NSF 24-569: MFAI

Mathematical Foundations of Artificial Intelligence

Webinar
June 12, 2024

Agenda

- MFAI Introduction and Motivation
- Overview of the MFAI Program
- Questions
  - from Registration
  - from Q&A
    - Submit your questions via the Q&A box at any point.
    - Questions can be submitted anonymously.
    - Please ‘upvote’ questions of interest.

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Mathematical Foundations of Artificial Intelligence

Multi-directorate Solicitation

- MPS/DMS: Division of Mathematical Sciences
- CISE/CCF: Division of Computing and Communication Foundations
- CISE/IIS: Division of Information and Intelligent Systems
- ENG/CMMI: Division of Civil, Mechanical and Manufacturing Innovation
- ENG/ECCS: Division of Electrical, Communications and Cyber Systems
- SBE/SES: Division of Social and Economic Sciences

Synopsis

- The MFAI program seeks to support research collaborations between mathematicians, statisticians, computer scientists, engineers and social and behavioral scientists to establish innovative and principled design and analysis approaches for AI technology.

Proposal Due Date

- October 10, 2024 (October 10, 2025 and October 9, 2026 thereafter)

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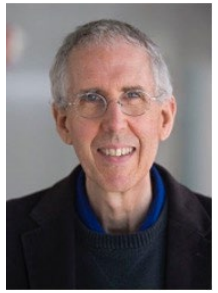
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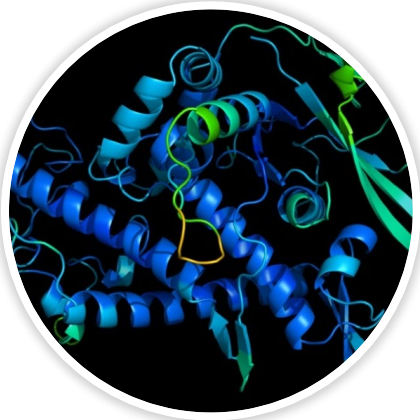
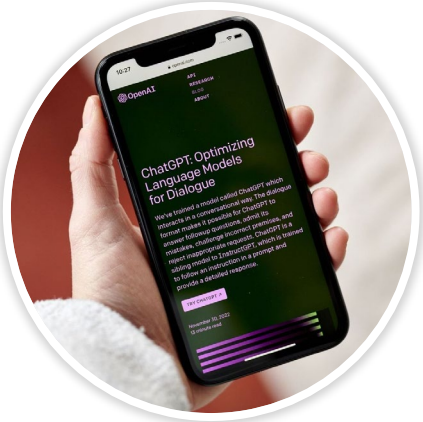
Motivation

AI innovations have experienced a step change in their capabilities in the past few years, and they continue to make breakthroughs and dominate in their performance across scientific disciplines, for example:

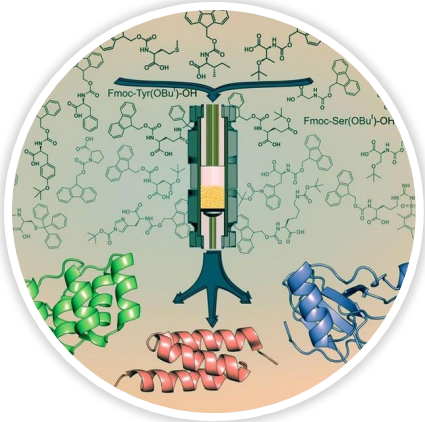


Protein Folding

Climate



Chatbots



Drug Synthesis

Recommender Systems

May 23, 2023
The National Artificial Intelligence R&D Strategic Plan

Strategy 1: Make **Long-Term Investments in Fundamental and Responsible AI Research**

- Advancing Data-Focused Methodologies for Knowledge Discovery
- Fostering **Federated Machine Learning** Approaches
- **Understanding Theoretical Capabilities and Limitations of AI**
- Pursuing Research on **Scalable General-Purpose AI Systems**
- Developing AI Systems and Simulations Across Real and Virtual Environments
- Enhancing the Perceptual Capabilities of AI Systems
- Developing More Capable and Reliable Robots
- Advancing Hardware for Improved AI
- Creating AI for Improved Hardware
- Embracing **Sustainable AI** and Computing Systems

https://www.whitehouse.gov/wp-content/uploads/2023/05/National-Artificial-Intelligence-Research-and-Development-Strategic-Plan-2023-Update.pdf

Major challenges that persist and are growing

Mathematical and theoretical foundations can make a significant impact on:

- Sustainable AI
- Socially responsible AI
- Explainable/Interpretable AI
- Trustworthy AI

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Scientific scope

- Goal: MFAI aims to support research collaborations consisting of mathematicians, statisticians, computer scientists, engineers, and social and behavioral scientists focused on the mathematical and theoretical foundations of AI.

- Research activities should focus on the most challenging mathematical and theoretical questions aimed at understanding the capabilities, limitations, and emerging properties of AI methods as well as the development of novel, and mathematically grounded, design and analysis principles for the current and next generation of AI approaches.

