Journal of Computational and Applied Mathematics 227 (2009) 1–4

Contents lists available at ScienceDirect

Journal of Computational and Applied Mathematics

journal homepage: www.elsevier.com/locate/cam

Preface

Introduction

The CONFERENCE IN NUMERICAL ANALYSIS (NumAn 2007) RECENT APPROACHES TO NUMERICAL ANALYSIS: THEORY, METHODS AND APPLICATIONS was held during September 3–7, 2007, in Kalamata, Greece. The approximately 120 participants came from Brazil, Canada, Cyprus, France, Greece, Israel, Italy, Japan, Romania, Russia, Switzerland, United Kingdom and the United States.

The web page of the Conference is hosted at the University of Patras and is accessible on the Internet at http://www.math.upatras.gr/numan2007/.

The aims of the Conference were:

- to bring together and bequeath scientific activities, directions and pursuits of scientists in Greece and abroad on subjects that pertain to the Conference,
- to foster an exchange of views and ideas,
- to study the theoretical background required for methods, algorithms and techniques used in applications,
- to search directions of theoretical results towards applications,
- to highlight open problems and future directions of numerical analysis.

The members of the Conference Organizing Committee were E. Gallopoulos, E.N. Houstis, I.S. Kotsireas, D. Noutsos and M.N. Vrahatis. The members of the Local Organizing Committee of the Conference were H.N. Vrahati, I.S. Kotsireas and M.N. Vrahatis.

Numerical analysis

Before attempting a presentation of Numerical Analysis, we would like to mention the teachings of **Plato**[1] (427–347 B.C.). In the famous work "**The Republic**" (Book 7) we read:

> *And all arithmetic and calculation have to do with number?*

In the famous work "**Laws**" (Book 5) we read:

> *The legislator is to consider all these things and to bid the citizens, as far as possible, not to lose sight of numerical order; for no single instrument of youthful education has such mighty power, both as regards domestic economy and politics, and in the arts, as the study of arithmetic. Above all, arithmetic stirs up him who is by nature sleepy and dull, and makes him quick to learn, retentive, shrewd, and aided by art divine he makes progress quite beyond his natural powers.*

The branch of science that is mainly concerned with numbers is **Numerical Analysis** which is considered as the art and science of computation.

The roots of Numerical Analysis are lost in ancient times. The **Babylonians** had started to construct mathematical tables since 2000 B.C. as we learn from a clay tablet containing the squares of the integers from 1 to 60. Moreover, the Babylonians worshiped the celestial bodies and kept detailed astronomical measurements. The great Greek mathematician and astronomer from Alexandria **Claudius Ptolemaeus** (middle of the 2nd century A.D.) possessed a Babylonian text that contained the dates of the eclipses of the Sun and the Moon since 747 B.C. In about 220 B.C. **Archimedes** discovered an approximative method based on inscribed and circumscribed regular polygons on a circle and using this method in his

[1] The translation has been taken from the website http://classics.mit.edu/.

0377-0427/$ – see front matter
doi:10.1016/j.cam.2008.07.015

celebrated work "**On the Measurement of the Circle**" he proved that the ratio of the perimeter of the circle over its diameter, i.e. the number π, is between $3\frac{10}{71}$ and $3\frac{1}{7}$. So Archimedes was the first person to discover the "limiting process" that he called "method of exhaustion", with which we can compute the areas of many shapes. While Archimedes' method of exhaustion was widely known, the details of Archimedes' calculations in the various applications of the method became known only in 1906, when the Danish philologist and historian Johan Ludvig Heiberg (1854–1928) unearthed the Archimedes Palimpsest in Constantinople. The Archimedes Palimpsest contains a manuscript of Archimedes to Eratosthenes titled "The Method of Mechanical Theorems". In this manuscript Archimedes explains the infinitesimal techniques that he used to prove his theorems referring to them with the name "the method".

The development of numerical analysis is closely related to computers. One of the purposes of numerical analysis is the transformation of mathematical problems in equivalent problems that can be processed by a computer so that they can be solved numerically. Such problems are for instance the solution of linear and nonlinear (systems of) algebraic equations, the approximation of functions, the solution of differential equations, the optimization of functions etc. So, numerical analysis is useful and often indispensable in other branches of applied mathematics, such as computer science, mechanics, computational dynamics, operational research, computational intelligence, data mining, cryptography, statistics etc. In addition, it is useful in other areas of applied sciences such as physics, astronomy, computational biology, physics of medicine, computational chemistry, meteorology, shipbuilding, topography etc.

