Dr. Sathyanarayan Rao

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Scientist — Digital Twin Developer — Computational Modeler

Summary

Research Scientist with expertise in predictive analytics, model coupling, and scientific computing. Specialized in creating digital twin solutions for agricultural and environmental systems. Strong proficiency in Python, C++, TensorFlow, and multi-language integration (C++/Fortran/Python). Kaggle Master with demonstrated ability to deliver data-driven solutions for complex industry challenges.

Technical Skills

- **Programming:** Python, C++, MATLAB, Fortran
- **Model Integration:** API Development, Model Coupling, Digital Twin Architecture
- **ML Frameworks:** TensorFlow, PyTorch, Scikit-learn, Keras
- **Software Engineering:** Docker, Git, CI/CD, WebSockets, API Integration
- **Web Development:** Hugo, JavaScript, HTML, CSS, PyQt

Work Experience

Founder & Content Creator — Compute Stories (YouTube Channel) 2024 – Present

- Created high-quality educational content covering computational physics, Python programming, and applied mathematics.
- Produced videos on Laplace transforms, Fourier analysis, qubits, and statistical modeling, simplifying complex concepts for a broad audience.
- Developed animated visualizations and scientific storytelling to improve engagement and learning.
- Utilized OBS Studio, Final Cut Pro, and audio editing tools to produce professional-quality content.
- Managed all aspects of video production, including scripting, narration, editing, and publishing.
- Building a growing audience of learners interested in science, coding, and computational methods.

Scientific Software Engineer — Phenorob Project, Forschungszentrum Jülich 2023 – 2024

- Architected project website using Hugo framework, enhancing stakeholder engagement and knowledge transfer.
- Developed interactive GUI for process-based crop models using PyQt, improving user adoption.
- Engineered model coupling solutions between C++ and Fortran codebases for integrated digital twin simulations.

- Implemented LSTM models for time-series data forecasting with published code reaching 1000+ users on Kaggle.

Research Associate — Indian Institute of Science, Bengaluru 2022 – 2023

- Designed predictive models for soil moisture forecasting with satellite data integration.
- Processed terabytes of remote sensing datasets for climate analytics and agricultural insights.
- Created high-engagement Kaggle notebooks and models with 1000+ views and industry application.
- Developed interactive Vue.js web application for visualizing agricultural datasets.

FNRS Research Fellow — eRoot Project, UCLouvain, Belgium 2016 – 2020

- Conducted research on plant root electrical properties under the FNRS-funded eRoot project (Grant: T.1088.15.)
- Developed computational models to simulate soil-root interactions using geoelectrical methods.
- Designed multi-scale plant simulation models, integrating experimental data and numerical models.
- Published high-impact journal articles in Vadose Zone Journal and Plant and Soil based on project outcomes.

Research Assistant — University of Paderborn, Germany 2015 – 2016

- Worked on a DFG-funded project developing FORTRAN code from scratch to simulate excitonic resonances in a two-level system.
- Implemented Maxwell-Bloch equation solvers to model light-matter interactions in semiconductor nanostructures.
- Conducted numerical analysis of nonlinear optical effects in quantum systems, contributing to fundamental research in exciton physics.

Research Assistant — Alabama A&M University, USA 2013 – 2014

- Conducted optical experiments involving lasers and precision optics.
- Desgined undergrad physics experiment and taught physics 101.
- Characterized photo deposition of bio molecules using Atomic Force microscope.

Research Assistant — University of Alabama in Huntsville, USA 2010 – 2013

- Worked on NSF-funded plasma turbulence research (Grant: NSF ATM0647157), studying current-free double layers in helicon devices.
- Applied **computational physics techniques** to simulate plasma-wave interactions.
- Co-authored multiple peer-reviewed articles in Physics of Plasmas, with significant citations.

Professional Projects

Digital Agricultural Avatar (Model Coupling, Hugo, JavaScript)

- Integrated multiple crop models for precision agriculture.
- Created cross-language integration solutions between C++ plant-scale and Fortran crop-scale models.
- Implemented responsive interfaces for visualizing complex agricultural simulations and scenarios.

