

## Study on the Impact of Smart Factory Technology in Factory Management Systems on Personnel Safety

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**Abstract:** In the era of digital transformation, factory automation management has gradually become the norm, integrating machinery, personnel, and big data into a unified and digital ecosystem. This not only creates a more flexible and high-productivity production environment but also enhances the overall safety of the factory premises. The 'Smart Factory - Personnel and Factory Site Safety Services' program integrates a central control platform, equipment management, personnel management, and factory safety into a smart factory management system, using a software and hardware architecture based on the Internet of Things. The primary goal of this system is to gain a comprehensive understanding of employees' work conditions to further optimize the production process and ensure the safety of the factory site. Through comprehensive data analysis, the system is expected to provide more insights, helping the management team plan resources more effectively, improve production efficiency, and provide a safer working environment, thus driving the future of smart manufacturing.

**Keywords:** Digital transformation, Factory automation management, Smart Factory, Personnel management

### I. Introduction

In the era of Industry 4.0, factory automation management has become a widespread industry standard, ushering in a revolutionary transformation that converts traditional factories into highly digitized and intelligent manufacturing environments. Throughout this process, machinery, personnel, and significant data resources are seamlessly integrated into a unified and interconnected ecosystem, resulting in increased production flexibility and efficiency and a substantial enhancement of overall factory safety. At the heart of this transformation lies the core of Smart Factory technology, which seamlessly bridges the physical and digital worlds, elevating factory operations to unprecedented levels.

To achieve greater efficiency and safety, the "Smart Factory - Personnel and Site Safety Services" program introduces the "Smart Factory Site Management System." This system, built upon a software and hardware architecture based on the Internet of Things, integrates central control platform, equipment management, personnel management, and factory safety as its four key facets. This integration allows for real-time insights into the working conditions of employees but also facilitates the optimization of the production process to ensure the overall safety of the factory. As factories expand, the scalability of this system becomes crucial, enabling swift transitions between different factory areas and providing real-time monitoring of vital information from all factory sites, including personnel location, machine operation status, and any potential anomalies.

Comprehensive data analysis is a pivotal advantage of this system, offering management teams more significant insights, aiding in more effective resource allocation, improving production efficiency, and providing a safer working environment. This system represents a significant milestone in current smart manufacturing and is poised to guide the future direction of intelligent manufacturing. In this new era, factory management is not solely about production but also about the safety and well-being of the workforce.

### II. Related Works

#### 2.1 Smart Factory Monitoring Dashboard

Given the potential need for future expansion of the factory premises, our platform allows for swift switching between factory areas to monitor real-time on-site conditions and integrate essential information from all factory areas, including personnel, machinery status, and any related anomalies. Therefore, in this case, we have designed a central control platform, which primarily comprises four essential functions, including "Online Personnel Count," "Online Machinery Status," "24-Hour Anomaly Status Statistics," and "Dashboard," as illustrated in Figure 1, to provide real-time information about personnel and equipment.



Figure 1. Central Control Platform

### 2.1.1 Centralized Online Machine Management

We can display the total number of machines in different factory areas and use four indicator colors, "red," "yellow," "green," and "gray," to provide real-time status statistics for the machines, as detailed in Figure 2. Furthermore, you can click on the top right corner to quickly switch to "Machine Operation Analysis Real-time Information," as shown in Figure 3.



Figure 2. Online Machinery

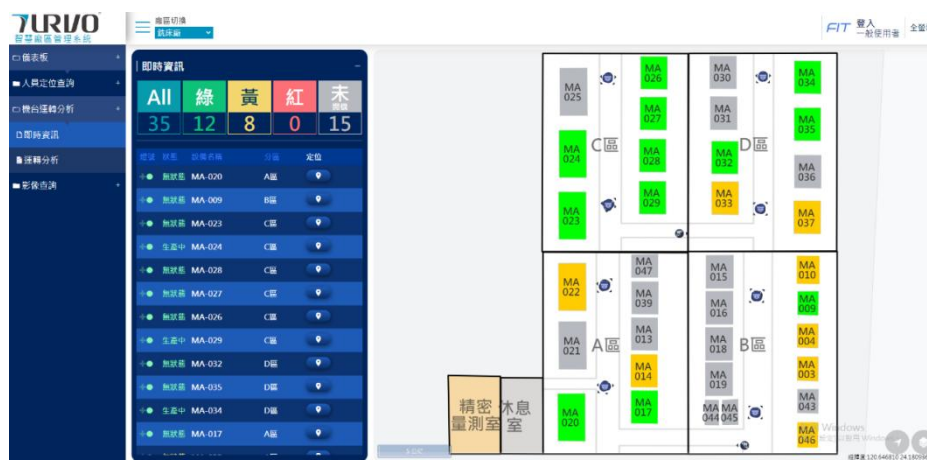


Figure 3. Real-time Machinery Data

**2.1.2 Online Personnel Count on Central Control Platform**

You can view the number of individuals currently wearing identification cards in different factory areas, as illustrated in Figure 4. Additionally, you can easily switch to the "Personnel Positioning - Locate Personnel" feature by clicking the button in the upper right corner, as shown in Figure 5. Within this functionality, you can access a list of personnel currently online, along with their respective area locations. This offers more comprehensive information to assist you in efficiently managing personnel positions and enhancing safety. Implementing this feature further elevates factory operations' overall efficiency and safety.



Figure 4. Dashboard Display of Online Personnel Count

**2.2 24-Hour Smart Factory Management System Aberration Status Statistics and Dashboard Display**

We provide statistics for two types of abnormal situations, including "Location Not Responding" for over 24 hours (as shown in Figure 5) and "Location Recovery Response" (as depicted in Figure 6). These statistics enable management personnel to quickly grasp the status of personnel anomalies and take necessary corrective actions. We display equipment, personnel, and camera location information through floor plans of various factory areas. This presentation provides real-time data and their relative positions, as illustrated in Figure 7. You can click personnel icons to access detailed information, including clock-in times and the latest system-based location detection times.

