CARMA AND ME
PREPARED FOR
CRM/UWS OPENING 28-05-2014
(AND CARMA ANNUAL RETREAT)

Jonathan M. Borwein FRSC FAA FBAS FAAAS

Laureate Professor & Director of CARMA, University of Newcastle

Priority Research Centre for
Computer Assisted Research Mathematics and its Applications

Revised: May 22, 2014
Title with apologies to:


Congratulations to All
CARMA’s Leadership

- Government, Industry and Academia: Australia and Overseas
- All have close connections with Newcastle

Jonathan Borwein, 2014

http://www.carma.newcastle.edu.au/jon
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CARMA’s Support Staff

Mrs Juliane Turner (EA)  Dr David Allingham (Scientific officer)  Andrew Danson (‘AGR’)

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  – **AGR** (Access Grid Room) is a misnomer: it is really an **ACE**
**Experimental mathematics** is the use of a computer to run computations—sometimes no more than trial-and-error tests—to look for patterns, to identify particular numbers and sequences, to gather evidence in support of specific mathematical assertions that may themselves arise by computational means, including search.

Like contemporary chemists—and before them the alchemists of old—who mix various substances together in a crucible and heat them to a high temperature to see what happens, today’s experimental mathematicians put a hopefully potent mix of numbers, formulas, and algorithms into a computer in the hope that something of interest emerges. (JMB-Devlin, 2008, p. 1)

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Top Ten Algorithms:

all but one well used in CARMA

Algorithms for the Ages

"Great algorithms are the poetry of computation," says Francis Sullivan of the Institute for Defense Analyses' Center for Computing Sciences in Bowie, Maryland. He and Jack Dongarra of the University of Tennessee and Oak Ridge National Laboratory have put together a sampling that might have made Robert Frost beam with pride--had the poet been a computer jock. Their list of 10 algorithms having "the greatest influence on the development and practice of science and engineering in the 20th century" appears in the January/February issue of Computing in Science & Engineering. If you use a computer, some of these algorithms are no doubt crunching your data as you read this. The drum roll, please:

1. **1946: The Metropolis Algorithm for Monte Carlo.** Through the use of random processes, this algorithm offers an efficient way to stumble toward answers to problems that are too complicated to solve exactly.

2. **1947: Simplex Method for Linear Programming.** An elegant solution to a common problem in planning and decision-making.

3. **1950: Krylov Subspace Iteration Method.** A technique for rapidly solving the linear equations that abound in scientific computation.


5. **1957: The Fortran Optimizing Compiler.** Turns high-level code into efficient computer-readable code.


7. **1962: Quicksort Algorithms for Sorting.** For the efficient handling of large databases.

8. **1965: Fast Fourier Transform.** Perhaps the most ubiquitous algorithm in use today, it breaks down waveforms (like sound) into periodic components.


10. **1987: Fast Multipole Method.** A breakthrough in dealing with the complexity of n-body calculations, applied in problems ranging from celestial mechanics to protein folding.

Experimental Mathematics:

Secure Knowledge without Proof. Given real numbers $\beta, \alpha_1, \alpha_2, \ldots, \alpha_n$, Ferguson’s integer relation method (PSLQ), finds a nontrivial linear relation of the form

$$a_0\beta + a_1\alpha_1 + a_2\alpha_2 + \cdots + a_n\alpha_n = 0,$$

where $a_i$ are integers—if one exists and provides an exclusion bound otherwise.

- If $a_0 \neq 0$ then (1) assures $\beta$ is in rational vector space generated by $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$.
- $\beta = 1, \alpha_i = \alpha^i$ means $\alpha$ is algebraic of degree $n$.
- 2000 Computing in Science & Engineering: PSLQ one of top 10 algorithms of 20th century

(2001 CISE article on Grand Challenges (JB-PB))
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**Experimental Mathematics:**

**Carving His Own Unique Niche, In Symbols and Stone**

By refusing to choose between mathematics and art, a self-described "misfit" has found the place where parallel careers meet.

**Profile: Helaman Ferguson**

**(BYU)** in Provo, Utah. What is unusual is how successfully he has pursued a dual career as mathematician and artist and the way he has brought the two together.

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**Jonathan Borwein, 2014**

**CARMA and Me**

http://www.carma.newcastle.edu.au/jon
Experimental Mathematics: PSLQ is core to CARMA


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CARMA and Me http://www.carma.newcastle.edu.au/jon
Exploratory Experimentation and Computation

David H. Bailey and Jonathan M. Borwein

The authors’ thesis — once controversial, but now a commonplace — is that computers can be a useful, even essential, and to mathematical research.

