RGSA – Revista de Gestão Social e Ambiental
ISSN: 1981-982X
Submission date: 3/4/2025
Acceptance date: 5/1/2025
DOI: https://doi.org/10.24857/rgsa.v19n6-018
Organization: Interinstitutional Scientific Committee
Chief Editor: Ana Carolina Messias de Souza Ferreira da Costa
Assessment: Double Blind Review pelo SEER/OJS

METALMECHANIC INDUSTRY CONNECTED TO THE INTERNET OF THINGS FOR GREATER EFFICIENCY IN THE MANAGEMENT OF COLLABORATIVE ROBOTS

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ABSTRACT

Objective: This research aims to analyze the role of collaborative robots in the context of the digital industry, highlighting their applications, impacts and contributions to safe automation and industrial connectivity.

Theoretical Framework: The digital industrial revolution is characterized by the integration of emerging technologies, such as the Internet of Things (IoT), artificial intelligence, cloud computing and cyber-physical systems that transform the way products are manufactured, services are provided and activities become robotic.

Method: The adopted methodology included research on platforms with themes related to research, for optimizing the workflow and reducing waste as a cutting-edge tool that facilitates real-time monitoring of metalworking industry activities in the management of collaborative robots.

Results and Discussion: The results suggest the efficiency in managing automation and real-time connectivity, making collaborative robots or cobots transformative elements of modern production in more flexible, safe, agile and adaptable collaborative production environments where human strength and machine precision act in synergy.

Research Implications: Unlike traditional industrial robots, which operate in isolation and require physical barriers to ensure worker safety, cobots are designed to interact directly with humans, sharing the same workspace efficiently and safely.

Originality/Value: The integration and connectivity of collaborative robots constitute an essential technology for the evolution of advanced and digital manufacturing, contributing directly to increased competitiveness, optimization of resources in processes and the preservation of humans in production environments.

Keywords: Intelligent Automation, CoBot, Industrial Connection, Collaborative Robots, Digital Manufacturing.

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INDÚSTRIA METALMECÂNICA CONECTADA À INTERNET DAS COISAS PARA MAIOR EFICIÊNCIA NA GESTÃO DE ROBÔS COLABORATIVOS

RESUMO

Objetivo: Esta pesquisa objetiva analisar o papel dos robôs colaborativos no contexto da Indústria digital, destacando suas aplicações, impactos e contribuições para a automação segura e conectividade industrial.

Referencial Teórico: A revolução industrial digital é caracterizada pela integração de tecnologias emergentes, como a Internet das Coisas (IoT), inteligência artificial, computação em nuvem e sistemas ciberfísicos que transformam a maneira como produtos são fabricados, serviços são prestados e atividades tornam-se robotizadas.

Método: A metodologia adotada contou com pesquisas nas plataformas com temas alusivos a pesquisa, por otimizar o fluxo de trabalho e reduzir desperdícios como uma ferramenta de vanguarda que facilita o monitoramento em tempo real das atividades da indústria metalmecânica na gestão de robôs colaborativos.

Resultados e Discussão: Os resultados sugerem a eficiência na gestão da automação e conectividade em tempo real, tornam os robôs colaborativos ou cobots elementos transformadores da produção moderna em ambientes produtivos colaborativod mais flexíveis, seguros, ágeis e adaptáveis onde a força humana e a precisão das máquinas atuam com sinergia.

Implicações da Pesquisa: Diferentemente dos robôs industriais tradicionais, que operam de forma isolada e exigem barreiras físicas para garantir a segurança dos trabalhadores, os cobots são projetados para interagir diretamente com seres humanos, compartilhando o mesmo espaço de trabalho com eficiência e segurança.

Originalidade/Valor: A integração e conectividade de robôs colaborativos constituem uma tecnologia essencial para a evolução da manufatura avançada e digital, contribuindo diretamente para o aumento da competitividade, otimização de recursos nos processos e a preservação de humanos nos ambientes produtivos.

Palavras-chave: Automação Inteligente, CoBot, Conexão Industrial, Robos Colaborativos, Manufatura Digital.

