Challenges of Emergency Management Digital Transformation in Industrial Parks

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ABSTRACT

Industrial parks are economic drivers of the cities where they are located. These parks are constantly at risk of catastrophe due to the diversity of industries and the dangerous materials used in their production processes. Despite this constant threat, there is a digitization shortfall in the emergency management process in industrial parks. This research paper seeks to describe the importance of digital transformation in industrial parks, as well as, how information systems can contribute to proper emergency management. Based on the preliminary analysis of the literature, it was possible to determine how the implementation of an emergency system would facilitate the prevention of catastrophes according to the analysis of scenarios, simulation, management, and proper coordination of emergencies in real-time. However, the proper functioning of this system depends on the implementation of environmental innovation, exploration, and observation skills, without neglecting the commitment of organizations and their material, human and technological resources to achieve a significant change.

Keywords

Digital Transformation, Safety, Industrial Parks, Emergency Management, Simulation.

INTRODUCTION

Industrial parks represent extensive urban areas often neglected, which contribute to the degradation of the urban environment, including low thermal comfort levels as a result of soil sealing and low albedo surfaces (Alves et al., 2022). These places are found in vulnerable areas where significant quantities of dangerous substances are stored or processed. Therefore, all the industries that carry out their productive activity in these places are exposed to different types of risks including natural, industrial, economic, financial, or health emergencies. The survival of such organizations is conditioned to appropriate management of risk factors. It is important to understand what the differentiating factor, which allows overcoming or preventing catastrophic events is within an organization. This success factor could be given by its resilience, defined by Patriarca et al. (2018) as a property of the system that confers the ability to remain intact and functional. Enhancing this definition Carden et al. (2018) states that resilience is the ability to resist stress or recover and regain its previous form.

Industrial facilities must always have active responsiveness, which can result directly from an appropriate development of emergency plans, development of new methodologies, skills, and technologies that allow the use of common designs and resources as a strategy to respond to new and emerging threats, which would allow preventing, evaluating, and controlling their consequences. Thus, Cozzani (2017) states that Information Systems (IS) can contribute to achieving this goal by improving the improvement of processes and risk prevention. From our perspective, it is of vital importance that industrial parks have an IS capable of managing emergency plans in dispersed locations in an accessible manner, as well as notifying, controlling, and activating

alerts in real-time through sensors and mobile technology, optimizing resources by enhancing the response in industrial parks. Therefore, it would be important to have industrial parks with infrastructure integrated with Industry 4.0 technology that allows users to monitor, control, and optimize the social, economic, and environmental repercussions of industrial activities (Pan et al., 2015). In this context, IS can be used in the phase of planning, preparation, detection, and responsiveness to emergencies in industrial parks through the design of emergency plans developed collaboratively. Thus, facilitating organizations with comprehensive management, planning, and responsiveness in light of emergencies.

This article is structured in the following sections. In the first section, a theoretical approach is described regarding digital transformation and technological resources that can be used by industries in the security monitoring process. In the second section, an explanation about industrial parks and the risks they are exposed to is given. Section three describes the proposal for a metadata modeling that integrates prevention, monitoring, and responsiveness to catastrophic events, and finally, the challenges of digital transformation are recognized. The paper ends with conclusions.

DIGITAL TRANSFORMATION IN INDUSTRIAL PARKS

Industry 4.0, which is known as the fourth industrial revolution, was named for the first time in Germany in 2011 as part of a new concept of economic policy based on high-tech strategies. This fourth industrial revolution, according to Roblek et al. (2016) is based on the digitization of production, automation, and correlation, for which it is necessary to have resources such as the Internet of Things (IoT), a Cyber-Physical System (CPS), Information and Communications Technology (ICT), Enterprise Architecture (EA), and Enterprise Integration (EI) (Lu, 2017). The implementation of these technologies seeks to improve processes and achieve a suitable digital transformation for the company.

Therefore, with the application of technological resources of Industry 4.0, it is possible to improve the internal processes and competitiveness of organizations. This phenomenon is usually called digital transformation, which according to Vial (2019) is a process that aims to improve an organization by causing significant changes in its properties through combinations of information, computing, communication, and connectivity technologies. Consequently, the expansion of new digital technologies makes digital transformation relevant to almost all industries. For this reason, nowadays companies are beginning to carry out digital transformation in a more systematic and strategically planned manner by creating measurable objectives and defining roles and responsibilities in the organization (Berghaus, 2016).

