My NSF CAREER Award Journey

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NSF CISE CAREER Workshop 2023

About me (Amir Arzani)

- My training:
  - BS: Isfahan University of Technology; Mechanical Engineering; 2010.
  - MS: Illinois Institute of Technology; Mechanical Engineering; 2012.
  - PhD: UC Berkeley; Mechanical Engineering; 2016.
  - Postdoc; UC Berkeley; Bioengineering; 2016-2017.
- Faculty positions:
  - Assistant Professor; Northern Arizona University; Mechanical Engineering; 2017-2022.
  - Assistant Professor; University of Utah; Mechanical Engineering and SCI Institute; 2022-
- My research (computational cardiovascular biomechanics):
  - Physics-based: Computational fluid dynamics (CFD), solid mechanics, dynamical systems, transport.
  - Data-driven: SciML, deep learning, sparse/reduced-order modeling.
  - Translational: Vascular disease, medical imaging, patient-specific modeling.

CAREER: Synergistic physics-based and deep learning cardiovascular flow modeling

- **Thrust 1:** Integrated deep learning and physics-based CI and combined experimental and computational modeling.
- **Thrust 2:** Blood flow physics theories with deep learning (interpretable AI).
- **Thrust 3:** On-the-fly/hybrid CFD physics-informed deep learning modeling.
- Education:
  - **Objective 1:** Develop FAST: Fluids, Art, and StoryTelling!
  - **Objective 2:** Integrate FAST with existing initiatives to promote STEM.

A summary of my CAREER journey

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A summary of my CAREER journey

- When did I start “thinking” about my CAREER?
  - Last year of my PhD in 2016!
- What percentage ended up in my 2021 proposal?
  - None!!!
- Writing/Submission timeline:
  - First attempt: Start writing Dec. 2019. Submit: July 2020. Program: Fluid Dynamics (CBET). Outcome: Competitive (Not funded).
  - Second attempt: Start writing Jan 2021. Submit: July 2021. Program: OAC (CISE). Outcome: Highly Competitive (Funded).
  - Changes in 2nd attempt: Minor changes to education program; Research thrusts completely changed (shared some common broad goals/intro)

My CAREER proposal

Page 1 (**Most Important!!**):

1. Project Overview and Significance.
One of the greatest challenges facing.. . X has shown its potential for ... . Despite accumulating evidence that...

A nice visualization figure!

The **overarching goal** of this CAREER is to integrate data science and flow physics within a synergistic physics-based and scientific machine learning CI to overcome major hurdles in .. Thrusts...

The **overarching scientific hypothesis** ...

The **expected scientific outcome** ... CI...

The **overarching education goal** is to excite and energize fluid mechanics and computer modeling learning experience at the undergraduate level and use this excitement to promote STEM...

Grand Challenge. .... I propose the notion of X within my CI to ....

My CAREER proposal

Page 2:

2. Research and Education Objectives.

A large overview figure summarizing the entire proposal.

Research thrusts:

Thrust 1: ... Task 1a, Task 1b.

Thrust 2: ...

Thrust 3: ... Task 3a, Task3b.

Education objectives:

Objective 1: Develop a new education program.

Objective 2: Integrate the program with regional initiatives.

My CAREER proposal

Pages 3–4$\frac{1}{4}$:

3. Intellectual Merit.

Cardiovascular flow in diseased arteries is complex, chaotic, and difficult to characterize. ...

My scientific machine learning framework is driven by well-recognized needs of the vascular flow community and will transform fundamental blood flow research by providing software to.... ...

My framework will enable innovative discovery by ... ...

I will advance cyberinfrastructure research by providing ... ...

Intellectual Merit and innovation for BOTH research domain and CI.

My CAREER proposal

Pages $4\frac{1}{4}$–$5\frac{1}{2}$:

4. PI's Relevant Prior Research.

PI's strengths and vision. ...

My data-driven cardiovascular flow story: let's connect blood flow physics and data science! ...

More preliminary data. ...

Based on my lab's work, I submit that a CI that ... could overcome major limitations of... and provide a deeper understanding of...

My CAREER proposal

Pages $5\frac{1}{2}$–$12\frac{1}{2}$:

5. Research Plan.

Each Thrust:

Overview. ... main objective... hypothesis... link to emerging areas of inquiry identified by NSF...

