COMBSTRU

Combinatorial Structure of Intractable Problems

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Combinatorial structure lies at the core of many decision, optimization and counting problems, which are difficult to compute and are relevant in many scientific, technological and social areas. Since the early development of complexity theory in the early 70's, an important mainstream of the research towards solving difficult problems has focused in what features on intractable problems distinguish the easy and the hard instances. The new interdisciplinary approach to study the combinatorial structure of these problems, which we develop in this proposal, could give a new perspective to understanding the opposed degree of difficulty for different instances of the same problem. The key to this understanding can lay in many and diverse aspects. The paradigmatic example is the Theory of Graph Minors, which revolutionized the study of algorithms in computer science. We aim to study intractable problems by

- stressing their differences and common features.
- classifying instances of particular problems by useful invariants or parameters.
- building common frameworks for apparently unrelated problems.

Typical examples of the structural approach in Combinatorics are

- Developing techniques analogous to the wonderful theory of graph minors of Robertson and Seymour, which has revolutionized computer science algorithms.
- Analyzing general structures, such as matroid, which have shown how graphs, algebra and geometric theories are of related nature.
- homomorphism based attacks on coloring problems, which are the core of many crucially important practical problems, typified by the Channel Assignment problem and by problems on optical networks.
- Study the phase transition that happens for some of these problems, as the instances evolve according to a choose parameter, and which could hint at the distribution of worst-case instances.

The fragmentation of expertise in these fields among European research groups demands the mobilization of a wide effort to coordinate different teams and leading scientists towards the achievement of a common goal. The growth of the organized consortium DIMATIA in the past five years, which gathers most of the partners in this proposal and is mainly focused on the described approach, provides the ground to ensure the success of such a project.

The high requirements in mathematical and scientific education of the above mentioned approach, together with the strong connection with current practical problems arising from real life applications in a broad scope of areas (such as computational biology and internet), gives an excellent opportunity for developing an European training system in the framework of this project. The development of such structural approach to combinatorial problems can be only provided by educating young researchers over a broad range of areas of pure and applied mathematics and computer science.

Participating Institutions

This project is an direct consequence of mutual experience of activity and previous work of research teams within DIMATIA network and previous cooperation with networks like ALTEC, ASMICS, DIMANET or DONET.

Integral part of our collective research experience is the European consortium DIMATIA, (*Discrete Mathematics, Theoretical Informatics and Applications*), which includes seven institutions involved in the project (Barcelona, Bielefeld, Bordeaux, Budapest, Pisa, Patras, and Prague), visit http://www.ms.mff.cuni.cz/acad/kam/dimatia. The center, formed in 1996 is generally viewed as the only European counterpart of DIMACS (*Discrete Mathematics and Computer Science*), a highly successful center which is in existence for more than 10 years, one of the national research centers in the US located at Rutgers university). DIMATIA organizes a variety of activities in all its partnership institutions including regular annual meetings, midsummer workshops, spring schools and both graduate for undergraduate students, and is a site of projected ERCIM working group on Theoretical Computer Science.

The continuation of the DIMATIA operation on the pan-European level is the core of this project. We believe that in the area described in the project Europe has strong competitive edge with is directed to future and young researches in boundary discipline of mathematics, computer science and applications.

The research teams of our project, while motivated by this broad activity, form a closely knit consortium, which is focused on the concrete goals of this proposal. We build a network of teams which mutually complement the advantages and existence of partners involved.

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