Thus, digital transformation has become a topic of great importance for companies since it changes relationships with customers, internal company processes, and the establishment of the value of organizations through the use of Information Technologies (Zaoui & Soussi, 2020). In the application of digital transformation, the strategy of change and the establishment of continuous practices of transparency and incorporation must be considered (Morton et al., 2020). This will allow organizations to create, capture and transfer information within companies by utilizing appropriate IS, the strategies for use, and the people who sustain the information for the use of IS (Porfirio et al., 2021).

The transformation and improvement of the different types of traditional industrial parks are inseparable from the replacement of the dominant industrial structure and the change in form and function (Bai & Lai, 2022). Therefore, to achieve a true digital transformation in industrial parks, information technologies must be incorporated through interconnected devices such as the Internet of Things (IoT), industrial applications in the cloud, and fifth-generation mobile networks (5G). To establish flexible and efficient solutions in response to security problems with the advantage that they may be of use to numerous heterogeneous devices, which companies have, generating a sustainable vision (Hatzivasilis et al., 2018).

The greatest disadvantage of the digital transformation applied to industrial parks is the lack of interoperable solutions that adjust to the integration and the utilization and management of many devices and associated services making it difficult to establish industrial environments with artificial intelligence. For this effect, the use of inter-organizational information systems, digital platforms, and the development of new IT capabilities (Delmond et al., 2016) would help generate scenarios, optimize resources, and improve the resilience of industries; but this must be strengthened through a collaborative process to create capacities. According to

(Helfat & Raubitschek, 2018) there are three types of capacities such as the capacity for innovation, environmental research, and discovery capacities, and lastly integration capacities. If companies can acquire these capacities, we could achieve collaborative resilience, which takes into account strategies, participation, and consideration of the situation (Mahajan et al., 2022).

Safety and Security in Industrial Parks

An industrial park as such emerged in North America and Europe in the 1950s as a solution to the issues of expansion and development. Thus, they can be described as "a large extension of land, subdivided and developed for the use of several companies simultaneously, (Pieser & Chang, 1998) and industrial buildings may be part of an integrated industrial park, or they may be individual buildings located in industrial districts or neighborhoods that are part of a "park-like setting". In addition, it can be considered as a community of companies that are in a common property sharing materials, energy, or infrastructures (Valenzuela-Venegas et al., 2018). Therefore, industrial activities generally seek proximity to each other to benefit from easy access to resources, logistics, and customers and can take advantage of their complementarity (Le Tallier et al., 2022).

In addition, industrial parks are located in places where different types of industrial activities are developed such as vehicular, metallurgical, chemical, food, etc., where different types of materials are used for production. Moreover, these companies store chemical materials, so these places often face threats, which can cause great damage and jeopardize the safety of the organizations that conform to them as well as the safety of the employees of such companies. In the normal functioning of these companies, their raw materials or manufactured, transported, and stored products are usually present in flammable, explosive, or toxic locations (Hao et al., 2015). This situation results in the frequent occurrence of pollution and personal injuries, and it also causes great threats to the surrounding environment.

It is important to highlight that in multi-company parks, safety, security, and environmental responsibilities are not always clear, and the risk map has changed since these places are always at imminent risk of emergencies or catastrophes of all kinds (Rui et al., 2014). Furthermore, this situation continues to be an obligation for the security management entities to prepare emergency plans, which allow facing any type of catastrophe more efficiently by taking advantage of the benefits that digital transformation provides us with. Additionally, it is important to consider the design of an integrated park, (Du et al., 2019) based on distributed storage, smart contract, non-manipulation, traceability, and other characteristics of technology (Abraham et al., 2022) in that regard, the incorporation of resources allows industries to encourage circular operations that lead to the creation of sustainable systems.

MODELING EMERGENCY SITUATIONS IN INDUSTRIAL PARKS

In this section, we propose a generic IS for serving as a reference for digital transformation processes of emergencies in industrial parks. From our perspective, is crucial to develop a metamodel for emergencies in dispersed locations. This model is the backbone of the application of advanced interaction models, the development of concept tests with advanced interfaces, and the definition of a process model of emergency response in industrial parks. Digital transformation plays a dominant role in achieving this objective through the production of an IS and understanding how the interaction of these, needs three pivotal phases such as information input, data processing, and as a result the responses or reports of the collected data. The information to be gathered should begin with the characterization of the dispersed locations within the business parks. Such will allow identifying where the security cameras and the infrared sensors that monitor temperature, humidity, and air concentration will be located, it will monitor all kinds of activities that potentially risks business parks into an emergency. The data coming from the cameras and infrared sensors should be transmitted immediately to the new SI, which will analyze any possible crisis in real- time, using the metamodel for emergency management.

