UNC Charlotte R1 Commission Call for Nominations:
Areas of Research and Scholarship Excellence

Title of the Area: Artificial Intelligence

List of Participating Disciplines, Academic Units and Departments:

1. College of Computing and Informatics: Department of Computer Science; Department of Software and Information Systems; Department of Bioinformatics and Genomics
2. College of Engineering: Department of Electrical & Computer Engineering, Department of Mechanical Engineering and Engineering Science
3. College of Health and Human Services: Department of Kinesiology
4. College of Liberal Arts and Sciences: Department of Political Science and Public Administration; Department of Psychological Science; Department of Communication Studies

Names of individuals leading the effort (in alphabetical order):

Srinivas Akella, Professor
Department of Computer Science

Samira Shaikh, Assistant Professor of Cognitive Science
Department of Computer Science and Psychological Science, School of Data Science

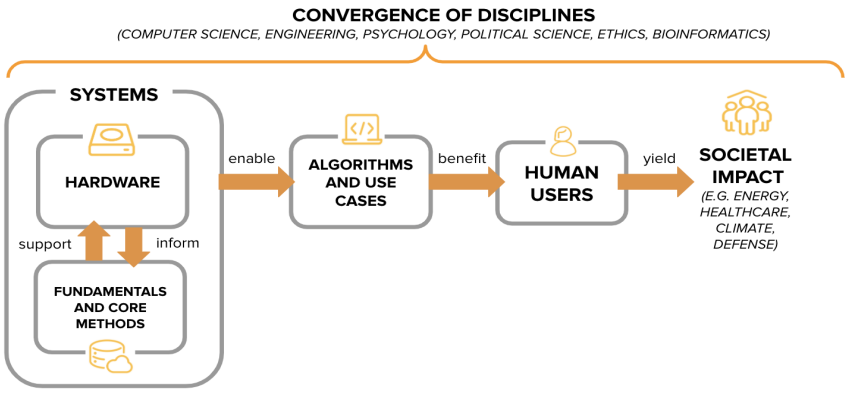
Andrew Willis, Associate Professor, EE Associate Chair, Director of Undergraduate Programs
Department of Electrical and Computer Engineering.

Target Category: Future Opportunity and Investment

Keywords (up to five): *machine learning, autonomous systems, human-assistive AI, high performance AI, ethical AI*

Executive Summary

We support UNC Charlotte's mission towards achieving R1 status by establishing the ***thematic area of* Artificial Intelligence** and Machine Learning, broadly construed, as an ***Area of Excellence for Future Opportunity and Investment***. Recent years have seen Artificial Intelligence (AI) impact almost every area of our lives from finance to medicine to consumer electronics. These AI-driven innovations translate into a global market that is expected to exceed $700 billion by 2027. Society faces a future where intelligent machines perform difficult tasks, interfacing and collaborating with humans, and augmenting human capabilities. This future presents tremendous opportunities. At the same time, it presents risks that we must manage, including those to privacy, security, ethics and fairness. Addressing these pressing opportunities and risks effectively requires a convergence of disciplines and perspectives. Our goal is to capitalize on our prior successes and invigorate our collective efforts under the broad umbrella of Artificial Intelligence. This broad theme necessarily encompasses a multitude of disciplines, and brings them together into a cohesive whole, with the common purpose of AI to improve human life.



