ADOPTION OF AI IN VEHICLE MANUFACTURING COMPANY: THE PROSPECT AND PROCEDURE

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ABSTRACT

This study examined the adoption of artificial intelligence in vehicle assembly in vehicle manufacturing company, assessing the prospect and procedure. The adoption of artificial Intelligence (AI) in vehicle assembly is revolutionizing the automotive manufacturing landscape, offering unprecedented levels of efficiency, precision, and adaptability. In the context of carrying out this research, the following subheads were explored among others: concept of artificial intelligence, concept of vehicle assembly and prospect of using ai for vehicle assembly among others. Prospect of using ai for vehicle assembly as mentioned in the study included: optimizing manufacturing processes, improving quality control and enhancing design. Furthermore, the study mentioned the procedure of vehicle assembly using artificial intelligence to include: virtual prototyping and design, assembly line optimization and quality control/inspection. In the same vein, the study also mentioned the militating factors to artificial intelligence-assisted vehicle assembly to include: technical complexity/reliability concerns, integration challenges with legacy systems and liability/legal ambiguity. Hybrid human-ai collaboration models, standardization of interoperability protocols and workforce upskilling and reorientation among others were mentioned as the mitigating strategies to the militating factors to ai-assisted vehicle assembly. The study concluded that adopting AI in vehicle assembly offers transformative benefits for manufacturing companies, including enhanced efficiency, precision, and adaptability. One of the recommendations made was that there should be an evaluation of existing manufacturing infrastructure, workforce skills, and data availability to identify areas suitable for AI integration and determine the level of investment required.

KEYWORDS: Artificial Intelligence, Vehicle Manufacturing and Company

INTRODUCTION

The adoption of Artificial Intelligence (AI) in vehicle assembly is revolutionizing the automotive manufacturing landscape, offering unprecedented levels of efficiency, precision, and adaptability. As the global automotive industry grapples with rising consumer expectations, cost pressures, and the demand for innovation, AI emerges as a transformative force that enhances productivity and quality while enabling smarter, safer, and more sustainable operations. From robotic automation and predictive maintenance to intelligent quality control and supply chain optimization, AI technologies are reshaping how vehicles are designed, assembled, and delivered (Berglund et al., 2020). Vehicle assembly lines have traditionally relied on manual labor and mechanized tools; however, the integration of AI has introduced intelligent robotics, machine vision systems, and real-time data analytics that significantly improve throughput and reduce error rates (Wuest et al., 2016). AI-powered robots are now capable of performing complex tasks such as welding, painting, and component

installation with high accuracy and minimal supervision. Additionally, machine learning algorithms analyze vast datasets from production environments to predict equipment failures, streamline workflows, and ensure consistent product quality.

The prospects of AI adoption in vehicle assembly are promising. Companies can achieve greater operational efficiency, cost savings, and flexibility in customizing vehicles to meet consumer needs. Moreover, AI facilitates the implementation of smart manufacturing or Industry 4.0 principles, where digital twins, IoT devices, and cloud computing converge to create intelligent production ecosystems (Mourtzis et al., 2018). These capabilities not only enhance competitiveness but also enable faster innovation cycles and adaptability to market dynamics. The procedure for implementing AI in vehicle assembly involves several critical steps, including assessing existing infrastructure, identifying key areas for AI intervention, selecting appropriate technologies, and investing in workforce training and change management. Collaboration with AI technology providers and ongoing evaluation of system performance are also essential to ensure sustainable integration and continuous improvement. Despite the technical and organizational challenges, the integration of AI into vehicle manufacturing presents a compelling opportunity for companies to lead in a rapidly evolving industry. As AI continues to mature, its role in vehicle assembly is expected to grow, driving a new era of intelligent, automated, and customer-centric manufacturing.

CONCEPT OF ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) according to Ogunode and Ukozor (2023) encompasses computer systems and technologies that emulate human intelligence, undertaking tasks like learning, reasoning and problem solving. These technologies include machine learning and robotics. To Alagbe (2023) Artificial Intelligence (AI) is the ability of a computer or machine to mimic the capabilities of the human mind for instance learning from examples and experience, recognizing objects, understanding and responding to language, making decisions, solving problems and combining these and other capabilities to perform frictions a human might perform, such as greeting a hotel guest or driving a car.

