



Title of Project : A multifaceted approach toward understanding the limitations of computation

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【Purpose of the Research Project】

The goal of this project is to establish strong mathematical foundations for understanding the limits of computation. In particular, we will develop various fundamental results that would suggest the next step toward resolving the $P \neq NP$ conjecture.

Mathematics has traditionally been regarded as the “language” of the sciences. In recent times *Computation* has become another “language” common to various scientific fields.

Although computation is pervasively in our daily lives, our understanding of computation is still partial. One typical example is the limit of the efficiency of algorithms. For solving a given computational problem, there are various algorithms, and designing efficient algorithms is one of the important subjects in computer science. On the other hand, one can easily expect that there should be a limit; for any problem, there should be a theoretical limit of improving its algorithmic efficiency. Unfortunately, however, we have not been able to understand such limits for most of the problems around us. An important question on the limits of computation is the $P \neq NP$ conjecture. Our goal is to develop techniques and theories for pushing the frontier of our understanding of the inherent limitations of algorithms, thereby advancing our understanding of computation.

【Content of the Research Project】

The 1990's saw various new techniques and exciting results on the limits of computation. Throughout the 2000's, these techniques were continually sharpened. Based on these efforts, we may soon enter the stage of expecting some big breakthrough results toward understanding the limits of computation. In this project, we will investigate these techniques and relationships among them and derive some multiple theories suggesting the next steps toward a big breakthrough. Motivated by this goal, world leading experts on various aspects of computations are uniting to form a research cloud consisting of nine groups investigating

computational limits from different view point. By intensively collaborating each other, we will explore the potential of various technique for bounding the limits of computation. Specifically, for typical techniques for analyzing computational lower bounds, we shall (i) give new interpretation as to how and why through the discussion by researchers with different scientific viewpoints, (ii) derive new relationships between these techniques and obtain new applications, and (iii) apply this knowledge to get innovative results, pushing the frontier of our understanding of the limits of computation. This is our research framework of this project.

【Expected Research Achievements and Scientific Significance】

We believe that the above explained research framework is strong enough to obtain many fundamental results, from which we may see new steps toward the $P \neq NP$ conjecture. Such results must reveal some aspects of computation; thus, although these are purely mathematical, they may lead some novel algorithms, new computational concepts, and even new areas for computation.

【Key Words】

NP problem: A computational problem such that for each given input, checking its solution candidate is relatively easy. This type of problem can be found in almost all fields of the sciences.

$P \neq NP$ conjecture: A conjecture claiming that there is some NP problem such that no efficient algorithm can compute its solutions.

【Term of Project】 FY2012-2016

【Budget Allocation】 536,500 Thousand Yen

【Homepage Address and Other Contact Information】

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