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Opinion
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The Application of Digital Twins to Biomedical Engineering Products

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Opinion

Digital Twins promises to vastly improve the efficiency, effectiveness and, most importantly, safety of biomedical engineering products. The Digital Twin, as shown in Figure 1 is comprised of three components. The first component is the physical product that needs to exist in our physical world. The second component is it's digital twin that exists in digital space. The last component is a connection between the physical and the virtual, with the physical providing data from the physical world and the virtual world providing both data and information that can be used in the physical world to replace wasting resources.

The underlying premises of digital twins is two-fold. First, digital twins move work from the physical world into the virtual world. Using digital bits instead of physical atoms is faster, cheaper and, in the case of biomedical engineering products, safer. Second, digital twins generate useful information that is a replacement for wasted physical resources. In the biomedical engineering product area, it is difficult to price the wasted resource of patient harm.

Digital Twins provide value in the three lifecycle phases of a biomedical engineering product: create, manufacture, use/support. In the create phase, biomedical engineering products are created, tested, manufactured, and use/supported in the virtual world. This has value because working with bits in the virtual world is faster, cheaper, and better than attempting to do the same work with expensive atoms in the physical world. Biomedical engineering devices can be modeled and simulated to see how they will perform when they are manufactured and used in patients. In this create phase, biomedical engineering products can be designed, and then virtually tested using simulation for decades or more to ensure its reliability. Virtual patients will have decades of use of products via simulations, such as implants, insulin pumps, and pacemakers. The virtual testing can be done on a wide range of situations that patients would encounter in the physical world.

One area that does not always get the proper attention in the create phase is the education and training of products. This is especially important in biomedical engineering products. These are products that have life and death implications in their installation and use. If the medical profession are not fully trained, and completely comfortable with these devices, then there is a major opportunity for unintentional errors and patient safety issues.

Doctors could gain biomedical engineering experience by operating on digital patients in a virtual environment, The simulation could present them with different scenarios that they may face in the operating room and walk them through appropriate responses. One of the main opportunities of digital twins and virtual environments is that the cost of making mistakes here is zero. The cost of making the same mistakes on actual patients is often incalculable. Transitioning into the manufacturing phase, biomedical engineering products can be custom, made for specific humans. For example, in the case of the patient needing an implant, the patient's bad knee is imaged. Then a digital twin of the knee is created that is identical to the patient's physical knee. The doctor examines that digital twin knee and makes any adjustments that the doctor deems necessary.

A physical knee is then created by a 3D printer by what is called additive manufacturing. A knee implant that exactly matches the patient's current knee has been created. When the doctor implants this knee, it is an exact replacement so it fits into place perfectly. There would be no need for on-the-fly manual adjustments. This will provide a much better product to the patient and make the operation safer, faster, and easier for the doctor. The installation and use of digital twins for biomedical engineering products is a major importance. The ability of doctors to be trained in simulation on the installation and support of new biomedical engineering products are extremely important. With all products that are new for any individual, especially doctors, there is always a learning curve. Using digital twins allows that learning curve to be done virtually and not on human patients.

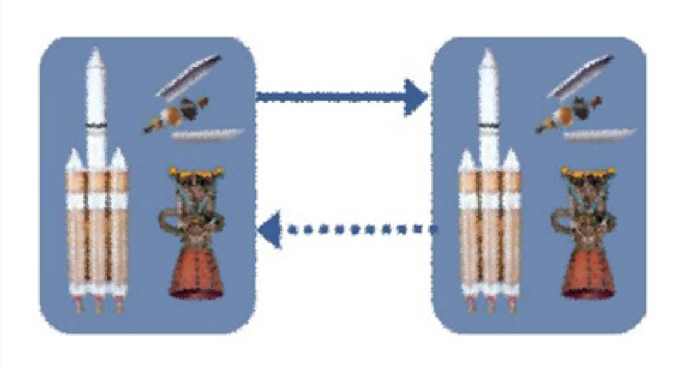

Figure 1: Digital Twin.

In the support phase, digital twins collect data and information about the usage of biomedical engineering products. Digital Twins also collects data on the health of the patient by sensing devices built into biomedical engineering products. That information has two uses. First it can be used to monitor and provide warning of issues with the patient.

Second, if the information of all the patients is aggregated, this can provide valuable data on both the products capabilities, and the patience health in the aggregate. Using Bayesian probabilities, the digital twin data can predict the deterioration or even failure of biomedical engineering products. Patients can be alerted to this and brought for remediation before adverse events even occur. This would be of tremendous benefit to the health and safety of patients. In summary, the application of digital twins could make for much more effective, affordable, and safer biomedical engineering products. It can improve the patients' lives by creating those products to the patients' individual requirements. Digital Twins can also provide valuable data on the overall patient population, so the probabilities about patient success can be predicted and issue corrected before the patients are inconvenienced or worse, harmed.

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