

A Journey Through Mathematics and Computing: From Algiers to Minnesota

Yousef Saad

Honorary Degree Ceremony
Πανεπιστήμιο Πατρών - University of Patras

Gratitude

- ▶ Mr. Rector, Vice-Rector, Dean, Professors, and distinguished guests.
- ▶ I am deeply honored and humbled to accept this honorary degree, and profoundly grateful to the University of Patras for this recognition.
- ▶ I share this honor with colleagues, mentors, former students, and advisees.
- ▶ Several of them are here today, making the occasion especially meaningful.

First. Acknowledgments:

➤ Long list of people to whom I am deeply indebted. Among them:

- My doctorate advisor: **Françoise Chatelin** (1941-2020)



- My Mentors:



Ahmed Sameh



Bill Gear
(1935-1992)



Beresford Parlett
(1932 - 2026)



Martin Schultz

• **Students**, & *Post-docs*:



Tianshi



Vasilis



Shashanka Daniel



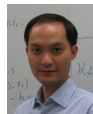
Ruipeng



Abdelkader



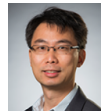
Jie



Thanh



Edmond



Kesheng



Bernie



Irene



Sangback



Yuanzhe



Agnieszka



Mohamed



Pierre



Haw-ren



Suzanne Yok



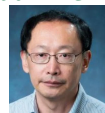
Matthias



Emmanuel



Xiao-Chuan



Andreas



Scott



Costas



Efi



... + 24 more

• You made this (continuing) journey truly amazing

THANK YOU

Why Patras matters to me

- ▶ I have had excellent ties with colleagues and special friends here.
- ▶ I have advised students and postdocs from Patras.
- ▶ In that sense, Patras has become part of my own academic story.

Greek Students at Minnesota

- ▶ For decades, I taught numerical linear algebra at Minnesota.
- ▶ The class often included Greek students.
- ▶ Many came from robotics, signal processing, and related areas; Many were connected to Patras.
- ▶ A few names remain vivid in my memory: Mourikis, Berberidis, Nicholas Kargas, Vasileios Ioannidis, Demetrius Zermas, + many others...
- ▶ Students from Greece were consistently among the strongest in the class.
- ▶ A few of them were exceptionally strong.

Theme of my presentation

- ▶ The changing nature of our field throughout my career
- ▶ The story begins with numerical analysis and early computing,
- ▶ ... moves through parallel computing and supercomputing,
- ▶ ... reaches today's AI revolution.
- ▶ A central lesson is that fields change, and we must adapt to change.

A personal timeline

- ▶ 1967–1970: University of Algiers, Algeria - BS in Mathematics
- ▶ 1969: First computer science course in Algeria
- ▶ 1970: Grenoble Numerical analysis
- ▶ 1980: University of Illinois Parallel computing
- ▶ 1981: Yale Intense collaboration; Work on Krylov methods
- ▶ 1986: Illinois (CSRD) - Practical Parallel computing
- ▶ 1988: RIACS/NASA Ames Iterative methods
- ▶ 1990: University of Minnesota Supercomputing
- ▶ 2017: The dawn of modern AI
- ▶ 2023: Phased retirement

1967: Algiers

- ▶ I began my B.S. in mathematics at the University of Algiers in 1967.
- ▶ Algeria was a new country, still recovering from the war of independence.
- ▶ Some outstanding French mathematicians came in solidarity and wanted to help: Prof. Chauvin, Prof. Lombardi, Prof. Fardoux, ...
- ▶ I owe them a great deal: They gave me not only knowledge, but also a deep passion for mathematics.

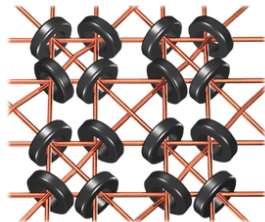
1969–1970: First Computing Course

- ▶ In 1969–1970, the university introduced Algeria's first computer science course.
- ▶ Algiers had one of the most powerful computers in Africa at the time: an *IBM 1620*.
- ▶ The machine used **decimal** arithmetic.
- ▶ It could store about 40,000 digits.
- ▶ That sounds microscopic today, but it was a marvel then.
- ▶ Flops rate: a few hundreds per second



Core Memory and Assembly Coding

- ▶ Memory was built essentially 'by hand' in those days.
- ▶ Core memory used tiny doughnut-shaped magnetic rings.
- ▶ Each core could be magnetized in different directions to store 1s and 0s.
- ▶ I loved that first course in Algies, especially coding part (in assembly!)
- ▶ It had an impact on my decision as to what to do next

