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Application of Digital Twin in Intelligent Vehicles Research

Feng Gu*, Lin Xi, Shengzhong Tang

Geely University of China, Chengdu 641423, China

Abstract: A digital twin (DT) is a virtual representation of a physical asset that is virtually indistinguishable from its physical counterpart. It includes design and engineering details that describe the asset's geometry, materials, components, and behavior or performance. In other words, it is a digital counterpart of a physical entity. Based on this, this paper takes the application of digital twin in the study of intelligent vehicles as a theme to reduce the difficulty of R&D and help researchers improve their academic research capabilities through the application of various aspects of vehicle structure, sensor data, and ergonomics. This can be reflected in the areas of vehicle structure design, sensor data presentation and analysis, human model building and simulation, and improving research efficiency.

Keywords: Digital Twin, Intelligent Vehicles, Ergonomics.

1. Introduction

A digital twin (DT) is a model that shows the virtual and physical spaces of a system. The system uses sensors, actuators, controllers, and interaction models to integrate the physical and virtual spaces into a single system. The model's processes connect the flow of data and information between the physical and virtual spaces. DT uses conceptualization, comparison, and collaboration tools to solve problems and innovate. It can simulate and optimize three research areas: automotive construction, sensor data, and ergonomics. The value of digital twin in scientific research is the continuous improvement of research methods through virtual-real fusion and virtual-real mapping.

From the automotive field, if the study of automobiles is viewed as a product, which is the object of digital twin technology application, it is possible to manage the laboratory, data, process and other facilities in the factory according to the whole life cycle of the product. Based on the multi-physical factors and multi-dimensional digital models, the numerical analysis technology can be used to analyze the physical performance of buildings and structural health management. For the transformation of automotive research, the digital twin technology can be used to share and interact with numerical space and physical space information in both directions and to track the lake comprehensively, and to carry out program comparison, parameter optimization and implement ability verification, etc.

Visualization is a very important element of digital twin technology. The 3D visualization of the digital twin structural dynamics analysis also plays a big role in automotive engineering. The visualization technology can not only show the 3D geometric model and appearance effect, but also show the physical phenomena and inherent characteristics that people cannot see in the real world, such as the vibration mode of the structure, the temperature field change, the airflow field distribution, etc. It is also possible to adjust the parameters and modify the physical characteristics through user interaction. It is also possible to adjust parameters and modify physical characteristics through user interaction, i.e., to optimize physical models, operational behavior and operation effects.

2. Application of Digital Twin in The Field of Automotive Structure Research

It is very common for digital twin to coexist in a system or process Different types of digital twin are usually classified into four types.

(1) Component twin

The component twin is the basic unit of the digital twin and is the smallest example of a functional component. Component twin are essentially the same, but are associated with relatively less important components.

(2) Asset twin

When two or more components work together, they form what are called assets. Asset twin allow the study of the interactions between these components, interactions that generate large amounts of processable performance data.

(3) System or unit twin

The next level involves the system or unit twin, which enables an understanding of how different assets come together to form an entire functional system. System twin provide visibility into asset interactions and may indicate performance enhancements.

(4) Process twin

Process twinning, or macro-level scaling, reveals how systems work together to create a complete production facility. Are those systems all synchronized to operate at peak efficiency? Does a delay in one system affect other systems? Process twin can help determine the precise timing scheme that ultimately affects overall effectiveness.

Digital twin is used in a wide variety of industries, especially manufacturing, to monitor performance, optimize progress, simulate results, and predict potential errors, but they also play a variety of roles throughout the product lifecycle, from design, to manufacturing, to delivery, to use, to end-of-life. Digital twin also play an equally important role in the design and manufacturing process of automotive structures. Digital twin excels at helping to streamline process efficiency, especially in industrial environments that use collaborative machine systems. As a result, the industries that have achieved the most success with digital twin are those that involve large-scale products or projects.

