

Preface

The 5th International Congress on Mathematical Software (ICMS 2016) was held during July 11–14, 2016, at the Zuse Institute in Berlin, Germany. There were four invited plenary talks and 139 contributed talks. From the submitted extended abstracts, 68 were accepted for the present proceedings.

The scope of mathematics is as broad as human thought. With the ever-increasing power and pervasiveness of technology, computation has emerged as a tool of mathematics rivaling (and many would say surpassing) proof. Many problems and models of wide interest in engineering and science are too complicated for step-by-step human solution in any reasonable time frame, but require solution immediately (although often not completely certain). We agree with the following statement in the preface to the ICMS 2014 volume:

We in the International Conference of Mathematical Software believe that the appearance of mathematical software is one of the most important modern developments in mathematics, and this phenomenon should be studied as a coherent whole. Our vision for ICMS is to serve as the major forum for mathematicians, scientists, programmers, and developers who are interested in software. Software is not static: Anyone who uses software knows that its typical “half-life” is frustratingly short: But it compiled properly just last year! There is constant renewal, development, and disruptive changes. It is partly caused by new mathematical advances, but often the pressure is from technological changes, e.g., the appearance of graphics processing units (GPUs).

Jack Dongarra in his invited paper discusses the major (and disruptive) changes that moving to “extreme scale” computing will cause. Exoscale computing and the importance of locality are leading to a new generation of algorithms and software.

Computation is a tool not only for applications to other subjects, but also for the modern development of mathematics. As in the wider world of engineering and science, computation that forms a proof as well as computation that constructs objects and reaches conclusions that are not completely certain have important roles. In his plenary talk, Wolfram Decker discusses the challenges to and progress in the integration of a number of powerful open source computer algebra software packages into a next-generation computer algebra system.

The knowledge base of mathematics, including theorems, precise definitions of objects, and a huge constellation of examples, is the bedrock for the development of new algorithms and software. Stephen Watt described in his plenary talk the progress toward the goal of an international mathematical knowledge base useable by individuals and software systems alike.

But computational mathematics and software goes even deeper, right down to the roots of the logical and constructive foundations of mathematics. In 2009 Vladimir Voevodsky added the concept of h-level (homotopy level) and the “univalence axiom” to homotopy type theory, where the basic objects are homotopy types and which

replaces set-theoretic formalizations of mathematics. This so-called univalent foundation had far-reaching consequences. It can be regarded as a new foundation for mathematics in general but it also allows mathematical proofs to be formalized, i.e., translated into the formal language that can be processed by a computer proof assistant, much more easily than before. In his plenary talk, Voevodsky explained how “univalent models” of type theories allow for the direct formalization of constructive mathematics and the formalization of classical mathematics by adding the axiom of excluded middle and the axiom of choice for types of certain h-levels. A considerable amount of mathematics has been formalized in the Coq library UniMath using the univalent point of view.

We are thankful to all the individuals whose effort and support made ICMS 2016 possible: the plenary speakers, all the contributors of abstracts and extended abstracts, the special session organizers, and the LNCS team at Springer under the leadership of Alfred Hofmann. We benefited from the experience of the ICMS Advisory Board chaired by Professor Nobuki Takayama and from Professors Chee Yap, Hoon Hong, and Deok-Soo Kim. Last but not least, we acknowledge the work of the local chair, Professor Thorsten Koch, and his committee at the Zuse Institute.

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Gert-Martin Greuel
Thorsten Koch
Peter Paule
Andrew Sommesse

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Greuel, G.-M.; Koch, T.; Paule, P.; Sommese, A. (Eds.)

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