In order to achieve the transformation of mathematical problems into problems that can be processed by a computer, numerical analysis develops "appropriate" methods. A method is termed appropriate when it yields with accuracy and certainty the required result, with the smallest possible computational cost in combination with the smallest possible required storage space (memory) for the intermediate results. The methods, that arise, are being described as algorithms (i.e. finite sequences of well defined numerical operations and logical expressions) so that they are implemented into computer programs. Numerical Analysis can be split into two related parts: (a) the theoretical part which is concerned with the creation of appropriate methods and (b) the applied part which is concerned with the implementation of the methods on a computer.

Unfortunately, in numerical analysis there is no "panacea", meaning that for each category of problems there is no particular appropriate method. There are various different methods available for solving a particular problem, each one with its advantages and disadvantages. It is of vital importance to lay out a detailed pre-processing scheme, in order to complete successfully a particular computation. It is of equal importance to treat very carefully the issues pertaining to accuracy, errors, and verification.

Based on the previous discussion, we can say that Numerical Analysis is the development and evaluation of methods for the computation of numerical results from numerical or exact input data. So Numerical Analysis could also be viewed as a kind of information processing, where the data are the input, the results are the output and the method of computation is the algorithm.

Synopsis of the NumAn 2007 conference activities

Monday, September 3, 2007

Opening Ceremony: The President of the Organizing Committee and Professor of the University of Patras, Dr. M.N. Vrahatis, addressed the Conference participants and declared the opening of the Conference. The Vice-Mayor of Kalamata, Honorable Mr. Nikos Basakidis and the representatives of the Holy Metropolis of Messinia addressed the Conference participants and wished them to have a very successful Conference and a pleasant stay.

The first invited speaker was Academician Nikolaos Artemiadis, ex-president of the Academy of Athens. The title of his talk was "**Educational Systems in Mathematics and Other Related Topics**".
The second invited speaker was Academician Athanassios Fokas, Professor at the University of Cambridge, England, UK. The title of his talk was "**Integrability, boundary value problems and imaging**".
The third invited speaker was Academician Panos Ligomenides. The title of his talk was "**The Reality of Mathematics**".
Two sessions with thematic titles "**Numerical methods for structured matrices**" and "**Boundary problems**" were held.

Tuesday, September 4, 2007

The first invited speaker was Professor Theodore S. Papatheodorou, Director of the High Performance Computing Laboratory of the University of Patras. The title of his talk was "**New numerical techniques for the resolution of initial and boundary value problems, based on Fokas transforms**".
The second invited speaker was Professor Dimitri Bertsekas, McAfee Professor of Engineering at the Massachusetts Institute of Technology, MIT, USA, and elected member of the United States National Academy of Engineering. The title of his talk was "**Approximate Solution of Very Large Linear Systems of Equations by Simulation**". He presented new algorithms for the solution of very large linear systems that arise in applications (e.g. 2^{200} equations with 2^{200} unknowns) using dynamic programming.
The first session of the day was titled "**Partial Differential Equations**". The talks were given by distinguished scientists from the Crete Polytechnic Institute and the University of Cyprus.
The second session of the day was titled "**Methods of resolution of linear and nonlinear systems and their applications**".

The talks were given by distinguished scientists from the Universities of Patras, Athens and Cyprus as well as from Israel and England.
The third session of the day was titled "**Methods of computational intelligence and their applications in real problems**". The talks were given by distinguished scientists from the Universities of Patras, Athens, the Demokritus University of Thrace and the University of London.

Wednesday, September 5, 2007

The first invited speaker was Professor Constantine Dafermos, Brown University, member of the Board of Governors, Weizmann Institute of Science, Israel, and corresponding member of the Academy of Athens. The title of his talk was "**Hyperbolic Balance Laws with Dissipation**".
The second invited speaker was Professor Anastasios Bountis, Director of the Research Center for Nonlinear Systems of the University of Patras. The title of his talk was "**A new method of studying order and chaos in conservative dynamical systems**".
The following session was titled "**Partial Differential Equations**". The talks were given by distinguished scientists from the University of Toronto and Brazil.
In the afternoon, the Conference participants visited the city of Ancient Messini and attended a reception sponsored by the Mayor Mr. Konstantinos Georgakopoulos and the Vice-Mayor Mr. Evangelos Kapsias. It was a very good opportunity for the distinguished Conference participants to witness the messinian hospitality and to enjoy the rich cultural heritage of the area. The comprehensive guide to the vast, well-preserved and magnificent archeological site from the responsible archeologists and Mr. Vice-Mayor was particularly appreciated.