Scientific premise and other studies. ...

....

Validation/assessment plan. ...

Potential challenges and alternative strategies. ...

Expected CI outcome ...

End with one paragraph 5 year future career plan (Years 6-10).

My CAREER proposal

Pages $12\frac{1}{2}$–end:

6. Education and Outreach Program.

Divide into two objectives.

Background. ... STEM education literature review ...

My proposition. My education program is motivated by **three hypotheses:** ...

FAST: Fluids, Art, and StoryTelling! Explain your proposed program..

Preliminary work. ... provide a figure..

Assessment plan. ... Maybe motivated by ABET? ...

Integration of research and education. Think of a two-way coupled interaction!

My CAREER proposal

Pages $12\frac{1}{2}$–end:

7. Broader Impacts. ... Impact on other fields, impact on broader areas, impact on industry, etc.

9. Timeline. ... Research and education activities.

10. Results from Prior NSF Support. ...

Research topic

How to select the research topic?

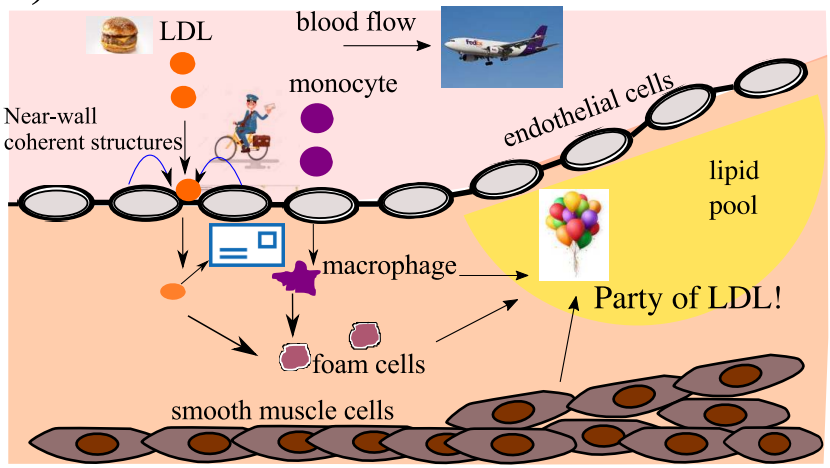
- CAREER is not just a research project but a **research vision**.
- Preferably a project that you initiated as a faculty (e.g., some/all of the preliminary data led by your students).
- Think about what you will be known for in the field in 5 years?
- With a future plan (Years 6-10) articulate how you will continue to lead.
- If you are excited about it $\longrightarrow$ much easier to sell it in writing!

In my case: The project linked my established strengths (flow physics and near-wall transport) with what me and my students had initiated (data-driven modeling of blood flow).

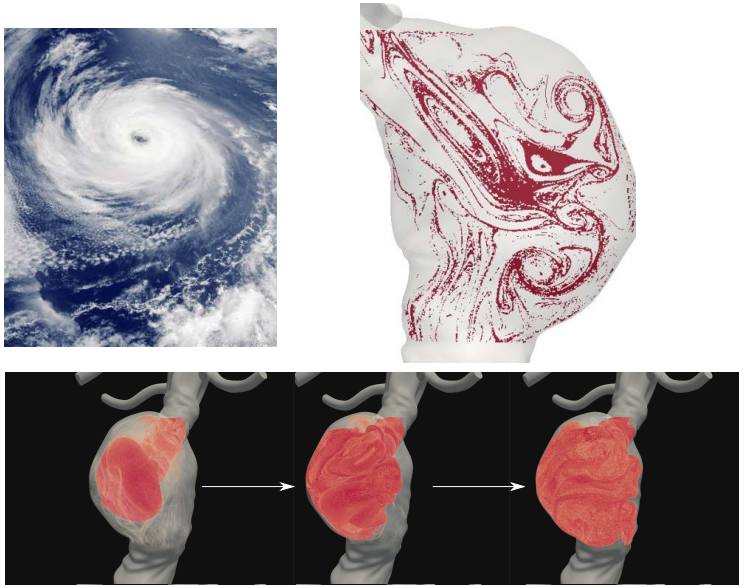
Education program

- **FAST: Fluids, Art, and StoryTelling:** Combine flow visualization (e.g., artistic computer visualization) with cartoons for effective communication of complex fluid flows within a story.

