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A Mystery of Human Biological Development -- Can It Be Used to Speed up Computations?

Olga Kosheleva

Vladik Kreinovich

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Olga Kosheleva and Vladik Kreinovich
University of Texas at El Paso
500 W. University
El Paso, Texas 79968, USA
olgak@utep.edu, vladik@utep.edu

Abstract

For many practical problems, the only known algorithms for solving them require non-feasible exponential time. To make computations feasible, we need an exponential speedup. A reasonable way to look for such possible speedup is to search for real-life phenomena where such a speedup can be observed. A natural place to look for such a speedup is to analyze the biological activities of human beings – since we, after all, solve many complex problems that even modern super-fast computers have trouble solving. Up to now, this search was not successful – e.g., there are people who compute much faster than others, but it turns out that their speedup is linear, not exponential. In this paper, we want to attract the researchers' attention to the fact that recently, an exponential speed up was indeed found – namely, it turns out that the biological development of humans is, on average, exponentially faster than the biological development of such smart animals as dogs. We hope that unveiling the processes behind this unexpected speedup can help us achieve a similar speedup in computations.

1 Formulation of the Problem

Many real-life problems probably require un-feasible exponential computation time. In most practical problems it is feasible to check whether a given candidate for a solution is a solution or not. For example:

- If we are given what supposed to be a detailed proof of a mathematical statement, then it is possible to check, step by step, that this proof is indeed correct.
- If we are given a dependence that all measurement results are supposed to satisfy, then it is easy to check, observation by observation, that this dependence is indeed satisfied.

- If we are given a design of a plane, then it is possible to simulate its reaction to different weather conditions and thus, check that this design satisfies all the given specifications.

The class of all the problems in which we can feasible check whether a given candidate is indeed a solution is known as NP. Some of the problems from this class can be solved in feasible time. The class of all such feasibly solvable problems is denoted by P; see, e.g., [9, 11].

It is still an open problem whether P contains all the problems from the class NP, i.e., whether P = NP. Most computer scientists believe that these two classes are different. What *is* known is that in the class NP, there are problems which are harder than all others – in the sense that every other problem from the class NP can be feasibly reduced to this problem. Such problems are known as *NP-complete*.

If P and NP are different – as most computer scientists believe – then for each NP-complete problem, it is not possible to have a feasible algorithm for solving all its instances.

Many practical problems have been proven to be NP-complete. Thus, for these problems, we cannot have a general feasible algorithm. Most probably, this means that these problems require exponential time like 2^n, where n is the size of the input. Such algorithms are not practically feasible – indeed, already for $n \approx 300$, the exponential time exceeds the lifetime of the Universe.

How can we solve NP-complete problems faster? Since we cannot feasibly solve NP-complete problems on usual computers by using known algorithms and known physical processes, a natural idea is to look for new algorithms and/or new physical processes that would hopefully allow us to solve these problems faster.

How can we find such algorithms and processes? One way is to look for real-life phenomena in which some instances are exponentially faster than others.

Faster does not mean exponentially faster. Of course, there are many cases when some processes are faster. A natural place to look is us humans, since we are actually solving many complex problems.

Our abilities to solve problems are different, so it is reasonable to look for people who can solve problems faster. For example, there exist people who can perform arithmetic computations much faster than others; see, e.g., [1, 2, 3, 5, 10, 12, 13]. However, it turns out that the corresponding speed-up factor is the same for all the problems [6, 7, 8], irrespective of the input size n. So, even if we learn the algorithm which is (subconsciously) used by these people, we will only decrease the computation time by a constant factor, but in general, exponential time remains exponential.

Similarly, a recent research [4] has shown that there is, on average, a constant difference between the times when men and women reach the same stage of biological development – which means that the corresponding phenomena also cannot be used for an exponential speedup.

What we do in this chapter. In this chapter, we show that there *is* a phenomenon with an observed exponential speed-up – a phenomenon related to human biological development. Thus, there is a chance that, by studying this phenomenon, we will be able to achieve a similar exponential speed-up in our computations – and thus, be able to solve NP-complete problems in feasible time.

2 Exponential Speedup Phenomenon: A Brief History and a Brief Description

A newly observed phenomenon. The story starts with attempts to compare biological development of different species, e.g., by comparing biological development of humans with biological development of very intelligent animals such as dogs. In the first approximation, this relation is described by a known linear formula: that a human age h corresponding to the same biological development stage as the dog's age d is approximately equal to

$$h \approx 7d.$$

This formula is known to be approximate. For example, right after birth, pups become independent more quickly than this formula – while human babies remain helpless for much longer relative time.

A recent research [14] analyzed a large amount of data on biological development of humans and dogs, and based on this data, came up with the following formula that provide a more accurate match between the times needed to reach the same biological development stages:

$$h = 16 \cdot \ln(d) + 31.$$

This is indeed an exponential speedup. What this logarithmic formula means is what takes exponential time $d = c \cdot 2^n$ to develop in a dog will take linear time

$$16 \cdot \ln(a \cdot 2^n) = (16 \cdot \ln(2)) \cdot n + (16 \cdot \ln(a) + 31)$$

in a human! So, this is indeed an – unexpected – example of an exponential speedup.

This is a very new result. At this moment, it is not clear where this speedup comes from – especially since until this result, no one noticed any fundamental difference between humans and higher animals in terms of simple (non-brain-related) biological development. Hopefully, a detailed analysis of the situation will reveal some mechanisms that will turn out to be useful to speed up computations as well.

Acknowledgments

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