

Aravind Bharathi
Engineering Physics
Indian Institute of Technology Bombay

CPI: x.xx

190260009
UG Second Year
DOB: 10.02.2002



Chennai, Tamil Nadu

Pursuing a minor in **Geo-informatics and Natural Resources Engineering** and honours in **Physics**

Publications

- Katla V., Valluvan A. B. et al. "An Approach to Star Tracker Design for Nano-Satellite Applications" extended abstract presented in National Conference on Small Satellite Technology and Applications, Trivandrum, India, 2020

Academic Achievements

- Secured a **perfect 10 CPI** in the Geo-informatics and Natural Resources Engineering Minor (Present)
- Achieved **xx.xx%** percentile out of 245,000 participants in **JEE Advanced** 2019 (May 2019)
- Achieved **xx.xx%** percentile out of 1,600,000 participants in **JEE Main** 2019 (April 2019)
- Secured **admission to the IISERs** on the basis of clearing the IISER Aptitude Test (June 2019)
- Attained **95.2%** in the All India Senior School Certificate Examination, Class 12 CBSE (May 2019)
- Secured a **perfect 10 CGPA** in Class 10 of Matriculation Studies under CBSE (May 2017)

Research Projects

Canopy Height Estimation

Guide: Professor J. Adinarayana, Head of Department, CSRE, IIT Bombay (October 2020 - May 2021)

- Conducted an extensive literature survey on the topics of **Computer Vision** and developed an understanding of techniques used in **Digital Photogrammetry** ranging from **Multi-View Stereo** Matching, **Structure from Motion**, and Depth-Map Estimation for large-scale scenes
- Generated and projected **dense point clouds** onto a 3D space, and analysed them using CloudCompare
- Investigated an open-source algorithm used in 3D modelling and optimised the source code to find the **height of crops** from drone-based **optical images**, and later geo-referenced the outputs using ground control points
- Applied computers and electronics to aid the **Indian Agricultural Sector** and learnt to handle **big data**
- This is a part of a much bigger project on **Data Sciences for Farming Support** (DSFS) Systems for Sustainable Crop Production Under Climate Change and involves multi-disciplinary consortium of research institutes under DST-JST scheme of Strategic International Collaborative Research Program



Technical Projects

Student Satellite Program

A 70 member student team dedicated to the vision of making IITB a centre of excellence in space technology

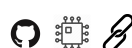
Star Tracker-based Attitude Determination System (March 2020 - Present)

A CubeSat-compatible Star Tracker-based Attitude Determination System to be tested on-board the PS4-OP

- Coded an **Iterative Feature Detection and Extraction Algorithm** on MATLAB followed by C++ to determine the centroids of stars from images simulating an outer-space environment for testing the Open-Loop Simulation of the Star Tracker and analysed the sources of error for the system like slew rate and de-focussing
- Reviewed a recursion based **Region Growth Algorithm** implemented as an alternate approach towards centroid determination
- Designed and reviewed the **layouts of Printed Circuit Boards** for a Voltage Regulator and a **SRAM Board** using EAGLE to interface with the electrical systems core FPGA module
- Implemented a **Star Matching Algorithm**, a **k-vector range searching** based algorithm that makes use of the distribution of centroids to match identified stars to a *Star Catalogue* of known celestial coordinates, on C and Embedded C to run tests on a micro-controller and conceive a hardware prototype for the mission
- The *matched* stars are used to estimate the attitude or orientation of the CubeSat when in orbit

Microcontroller Interfacing (February 2020)

- Understood and implemented **UART and SPI communication protocols** to achieve data transmission and sensor interfacing between two **ATxmega microcontrollers** using Embedded C on Atmel Studio



Astronomy Animation Team

Guide: Dr. Akshat Singhal, Department of Physics, IIT Bombay

(July 2020 - Present)

- Developed **animation techniques** and gathered experience in **scriptable Python-based animation**
- Learnt and applied the various principles behind **representing rotations** from Axis Angles to **Quaternions**
- Rendered a procedural and qualitatively accurate **animation of a 3-body system** under a planar constraint
- Created procedural textured meshes for supernovae explosions and **gravitational wave projections**
- This initiative began through *Krittika*, Institute Technical Council, the Astronomy Club of IIT Bombay



Quantum Imaging Using Complex Degree of Coherence

Guide: Prof. Anshuman Kumar, Department of Physics, IIT Bombay

(March - April 2021)

- Studied and analysed methods of **optimal imaging and metrology** of remote bodies by measuring quantum parameters using linear optics and photon number resolving quantum detectors
- Created an **executable paper** out of a physical review letter in the form of an interactive Python notebook
- Performed statistical analysis to fit the experimental data to the theoretical probability distributions
- Simulated a **classical imaging environment** demonstrating the Rayleigh diffraction limit
- Implemented a **quantum simulation framework** and an **image reconstruction algorithm** based on Fourier Transformation. These imaging schemes open avenues to improved imaging of stellar bodies



