

*and neuroscience as well as in computer and data science.* The program will support many research projects of national importance led by DANCERT scientists, including research in neuropsychiatric and neurodevelopmental disorders (e.g., autism spectrum disorders), neuromusculoskeletal control, neural plasticity, driving safety and behavioral cybersecurity. It will also serve to bootstrap new research projects at the intersection of the two scientific domains central to the program.

Our vision and thematic basis is well-aligned with a workshop on the Research Interfaces between Brain Science and Computer/Data Science, hosted by NSF and CCC (Computing Community Consortium) in 2014. The program is also well-aligned with the former President Obama's BRAIN initiative. It is clear that it would have impact not only at UAB and the state of Alabama but also globally, since it centers on people's health, well-being and safety/security.

**Desired outcomes and the conceptualization of the plan of work to achieve them:**

The primary *merits*, *outcomes* and *highlights* of the program are as follows:

1. **Unique Interdisciplinary Training:** Trained via a strong curriculum in Data Science, Psychology and Neuroscience as well as focused professional, entrepreneurial and communications paradigms, the program graduates will possess skills vital to solving challenging problems at the intersection of these disciplines in a scientifically sound fashion, and be fully prepared for long-term academic or industrial careers in these domains.
2. **Well-Integrated Research Thrusts:** Equipped with the above interdisciplinary training, the program graduates will pursue cutting-edge, high-impact projects categorized under four major research thrusts towards "*harnessing the data revolution*": (1) *mental and physical disorders/impairments*, (2) *the aging brain*, (3) *driving safety*, and (4) *behavioral cybersecurity*. The research in these thrusts is potentially transformative as it attempts to solve real-world problems with a novel approach combining data science and neuroscience. The problems addressed are of national importance as they impact people's overall health, safety and online security. These thrusts are also well integrated with one another and build upon the team's existing capabilities in related areas.
3. **Minority Recruitment and Retention:** The program will attract students from minority populations and retain them (e.g., collaborating with UAB's Office for Diversity, Equity and Inclusion [UAB-DEI], UAB's NIH NINDS Neuroscience Roadmap Scholars program [UAB-RMS] and Historically Black Colleges and Universities (HBCUs) in Alabama and nearby states). Many of our existing programs already have a strong track record at recruiting and retaining minorities. In addition, we will collaborate with an *NSF INCLUDES* site at UC Irvine, aimed at promoting participation and success of women in technology areas.
4. **Rigorous Evaluation and Continuous Improvement:** The program will be rigorously evaluated and continuously improved following a formative and summative evaluation strategy.

The project's biggest broader impact lies in *advancing research on understanding the brain to improve people's mental and physical health, their driving safety and their online security* by means of a *growing workforce of hybrid data science/neuroscience professionals* trained through the program. These graduates will develop a creative mindset and curiosity to be continuous learners, so their skills can evolve as the disciplines themselves evolve, ensuring that both their employers and these graduates have long-term benefits.

## **List of potential team members (individuals and organizations) from inside and outside UAB**

**Table 1: UAB DANCERT Core Team**

<b>PI</b>	Nitesh Saxena (CS)
<b>Co-PIs</b>	Rajesh Kana (Psychology); Kristina Visscher (Neurobiology); Chengcui Zhang (CS); and Yuliang Zheng (CS)
<b>Senior Personnel</b>	David Brown (Physical Therapy); Despina Stavrinou (Psychology); Lori McMahon (Graduate School, and Cell, Developmental and Integrative Biology); and Da Yan (CS)
<b>External Evaluator</b>	Jeffery Carver (CS, University of Alabama-UA)

Leading the effort is *Nitesh Saxena*, an established researcher and educator in Computer Science. Saxena has significant prior experience developing and administering educational/traineeship programs in Computer Science, especially those cutting across Computer Science and other disciplines. In particular, he is the director of UAB's recently funded *NSF Scholarship for Service (SFS)* program (a unique collaboration between Computer Science and Criminal Justice) and a director of UAB's MS CFSM (Computer Forensics and Security Management) program (a collaboration between Computer Science, Criminal Justice, and Management). Formerly, he was the principal architect and a co-director of a highly successful MS program in cybersecurity at the NYU's School of Engineering, and had been actively involved with *NYU's SFS and inter-disciplinary NSF IGERT* programs as a senior person. Although a Computer Scientist by formal training, Saxena has established a collaborative relationship with the Neuroscience community, in part based on his pioneering and transformative work applying Neuroscience principles to the field of cybersecurity leading to an *award winning paper* [Neupane et al, NDSS, 2014] and an NIJ fellowship award. *Neuroscience-inspired* cybersecurity is one of DANCERT's core research thrusts.

DANCERT Co-PIs are *Rajesh Kana, Kristina Visscher, Chengcui Zhang* and *Yuliang Zheng*. Kana is a faculty member in Psychology, a renowned expert in Neuroscience and a co-director of the UAB's Undergraduate Neuroscience Program. Visscher is a leading faculty in Neurobiology working on Neuroscience, and the director of UAB's Visual Brain Core, an initiative to help produce cutting edge research examining the visual brain. Zhang is a data science expert and the CS graduate (MS+PhD) program director, and has been developing inter-disciplinary graduate programs, including the MS Data Science (collaboration between Computer Science and Management) being launched Fall 2018. Finally, Zheng is the Chair of CS and a well-known Computer Science expert with research in cybersecurity and data science, having notable prior experience co-leading many prominent educational programs (including current UAB SFS program and the past SFS programs at UNC Charlotte).

The DANCERT team also includes core senior personnel who are CS, Psychology, Physical Therapy (Rehabilitation Science), and Cell, Developmental and Integrative Biology faculty members (Table 1), whose research and teaching has a significant focus on Neuroscience/Data Science. *Lori McMahon* is also the Dean of UAB's Grad School. *Jeffery Carver*, Computer Science faculty member of University of Alabama (UA), will be leading the responsibility for the evaluation of DANCERT. DANCERT's executive and planning committee is supported by members from *top-level UAB administration*, and DANCERT's *external advisory board* includes directors of *Neuroengineering IGERT programs* from two top-tier universities (UIUC and UMN) and a former *NSF SFS program director*.