The metamodel includes interfaces and document engineering, which allow the analysis of real-time crisis scenarios for emergency management in industrial parks with all the benefits that it entails in terms of simulation and flexibility. With scenarios that consider the various phases of emergency management such as

the response, control, and mitigation of the damage generated by the crisis. Scenarios for response and control during emergency management, scenarios that support group decision-making for the implementation of contingency plans during emergency management, or scenarios to improve collaboration between rescue services, police, and military staff during crisis scenarios (Figure 1).

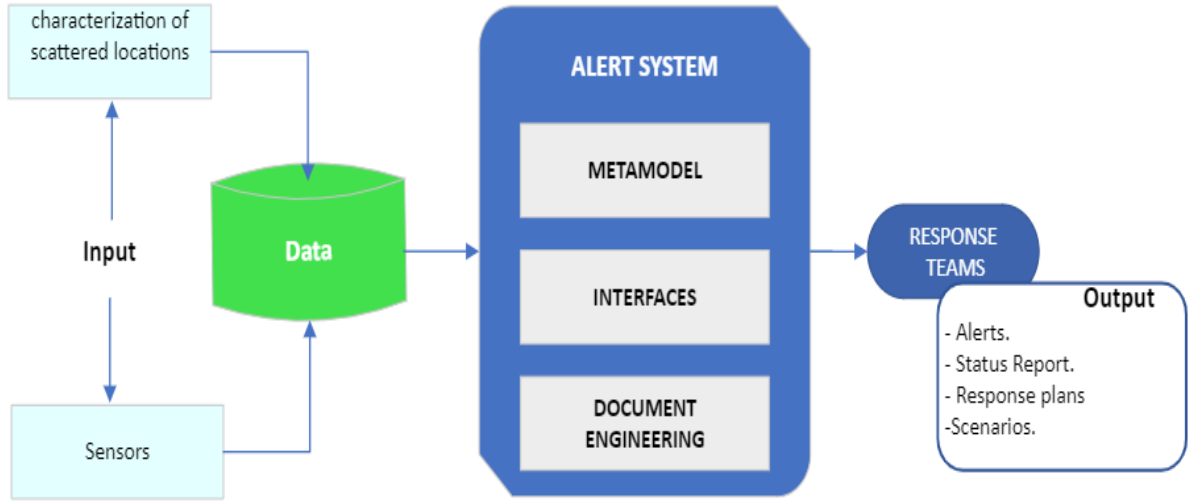

Figure 1. System Outline

Although scenarios play a very significant role in the current management and responsiveness to emergencies in both, the main international and national organizations, we identified the lack of developments capable of producing and analyzing this set of scenarios in more complex crises in real-time. This is where the intervention of IS comes into play for the efficient creation of emergency plans, which integrate these capacities, facilitating outstanding communication and interaction between the participants, promoting a better understanding and analysis of the situation from different perspectives, and improving their document management. There is currently a lack of a simulation and analysis methodology capable of integrating data of different nature to provide successful support for decision-making in real-time.

Therefore, our proposal is based on the successful use of Industry 4.0 resources; it will allow the development of multiple perspectives regarding economic, environmental, and social sustainability and provide a framework to think of a strategy for the design of sustainable industrial parks (Cochran & Rauch, 2020). The establishment of an emergency management system that allows the design of simulated scenarios for training, in such a way that emergency management capacity is produced, as well as for the evaluation of the plan itself, in such a manner that its benefits and weaknesses can be identified. Hence, three components are proposed to be considered and developed with the interaction of Information Systems. The first component considers the analysis of scenarios and emergency simulation, the second component contemplates the management of emergencies, and the third component considers real-time coordination through a system that manages the interaction of these three scenarios (Figure 2).

