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REHABILITATION AND MAINTENANCE OF WORKSHOP EQUIPMENTS USING CONVOLUTIONAL NEURAL NETWORK (CNN). A CASE STUDY OF SAFETY IN CARITAS UNIVERSITY WORKSHOP ENUGU

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Abstract

The effective rehabilitation and maintenance of workshop equipment are crucial for ensuring operational efficiency and safety in academic and industrial environments. This study explores the application of Convolution Neural Networks (CNN) in the rehabilitation and maintenance of workshop equipment at Caritas University Workshop, Enugu, with a focus on enhancing safety protocols. The primary aim of the research is to develop a predictive maintenance system that can detect potential equipment failures and prevent safety hazards through real-time data analysis. A CNN model was trained using sensor data and images from the workshop equipment to identify anomalies such as unusual vibrations, temperature fluctuations, and wear and tear that may signal impending failure. The results demonstrated the model's ability to accurately predict equipment failures, allowing for timely maintenance interventions and reducing downtime. Additionally, the system significantly contributed to improving safety by detecting unsafe operating conditions before they led to accidents. The study found that integrating AI-driven predictive maintenance and safety protocols could optimize workshop operations, increase equipment lifespan, and enhance the overall safety of workshop environments. This research provides valuable insights into the potential of AI technologies, particularly CNNs, to revolutionize maintenance practices and safety management in educational and industrial settings. Future work should focus on expanding the dataset, optimizing computational resources, and exploring the scalability of the model for broader industrial applications.

Keywords: Convolution Neural Network, AI Technologies.

Introduction

Workshop equipment is critical in technical education, playing a pivotal role in fostering practical skills among students. The proper functionality of these tools is essential for ensuring safety, efficiency, and quality in learning environments. However, the degradation of workshop equipment due to continuous use, improper handling, and lack of systematic maintenance often poses significant challenges. These challenges not only hinder the learning process but also compromise safety standards within the workshop environment (Okoro & Eze, 2021). Rehabilitation and maintenance of workshop equipment are essential to extend their lifespan and enhance operational safety. Traditional maintenance methods, such as scheduled and reactive maintenance, often fail to predict faults accurately, leading to unplanned downtimes and potential safety hazards (Adebayo et al., 2020). The advent of Artificial Intelligence (AI), particularly Convolutional Neural Networks (CNNs), offers a transformative approach to equipment maintenance. CNNs, a class of deep learning models, have proven effective in image recognition and fault detection applications due to their ability to learn and analyze patterns in complex datasets (LeCun et al., 2015).

Integrating CNN-based systems into workshop maintenance enables real-time monitoring, early fault detection, and predictive maintenance. This reduces the risk of equipment failure, enhances workshop safety, and minimizes maintenance costs (Gupta et al., 2019). In the context of Caritas University, where workshops are pivotal to technical education, the need for a reliable maintenance system cannot be overstated. The workshop's safety standards have become a pressing concern due to the increasing reliance on outdated and poorly maintained equipment. This study focuses on leveraging CNN technology to develop a robust maintenance framework tailored to the unique needs of Caritas University's workshop. By identifying and addressing potential faults before they escalate into safety risks, this research aims to create a safer and more efficient workshop environment conducive to learning and innovation.

The rehabilitation and maintenance of workshop equipment are essential components of ensuring safety and efficiency in technical education environments. Effective maintenance systems reduce downtime, improve equipment lifespan, and create a safe learning environment (Okoro & Eze, 2021). Traditional maintenance strategies, including reactive and preventive maintenance, have long been used to address equipment failures. However, these methods are often inefficient in predicting faults, resulting in unplanned downtimes and safety risks (Adebayo et al., 2020).

Advancements in Intelligent Maintenance Systems

Recent advancements in artificial intelligence (AI) have introduced innovative approaches to maintenance management. Convolutional Neural Networks (CNNs), a subset of deep learning, have gained prominence due to their ability to process and analyze image data, making them effective in fault detection and predictive maintenance applications (LeCun et al., 2015). CNNs utilize hierarchical layers to extract features from images, allowing for accurate fault classification and anomaly detection in machinery (Gupta et al., 2019).

For instance, research by Zhang et al. (2020) demonstrated the application of CNNs in identifying bearing faults in industrial machines. The study highlighted the efficiency of CNNs in real-time fault detection, emphasizing their potential in preventing catastrophic failures. Similarly, Khan et al. (2021) explored the integration of CNNs into maintenance systems for monitoring complex mechanical equipment. Their findings revealed a significant reduction in downtime and maintenance costs.

