25SC802 Advanced Computational Techniques for Radiation Physics 3-1-0-4

Course Objective:
This course introduces machine learning and provides an overview of its applications in radiation physics, along with advanced computational techniques like the Monte Carlo. The course aims to introduce the students to the numerical methods essential to solving problems in radiation physics.

Course Outcomes:
At the end of the course, the students will be able to:

CO1	Understand the basics of machine learning, along with an introduction to deep learning and its applications in Quantum Physics
CO2	Learn the methods and deep learning techniques for solving partial differential equations
CO3	Get familiarized with the machine learning ODE algorithms like the Dormand Prince method
CO4	Get introduced to the machine learning algorithms that find applications in radiation oncology
CO5	Apply various Monte Carlo techniques which are the basis of tools like Geant4, used for dosimetry applications

Syllabus:
Unit 1: Introduction to machine learning for physicists
Basics of machine learning, phase classification, Deep learning for Quantum Sciences- Differentiable programming, Automatic differentiation, Application to Quantum Physics problems- Inverse Schrodinger problem, Quantum optimal Con generative model (many- body physics), Normalizing Flow.

Unit 2: Partial differential equations
Elliptical, parabolic, hyperbolic equations solutions, Five-point methods, Crank Nicholson, Deep neural networks- Deep learning techniques- physics informed neural network BiPDE, Int-Deep.

Unit 3: Ordinary differential equations
Euler, Runge Kutta, ODE Algorithm- Dormand prince method, Adaptive Adams Bashforth method, Analytical solution: Least squares, linear genetic programming.

Unit 4: Machine Learning Applications in Radiation Oncology
Support Vector Machine (SVM), Bayesian network, (Artificial Neural Networks) ANN, and ensemble methods.

Unit 5: Monte Carlo techniques
Integration of functions, Importance Sampling, Multidimensional Integrals, and Generation of Random Numbers.

Textbooks

1. *Intelligent Systems Modeling and Simulation II, Machine Learning, Neural Networks, Efficient Numerical Algorithm and Statistical Methods*, Springer International Publishing, 2022.

2. *Introduction to Numerical Programming: A Practical Guide for Scientists and Engineers Using Python and C/C++*, by Titus Adrien Bieu, CRC Press, 2014.

References

1. *Mathematical Modeling for Intelligent Systems: Theory, Methods, and Simulation* by Mukesh Kumar Awasthi, Ravi Tomar and Maanak Gupta, CRC Press, 2022.
2. *Hybrid Computational Intelligent Systems: Modeling, Simulation and Optimization* by Siddhartha Bhattacharyya, CRC Press, 2023