GAIN Collaborative Research Program (CRP)

SC EPSCoR Solicitation Number 7-CRP2024

GAIN CRP Program Objectives

The goal of the GAIN CRP (Grants for Applications in Industry and Networking Collaborative Research Program) is to encourage faculty researchers at the three South Carolina comprehensive research universities (CRUs), Clemson University, the Medical University of South Carolina, and the University of South Carolina Columbia campus; and predominately undergraduate institutions (PUIs) including HBCUs to build collaborative CRU/PUI academic research teams that will compete effectively for research funding to support the U.S. NSF EPSCoR funded ADAPT in SC (*AI-Enabled Devices for the Advancement for Personalized and Transformative Health Care in South Carolina*) project. The vision of ADAPT in SC is to build research capacity at the nexus of Artificial Intelligence (AI), life and social sciences, and bioengineering through fundamental research, education, workforce development, and industry engagement. Proposals submitted in response to the GAIN CRP solicitation must include at least two investigators.

ADAPT in SC Research Priorities

Proposals must respond to one of the following research themes:

- Theme 1 - Biomedical AI
- Theme 2 - XAI-enabled Biomedical Devices for Diagnostic and Planning Applications
- Theme 3 - DL-Imaging Model-Enabled Biomedical Devices for Personalized Prognostic and Treatment Applications
- Theme 4 - DT-Enabled Biomedical Devices for Rehabilitation and Therapy

For the ADAPT in SC project, biomedical devices are broadly defined to include conventional mechanoelectrical apparatus (e.g., X-ray machines, pacemakers) and biomedical digital systems such as computer-based biomedical information analyzing systems and predictive models and tissue-engineered implantable biological constructs. The following are major themes of research in ADAPT in SC. Proposals may be submitted to address any of these themes.

Theme 1 - Biomedical AI

Biomedical AI is an emerging interdisciplinary field where innovations sprout new theories, models, and algorithms in AI and data science and in synergistic integration of AI with targeted biomedical devices and their downstream applications in complex biomedical settings. Proposals on this topic will conduct research related to the development of theoretical foundations of biomedical AI, AI-ready data acquisition and preprocessing, multimodal data fusion technologies,

deep learning algorithms, physics-informed ML models, and software tools to facilitate the use of mechanistic and AI models, sometimes with limited amounts of data.

Proposals on this theme may address one or more of the following:

1. Tackle three key research challenges in biomedical AI: small data size; multimodal data; and unannotated data.
2. Develop new data-enrichment methods for given small datasets.
3. Develop techniques for generating AI-ready data.
4. Adapt current post hoc XAI techniques to achieve interpretable and trustworthy outcomes in biomedical devices.
5. Build a comprehensive data-driven modeling framework, integrating physics, mechanistic modeling, and machine learning.
6. Explore new AI methods for biomedical device developments with integrated security measures.
7. Develop new uncertainty quantification methods to test the robustness of the AI tools integrated with the proposed biomedical devices.
8. Apply latent variable space and/or inductive logic programming approaches to data fusion.
9. Create new statistical approaches to analyze transparency and trust in AI modeling.

Theme 2 - XAI-enabled Biomedical Devices for Diagnostic and Planning Applications

Explainability is crucial to rationalizing and cross-checking model outcomes to ensure that the AI-informed decisions made are reliable and trustworthy. The major challenge to implementing AI in biomedical devices is a tradeoff between the explainability and accuracy of the AI models. Highly accurate, complex models like deep neural networks (DNNs) trained by significant amounts of data tend to be less explainable, but explainable algorithms like decision trees usually lead to low accuracy for complex tasks. As an emerging field in trustworthy AI, XAI (Explainable AI) endeavors to find explanations for complex models using ante hoc or post hoc methods. Ante hoc methods address explainability from the beginning, whereas post hoc methods rely on an external explainer of an already trained model. Proposals on this topic will use XAI to improve the explainability of the diagnostic or treatment decisions made from multimodal clinical data to provide insights into important causal factors and to obtain domain experts' trust, high prediction accuracy, and safe, continuous workflows from initial diagnosis to treatment end.