INDUSTRIA METALMECÁNICA CONECTADA AL INTERNET DE LAS COSAS PARA UNA MAYOR EFICIENCIA EN LA GESTIÓN DE ROBOTS COLABORATIVOS

RESUMEN

Objetivo: Esta investigación busca analizar el rol de los robots colaborativos en el contexto de la indústria digital, destacando sus aplicaciones, impactos y contribuciones a la automatización segura y la conectividad industrial.

Marco teórico: La revolución industrial digital se caracteriza por la integración de tecnologías emergentes, como el Internet de las Cosas (IdC), la inteligencia artificial, la computación en la nube y los sistemas ciberfísicos, que transforman la forma en que se fabrican productos, se prestan servicios y se robótican las actividades.

Método: La metodología incluyó la investigación en plataformas con temas relacionados con la investigación, para optimizar el flujo de trabajo y reducir el desperdicio como una herramienta de vanguardia que facilitam la monitorización en tiempo real de las actividades de la indústria en la gestión de robots colaborativos.

Resultados y discusión: Los resultados sugieren la eficiencia en la gestión de la automatización y la conectividad en tiempo real, convirtiendo a los robots colaborativos o cobots en elementos transformadores de la producción moderna en entornos de producción colaborativa más flexibles, seguros, ágiles y adaptables, donde la fuerza humana y la precisión de las máquinas actúan en sinergia.

Implicaciones de la investigación: A diferencia de los robots industriales tradicionales, que operan de forma aislada y requieren barreras físicas para garantizar la seguridad de los trabajadores, los cobots están diseñados para interactuar directamente con los humanos, compartiendo el mismo espacio de trabajo de forma eficiente y segura.

Originalidad/Valor: La integración y la conectividad de los robots colaborativos constituyen una tecnología esencial para la evolución de la fabricación avanzada y digital, contribuyendo directamente al aumento de la

competitividad, la optimización de recursos en los procesos y la preservación de la presencia humana en los entornos de producción.

Palabras clave: Automatización Inteligente, CoBot, Conexión Industrial, Robot Colaborativo, Fabricación Digital.

1 INTRODUCTION

The digital industry represents a new paradigm in the way production processes are structured, marking the convergence between the physical and digital world characterized by the integration of emerging technologies, such as the Internet of Things (IoT), artificial intelligence, cloud computing and cyber-physical systems , which transform the way products are manufactured, services are provided and data is managed (Moura; Moura, 2019).

The integration of the Internet of Things (IoT) in the metalworking industry enables advanced and optimized management of collaborative robots, improving operational efficiency and decision-making. Smart sensors and interconnected monitoring systems allow the continuous collection and analysis of data on machine performance, identifying patterns, factors and levels of operability (Moura *et al* ., 2024).

Anticipating failures to reduce costs with predictive maintenance. In addition, communication between devices enabled by IoT enables the dynamic adaptation of production processes, ensuring greater precision and safety in industrial operations. Thus, the application of IoT in the metalworking industry not only increases productivity, but also promotes the convergence between automation, artificial intelligence and digital manufacturing, boosting the sector's competitiveness, which corroborates that collaborative robots or *cobots* are gaining prominence as one of the main transformative elements of modern production (Santoni; Lucato, 2021).

Unlike traditional industrial robots, which operate in isolation and require physical barriers to ensure worker safety, *cobots* are designed to interact directly with humans, sharing the same workspace efficiently and safely. This feature enables the creation of more flexible, agile, and adaptable production environments, where human strength and machine precision work synergistically and save the workforce from physical and mental stress (Silva *et al.*, 2024).

Collaborative robots are equipped with intelligent sensors, learning algorithms and rapid response systems, which make them capable of detecting movements, adapting tasks and

interrupting their operation in case of imminent risk, promoting a safer and more ergonomic environment (Toniolo *et al* ., 2024).

Reducing errors and increasing productivity becomes more assertive with *cobots* since they are effective in performing repetitive, exhaustive or high-precision tasks, allowing the human workforce to focus on activities with greater added value (Shingo , 1986; Slack; Chambers; Jonhston , 2009).

Not being a denier in the digital age and anticipating and preventing damage from repetitive tasks (Moura *et al.*, 2021) promotes a reconfiguration of jobs and requires new skills from workers who start to work together with technology, taking on supervision, programming and maintenance functions (Neto *et al*., 2023).

