www.pipelinepub.com
Volume 21, Issue 9

Why AI & AR/VR Can Help Aerospace Manufacturers Like Boeing Improve Design and Maintenance of Aircrafts

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The aerospace industry prides itself on operating at the forefront of technological innovation, yet it consistently seeks ways to improve aircraft design and maintenance. Issues ranging from optimizing intricate engineering processes to ensuring meticulous inspections and repairs present ongoing challenges for manufacturers. This critical demand for precision and efficiency has paved the way for the integration of advanced technologies. Specifically, Artificial Intelligence (AI), Augmented Reality (AR), and Virtual Reality (VR) are proving to be transformative tools, fundamentally changing the landscape of aerospace manufacturing and maintenance.

Current Challenges in Aerospace Manufacturing

The aerospace manufacturing sector currently grapples with several significant challenges that underscore the need for advanced technological solutions. Supply chain disruptions, exacerbated by global events, continue to impact production timelines and material availability, forcing manufacturers to seek more resilient and adaptable processes. The increasing complexity of modern aircraft designs also presents a hurdle, requiring higher precision and more sophisticated assembly techniques.

Moreover, the industry faces a looming skilled labor shortage. As experienced personnel retire, there's a growing need to onboard and train new employees rapidly and effectively, all while maintaining stringent safety and quality standards. These pressures collectively emphasize the urgency of innovative approaches to enhance efficiency, mitigate risks, and support a more agile manufacturing environment.

Design Process Enhancement through AI

AI algorithms play a pivotal role in generative design, allowing engineers to input constraints and requirements, and then using machine learning to generate numerous design iterations. This accelerates the design phase, ensuring optimized and innovative solutions. AI-powered predictive analysis aids in simulating various scenarios, predicting potential issues, and optimizing designs accordingly. This significantly reduces the trial-and-error approach, leading to more robust and efficient aircraft designs.

AI-driven predictive maintenance uses data analytics to predict when components are likely to fail. This proactive approach minimizes downtime, lowers maintenance costs, and improves overall aircraft reliability. AI-powered image recognition and machine learning algorithms enhance quality control processes in manufacturing. This ensures that each component meets stringent quality standards, contributing to the overall safety and performance of the aircraft.

The Role of Robotics in Aerospace Manufacturing

Robotics is rapidly becoming an indispensable component of modern aerospace manufacturing, addressing many of the industry's challenges. Industrial robots are increasingly deployed for tasks requiring high precision and repetitive actions, such as drilling, riveting, painting, and composite lay-up. Their ability to perform these tasks with consistent accuracy surpasses human capabilities, leading to fewer defects and improved product quality. Robotics also significantly enhances efficiency and speeds up production cycles, which is critical for meeting the high demand for new aircraft.

Furthermore, robots improve workplace safety by automating hazardous or ergonomically challenging tasks, allowing human workers to focus on more complex, strategic roles. Collaborative robots, or cobots, are also gaining traction, designed to work alongside human operators, assisting with heavy lifting or intricate assembly, thereby combining the strength and precision of automation with the adaptability and problem-solving skills of human workers.

The Power of Digital Twins

Digital twins are revolutionizing the aerospace industry by creating virtual replicas of physical aircraft, components, or systems. These dynamic digital models are continuously updated with real-time data from sensors on their physical counterparts, providing a comprehensive and up-to-the-minute view of their status and performance. In the design phase, digital twins allow engineers to simulate and test various configurations and materials virtually, predicting how designs will perform under different conditions before any physical prototype is built. This iterative virtual testing drastically reduces development time and costs.

During manufacturing, digital twins can monitor the production process, identifying deviations from specifications and flagging potential quality issues in real time. This allows for immediate corrective action, preventing costly rework and ensuring the highest quality standards. For maintenance, a digital twin provides a detailed history of an aircraft's operational life, including flight hours, maintenance records, and sensor data. This rich dataset enables highly accurate predictive maintenance, allowing airlines to proactively anticipate component failures and schedule maintenance, minimizing downtime, and optimizing resource allocation. The insights gained from digital twins also inform continuous design improvements, creating a feedback loop that enhances future aircraft generations based on real-world performance data.

AR and VR in Aircraft Assembly & Maintenance

AR and VR technologies enable engineers to visualize and interact with 3D models of aircraft components during the assembly process. This not only improves precision but also reduces the likelihood of errors. Remote Assistance: AR allows experts to provide real-time guidance to technicians on the assembly line, even if they are located remotely. This is particularly valuable in a globalized industry where experts may not always be physically present.

AR and VR for Workforce Enablement

Beyond design and direct maintenance, AR and VR plays a substantial role in workforce enablement for manufacturing teams, addressing the critical need for effective training and knowledge transfer. AR and VR-based training programs provide realistic simulations for pilots, ground crew, and maintenance personnel. This hands-on training enhances skills, improves decision-making under pressure, and contributes to overall safety. New hires can immerse themselves in virtual environments that replicate real-world assembly lines, allowing them to practice complex procedures in a safe, repeatable, and controlled setting without tying up actual machinery or components. This accelerates the learning curve and builds confidence.

For maintenance, AR overlays maintenance instructions onto physical aircraft components, guiding technicians through complex procedures. This ensures accuracy and reduces the learning curve for new technicians. This "on-the-job" guidance reduces errors and improves efficiency, especially for intricate tasks. Furthermore, AR and VR can facilitate knowledge sharing among experienced and novice employees. Senior technicians can create AR-guided workflows that capture their expertise, providing a valuable resource for less experienced colleagues and ensuring critical institutional knowledge is retained and disseminated effectively.

The Importance of 3D & AI in Immersive Mixed Reality

One of the key requirements for engineering teams and mixed reality applications is to precisely overlay on an object its model or the digital twin. This helps provide work instructions for assembly and training and catches any errors or defects in manufacturing.

The user can also track the object(s) and adjust the rendering as the work progresses. Most on-device object tracking systems use 2D image and marker-based tracking. This severely limits overlay accuracy in 3D because 2D tracking cannot estimate depth with high accuracy and, consequently, the scale and the pose. This means that even though users can get what looks like a good match when looking from one angle and position, the overlay loses alignment as the user moves around in 6DOF.

Aerospace design teams are overcoming these challenges by leveraging 3D environments and AI technology into their immersive mixed-reality design and build projects. Deep learning-based 3D AI allows users to identify 3D objects of arbitrary shape and size in various orientations with high accuracy in the 3D space. This approach is scalable with any arbitrary shape. It is amenable to use in enterprise use cases requiring rendering overlay of complex 3D models and digital twins with their real-world counterparts.

Why Working in a Cloud Environment is Crucial

Aerospace designers and manufacturers should be cautious in how they design and deploy these technologies because there is a significant difference in the platform on which they are built and maximized for use. Even though technologies like AR and VR have been in use for several years, many manufacturers have deployed virtual solutions on devices where all the technology data is stored locally, severely limiting the performance and scale needed in today's virtual designs. It limits the ability to conduct knowledge sharing between organizations, which can be critical when designing new products and understanding the best way for virtual buildouts.

Aerospace manufacturers today are overcoming these limitations by leveraging cloud-based (or remote server-based) AR and VR platforms powered by distributed cloud architecture and 3D vision- based AI. These cloud platforms provide the desired performance and scalability to drive industry innovation at speed and scale.

By integrating these technologies, aerospace manufacturers can streamline their operations, continue to focus on improving the success of their maintenance procedures, reduce costs, and enhance both customer and facility team experiences.

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