Computer Science: Math In Action

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Math Day 2011



http://lazowska.cs.washington.edu/MathDay2011.pdf

Forty years ago ...



























[Peter Lee, DARPA, and Pat Lincoln, SRI]







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With forty years hindsight, which had the greatest impact?

Unless you're big into Tang and Velcro (or sex and drugs), the answer is clear ...





And so is the reason ...

EXPONENTIALS STUS

The past thirty years ...





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The top innovations of the last 30 years, according to judges	The New York Ti
at the Wharton School of the	WORLD U.S. N.Y. /
University of Pennsylvania.	Search Business
1. Internet, broadband	
2, PC and laptop computers 3. Mobile phones	
4, E-mail	THE COUNT
5, DNA testing and sequencing	By PHYLLIS KORKI Published March 7 2009
6. Magnetic resonance imaging	In response to the sh
7, Microprocessors	gave the following an and the cheese Danis
8. Fiber optics	Life Changers
9. Office software	The top innovations of 30 years, according that the Wharton School
10. Laser/robotic surgery	University of Pennsyl 1. Internet, broadban
11. Open-source software	2. PC and laptop com 3. Mobile phones
12. Light emitting diodes	4, E-mail
12. Light enhancing doues	6. Magnetic resonanc
13, Liquid crystal display	8. Fiber optics
14, GPS devices	9. Office software 10. Laser/robotic surge
15. E-commerce and auctions	11. Open-source softw 12. Light-emitting diod
16 Media file compression	13. Liquid crystal displ 14. GPS devices
To, media ne compression	15. E-commerce and a 16. Media file compres
17, Microfinance	17, Microfinance 18. Photovoltaic solar e
18. Photovoltaic solar energy	19, Large-scale wind to 20, Internet social netwo
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20, Internet social networking	A version of this arbein appen New York address
THE NEW YORK TIMES	Click here to enjoy the co





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6:38 PM

Get Started No, thanks

My Account Welcome, lazowska Log Out Help



The most recent ten years ...

- Search
- Scalability
- Digital media
- Mobility
- eCommerce
- The Cloud
- Social networking and crowd-sourcing















Amazon.com EC2 pricing over a 3-year period

- Over time, the price to real 3 unit of resources for three years of continuous usage has failen dramatically as Amazon towers prices, others new instance types, and of new long-torm pricing plans.
- Price includes up-front reservation charge plus continuous hourly usage fees for 3 years
- The price is defined as the lowest possible price regardless of instance type. For example, a High CPU instance offers 20X the compute power, but only costs 3X the
 amount. Similarly, a High Mentory instance type offers 10X the main memory, but only costs about 6X the price. So the cost per unit (either compute or memory)
 dropped when these new instance types were announced.
- The two resources are normalized to 1 EC2 compute unit (blue) (approximately equivalent to a 1.0 GHz CPU) and 1 GB of RAM (red)
- These prices are potentially overstated, since existing customers benefit from a price reduction just like new customers. So your total cost for a 3-year deployment in 200 is lower if prices are reduced in 2008.

Belgian brewery's former electrical generating plant, now used as a tasting room



In the next ten years, we'll put the "smarts" in ...

- Smart homes
- Smart cars
- Smart health
- Smart robots
- Smart science (confronting the data deluge)
- Smart crowds and humancomputer systems
- Smart interaction (virtual and augmented reality)





Presidents Council of Advisors on Science and Technology, December 2010



REPORT TO THE PRESIDENT AND CONGRESS DESIGNING A DIGITAL FUTURE: FEDERALLY FUNDED RESEARCH AND DEVELOPMENT IN NETWORKING AND INFORMATION TECHNOLOGY

Executive Office of the President

President's Council of Advisors on Science and Technology

DECEMBER 2010



"NIT [Computer Science] is arguably unique among all fields of science and engineering in the breadth of its impact ...

"Recent technological and societal trends place the further advancement and application of [Computer Science] squarely at the center of our Nation's ability to achieve essentially all of our priorities and to address essentially all of our challenges:



"Advances in [Computer Science] are a key driver of economic competitiveness ...

"Advances in [Computer Science] are crucial to achieving our major national and global priorities in energy and transportation, education and life-long learning, healthcare, and national and homeland security ...

