Sajed Zarinpour Nashroudkoli

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Education

Sep. 2017
Oct. 2020

M.Sc. in Applied Mathematics, Institute for Advanced Studies in Basic Sciences, Iran
Numerical Method for Solving PDEs with Uncertainty Using Neural-Network

- Implemented a new layer for padding inputs using tf [GitHub Repo]
- Gained extensive knowledge on biophysical models

▪ Python ▪ Numpy ▪ Bash ▪ TensorFlow ▪ Keras ▪ Matplotlib ▪ Octave ▪ Latex

Sep. 2012
Sep. 2017

B.Sc. in Applied Mathematics, University of Guilan, Iran
Study on GMDH Algorithm for Stock Price

- Represented a novel definition for Graphs to solve recursive problems including conditional based actions to solve NP-hard partition problem [GitHub]

▪ MATLAB (Octave) ▪ C++

Skills

Comupter Skills ▪ Linux ▪ Python ▪ TensorFlow ▪ Keras ▪ Numpy ▪ Pandas ▪ MATLAB ▪ NgSolve ▪ git ▪ Freefem++ ▪ C++ ▪ Julia ▪ RDBMS ▪ LaTeX

Soft Skills ▪ Teamwork ▪ Stress Management ▪ Innovation

Research & Interests

- Mathematical Modeling
- Biological Systems
- Finite Element Method
- Numerical Analysis
- Deep Learning
- Inverse Problems

Experiences

Apr. 2024
Present

Senior Web Developer at Islamic Azad University Electronic Campus, Tehran

Dec. 2023
March 2024

Web Developer at Motegharen, Rasht

Jan. 2021
Nov. 2023 **Conscription at** Iranian Traffic Police, Tehran

Dec. 2020
Nov. 2021 **Database Analyst / Developer at** Tavana System, Zanjan

Schools & Conferences

2020 **IASBS Student Presentations in English**
- Presented: On Solving Partial Differential Equations using Neural Networks

Institute for Advanced Studies in Basic Sciences

2021, 2024 **Population Dynamics**
Jena University

2021 **An Introduction to Variational Analysis (Summer School)**
Miami University, Urmia University of Technology

2020, 2021 **One World IMAGINE seminars**
Siam

2020 **Solving inverse problems with deep learning**
UC Berkeley Applied Math Seminar

2019 **Introduction to Data Science in R**
Institute for Advanced Studies in Basic Sciences

2019 **From Biophysical Modeling to Simulation Codes (Winter School)**
Graz university, Isfahan University of Technology

Languages

English - ***Upper Intermediate*** Listening C1, Reading B2, Spoken Interaction C1, Spoken Production C1, Writing C1 (According to European language levels: Basic user (A1, A2) - Independent user (B1, B2) - Proficient user (C1, C2))

German - ***(Beginner)***

References

Dr. Khadijeh Nedaiasl - Assistant Professor of Applied Mathematics (M.Sc. Supervisor)
Email: nedaiasl@iasbs.ac.ir,
Address IASBS, mathematics department

Dr. Parvin Razzaghi - Assistant Professor of Computer Science and Information Technology (M.Sc. Advisor)
Email: p.razzaghi@iasbs.ac.ir,
Address IASBS, computer science and information technology department

February 24, 2025
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Fakultät für Mathematik
Institut für Angewandte und Numerische Mathematik
Arbeitsgruppe 3: Wissenschaftliches Rechnen
Englerstr. 2
D-76133 Karlsruhe
GERMANY

Subject: Motivation Letter for Doctoral Researcher (f/m/d) Project B7 "Dynamics of electrical depolarization waves in the heart"

Dear Prof. Dr. Christian Wieners and the Selection Committee,

I am writing to express my strong interest in the Doctoral Researcher position for Project B7, "Dynamics of electrical depolarization waves in the heart," at CRC 1173. With a Master's degree in Numerical Analysis from the Institute for Advanced Studies in Basic Sciences (IASBS), Iran, I have developed a strong foundation in combining machine learning methodologies with traditional numerical techniques for solving partial differential equations (PDEs). The opportunity to contribute my expertise in numerical modeling and programming to the interdisciplinary challenges of simulating heart function within Project B7 is particularly compelling to me.

During my Master's studies, I worked extensively on numerical methods for solving PDEs with uncertainty, utilizing deep learning techniques. Initially motivated by challenges in biophysical modeling, I explored applications in breast deformation under compression, melanoma cancer modeling, and cellular growth simulations. While my thesis ultimately focused on developing a novel neural network approach for solving PDEs with domain uncertainties, these projects provided me with valuable experience in computational modeling and finite element methods—both of which are directly applicable to simulating depolarization waves and heart muscle contraction. Additionally, I implemented a custom periodic padding layer in TensorFlow/Keras to efficiently handle domain uncertainties, demonstrating my ability to develop innovative numerical techniques. Furthermore, presenting my research findings at the IASBS Student Presentations in English further solidified my communication skills in an academic setting.

