The MASTER XR Platform for Robotics Training in Manufacturing

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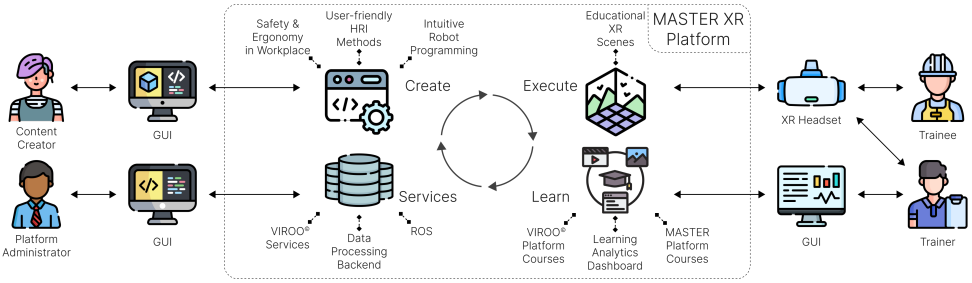

Figure 1: The MASTER XR Platform has four modules: Create, Execute, Services, and Learn, tailored for different user groups.

Abstract

The MASTER project introduces an open Extended Reality (XR) platform designed to enhance human-robot collaboration and train workers in robotics within manufacturing settings. It includes modules for creating safe workspaces, intuitive robot programming, and user-friendly human-robot interactions (HRI), including eye-tracking technologies. The development of the platform is supported by two open calls targeting technical SMEs and educational institutes to enhance and test its functionalities. By employing the learning-by-doing methodology and integrating effective teaching principles, the MASTER platform aims to provide a comprehensive

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learning environment, preparing students and professionals for the complexities of flexible and collaborative manufacturing settings.

CCS Concepts

• **Human-centered computing → Mixed / augmented reality**.

Keywords

Industry 4.0, Extended Reality (XR), Robotics, Worker Training, Manufacturing, Human-Robot Collaboration, Eye Tracking

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1 Introduction

Industries are increasingly adopting robots and XR technologies to implement Industry 4.0 production models, necessitating that workers understand these technologies, particularly in collaborative manufacturing settings. This involves programming robots frequently and maintaining safe shared workspaces, where awareness of robot actions can help mitigate stress and potential dangers [2]. Consequently, students and professionals must learn to program and collaborate with robots safely. XR technologies can enhance learning [3] and are expected to create 1.2-2.4 million new EU jobs and grow European markets by €35-65 billion by 2025 [5]. Specific education and training programs are essential for transitioning to XR-based workspaces. The EU project MASTER [2] aims to provide an open XR platform for worker training in robotics and human-robot collaboration. The platform will facilitate the creation of XR-based training scenarios and materials and provides key functionalities for creating safe robotic environments, programming flexible robotic applications, and integrating advanced interaction techniques based on eye tracking. Two open calls will support the platform. The first targets SMEs to integrate their XR developments into the platform. The second aims to attract educational institutes to prepare training material using the above tools and test the proposed functionalities. A validation methodology will be proposed and iteratively improved during the project to achieve this.

2 MASTER XR Platform

The MASTER project aims to enhance human-robot collaboration by providing an XR platform for teaching and training robotics in manufacturing. The platform[1] supports various roles, and provides tools for creating and managing immersive content in single-user and collaborative settings. The system architecture (Figure 1) comprises several modules:

- **Create:** Focuses on developing robotics XR educational content. It integrates elements developed by the MASTER consortium and first open call applicants, including: (i) Safety and Ergonomics in the Workplace, (ii) Intuitive Robot Programming, and (iii) User-Friendly HRI Methods.
- **Execute:** Offers a runtime environment to execute robotics XR content. It supports add-ons and custom solutions, ensuring flexibility and adaptability to various training scenarios.
- **Services:** Manages users and sessions, integrates external services like ROS for advanced robotics, and includes a backend for interactive machine learning and analytics.
- **Learn:** This module aims to include a learning management system for didactic materials and a dashboard like [1] for trainers to analyze data collected during educational lessons.

[1]Based on the VIROO® platform: https://www.virtualwareco.com/viroo/

3 Educational Scenes

The educational system within the MASTER platform is designed to align with effective teaching principles for complex learning in technical contexts, based on models like those by [4]. It employs a learning-by-doing approach, emphasizing hands-on experience, leveraging XR technology to simulate industrial settings. XR scenarios facilitate practical knowledge application, allowing for non-destructive error simulations and group interactions that boost student engagement and motivation.

Educational use cases in the MASTER platform aim to help learners achieve specific learning objectives through practical application in XR scenes. These use cases are categorized into identification, problem solving, process following, and knowledge repositories, each with detailed descriptions and resources linked to learning goals. Approximately 20 reusable scenes will be developed, showcasing MASTER project technologies and serving diverse audiences. In addition, the platform will include content management, student access, and activity tracking features, enabling trainers and content creators to design new activities and develop XR content.

4 Conclusion and Future Directions

This report highlights the progress of the MASTER project in integrating XR technologies to enhance robotics training in manufacturing. Future work will expand platform features, develop content, and validate effectiveness through user studies.

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