When analyzing the role of collaborative robots in the context of the digital industry, their applications, impacts, and contributions to safe automation and industrial connectivity stand out, since the adoption of collaborative robots in different industrial sectors values greater competitiveness, productivity, and real-time product customization. Issues of occupational health, ergonomics, professional qualification, and sustainability of production processes become key elements for the digital transformation of factories (Venanzi; Silva; Hasegawa, 2020).

Tactics that improve production planning and management ensure the efficient use of technological resources, allied to effective planning to achieve the desired performance levels and prevent errors, bottlenecks and fatigue, making manual management obsolete and inefficient (Tubino, 2007).

Such improvement in management achieves a cyber-physical reference model for industries and other organizations in productive and competitive practices (Dias, 2010; Sousa *et al*., 2024).

Advanced and technological manufacturing requires frequent breaks in the initial phase for training, qualification and qualification of the workforce so that they can perform their roles with minimal mental and physical fatigue and maximize peroduvity in collaborative environments (Antônio De Moura *et al*., 2024).

2 LITERATURE REVIEW

According to Tubino (2007), restructuring manufacturing processes requires efficient planning and control to ensure good results and competitiveness. Industry 4.0 transforms production processes by integrating digital technologies such as the Internet of Things (IoT),

artificial intelligence (AI), cloud computing, big data and cyber-physical systems , increasing connectivity and industrial automation, which increases efficiency and agility (Vieira *et al.*, 2019).

Digitalization connects machines and systems across the value chain, enabling real-time data collection and analysis, guiding more accurate decisions, minimizing failures and optimizing resources (Demarco *et al.*, 2025).

The convergence between the physical and digital, enabled by sensors, actuators, and intelligent algorithms, ensures autonomous control of production processes. Strategies such as predictive maintenance and digital simulations increase industrial performance. In this scenario, collaborative robots work with workers in a safe and flexible manner, favoring activities that require customization and reducing ergonomic risks (Aguiar; Pinto, 2024; Soares; Lucato, 2021).

With the support of artificial intelligence (AI) and *machine learning*, automated systems learn from data, recognize patterns and make decisions, contributing to continuous improvement. The integration between collaborative robots and data analysis platforms enhances productivity, quality and efficient use of resources, reducing operational costs (Kovaleski , 2019; Vido *et al* ., 2020; Venanzi ; Silva; Hasegawa, 2020).

Intelligent automation and industrial connectivity underpin the digital industry by integrating physical and digital systems, transforming production processes and business models. Technologies such as *the Internet* of Things (IoT), artificial intelligence (AI) and cyber-physical systems increase efficiency, autonomy and operational adaptability by promoting decision-making based on real-time data and minimizing failures (De Moraes *et al.*, 2022).

Connected sensors and devices form industrial networks capable of reacting quickly to changes in demand and operating conditions (Demarco *et al* ., 2025). This configuration enables customization at scale, production tracking, predictive maintenance, and waste reduction, in addition to promoting improvements in quality. The use of big data and analytical tools strengthens agility in decision-making and allows for continuous adjustments (De Carvalho; Ferreira, 2020).

Despite advances, challenges such as system interoperability, cybersecurity and professional qualifications still limit the full adoption of these technologies (Lopes; Filho, 2024). Transformation requires investments in infrastructure, cultural change and training, redefining the human role for analytical and strategic functions.

Collaborative robotics represents a strategic advancement in automation by integrating with Industry 4.0 technologies. Unlike traditional robotics, cobots operate safely alongside

humans, without physical barriers, which expands their use in environments that require flexibility and direct interaction (Santoni; Lucato, 2021). Initially, industrial robotics performed repetitive and dangerous tasks, isolated from operators. Despite its efficiency, it demanded high costs for safety and infrastructure, restricting its use to large productions, as illustrated in Figure 1 (Soares; Lucato, 2021).

Figure 1

Collaborative robot (Cobot) in operation

With Industry 4.0, demands for greater customization, short cycles, and integration have emerged, favoring the adoption of *cobots* that operate with agility and precision, in addition to contributing to ergonomics in the workplace. Intelligent sensors and actuators, cameras, and adaptive systems adjust their actions to human presence, mitigating operational risks. The incorporation of artificial intelligence, machine learning, and digital connectivity enables them to adapt to the manufacturing environment (Lopes; Filho, 2024; Soares; Lucato, 2021; Neto *et al.*, 2023).