Beyond my academic pursuits, my experience as a software developer helped me cultivate valuable teamwork, problem-solving, and time management skills. Collaborating within multidisciplinary teams to deliver projects under tight deadlines has honed my communication and adaptability. This period of professional software development, undertaken alongside personal responsibilities including caring for my elderly father, broadened my skillset and reinforced my dedication to focused, impactful work. With my family situation now stabilized and with renewed energy, I am eager to fully dedicate myself to research and return to my academic passion, specifically within a field that combines mathematical rigor with real-world impact, such as Project B7.

What particularly draws me to Project B7 is its focus on the mathematical and computational challenges associated with cardiac dynamics. My participation in international conferences and schools on inverse problems, biophysical modeling, and numerical analysis has further solidified my interest in this field. I am excited about the prospect of contributing to developing efficient numerical methods for simulating heart function, particularly in a collaborative research environment such as CRC 1173, which aligns perfectly with my long-term aspiration to conduct impactful research at the interface of mathematics and healthcare.

With my background in numerical analysis, robust programming expertise, and deep-seated passion for applying mathematics to understand biological systems, I am confident in my ability to make significant contributions to Project B7.

Thank you sincerely for considering my application. I look forward to the opportunity to join your research group, collaborate with esteemed researchers, and further develop my expertise in computational mathematics and biomedical applications.

P.S. I am in the process of obtaining my official Master's degree certificate, which I anticipate receiving within the next 3-4 months. Unofficial transcripts and confirmation from my supervisor, Dr. Khadijeh Nedaiasl, are available immediately and I will gladly provide the official certificate as soon as it is issued.

Sincerely,

Sajed Zarinpour Nashroudkoli

Statement of Research

Introduction

The convergence of numerical analysis, deep learning, and biological systems presents a fertile ground for addressing complex phenomena governed by partial differential equations (PDEs). Project B7, "Dynamics of electrical depolarization waves in the heart," within the Collaborative Research Center (CRC) 1173, offers a compelling opportunity to contribute to this interdisciplinary domain. Specifically, the project's focus on accurately simulating cardiac depolarization while accounting for the dynamic deformations of the heart muscle poses a significant computational challenge, necessitating the development of advanced numerical methodologies. This research aims to advance the state-of-the-art in cardiac modeling by integrating established numerical techniques with innovative machine learning approaches.

Previous Research Experience

My graduate research at the Institute for Advanced Studies in Basic Sciences (IASBS) centered on the development and application of neural network-based methodologies for solving PDEs with uncertainty. This research involved the synthesis of deep learning techniques with classical numerical methods, resulting in the creation of a novel computational framework. A key contribution was the implementation of a custom periodic padding layer within the TensorFlow/Keras environment, designed to efficiently manage domain uncertainties. This experience provided a robust foundation in numerical algorithm development and implementation, alongside proficiency in Python, TensorFlow/Keras, and related computational tools. Furthermore, the initial motivation for this research stemmed from biophysical modeling challenges, including simulations of breast deformation, melanoma cancer modeling, and cellular growth, which fostered a keen interest in applying advanced computational techniques to biological systems.

Research Goals

The overarching research objective within Project B7 is to contribute to the development of sophisticated mathematical models for cardiac depolarization, explicitly incorporating the intricate dynamics of heart muscle contraction. This will involve extending and refining existing modeling paradigms within the CRC, leveraging recent advancements in biophysical understanding.

A central component of this research will be the utilization of the CRC's M++ finite element system to generate initial solution frames. Given the computational demands associated with simulating dynamic cardiac deformations, I propose to integrate physics-informed neural networks to learn and refine these initial solutions. By training neural networks on the output of M++ simulations, a hybrid methodology will be developed, synergistically combining the accuracy of finite element methods with the efficiency and adaptability of deep learning. This approach will enable the capture of the complex spatiotemporal dynamics of depolarization waves, enhancing the fidelity of cardiac simulations.

Specifically, the research will focus on:

- The development of hybrid numerical schemes that seamlessly integrate M++ simulations with neural network-based refinement.
- The application of physics-informed neural networks to learn the underlying biophysical principles of cardiac depolarization, thereby improving the accuracy of time-dependent simulations.
- The exploration of efficient interpolation and extrapolation techniques to generate high-resolution simulation data from learned neural network representations.

Ultimately, this research aims to develop robust and scalable computational tools that will advance our understanding of cardiac function and contribute to the overarching objectives of Project B7 and CRC 1173. The interdisciplinary nature of this endeavor, facilitating collaboration between mathematicians and biomedical engineers, is particularly compelling.