CIRCUIT COMPLEXITY THEORY

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PRE-REQUISITES : Basic undergraduate course in Theory of Computation and Algorithms. Undergraduate algebra and discrete mathematics.

INTENDED AUDIENCE : Computer Science advanced undergraduate and postgraduate student interested in theoretical computer science

COURSE OUTLINE :

This is a course on Boolean Circuit Complexity. In this course we study the Boolean circuit model of computation. We prove upper and lower bounds on circuit resources such as depth and size. The course is entirely mathematical, and a good level of mathematical maturity is essential. Prior knowledge of discrete mathematics, probability and basic algebra are prerequisites for this course. The course is intended for students who wish to pursue research in theoretical computer science.

ABOUT INSTRUCTOR :

Prof. Raghunath Tewari is an Associate Professor in the department of Computer Science and Engineering at the Indian Institute of Technology, Kanpur. His primary research interest is in the domain of computational complexity theory. Prof. Tewari did his B.Sc. from Chennai Mathematical Institute in 2005 and Ph.D. from University of Nebraska-Lincoln in 2011.

COURSE PLAN :

Week 1: Boolean functions, circuits, formula, Shannon's Theorem, Riordon-Shannon Theorem
Week 2: Khrapchenko's Theorem and its applications, Nechiporuk's Theorem, Random Restriction
Week 3: Subbotovskaya's lower bound on formula size, Andreev function, Polynomial sized monotone formula for majority (Valiant's Theorem)
Week 4: Complexity of basic arithmetic operations - addition, multiplication, division
Week 5: Bounded depth circuits, the complexity classes, NC, AC and TC. Division, powering and iterated products in NC (Beame-Cook-Hoover Theorem)
Week 6: Uniform model of computation - Turing machines and its relationship with circuits
Week 7: Method of approximations, monotone lower bound on cliques of small size
Week 8: Monotone lower bound on cliques of arbitrary size
Week 9: Razborov-Smolensky lower bound for parity
Week 10: Lower bound for parity using Hastad's Switching Lemma
Week 11: Communication complexity and its relation to circuit complexity, Karchmer-Wigderson Theorem
Week 12: Recent advances in circuit lower bounds