


Chapter 11

Augmented Reality: Transforming Manufacturing in the Industry 4.0 Era

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ABSTRACT

This chapter provides a comprehensive examination of Augmented Reality (AR) in manufacturing, covering its introduction, types, implementation strategies, advantages, challenges, applications, and methodologies for implementation. We present a brief overview of AR technology in the context of Industry 4.0 and its significance in manufacturing. It highlights the potential of AR to bridge the gap between the physical and digital worlds. We then discuss the various types of AR technologies relevant to manufacturing along with the working of AR technology. The numerous benefits of adopting AR in manufacturing and the systematic methodology for implementing AR in manufacturing environments is presented. Five applications of AR in manufacturing from real industries have been presented. The advantages, common challenges and barriers to AR implementation in manufacturing are discussed. This research provides a comprehensive roadmap for leveraging AR technology in manufacturing, offering insights into its potential, challenges, and practical implementation strategies.

1. INTRODUCTION

Augmented reality (AR) constitutes an interactive encounter that enriches the physical world by integrating computer-generated sensory data. Through the utilization of software, applications, and devices like AR glasses, this technology superimposes

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digital elements onto real-world settings and objects. Such augmentation enhances user engagement, transforming everyday surroundings into interactive learning spaces, which is especially beneficial in fields like manufacturing and Industry 4.0. It enables industrial practitioners to seamlessly integrate with machinery and systems, optimizing technology and Internet of Things (IoT) networks through human insight, observation, and inventive thinking. AR applications are widely available on smartphones and portable devices.

1.1 Understanding Augmented Reality

AR devices are hardware tools that improve our senses of sight, sound, and touch by superimposing virtual information over the real world. Table 1 provides an explanation of augmented reality from various perspectives. These devices can be divided into a number of categories. Headsets and smart glasses, handheld devices, projection-based systems, spatial augmented reality (SAR), head-up displays (HUD), and augmented reality contact lenses are the first six groups of this categorization (Azuma et al., 2001; Mendoza-Ramírez et al., 2023; Milgram et al., 1995). This categorization is also represented in Figure 1.

Table 1. Augmented reality is represented using various perspectives

Aspect	Description
Definition	Augmented reality superimposes digital information over the actual environment, improving the user's experience of reality. (Chatzopoulos et al., 2017).
Implementation	Operates mainly through mobile devices such as smartphones or tablets. In industries where hands-free operation is crucial, AR experiences are facilitated through glasses or headsets (Kipper and Rampolla, 2013).
Applications	Applied in various fields, including gaming, retail, navigation, and manufacturing, enhancing tasks with digital overlays and information (Dargan et al., 2023).
Interaction	Enables users to interact with digital information overlaid onto the physical world, often through gestures or voice commands.
Use of Devices	Primarily accessed through smartphones or tablets; in specific industries, glasses or headsets are preferred for hands-free operation.
Example Scenario	In manufacturing, AR glasses overlay assembly instructions onto machinery, allowing technicians to perform tasks with real-time guidance.

Augmented Reality operates by overlaying digital content onto real-world objects, enabling users to engage with a blended 3D environment that merges physical and digital elements. However, AR's effectiveness lies in its integration within a connected Industry 4.0 framework, incorporating various technologies like big data and automated robotics. Table 1 provides an explanation of augmented reality from various perspectives.

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