"Advances in [Computer Science] accelerate the pace of discovery in nearly all other fields ...

"Advances in [Computer Science] are essential to achieving the goals of open government."



"All indicators – all historical data, and all projections – argue that [Computer Science] is the dominant factor in America's science and technology employment."

Science and Technology Job Growth, 2008-2018 (Bureau of Labor Statistics)





"The gap between the demand for [Computer Science] talent and the supply of that talent is and will remain large."

Annualized Job Openings vs. Annual Degrees Granted





Is this a great time, or what?!?!



History: Babbage's Difference Engine #2

Need to tabulate polynomial functions

E.g., for trig tables

Concept proposed in 1822

- "Note on the application of machinery to the computation of astronomical and mathematical tables"
- Project terminated due to cost overruns
- Analytical Engine described in 1837
- Difference Engine #2 designed 1847-49







Crank-powered



Evaluates degree 7 polynomials



Prints the results (or makes plates)



8000 5 parts tons

11'

History: Electronic Numerical Integrator and Calculator (built 1943-46)



8.5' (h) x 3' (d) x 80' (linear) 30 tons 150 kW of power 17,468 vacuum tubes
7,200 crystal diodes,
1,500 relays
70,000 resistors
10,000 capacitors
5 million hand-soldered joints



History: The transistor (1947)

William Shockley, Walter Brattain and John Bardeen, Bell Labs





The integrated circuit (1958)

Jack Kilby, Texas Instruments, and Bob Noyce, Fairchild Semiconductor Corporation





History: Moore's Law and exponential progress (1965-today)

Gordon Moore
















History: Progress in algorithms is even more astounding



Deep Blue, 1997





Price \$19.99 & eligible for free shipping with Amazon Prime

Deep Fritz, 2002



Watson, 2011

Ken Jennings, Watson, Brad Rutter





Watson, 2011

Bill Cassidy, Watson, Rush Holt



Today: Revolutionizing transportation

DARPA Grand Challenge





DARPA Urban Challenge

Today: Revolutionizing transportation







Google autonomous car on US 101 near Mountain View CA

Autonomous Driving

Google's modified Toyota Prius uses an array of sensors to navigate public roads without a human driver. Other components, not shown, include a GPS receiver and an inertial motion sensor.



But there's more at stake ...

- Energy and the environment
 - Highway transportation uses 22% of all US energy
- Efficiency and productivity
 - Traffic congestion in the US is responsible for 3.6 billion vehicle hours of delay annually
- Equity
 - The elderly, and low-income individuals forced to the exurbs, are disadvantaged
- The economic and environmental costs of manufacturing automobiles

And computer science is central to the solutions ...

- Real-time sensor information for transit location
- Intelligent routing of neighborhood jitneys connecting to transit arterials
- Personalized, real-time information for choosing travel options
- Zipcar on steroids



- Routing around congestion, for transit and personal vehicles
- Greater vehicle density through semi-automated control

Today: Transportation is one dimension of energy

The smart grid

- Engineering
- Control
- Conservation (intelligent structures)
- Information technology as a substitute for energyintensive goods and services
- Information technology as a tool for discovering and water designing new energy sources
- Improved energy efficiency in computation





power

ON

[Shwetak Patel, UW]

Today: Health / Personalized health monitoring



Omron pedometer



Nike + iPod



Bodymedia multi-function



Biozoom: body fat, hydration, blood oxygen, etc.



Glucowatch: measuring body chemistry

Today: Health / Evidence-based medicine

- Machine learning for clinical care
- Predictive models
- Cognitive assistance for physicians



Today: Health / Neurobotics









[Yoky Matsuoka and Raj Rao, UW]

Today: Health / P4 medicine





Today: Human-computer systems



Luis von Ahn

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Hours per year, world-wide, spent playing computer solitaire: 9 billion Hours spent building the Panama Canal: 20 million (less than a day of solitaire)



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The New York Eimes

Years 1851-1980 were fully digitized, start to finish, in 2009!