In smart production systems, *cobots* perform tasks that require precision, repetition, and ergonomics, such as assembly, packaging, and inspection. This performance increases productivity and quality, in addition to improving working conditions by reducing physical effort and the risk of injury (Vido *et al* ., 2020; Soares; Lucato, 2021).

The possibility of rapid reconfiguration through intuitive interfaces facilitates customized and small-batch production, adapting to the demands of dynamic markets. However, the adoption of these robots requires structural and cultural changes in organizations.

Demands such as interoperability, cybersecurity, data reliability, and cross-platform compatibility impose challenges and high technicality (Santana, 2020; Santoni; Lucato, 2021).

The insertion of collaborative robots (cobots) in the industry presents disadvantages such as programming complexity and the need for integration with cyber-physical systems , requiring compatible infrastructure and trained professionals (Aguiar; Pinto, 2024).

From an economic perspective, the high costs of acquisition, layout adaptation, staff qualification and maintenance restrict access to cobots , especially in small and medium-sized companies. The difficulty in measuring productivity gains and the delay in return on investment compromise the financial viability of their adoption (De Carvalho; Ferreira, 2022).

Culturally, there is persistent resistance to innovation. Insecurity about the possible replacement of the workforce and low familiarity with advanced technologies make it difficult for workers to accept them. In more conservative business contexts, the absence of a culture focused on continuous learning and technological innovation intensifies these challenges (Santoni; Lucato, 2021).

3 MATERIALS AND METHODS

The adopted methodology included research on platforms with themes related to research and which optimizes the workflow and reduces waste as cutting-edge actions that facilitate real-time monitoring of metalworking industry activities in the management of collaborative robots in shared industrial environments, as shown in Figure 2.

Figure 2

cobot activity in a shared environment

Production in an advanced manufacturing environment with human-robot interaction is optimized for efficiency and safety. The centrally positioned human worker supervises and collaborates directly with two *cobots* (collaborative robots). These cobots , equipped with sensors and safety algorithms, operate in close proximity to the human, indicating the implementation of intuitive *interfaces* and the overcoming of traditional physical barriers, that is, the transition to symbiotic work ecosystems, where human cognitive agility and robotic precision converge to optimize processes and mitigate ergonomic and operational risks (Moura *et al* ., 2021; Luo ; Thevenin ; Dolgui , 2023).

The bibliographic research included a literature review with the aim of enriching debates on existing methodologies and discoveries, in addition to fostering new perspectives for future investigations.

According to Lakatos and Marconi (2021), the study is exploratory in nature, seeking an in-depth understanding of the central theme. This approach allowed the analysis of values, beliefs, customs, representations, reasons and attitudes of different entities, whether individual or collective, providing a comprehensive view of the phenomenon studied.

A qualitative approach was adopted, as defined, which favors the interpretative analysis of data, without resorting to statistical methods. For the selection of the material, the *Google* Scholar and *Scielo* databases were used, considering publications from recent years.

The selected articles were strictly aligned with the proposed theme, and those that did not meet the criteria of relevance and coherence were discarded. After screening, the data were analyzed and interpreted in detail, with the aim of organizing and consolidating the information obtained, in order to contribute with solutions relevant to the problem investigated (Lakatos; Marconi, 2021).

4 RESULTS AND DISCUSSIONS

The interaction promoted by *cobots* requires the use of intuitive learning systems, such as *teach -in*, which facilitates their adaptation to production demands.

Connectivity with technologies such as artificial intelligence, the Internet of Things and cyber-physical systems reinforces the role of these robots in industrial digitalization, strengthening operational efficiency and expanding companies' ability to respond to market demands.

The effective integration of cobots can accelerate the digitalization of operations and create safer, more adaptable and sustainable work environments. When applied properly, collaborative robots enhance cooperation between humans and machines, consolidating themselves as central elements in the evolution of current production systems.

4.1 OPERATIONAL BENEFITS IN A SHARED HUMAN-COBOT MANUFACTURING ENVIRONMENT

Figure 3 illustrates the operational benefits in a shared human- cobot factory environment.

