Virtual Reality & Intelligent Hardware

• **Editorial** •

Virtual-reality and intelligent hardware in digital twins

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Several new models and formats for the digital transformation of the manufacturing industry appear because of the rapid integration of information technology and the real economy, as well as the increasingly obvious evolution trend of industrial digitalization, networking, and intelligence. Among them, digital twins have increasingly become a research hotspot in all sectors of the industry and have broad prospects. It maps physical objects in virtual space in a digital way and simulates their behavioral characteristics in real environments. It makes the gap between virtuality and reality disappear based on their closed-loop interaction. Digital twins are undoubtedly an important and strategic technology in response to familiar products, production, and services. It can also speculate some indicators that cannot be directly measured by machine learning through collecting the direct data of limited physical sensor indicators. This can realize an assessment of the current state, a diagnosis of past problems, and a prediction of future trends, and simulate possibilities to provide more comprehensive decision support.

Driven by "Industry 4.0/5.0", the concept of "Digital Twins" is setting off a new wave of industrial simulation boom. Entity industrial objects or systems are fully digitized, and models including virtual objects, virtual processes, and virtual plant areas are established. These digital twins can be placed in virtual environments to analyze, simulate, verify, test, and adjust various situations such as product or process optimization, optimizing the operation of real objects or systems, and increasing their added value. Also, the expression of "virtual reality" for scene visualization and the new scene interaction mode will be more conducive to better visual effects and interactive operations in the digital world. The combination of digital twins and virtual reality is currently widely used as guidance instructions for operation and maintenance, early warning of error prevention, and information tips to improve the efficiency and accuracy of operators. Virtual reality brings users better vision and senses through smart hardware like glasses and helmets. However, there is still room for improvement in the technical level of smart hardware. And rational hardware configuration and cost-reduction can be realized gradually with the improvement of R & D. Now the focus in this field should be how to enhance user experience and enrich products.

In "Integrating digital twins and deep learning for medical image analysis in the era of COVID-19", the authors introduce a digital-twin-based smart healthcare system integrated with medical devices to collect information regarding the current health condition, configuration, and maintenance history of the device/machine/system. Furthermore, medical images, that is, X-rays, are analyzed by using a deep-learning model to detect the infection of COVID-19. The designed system is based on the cascade recurrent convolution neural network (RCNN) architecture. In this architecture, the detector stages are deeper and more sequentially selective against small and close false positives. This architecture is a multi-stage extension of the RCNN model and sequentially trained using the output of one stage for training the other. At each stage, the bounding

boxes are adjusted to locate a suitable value of the nearest false positives during the training of the different stages. In this manner, the arrangement of detectors is adjusted to increase the intersection over union, overcoming the problem of overfitting.

In "Measuring 3D face deformations from RGB images of expression rehabilitation exercises", a complete framework that allows the construction of a 3D morphable shape model (3DMM) of the face is presented for fitting to a target RGB image. The model has the specific characteristic of being based on localized components of deformation. The fitting transformation is performed from 3D to 2D and guided by the correspondence between landmarks detected in the target image and those manually annotated on the average 3DMM. The fitting also has the distinction of being performed in two steps to disentangle face deformations related to the identity of the target subject from those induced by facial actions.

In "Deep inside molecules — digital twins at the nanoscale", head-mounted virtual reality displays connected to molecular simulation engines were used to create interactive and immersive digital twins. They were used to perform tasks relevant to specific use cases. Three areas were investigated, including model building, rational design, and tangible models. Here, authors report several membrane-embedded systems of ion channels, viral components, and artificial water channels. Authors were able to improve and create molecular designs based on digital twins. The molecular application domain offers great opportunities, and most of the technical and technological aspects have been solved. Wider adoption is expected once the onboarding of VR is simplified and the technology gains wider acceptance.

"Balanced-partitioning treemapping method for digital hierarchical dataset" presented a treemapping method based on balanced partitioning that enables excellent aspect ratios in one variant, good temporal coherence for dynamic data in another, and in the third, a satisfactory compromise between these two aspects. To layout a treemap, all the children of a node were divided into two groups, which were then further divided until groups of single elements were reached. After this, these groups were combined to form a rectangle representing the parent node. This process was performed for each layer of the hierarchical dataset. For the first variant from the partitioning, the child elements were sorted and two groups, sized as equally as possible, were built from both big and small elements (size-balanced partition). This achieved satisfactory aspect ratios for the rectangles but less so temporal coherence (dynamic). For the second variant, the sequence of children was taken and from this, groups, sized as equally as possible, were created without the need for sorting (sequence-based, good compromise between aspect ratio and temporal coherency). For the third variant, the children were split into two groups of equal cardinalities, regardless of their size (number-balanced, worse aspect ratios but good temporal coherence).

"Novel virtual nasal endoscopy system based on computed tomography scans" presents a system for simulating a medical examination procedure in the nasal cavity for training and research purposes, using a patient′s accurate computed tomography (CT) as a reference. The pathologies that are used as a guide for the development of the system are highlighted. Furthermore, an overview of current studies covering bench medical mannequins, 3D printing, animals, hardware, software, and software that use hardware to boost user interaction, is given. Finally, a comparison with similar state-of-the-art studies is made. The main result of this work is interactive gamification techniques to propose an experience of simulation of an immersive exam by identifying pathologies present in the nasal cavity such as hypertrophy of turbinates, septal deviation adenoid hypertrophy, nasal polyposis, and tumor.

"Digital twin intelligent system for industrial internet of things-based big data management and analysis in cloud environments" surveys and illustrates multiple open challenges in the field of industrial Internet of Things (IoT)-based Big Data management and analysis in Cloud environments. Challenges arising from the fields of machine learning in cloud infrastructures, artificial intelligence techniques for big data analytics in cloud environments, and federated learning cloud systems are elucidated. Additionally, reinforcement

learning, which is a novel technique that allows large cloud-based data centers, to allocate more energy-efficient resources is examined. Moreover, authors propose an architecture that attempts to combine the features offered by several cloud providers to achieve an energy-efficient industrial IoT-based big data management framework (EEIBDM) established outside of every user in the cloud. IoT data can be integrated with techniques such as reinforcement and federated learning to achieve a digital twin scenario for the virtual representation of industrial IoT-based big data of machines and room temperatures.

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