Today: Games for scientific discovery



David Baker







foldit 02:59:51 GMT foldit BETA Solve Puzzles BLOG • GROUPS PLAYERS PUZ	ZLES RECIPES FORUM WIKI FEEDBACK ABOUT	
Click to learn how you ontribute to science by playing Foldit.	GET STARTED: DOWNLOAD Win Beta Win XP/Vista Intel OS X 10.4 or later RECOMMEND FOLDIT USER LOGIN Username: *	
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we want with the second	Log in Create new account Request new password Sign in using Facebook Connect with Facebook	

http://fold.it/portal/

David Baker and Zoran Popovic

Solve Puzzles for Science

BLOG S GROUPS PLAYERS PUZZLE



BootsMcGraw

Global Soloist Rank: #6 Global Soloist Score: 3784 Cases

20:46:49 GMT

Profile

Name:	BootsMcGraw
Location:	Dallas, Texas USA
Started Folding:	12/06/08
About me:	An educated redneck here, from Dallas, Texas.
	When I was in grad school in 1985 at the State University of New York at Buffalo, my master's thesis was to construct and present a computer program that predicted the secondary structures (helix, sheet, loop) of proteins based on their amino acid sequences. Tertiary structure (i.e. folding) prediction was a pie-in-the-sky fantasy.
	Imagine my delight, a quarter century later, to find out that not only are people determining tertiary structures of proteins, but they've made a *game* of it.
Hobbies:	Licensed Massage Therapist; also a photographer, videographer, and webmaster. I have studied health and nutrition for over twenty years. Ask me my opinions about the subject.
Group:	Contenders

Today: Games for learning

Refraction: Teaching Fractions through Gameplay

Abstract

Refraction is a new puzzle game for teaching fractions. The game is not obviously a lesson in fractions, but requires knowledge of fractions to succeed. We built this game in cooperation with experts in learning, early mathematics, virtual manipulatives, and game design. In Refraction, the player must partition lasers in order to power spaceships containing various animals who have gotten stuck in space, as shown in Figure 1. These animal spaceships all require different fractions of the lasers, and the player is given several pieces that split and bend the lasers to reach the animals and satisfy these requirements. These mechanics can be used teach many important fraction concepts, such as equal partitioning, addition, multiplication, mixed numbers, improper fractions, and common denominators. The game itself is





Zoran Popovic

instrumented so that it records everything the player does, allowing teachers and researchers to analyze play data.



Games for scientific discovery





http://games.cs.washington.edu/

Today: Games for recreation





Kinect is the direct result of technology transfer from Microsoft Research

Today: Crowdsourced national security





Mine Station Dam Old Chinese Customs StaitDam (under construction) Lake Changjin National Park Dam Station Factory ComplexElite Station Mine Mine Station Mine Changjin-up Airfield Dam Station anch a Interesting Site Station Mine) Dam Dam Station Station Monument Dam Mine Monument Monument ____Mine Dam DamDam Dam Burial Mounds Station spected underground nuclear site Station DamMyohyangsan mountains MonumentBarrage DamMonumentater Treatment Fe Dam Taechon Hydroelectric Power PleStation Dam Ryonghwa Temple (Mt. Paegun) a checkpoint Nyongwon Power Plant ______ Long live 3 great revolutions" (Agriculture, I /ihwan Island on Taegye I Yongbyong Fuel Fabrication Complex Entrance Gate "Give up your lifetor the sake of our leader, Kim Jong il" Coal Mines Margaan Airfield Maengsan Airlield Bukchang Thermal Power Pi Coal Depot Dam Coal Loading DepEroded hill sides Station Station Hwa, Former Director of National Security Agence imu Island Sea-Bird Breeding Site 📍 Station Coal Mine DamNavy base Military Communications ToweDamMine Pyongyang Ostrich Farm Monumen Mine Dam Dam Chosan Revolutionary Site Technology and Economy Dam Mine Dam Dam Runway Under Construction ese revolutionary lights Coal Mine Station College of Animal Husbandry (Wonsan Ag ormation Center of New Technology and Economy with veteran anti-Japanese revolutionary lighte Coal Min Station Mine Ancient Fort Wall DamMine MineSinpyong Resting Place Restaurant Burial Mounds (Arduous March) Toha Ri North Airfield Dam Minets change our dream to (meat?)"Dam Pyöl-Kümgang Dam Dam Hoeyang Southeast Airfield Dam Dam Station Abandoned pool Kungangguks (Penta station Hoeyang Southeast Airfield Dam BDam d Turntable Dam DamDam DamDam DamDam DamDam Fire to clear farm land DamRK Kumgang te Raliway and Turntable of US bombing: 400 mothers 102 child Schung South Airfie Dam Dam/onument Dam Great revolutions (Agriculture, Industry, Intellect Kim Jong II on the spot guidance o Nuchon Ni Highway Strip Dam Dam Dam Dam Monument Monument Dam Mine Dam With our own power we have developed Mine Dam Dam Dam Dam gy of the great leader. Comrade Kim II Sun Burial Mound Military training grounds? Haeju Naval Base, Burial Mounds (Arduous March) Haeju Naval Baser - MonumenDam Kangryong/Ongjin Crane HabitaBurial Mound Image © 2009 TerrâMetrics and Bridge North Korean Ships Dam Dam Mc@ 2009 Cnes/Spot Image Image © 2009 DigitalGlobe GOOGLE Image/NASA Dam 39"30'42.98" N 125°11'35.89" E Eye alt 246.33 mi elev 138 ft



