CNC Work Cell Safety and Automation Enhancement

Overview

This document outlines a comprehensive solution to enhance safety, automation, and visibility across a robotic CNC work cell. The system comprises a robot operating on 4 Parker servo drives that travels along a rail, interfacing with six individual CNC machines. The proposed solution leverages commercially available industrial hardware that integrates seamlessly with the existing infrastructure while maintaining independent control over its own software. All selected components comply with industrial safety standards and prioritize modularity, software independence, and minimal physical rewiring.

Hardware Selection Summary

The solution incorporates several key hardware components: 1. **LIDAR Units**: Six SICK microScan3 PRO safety laser scanners for static zone protection (five between CNCs and one at the front of the cell on the West end), plus one mobile unit mounted on the robot. These units provide reliable area monitoring with SIL 2/PL d safety ratings. 2. **Industrial Cameras**: Six Banner Engineering VE Series Smart Cameras positioned to monitor each CNC machine's process, capable of capturing event-based snapshots and providing live feeds. These cameras support EtherNet/IP and Modbus/TCP protocols. 3. **Autonomous Mobile Robot (AMR)**: A MiR250 AMR with a 250 kg payload capacity (exceeding the required 220 kg) for transporting materials from the staging area to the quality control zone. The AMR features advanced navigation and obstacle avoidance capabilities. 4. **Pressure-Sensitive Mats**: Six MatGuard Pressure Sensitive Safety Mats placed in front of each mill to detect operator presence and trigger appropriate safety responses. These mats are moisture and abrasion resistant for long-term durability in industrial environments.

Integration Strategy

All selected hardware components utilize standard industrial communication protocols (EtherNet/IP, Modbus TCP, and IO-Link) that ensure seamless integration with the existing robot control system. The integration approach emphasizes clean software separation through the following strategies: 1. **Protocol Compatibility**: Each device communicates via standard protocols accessible through the robot's IO layer, which is programmable in Python and C++. 2. **Independent Control**: Each hardware component maintains its own software control while interfacing with the main system through well-defined APIs and protocol interfaces. 3. **IO Mapping**: Unused IO ports on the CNC machines and robot control cabinet are utilized for connecting the new components, minimizing physical rewiring requirements. 4.

Modular Architecture: The solution employs a modular design where each component can be added, removed, or replaced without affecting the overall system functionality. 5. **Safety Compliance**: All components meet relevant industrial safety standards (ISO 13849, IEC 62061) and integrate with the existing safety architecture.

Installation & Layout

The installation follows a systematic approach to minimize disruption to ongoing operations: 1. **LIDAR Placement**: Static LIDAR units are mounted at strategic positions to cover the five zones between CNC machines and the western entrance zone. The mobile unit is securely attached to the robot structure with appropriate vibration damping. 2. **Camera Positioning**: Each VE Series camera is positioned to provide optimal viewing angles of the respective CNC machine's work area, with proper lighting considerations and protection from coolant splashes. 3. **Pressure Mat Installation**: Safety mats are installed directly in front of each CNC machine with appropriate ramped edges for smooth transitions and secured using industrial adhesives. 4. **AMR Path Planning**: The MiR250 AMR operates on a predefined path between the staging area and quality control zone, with charging stations strategically placed to ensure continuous operation. 5. **Cabling and Networking**: Industrial-grade Ethernet cabling connects all components to the existing network infrastructure, with proper strain relief and protection from mechanical damage.

Conclusion

This integrated solution significantly enhances the safety, automation, and visibility of the CNC work cell while maintaining compatibility with the existing infrastructure. By selecting commercially available components with standard industrial protocols, the implementation ensures reliability, maintainability, and future expandability. The modular design allows for phased implementation and easy upgrades as technology advances. This approach delivers immediate safety improvements while establishing a foundation for future Industry 4.0 initiatives.