Doing Research under Extreme Conditions

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Despite drastic cuts to university and research institute budgets, research activities by Iranian scientists has continued. This article presents work being performed by the Complex System Group at the University of Zanjan. Most of the computational works are carried out on multicore processors or parallelized manually on different PCs.

Knowledge promotion is one of the simplest and most direct ways to improve life in all its dimensions. The main responsibility for such promotion lies with scientists. There is no difference between scientists around the world—together they form a unique body, without consideration for geographic region. Any deletion or omission would damage this body and, consequently, have an unfavorable impact on the ideal picture of a peaceful world. As scientists, our mission is to protect world peace and human dignity. Therefore, we should keep our integrity and eliminate obstacles to scientific research.

In the following article, I describe the difficult research conditions in Iran, including being deprived of access to needed facilities, particularly for high-performance computing (HPC). I also explain our efforts to overcome these difficulties.

THE COMPLEX SYSTEMS GROUP AT THE UNIVERSITY OF ZANJAN

The University of Zanjan is a public university located in Zanjan, the capital of the Zanjan province and one of the largest cities in the Iranian Azerbaijan region. It is situated 298 km northwest of Iran’s capital, Tehran.

Founded in 1975, the University of Zanjan is one of the largest universities in the country. It has four faculties—engineering, sciences, humanities, and agricultures—and hosts a community of approximately 400 faculty members and more than 10,000 students.

The University of Zanjan’s Department of Physics was established in 1989 as a part of the Faculty of Sciences. Nowadays, the department includes 27 faculty members working on the major fields of condensed matter physics, nanophysics, complex systems, atomic-molecular physics, and astrophysics.
The University’s Complex Systems Group (CSG), which I head, began in 2006 by taking master’s and doctoral students. In CSG, we investigate the statistical and dynamical properties of various complex systems to understand the governing rules of their behaviors and the underlying physics. Currently, CSG includes one faculty member, five PhD graduates, and six PhD students (see Figure 1). We also collaborate with researchers and faculties at other universities, whether in Iran or abroad.

![Figure 1. Members of the Complex Systems Group, in front of the University of Zanjan’s Faculty of Sciences (April 2010).](image)

**COMPLEX SYSTEMS GROUP ACTIVITIES**

Here, I briefly describe the projects that have been accomplished by or are currently underway in our group.

**Structural Properties of Real Complex Networks**

Most of our research in this area focuses on the properties of earthquake networks. Our aim is to find connections among the topological properties of earthquake networks and the empirical laws of seismicity. We are also interested in research on earthquake forecasting.1–5

**Dynamical Processes on Complex Networks**

Our main object here is studying how the dynamics of a process are affected by the mesoscopic structural properties of networks. The existence of chimera-like states in the synchronization process, suppression of explosive synchronization, and changes in the spreading rate of diseases are just a few of the consequences of the mesoscopic structure of networks.6,7

Environmental randomness also influences the dynamics of a process. For example, in the voting process, the rate of consensus changes when some nodes with constant opinion (zealots) exist. The fixation probability and fixation time are significantly altered in the evolutionary dynamics if we consider random distribution for wild-type or mutant fitness (see Figure 2).8–10

**Natural Language Complexity**

Text can be considered a complex system: words are its constituents that interact with one another through grammatical rules and meanings. The concept of a text is the collective behavior of the words within it. We are interested in studying the properties of text by using methods such as fractal pattern analysis, complex network theory, and nonextensive statistical mechanics. The results are used for text-mining issues and genomic and proteomic data analysis.11–17
Fractal Structures in Complex Fluids

In this area, our goal is the experimental and theoretical study of complex fluids. Fractal structures in fluids is the main theme of our research. In particular, we are interested in studying the spread of surfactants and their instabilities on fluid layers. We intensively use image processing algorithms to find the fractal dimension of the observed structures in our works.

Time-Series Analysis

We are taking two approaches to time-series analysis. First, we are interested in unifying and finding the relation among different methods for measuring complexity in systems. Second, we are analyzing complexity in real systems. Quantifying climate change, classifying climate, and diagnosing brain (psychological) diseases from associated series are also topics of interest.

TRAINING FOR HIGH-PERFORMANCE COMPUTING

The students in our department are taught HPC through short (one-day) unofficial courses. They are acquainted with the concept of parallel programming, multicore processing, CPU cluster computing, and the parallel algorithms on GPU. Unfortunately, we are faced with a lack of facilities to provide HPC. Although a few private companies and public institutions provide HPC services, they are more expensive and university funding cannot cover the cost of using them. International services are beyond our reach. For a long time, our requests to download open source software were rejected by sites such as Sourceforge, Nvidia, and Google Code. Many Iranian scientists have unofficially used HPC services in foreign institutes and universities with the help of their colleagues in other countries. I personally had the opportunity to use a cluster with 192-nodes during sabbatical leave at the University of Waterloo in Canada.

The CSG office in the Faculty of Sciences building, where our group members perform their studies, is equipped with multicore PCs. They are used for simulations and calculations with OpenMPI and Openmp but can hardly meet our research demands. We had access to 64-node cluster processors but it is down due to maintenance difficulties (buying spare parts) and university budget cuts. Hence, we face difficulties with numerical and simulation works. We are trying to get financial support from the Ministry of Science, Research and Technology, but this is a bureaucratic, time-consuming process.
Moreover, restrictions on international money transfer cause many problems for us. For instance, this issue has affected payment of fees for publication of our reports or participation in scientific events.

CONCLUSIONS

As a final point, on behalf of CSG, I would like to express appreciation for our colleagues around the world for their spiritual and material support. This is what makes our world a better place in which to live. We also thank Nature Springer and the Public Library of Science for helping us by waiving publication fees. Our special thanks goes to the editors of *Computing in Science & Engineering* for publishing this article.

REFERENCES


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