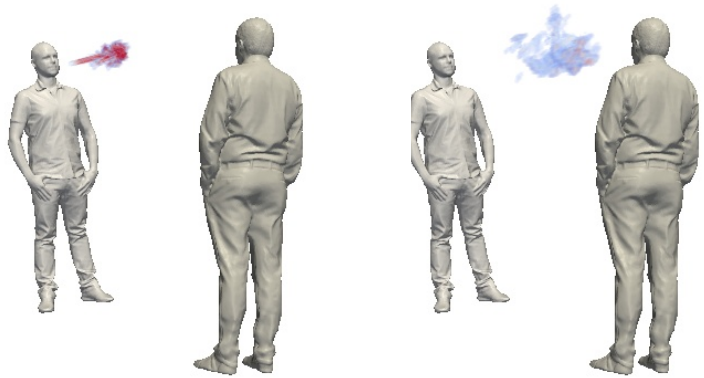
a)



b)



c)



d)

Education program and integration with research

- **Approach:** Integrate FAST in class projects with data produced from this project and use the outcome for outreach activities. Similarly for undergraduate researchers.
- **Activities:** FAST in regional initiatives (e.g., STEM City), Student-centered vision, Broadening participation in computing (BPC).
- **Integration with research:** FAST integrates data from the research program (**research** $\rightarrow$ **education**). Students will inspire new research possibilities by integrating their work within a story (**education** $\rightarrow$ **research**).

Finding the right program

- **Initial attempt:** NSF ENG Fluid Dynamics Program.
  - Focused on data-driven reduced-order blood flow modeling for near-wall flow physics.
  - Positive ratings but the panel not excited enough.
- **Second attempt:** NSF CISE OAC Program.
  - Focused on integrating deep learning and physics-based modeling. Flow physics still one of the thrusts.
  - Why OAC?
    1. Similar recent funded projects.
    2. Prior successful CRII grant.
  - 1st attempt reviews? Only useful for minor edits in this case.
- A strategic but a bit risky decision!

Additional advice

- Highlight your group's work throughout the grant as appropriate
  - Use: I have.. (first-author paper), My student has... (student first author),
- Letters of support: Both research and education.
- Take the education program seriously! Stick to what makes YOU excited the most.
- Chair letter: If from an R2 school make sure chair mentions time protected for research.
- Make sure you know the program well before you submit (unsolicited submission first!)
- First pages: Write for a general audience within the program.
  - **My formula:** 1- Find the farthest away area from you within the program. 2- Imagine that person's background. 3- Write for them!

Additional advice

- Resubmission: Reviews you get have emotions vanished and dry facts are what you see. Emotions are responsible!
- Do not be descriptive. Keep a story even in approach.
- Identify where community's/panel's excitement meets your excitement!

My final word!

- Do not give up if you trust the quality of your work (keep improving). Always accept the blame!

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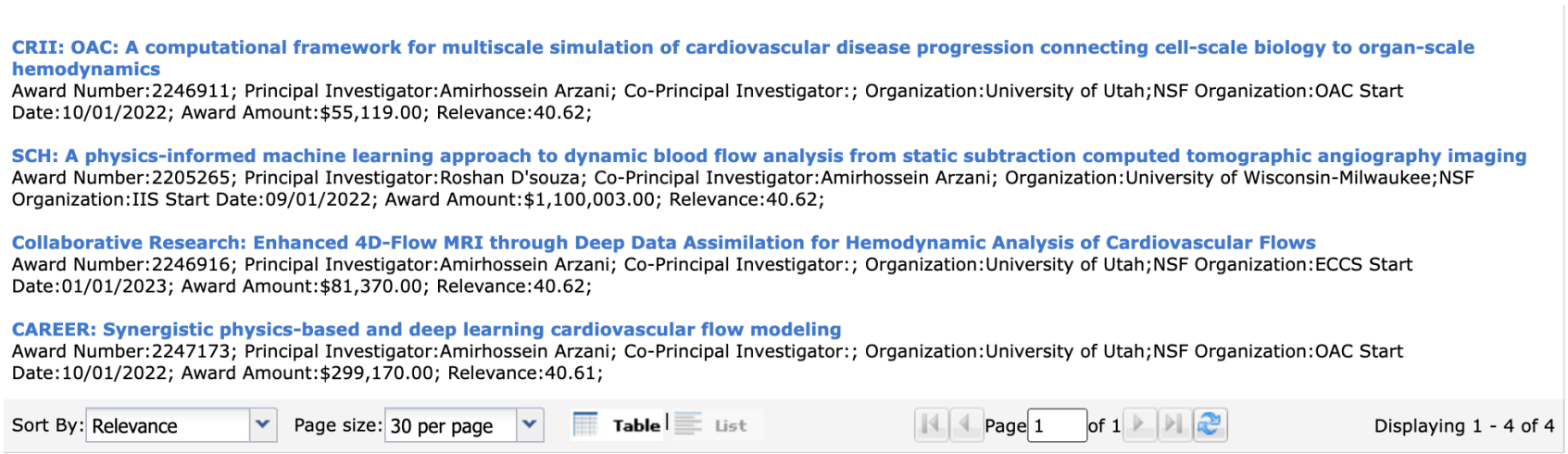
- My research.gov (first two years)