Docker Containers for Agricultural Modeling (Docker, DevOps)

- Created containerized solutions for complex scientific software deployment, reducing setup time.
- Developed CPlantBox GUI Docker with VNC viewer for 3D plant modeling visualizations.
- Built DuMuX-ROSI-Jupyter Docker enabling seamless integration of simulation tools for stakeholders.

AI & Predictive Analytics Projects (TensorFlow, Data Pipeline Engineering)

- Developed LSTM and Random Forest models for environmental variable forecasting using satellite data.
- Achieved Kaggle Master status (Top 2%) with 10 Silver & 12 Bronze medals.

Real-time Data Processing System (Python, WebSockets, Financial APIs)

- Implemented automated data processing system using real-time streams via WebSockets.
- Integrated multiple broker APIs for seamless data access and processing.
- Developed technical indicator algorithms for optimized decision-making in time-sensitive applications.

High-Performance Computing Solutions (FORTRAN, MPI, MATLAB)

- Engineered parallel computing simulations for complex physical systems with published results.
- Created scalable computational models for environmental systems.

Healthcare Analytics Application (Gradio, Python)

- Designed scalable machine learning architecture for healthcare analytics as a consultant.
- Developed interactive prototype using Gradio for stakeholder visualization and feedback.

Educational Content Creation (Final Cut Pro, Video Production)

- Created professional educational content on computational science.
- Developed "Compute Stories" youtube channel with technical concepts.
- Applied video production skills to effectively communicate complex scientific topics.

Education

PhD in Engineering Sciences, UCLouvain, Belgium 2016 – 2020 Thesis: Predictive Modeling of Electrical Signatures of Plant Roots Advisor: Prof. Mathieu Javaux

MS in Optical Physics, Alabama A&M University, USA 2013 – 2014 GPA: 4.0/4.0

MS in Electrical Engineering, University of Alabama in Huntsville, USA 2010 – 2012 GPA: 3.9/4.0

BE in Electronics and Communication Engineering, Visvesvaraya Tech University 2006 – 2010 GPA: First Class with Distinction

Selected Publications

Journal Articles

- Rao, S., et al. (2020). Imaging plant responses to water deficit using electrical resistivity tomography. *Plant and Soil*, 29 citations.
- Rao, S., et al. (2020). Sensing the electrical properties of roots: A review. *Vadose Zone Journal*, 19(1), 71 citations.
- Rao, S., et al. (2019). Impact of maize roots on soil–root electrical conductivity: A simulation study. *Vadose Zone Journal*, 18(1), 35 citations.
- Singh, N., Rao, S., et al. (2013). Waves generated in the plasma plume of helicon magnetic nozzle. *Physics of Plasmas*, 20(3), 27 citations.
- Rao, S., Singh, N. (2012). Numerical simulation of current-free double layers created in a helicon plasma device. *Physics of Plasmas*, 19(9), 39 citations.
- Singh, N., Rao, S. (2012). Plasma turbulence driven by transversely large-scale standing shear Alfvén waves. *Physics of Plasmas*, 19(12), 3 citations.

Book Chapter

- Rao, S., Ranganath, P. (2025). Climate-Resilient Agriculture: Leveraging Language Models for Mitigation and Adaptation. In *Mitigation and Adaptation Strategies Against Climate Change in Natural Environments*.

Conference Proceedings

- Rao, S., et al. (2019). Investigation of Electrical anisotropy as a root phenotyping parameter: Numerical study with root water uptake. *Geophysical Research Abstracts*, 21.
- Rao, S., et al. (2019). Relationship between electrical anisotropy of soil-root continuum and geometrical architecture of root system. *National Symposium for Applied Biological Sciences*.
- Rao, S., et al. (2017). A forward model for electrical conduction in soil-root continuum: a virtual rhizotron study. *4th International Workshop on Geoelectrical Monitoring*.
- Rao, S., et al. (2017). Characterizing root system characteristics with Electrical resistivity Tomography: a virtual rhizotron simulation. *EGU General Assembly Conference Abstracts*.