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Methodological procedure of technology monitoring integrated with artificial intelligence for Puerto Moa Enterprise

Procedimiento metodológico de vigilancia tecnológica integrado con la inteligencia artificial para el Puerto Moa

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Abstract: This research is aimed at proposing a methodological procedure to establish a technology monitoring system in port operations with the integration of artificial intelligence, allowing Puerto Moa Enterprise to achieve proper decision-making, productive efficiency, and sustainability in its port operations. This is an explanatory study, conducted during the 2023–2024 period at Puerto Moa Enterprise, located in Moa, Holguín province. A diagnostic assessment was carried out through interviews to develop the procedure for the company, incorporating artificial intelligence techniques and methods. The essential guidelines the methodological procedure must meet when designing a Technology Monitoring System integrated with artificial intelligence are established. The system is aimed at promoting port processes digitalization and favoring the company's managers.

Keywords: Digital transformation, computer application, port facility

Resumen: La presente investigación tiene como objetivo proponer un procedimiento metodológico para el establecimiento de un sistema vigilancia tecnológica en las operaciones portuarias con la integración de la inteligencia artificial, que le permita a la Empresa Puerto Moa una adecuada toma de decisiones, eficiencia productiva y sostenibilidad en sus operaciones portuarias. Es un estudio de tipo explicativo, desarrollado en el período 2023-2024, en la Empresa Puerto Moa, ubicada en Moa, provincia Holguín. A través de la entrevista, se realizó un diagnóstico para elaborar el procedimiento para la empresa incorporando las técnicas y métodos de la inteligencia artificial. Se establece las pautas esenciales que debe cumplir el procedimiento metodológico para el diseño de un Sistema de Vigilancia Tecnológica integrando la inteligencia artificial, el cual está encaminado a favorecer la digitalización de los procesos portuarios y a los directivos de la empresa.

Palabras claves: Transformación digital, aplicación informática, instalación portuaria

1. Introduction

The speed of technological change forces companies to adopt the most current trends in order to predict disruptions in industrial and commercial processes. Emerging technologies, especially network interconnection, eliminate boundaries between industries and create an entirely new business model (Ilisevic *et al*., 2018). Hence the importance of digital transformation for the business world in any sector of the economy, including port operations. These advances require companies to have advance information, monitor technological processes, and update their strategies using artificial intelligence methods.

According to Quintero *et al.* (2021), seaports are vital to commercial activities of nations. Through them, an important part of international trade is carried out as strategic zones to strengthen the economy.

The digitalization of processes in port terminals improves productivity, effectiveness, and sustainability in logistics, establishing itself as one of the opportunities for the world (Inkinen *et al.,* 2019). Therefore, it is necessary investing in their technologies and cooperating among different industry actors, facilitating information exchange, improving coordination between their areas and their collaboration.

Digitalization is taking the maritime industry beyond its traditional borders and offers new opportunities to improve productivity, efficiency, and logistics sustainability (Reyes *et al.,* 2025; Jadan Landivar e*t al.,* 2025). The smart port concept aims at adopting modern information technologies enabling better planning and management within and between ports (Kersten, 2017; González *et al.,* 2020). According to Hinojosa-Montañez *et al.* (2023), the smart port conception is based on operational efficiency, business resilience, asset management, safety and security, energy efficiency, and environmental management principles.

Ports digital transformation, to become smart ports, requires not only the use of digital technologies but also an adequate competitive digital strategy for both clients and users as well as for the environment in which it operates (Schiavi, 2023). When ports use advanced technologies, they provide more competitiveness to the company (Giraldo *et al*., 2024), allow real-time monitoring, and optimize energy efficiency (Dos Santos *et al*., 2024).

However, port management and logistics face multiple challenges. These include the need for modern infrastructure, adequate maritime transport regulation, integration of emerging technologies such as artificial intelligence and the Internet of Things, as well as sustainability within marine resources management (Boyano *et al.*, 2024).

Modern seaports play an important role in ensuring efficient and safe cargo flows within global logistics networks. Furthermore, they offer various types of value-added logistics services, such as those facilitating global supply chain postponement strategies (Sánchez *et al.,* 2017). Achieving such strategies efficiently and safely depends largely on accurate and timely information flows, which is possible through the digitalization of their processes using artificial intelligence.

Technology monitoring using artificial intelligence has been incorporated as one of the most important practices in the business field at national and international levels. Innovation in the port sector requires citizen participation and people's talent to improve creativity, as well as tools to manage change in ports (González *et al.*, 2020). In this sense, ports which digitalize all their processes and innovate must take into account external and internal factors that may affect them, recognizing organizational management as a cornerstone to achieve efficiency; external factors will evaluate competitors, growth levels, and establish new relationships.