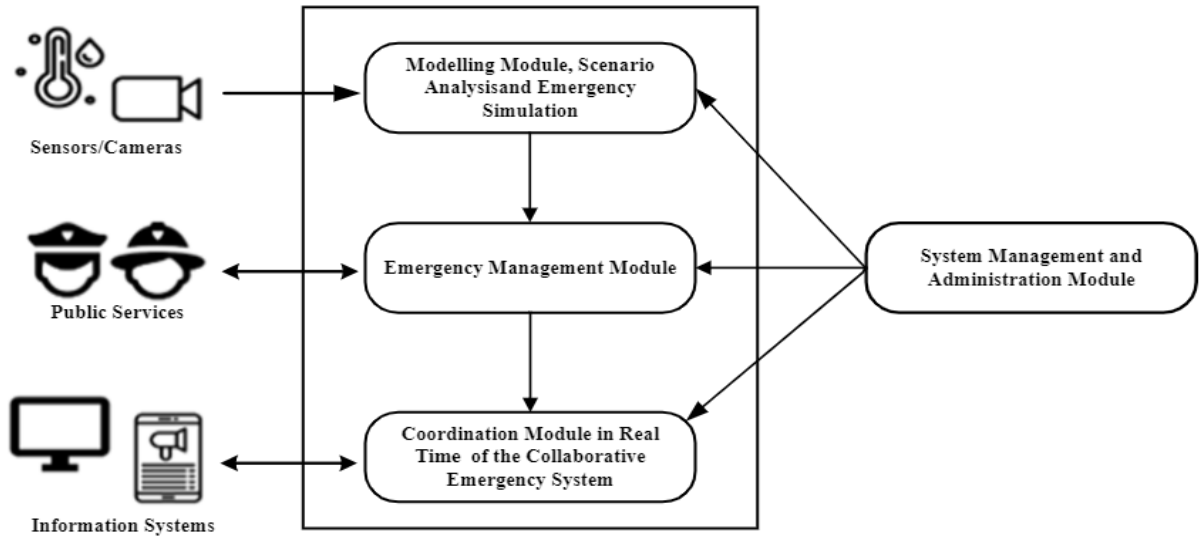

Figure 2. Modules of the Emergency Management System

The emergency management system should be able to "plan and prepare for", "seize", "recover" and "adapt" to any unfavorable event that may occur in the future (Sharifi & Yamagate, 2016). Thus, the modeling component, scenario analysis, and emergency simulation will be based on the dynamic analysis of emergency scenarios (incidents → essential services → responsiveness to the incident) based on the modeling of these scenarios by linking variables, in such a manner, that risks that may be triggered can be anticipated in different emergencies. By sensors (Ansaldi Silvia M. & Bragatto Paolo, 2022) which can be widely distributed throughout the entire establishment, in the workplace, and can be utilized by the employees. Together with Artificial Intelligence, they offer a great opportunity to make safety management at service sites much more dynamic and collaborative.

Meanwhile, the second component of emergency management must achieve intelligent management of emergencies in Industrial Parks to carry out the coordination between those involved more efficiently. This can be achieved through adequate intercommunication via the industrial internet (Boyes et al., 2018) which includes two key components: the connection of sensors and transducers of industrial machines to the local processing of the Internet and the subsequent connection with other important industrial networks that can achieve value independently.

As for the coordination module of the collaborative emergency proposal in Industrial Parks in real time, it must allow communications between the system and the actors involved, enabling very cautious coordination of the response teams. Thus, this information and emergency management system based on new technological advances can assist in the development of safety ideas between intelligent facilities and applications that are possible due to world organizations, (Saber et al., 2019) based on scientific knowledge to be successful.

CHALLENGES

Although digital transformation is a process aimed at improving the competitiveness of companies through digitization, optimization of production, automation and adaptation, human-machine interaction, and automatic data exchange and communication (Sousa & Rocha, 2019). Effective digital transformation will take place when organizations embrace the potential learning in the design and the content delivery process, informal problem solving, knowledge exchange, communities of practice, and user-generated content. The main challenges that industrial parks must overcome include.

Innovation Capacity

Considering that, the organizations, which carry out their activity, are different and use different types of raw

material for the manufacture of their products, which makes them vulnerable to industrial catastrophes; it is important to design an integrated and participative system with the modeling of an information system for emergency management.

Capacity for environmental exploration and detection through the development of a technological solution that allows modeling, simulation, and intelligent management of collected data with the application of advanced interaction models, the establishment of concept tests with advanced interfaces, and the definition of a process model that guarantees collaborative participation in cases of emergency.

Integration Capacities

Furthermore, digital transformation must be carried out independently between the administrators of the transformation and its beneficiaries and with participation in the processes of socialization and training in the use of new technologies. It is important to create a competitive advantage for organizations by participating in efforts to systemize processes, and by assuming responsibility for the use and treatment of data generated by organizations.

CONCLUSIONS

Industrial parks are places of economic development and infrastructure within big cities, but they have always been exposed to constant threats, which makes them an easy target for various types of catastrophes. Currently, the implementation of Industry 4.0 is oriented towards a process of building resilience in the face of adverse events to which they may be exposed. Organizations in the security field need to have the capacities to anticipate, confront, and adapt to problems that may arise without it meaning that they are affected by these events.

Additionally, the industries must be enclosed in the design of a participative and inclusive safety plan that allows the use of digital transformation to produce an emergency management system, which in real-time allows them to have the necessary restorative measures and the ability to respond. Yes, technological resources can help prevent catastrophes, but it is important to emphasize that these technological resources are successful due to the adequate intervention of the human being, and this can be achieved through participatory processes in which its functioning is socialized.

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