Motion-Based Handwriting Recognition System

Institute Technical Summer Project, Institute Technical Council, IIT Bombay

(April - June 2020)

- Modelled a method of input to enable **writing in air or any surface** as part of a team of 4 members
- Coded the **signal processing** block of a trajectory recognition algorithm for a **pen-type** portable device
- Extracted and classified the reduced features with the help of a **Probabilistic Neural Network**



Course Projects

Light-based Feedback Control System

[PH 233]

Guide: Prof. Pradeep Sarin, Department of Physics, IIT Bombay

(March - April 2021)

- Designed and fully assembled a light-disturbance-detector which included a proportional-integral-derivative controller, actuator and a phototransistor-based plant on a breadboard
- Measured the amplitude of a light-based disturbance introduced in the system to great precision

Analysis of Meteorological Shapefiles

[GNR 402]

Guide: Prof. Surya Durbha, CSRE, IIT Bombay

(March - April 2021)

- Analysed shapefiles and generated a spatial database of meteorological data collected from IMD, demonstrating spatial indexing and executing other operations



Analysis of Data from Underlying Event Characteristics

[PH 219]

Guide: Prof. Sadhana Dash, Department of Physics, IIT Bombay

(October - December 2020)

- Analysed **5.5 Gigabytes of data** generated from over **2 million** underlying event characteristics from charged particles in $p - p$ collisions, using a proprietary particle physics data analysis tool called **ROOT**
- Particles are observed as *tracks* in the detector and the *leading track* is the direction of the track along the particle with highest momentum. The no. of particles emitted in each event is given by the multiplicity class
- **Classified the events** based on the azimuthal angle with respect to the axis defined by the *leading track* and rapidity (speed) of the particle, and plotted the observations for different multiplicity classes



Fast Adder based Arithmetic-Logic Unit

[EE 224]

Guide: Prof. Virendra Singh, Department of Electrical Engineering, IIT Bombay

(December 2020)

- Designed a signed **16-bit Arithmetic-Logic Unit (ALU)** which computes signed addition, subtraction, NAND and XOR operations using Structural VHDL based on the *fast adder Kogge-Stone Architecture*
- Made test cases and verified the design using a testbench, and **simulated output waveforms** on Quartus



Optical Sensor for Tropical Rainforest Imaging

[GNR 401]

Guide: Prof. Avik Bhattacharya, CSRE, IIT Bombay

(September - October 2020)

- Proposed a space-borne image sensor to critically understand the **effects of climate change** and capture significant temporal remote sensing data after a **critical survey and analysis** of current satellite payloads
- **Bridged the gap** between the need for expensive airborne hyperspectral imaging while providing continuous data needed to map carbon stocks and flux at the **broad spatial scales** required throughout the year



Positions of Responsibility

Division Lead

Astrophysics Division, Astronomy Animation Team, IIT Bombay

(March 2021 - Present)

- **Led a team of 4** to create physically accurate models of astrophysical systems through procedural animation
- Developed **coding practices** for scriptable animation and oversaw the development of an open-source library



Institute Technical Convener

Maths and Physics Club, Institute Technical Council, IIT Bombay

(May 2020 - April 2021)

- **Adapted the structure** of the club to an online format by organising several talks and **group discussions** while **curating trivia questions** for numerous online quizzing events for our **community of enthusiasts**
- Formulated and **led a targeted plan** to increase the frequency and quality of engaging content by **writing blog posts** and articles on little-known scientists and about **diverse concepts in science**
- Engaged **over 10000 followers** on our social media platforms, the result of a **3-fold increase** in this tenure
- Kept the **Club's Website** up-to-date, **building and expanding** on the work done by our past members
- Hosted a group discussion on Information Theory and Entropy which was attended by **over 100 enthusiasts**
- Designed and conducted a 4-day workshop on Number Theory and Cryptography with **over 400 attendees**
- Developed the course content, framed questions, **conducted live hands-on-sessions** and **delivered talks** for guiding the participants to understand the underlying concepts while clearing doubts in the QnA forum
- Hosted Bazinga! the club's **Flagship Event**
- Avid **science communicator** breaking down everything from the fundamentals of science to complex theories for non-experts



Teaching and Mentoring

Teaching Assistant

FIITJEE Tamil Nadu and Kerala

(July - September 2020)

- Helped in the **curation and reviewal of content** for one of the **premier institutes** for JEE coaching
- **Crafted presentations** with **L^AT_EX** scripts and animations for a learner-centric online mode of teaching

Key Courses Taken

Mathematics and Computing Numerical Analysis, Complex Analysis, Differential Equations, Linear Algebra, Calculus, Data Analysis and Interpretation, Computer Programming and Utilisation, Scientific Computation and Mathematical Modelling[†], Machine Learning and Deep Learning[†]

Physics General Theory of Relativity, Quantum Mechanics I, Waves, Oscillations and Optics, Classical Mechanics, Special Theory of Relativity, Thermal Physics, Electricity and Magnetism, Quantum Physics and Applications