Hinojoza-Montañez (2023) notes that in today's world, ports are at the forefront of problems that can be solved with the inclusion of technology; however, the proper selection of tools that facilitate port operations is important. Artificial Intelligence (AI) is gaining more ground in many sectors (García & Sanchez, 2023; Erazo-Luzuriaga *et al.*, 2023), including the port sphere (Alonso-Medina & Sanz-Sáiz, 2024; Wang *et al*., 2024; Xu *et al.*, 2024; Huy *et al*., 2024). Artificial Intelligence application in ports can be an important tool to optimize processes and improve efficiency. These solutions in the port sector have characteristics that make AI an exponential technology with great transformative power to make terminals, in particular, and ports, in general, more efficient, safer, sustainable, and more resilient places (Gutarra, 2020).

Strategic monitoring covers four axes: competitive, commercial, technological, and environmental monitoring. San Juan & Romero (2016) define it as an orderly and constant environment observation and analysis process. In this sense, it is evidenced that the establishment of a technology monitoring system, requires the provision of the right infrastructure and highly competitive and qualified personnel in topics related to AI tools, enabling companies to process high volumes of information.

Puerto Moa Company provides loading and unloading operations, reception, storage, and transportation of goods services. Its fundamental function is nickel exportation and supplies importation for mining-metallurgical industries and the new investments developing in the area. Puerto Moa Company shares Moa's port area with other user entities, including CUPET's reception, storage, and distribution facilities and Moa Nickel S.A. Mining Company's facilities destined for the reception and storage of raw materials like sulfuric acid, LPG, sulfur, and carbonated sludge. It also has an area to dry and store nickel sulfide to be exported. Due to its social importance, it has been studied from various perspectives in order to improve its operations (Guilarte *et al*., 2021; Corney *et al.*, 2025); however, these studies have been related to port operations or the environmental impact they cause, lacking the provision of an adequate monitoring systems for this port institution.

Monitoring systems in port areas allow improving security at the facility and the operations carried out in there. In the case of Puerto Moa Company, its security is essential to maintain port, mining, and metallurgical operations in the region and to efficiently manage risks in a timely manner, especially when receiving and accumulating products highly dangerous to humans and the environment.

In a preliminary analysis related to technology monitoring, it was confirmed that the personnel working at the institution lack the knowledge to establish a monitoring system with the tools provided by artificial intelligence, thus preventing a digital transformation in the company's operations, which negatively influence port and logistics processes due to the high volume of data to be processed, causing inefficiency in the information flow, and hindering its development as a competitive company.

This study is aimed at proposing a methodological procedure to establish a technology monitoring system in port operations with the integration of artificial intelligence, for proper decision-making, productive efficiency, and sustainability at Puerto Moa Company.

With this procedure, contribution is made not only with an effective methodology for port security but it can also be applied to other companies in the territory with the purpose of increasing technology monitoring in industrial zones.

2. Materials and methods

This is an explanatory study, conducted during the 2023–2024 period at Puerto Moa Company, located in Moa, Holguín province. It was carried out from the workers' and executives' perspective, using non-probabilistic sampling, since the elements of the population are selected without all having the same probability of being chosen, based on convenience criteria, researcher judgment, or accessibility.

Through interviews, a diagnostic assessment was carried out to develop the procedure for the company, incorporating artificial intelligence techniques and methods.

The proposed procedure consists of 5 stages:

1. Assessment of the company's needs and objectives

2. System design

3. Infrastructure implementation

4. Personnel training

5. Total implementation of the technology monitoring system

3. Methodological procedure for technology monitoring integrated with artificial intelligence

The procedure for technology monitoring integrated with artificial intelligence constitutes a strategic approach that combines a systematic collection of information on technological advances, market and competence trends, with intelligent tools capable of automatically analyzing large volumes of data.

This integration enables opportunities identification, risks anticipation, and support real-time decision-making, optimizing the monitoring process efficiency. Implementing a technology monitoring system using artificial intelligence at Puerto Moa Company involves several key steps to follow:

1. Assessment of the company's needs and objectives

The personnel authorized to carry out the implementation of the technology monitoring system must describe the current situation of the company, collecting information on its port operations, available resources, and administrative and logistical processes. Afterwards, port operations must be evaluated through historical and real-time data analysis, identifying inefficiencies, bottlenecks, and risk patterns when loading, unloading, and handling goods.

Therefore, to identify the areas in need of intervention in terms of safety, efficiency, and management, it is necessary to carry out a comprehensive analysis of the organization's processes and activities, based on direct observation, document review, and operational data collection. In the safety sphere, existing risks, compliance with standards, and prevention and control protocols effectiveness must be assessed, identifying vulnerabilities and possible incidents. Regarding efficiency, execution times, the use of human and material resources, as well as the presence of bottlenecks or waste affecting performance, are analyzed. Finally, in the management matter, planning, control, communication, and decision-making mechanisms are reviewed, identifying coordination failures, lack of reliable information, or performance indicators absence.

The determination of the technology monitoring system's general and specific objectives must be carried out in a structured manner and aligned with the organization's strategy. First, the general objective must be defined, which states the system's main purpose.