Jeff Shallit wrote this in his recent review (8624276) of [10]. As we hope to make clear, Shallit was entirely right in that many, if not most, research mathematicians now use the computer in a variety of ways to draw pictures, inspect numerical data, manipulate expressions symbolically, and run simulations. However, it seems to us that there has not yet been substantial and intellectually rigorous progress in the way mathematics is presented in research papers, textbooks, and classroom instruction or in how the mathematical discovery process is organized.

Mathematicians Are Humans

We share with George Polya (1887–1985) the view [12, p. 2] that, while important, intuition comes to us much earlier and with much less outside influence than formal arguments.

David H. Bailey is Chief Technologist of the Computational Research Department at Lawrence Berkeley National Laboratory. He earned a B.A. from Harvard, a Ph.D. from the University of California at Berkeley, and has held several positions at IBM, Lawrence Livermore National Laboratory, and Lawrence Berkeley National Laboratory. Jonathan M. Borwein is Associate Professor at the Centre for Computer Assisted Research Mathematics and its Applications (CARMA) at the University of Newcastle. His email address is jonathan@carma.newcastle.edu.au.

NOTICES OF THE AMS
VOLUME 58, NUMBER 10

AMS Embargoed PR

Notices of AMS 2011: ... and hundreds of online re-publications

Jonathan Borwein, 2014

http://www.carma.newcastle.edu.au/jon/
CARMA’s Mandate

Mathematics, as “the language of high technology” (Tom Brzustowski) which underpins all facets of modern life and current Information and Communication Technology (ICT), is ubiquitous. No other research centre exists focusing on the implications of developments in ICT, present and future, for the practice of research mathematics. CARMA fills this gap.

Through exploitation and development of techniques and tools for computer-assisted discovery and disciplined data-mining including mathematical visualization.

CARMA’s Access Grid Room (2008)

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CARMA’s 2008 Objectives: largely met

To perform R&D relating to the informed use of computers as an adjunct to mathematical discovery (including current advances in cognitive science, in information technology, operations research and theoretical computer science)

- Of mathematics underlying computer-based support systems and to undertake mathematical modelling of such activities
- To promote and advise on use of appropriate tools (hardware, software, databases, learning object repositories, mathematical knowledge management, collaborative technology) in academia, education and industry [Global quick success, locally slower]
- To make University of Newcastle a world-leading institution for Computer Assisted Research Mathematics and its Applications¹

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Communication and Computation: are entangled


CARMA’s ‘Deep’ History

(Daniel Lord Smail)

A co-evolution of symbolic/numeric (hybrid) computation, experimental maths, collaborative technology and HPC.

Experimentally-found modular fractal took three hours to print in 2003.

1982 PBB & JMB ‘minor’ work on fast computation at Dalhousie; experimental mathematicians before term was current.²

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- (unreasonable) persistence—with senior administrators
- having a clear set of (attainable but ambitious) targets
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CARMA’s Structure and Membership

Currently **36** Members, 8 Associates, 7 Student Members:

- Steering Committee (George Willis FAA, Deputy Director)
- External Advisory Committee (IBM (GAJ chair), Melb, LBL)
- Scientific, Administrative and AGR Officers
- Members and Students from Newcastle and External Members from Everywhere: http://carma.newcastle.edu.au/people/

Frequent visitors: both student and faculty, short and long-term

CARMA’s AMSI AGR and Inner Sanctum Rooms

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Scientific Activities carma.newcastle.edu.au/carmaevents.shtml

- **Regular Colloquia and Seminar Series**
  - ΣOpt over AG, Group Theory
  - Int’l Webinar, Discrete Maths, Education, Applied Analysis and Number Theory, Student

  - ANZIAM SIGMAopt AGR Seminar with UoSA and RMIT
  - Trans Pacific Workshop: with UBC-O and SFU (monthly-ish)
  - Short Lecture Series (2-5 lectures)
    - 2010 Rockafellar *Risk* and Diestel *Haar measure*
    - 2011 Cominetti *Scheduling* and Zhu on *Finance*
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- **IP Down Under** for INFORS 2011 (July 2011)
- **van der Poorten memorial meeting** (March 2012), **EViMS** (Nov) and **ICERM** (Dec)
- **ANZIAM 13** (Feb 3-7), **SPOM** (Feb 9-12) & **MPE13** (July)
- **2013–14** Eight more Workshops (2 at ANU, 1 at **ICERM**) and Student Conf. All have some external funding.
  - Sept 13: Hickson (Infectious Diseases)
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**AGR**  Grid-enabled connected-rooms for classes, seminars, meetings:

- **V205** for dis-located collaboration;
- **V206** for co-located collaboration.

**HPC**  104 core MacPro x-grid Cluster; 144-core HTCondor cluster (64 GB) (RedHat); 12-core (24 hyperthreaded) Linux server (192 GB RAM) + access to NSW/National compute services.