Electrical Digital Systems, Electronics and Semiconductor Devices, Transistor Circuits lab, Op-amp Circuits lab

Geoinformatics Geographic Information Systems, Remote Sensing and Image Processing

[†] workshops attended

Technical Skills

Programming Languages with High Proficiency C++, Python, MATLAB

Programming Languages with Good Exposure VHDL, ROOT, Embedded C, C, R, HTML

CAD and Simulation Frameworks EAGLE, Blender, MeshLab, CloudCompare, SPICE, Audacity

Integrated Development Environments Jupyter, Visual Studio Code, QGIS, Atmel Studio, Quartus Prime, RStudio, Android Studio

Short Projects

Spatial Interpolation to Predict Rainfall Patterns

Guide: Prof. Surya Durbha, CSRE, IIT Bombay

(March - April 2021)

- Predicted rainfall patterns using various **deterministic and stochastic models** such as IDW, trend surface analysis and kriging ranging from spherical to exponential on the statistical computing language R

High-Performance Computing in GIS

Guide: Prof. Surya Durbha, CSRE, IIT Bombay

(January - February 2021)

- Studied and analysed parallel / distributed architectures and programming models for well-known problems in GIS such as **map matching** and **slope computations** through MPI over NoW and CUDA on GPU

Hyperspectral Image Processing

Guide: Prof. Biplab Banerjee, CSRE, IIT Bombay

(November - December 2020)

- Implemented an **unsupervised learning method** to detect and extract spatial features from **191 bands** of a hyperspectral cube

Physical Cosmology | Summer of Science

Maths and Physics Club, Institute Technical Council, IIT Bombay

(April - June 2020)

- Made a report containing an overview of the **Big Bang theory**, its foundation and **observational support** and performed **scientific computing in Astronomy** on datafiles of images taken in outer space

Remote Controlled Bluetooth Bot | XLR8

Electronics and Robotics Club, Institute Technical Council, IIT Bombay

(September 2019)

- Assembled a Bluetooth controlled bot capable of dodging obstacles and **navigating a challenging circuit**

Public Speaking

Technical:

- Hosted a **group discussion on Game Theory** which was attended by **over 50 enthusiasts** as part of the Maths and Physics Club, IIT Bombay (January 2021)
- Delivered a series of **online lectures** and conducted live hands-on sessions as part of the **Number Theory and Cryptography Workshop** hosted by the Maths and Physics Club, IIT Bombay (December 2020)
- Hosted a **group discussion on Information Theory** and Entropy which was attended by **over 100 enthusiasts** as part of the Maths and Physics Club, IIT Bombay (November 2020)
- Represented the school in the **mathematical modelling** competition at the state level **STEM expedition** conducted by CBSE (January 2018)

Miscellaneous:

- Anchored the **Ground Station Workshop** hosted by the Ham Radio Club, IIT Bombay (January 2021)
- Anchored the **Online Fresher's Tech Orientation** for the Institute Technical Council (December 2020)
- Invited** to deliver two closed talks on **"Motivation for JEE"** to high school students attended by over 250 students each (July 2020)
- Performed at a stand-up comedy event hosted as part of a Freshers ice-breaker platform by the Institute Cultural Council (September 2019)
- Placed second** in Stance Drafting at Ampersand 2018, Chettinad Vidyashram, Chennai (July 2018)

Extra-curriculars

Music:

Awarded the **Level 3 Certificate** in Graded Examination in Music Performance, the **highest possible Grade 8**, for Piano, along with **32 credits** for Qualifications and Credit Framework by the **Trinity College of London** - becoming one of the youngest Indian to accomplish this in the process (2010 - December 2016)

- Placed third in the inter-hostel Music Arcade competition at IIT Bombay (February 2020)
- Performed at **Surbahaar**, the flagship concert hosted by Symphony attended by over **2200** (October 2019)
- Won **second place** in performing arts - western music - in Freshiesta, IIT Bombay (September 2019)
- Performed in the **choir of the 57th Convocation** in IIT Bombay (August 2019)
- Represented the school at various regional and state level musicals (June 2017 - September 2018)
- Awarded a **special mention for individual musical excellence** at a regional level music competition hosted by Bhavan's Rajaji Vidyashram (June 2018)

Sports:

Long-Distance Cyclist and Recreational Triathlete

(2017 - Present)

- Completed a **year long training** in Football under the **National Sports Organisation** (March 2020)
- Completed the **WCCG Mass 100, a 100km cycling tourney** around Chennai (June 2019)
- Represented the school at the regional and state level at various Football Tournaments (2012 - 2017)

Technical:

- Moderated a 3-day workshop on **Gravitational Wave Analysis** with over 200 participants (December 2020)
- Placed first** in the **Programming Contest** held at KCG College of Technology, Chennai (September 2018)

Miscellaneous:

- Achieved a highest **typing speed** of **112 words-per-minute** and an average of 98 wpm (Present)
- Organiser at **Techfest 2019**, IIT Bombay managing a **footfall of over 130,000** (January 2020)