Bhavya Bhatt

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EDUCATION

Indian Institute of Technology, Mandi Mandi, Himachal Pradesh
B. Tech., Computer Science (Aug 2016 - July 2020)
GPA: 8.07 (Upto 6th Semester)

RELEVANT COURSEWORK TAKEN UP

Fourth Semester:

- Mechanics of Particles and Waves - General introduction to Lagrangian and Hamiltonian Mechanics
- Classical Electrodynamics
- Continuum Mechanics - Advanced fluid dynamics, general tensor formalism, Naiver-Stokes equation, energy conditions, linear and nonlinear fluids, numerical methods for solving velocity potential field under given boundary conditions
- Special Topics in High Energy Physics - Dirac Equation, Feynman diagrams, particle interactions and calculations of invariant amplitude (electron-positron scattering or electron-meson interaction), Quantum Electrodynamics

Fifth Semester:

- Special Topics in Quantum Mechanics - Non-relativistic and relativistic scattering theory, second quantization and related formalism, angular momentum theory and spin formalism

Sixth Semester:

- Advanced Statistical Mechanics

AREA OF INTEREST

- Quantum Field Theory: gauge theories and their generalization to curved spacetime. Formulation of emergent classical spacetime from quantized spacetime.
- General Relativity: modifications in Einstein's gravity involving torsion.
- Cosmology
- Mathematics: Analysis on manifolds, topology, differential geometry, group theory, stochastic processes and stochastic calculus, chaos theory.
- Computational Physics: Implementations of optimized numerical algorithms relevant in the field of astrophysics.
- Learning Theory: Theoretical statistical computational learning theory.

PROJECTS

Second-Order phase transitions in neural based learning models:

- This project is a sub part of my major technical project at IIT Mandi. This project deals with theoretical studies of learning algorithms using neural network models and their bifurcation limits.
- Current neural based models assumes only first-order linear dependence between the attributes of data and impose non-linearity on these first-order terms.
- The whole formalism shatters when there is significant second-order dependence which can have critical phase transitive behaviour in gradient field which in turn results in large variations across batches of data.
- This large variations results in just addition of random noise to the parameters of the model and affects learning of the model significantly.
- This project tries to formalize a new framework for second-order learning in which we can make parameters of the models as statistical fields and study their critical phase transition exponents and bifurcation limits.

Path Integrals formulation for Collapse Models:

- For my summer research internship at TIFR (Tata Institute of Fundamental Research, Mumbai), I worked under the guidance of Dr. Tejinder Pal Singh (Senior Prof. - Dept. Of Astronomy and Astrophysics), leading a group of 5 students from various IITs.
- As part of the project, I had the opportunity to formulate path integral approach for some of the collapse models (mainly GRW, QMUPL and CSL models) of quantum measurement problems.
- While working on the formulation, I was able to find new approaches for the above stated problem (which was conventionally done by comparing the noise function and the imaginary potential in the action for the propagator) by the proper application of jump operators in every infinitesimal time interval, with appropriate probabilities (Poisson process) and also by calculating the final density matrix function(since the probabilistic model involved mixed states).
- We challenged the idea that the classical limit of quantum mechanics is not just Planck constant tends to zero, but also some mechanism to kill superposition (which is the reason why we don't observe superposition in macroscopic world) which has candidate theory such as collapse models and only then we can recover classical statistical limit like Liouville equation or Hamilton-Jacobi equation.

EinsteinPy: a Python package for Numerical Relativity

- This package was founder by me and my enthusiastic batch mates who were struggling to learn numerical relativity but was not able to find any software support for beginners.
- This library is first to provide support for numerical relativity and relativistic astrophysics problems in Python programming language.
- EPY provides a clean interface for code implementation which can be used by anyone who has little or no programming background and want to simulate their relativistic systems.
- I am physics advisor and non-core developer in the organisation.

PyGlow: a Python package for Information Theory of Deep Learning

- I am the author of this package and is part of an ongoing final year major technical project in the field of "Mathematics of Deep Learning". The Project aims at developing new theoretical ideas which can provide mathematically formal answers to some of the profound questions in the field of deep learning.
- These questions include the mysteries of generalization, optimal architectures, memorization and compression phase in context of deep neural networks.
- The project demands the need for exploring cross field topics from information theory, statistical physics, group theory and complexity theory and experiment with these ideas in code.
- As a result of this project, all the experimentation code is available in form of a Python library package PyGlow which can be installed from PyPI with command "pip install PyGlow".
- This library is also one of the attempts to develop keras like API in PyTorch backend.

Non-Geodesic Raychaudhuri Equation:
Having always been fascinated by general relativity, I am currently working on an interesting and self-thought out project on formalising the stress vector being applied on cosmological fluid(fluid mechanics in Riemannian and Pseudo Riemannian geometry) and to study the motion of the resultant non-geodesic curves. It also include the formalism of the fracture point of the material, mainly using the B tensor, it's decomposition and Raychaudhuri equation, for non-geodesic congruences.

AWARDS AND ACHIEVEMENTS

- Coauthor of a scientific paper submitted in the Physical Review Journal titled, "Path integrals, spontaneous localization and classical limit"
  link to the paper on arXiv - Path integrals, spontaneous localisation, and classical limit.
- Speaker at Space Technology and Astronomy Cell(STAC), IIT Mandi - Astronomy and Astrophysics Department on the topic "General Relativity and Geometry in Physics" for the academic year 2017 - 2018
- Secured 1st position in TopCoder Hackathon for Euler's Notes - Android based project for hearing imparied people

SKILLS

Computer Science and Applied Mathematics:
Data analysis, data Mining and machine learning algorithms, deep learning and related optimization mathematics, parallel computing platforms (Nvidia CUDA, openmpi) and basic parallel algorithms, basic knowledge of quantum computing.

Other Engineering Skills:
Computer programming in Python, C, C++, C#, Fortran, on single and multi-core machine, distributed and parallel platforms, signal processing, probability and random processes, digital electronics.

Software skills:
Have proficient knowledge in various software tools like:

- Scikit-learn - a free software machine learning library for the Python programming language
- Keras - a high-level API to build and train deep learning models
- TensorFlow - an open-source software library for dataflow programming across a range of tasks
- SymPy - a Python library for symbolic computation
- Wolfram Mathematica - a modern technical computing system spanning most areas of technical computing
- Einstein Toolkit - a community-driven software platform of core computational tools to advance and support research in relativistic astrophysics

HOBBIES

- Sketching