Proposals on this theme may address one or more of the following:

1. Explore the degree to which XAI approaches improve understanding of diagnostic outcomes.
2. Develop strategies for classification of bioimages from small data sets.
3. Use XAI approaches to accommodate multi-modal data (images and biosensor data) in biomedical classification.
4. Develop AI tools to accelerate the identification of biochemical compounds from complex biological samples.
5. Use XAI to assist decision-making for drug dosage control.

Theme 3 - DL-Imaging Model-Enabled Biomedical Devices for Personalized Prognostic and Treatment Applications.

Novel DL (Deep Learning) techniques are needed to actualize high-performance biomedical devices for prognosis and/or treatment. Current devices for these purposes depend on multiple data sources to make the final treatment decision, directly guide the treatment, or implement the treatment. Constructing a model that can effectively integrate multimodal data remains a challenge. Moreover, in many applications, there are limited human samples (e.g., patients) from whom the data can be collected, not to mention the limited number of samples that clinical experts can effectively annotate. Building high-performance DL models from a limited amount of data is critical for the successful development of AI-enabled biomedical devices. Furthermore, the data collected by different investigators, labs, and instruments have an inherent bias. The ability to generalize DL models constructed from limited data sources to many application scenarios determines whether the AI-enabled medical devices can be effectively applied to a general group. Additionally, current clinical practice seeks to leverage big data repositories collected over many years while still tailoring treatment for individual patients. Therefore, developing DL models for medical devices is different from training DL models in general image or text classification, where a large amount of training data is available. The ADAPT in SC will focus on innovation in the DL models and training data processing.

Proposals in this area will conduct fundamental research on creating DL models for AI-enabled biomedical devices for prognosis and/or treatment from limited data. This research thrust aims to advance the field of AI-enabled medical devices for prognosis and/or treatment. The primary outcome of this research thrust will be fundamental knowledge that governs generating high-performance, generalizable DL algorithms from limited data.

Proposals on this theme may address one or more of the following:

1. Improve ML algorithms for unannotated, incomplete, and limited available biomedical data.
2. Develop novel strategies for integrating multimodal data with imaging data.
3. Explore new methods for integrating clinically relevant data.
4. Translate XAI techniques to address the “black box” issue in DNNs.
5. Implement AI-enabled image analysis and multimodal data fusion into a risk stratification and decision-making tool for prognosis and treatment.

Theme 4 - DT-Enabled Biomedical Devices for Rehabilitation and Therapy

Rehabilitation is an important process for patients to optimize recovery following medical treatment. Today, for a given medical problem, there is a host of rehabilitation procedures and methods. However, determining the best or most suitable rehabilitation method for a given patient is difficult. Likewise, medical treatment of chronic diseases such as diabetes and cancer or rapidly developing ones such as sepsis requires physicians and patients to navigate through a sea of treatment pathways to identify the one suitable for the individual patient. An overarching scientific challenge is developing a system for an individual patient so that various available rehabilitation treatment regimens or active medical treatment pathways can be monitored and analyzed, and the

outcome inferenced. The use of AI-enabled digital twins (DTs) can be a viable solution. A DT is a virtual representation of an object or system that spans its lifecycle; it synchronized with the real system in real-time and uses simulation to analyze and forecast the future state, ML, and causal analysis to aid decision-making and design of the patient-specific treatment pathway. An AI-enabled rehabilitation DT would be an ideal platform for clinicians to design an optimal rehabilitation strategy for a specific patient to realize a personalized treatment pathway. For diabetes, cancer, or septic patients, a DT can provide an intelligent assistant for the physician and patient to develop and optimize the treatment pathway dynamically. For the elderly and less serviced communities, DTs would provide additional AI-enabled, user-friendly instructional materials and devices.

