AI upgrades the digital twin

The concept of the digital twin is a familiar one, but the accelerated learning and repeatability offered by artificial intelligence raises its profile. By **Alex Brinkley**

Virtual representations and simulated models of manufacturing models – or digital twins – were first proposed by Dr Michael Grieves at the Society of Manufacturing Engineers conference in 2002. It was based on the idea that a "digital informational construct about a physical system could be created as an entity on its own. This digital information would be a twin of the information that was embedded within the physical system itself and be linked with that physical system through the entire lifecycle of the system".

As factories adopt the internet of things (IoT), combined with condition-based machine to machine (M2M) devices for monitoring and tracking machinery and operations, digital twins are becoming commonplace.

Analyst firm, Gartner predicts that by 2022, over two thirds of companies that have implemented IoT will have deployed at least one digital twin in production.

5G advances

At this year's Hannover Messe, Ericsson and industrial automation company, Comau, demonstrated a digital twin, enabled by 5G connectivity. The demonstration featured a digitised version of an assembly line in an automotive plant. Using 5G connectivity to collect data from sensors on machine and processes, parameters such as vibration, temperature and pressure were displayed on a digital dashboard on a standard tablet. The data could be used to identify interruptions and operations that could potentially slow down the operation.

At the time, Ericsson advocated the use of 5G connectivity to collect a "stable, continuous and massive flow of data in real time, which is vital of automation processes". The low latency rate means that data can be displayed as visual outputs and data analysis can predict faults and malfunctions and identify component parts to be replaced or repaired.

Digitally interconnected equipment delivers real-time production data where and when it is needed, explained Maurisio Cremonini, Head of Marketing and Digital Initiatives Platform, at Comau.

"Digitised analytics provide customers with a wealth of information that is made available locally and remotely," he said. He believes 5G will enable a digital transformation within industry 4.0, "specifically for low latency, bandwidth and plug and play connectivity of factory equipment," added Cremonini.

Companies like General Electric used simulations and physics to try and predict what a machine is doing, but over time this has changed. "It's literally digital," said Andrew Cresci, Industrial Business Development Manager, NVIDIA, "relying on measured data and sensors".

Above: Using 5G connectivity, data can be collected and displayed on a digital dashboard on a standard tablet

Accurately tracking and gathering data for long periods of time, gives operators the ability to understand performance and predict the future. "This is the crux of artificial intelligence [AI]," said Cresci.

Introducing AI

AI brings repeatability to the digital twin, said Cresci. NVIDIA has worked with Bosch to develop predictive maintenance in domestic boilers, which send a text to the owner if the pressure drops, or if the temperature rises above pre-set limits. To accommodate the hundreds of boiler types in the company's range, an AI mini-digital twin was created, using the same algorithm and the same neural network so that it could be trained to learn for itself. This way, the digital twin could be replicated across the range of boilers.

"The beauty of a digital twin is that once you have got your mind around one type of machine, it's relatively easy to retrain and adapt and reuse; you can take AI and repeatedly reuse it instantly making data scientists more productive," Cresci said.

Data scientists can be called on to make sense of data outputs during testing. This analysis can then be the basis for a neural network and AI learning. At United Technologies, a helicopter sub-system was tested using a digital twin as the sub-system. A data scientist was able to examine the data and identify what was normal behaviour, what was due to wear and what was a potentially failing spindle. Once these behaviours were labelled, AI was able to learn and repeat with increased accuracy.

Graphics processing units (GPUs) enable the compute-intensive operations in real time, which is bringing AI to mainstream use, continued Cresci. The company's CUDA (Compute Unified Device Architecture) is a parallel computing platform and application programming interface (API) model for GPUs. AI is maths – essentially, statistical linear algebra, explained Cresci, which will be too slow without a GPU. Company scientists can write algorithms to run on NVIDIA libraries and use Jetson, the industrialised supercomputer on a module, to train large data servers, with smaller Jetsons at the edge for local decisions.