This objective must be clear, comprehensive, and consistent with the institutional mission and vision.

Subsequently, specific objectives are established, disaggregating the general objective into concrete and achievable goals, oriented towards specific actions such as identifying technological trends, monitoring competition, detecting risks and opportunities, improving innovation, or supporting key areas such as safety, efficiency, and management. These specific objectives must be measurable, realistic, and defined based on the organization's real information needs, thus ensuring the effectiveness of the technology monitoring system. They can be measured through the SWOT matrix, interviews, process mapping, and gap analysis.

2. System design

In this first step, the most appropriate technology for the company must be selected, as it consists of identifying and combining tools that allow for capturing, processing, analyzing, and interpreting strategic information automatically, efficiently, and reliably. This selection must cope with the system's objectives, the organizational context, and the resources availability. As main technologies, Data Acquisition is proposed for information capture and collection; Big Data for the storage system; NLP as a natural language procedure; Machine Learning as automatic learning; Dashboards as visualization systems and control panel; automation and intelligent alert systems; and cybersecurity and access control.

A software must be designed to integrate the technology monitoring system and enable business acquisition and their management, allowing executives to make timely decisions.

At a third stage, the integration of the designed technology monitoring system with artificial intelligence must be achieved, where the following technologies can be used: Big Data, Algorithms, Machine Learning, Deep Learning. In relation to artificial intelligence, these operations are possible due to the amount of data collected that triggers this mechanism to solve complex models based on a given problem (Gómez, 2016).

At a fourth stage, a clear and user-friendly interface must be designed for the staff operating in the company, allowing them to monitor and control the designed system. In this stage, it is necessary to carry out requirements diagrams, system layers, UML diagrams, interface prototypes, machine learning, expert systems, data flow diagrams, process maps, scenario simulation, prototypes, and apply expert review as well as pilot tests.

3. Infrastructure implementation

At this point, it is necessary to install equipment (data servers, mass storage systems, network infrastructure, backup and recovery devices, computing equipment, workstations for analysts and administrators, virtualization equipment, uninterrupted power supply systems) in order to establish a platform that centralizes the data collected by the technology monitoring system and facilitates analysis, through artificial intelligence, for decision-making in the company.

The equipment for a data centralization platform must be established to guarantee capacity, security, continuity, and scalability, hence information can be available and ready for strategic analysis and decision-making in an integrated and reliable manner. To achieve this, the Capacity Planning technique must be implemented, as well as information flow mapping, distributed databases, replication and versioning, segmentation, redundancy, load balancing, and security.

4. Personnel training

Upgrading and training courses should be developed to train personnel into the use of the technology monitoring system, including the analysis and interpretation of data generated by artificial intelligence and possible warnings to take into account.

Additionally, a unique procedure must be created to allow personnel working with the technology monitoring system to know how to act according to the different system alerts or detected incidents. This step requires upgrading courses; training; workshops; user manuals and quick guides.

5. Total implementation of the technology monitoring system

Once the previous steps are completed, the total deployment of the system in all port operations must be carried out.

The technology monitoring system using artificial intelligence will allow rapid and reliable decision-making, will evaluate the port's progress, and will be able to work towards a port 4.0.

Once the technology monitoring system has been designed and implemented, the specialists in charge of this activity must systematically provide feedback, in order to correct each part of the process and make the necessary adjustments. It is essential ensure all operations comply with the regulations established by the country regarding collected data protection.

Discussion

Port security is of great importance not only for the facility's protection; it is essential to secure trade, maritime services, and the economy. Port monitoring is essential to achieve port facilities goals in a relevant and safe way. Technology monitoring using artificial intelligence must be incorporated as one of the most important practices into the business field of port areas to guarantee operational efficiency.

The digital transformation of Moa's port will enable its future transformation into a smart port by adopting digital technologies and competitive digital strategies. The implementation of a technology monitoring system will enable real-time supervision and optimize port activities.

The implementation of this technology monitoring system will provide the company with multiple advantages related to the facility's security, the working staff, and port operations. At the same time, it can be applied to other companies from Cubaníquel Business Group lacking technology monitoring systems. This procedure can be modified, corrected, or adapted according to the needs of the entity applying it, or transformed for the port company itself in the event of significant changes in its structure or mission.

Conclusions

Digitalization in port companies can be achieved if a harmonious organizational structure is established. The proposed procedure allows, through five stages, the application of a methodology designed for the implementation of a technology monitoring system integrated with artificial intelligence for Puerto Moa Company.

To achieve digital transformation in port operations, it is necessary to have strategies where clear and aligned objectives are established, as well as collaboration between areas so it can analyze the different options, costs, and benefits this process can bring.

The procedure to design the Technology Monitoring System integrated with artificial intelligence is aimed at promoting the digitalization of port processes in Puerto Moa Company. With its implementation, the entity's managers will count on updated and relevant information for the facility's security, staff, and operations, which in turn will favor decision-making processes.

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Adolis José Leyva Corney: Formal analysis/Research