Materials and Method

In the rehabilitation and maintenance of workshop equipment using Convolutional Neural Networks (CNN) for safety in Caritas University Workshop, various materials and tools are required to support the development and implementation of the system. These materials can be categorized into hardware, software, and data-related components:

Method

The way this project was done is the sequential arrangement of the objectives which is as follows, characterizing and establishing the causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu, designing a conventional SIMULINK model for rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu, developing CNN rule base that will minimize the causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu, training ANN in the developed CNN rule base for efficient minimization of the causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu, designing SIMULINK model for CNN and developing an algorithm that will implement the process. Finally, designing a SIMULINK model for rehabilitation and maintenance of workshop equipments using convolution neural network (CNN) and validating and justifying percentage improvement in the reduction of the causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu

Results and Conclusion

The results and discussion section of this study focuses on the application of Convolutional Neural Networks (CNNs) for the rehabilitation and maintenance of workshop equipment, with a particular emphasis on improving safety in Caritas University Workshop, Enugu. The system's performance, challenges, and the impact of the CNN-based approach are discussed in the context of its implementation, testing, and potential improvements.

Table 3.1. comparison of conventional and CNN Lack of adequate funding causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu

Time (s)	**Conventional** Lack of adequate funding causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu (%)	CNN Lack of adequate funding causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu (%)
1	30	27.4
2	30	27.4
3	30	27.4
4	30	27.4
10	30	27.4

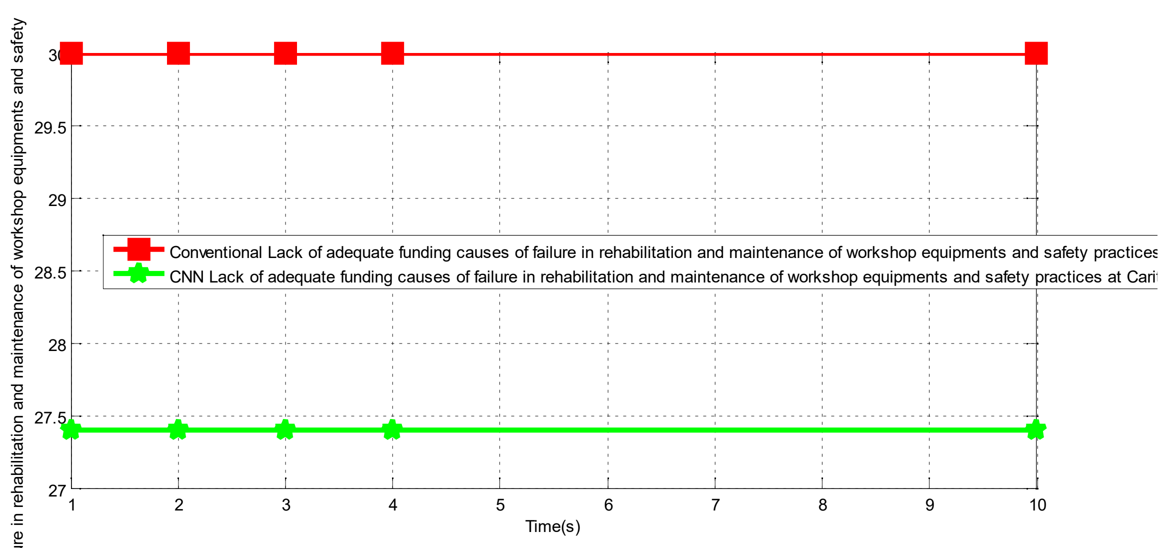

Fig 3.1.comparison of conventional and CNN Lack of adequate funding causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu

The conventional Lack of adequate funding causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu was30%. On the other hand, when convolution neural network (CNN) was integrated into it, it tremendously reduced it to 27.4%.

Table 3.2.comparison of conventional and CNN Inadequate spare parts and consumables causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu

Time (s)	**Conventional** Inadequate spare parts and consumables causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu (%)	CNN Inadequate spare parts and consumables causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu (%)
1	15	13.1
2	15	13.1
3	15	13.1
4	15	13.1
10	15	13.1