According to the data from the digital twin, during the research process, the assembly manufacturing resource requirements proposed by the process are prepared in place during the assembly work preparation phase. Too can have a faster and more thorough understanding of the assembly process, reducing the avoidance of mis-assembly and omission. According to the simulation animation of the digital twin, the assembly rhythm will be more accurate and the assembly sequence will no longer be wrong to avoid wasting time and manpower. At the same time, based on the design drawings, for each key fit size that needs to be controlled, a mathematical model is constructed to calculate the key fit size by the key size of the off-weight parts. The tolerances of the critical fit dimensions are also recorded. In the research team, the simulation animation and product description materials serve as a more visual product introduction and dynamic user manual, so that other researchers can understand the product more clearly and reduce the time wasted in communication.

The digital twin makes full use of the assisted 3D model of the product. It can realize the interactive definition and analysis of the assembly process of the product by the assembly process planner in the computer environment. This includes the establishment of a 3D model of each component part of the product, assembly sequence, 3D assembly path in space, traditional assembly process file output, assembly process decision, virtual simulation, etc. And the 3D process can be used to guide the 3D assembly manufacturing, thus enabling the assemblers to complete the assembly work more intuitively, accurately and efficiently, thus improving the quality and efficiency of the assembly and reducing the assembly time and cost.

3. Application of Digital Twin in Sensor Data Presentation and Analysis

The digital twin is a virtual environment designed around a bidirectional flow of information. The first information flow occurs when an object sensor provides relevant data to the system processor, and then the reverse information flow occurs when the processor generates insights and shares them with the original source object, which is displayed on the interface.

The price of IoT sensors continues to fall each year, allowing more companies to afford to use IoT. However, people often underestimate the conditions that must be met to connect their devices, their businesses, and their industries. In addition, there are many applications programming interfaces (APIs) and other development methods. And there are many questions that must be answered, such as access, information flow and storage, before an organization can build a truly secure and purposeful digital nervous system. Each connection point creates a possible vector for a cyber-attack. Therefore, each connection point needs to be designed, developed and deployed. Without a platform that helps drive uniformity, the workload can be enormous. The digital twin creates a logical taxonomy for data from the IoT and how that data can be classified and used. The ability to shape datasets based on physical, digital and electromechanical attributes enables organizations to manage their data requirements. Based on the volume of data, data analysis is more effective. But based on the need to create data sets that analysts and data scientists can use, it becomes less efficient. By using digital twin to classify, visualize and contextualize data, teams can segment their activities, create hypotheses and communicate results to their non-technical or non-analytical counterparts. Adding statistical analysis tools and models that perform a large number of calculations on rich models with multiple attributes makes it easier to predict failures, traffic and feasibility.

The laboratory is an important part of the science and technology innovation system, and the automotive industry is no exception. The integration of digital twin technology into laboratories is a model exploration of the science and technology innovation system. Traditional laboratories have a lot of basic research work and tend to ignore the improvement of the technical application level of the laboratory itself, but the application level of digital twin technology happens to be closely integrated with the field scenario, and digital construction solutions can promote the construction of digital twin laboratories, thus forming a new research model.

The use of digital twin technology to create virtual laboratory models can be based on the mapping of the real scene, the laboratory more intuitive and more three-dimensional in digital form. Not only that, the digital twin lab can also data the lab and the contents inside it. In addition to the experimental scenes, the appearance of the experimental equipment display, but also through the data to see the functional parameters of the equipment, operating conditions, etc. This way the researcher will have a more thorough grasp of the basic situation of the laboratory, so that he can understand the current equipment level can support the experimental standard.

In the traditional experimental mode, after an experimenter uses the instrument to test or operate, the test data of each machine needs to be manually summarized and uploaded to the database for analysis. This mode of data collection requires a lot of time, and is prone to error records. The digital twin lab can access all kinds of testing equipment, collect and upload testing data in real time, and automatically analyze them according to relevant professional knowledge and formulas, so that experimenters can save time in collecting data information and devote more energy to R&D to improve R&D efficiency and progress.