The figure above highlights our core approach. Our team members have the expertise to design and leverage innovative computing **hardware** informed by and optimized for the **fundamental principles and algorithms** of AI. These AI tools will augment and serve **human users** by enabling them to interact with and leverage AI systems using intuitive visualization and interaction in order to solve real-world problems with **societal impact** in domains such as healthcare, climate change, and future of work. Traditionally, these different fields have been siloed and the organizational structures at UNC Charlotte reflect that reality. Our goal with this proposal is to bring together all these actors to form more tightly connected teams that will engage in cutting-edge research and education that leverages our unique strengths and expertise. The key distinguishing aspects of this consortium for the ***Area of Excellence for Future Opportunity and Investment*** are that we bring together (1) a broad coalition of researchers from multiple disciplines with (2) a vision towards gaining prominence by aligning our goals with national, state, regional and UNC Charlotte priorities, while leveraging (3) a substantive record of sustained success. As evidence of our **track record of success**, our team of AI researchers has received over $40M in funding (in the past 5 years alone) and published over 1000 papers in high impact venues and journals. The faculty listed in this proposal are well-positioned to enhance existing as well as emerging education programs to train the next generation of scholars and tech workers in AI, through our continued mentorship of graduate students, towards positive societal impact. Our vision with this area of excellence proposal is to make progress on the several short- and long-term goals outlined in the next sections to catapult UNC Charlotte towards recognition as an R1 research institution.

Evidence of Strength and Excellence

UNC Charlotte is poised to develop a comprehensive approach to make breakthroughs in AI research. This involves **building on our expertise and excellence** in all components to achieve excellence in AI technologies. This is evident from the strengths of our AI faculty in these ***foundational areas*** (with a few representative faculty names listed in each area):

1. **Machine Learning:** (Bunescu, Holleman, Terejanu, Chen, Krishnan, Lee, Rooshenas) Our faculty are actively developing fundamental machine learning (ML) and data mining methods including reinforcement learning, energy-based methods, and deep learning.

2. **Autonomous Systems:** (Akella, Arafa, Conrad, J. Fan, Ghasemi, Maity, Shin, Wang, Willis, Wolek) An autonomous agent must perceive its environment using computer vision and act purposefully to effect physical changes. Our faculty have expertise in object tracking, semantic and 3D scene understanding, federated learning, robot motion planning and control, multiple robot coordination, and embedded AI.

3. **Human-Assistive AI:** (Bunescu, Levens, Lu, Ras, Shaikh, Windett, Zadrozny) AI techniques such as natural language processing (NLP) and visualization combined with human-computer interaction (HCI) techniques including augmented reality (AR) and virtual reality (VR) will augment human capability by enabling people to interact naturally and leverage AI systems intuitively and transparently.

4. **High Performance AI:** (Dai, Saule, Tabkhi, Yan) High-performance and efficient systems create new AI use cases. We have the expertise to design and leverage current and emerging computing hardware, and make performant systems easily programmable to deploy our fundamental machine learning and AI methods.

5. **Ethical, Explainable, and Trustworthy AI:** (J. Fan, L. Fan, Gallicano) Data privacy research protects sensitive data. Diversity and inequity issues for under-represented and under-served groups are addressed by improving data representation and fairness in AI and ML. Deepfake detectors assess the integrity of digital content and automatically detect falsified images or videos in real time to provide trustworthy information.

The AI research strength of our team can also be seen from its funding and publication activity in the adjoining table. Two of our faculty (Chen, J. Fan) have been recognized by Stanford University as being among the top 2% of the world's most-cited researchers. Four of our faculty (Akella, Lu, Saule, Yan) are CAREER award winners and one (Zadrozny) is an AAAI Feigenbaum Awardee. Faculty have won conference best paper awards (Lee, Park, Tabkhi, Wang) and received college teaching excellence awards (Ahmed, Akella, Dorodchi, Shin, Willis). Two are involved in entrepreneurial activity (Parkhideh: Sinewatts, Holleman: Syntiant). We have received a US DoEd GAANN Fellowship

Total Submitted Funding (as PI or co-PI)	> $310 MM (past 5 years)
Total Awards (as PI or co-PI)	> $40 MM (past 5 years)
Total Journal Publications	Over 330
Total Conference Publications	Over 750
Total Citation Count	Over 32000
H-index	*M=16.9, Stdev=8.9*