AI can examine the data and identify an anomaly and continue to learn and identify errors. A system specialist can label that anomaly, which is used in the next level of training when something is wrong, which is easily identified using [NVIDIA's] hardware, compute systems, software infrastructure and tools, such as Tensorflow, proposed Cresci.

"In my opinion, this is one of the biggest benefits of AI – an ability to be repeatable and learn in a new environment very quickly," he said.

There are several tools that can guide operators through a remote factory and provide information via tags connected to IT and product lifecycle management (PLM) sources.

"We see the digital twin as the key to optimising the performance from the cell to the factory in a global network," commented Thomas Maurer, Senior Director, Strategic Communications, Siemens Digital Industries Software. All of its factories operate digital twins.

Its Intosite is a 'classic' digital twin tool, used for visual planning, simulation and monitoring. Maurer quipped that it is GoogleEarth for manufacturing. Operators can be in an office and managing a global network of factories. It oversees order fulfilment and stock levels for the environment in which the plant is operating at that time.

As demonstrated at Hannover Messe, the connected factory and the sensor data it produces is becoming more relevant. Information can be gathered from sensors for worrying conditions and to understand why a system is varying from its normal course. For example, in a PCB factory, a reflow oven can be monitored for the correct temperature and speed to ensure the soldering and machine quality are to the expected levels.

For overall equipment effectiveness (OEE) and data analysis, the MindSphere application platform enables developers to create apps from information from multiple sources to navigate and contextualise the equipment in a particular factory. It is also possible, added Maurer, to reach down to an individual machine and interrogate individual products.

It connects machines and can turn them into machines with sensors: "essentially connected to change the machine into an edge device," Maurer said. Using condition monitoring algorithms for comparison with historical data, it adds intelligence. It can initiate activity when routed through Teamcenter, the company's enterprise lifecycle management tool. It supports managers in planning, initiating extra shifts, changing resources and assess the product on the production line itself.

"CFD, machine learning and an interactive design process can optimise design-based simulation."
Thomas Maurer

Maurer explained its role of Action on Insight as part of the closed loop of the digital twin. "It can ask: Under this workload, we are seeing this condition – is this normal or do we need to look at it?"

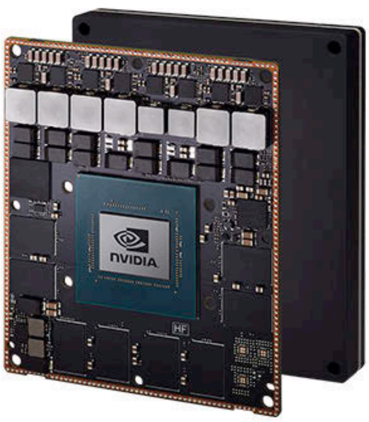
By comparing against the baseline data, the digital twin can also 'Marty McFly' a production line. Maurer explained: "By being able to look at future capacity requirements, based on the factory's performance, it is possible to identify where capacity is expected, what material will be needed and where to meet this future demand. Then it can go 'Back to the Future' and make adjustments".

The importance of operating in real time is vital when products are built to order. Designers used to be focused on validating a design, now they use simulation and AI to drive generative design.

The idea of generative design, using AI, marks a paradigm shift in design for Maurer. Most companies can optimise the topology but using computational fluid dynamics (CFD) to effect what the design is going to look like creates an exciting prospect.

"CFD, machine learning and an interactive design process can optimise design-based simulation," he asserted. He conceded that investment in machine learning is still needed but today electronics, mechanical and physical engineers are all using simulation to drive design.

Generative design will be the convergence of simulation and design, and allow engineers to concentrate on the functional part of the design. "Design is going to be model-based, using functional design tools to develop functions, and physical design, using intelligence to feedback and see what a design does," predicted Maurer.



Below: Data scientists can run algorithms to run on Nvidia libraries and use Jetson to train large data servers with smaller Jetsons at the edge for local decisions