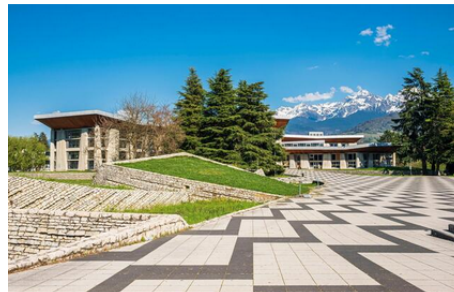


1970: To Grenoble

- ▶ I received a “bourse de coopération” from France.
- ▶ My goal: study numerical analysis in Grenoble.
- ▶ At one point, someone tried to redirect me toward automatic translation.
- ▶ I ended up in Grenoble, the “capital of the Alps” doing what I wanted.
- ▶ It was a beautiful place filled with intellectual energy.

Grenoble and Scientific Computing

- ▶ Grenoble was a major center for computer science and numerical computing.
- ▶ I was told that the aerodynamics of the Concorde were computed in Grenoble and Toulouse.
- ▶ Numerical analysis, however, was often seen as “bricolage” or “tinkering” rather than serious mathematics.
- ▶ IMAG: Institut de Mathématiques Appliquées de Grenoble.



Kuntzman, Gastinel, and Vision

- ▶ Prof. Kuntzman (Founder of IMAG) saw the potential of computers early.
- ▶ He had traveled to the United States in the 1950s.
- ▶ His student Noël Gastinel later directed IMAG.
- ▶ Gastinel often recalled how some “Parisians” dismissed Kuntzman’s vision.
- ▶ They regarded his interest in computers as eccentric.
- ▶ Gastinel believed this attitude cost France a decades delay in computer technology.



Noël Gastinel

Prof.
Gastinel



Prof.
Chatelin

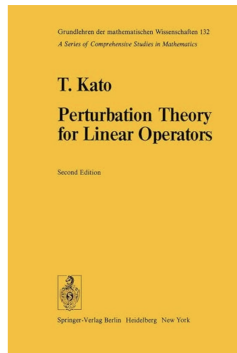
1980: University of Illinois

- ▶ By the late 1970s, parallel computing was flourishing in the United States.
- ▶ The goal was to use many processors to solve one problem.
- ▶ At a SIAM meeting in Knoxville in October 1978, I met Ahmed Sameh.
- ▶ **Ahmed Sameh** and **Bill Gear** later offered me a position at Illinois.
- ▶ I joined Illinois in January 1980 for one year.
- ▶ I was fascinated by parallel computing – Ahmed was a pioneer in the field.
- ▶ I was also fascinated by the United States as a country where *everything* was simple and where *anyone* could make it.

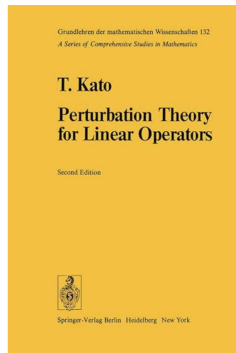
1981: A year in Berkeley



- ▶ Prof. Parlett (U. Cal Berkeley) invited me to Berkeley for one year.
- ▶ Big activity around eigenvalue problems..
- ▶ Berkeley housed giants of mathematics
- ▶ Tosio Kato was there. While in Grenoble I studied his voluminous book (*'Perturbation theory for linear operators'*). Here he was - a quiet, short man, with an enigmatic smile.



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- ▶ Other giants: W. Kahan, S. Smale, A. Chorin, L. Zadeh, ...

1981: Yale

- ▶ At the end of 1981, Martin Schultz hired me at Yale.
- ▶ I spent five years there, with one year back in Algeria.
- ▶ I worked among remarkable people.
- ▶ Stan Eisenstat, Tony Chan, Howard Elman, Leslie Greengard, Ilse Ipsen, Vladimir Rokhlin were part of that environment.
- ▶ Hats off to Martin Schultz for assembling such a great team

A Productive Research Environment

- ▶ It was an exciting time for numerical linear algebra.
- ▶ My own work on iterative methods (**GMRES**) came from that era
- ▶ The Fast **Multipole Method** work of Rokhlin and Greengard also came from that period
- ▶ The atmosphere was bubbling with innovation
- ▶ I worked on iterative methods, underwater acoustics, parallel computing, approximation theory, and other topics,
- ▶ Looking back, it was one of the most productive periods of my life.
- ▶ What made it possible was curiosity, synergy, encouragements, and the desire to excel.