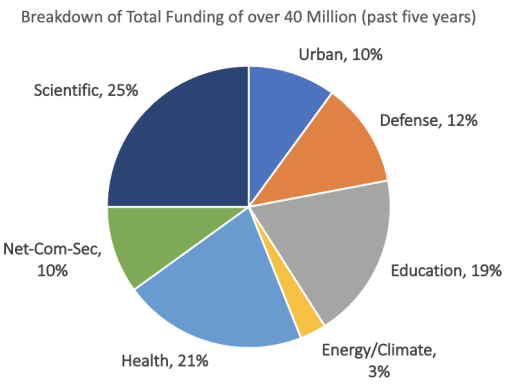
Award ($746K) to support PhD students in Artificial Intelligence and Cybersecurity. Collectively, the faculty involved in this effort currently advise 84 PhD students, have graduated 48 PhDs, and have graduated 182 MS students with thesis (and also have advised hundreds of MS students on non-thesis research projects). Our alumni are employed at leading AI companies such as Amazon, Facebook, and Google.

Regional Partnerships: We have funded AI collaborations with regional partners such as the Electric Power Research Institute (EPRI, Shin: visual detection of cracks in nuclear reactors), and RTI International along with NC DOT and NC SHP (Akella: collision scene reconstruction using drones). We collaborate with Atrium Health and have submitted proposals to NSF/NIH smart health programs (Wang: cognitive AI assistants for nurses and precision patient monitoring via deep radar sensing). We have collaborations with Wake Forest University Health Sciences and Duke University Medical Center (Ge: ML to improve intensity modulated radiation therapy) and medical device companies (Holleman: Ambulatory EEG with NeuroDyne). We participate in Discovery Place's AI exhibit, and several alumni work at Duke Energy Optimist Hall.
National Partnerships: We have funded collaborations with Idaho National Lab (Wang: deep learning for biometric security), Intel (Wang: distributed and federated deep learning technologies over wireless edge devices), and Dept. of Energy's Oak Ridge National Lab and Dept. of Defense's Army Research Laboratory (Parkhideh: intelligent DC-AC and DC-DC power converters, reliability and time-to-failure prediction for power grid components).

This proposal necessarily presents only a snapshot of the breadth and impact of our faculty research in AI. As AI continues to result in transformative discoveries and reshape the landscape of multiple disciplines, not only in STEM but more crucially in non-STEM disciplines, it is crucial to emphasize inter-disciplinary research and education. As AI is deployed in service of not only rote, repetitive tasks but more synergistic tasks with humans, we need expertise that spans not only foundational areas of AI but also the use of AI, in grappling with the ethical, legal and social issues associated with technology. As representative examples of ***broad social impacts and convergence of disciplines***, we highlight two grants received by members of this team from the inaugural NSF Convergence Accelerator program. One of these projects used AI to create a tool for citizens to become deeply engaged and informed of the mechanisms of their governing institutions and the other uses AI to improve the recruitment and training for firefighters and nurses and bridge them with more STEM skills needed for future technologies

Use of Additional Resources: Our goal is to build a ***cohesive AI community*** for incubating fundamental research as well as use-inspired technologies by actively promoting collaboration internally among the members and externally with industrial partners. Building on the strong track record of researchers in these areas, many of whom are already actively collaborating, this AI initiative will bring all these actors together to form a more tightly connected team. To build a strong collaborative research culture, break down disciplinary silos, and serve as the campus hub for AI, ***we propose to develop a virtual AI Institute.*** This will be achieved through biweekly AI seminars, informal proposal brainstorming sessions, and small seed grants. ***Our eventual goal is to create an AI Institute at UNCC***, to be established with NSF and industry support.

