Digital Twinning and the Complexity of Reality

Digital twinning is based on the idea that a digital informational construct of a physical system can be created as a separate entity. The digital information is a 'twin' of the information embedded within the physical system itself, and is linked to it throughout the entire system life cycle. Rapid development of the digital twin approach offers mining companies the promise of optimizing processes and automating decision-making – if they are brave enough to tackle the complexity of reality.

The basic concept of the 'digital twin' model has remained fairly stable from its inception in 2002 when it was introduced by the University of Michigan's then-new Product Lifecycle Management Centre. The premise driving the model is that each system consists of two subsystems – the physical system that has always existed and a new virtual system that contains all of the information about the physical system. This means that there is a mirroring or twinning of systems between what exists in reality to what exists in virtual space and vice versa. In most cases the virtual system will contain many sub-virtual systems.

Transforming data

Digital twin systems are about the traditional transformation of big data into information, knowledge and mining wisdom. The reality in today's competitive mining world is that an operations team must consider global factors even even at the local level.

The digital twin must work under such pressures and exploit this dynamic, big data environment. Data collected by itself, unanalysed, is essentially an expensive and fruitless exercise, even if the twin is a small entity with few parameters. Data must be transformed into meaning and insight.

An important difference between the digital twin concept and the traditional simulation concept is that the digital twin is always at work and always active. In contrast, older-style simulators are fed old data or generated disturbance data, with the results observed and a conclusion created. The digital twin workflow is dynamic and fundamentally different.

The operator typically sees data filtered through the digital twin, which could be performing many functions that may not need operator intervention or clarification. The digital twin interacts with big data or AI tools which help shape the digital twin, and could be optimising (and disturbing) digital twin behaviour. Operators have the option to bypass the digital twin analysis and access direct data, access big data analytics information or access AI information.

Intuition plays a big part in operator decision making. While this can be supplanted by deep learning techniques, there is still a chasm between autonomy and intuition especially in the face of complexity. One of the concerns in digital twin proposals is that of interoperability. In future worlds, systems, equipment, modelling, analytical, and automation processes do not live in isolation. The cyberphysical systems (machines and equipment) communicate with each other and with the mining staff around them (operators, planners, managers) so interoperability must be assured and seamless.

A digital twin adds value to an operation

It needs to operate in a 'plug and play' environment. To say that this is a revolutionary concept, is an understatement. The digital twin promises to optimise processes, effect quick decision making, and potentially so much more.

In the future, we could see a short cycle, where an autonomous decision-making process leads to changes in the digital twin in a strategic sense with wide implications, as well as a real-time effect within a mining operation. While it is early days, we are seeing a rapid development in this technology, suggesting possibilities that we cannot even imagine.

The complexity of reality

The digital twin is a reflection of a perceived reality, in physical characteristics as well as in planning and management. However, collecting data is not enough. Various levels of analytics, visual representations, machine learning and AI techniques now enable us to see and reflect on reality in novel and potentially powerful ways.

How capable are we to handle these new frontiers? In creating a digital twin, do we proceed with traditional, lengthy, purely functional analysis of the whole operational environment, or do we embark on a more epistemological approach? The latter is harder, but importantly, promises a better understanding of the complex reality of a mining operation.

Recent history shows that we are, en masse, incapable of thinking beyond simple cause and effect systems analysis. Such linear thinking is well entrenched in society, politics and management philosophies.

Where does this leave digital twin philosophy?

The obvious answer is to vaguely suggest that the digital twin concept is an evolving field. Mining companies must take baby steps toward a vision of future mining, knowing that they need to expand their understanding of complex reality, non-linear systems, advanced decision theory concepts and the power of deep learning and Bayesian technologies. Success is there for the adventurous, collaborative open-minded pioneers.

This article has been written by Chris Green, Maptek Core Technologies Product Manager, and was originally published in Forge, the free quarterly Maptek newsletter that includes case studies, product and corporate news.