1986: CSRD (Illinois)

- ▶ In Fall 1986, I returned to Illinois joining the Center for Supercomputing Research and Development(CSRD)
- ▶ CSRD created in 1984, Goal: to build a parallel computer named *Cedar*
- ▶ Leadership: David Kuck, Duncan Laurie, Ahmed Sameh, and Ed Davidson.
- ▶ They assembled a big multidisciplinary team: hardware, algorithms, software, and applications.
- ▶ Amazing colleagues: E. Gallopoulos, K. Gallivan, P-C. Yew, W. Jalby, H. Wijshoff, A. Weidenbaum, D. Padua, ..., many others
- ▶ Another extraordinary hub of productive interdisciplinary research

- ▶ Goal: to build a fully parallel computer (Cedar) based on a shared memory computer, with working software, and deploy it on real applications
- ▶ Ahead of its time and ambitious, it took a long time -
- ▶ Earlier: Univ. of Illinois had another project that was ahead of its time: The Illiac IV from the 1970s: 1 quadrant completed in 1975 – Peak Speed: 50 MFLOPS -
- ▶ ILLIAC's Original architect: Daniel Slotnick
- ▶ Both projects (ILLIAC, Cedar) did not achieve their original goals - but had a major impact on the field

1988: RIACS

- ▶ The “Research Institute for Advanced Computer Science” (RIACS) was located within NASA Ames in Mountain View, California.
- ▶ It was phenomenal to be in Moffett field inside NASA Ames: Lots of groups doing research on fluid dynamics, huge wind-tunnel, big computing facilities, proximity to Stanford, Berkeley, and a flourishing computer industry
- ▶ There was a huge wind-tunnel at Ames. Around that time Boeing started to rely entirely on numerical simulations [no wind tunnels]
- ▶ Increased need for good (iterative) algorithms and high-performance computers.

1990: Arrival in Minnesota

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- ▶ I came from a warm, tropical stay in Taiwan to a beautiful but frigid place.
- ▶ Someone joked that I was going to live in a freezer for much of the year.



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- ▶ Before I left RIACS a colleague asked: 'Why are you going to Minnesota? It is very cold in winter and their national bird is the mosquito'
- ▶ Both warnings turned out to be valid. But "You follow the bread"..
- ▶ and at the time, Minnesota was a world center of supercomputing.



Minnesota and Supercomputing

- ▶ Minnesota had won a major Army Research Office grant in 1987.
- ▶ The result was the **Army High Performance Computing Research Center**.
- ▶ The grant supported hires across many disciplines: computer science, geophysics, chemical engineering, and more.
- ▶ The goal was to strengthen the local supercomputing ecosystem.

The Silicon Prairie

- ▶ Minnesota was home to Cray research, founded by Seymour Cray.
- ▶ Seymour Cray was a University of Minnesota alumnus and former CDC employee.



- ▶ CDC + other computer companies were also part of the regional history
- ▶ The phrase “silicon prairie” emerged in this context.
- ▶ Strong Engineering Departments at the U. needed High-Performance hardware

Institutes and Big Machines

- ▶ The Institute for Mathematics and its Applications began in 1982 with NSF support.
- ▶ Minnesota was sometimes described as a “mecca of mathematics”.
- ▶ The University of Minnesota was the first U.S. university to acquire a supercomputer.
- ▶ That machine was a Cray-1.
- ▶ It could perform roughly 200 million floating-point operations per second.
- ▶ It cost more than 10 million dollars.
- ▶ A modern phone now exceeds that performance many times over.

The Minnesota Supercomputing Ecosystem

- ▶ The Minnesota Supercomputing Center launched in 1982.
- ▶ The Minnesota Supercomputing Institute launched in 1984.
- ▶ Their purpose was partly to support Cray-related research in the state.
- ▶ The center acquired machines such as the Cray-2 and the ETA-10.
- ▶ IBM Rochester and Honeywell were also part of the broader regional ecosystem.

The Closing of a Chapter

- ▶ In 2007, Minnesota lost the AHPCRC, which moved to California.
- ▶ In 2015, Minnesota lost the IMA – a terrible loss.
- ▶ The MSI and MSC essentially merged.
- ▶ Minnesota gradually disappeared from the TOP500 supercomputer list.
- ▶ A major chapter in the region's supercomputing story had closed.