Trusani and Houngbonon (2019) defined AI as a combined large volume of data with computing power to stimulate human intellectual ability such as reasoning, language processing, perception, vision recognition and spatial processing. Artificial Intelligence refers to the study of intelligence machine and software that can reason, learn, gather knowledge, communicate, manipulate and perceive objects (Verma 2018). Artificial Intelligence is a part of computer science that deals with intelligence in human behaviors (Ocana, Valenzuela-Fernandez and Garro-Aburto, 2019). The ability of a digital computer or computer-controlled robot to carry out actions often performed by intelligent beings is known as artificial intelligence (Copeland, 2002). Artificial intelligence is commonly used to describe the endeavor of creating systems that possess human-like cognitive processes, such as the capacity for reasoning, meaning-finding, generalization, and experience-based-learning.

CONCEPT OF VEHICLE ASSEMBLY

According to Womack et al, (1990) vehicle assembly refers to the process of putting together various components and subsystems to create a complete, functioning vehicle. This includes installing the engine, transmission, chassis, body panels, electrical systems, interior components and other essential parts in a coordinate step-by-step manufacturing process.

Vehicle assembly is typically carried out in assembly plants using a combination of automated machinery, robotics and manual labor. Often broken down into phases like body shop, paint shop, trim, and final assembly, the process is a crucial part of the automotive production process. The organized procedure by which automobile parts are methodically assembled to produce a working car is known as vehicle assembly. It includes a number of phases, from final quality inspections to chassis formation.

Srinivasan & Tesfay (2011) vehicle assembly refers to the systematic integration of components and subsystems into a complete vehicle. The process follows a structured sequence to ensure operational integrity, quality and cost efficiency in production. Vehicle assembly is the transformation of partially fabricated components into finished products through defined assembly processes in manufacturing plants, commonly used by OEMs (Original Equipment Manufacturers) (Kaminski & Baraldi, 2018).

Islamoglu et al. (2014) assembly in the automotive industry is often modular, where vehicles are built by integrating preassembled modules into a chassis, optimizing labor productivity and scalability. Kathmann et al. (2023) vehicle assembly involves dynamically integrating functional subsystems during manufacturing, a process now influenced by the rise of autonomous vehicle design and intelligent sequencing. Assembly layouts in the automotive industry are being redefined by smart manufacturing and flexible production cells, enabling the integration of distinct vehicle types on the same line (Hottenrott et al. 2023).

PROSPECT OF USING AI FOR VEHICLE ASSEMBLY

Artificial Intelligence (AI) is rapidly transforming vehicle assembly lines, enabling smarter manufacturing through autonomous robotics, data-driven optimization, predictive analytics and real-time quality assurance. The following are the prospects of using artificial intelligence for vehicle assembly:

- **Optimizing Manufacturing Processes:**

Production optimization in manufacturing is all about fine-tuning your production processes to achieve the highest levels of efficiency, quality and cost-effectiveness for your business. By optimizing production, you can reduce waste, lower costs and boost overall productivity while keeping customers happy and your bottom line consistent.

- **Improving Quality Control:**

Quality control may generally be defined as a system that maintains a desired level of quality through feedback on products /service characteristic and implementation of remedial actions, incase of a deviation of such characteristics from a specified standard.

- **Enhancing Design:**

Enhancing design refers to the process of improving or upgrading a design to make it more effective, functional, appealing or user-friendly. This could apply to a wide range of fields.

- **Boosting Safety:**

Boosting safety means taking actions or implementing measures that increase the level of protection against harm, accidents or hazards in a given environment. In fields like engineering, manufacturing or transportation (including vehicle assembly), this refers to improving systems, designs or procedures to reduce risks to workers, users or the public.

- **Reducing Costs:**

Reducing costs refers to the process of lowering expenses or minimizing the financial resources required to produce goods, deliver services or operate a system. In industrial, manufacturing or business contexts, cost reduction aims to maximize efficiency, eliminate waste, improve processes and increase profitability without compromising quality or safety.

- **Predicting Supply Chain Disruptions:**

Predicting supply chain disruptions refers to the process of identifying and anticipating potential events or risks that could interrupt the normal flow of goods, materials or services within a supply chain. This involves the use of data analysis, forecasting models, artificial intelligence and risk management strategies to proactively detect issues before they impact operations.

