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Réception des nouveaux Associés étrangers sous la coupole de l'Institut de France

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In my lifetime, basic computing processor speed has doubled every 18 months. The accumulated effect of tens of generations of doubling is staggering.

But speed of a single processor is a *sideshow*: it misses the *real* power revolution. Modern 'information technology' – transparent networks of clouds and clusters of computers spread all over the globe, instantly connected -- creates an emergent *hypercomputer*. Using this hypercomputer, today's graduate student can compute in 1 day what would have taken 10 years, only 10 years ago. So growth of power is *accelerating*.

We stand in an historic building, where a great academy holds high the standards of great intellectual achievement. My own thoughts turn to the Mathematics section I am humbly joining today, and the particularly great standard of excellence set by French mathematics, and its academy members.

What does the hypercomputing revolution say about the future of mathematics and of intellectual life? Does hypercomputing erase the need for clever intellectuals? Traditionally, intellect offered ways to *avoid* heavy computation. If we no longer avoid computation, are we headed for a less intellectual world, where people solve problems by brute force rather than clever thinking?

No. Look at the opportunities. The real story of our era is **not** hypercomputing. That's only a sideshow. Once everyone realizes that computing is essentially instant and free, our era will finally be recognized as the era of **data deluge.**

Science and technology are compulsively innovating in the measurement and sensing of our world. From the largest scales – extragalactic -- or the smallest scales -- subatomic ; personal genomics, brain activity, global climate, consumer behavior or financial markets, we are in every field constantly seeing innovative new measurements and data types, at overwhelming density and detail, creating huge and very rich data bases.

In the new era: every conceivable phenomenon will be measured, in increasing detail. Instead of data deluge, let's be more precise; call this the era of *hyper-measurement.*

I have seen first-hand the evolution of hyper-measurement at work in oil exploration, physical chemistry, medical imaging, or molecular biology and numerous other fields. All this data needs to be analyzed, pulled apart into underlying structures; uncovering these structures created new intellectual questions. Of course, classical statistics and signal processing were often helpful, but my own work typically suggested compelling opportunities going beyond classical methods. Exploiting those opportunities required me to learn quite a bit of "Pure" Mathematics in Harmonic Analysis and High-Dimensional Probability, which eventually helped me (and my co-authors) develop new and practical but also subtle and surprising ways to extract information from raw data.

I spoke this morning here at the Académie, so I only give one specific example of my interests. It has become possible to extract clear medical images while keeping the patient immobilized for much less time than previously (factor of 7, clinically tested). The motivation for this practical success is two mathematical facts. Take the wavelet transform of a medical image: it is sparse – it belongs to an l_p ball with small p. For an l_p ball in high dimensions take a low co-dimensional slice: the radius is tiny. These facts, easy to pronounce, required a lot of patient work by inspired mathematicians. Why would one ever consider an l_p ball with small p -- the physical sphere has p=2? Why would one consider low co-dimension slices in high dimensions? Academy Member Yves Meyer can shed light for reasons one would consider the l_p balls with small p, and Member Gilles Pisier can shed light for reasons one would study random slices of such balls; see the excellent books they have written. It was surprising to find that such ideas, which I first learned merely for their stark beauty, could be so full of meaning.

In general, I feel much more drawn today to "Pure" mathematics because of the hyper-measurement revolution. The *surprising practicality* of "Pure" mathematics is the biggest intellectual lesson I have learned.

What does this teach us? Today's mathematical heritage was inspired by great questions in mathematical physics: movement of the planets, electricity, and magnetism. Tomorrow's mathematical heritage will be shaped by new opportunities today's data deluge and its aftermath.