The TOP500 Descent

- ▶ June 2007: ranked number 45.
- ▶ November 2007: ranked number 62.
- ▶ June 2008: ranked number 125.
- ▶ November 2008: ranked number 268.
- ▶ June 2009: ranked number 492.
- ▶ After that: gone from the list.

2017: The Dawn of Modern AI

- ▶ As the supercomputing chapter was closing, artificial intelligence was rising.
- ▶ AI had begun decades earlier – but its recent revolution was accelerated by discoveries in the mid-2010s.
- ▶ 'Transformers' played a central role.
- ▶ I often say that numerical methods and high-performance computing saved AI.
- ▶ Early symbolic AI struggled, while neural networks returned with new power.

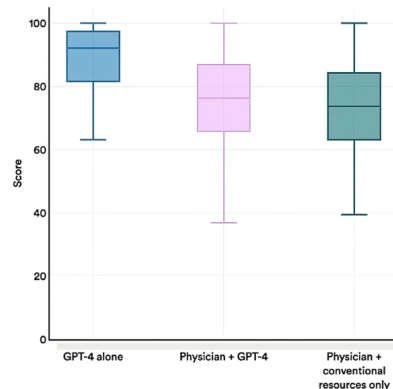
The BIG AI wave

- ▶ AI is making **astounding** progress ...
- ▶ Synergies: Hardware, openness, focus, ..
- ▶ Today: AI can solve university-level Homeworks
- ▶ Soon: will do the work of a doctor, engineer, ..

Ref: L. Aschenbrenner *'Situational awareness: The decade ahead'* (2024). Convincing argument that AGI [Artificial General Intelligence] will be with us within a few years.

LLM performance in clinical diagnosis

Source: Goh et al., 2024 | Chart: 2025 AI Index report



A Recent Milestone: Gold at the Math Olympiad (July 25)

World

Humans triumph over AI at annual math Olympiad, but the machines are catching up

Updated on: July 22, 2025 / 12:06 PM EDT / CBS/AFP

[Add CBS News on Google](#)

Sydney – Humans beat generative AI models made by Google and OpenAI at a top international mathematics competition, but the programs reached gold-level scores for the first time, and the rate at which they are improving may be cause for some human introspection.

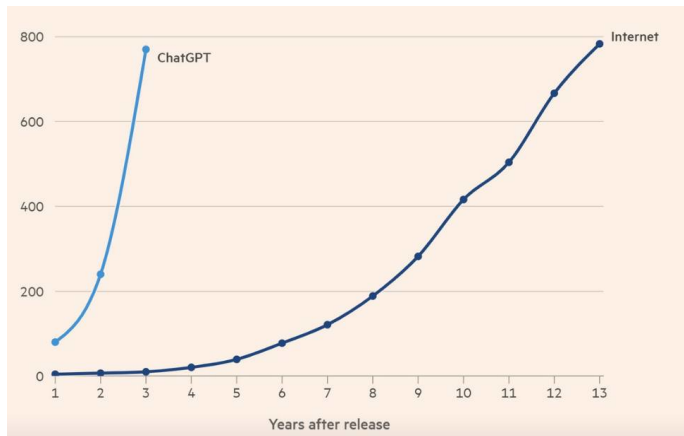


- Came 18 years earlier than predicted 5 years ago...

'The fastest Technology adoption in history'

"The internet took 13 years to reach 800M users. Chat-GPT just did it in 2."

source: Financial Times



Super-Intelligence (ASI)



Does anything humans can do intellectually

- ▶ An AGI can be a doctor, an artist,
- ▶ Can solve math problems,
- ▶ Reason, Create knowledge
- ▶ ...