Regarding the cameras, we distinguish between fisheye and bullet cameras. Fisheye cameras not only display panoramic images in the system but also allow image queries from various angles and support multi-window parallel viewing, as demonstrated in Figure 8. This integrated functionality delivers comprehensive data and information to assist management in effectively monitoring factory operations and addressing exceptional situations.



Figure 5. Location Not Responding



Figure 6. Location Recovery Response

### III. Introduction to the Method

#### 3.1 Personnel Location Query

List of currently online employees in various factory areas for in-depth research into employee attendance, as shown in Figure 7. The list includes employee names, zones, timelines, and locations, updating data every 5 seconds. Furthermore, we provide support for querying the work routes of individual employees for the past two days, facilitating tracking and analysis of any abnormal events. For employees of interest, you can find them in the factory area personnel list and then access the factory area personnel timeline page, as shown in Figure 8, to obtain detailed information about their work routes over the past two days. Enter your desired date range and click the "Query" button; the system will display the employee's sign-in time within the selected date range and their entry time, dwell time, exit time, and relevant machine numbers in each zone.



Figure 7. Personnel Location List



Figure 8. Factory Personnel List - Timeline and Timeline Query Results

#### 3.2 Multiple Path Comparison Analysis

Simultaneously track the pathways of multiple employees. Select the desired time range and adjust the time axis units (from a minimum of 1 minute to a maximum of 1 hour). Choose the employees you want to track (up to 3 individuals), as shown in Figure 9. After clicking the "Query" button, the platform displays individual pathways in different colors and a time-based representation of the areas where they have stopped, as illustrated in Figure 10. The path for unique A is shown in blue, and the pathway for individual B is displayed in green.



Figure 9. Multiple Path Comparison Analysis

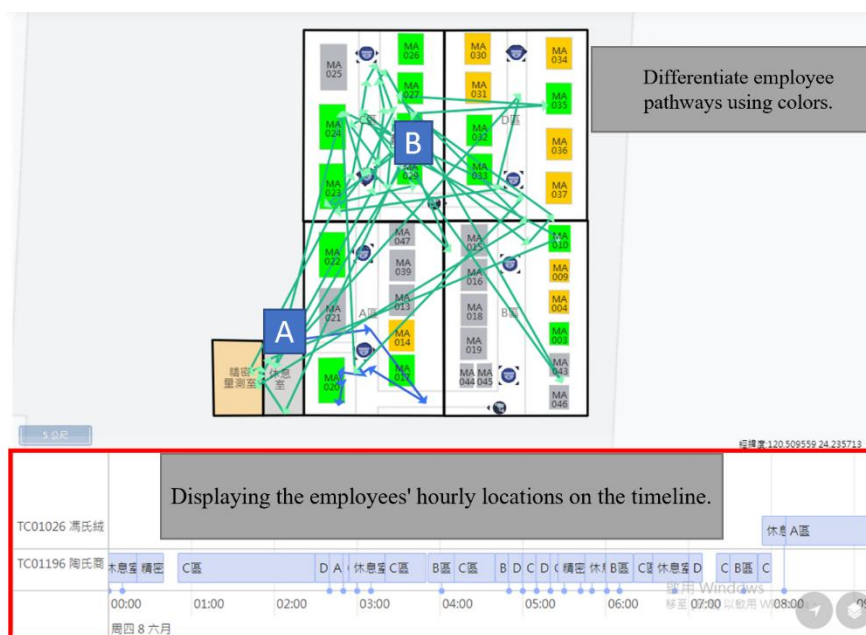


Figure 10. Multiplayer path comparison analysis query results (Dashboard)

### IV. Results and Discussion

#### 4.1. Real-time Machine Operation Information Analysis

They are utilizing different colored indicator lights to distinguish the current operational status of machines in various factory zones, making it convenient for managers to grasp the overall operation situation. If one wishes to pinpoint the location of a specific device, clicking on the icon will result in a red flashing circle on the map, indicating the position of that machine, as shown in Figure 11. You can instantly view the operating conditions of individual or all devices in different factory zones. It is also possible to select the desired machine number and time, click the button, and quickly interpret the production data of that machine within a specific period from the statistical charts, as depicted in Figures 12 and 13.



Figure 11. Real-Time Information



Figure 12. Operational Analysis Query Results



Figure 13. Real-time Status of Operational Analysis for Each Machine (Dashboard)

## V. Conclusions

### 5.1 Conclusion

- (1). **Real-time Monitoring and Retrieval Function:** The system provides robust real-time monitoring and retrieval functions, allowing users to view camera feeds anytime. Users can select specific areas, browse image lists, and quickly locate the position of a particular camera. This is especially helpful for management personnel, particularly in emergencies, as they can trace historical image records. Furthermore, the system offers an image rotation feature, enabling simultaneous viewing of feeds from all cameras and enhancing management's convenience.
- (2). **System Management and Function Flexibility:** System administrators can perform account logins and management through the system management function. Additionally, the system provides "Project Function Management," allowing administrators to adjust the order of tasks on the left side to accommodate the expansion of system capabilities. This enhances system flexibility as new extension features can be added through simple configurations and role permission settings. This means the system can continuously expand and upgrade to meet evolving needs.

In summary, this intelligent factory system not only features real-time monitoring, historical image retrieval, and simultaneous viewing of multiple cameras but also provides system administrators with function management and flexibility to adapt to changing requirements. This will help improve factory operations' efficiency and security.

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