Figure 3

Operational and administrative benefits in a shared human- cobot manufacturing environment

***Cobot* management**	**Operational and administrative advantages**
Increased Safety and Production Efficiency	Enables greater ability to perform repetitive, physically demanding or high-precision tasks consistently, in direct collaboration with human operators.
Repetitive , monotonous and standardized operations	The inherent repeatability and accuracy of cobots minimizes human error in critical tasks such as assembly, inspection and welding, leading to reduced defect rates and rework.
Reduction of injuries and physical and emotional fatigue	Handling dangerous, monotonous or ergonomically challenging tasks to cobots significantly reduces the risk of musculoskeletal injuries and workplace accidents for human operators. This not only protects the health and safety of workers, but also reduces costs associated with compensation and absenteeism.
Innovation and development in new applications and tasks	Integrating cobots into manufacturing environments can drive research and development as teams explore new applications, optimize collaboration algorithms, and develop custom solutions.
Lessons learned and continuous improvement	Continuous improvement with reduction or elimination of production and supply bottlenecks. It is possible to adjust and implement improvements in favor of productivity.

The results show that collaborative robots play a strategic role in transforming production systems. The literature indicates that, when operating in shared environments, cobots increase the flexibility of production lines and enable mass customization with greater safety, precision and efficiency.

5 FINAL CONSIDERATIONS

The analysis demonstrated that collaborative robots play a central role in Industry 4.0 by enabling intelligent automation, connectivity and integration between operators and machines. According to the literature, these devices advance in relation to traditional robotics by offering greater flexibility, safety and efficiency in production processes by performing everything from repetitive tasks to complex operations that require precision and interaction with humans, standing out for their adaptability to the factory environment, ease of reprogramming and contribution to reducing occupational risks.

The integration of *cobots* Technologies such as IoT, AI and cyber-physical systems reinforce their importance as strategic components in smart factories by promoting more dynamic, safe and personalized production lines, aligned with the demands of modern manufacturing. However, their adoption still faces obstacles, such as high initial costs.

It is concluded that for the metalworking industry connected to the Internet of Things for greater efficiency in the management of collaborative robots, *cobots* represent an essential innovation for industrial modernization, increasing competitiveness, optimizing processes and promoting safer and less anti-ergonomic work environments.

As future research, it is suggested to explore its economic and social impacts, in addition to strategies to overcome technical and institutional barriers to its implementation.

REFERENCES

Aguiar, A. L. S.; Pinto, V. P. Alocação de tarefas para múltiplos VANTs colaborativos. Revista Ibérica de Sistemas e Tecnologias de Informação, n. E70, p. 561-573, 2024.

Antônio De Moura, R., Regina De Oliveira, M., Goussain, B. G. C. S., Silva, M. B. (2024). Neuroergonomics approach in workplace aiming to standardize movements and increase workers sense of well-being. 24, 472–482. https://doi.org/10.53660/CLM-3313-24H27

De Carvalho, F L. S.; Ferreira, J. L. 2022. Análise da maturidade do processo de desenvolvimento de produtos associados a indústria 4.0 no mercado capixaba através de pesquisa aplicada. Brazilian Journal of Production Engineering, v. 8, n. 2, p. 01-21, 2022.

Demarco, L M. *et al*. Análise de manutenção de robôs colaborativos numa empresa do ramo de ar-condicionado. Revista de Gestão e Secretariado, v. 16, n. 1, p. e4594-e4594, 2025

De Moraes, P. M., *et al*. Desafios no planejamento de implementação de robôs colaborativos nos processos produtivos industriais. Revista Brasileira de Mecatrônica, v. 5, n. 2, p. 29-42, 2022.

Kovaleski, F. Gestão de recursos humanos: comparação das competências hard skills e soft skills listadas na literatura, com a percepção das empresas e especialistas da indústria 4.0. 114 f. Dissertação (Mestrado em Engenharia de Produção) - Universidade Tecnológica Federal do Paraná, Ponta Grossa, 2019.

Lakatos, E. M.; Marconi, M. A. Metodologia do Trabalho Científico. 9ed. São Paulo: Atlas, 2021.