Today: ICTD - Empowering the developing world





[Tapan Parikh, UW and UC Berkeley]

UW Computer Science & Engineering

Ranked among the top 10 programs in the nation

- MIT, Stanford, Berkeley, Carnegie Mellon, Illinois, Washington, Cornell, Princeton, Georgia Tech, Princeton, Caltech, Wisconsin ...
- Two undergraduate programs
 - Computer Science (College of Arts & Sciences)
 - Computer Engineering (College of Engineering)
- 160 Bachelors students per year
 - We also grant ~85 Masters and ~20 Ph.D. degrees annually



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- "Regular Admission" for UW students who have fulfilled a set of prerequisites (math, physical sciences, computer science, etc.)
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 - Offered every quarter
- Direct Admission" for top high school students
 - Offered in the spring, for autumn quarter, coordinated with the UW Admissions Office and the UW Honors Program



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What can we uniquely do?

- Get students into the lab
- Make them our partners in discovery
- Prepare them for life-long learning at the forefront of knowledge and society





DECEMBER 24, 2007 | BUSINESSWEEK.COM

BusinessWeek

GOOGLE'S NEXT BIG DREAM...

Imagine what you could do with the world's mightiest computer BY STEPHEN BAKER



CENTRAL BANKERS TO THE RESCUE 0225

> Christophe Biscigli Google's master of "cloud" computing

CNNMONEY.com News Markets Technology Personal Finance Small Business CNN.com

FORTUNE

Home Fortune 500 Fortune Tech Street Sweep Investing Management

The smartest people in tech

Smartest Engineer: Christophe Bisciglia

21 of 50 Back Next

Rankings

Co-Founder, Cloudera

What kinds of problems could we solve if everyone had access to the computing heft that powers Google? Christophe Bisciglia joined the search giant as a software engineer when he was just out of college and quickly realized that if he shifted his digital workload from an individual computer to a cluster of networked computers, he could crunch data faster. Problem was, most scientists didn't have access to the kind of web-based, or "cloud," computing power of Google.

After teaching a class called Google 101, which taught software engineers at the University of Washington to program on a cloud-size scale, Bisciglia, 29, became obsessed with the possibilities emerging from an open-source project called Hadoop. Hadoop lets engineers take advantage of the massive computing efficiencies that come from networking hundreds of computers. He left Google in 2008 to help start Cloudera, which makes it easier for customers to turn their data into insights using Hadoop.

Bisciglia resigned from Cloudera in June but tells Fortune he remains comr massive power of the cloud in new ways. Brains and brawn are definitely a --J.H.

NEXT: Engineer runners-up: Cheever and D'Angelo



- How we chose the smartest people in tech



http://www.cs.washington.edu/WhyCSE/

Power to Change the World

People enter computer science for all sorts of aspirational reasons

Pathways in Computer Science

A computer science education is the gateway to all sorts of careers in addition to the software industry

A day in the life

The software industry is pretty cool

http://lazowska.cs.washington.edu/MathDay2011.pdf





