

Data intensive approach in modern sciences

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The purpose and methodology of science is based on the functioning of human intelligence and overlaps to a large extent with the specificities of everyday thinking. This was true in historical times and in the scientific big data era, aided by modern artificial intelligence.

When we describe thinking, we usually distinguish between the observed reality and the thinker. Information flows from the world through the senses into our minds, where an internal, simplified version of reality, a "model", is dynamically formed based on our innate "hardware" and "pre-installed software". This internal model represents the objects, creatures and phenomena of the outside world. The representation is not passive, like a photograph or a film, but dynamic, capable of dealing with phenomena and events, and also capable of rehearsing situations that have not happened and also to make predictions. Science has taken this process of perception and modelling to extremes and has extended it beyond the limits that evolution has readily provided.

Our organisms as a whole have evolved to specialise in performing the functions necessary for survival, and are therefore not universal. With our eyes we can see the phenomena around us with high temporal and spatial resolution, but we cannot see the trajectory of a bullet, we cannot resolve the scale of cells, and we cannot see the faint galaxies. In fact, we can only detect the narrow band of the entire electromagnetic spectrum, visible light, not radio waves and gamma rays.

The invention of the telescope, followed by a number of other instruments capable of detecting the broader range of the electromagnetic spectrum, played a major role in the development of astronomy and, through it, modern science. Telescopes can be seen as a prosthesis that gives our eyes capabilities we did not have before.

We may be less aware of it, but like our senses, our brain is a purpose-built device, too, rather a universal intelligence. On the one hand, we are amazed at how sophisticated is the human intelligence already at birth. An infant can imitate a face which process involves

complex image recognition and coordinated control of many muscles: all feats that modern computers with their enormous capacity cannot match. However, it takes six to eight years on average to learn to perform elementary operations on numbers below 20. In the same way that there was no evolutionary pressure to develop a gamma detector eye, it is likely that the talent for courting took precedence over the ability to divide a fraction by a fraction in the allocation of mental capacity, although the latter could be achieved with surprisingly few neurons.

It is not only our senses that need prostheses, even the minds of most talented scientists are not universal and limited in capacity. Our short-term memory buffer can only hold 7 ± 2 items, and while we know the multiplication table of 10 by reflex, not many people can multiply ten-digit numbers in their heads. The simplest mental prosthesis is paper and pencil: with a little patience, writing can be used to perform very complex operations

These sensory and brain prostheses, hardware and software additions, have enabled us to perceive modalities, develop theories and understand phenomena that would have been impossible with instinctive human reasoning. The science and the technology that has been built on it has transformed and is transforming the world.

Science has entered a new era, from understanding the simple to understanding increasingly complex phenomena. To describe complex reality, complex models are needed, which often cannot be derived from fundamental laws. This approach has received a new impetus in recent years with the framework of artificial intelligence. Beyond the applications in everyday life, this approach is gaining ground in sciences, including physics. This transformation is demonstrated by the articles in this issue and by the fact that the 2022 EPS Forum will also dedicate a special section to machine learning and artificial intelligence. ■

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