Малыженков Павел Валерьевич
канд. экон. наук, доцент
ФГАОУ ВПО «Национальный исследовательский
университет «Высшая школа экономики»
г. Нижний Новгород, Нижегородская область

ЦИФРОВЫЕ ДВОЙНИКИ В ИННОВАЦИОННОМ КОНТЕКСТЕ ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЙ В РАМКАХ КОНЦЕПЦИИ ИНДУСТРИИ 4.0

***Аннотация**: в статье речь идёт о том, что долгое время инженеры, разрабатывающие изделия, не имели никакой информации о том, как эти изделия потом реализуются. Для них изделия отправлялись как бы «на темную сторону Луны». Управление полным жизненным циклом изделия от идеи до вывода из эксплуатации оставалось идеей из области научной фантастики. Теперь все изменилось. На промышленных предприятиях появилось технологическое понятие «цифровой двойник» – компьютерный образ, соответствующий конкретному физическому изделию. Отныне, если изделие оснастить датчиками (на этапе проектирования или модернизации), можно организовать полноценную обратную связь. Изделие будет собирать данные из реального мира и передавать их в цифровой мир.*

***Ключевые слова**: цифровые двойники, инновации, промышленные предприятия, концепция индустрии.*

Content is licensed under the Creative Commons Attribution 4.0 license (CC-BY 4.0)

Malyzhenkov Pavel Valerievich
Cand. Sci (Economy), Associate Professor
National Research University
Higher School of Economics
Nizhni Novgorod, Nizhny Novgorod region

DIGITAL TWINS IN THE INNOVATIVE CONTEXT OF INDUSTRIAL ENTERPRISES WITHIN THE FRAMEWORK OF THE INDUSTRY 4.0 CONCEPT

Abstract*: the article touches on the fact that for a long time, engineers designing products had no information about how those products then performed in real life. For them, the products were sent like «to the dark side of the moon». Managing the complete life cycle of a product from idea to decommissioning remained an idea from the realm of science fiction. Now everything has changed. Industrial enterprises introduced the technology concept of a «digital twin», a computer image corresponding to a specific physical product. From now on, if a product is equipped with sensors (at the design stage or during modernization), it is possible to organize a full-fledged feedback loop. The product will collect data from the real world and transmit it to the digital world.*

Keywords*: digital twins, innovation, industrial enterprises, industry concept.*

1. The concept of a digital twin

A digital twin is a computer image (digital model) of a specific physical product. It may include its geometry, parameters (characteristics) and other information. A digital twin can be very detailed and reflect a wide range of product characteristics.

It may contain:

– digital model of the product;

– specification of materials;

– manuals and data on product maintenance;

– information about the behaviour of the product under various conditions.

Содержимое доступно по лицензии Creative Commons Attribution 4.0 license (CC-BY 4.0)

This may also include the connection of the product with objects connected to it, software responsible for controlling the product, monitoring the operating condition and operation, etc.

A digital twin is especially valuable when it most accurately reflects the actual state and performance characteristics of its physical counterpart.

2. Digital twin in the industry: *case*

2.1 Digital twins application along the production process

Let’s imagine a company that produces engines. First, the engine is designed in the traditional way, requirements are prepared, and system design procedures are followed. It is then modeled in a CAD program and when engines are manufactured in a factory, digital twins are born along with them. A digital twin is created for each physical engine at the time of production and becomes an exact digital copy of it.

The digital twin then goes through all stages of the physical engine's life cycle. Ideally, a digital twin of an engine exactly matches its physical counterpart and reproduces its state at any time throughout its entire service life. In other words, the digital twin appears when the engine is created, develops and changes during the maintenance and modernization of the physical product, and at the end of its service life is removed from service along with it.

The digital representation allows the physical motor to be controlled over its entire service life. Thus, customers receive full-fledged product life cycle management technology. The engine may be used more than expected, it may need repairs or replacement of parts, something else may happen – all this will be reflected in the digital twin.

It is worth noting that the engine can independently collect and send various data to developers and even perform self-diagnosis. In this case, the digital twin will allow the customer to «see» the physical engine and receive complete information about it. There are many views available for digital twins that reflect different subsets of data. Both traditional dashboards and display of information in the context of 3D models, as well as in augmented reality mode, are supported.

Content is licensed under the Creative Commons Attribution 4.0 license (CC-BY 4.0)

The augmented reality view can include sensor readings, maintenance instructions, and even information from other systems, such as owner records from a CRM system, etc.

2.2 The advantages of digital twins in the production

The digital twin, besides, allows you to distinguish valuable data from less useful data. A digital twin is information that describes a product and is located in the accounting systems that interact with such systems through API application programming interfaces implemented in them. It «understands» the relationship between products and information about them stored in other systems. That is, the information that makes up the digital twin «lives» in systems accessed by the platform, which acts as an intermediary between the digital twin and the applications that use it. Applications receive information from digital twins and can manage them through the API that it offers.

Solutions then come into play that enable predictive analysis of the collected data and filter it for further processing using mining techniques. Of course, no application will be able to magically determine what exactly the customer wants to see, and will not offer a universal recipe for further actions. But PTC's solution gives you access to all the data you need to understand all your options and make informed decisions.