NSF	2003729		Northern Arizona Univ View SAM Legal Business Name	Elements: HemoPost: An open-source framework for novel and...	Declined	03/11/2020	10/31/2019	$599,830
NSF	1948187		Northern Arizona Univ View SAM Legal Business Name	Collaborative Research: Multiphysics biotransport processes in aortic valve...	Declined	10/25/2019	08/14/2019	$200,149
NSF	1923058		Northern Arizona Univ View SAM Legal Business Name	Coupled Transport, Shear Stress, and Growth Processes in...	Declined	05/17/2019	02/08/2019	$435,893
NSF	1923290		Northern Arizona Univ View SAM Legal Business Name	Collaborative Research: Multiscale mechanobiology models for calcific aortic...	Declined	04/25/2019	02/11/2019	$228,341
NSF	1850219		Northern Arizona Univ View SAM Legal Business Name	CRII: OAC: A computational framework for multiscale simulation...	Declined	04/12/2019	08/08/2018	$174,993
NSF	1849884		Northern Arizona Univ View SAM Legal Business Name	CRII: OAC: A computational framework for multiscale simulation...	Withdrawn	08/10/2018	08/07/2018	$174,993
NSF	1804236		Northern Arizona Univ View SAM Legal Business Name	The Hidden Role of Wall Shear Stress in...	Declined	03/19/2018	10/19/2017	$333,994

My final word!

- Do not give up if you trust the quality of your work (keep improving). Always accept the blame!
- NSF award search for my name (now)



CRII: OAC: A computational framework for multiscale simulation of cardiovascular disease progression connecting cell-scale biology to organ-scale hemodynamics
Award Number:2246911; Principal Investigator:Amirhossein Arzani; Co-Principal Investigator:; Organization:University of Utah;NSF Organization:OAC Start Date:10/01/2022; Award Amount:$55,119.00; Relevance:40.62;

SCH: A physics-informed machine learning approach to dynamic blood flow analysis from static subtraction computed tomographic angiography imaging
Award Number:2205265; Principal Investigator:Roshan D'souza; Co-Principal Investigator:Amirhossein Arzani; Organization:University of Wisconsin-Milwaukee;NSF Organization:IIS Start Date:09/01/2022; Award Amount:$1,100,003.00; Relevance:40.62;

Collaborative Research: Enhanced 4D-Flow MRI through Deep Data Assimilation for Hemodynamic Analysis of Cardiovascular Flows
Award Number:2246916; Principal Investigator:Amirhossein Arzani; Co-Principal Investigator:; Organization:University of Utah;NSF Organization:ECCS Start Date:01/01/2023; Award Amount:$81,370.00; Relevance:40.62;

CAREER: Synergistic physics-based and deep learning cardiovascular flow modeling
Award Number:2247173; Principal Investigator:Amirhossein Arzani; Co-Principal Investigator:; Organization:University of Utah;NSF Organization:OAC Start Date:10/01/2022; Award Amount:$299,170.00; Relevance:40.61;

Sort By: Relevance Page size: 30 per page Table | List Page 1 of 1 Displaying 1 - 4 of 4

Acknowledgments

Thank you NSF!

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NSF CRII OAC
NSF ECCS CCSS
NSF CAREER OAC
NSF SCH

AHA 19AIREA34430058

VA Merit Award contract

Research contract

Flinn research grant