IISc Swarnajayanti Fellow to combine various areas of math's to contribute to big data

Dr. Apoorva Khare, a faculty at the Indian Institute of Science, Bengaluru who is one of the recipients of this year's prestigious Swarnajayanti Fellowship funded by the Department of Science & Technology, will connect multifarious areas in mathematics make fresh progress in a classical area and find modern applications in various 'big data' problems including climate change and disease detection.

He has diverse interests in mathematics, including positivity and analysis, representation theory, discrete mathematics, including combinatorics, and his research supported by the Swarnajayanti Fellowship will connect his above interests, to contribute to big data in broader sciences. Dr. Khare's work could have numerous applications in applied fields, including the study of climate change, gene-gene interactions in disease detection, and financial instruments, as well as understanding fundamental questions involves understanding multivariate dependencies.

In his research, Dr. Khare studies functions that preserve positivity in various forms when applied to continuous and discrete data (such as kernels, matrices, and moment sequences). He further aims to develop two-way connections to algebra, combinatorics (e.g., symmetric function theory) and other subfields of mathematics, drawing motivation from applied fields and modern requirements.

On the mathematical side, Dr. Khare has discovered novel symmetric function identities, extending 100-year old formulas by Cauchy and Frobenius. With his collaborators, he has further discovered a new graph invariant arising from positivity, proved new results on scalar and matrix inequalities, made novel contributions to moment problems and demonstrated how algebra (Schur polynomials) is indispensable in studying positivity, and at times even provided the first examples for classical problems unsolved for 70+ years.

In modern problems, one often has sample covariance matrices of size 100,000+. These are highly singular and have no sparsity pattern (structure of zero entries), usually in contrast to a highly sparse or far lower-dimensional underlying model. Thus one seeks to improve these estimators.

However, traditional optimization-based tools such as compressed sensing or Least Absolute Shrinkage and Selection Operator (LASSO) are iterative and not scalable to very high dimensions. A recent, scalable alternative is to entry wise regularise ultra-high dimensional covariance matrices, which makes it critical to understand entry wise positivity preservers. Thus, the entry wise calculus studied by Dr. Khare and his coauthors also finds motivation and application in current research methodology in disease detection and climate change.

With his work recognised in India and abroad, Dr. Khare's work has also previously received a Ramanujan Fellowship and a MATRICS grant from Govt. of India, grants from the Infosys Foundation, and the Tata Trusts among many other national and international awards.

Alumni of Indian Statistical Institute at Kolkata, and the University of Chicago, he has carried out research and teaching at Yale University and Stanford University and collaborates with algebraists, analysts, probabilists, and statisticians for his work.

Finally, Dr. Khare is passionate about teaching and mentoring the next generation of students and researchers and designed and introduced a course at Yale in 2011, popularising mathematics for non-math students. With the support of the Swarnajayanti Fellowship, Dr. Khare hopes to continue conveying his passion for mathematics to students.