**Web Services** include various archives and:
- DocServer http://docserver.carma.newcastle.edu.au:
  - CECM → DDRIVE → CARMA Archie → Mosaic → Google
- Inverse symbolic calculator (ISC Plus)
  http://isc.carma.newcastle.edu.au
- BBP digit database http://bbp.carma.newcastle.edu.au
- The Top Ten Numbers University Outreach
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- **The Top Ten Numbers University Outreach** http://numbers.carma.newcastle.edu.au
- **Maths Hunter** http://ask.carma.newcastle.edu.au for School Outreach: β-test
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**HPC** 104 core MacPro x-grid Cluster; 144-core HTCondor cluster (64 GB) (RedHat); 12-core (24 hyperthreaded) Linux server (192 GB RAM) + access to NSW/National compute services.

**Web Services** include various archives and:

  - CECM → DDRIVE → CARMA Archie → Mosaic → Google

- **Inverse symbolic calculator** (ISC Plus)
  - [http://isc.carma.newcastle.edu.au](http://isc.carma.newcastle.edu.au)

- **BBP digit database** [http://bbp.carma.newcastle.edu.au](http://bbp.carma.newcastle.edu.au)

- **The Top Ten Numbers University Outreach**
  - [http://numbers.carma.newcastle.edu.au](http://numbers.carma.newcastle.edu.au)

- **Maths Hunter** [http://ask.carma.newcastle.edu.au](http://ask.carma.newcastle.edu.au) for School Outreach: β-test

Jonathan Borwein, 2014
Note #1 on Walks (see next page)

Request to Members:

1. Remember there is seed funding and help for all good projects: (http://carma.newcastle.edu.au/reads/)

2. Bookmark the Home page

3. Regularly monitor Events and make sure they are advertised

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CARMA and Me  http://www.carma.newcastle.edu.au/jon/
Walking on Real Numbers
A Multiple Media Mathematics Project

Visit our extensive WALKS gallery.

PUBLICATIONS
View our article from the Mathematical Intelligencer, as well as related publications. In this section.

PRESENTATIONS
This section contains presentations related to our research.

PRESS SVMRACGE
We have received coverage in the popular press for our work! It all started with the original "Wind" article and news has grown from there.

GALLERY
Our extensive gallery of research images.

GIGAPAN IMAGES (external link)
Clicking here will take you to see very Hi-res research images of number walks.

LINKS
Our page of links that are associated with the project.

MOTIVATED by the desire to visualize large mathematical data sets, especially in number theory, we offer various tools for representing floating point numbers as planar (or three dimensional) walks and for quantitatively measuring their "randomness". This is our homepage that discusses and showcases our research. Come back regularly for updates.

RESEARCH TEAM: Francisco J. Aragón Artacho, David H. Bailey, Jonathan M. Borwein, Peter B. Borwein with the assistance of Jake Fountain and Matt Skerritt.

CONTACT: Fran Aragon

See http://carma.newcastle.edu.au/walks/

Jonathan Borwein, 2014

Turtle plots of $\pi$ and paper-folding
Member Services

- We offer a variety of services to our members and their students (and to many others)
  - some are forced upon us by problems with UofN Academic Computing support
  - taking money from research
  - relying on significant subsidy from the Director’s other funds

See details at:
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See details at:
Non-traditional Publication


October 25 2012: Music and Maths Concert
Hear Pi at http://carma.newcastle.edu.au/walks/

Jonathan Borwein, 2014

CARMA and Me http://www.carma.newcastle.edu.au/jon
Conclusions

• We are Pragmatic Dreamers
  – always aiming slightly too high
• The members’ enthusiasm and work ethos is superb. We all own CARMA
• We cover all bases – research, applications, outreach and education
  – We can not fund education. I am, however, strongly in favour of early introduction to research.
    (Eliot Phillipson, former CFI and CIHR President)
  – an AMSI ‘maths hot spot’ (one of two). Very strong participation at AustMS, ANZIAM and AMSI conferences
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2012 CARMA shirts (Ballarat AMS)

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Happy pi day!!
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Not Bad for the First Five Years ... and we have big plans

Given real support from P/VC for:

- hiring next CARMA Director/HoS;
- to make Pure Maths an ERA ‘5’; Maths a top 100 department.

Related Material

1. Feasibility Methods: Divide and Concur
   http://carma.newcastle.edu.au/DRmethods/

2. Experimental Mathematics: for Everything
   http://www.carma.newcastle.edu.au/expmaths/

3. Pi Day:

4. Walking on Numbers: a Viral Success
   http://walks.carma.newcastle.edu.au/

5. Lattice Sums: Then and Now

6. The Director’s Blogs

Jonathan Borwein, 2014
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2010: Communication is not yet always perfect
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Jonathan Borwein, 2014
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