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Specific research goals include:

- A fundamental mathematical and statistical understanding of the factors determining the capabilities and limitations of current and emerging AI systems, including, but not limited to, foundation models, generative models, deep learning, statistical learning, federated learning, and other evolving paradigms;
- The development of mathematically grounded design and analysis principles for the current and next generations of AI;
- Rigorous approaches for characterizing, validating, and quantifying uncertainties in machine learning algorithms and their predictions, as well as research enabling provably reliable, translational, general-purpose AI systems and algorithms;
- Encouragement of new collaborations across this interdisciplinary research community and from diverse institutions.

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Scientific scope: Mathematical Foundations

Opportunities for advancing the mathematical foundations of modern AI include, but are not limited to,

- statistical inference and methodology, formal and symbolic logic, topology, complexity theory, algebraic geometry, representation theory, and analysis approaches such as dynamical systems, partial differential equations, mean field theory, approximation theory, and optimization theory,

which, in turn, could facilitate the interpretability, transferability, generalizability, and scalability of AI.

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Additional Considerations

Successful proposals will:

- describe an actionable approach for advancing the mathematical and theoretical foundations of the current and/or next generation of AI methodologies through targeting at least one key technical obstacle;

- make clear the innovative mathematical and theoretical contributions that will be addressed in the project;

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Additional Considerations

Proposals should also:

- clearly demonstrate substantial collaborative contributions from team members with complementary expertise and should highlight how the complementary expertise of the team provides a unique opportunity for progress;

- contribute to the development of the diverse, multidisciplinary research workforce that will continue to advance the field in the future through the research involvement of students, and/or postdoctoral associates.

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Additional Considerations

- This program welcomes the submission of proposals that include the participation as e.g., PI, co-PI, senior/key personnel, postdoctoral scholars, graduate or undergraduate students, or other trainees from the full spectrum of diverse talent in STEM, including members of historically under-represented or under-served populations. It also includes diverse institutions including Minority-Serving Institutions (MSIs), Primarily Undergraduate Institutions (PUIs), and two-year colleges, and major research institutions.

- Proposals from EPSCoR (Established Program to Stimulate Competitive Research) jurisdictions are especially encouraged: https://new.nsf.gov/funding/initiatives/epscor

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Logistics

- **Proposal deadline(s)**: October 10, 2024 (October 10, 2025 & October 9, 2026 thereafter)
- **Anticipated total funding**: up to $8,500,000 per year
- **Anticipated number of awards**: ~8-15 per year
- **Award size**: expected to range between $500k - $1.5M
- **Duration**: up to 3 years

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Eligibility

Who May Submit Proposals:

- Proposals may only be submitted by the following:
  - Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members.
  - Non-profit, non-academic organizations: Independent museums, observatories, research laboratories, professional societies and similar organizations located in the U.S. that are directly associated with educational or research activities.

Limit on Number of Proposals per Organization:

- There are no restrictions or limits.

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Eligibility

Who May Serve as Principal Investigator (PI):

- As of the date the proposal is submitted, any PI, co-PI, or senior/key personnel must hold either:
  - a tenured or tenure-track position, ***or***
  - a primary, full-time, paid appointment in a research or teaching position

  at a US-based campus of an organization eligible to submit to this solicitation (see above), with exceptions granted for family or medical leave, as determined by the submitting organization. Individuals with ***primary*** appointments at for-profit non-academic organizations or at overseas branch campuses of U.S. institutions of higher education are not eligible.

Limit on Number of Proposals per PI or co-PI: 1

- A Principal Investigator (PI) or co-Principal Investigator (co-PI) can be part of no more than one proposal per deadline in response to this solicitation.

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Review Criteria

National Science Board Merit Review Criteria

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

Additional Solicitation Specific Review Criteria: In addition to the National Science Board merit review criteria, reviewers will be asked to review how well the proposal addresses the following aspects:

- Is there is a compelling collaboration plan which clearly articulates the added value and complementary expertise spanning the necessary areas of knowledge?
- To what extent does the proposal clearly articulate the mathematical and theoretical innovations?

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Review Criteria

Supplementary Documentation:

- Since the success of collaborative research efforts is known to depend on thoughtful coordination mechanisms that regularly bring together the various participants of the project, a **Collaboration Plan** is required, even when the investigators are affiliated with the same institution.
- **Up to two pages** are allowed for **Collaboration Plans** and they **must be submitted as a document under Supplementary Documents**.
- The length and level of detail provided in the Collaboration Plan should be commensurate with the complexity of the proposed project.
- Collaboration Plans and proposed budgets should demonstrate that key personnel, and especially lead PIs, have allocated adequate time for both their individual technical contributions and the leadership of collaborative activities necessary to realize the synergistic effects of multidisciplinary research.

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Q&A

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Thank you!

- Contact: mfai@nsf.gov

- Program homepage:
  - https://new.nsf.gov/funding/opportunities/mathematical-foundations-artificial-intelligence