A digital twin creates the most complete understanding of the operation of a specific product instance. A digital twin corresponds to one specific instance of a product. Returning to the engine example: a customer produces hundreds of thousands of engines per year, and each of them has its own digital twin.

The principle of uniqueness of digital twins reflects an atomic approach to organizing information. In effect, this is where big data principles are applied to a specific piece of equipment. But information from multiple digital twins of the same product (or multiple similar products) can be combined to provide insight into the overall performance of products and entire product lines.

Considering the volume of engine production, in just one year we will receive a huge amount of data. The customer may say: «We produced 500,000 engines of this model, and there are digital twins for all of them. We need to collect information from all the twins.” For example, you can evaluate the performance of digital twins of

Содержимое доступно по лицензии Creative Commons Attribution 4.0 license (CC-BY 4.0)

products manufactured in a specific plant, made from components from specific suppliers, shipped to a specific country, passed through a specific distributor, located in a specific operating environment, or owned by a specific customer. Our solution should give the customer the opportunity to conduct data mining in the way they need and benefit from it.

A digital twin acts as an intermediary between a physical product and important information about it, such as maintenance data. A digital twin is not a separately stored copy of all product data. Thanks to the data structure in the platform, business logic and connections between all the systems where valuable product data is stored, the digital twin can combine information from different sources. The detailed data that makes up a digital twin typically remains in existing storage systems.

The digital twin contains an expanded set of data related to a specific physical instance, including information from the resource planning (ERP) system about the date the product was shipped to the customer and information about completed service activities from systems offered by other vendors. The customer may also need information about the owner of the product from the CRM system. Products and applications that customers create will work with individual elements of the twin, providing valuable information.

A digital twin needs to be updated. If the digital twin becomes the central component that provides access to all product information, then the work of many people updating the twin will have to be coordinated, be it service workers, production personnel or third-party suppliers. For example, imagine a situation where a customer performs maintenance and orders spare parts. It can then also register parts and update their configuration records. In this case, the service specialist will be involved in updating the digital twin. With digital twin management technology, this is extremely simple.

The experts believe that the information contained in the digital twin will be useful to a variety of people. Consumers and product owners will be able to use the digital twin in everyday life. For example, the owner of a car can simply point a mobile phone or tablet at it and find out when the next maintenance is required.

Content is licensed under the Creative Commons Attribution 4.0 license (CC-BY 4.0)

The digital twin will show the consumer important data: engine oil level, information about the operation of vehicle systems, etc. On the other hand, an engineer or technician will be able to see an «X-ray» of the engine and determine which parts need repair, how many hours the engine has been running, or other types of information entirely. Some customers see the great promise that the digital twin brings to customers' use of intelligent, connected devices.

The experts expect that customers who already have equipment that creates large volumes of data will be primarily interested in a digital twin. They may, for example, need to improve the quality of service based on data collected from communicating devices. This is a developed IoT infrastructure. Many customers collect data but don't know what to do with it. This is the initial stage, at which the infrastructure is not yet sufficiently developed. It is necessary to focus on working with customers who already have equipment installed and operating. Integration with applications will allow them to quickly get commercial results.

As mentioned earlier, a digital twin is a large array of available data, which means convenient ways to work with it are needed. For those who are close to the CAD environment, the contextual presentation of information in a 3D digital twin will be convenient. If the user is close to the product, AR mode will be most effective, especially for information that is most useful in the context of the physical product.

3. Conclusion

So, the company will be in a position of competitive advantage if it has a full range of resources to implement such augmented reality. You can take a mobile device, select a specific production engine, find 3D data and project it onto real parts, exactly where they actually are. Converge will allow you to take all the IoT data coming from this engine and transfer it to your device in augmented reality mode. Interestingly, when customers see the digital twin, they begin to understand why IoT solutions play an important role and what can be achieved with their use. The digital twin is driving interest in core products and activities in the IoT market.

Содержимое доступно по лицензии Creative Commons Attribution 4.0 license (CC-BY 4.0)

References

1. Bayrak, T. (2022). Defining characteristics of the most innovative companies. International Journal of Research, Innovation and Commercialisation, 4(1), 63–73.

2. Beltrami M., & Orzes G. (2019). Industry 4.0 and sustainability: a systematic literature review. Decision Sciences in a Connected World. Proceedings of the 10th Annual EDSI Conference.

3. Buchi, G., Cugno, M. & Castagnoli, R. (2020). Smart factory performance and Industry 4.0. Technological Forecastig and Social Change, 150(119790).

4. Dalenogare, L.S., Benitez, G.B., Ayala, N.F., & Frank A.G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. Int. J. Prod. Econ., 204, 383–394.

5. Jabbour, A.B.L. de Sousa, Jabbour, C.J.C., Foropon, C., & Godinho Filho, M. (2018). When titans meet-Can industry 4.0 revolutionise the environmentally-sustainable manufacturing wave? The role of critical success factors Technol. Forecast. Soc. Change, 132, 18–25.

Content is licensed under the Creative Commons Attribution 4.0 license (CC-BY 4.0)