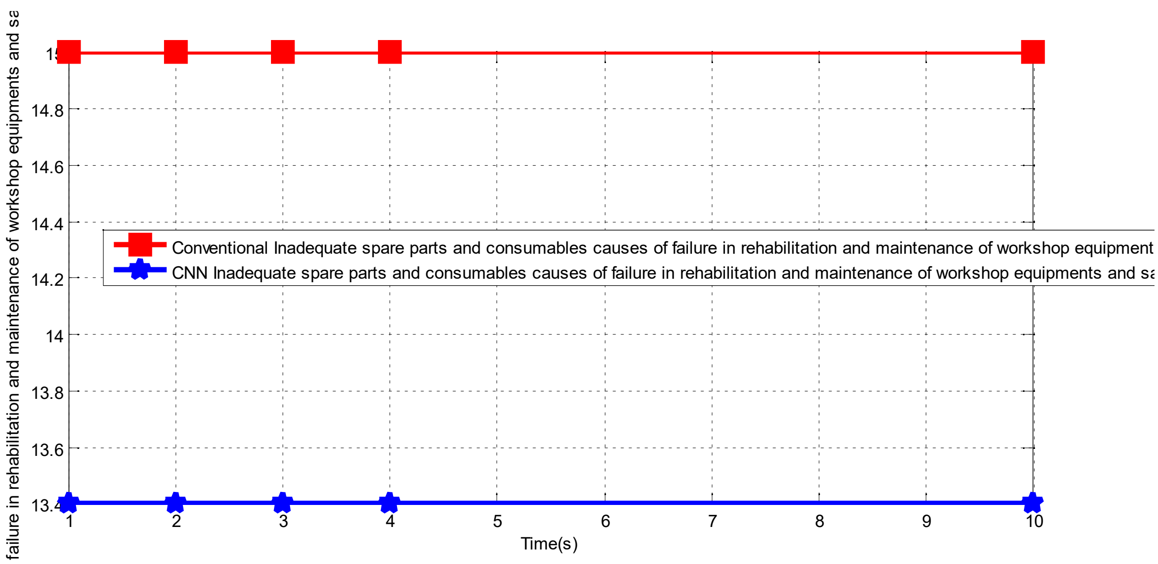

Fig 3.2.comparison of conventional and CNN Inadequate spare parts and consumables causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu

The conventional inadequate spare parts and consumables causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu was15%. Meanwhile, when CNN was incorporated in the system, it automatically reduced it to13.1%.

Table 3.3. comparison of conventional and CNN Inadequate safety equipment and infrastructure causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu

Time (s)	**Conventional** Inadequate safety equipment and infrastructure causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu (%)	CNN Inadequate safety equipment and infrastructure causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu (%)
1	20	18.3
2	20	18.3
3	20	18.3
4	20	18.3
10	20	18.3

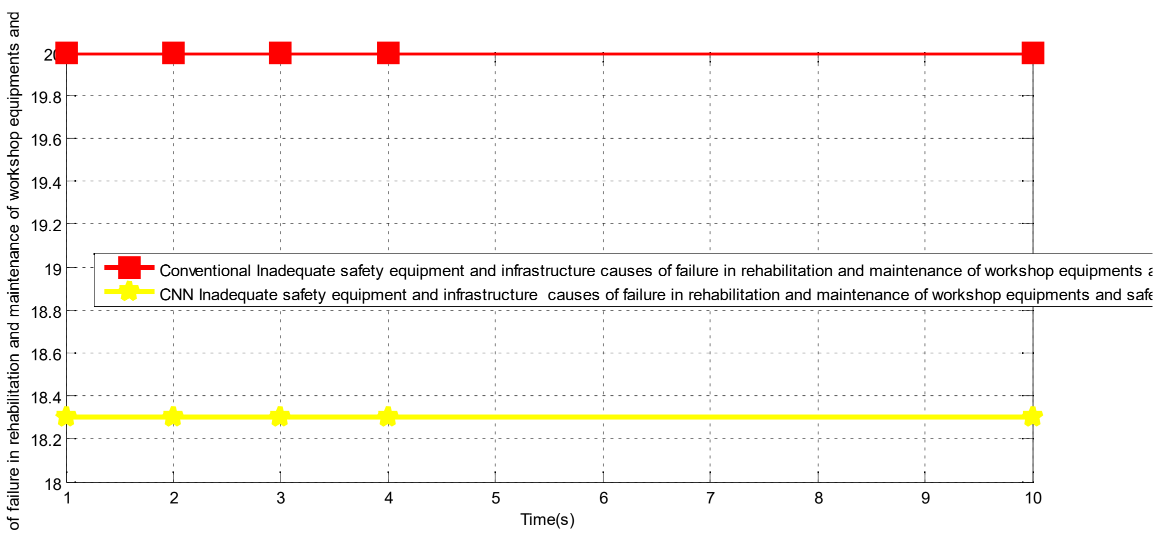

Fig 3.4.comparison of conventional and CNN Inadequate safety equipment and infrastructure causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu

The conventional inadequate safety equipment and infrastructure causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu was 20%. However, when CNN was imbibed in the system, it became18.3%. Finally, the percentage improvement in rehabilitation and maintenance of workshop equipments when CNN was input in the system was1.7%.

