Digital Twins: Models Everywhere

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EXTENDED ABSTRACT

Digital twins are catching on. People of different trades talk about models and appreciate that models can serve to improve our relationships with an increasingly complex reality. This is very promising, but as modelers we should make sure that we know properly what a model is, and why we want the models that we make or use.

Modeling is not new. Models have helped to understand the actual world for a long time. In the early days of computing, models were created and realized in programs to simulate situations of the real world. This was used to plan track layout of railroad stations and strategies for vaccinating the population for tuberculosis. The pioneers did not talk about digital twins at that time, but they could have if they had had our vocabulary.

While the pioneers had to wait a long time between their digital results and the changes of the represented reality, the time gap has decreased drastically and now the feedback from the digital twins may affect the represented reality in milliseconds. But this is not new, either. We have created real-time systems for many years, where the digital components have been programmed to represent and control some piece of reality in the right direction.

So, what's new with digital twins?

Technically, there is not much new technology with digital twins, but it may still have a great impact. Here are some aspects that make digital twins useful and promising:

1. People of different competences find digital twins fruitful as "living" representations of complex systems that may serve as their common base for understanding.
2. Modern systems often involve sensors and actuators that are directly connected to the actual systems, such as smart homes or advanced production. This makes digital validation necessary for the safety of using the actual system.
3. Physical systems are not like computer programs. They are affected by physical wear and tear, and digital twins can serve as their cleaner counterparts which are still accurately updated by data from the actual systems.
4. Modern systems are more dynamic than before and therefore it becomes important to have digital representations that behave in ways corresponding to the dynamic world, and that can be visualized in many different ways depending on the purpose.
5. Modern systems should work 24/7. They must evolve without having to stop and reboot. They must handle the data in real time. They cannot wait until later to do the analysis because the data keeps coming.

We need concepts and notation for describing digital twins and their evolution.

Digital twins seem to come in three categories depending on their rough purpose:

1. Digital twins for monitoring. The digital twin visualizes the actual twin and prepares human decisions. The presentation may include historical data.
2. Digital twins for simulation.The digital twin executes with current data to project behaviors of the future. This gives an even better background for human decisions as they can see what-if scenarios, but the model must be more advanced.
3. Digital twins for control.The digital twin is used to control the actual twin. This is automation. There is no human in the loop and the digital twin must be even more accurate and reliable.

Digital twins may evolve from monitoring through simulation to control as the trust in the digital representation increases and the purposes are well defined.

Digital twins are models for the future.

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