Thursday, September 6, 2007

The first invited speaker was Professor Apostolos Hadjidimos, University of Thessaly, Professor Emeritus of the Universities of Ioannina and Crete. The title of his talk was "**Extrapolation and Cayley Transforms**". The speaker dedicated his talk to the victims of the then recent catastrophical fires in Greece.
The following two sessions were titled "**Computational Linear Algebra and Applications**". The talks were given by distinguished scientists from Greece, Japan, USA and Switzerland. The speakers presented new methods and techniques of Computational Linear Algebra that are applied in hard real life problems such as the computation of electronic structures that will be used in the design of semiconductors as well as the huge computational problems that arise during the recovery and date processing on the internet.
The next session was titled "**Nonlinear and dynamical systems**". The talks were given by researchers from Greece, France and Brazil, who presented techniques for the solution of nonlinear systems, methods for locating periodic orbits and other applications. The real life problems tackled by these methods arise in several different areas of Science, such as Medicine (modelling of electroencephalograms), Biology, Meteorology and Computer Science.
The scientific program of the day closed with a panel discussion featuring the Conference invited speakers. During the discussion, a number of constructive opinions were proposed and debated. In addition, several Conference participants had the chance to interact with the members of the panel.
The Conference dinner was held at the end of the day. It was attended by the Conference participants, as well as dignitaries from the Kalamata City Hall and the Messinia Municipality. The invited speakers and Captain Vassilis Konstantakopoulos received especially designed commemorative gifts. The remaining dinner participants received gifts as well. The President of the Conference Organizing Committee, Prof. Michael N. Vrahatis, addressed the dinner participants and thanked wholeheartedly the Conference sponsors: the Holy Metropolis of Messinia, the Messinia Municipality, the Kalamata City Hall, the Municipality of Ithomi, the Local Union of Messinia Municipalities, the University of Patras, Wilfrid Laurier University, Captain Vassilis Konstantakopoulos, Maplesoft, MP & Associates, Mrs. Eleni N. Vrahati, AGREXOP S.A. Giogros Gkoumas, Eleni N. Vrahati Insurances and Antonis Psonis et al. He also thanked the hotel Elite for their hospitality and efficiency. The Vice-President of the Conference Organizing Committee, Prof. Ilias S. Kotsireas presented an award sponsored by Maplesoft, to Mr. Aristidis G. Vrahatis, Vassilios I. Galanis, Michael G. Epitropakis and Emmanuel K. Oikonomakis. The award comprised a Maple 11 box of the approximate value of 1,000 euros.

Friday, September 7, 2007

The invited speaker of the day was Professor Constantino Tsallis, member of the Sante Fe Institute and the National Academy of Sciences of Brazil. The title of his talk was "**Entropy, nonextensive statistical mechanics, and numerical applications**".
The following two sessions were titled "**Differential Equations**". The talks were given by distinguished scientists from Greece, Cyprus and Italy, on topics from semi-elliptic differential equations to theoretical mathematics.
The next session was titled "**Applications of Numerical Analysis and Computational Intelligence**". The talks were given by researchers from Greece and Brazil.

The scientific program of the day closed with a review of the Conference activities, during which many constructive observations and suggestions were put forward and discussed. It is important to note that many Conference talks were broadcasted live through the internet in the Universities of Patras and Cyprus.

Closing Ceremony: The President of the Conference Organizing Committee, Prof. Michael N. Vrahatis, thanked the Conference participants and wished that since NumAn 2007 was so successful, it would be nice for NumAn 2008 to be held in the beautiful and hospitable city of Kalamata as well.

Acknowledgments

Besides the undersigned who acted as referees at various stages of the evaluation process the Guest Editors would like to mention the following colleagues whose help in the evaluation of the manuscripts included in the present Special Issue was invaluable. Their contribution towards this edition is gratefully appreciated and acknowledged: Professors George Akrivis, Carlos J.S. Alves, C. Rodolfo Araya, Costas Bekas, Peter Blossey, Kevin Burrage, C.S. Chen, Anthony Chronopoulos, Graeme Fairweather, Luca Gemignani, Peter R. Graves-Morris, Johan Helsing, Jacques Henrard, Nicholas J. Higham, Dimitris Iakovidis, Jean-Claude Jolly, Tilemachos J. Kalvouridis, Stavros A. Karkanis, George D. Magoulas, Jose Mario Martinez, Nicola Mastronardi, Erik Mosekilde, Konstantinos E. Parsopoulos, Yousef Saad, Eric Sonnendrucker, Andreas Stathopoulos, Stephen Thomas, Dale R. Welch, and Apostolos Yeyios.

Last but not least, the Guest Editors would like to express their cordial thanks to Professor Luc Wuytack, Principal Editor of Journal CAM, without the help of whom this Special Issue would not be possible and also the Publishers of the *Journal of Computational and Applied Mathematics*, Elsevier B.V.

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