24WN802 **Mathematics for Deep Learning** **4 0 0 4**

Summary
The course is aimed at giving the students who study deep learning a grasp of the various mathematical tools needed for analysis of the different mathematical concepts employed in deep learning. It has come to the notice of the instructor that many students, particularly at the PhD level, are deficient in the mathematical background needed for the analysis of the various deep learning techniques, and consequently, the course is being proposed. The course will cover the topics important for the mathematical analysis of deep learning.

The course will contain four hours of theoretical lectures per week.

Prerequisites
Basic linear algebra, basic calculus, and basic probability – all of which should be covered in undergraduate mathematics courses.

Syllabus
Optimisation theory
Gradient descent method, variants of gradient descent method, conjugate gradients, Newton's method, Lagrange method of multipliers – 14 hours

Graph theory
Basics of graph theory – 6 hours

Topology
Basics of topology, metric spaces, compact sets, perfect sets, connected sets, numerical series, upper and lower limits, power series, continuity and differentiability – 10 hours

Vector calculus
Computing the derivative of a vector, or a tensor. Gradient, Jacobian, Laplacian and Hessian operators. The basic theory behind them. - 12 hours

Functional analysis
Basics of functional analysis, normed spaces and their properties, inner product spaces and their properties – 6 hours

Reference books
1) Richard Trudeau, ``Introduction to graph theory''
2) Walter Rudin, ``Principles of mathematical analysis''
3) Dimitris Bertsekas, ``Introduction to linear optimisation''
4) Susan Colley, ``Vector calculus''
5) Erwin Kreyszig,``Introductory functional analysis and its applications''

Course outcomes

CO1 Students can learn to analyse the various deep learning models mathematically

CO2 Students can learn how to create new activation functions and modify existing functions in response to their environment

CO3 Students can design better deep learning models, understanding the advantages and disadvantages of the various components of deep networks.

Evaluation pattern

The course carries four credits. The evaluation pattern is given below:

5 assignments – 40 points. The assignments are designed to test the student's understanding of the materials. These are both theoretical and problem oriented so that the student can assess his own abilities in handling the different aspects of the course.

1 mid term – 30 points [theory+viva]

1 final exam – 30 points [theory+viva].

The exams and viva are used to test the understanding of the student. They are meant to discern the ability of the student to think on the spot and complete tasks within a specific time frame.

Importance of the course:

The course focusses on the basic necessary mathematical tools for students to comprehend the various mathematical concepts that underpin the different deep learning techniques, and quantitatively analyse the advantages and disadvantages of using the different techniques in the different situations. It is important to understand that this course is not a coverage of all the techniques in these areas. This course is specifically targeted to teaching computational techniques and mathematical principles that are vital for deep learning. This skill would be greatly prized even in the industry outside, apart from being a vital component in the arsenal of skills deployed by the student.

Signature with Date:

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