DT is a concept derived from the aerospace industry, where aircraft or spacecraft need to be evaluated virtually under potentially challenging or hazardous conditions to determine the need for replacement or reinforcement procedures. This concept perfectly fits the healthcare industry, but a fully functional DT platform in the healthcare industry has yet to be developed. Proposals in this area should address the development of such a platform that can be used for patients in various medical categories and communities.

Proposals on this theme may address one or more of the following:

1. Develop methods for identifying foundational characteristics of a biomedical device to predict outcomes and infer causality.
2. Establish a DT framework consisting of multiple data types and model types (e.g., data-driven vs. mechanistic model-driven platform).
3. Identify and implement a digital twin module that optimally addresses the needs of a biomedical device.
4. Implement a developed DT model with a biomedical device for rehabilitation or a specific disease.
5. Create DT-enabled biological cell-based implantable biomedical devices.
6. Establish DT-based multiscale, mechanistic models for biomedical device developments.
7. Develop fundamental theories and technologies for time series modeling and causal analysis.

Award Information

Maximum Funding Amount Per Project: $70,000.00
Project Duration: 18 months
Estimate Number of Awards: Depends on quality of proposals and availability of funds.
Anticipated Project Start Date: Projects can start as early as May 1, 2025.

Eligibility

- The PI and Co-PI(s) must be faculty members at any South Carolina college or university.
- **Current GAIN CRP PIs and Co-PIs and current GAIN PIs** are not eligible to serve as PI or Co-PI on 7-CRP2024 GAIN CRP proposals.

- Former SC EPSCoR Program Seed Funding PIs (e.g., GEAR, GEAR CRP, SAN, Phase-0) who did not submit final project reports to the SC EPSCoR State Office are not eligible to apply.
- Proposals that include faculty from an underrepresented minority group or from a Historically Black College or University (HBCU) are encouraged.
- A minimum of two undergraduate students must be identified for participation in the project.
- Graduate student support is encouraged especially for students from underrepresented minority groups.
- The home institution of the PI will serve as the fiscal agent and will establish sub-award(s) for the institution(s) of the Co-PI(s).

Deadline

Full Proposal – Thursday, September 26, 2024 – 5:00 PM EST

Full Proposal Content

The sections below represent the body of the proposal. Failure to submit the required sections will result in the proposal not being accepted or being returned without review. *Note: Where indicated, the number of pages refers to the maximum number of pages allowed and must not be exceeded*.

1. **Cover Page (2 Pages)**

   Use the Cover Page form in Appendix A.

2. **Project Summary (1 Page)**

   Proposals must contain an NSF compliant project summary not to exceed one page in length. The Project Summary consists of a) an overview, b) statement on the intellectual merit of the proposed activity, and c) a statement on the broader impacts of the proposed activity.

   The overview includes a description of the activity that would result if the proposal were funded and a statement of objectives and methods to be employed. The statement on intellectual merit should describe the potential of the proposed activity to advance knowledge. The statement on broader impacts should describe the potential of the proposed activity to benefit society and contribute to the achievement of specific, desired societal outcomes.

   The Project Summary should be informative to other persons working in the same or related fields, and, insofar as possible, understandable to a broad audience within the scientific domain. It should not be an abstract of the proposal.

3. Project Description (10 Pages)

The Project Description should provide a clear statement of the work to be undertaken and must include the best scientific and strategic (long-term) objectives of the proposed work and expected significance, the relationship of this work to the present state of knowledge in the field, and the work plan. The Project Description section should have the following sections:

a. Objectives of the Proposed Work and Relevance

State the objectives of the proposed work and explain how it relates to ADAPT in SC research priorities outlined in the Program Objectives section.

b. Prior Relevant Research

Describe the proposed research project including significance of research and a review of relevant literature related to the proposed work.

c. General Research Plan

Describe the research framework, hypothesis, research questions, methods and procedures, potential outcomes, etc. Describe the broad design of activities to be undertaken (e.g., experimental methods and procedures). Proposers should address what they want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. The research activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified. These issues apply to both the technical aspects of the proposal and the way in which the project may make broader contributions.