Procedure of Vehicle Assembly Using Artificial Intelligence

The procedures for vehicle assembly using artificial intelligence include:

- **Virtual Prototyping and Design:**

A virtual prototype is an executable software model that runs on a host system. It emulates the hardware, including CPU instruction sets, memory maps, registers and interrupts at a sufficient level that can be tailored for software development.

- **Assembly Line Optimization:**

An assembly line is a manufacturing process consisting of various tasks in which multiple parts are sequentially assembled into a product at several workstations to produce the final product. It is widely used in mass production for manufacturing various types of product such as automobiles or electronic products.

- **Quality Control and Inspection:**

Quality control (QC) is a system that ensures that manufactured products are produced and maintained to a high standard. Quality control requires companies to create an environment where management and employees strive for perfection. This is done by training personnel, creating product quality benchmarks, and testing products for statistically significant variations. QC requires the establishment of well-defined controls to help standardize production and reactions to quality issues.

- **Supply Chain Management:**

Supply chain management (SCM) is the monitoring and optimization of the production and distribution of a company's products and services. It seeks to improve and make more efficient all processes involved in turning raw materials and components into final products and getting them to the ultimate customer. Effective SCM can help streamline a company's activities to eliminate waste, maximize customer value, and gain a competitive advantage in the marketplace.

- **Sourcing and Matching Equipment:**

Sourcing refers to the strategic process of planning, acquiring, and managing the resources companies need to produce their products or offer their services effectively. This includes

evaluating the costs, quality, and availability of these resources to achieve a sustainable competitive advantage and minimize operational risks.

The Militating Factors to AI-Assisted Vehicle Assembly

AI-assisted vehicle assembly has emerged as a transformative innovation in the automotive industry. However, several militating factors impede its widespread adoption. These factors span technical, ethical, legal, organizational and socio-economic dimensions. Below is a comprehensive analysis of the key obstacles:

- ✓ **Technical Complexity and Reliability Concerns**

AI systems in vehicle assembly must operate with extreme precision. However, complex environments, sensor inaccuracies and unpredictable edge cases can disrupt performance.

- ✓ **Integration Challenges with Legacy Systems**

Retrofitting AI into existing vehicle assembly lines is not seamless. Many factories use legacy machines that are incompatible with AI-driven control systems.

- ✓ **Liability and Legal Ambiguity**

AI errors in assembly could cause product defects or safety hazards, raising unresolved questions about liability.

- ✓ **Explainable AI (XAI) Frameworks**

To combat the "black-box" nature of AI, XAI tools provide interpretable decision-making, increasing trust in quality control systems.

- ✓ **Workforce Resistance and Skill Gaps**

Many factory workers view AI as a threat to their jobs leading to resistance against automation. Moreover, there is a shortage of technicians trained to manage AI systems.

Mitigating Strategies to the Militating Factors to AI-Assisted Vehicle Assembly

To address the challenges of AI-assisted vehicle assembly, a range of mitigating strategies has emerged across the technical, regulatory, organizational, and workforce domains. These strategies are essential to ensure the safe, scalable and efficient deployment of AI systems in automotive manufacturing.

- ✓ **Hybrid Human-AI Collaboration Models**

Instead of full automation, implementing collaborative AI that augments human capabilities can reduce workforce resistance and improve adoption.

- ✓ **Standardization of Interoperability Protocols**

AI modules often face issues when integrated with legacy machinery. The development and adoption of standardized data protocols and APIs help mitigate this.

- ✓ **Workforce Upskilling and Reorientation**

Addressing skill gaps through targeted training ensures workforce adaptability to new AI systems.

CONCLUSION

Adopting AI in vehicle assembly offers transformative benefits for manufacturing companies, including enhanced efficiency, precision, and adaptability. AI-driven automation and data analytics streamline production processes and reduce operational costs. The prospects for AI integration are promising, aligning with Industry 4.0 advancements. Successful implementation requires careful planning, infrastructure readiness, and workforce training. Despite initial challenges, the long-term gains in productivity and competitiveness are substantial. AI adoption is not just a trend but a strategic move toward the future of smart manufacturing.

RECOMMENDATIONS

- Evaluate existing manufacturing infrastructure, workforce skills, and data availability to identify areas suitable for AI integration and determine the level of investment required.
- Implement small-scale AI pilots in targeted areas such as quality control or predictive maintenance to test the technology's effectiveness before scaling up.
- Provide continuous training and development for employees to ensure they can work effectively alongside AI systems and adapt to new roles.

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