Through the equipment data coming from sensors, the data collection team can make accurate data collection of PLC, robots, meters and machine vision equipment, while flexibly using auxiliary equipment such as all-in-one machine, PDA, barcode and RFID for real-time collection of laboratory production data. Real-time collection of laboratory site equipment operating parameters, at any time to track the equipment operating conditions, automatically achieve state early warning, the impact of production equipment problems in the nascent state. Statistical operation and maintenance monitoring Kanban through the collection of equipment operation data. After analysis by researchers, the Kanban board is used to view the operation status, equipment maintenance, and equipment failure, and to promptly remind maintenance or replacement of equipment with high failure rate, helping enterprises to predict equipment risks in advance and manage equipment more quickly and comprehensively. The use of visual graphics to visually show the core indicators of the research link to achieve the situation, so that researchers can use it as a basis to plan experiments and improve methods item by item to maximize research efficiency.

The digital twin lab is a breakthrough in digital labs. The technology can be permeated in laboratory research in various industries, providing a technological guarantee to promote experimental development. In the mathematical twin system, the mapping of the laboratory breaks through the traditional model and better integrates the interaction between the real and virtual worlds.

4. Application of Digital Twin in Automotive Ergonomics

Starting from product thinking, the 3D modeling restores and simulates the human body in driving and riding in the vehicle, presenting the human body data and vehicle status simultaneously, giving designers a more intuitive feeling of the design, enhancing designers' perception of anthropometric data, and providing strong support for the design. The use of digital twin 3D simulation can reduce the number of tests and rework, thus significantly reducing design costs, reducing design delays and improving research efficiency.

Experimental data collected by wearable sensors in a simulated environment is evaluated by an automated method for all aspects of ergonomics. This method is a faster and more accurate way to perform the evaluation than manual analysis, improving efficiency. Moreover, this method avoids more subjective judgments of analysts and is objectively based on the ergonomic indices used.

The workstation can be continuously monitored throughout the evaluation process and adjustments to the ergonomics index can be made when necessary (e.g., in the event of a change in production volume). In addition, ergonomists and engineers can identify critical situations based on real data and propose solutions (e.g., changes in workstation layout) to reduce the risk index. Further, such solutions can also be validated by means of digital simulations prior to implementation using digital twins.

In anthropometry, models can be built using the digital twin method. The model can consist of a connected structure with multiple degrees of freedom and a skin surface that deforms with the angular changes of the individual joints. The analysis is based on information from a database of body dimensions for different heights and weights. Even in safety testing tests, the digital twin approach can be used to speak of various body sensor values simulated and analyzed in a virtual digital environment, achieving the goal of reducing the number of traditional crash tests, and reducing the cost and saving the time of the study.

5. Conclusion

Existing intelligent vehicle research is undergoing fundamental change. The digital revolution is sweeping across the industry, changing the paradigm of scientific research in disruptive ways. The digital twin is an important part of this transformation. Digital twin has an almost unlimited future, as the continued growth of cognitive functions continues to facilitate the use of digital twin. So, digital twin is always learning new skills and capabilities, which means they can continue to generate the insights needed to help produce better quality intelligent vehicle research and increase productivity.

In the future, as digital twin models become more mature, more widespread, and even put on the market, more parameters that affect energy consumption will be modified in real time. More data will also be required to optimize the digital twin model, with smaller sampling intervals, and the whole process of collection, processing, optimization and prediction will become more intelligent.

In summary, the vision of the digital twin is to enable good decision making, provide value to your physical and digital operations, and support the transformation of individual intelligent vehicle research. While the digital twin will solve many problems, researchers should also recognize that the digital twin is a revolutionary solution that will help ensure efficiency and efficacy gains in research and continue to bring value to research and academia.

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