Sudhanshu Bharadwaj

Research Assistant at Indian Institute of Science, Bangalore

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Research Interests

Neural Interfaces, Closed-loop stimulation, Neural decoding, Neural representations, Vision, Deep-learning and Machine-Learning, Algorithms

Research Experience

Research Assistant

Vision Lab, IISc Bangalore
Dr. SP Arun, Center for Neuroscience, IISc — *August 2024-Present*

- **Visual Reconstruction Project**: Analyzing monkey neural data that I had recorded with goals:
  - *Generalized Visual Reconstruction*: Investigating methods for generalized visual reconstruction across a variety of conditions like: adversarial image classes, videos, natural vision of freely-moving and sleeping monkeys.
  - *Improved reconstruction methods*: Experimenting with generative models like GANs, Diffusion, VQ-VAE's to improve reconstruction. Adapting SoTA fMRI reconstruction methods to work with neural data.

Bachelors Thesis Student

Vision Lab, IISc Bangalore
Dr. SP Arun, Center for Neuroscience, IISc — *June 2023-July 2024*

Lead two major studies to investigate neural representations in the IT, PFC and PMv cortex in macaques:

- **Image Reconstruction**: I successfully reconstructed natural images from their neural response in IT (passive fixation on images). This work is summarized in my Bachelor's Thesis:
  - *Handling large datasets*: Recorded 25 sessions/days of neural data. Implemented many optimizations for big-data, eg: a high-speed implementation of a MUA detection algorithm (that improved runtimes by 10x).
  - *Extensively worked with DNNs*: Developed an end-to-end pipeline to reconstruct natural images (from neural responses) with high accuracy using GAN's. Routinely used CNN's, transformers and other foundational models.
- **Visual representations in video-game playing monkeys**: We trained monkeys to navigate a 2D video-game map, to study novel questions on virtual-navigation, path-planning and agency.
  - *Experiment design*: Designed a multi-armed bandit task, to probe the neural encoding of agency in video games.
  - *Monkey training*: Trained 2 monkeys to control a on-screen video-game character with 4 arrow keys, and then perform precise player inference among multiple players using probabilistic reward scheme (over 70 sessions).
  - *Coding behavioral experiments*: Developed a custom video game for monkeys on MonkeyLogic-MATLAB (which in addition had to handle eye-data, touch-data, send behavior codes, dispense juice reward).

Part-time Research Intern

NeurOscillations lab, IISc Bangalore *Dr. Supratim Ray, Centre for Neuroscience, IISc* — *June 2022- December 2022*

Studied the encoding of natural images of the V1 region of the primate visual cortex, in LFP signals using Image-processing, ML and CNN based methods. Notably looked for evidence of predictive coding in V1.

Education

- **Indian Institute of Science, Bangalore** — CGPA: 8.5/10
  Bachelors of Science (Research) - Biology Major (Bachelor's Thesis) — *Aug 2020 -May 2024*
  - IISc, India's No.1 Research University is a leading international STEM research university. [Gov-India,QS]
  - The 4-year B.S degree at IISc is a multidisciplinary research program that includes engineering and math.
- **Base PU College , Mysore** — STEM Grade: 96/100
  12th grade (PUC) with a specialization in science — *May 2018-July 2020*

Techniques and Skills

- **Neuroscience**:
  - Creating experiments: PsychoPy, PsychToolBox and MonkeyLogic.
  - Neural Data analysis: SpikeInterface, Chronux, Fieldtrip, CEBRA, Deep-lab-cut and NWB
  - Monkey Handling: Worked with, trained, managed neural implant in *Macaca radiata* over a period of 1.5 years.
- **Programming and Data Science**:
  - Programming languages: Python, MATLAB (Expert), R, C, C++ with OpenGL, and Java (Basic)
  - ML/DL: Pytorch, Tensorflow, scikit-learn;
  - Data Science: scipy, joblib, hdf5, numba, seaborn, scikit-image, cupy, pandas and numpy
- **Undergraduate biology laboratory skills**: Basic microbiology skills like cell culturing, DNA/protein extraction plasmid insertion; Field ecology; Spectroscopy and essential chemistry skills

Selected Distinctions and Awards

- **KVPY SA and SX**: Ranked 108 and 57 among 250,000 students, to secure admissions in India's top research Universities and a four-year fellowship. KVPY is prestigious fellowship worth INR 3.5 Lakhs awarded to the leading UG research students in the country.
- **JEE(Main)**: Placed in the top 0.2% of an India-wide examination taken by 1 million candidates.(Rank- 2188) JEE is an entrance exam to most STEM undergraduate universities across India.
- **Indian Physics, Chemistry, and Astronomy Olympiads** : Qualified for the second round and was in the top 1% of the country. NSE-A/P/C's are preliminary stages of the international Olympiads.

Relevant Bachelor's Coursework

Even though I majored in Biology, my bachelor's degree consisted of interdisciplinary coursework across many departments like: **Pattern recognition and Neural Networks**, Digital Image Processing, Algorithmic Foundations of Big Data Biology, Data Structures and Algorithms, **Neural Signal Processing**, Topics in Systems and Cognitive Neuroscience,Advanced Ecological Statics,Theoretical and Mathematical Ecology, Molecular Systems Biology.

A full transcript of all courses can be found here

Relevant Projects

- Predicting RNA secondary structures using CFG's — Project Page
  Replicated paper to predict RNA secondary structure with 71% accuracy using stochastic context-free grammars and the Expectation-Maximization Algorithm. Developed a python JIT implementation for high speed.
- Predicting Depth of Anesthesia using EEG — Project Page
  Used patient monitoring data to extract complicated EEG features (like burst suppression, signal entropy, power in frequency bands) to predict the depth of anesthesia along with body vitals, of a patient undergoing surgery.
- Psychophysics experiment to measure motion detection thresholds — Project Page
  Designed a PsychoPy experiment to measure the visual-motion detection thresholds in the central and peripheral visual area. Collected and analyzed the data of 11 participants.
- Lab tutorials — Github Page
  Code for the tutorials I conduced in the lab on python and CNN's, as well as a worksheet I designed for lab interns to udnerstand neural data analysis.

Teaching and Mentorship Experience

- **Teaching Assistant, Computational Epidemiology** ECE, IISc
  Prof.Rajesh Sundaresan, ECE, IISc *Jan-April 2024*
  - **Weekly TA hours**: Addressed doubts and helped students with course content on a weekly basis. Taught new concepts, developed and solved problems with students.
  - **Evaluation**: Graded assignments and exam-papers.

Positions of Responsibility

- **Head of Sponsorship and Corporate Relations** Pravega, IISc *Dec 2021- Sept 2022*
  - Lead a team of 15 to procure funding of over 5.5 million INR for the college festival
  - Re-established connections post-COVID and closed deals with several companies like Airbus, Coca-Cola, Pizza hut and ArtPark

Test Scores

- GRE-General (pdf of test report) 322/340
- TOEFL-iBT (pdf of test report) 114/120

Other Information

- Proficient in English, Hindi, and Kannada.
- Other hobbies of mine include theater, cycling and satirical journalism