Lopes, R. R.; Filho, J. L. O papel dos robôs colaborativos na revolução da Indústria 4.0. Revista Interface Tecnológica, v. 21, n. 1, p. 172-183, 2024.

Luo, D.; Thevenin, S.; Dolgui, A. A state-of-the-art on production planning in Industry 4.0. Int. J. Prod. Res. 2023, 61, 6602–6632. Cross Ref.

Moura, R. A. de, Santos, D. F. A., Goussain, B. G. S., Oliveira, M. R. de, & Silva, M. B. (2024). Design of Experiments (DoE) for non-specialists in statistics in the food industry: trials with popcorn. RGSA, 18(10). DOI: https://doi.org/10.24857/rgsa.v18n10-229

Moura, R., Marques, D., Costa, J., & Silva, M. (2021). A urbanidade da higiene ocupacional na era digital e o negacionismo social da antecipação e prevenção. 2021. Sodebras 16(184), 29-33. ISSN 1809-3957. DOI: https://doi.org/10.29367/issn.1809-3957.16.2021.184.29

Moura, J. L.; Moura, R. A. (2019). Interação humano-máquina no sistema produtivo da indústria 4.0 visando aumentar a produtividade e reduzir lesões por esforços repetitivos. Fatec SJosé Campos/SP. DOI: https://doi.org/10.37619/issn2447-5378.v1i6.213.217-227

Neto, Osvaldo Rinaldi *et al*. Aplicação de inteligência artificial para robótica industrial: um estudo visando a indústria 4.0. Revista Interface Tecnológica, v. 20, n. 2, p. 571-585, 2023.

Santana, K. A. Método metaheurístico multiobjetivo para o cálculo de rotas de robôs colaborativos com restrições energéticas. 2020. 94f. Dissertação (Mestrado em Engenharia da Computação e elétrica) - Universidade Federal do Ceará, Campus de Sobral, 2020.

Santoni, F.; Lucato, A. V. R. (2021). Robótica colaborativa: A utilização de robôs nos processos produtivos. RECIMA21-Revista Científica Multidisciplinar-ISSN 2675-6218, v. 1, n. 1, p. e210914-e210914, 2021.

Shingo, S. Zero Quality Control: source inspection and the Poka-Yoke System. Portland: Productivity Press, 1986.

Silva, E. A.; Camargo, A. A.; Silva, M. B.; Moura, R. A. (2024). Neuroergonomía y Tecnologías inmersivas para lograr un envejecimiento saludable sin dolor y además sin ortesis. Revista Exatas. V.30. UNITAU. DOI: https://doi.org/10.69609/1516-2893.2024.v30.n2.a3916

Slack, N.; Chambers, S.; Jonhston, R. Administração da Produção. 3 ed. São Paulo: Atlas, 2009.

Soares, R.; Lucato, A. V. R. 2021. Robótica colaborativa na Indústria 4.0, sua importância e desafio. Revista Interface Tecnológica, v. 18, n. 2, p. 747-759, 2021.

Sousa, V. J. D E, Richetto, M. R. S., Moura , R. A. De, Oliveira , M. R. De, & Silva, M. B. (2024). Analysis of management practices in a non-governamental organization. RGSA, 18(11), e09646. DOI: https://doi.org/10.24857/rgsa.v18n11-045

Toniolo, L. C. *et al*. Práticas relacionadas à indústria 4.0 e suas aplicações no campo da ergonomia: análise das aplicações robôs colaborativos (cobots) e exoesqueletos. Revista Ação Ergonômica, v. 15, n. 2, 2024.

Tubino, D. F. Planejamento e Controle da Produção: estudos sobre a teoria e prática. Atlas, 2007.

Venanzi, D.; Silva, O. R; Hasegawa, H. L. Indústria 4.0: Estudo de Múltiplos Casos no setor industrial de Sorocaba-SP. Revista Científica Hermes, v. 26, p. 137-156, 2020.

Vido, M. 2020. O impacto do robô colaborativo nas prioridades competitivas: estudo de caso em um fornecedor automotivo. Gestão & Produção, v. 27, p. e5358, 2020.

Vieira, F. F. S. *et al*. 2019. Desvendando o conceito indústria 4.0 e o uso de suas tecnologias. Itegam-Jetia, v. 5, n. 19, p. 21-28, 2019.