Exceeds best human minds in all domains

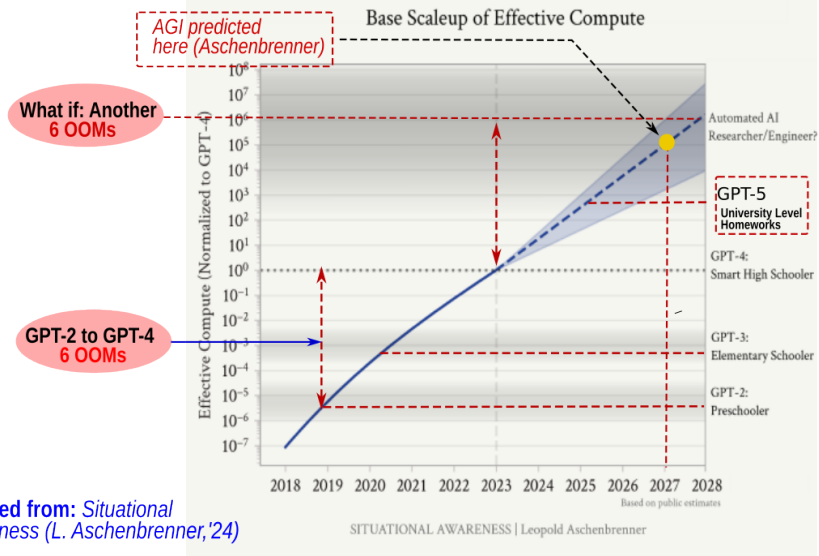
- ▶ If $AGI = 1$ then ASI could be 10^4 ?
- ▶ Imagine: Scientific Breakthrough in Minutes
- ▶ Self-improvement $\rightarrow$ Exponential $\uparrow$

AGI by 2027?

AGI by 2027 is strikingly plausible. GPT-2 to GPT-4 took us from pre-schooler to smart high-schooler abilities in 4 years. Tracing trend-lines in compute (0.5 orders of magnitude or OOMs/year), algorithmic efficiencies (0.5 OOMs/year), and “unhobbling” gains (from chatbot to agent), we should expect another preschooler-to-high-schooler- sized qualitative jump by 2027. (L. Aschenbrenner, 2024)

- Predicts: Superintelligence (ASI) will follow quickly because “AGIs will compress 5+OOMs into 1 year”

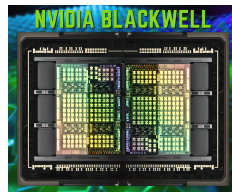
OOM = Order of Magnitude (compute scale, algorithms, + ...)



Adapted from: *Situational Awareness* (L. Aschenbrenner, '24)

GPUs and the New Computing Engine

- ▶ Neural networks were forgotten, then rediscovered.
- ▶ Their power was lifted by *Graphical Processing Units*.
- ▶ GPUs became engines for modern AI computation.



Blackwell B100

- ▶ Their architecture result in massive gains in computational time for matrix and tensor operations.
- ▶ A GPU is a marvel of modern computer hardware

H100

One SM $\equiv 4 \times (16 \text{ int32} + 32 \text{ FP32} + 16 \text{ FP64} + 1 \text{ TensorCore}) \rightarrow$

H100 chip with 144 Streaming Multiprocessors (SMs) ↓



Blessings and Disruptions

- ▶ No one can fully predict where the AI revolution will lead.
- ▶ Certainly: **serious disruptions lie ahead of us** and ...
- ▶ ... scientists *need to adapt*
- ▶ From my perspective: one disruption is the negative impact on current **culture** in my own field
- ▶ Challenge: learn new tools, adapt what we know to AI, and adapt our way of thinking.

Blessings and Disruptions

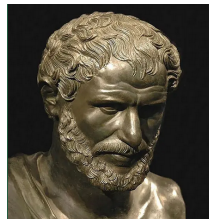
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“When one door closes, another opens. But we often look so long and so regretfully upon the closed door that we do not see the ones which open for us.” **Alexander Graham Bell**

Reflections on a Lifetime in Research

- ▶ As researchers, we strive to reach the top,
- ▶ .. to prove theorems, develop ideas, solve unsolved problems.
- ▶ If we fail, we try again, and again
- ▶ Time passes as we continue our endeavors.
- ▶ We reach the summit of our career.
- ▶ But as we mature we reflect on it all ... with a different perspective

- ▶ In Greece, you say: Πάντα ῥεῖ.
- ▶ Panta rhei: everything flows.
- ▶ *“No man ever steps in the same river twice, for it’s not the same river and he’s not the same man.”*



Heraclitus
of Ephesus

Related:

- ▶ *Sic transit gloria mundi*: “Thus passes the glory of the world.”
- ▶ Ματαιότης ματαιότητων, τὰ πάντα ματαιότης.

Change

- ▶ Fields change, Tools change, Institutions change (*'the river'*)
- ▶ Our interests and view of the world change (*'the man crossing the river'*)
- ▶ What remains?

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- ▶ What remains is the human spirit of creation and connectedness,
- ▶ ... the friendships,
- ▶ ... the many lives we changed and those that made us what we are.
- ▶ This is why this gathering fills me with happiness.

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Ευχαριστώ

Thank you