



HPC/HPDA digital technologies servicing health

TERATEC's reflection for the development of uses of these technologies in France

Press release June 2020

Digital technologies with HPC/HPDA in particular will play a leading role at all levels in the field of health. From studying fundamental mechanisms to search for new molecules and new therapies, it will include epidemics monitoring and development of telemedicine and personalized medicine.

The very serious health crisis caused by Covid-19 demonstrated the importance of these digital technologies for intensive computing, modelling and simulation, machine learning and artificial intelligence to accelerate tools development to contend it. France has leading skills in the medical field and digital technologies as well to play a pioneering role in this sector.

Themes presented below, being non exhaustive, show the variety of possible applications and the potential of HPC/HPDA to contribute to improve health conditions.

1. Digital Patient - Drug Testing and Qualification, and Personalized Medicine

In recent years, the concept of the "digital twin" has developed in many industrial sectors. The health sector should be able to benefit from it rapidly. In the short term, digital twins can be applied for certain functions of the human body. In a slightly more distant future, we can think of a personalized digital twin, taking in each person's parameters. Such a digital twin will play a fundamental role particularly in the following two issues:

- The certification of new drugs and vaccines and targeted therapeutic trials. The use of digital twins should make it possible to considerably reduce clinical trials and certification time required.
- The development of personalized medicine and patient monitoring. In the long term, it is conceivable to rely on digital twin to collect each patient's parameters regularly, to be updated for one's lifetime. This should make it possible to adapt treatments to specificities of the patient, in particular through the use of elaborate pharmacokinetic models.

A digital twin should necessarily be one extremely complex model of the different human body functions. Its development will be a very large-scale project requiring the mobilization of many multidisciplinary teams over long periods of time. We are at the dawn of what happened in industry over the last thirty years. This is a fundamental digital revolution.

2. Home medicine and patient monitoring

With ageing of the population, the development of chronic diseases and multi-pathologies and the increasingly frequent emergence of major epidemics, it is essential to develop systems based on home medicine, incorporating telemedicine to complement the current hospital schemes. Availability of relatively inexpensive multifunction sensors and treatment injectors, reliable and secure digital transmission capacities and the development of adapted therapies make it possible to consider the deployment of this approach on a large scale very quickly.

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Other benefits from this approach are also expected, in order to collect a considerable amount of extremely useful data for drug research and the impact of various therapies. It is also a basic tool for prevention allowing early detection of various health risk factors as in Alzheimer's or stroke.

Its deployment will require very significant computing resources to process all patient data, both in the disease detection, prevention and treatment phases. It will make use of the most recent work in terms of data processing and artificial intelligence.

3. New molecules - new drugs

The capabilities for genome sequencing and associated data processing have made considerable progress in recent years. Massive databases of genomes can now be cross-referenced with the equally huge databases of molecules and drugs. However, relevant data processing will require significant work in terms of analysis and intelligent learning. Furthermore, other stages to deal with complexity will have to be addressed, moving from the genomic stage to the proteomics and the molecule, or even the system itself. This considerably increases the complexity and size of the problems to be dealt with digitally. All this work must also contribute to the development and large-scale implementation of the concept of personalized medicine.

4. Epidemiology and data processing

If necessary, the development of the Covid-19 pandemic demonstrated the need to rely on early warning signals of future epidemics and to know as much as possible about their characteristics. This must be achieved using a network of customized sensors, field information (sentinel network...) and algorithms adapted to the detection of weak signals within very large databases.

It is essential to pursue the development and exploitation of large models of epidemic propagation. Such models already exist and have demonstrated their prediction capacity but it is essential to further increase their complexity by taking more parameters into account, in order to increase their predictive features as well as local specificities. They will therefore require ever greater computing power. Based on probabilistic approaches, these models require very large number of simulations and are therefore quite costly in terms of computing time. Significant work must be undertaken for the development and validation of these algorithms. Their implementation will require powerful means of data processing and analysis as well.

5. Bio-production

Large-scale production of medicines or vaccines also poses very specific problems, particularly in terms of process control and compliance with strict quality and traceability constraints. The major technologies developed for what is commonly referred to as Industry 4.0 must be adapted to the specificities of the medical field.

- The development of innovative methods and tools for production processes control based on machine learning technologies. This will require the use of the most recent technologies in embedded Artificial Intelligence.
- The development of methods for the design of production processes. It is a question of being able to customize these production lines according to highly variable characteristics.

Such examples illustrate the major role that digital technologies, and in particular HPC/HPDA tools, will play in the new health system that France needs to build. At a time when important discussions are being held, it is essential for our country to take into account these digital technologies that will contribute to the implementation of a new high-performance health system at the best world level.