Aravind Bharathi

Engineering Physics with Honours
Indian Institute of Technology Bombay

CPI: x.xx
Minor: Geoinformatics Engineering

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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 **99+% percentile** out of 1.6 million candidates in the Joint Entrance Examination *(2019)*
- Attained **95+%** in the All India Senior School Certificate Examination, Class 12 CBSE *(2019)*
- Secured a **perfect 10 CGPA** in Class 10 of Matriculation Studies under CBSE *(2017)*

Research Projects

Canopy Height Estimation

Principle Investigator: Prof. J. Adinarayana, Institute Chair Professor, IIT Bombay *(Oct 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 3D space and rendered polygon meshes
- 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
- Matched results from professional-grade software and attained a RMSE value of 20cm
- 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

Computational Geometry | Reading Project

Guide: Prof. A. Agrawal, Department of Computer Science and Engineering, IIT Madras *(May - July 2021)*

- Read about the design and analysis of algorithms, asymptotic notations, line segment intersections, polygon triangulation, incremental and randomised linear programming, unbounded linear programming, linear programming in higher dimensions, orthogonal range searching, Voronoi diagrams, Delaunay triangulation and convex hulls

Student Satellite Program | Electrical

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

Astronomy Animation Team | Technical Animator

Advisor: 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**

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

Light-based Feedback Control System

Guide: Prof. Pradeep Sarin, Department of Physics, IIT Bombay *(March - April 2021)*

- Designed and **fully assembled** a light-disturbance-detector which included a **PID controller**, actuator and a phototransistor-based plant on a breadboard and measured the amplitude of disturbance to great precision

Analysis of Data from Underlying Event Characteristics

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

Optical Sensor for Tropical Rainforest Imaging

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

Motion-Based Handwriting Recognition System

Insitute Technical Summer Project, 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**

A comprehensive list of all projects can be found on **this website**

Positions of Responsibility

Division Lead | Astrophysics

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**
- 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**
- Avid **science communicator** breaking down everything from the fundamentals of science to complex theories for non-experts

Teaching and Mentoring

Department Academic Mentor

Department Academic Mentorship Program, Department of Physics, IIT Bombay *(May 2021 - Present)*

- Selected into a team of 12 based on ethics, **interviews and extensive peer reviews** to academically guide and counsel 8 sophomore students and bridge the gap between students and faculty members

Content Developer

FIITJEE Tamil Nadu and Kerala, India *(July - September 2020)*

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

Key Courses Taken

Numerical Analysis	Special and General Relativity	Group Theory	Optics and Photonics
Complex Analysis	Quantum Mechanics I and II	Data Analysis	Image Processing
Linear Algebra	Differential Equations I and II	Calculus III	Microprocessors Lab

Technical Skills

Programming Languages C++, Python, MATLAB, C, VHDL, ROOT, Embedded C

CAD and Simulation Frameworks EAGLE, Blender, SPICE, Quartus Prime, Audacity

Integrated Development Environments Jupyter, Visual Studio Code, Atmel Studio

Extra-curriculars

Science Communication and Public Speaking:

- Hosted a group discussion on Game Theory for the Maths and Physics Club *(January 2021)*
- Delivered a **talk on Cryptography** as part of a Number Theory Workshop *(December 2020)*
- Hosted a group discussion on **Information Theory and Entropy** attended by **over a 100** *(November 2020)*
- **Invited** to deliver two talks on the motivation for JEE attended by **over 250 each** *(July 2020)*
- Sole high school representative at the national level CBSE **mathematical modelling** competition *(January 2018)*

Music, Sports and Volunteer Activities:

- 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 Indians** to accomplish this in the process *(2010 - 2016)*
- Long-Distance Cyclist and Recreational Triathlete. Completed multiple 100+km cycling tourneys *(2017 - Present)*
- Achieved a highest **typing speed** of **112 *words-per-minute*** and an average of 98 words-per-minute *(Present)*
- Anchored the 2021 **Ground Station Workshop** for the Ham Radio Club, the online **Fresher's Tech Orientation** for the Institute Technical Council and the Maths and Physics Club's **flagship quizzing event** *(2020 - 2021)*
- Organiser at **Techfest 2019**, IIT Bombay managing a **footfall of over 130,000** *(January 2020)*