Proposers must clearly identify the broader impacts (as a separate subsection) of the proposed work and accomplishments to be expected at the end of the project. Specific milestones must be carefully stated to aid in proposal evaluation.

d. Timeline for Implementing Proposal Activities Chart

Include a timeline for implementing proposal activities. Describe each major proposal activity and identify the quarters during which the proposed activity will be conducted. Each activity must list the name(s) of the party responsible for completing the activity. Employ the chart template below immediately after the General Research Plan section. Add or delete rows as needed.

Activity (Name of Responsible Party)	Year 1				Year 2	
	Q1	Q2	Q3	Q4	Q1	Q2

e. Plans to Leverage GAIN CRP Funding

Describe the plans to leverage GAIN CRP funding and explicitly address the targets and opportunities for future project funding and the sustainability of the effort. Outline a plan for submitting research proposals to national and private funding agencies to attract research grants. The plan must include the names of potential agencies and the programs and dates (if known) that will be targeted.

4. Collaboration Plan (2 Pages)

The Collaboration Plan must include the rationale for the collaboration, how the team will function, and how the collaboration will benefit the investigators, students and the institutions. Describe the role of each team member. Also, describe prior collaborations, if any, among team members. Describe institutional collaboration readiness as it relates to resources and infrastructure that will contribute and benefit the collaboration and overall project. Also address how conflict will be mitigated and managed.

5. References Cited

Reference information is required. Each reference must include the name of all authors (in same sequence in which they appear in the publication), the article and journal title, book title, volume number, page numbers, and year of publication.

6. Results from Prior SC EPSCoR Support (1 Page per Award)

Note: If the senior personnel have not received support from SC EPSCoR, include a statement to the effect. The purpose of this section is to assist reviewers in assessing the quality of prior work conducted with current or prior SC EPSCoR Program funding. If any PI or Co-PI identified on the proposal has received a SC EPSCoR Program award as a PI since January 1, 2020, the following information must be provided:

- Title of the project, start date, date completed, and award amount.
- Summary of the results of the work completed, including accomplishments, supported by the award. The results must be separately described under two distinct headings: Intellectual Merit and Broader Impacts

- A listing of the publications resulting from the award (a complete bibliographic citation for each publication must be provided either in this section or in the References Cited section of the proposal); if none, state "No publications were produced from this award".

If the project was recently awarded and therefore no new results exist, briefly describe the proposed work.

7. **Biographical Sketches**

A biographical sketch is required for the PI and Co-PI in NSF format. ***Please note*** the new NSF Biographical Sketch format effective May 20, 2024. Biographical Sketch must be created and certified in SciENcv (Science Experts Network Curriculum Vitae). For more information on NSF format, visit https://new.nsf.gov/funding/senior-personnel-documents#biographical-sketch-0bd.

8. Synergistic Activities (1 Page)

A one-page Synergistic Activities document is required for the PI and Co-PI in NSF format. ***Please note*** the new NSF Synergistic Activities format effective May 20, 2024. For more information on the Synergistic Activity format, visit https://new.nsf.gov/funding/senior-personnel-documents#synergistic-activities-ec2

9. Budget and Budget Justification

Use the Budget form in Appendix B. If the PI and Co-PI are from two different institutions, two different budget sheets must be submitted: one for the PI and one for the Co-PI. The PI's budget sheet Section F must show the Co-PI's total budget amount as a subaward.

The budget justification must be composed of no more than two pages for each institution and must include the following sections:

- Senior Personnel
- Other Personnel
- Fringe Benefits
- Materials and Supplies
- Equipment
- Domestic Travel Support
- Publication Costs
- Other Direct Costs

10. Current and Pending Support

The Principal Investigator must submit Current and Pending Support in NSF format. ***Please note*** the new NSF Current and Pending Support format effective May 20, 2024. Current and Pending Support must be created and certified in SciENcv (Science Experts Network Curriculum Vitae). For more information, visit https://new.nsf.gov/funding/senior-personnel-documents#current-and-pending-other-support-5db

11. List of Conflicts

Provide conflicts of interest (COI) for each project participant on Appendix C. Conflicted individuals to be identified for each project participant include:

- Ph.D. Advisor: Ph.D. Advisor of the participant (a direct advisor, not simply a thesis committee member) at any time in the past.
- Ph.D. Advisee: Ph.D. advisee of the participant (a direct advisee, not simply where student is on thesis committee) at any time in the past.
- Co-author: a co-author of the participant (includes papers under review and in preparation) within the past 48 months.
- Co-PI: a co-investigator of the participant (includes proposals under review and in preparation) within the past 48 months.
- Postdoc Advisor: Postdoc Advisor of the participant (a direct advisor, not simply a collaborator) within the past 48 months.
- Postdoc Advisee: Postdoc Advisee of the participant (a direct advisee, not simply a collaborator) within the past 48 months.
- Collaborator: a collaborator other than those listed above within the past 48 months (do not list individuals who have merely shared or received data, software, or other intellectual property).
- Co-editor: a co-editor of the participant during the past 24 months.

Budget Information

Funding for the GAIN CRP Program is intended to support salaries and fringe benefits, materials and supplies, domestic travel support, publication costs, etc.

- The budget requested may not exceed $70,000.00 per proposal.
- A maximum of one month of summer salary for the PI and/or Co-PI is allowed. No other senior personnel may receive funding from this program.
- Salary support is allowed for post-docs, student researchers, and other staff.
- Indirect costs are not allowed under this solicitation.
- Tuition is not an allowable cost.
- Cost-share is not required but encouraged.
- Awardees should ensure that costs claimed under SC EPSCoR Program grants are allowable, allocable, and reasonable.

Submission Instructions

PIs should submit their proposals via the SC EPSCoR Portal at https://scepscor.org/Solicitations/portal/.

Proposal Review Process

Proposals that meet the eligibility requirements and the guidelines of this solicitation will be evaluated by external reviewers (outside South Carolina) based upon the extent to which they meet specific criteria including but not limited to:

- The potential of the proposed research to advance knowledge and understanding within the research priorities outlined in the Program Objectives section (Intellectual Merit).
- The potential for the proposed activity to benefit society, advance desired societal outcomes and broaden participation of groups that are under-represented based on gender, ethnicity, and disability (Broader Impacts).
- Whether the plan for carrying out the proposed activities is well-reasoned, well-organized, and based on a sound rationale, and whether it incorporates a mechanism to assess success.
- How well qualified is the PI/Co-PI team to conduct the proposed activities.
- The adequacy of available resources to carry out the proposed activities.
- The likelihood that the research will lead to extramural funding.
- How well does the proposed activity advance discovery while promoting, mentoring, training, teaching, and learning?

Award and Reporting Requirements

- All GAIN CRP PIs and Co-PIs will be considered part of the ADAPT in SC Project and are expected to participate in ADAPT in SC activities which include attending meetings and contributing to the annual report submitted to the U.S. National Science Foundation (NSF).
- All publications (e.g., research publications, press releases, other publications or documents about the research funded by the SC EPSCoR Program) and presentations resulting from the GAIN CRP ***are required*** to include an acknowledgement of SC EPSCoR Program support and a disclaimer. "*Research reported in this [publication, press release, presentation] was supported in part by the U.S. NSF and SC EPSCoR Program under award number (U.S. NSF Award # OIA-2242812 and specific SC EPSCoR grant number). The views, perspective, and content do not necessarily represent the official views of the SC EPSCoR Program nor those of the U.S. NSF*."
- SC EPSCoR Program reserves the right to conduct site visits during the project period for evaluation and reporting purposes. Awardees are expected to provide required information and documentation to the SC EPSCoR Program staff and External Evaluator as needed.
- Reassurance of Responsible Conduct of Research (e.g., CITI Certification) are required for student researchers and postdocs to be submitted to SC EPSCoR Program State Office.
- Progress reports are due every six months after the start date of the award. A template will be provided to the PIs.
- A final report will be due 60 days after the end of the award.

Contact Information

General inquiries regarding this program should be made to:

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