Alignment with Regional and National Priorities



Our foundational AI research and application domains are well-aligned with federal AI priorities outlined in the *National AI R&D Strategic Plan: 2019 Update* [1] and DARPA's $2 billion *AI Next Wave* campaign [2]. They match the Computing Community Consortium Roadmap for AI Research [3] and recommendations of the President's Council of Advisors for Science and Technology [4]. NSF invests over $500 million annually on AI [5]. Two of NSF's Big Ideas [6] focused on AI have led to the *Harnessing the Data Revolution* [7] and *Future of Work at the Human-Technology Frontier* [8] programs (where we received $1.5M). **One of our key objectives is to identify a focus area for our collaborative efforts and develop a successful proposal for the NSF *National AI Research Institutes* program** [9]. Our research, as illustrated below, aligns well with UNC Charlotte's strategic goals of (a) Powering the future through research and creative discovery, and (b) Driving progress for the region, state, nation and world, and addressing critical areas of societal importance.

Healthcare: Monitoring social interactions of stroke patients using computer vision (NIH, $2.8M). Monitoring COVID-19 pandemic via wastewater sampling optimization strategies. Applying AI to improve radiation therapy treatment planning (NIH, $848K).

Scientific Discovery: Developing computer vision software to track insects and understand their behavior (NSF, $1.6M), and techniques to optimize sparse linear algebra kernels for nuclear physics, fluid mechanics, and academic network analysis (NSF, $500K).

Energy and Climate Change: Developing automated crack detection in nuclear reactors (EPRI, $337K), and AI to improve smart grid power converter reliability (DOE, $200K).

Networking, Computing and Cybersecurity: Developing multi-hop federated deep learning infrastructure (NSF, $670K), and UAV swarms for on-demand edge computing (NSF, $333K). Using NLP to understand cyber and electronic warfare (ONR, $150K), and personalized agents to counter social engineering attacks (DARPA, $1.2M).

Personalized Education and Lifelong Learning: Developing AI-enabled AR/VR gaming and behavior modeling for innovative education of nurses and first responders (NSF $2.5M).

Urban Science/Smart City: Developing intelligent camera network to improve pedestrian safety while protecting privacy with real-time edge computing (NSF, $1.9M).

Defense: Developing algorithms for robot swarms to perform urban coverage (DARPA, $431K), and UAVs to inspect critical infrastructure (power lines) after disasters (NSF, $266K).

References

[1] https://www.nitrd.gov/news/National-AI-RD-Strategy-2019.aspx
[2] https://www.darpa.mil/work-with-us/ai-next-campaign
[3] https://cccblog.org/2019/08/07/a-20-year-community-roadmap-for-ai-research-in-the-us-is-released/
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[9] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505686

Supporting Documents

Name	Title	Dept.	Contribution or Expertise
Dewan Ahmed	Teach. Assoc. Prof.	CS	ML to predict student educational outcomes.
Srinivas Akella	Prof.	CS	Robotics, motion planning, multiple robot coordination.
Ahmed Arafa	Asst. Prof.	ECE	AI, federated learning, security, communication, networking.
Razvan Bunescu	Assoc. Prof.	CS	ML for NLP, biomedical informatics, software engineering, music information retrieval, computer architecture, computational creativity.
Chen Chen	Asst. Prof.	ECE	ML, AI, computer vision.
Jim Conrad	Prof.	ECE	AI, autonomous systems, robotics.
Dong Dai	Asst. Prof.	CS	AI/ML to improve the performance of High Performance Computing systems.
Luke Donovan	Asst. Prof.	KIN	AI models to identify musculoskeletal injury risk and AI-based rehabilitation programs to improve quality of life even with musculoskeletal injuries.
Mohsen Dorodchi	Teach. Prof.	CS	ML and predictive AI analytics for educational learning assessment, management and development.
Jianping Fan	Prof.	CS	Computer vision, large-scale image recognition, privacy-preserving image sharing, deepfake detection.
Liyue Fan	Asst. Prof.	CS	AI research and applications that protect the privacy of data contributors.
Alexia Galati	Asst. Prof.	PSY	AI and formal dynamical models to examine cognition and interpersonal coordination.
Tiffany Gallicano	Assoc. Prof.	COM	Ethical permissibility, activism, AI algorithm usage
Yaorong Ge	Prof.	CS	AI/ML methods in clinical applications, e.g., to improve radiation therapy treatment planning.
Amirhossein Ghasemi	Asst. Prof.	MEES	Design of human and AI collaborative control paradigms for human-machine interaction.