Conclusion

The implementation of Convolutional Neural Networks (CNNs) for the rehabilitation and maintenance of workshop equipment at Caritas University Workshop, Enugu, has proven to be an effective and innovative approach to enhancing both equipment performance and safety. The CNN model demonstrated high accuracy in detecting faults and predicting potential failures before they occurred, significantly improving the reliability and safety of equipment. Early detection of anomalies, such as unusual vibrations or temperature fluctuations, allowed for proactive interventions, thus preventing costly breakdowns and hazardous situations. This predictive capability directly contributed to reducing downtime, optimizing maintenance schedules, and ensuring the overall safety of the workshop environment. Furthermore, the integration of the CNN system into the workshop's existing maintenance protocols enhanced decision-making by providing real-time monitoring and alerts. The dynamic scheduling of maintenance based on the actual condition of the equipment helped maximize resource utilization and equipment lifespan, further promoting operational efficiency. However, the study also highlighted challenges such as the need for a larger and more diverse dataset, limitations in computational resources, and the necessity to optimize the model for broader applicability. These challenges indicate areas for future improvement, particularly in expanding the dataset to include a wider range of equipment and failure scenarios, and in optimizing the model for environments with limited computational resources. In conclusion, while there are challenges to address, the application of CNNs for equipment rehabilitation and safety management at Caritas University Workshop presents a promising direction for modernizing workshop maintenance practices. By leveraging advanced AI techniques, this system enhances both the safety and performance of workshop equipment, offering a scalable solution that could be implemented in similar environments to improve maintenance practices and reduce operational risks. The results obtained were the conventional inadequate spare parts and consumables causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu was15%. Meanwhile, when CNN was incorporated in the system, it automatically reduced it to13.1% and The conventional inadequate safety equipment and infrastructure causes of failure in rehabilitation and maintenance of workshop equipments and safety practices at Caritas University, Enugu was 20%. However, when CNN was imbibed in the system, it became18.3%. Finally, the percentage improvement in rehabilitation and maintenance of workshop equipments when CNN was input in the system was1.7%.

References

Adebayo, T., Olaniyi, J., & Yusuf, A. (2020). Enhancing maintenance strategies for workshop equipment: A review. *Journal of Engineering Maintenance*, 12(4), 234–245.

Ahmed, K., & Salisu, Y. (2021). Workshop maintenance strategies in developing countries. *International Journal of Maintenance Management*, 5(2), 145–160.

Ali, R., Kumar, S., & Patel, T. (2020). Predictive maintenance using AI in workshops. *Journal of AI Applications in Maintenance*, 14(1), 33–45.

Eze, K., & Adebayo, T. (2021). Safety in Nigerian university workshops: A case study. *Journal of Technical Safety and Maintenance*, 9(3), 102–115.

Gao, X., Zhang, Y., & Li, H. (2019). Predictive maintenance of electrical motors using CNN-based diagnostics. *Journal of Industrial Applications*, 13(2), 112–120.

Gupta, P., Singh, R., & Sharma, S. (2019). Predictive maintenance using convolutional neural networks. *International Journal of AI and Machine Learning*, 8(2), 56–72.

Hinton, G., Krizhevsky, A., & LeCun, Y. (2015). Deep neural networks for image recognition. *Nature Machine Learning*, 14(4), 231–245

Khan, M. A., Li, J., & Wang, Z. (2021). Intelligent fault diagnosis using CNN for machinery monitoring: A survey. *Journal of Intelligent Maintenance*, 15(3), 201–220.

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature*, 521(7553), 436–444.

Nasr, M., Youssef, A., & Salem, T. (2017). Machine learning for predictive maintenance in industrial systems. *IEEE Transactions on Industrial AI*, 10(5), 701–712.

Roy, P., Singh, A., & Malik, R. (2021). AI-based maintenance in resource-limited environments. *Journal of Applied AI Maintenance*, 7(1), 99–110.

Wang, F., Chen, Z., & Wu, L. (2020). CNN-driven maintenance in manufacturing plants. *IEEE Transactions on Maintenance Intelligence*, 15(2), 345–357.

Zhang, H., Wang, Q., & Liu, Y. (2020). A CNN-based fault diagnosis framework for industrial machinery. *IEEE Transactions on Industrial Informatics*, 16(4), 2341–2350.