Mirsad Hadzikadic	Prof.	SIS	ML for complex adaptive systems, and network science.
Jeremy Holleman	Assoc. Prof.	ECE	Low power and micro scale AI/ML integrated circuits.
Siddharth Krishnan	Asst. Prof.	CS	Data mining, ML, NLP, and AI for solving social informatics represented as large graphs.
Minwoo Lee	Asst. Prof.	CS	ML, reinforcement learning, transfer learning, human-guided AI learning, with application to wireless networking, and IoT/IoE.
Sara Levens	Assoc. Prof.	PSY	Neural and genetic mechanisms underlying emotion processing and cognition
Ann Loraine	Assoc. Prof.	BIG	ML to annotate genomic datasets, classifying biologically meaningful genomic data scenes.
Aidong Lu	Prof.	CS	Immersive analytics using virtual/augmented reality for real-time collaboration and virtual training
Weijun Luo	Res. Assoc. Prof.	BIG	ML design methods, neural architectures, and bayesian networks for genomic and medical data analysis.
Dip Maity	Asst. Prof.	ECE	AI, controls, optimization.
Taghi Mostafavi	Assoc. Prof.	CS	ML for intelligent sensors and predictive models to identify early stage cancer receptivity.
Xi Niu	Assoc. Prof.	SIS	AI and ML to understand the behavior of users of recommendation systems.
Albert Park	Asst. Prof.	SIS	AI applied to health care contexts.
Babak Parkhideh	Assoc. Prof.	ECE	AI/ML to improve smart grid reliability and performance.
Benjamin Radford	Asst. Prof.	PLS	political conflict, cybersecurity, and the application of machine learning to problems in these domains
Zbigniew Ras	Prof.	CS	AI, ML, data mining for healthcare, business, and art analytics and music information retrieval
Pedram Rooshenas	Asst. Prof.	CS	Machine learning, energy-based models, and deep learning.
Erik Saule	Assoc. Prof.	CS	HPC design methods to address AI computational

			bottlenecks and sparse data problems.
Samira Shaikh	Asst. Prof.	CS	Computational Sociolinguistics, Natural Language Processing, Machine Learning, Intelligent Agents
Min Shin	Prof.	CS	Computer Vision and ML for tracking objects in scientific and engineering applications.
Hamed Tabkhivayghan	Asst. Prof.	ECE	ML high performance computing, real-time ML.
Gabriel Terejanu	Assoc. Prof.	CS	AI models to explain hidden mechanisms in science and engineering applications and extract causal relations from observational data.
Abbey Thomas	Asst. Prof.	KIN	AI to quantify human movement during sports to predict injury risk and to train athletes for injury prevention.
William Tolone	Prof.	SIS	Developing a secure virtual information fabric for big data that enables data-driven decision-making from previously non-shareable data.
Pu Wang	Asst. Prof.	CS	ML in wireless sensing and security, reinforcement learning, federated learning for edge computing and swarming intelligent networked robots.
Andrew Willis	Assoc. Prof.	ECE	AI, autonomous systems, computer vision, robotics.
Jason Windett	Assoc. Prof.	PLS	representation in American politics with a focus on state politics, state courts, and gender and politics
Artur Wolek	Asst. Prof.	MEES	Autonomous systems including robot path planning, probabilistic reasoning, and decision-making.
Yonghong Yan	Assoc. Prof.	CS	High performance computational accelerators for computer vision, programmability of high performance computing devices by AI/ML experts.
Wlodek Zadrozny	Prof.	CS	AI for natural language analysis, understanding and inference and its application to medical informatics.