Journal of Science, Computing and Engineering Research (JSCER)
Volume-8, Issue-4, April 2025.
DOI: *https://doi.org/10.46379/jscer.2025.080423*

ADDRESSING UNPREDICTABLE POLY PULLEY FAILUERS IN CABLE BELT CONVEYOR SYSTEMS

[1]R.Anusuya, [2]Arnav Sharma, [3]Anshita Saini, [4]Aman Yadav, [5]Harendra Saini, [6]Prince Baghel

[1]Professor, Department of CSE, Modern Insitute of Technology and Research Centre, Rajasthan, India.

[2,3,4,5,6] UG Student, Department of AI&DS, Modern Insitute of Technology and Research Centre, Rajasthan, India

Article Information

Received	:	20 April 2025
Revised	:	21 April 2025
Accepted	:	23 April 2025
Published	:	25 April 2025

Corresponding Author:

Arnav Sharma

Abstract— This Our project involves developing an AI-based web application using React and MongoDB, leveraging Machine Learning and Deep Learning technologies to predict pulley failures and locate cracks on conveyor belts in industrial settings. This solution addresses the issue of unpredictable poly pulley failures in cable belt conveyor systems by integrating predictive maintenance sensors and quick change pulley mechanisms. Users interact with the system by uploading audio, video, or image data, enabling the application to analyze features like cracks and corrosion using Convolutional Neural Networks (CNNs) with Auto Encoders. The application predicts the operational status and health of pulleys, utilizing a dataset comprising over 7,000 entries related to past pulley failures, material types, and standards. With its focus on minimizing downtime, enhancing safety, and improving reliability, the system is designed to cater to professionals and organizations managing conveyor systems. The project has reached an advanced Technology Readiness Level (TRL), with its core functionalities, user interface, and database integration fully operational, ensuring readiness for real-world deployment. Secured by Intellectual Property (IP), the solution represents a unique approach to mitigating unpredictable pulley failures, providing a robust and scalable predictive maintenance tool for industrial applications.

Citation: R.Anusuya, Arnav Sharma, Anshita Saini, Aman Yadav, Harendra Saini, Prince Baghel, “ator”, Journal of Science, Computing and Engineering Research, 8(04), April 2025.

I. INTRODUCTION

The project titled "Addressing Unpredictable Poly Pulley Failures in Cable Belt Conveyor Systems" presents a cuţng-edge solution to a critical issue in industrial material handling systems— unexpected failures of poly pulleys. These failures ‘ lead to significant operational disruptions, costly maintenance, safety hazards, and production losses. Our solution leverages the power of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) to build a predictiv

maintenance system that can foresee pulley breakdowns and identify structural anomalies like cracks and corrosion in conveyor belts. The application is developed using modern technologies such as React for the frontend and MongoDB for backend data management. The system allows mine operators and maintenance personnel to upload various data types—images, audio recordings, and videos—which are then processed using Convolutional Neural Networks (CNNs) and Autoencoders to detect early signs of mechanical wear or impending failure.

The innovation lies in the combination of advanced data analytics with a proprietary quick-change pulley mechanism that significantly reduces replacement time and enhances system scalability. The plaţorm includes features like manual input modes, real-time fault detection, and a historical database of pulley performance, making it a comprehensive tool for predictive diagnostics. Currently at an advanced development stage, the project demonstrates strong potential for real-world deployment in heavy industrial seţngs, supported by extensive dataset training and robust intellectual property protection.

II. PROBLEM STATEMENT

In many industrial sectors, especially mining and heavy manufacturing, cable belt conveyor systems play a critical role in transporting materials efficiently over long distances. A key component of these systems is the poly pulley, which guides and supports the belt. However, these pulleys are prone to unexpected failures due to factors such as wear and tear, material fatigue, and operational stress.

These failures are difficult to predict with traditional maintenance methods and ‘ result in sudden downtime, impacting productivity and increasing operational costs. The main challenge lies in the lack of a reliable and intelligent system to monitor the real-time health of poly pulleys and detect early signs of failure, such as cracks or misalignments. Current practices are largely reactive—

maintenance is ‘ performed aŌer a problem has occurred. This leads to frequent production stoppages, higher maintenance expenses, potential safety hazards for workers, and disruptions in the overall workflow. Additionally, conveyor systems are ‘ located in harsh environments, making manual inspection difficult, time-consuming, and unsafe. Our project aims to address this issue by creating an AI-based predictive maintenance system that can automatically detect faults and assess the condition of pulleys using image, audio, and video data.

The solution offers early warning capabilities, enabling operators to take preventive action before a failure happens. It incorporates machine learning models trained to analyze paΣerns from historical data, identify risk factors, and predict potential breakdowns. By automating fault detection and enhancing predictive accuracy, the system improves safety, reduces unplanned maintenance, and significantly boosts the reliability and efficiency of cable belt conveyor operations.

III. PROPOSED METHOD

The proposed method uses an AI-based web application that analyzes images, audio, and video data with machine learning models to predict poly pulley failures in conveyor systems. By detecting early signs of damage like cracks or corrosion, it enables timely maintenance and reduces downtime.

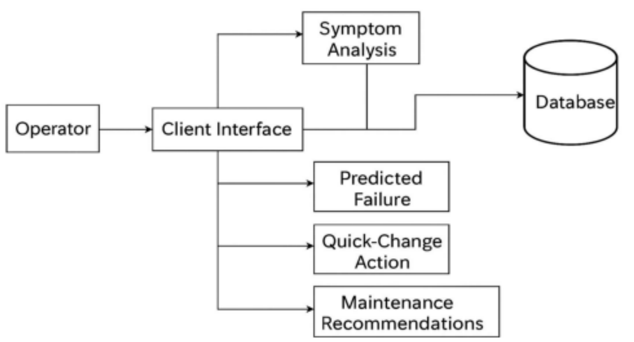

Fig. 1 : Proposed System

Implementation System Architecture

1. **Input Layer:**

Manual Input: Pulley material, belt type, load capacity, and usage hours.

- Multimedia Input:
- Upload images of pulley systems.
- Upload audio/video files capturing belt operations.

2. **Data Preprocessing:**

Data Collection:

- Gathered over 7000+ data entries from past pulley failures, including image, audio, and operational parameters.

•Normalization:

- Preprocessed images and audio signals. Standardized input values for consistent model performance.

3. **Deep Learning Model Development:**

Model Selection:

- CNN used for image and crack feature analysis.
- Autoencoder used for anomaly detection in multimedia inputs.

4. **Training Process:**

- Split dataset into training, testing, and validation sets.
- Used real-time conveyor data and manual entries for model accuracy.

5. **Evaluation Metrics:**

Accuracy:

- Assessed fault prediction precision on unseen data.

Recall & Precision:

- Measured effectiveness in detecting pulley-related issues.

Confusion Matrix:

- Evaluated model performance across various fault types.

6. **User Interface Development:**

Frontend:

- Built using React JS for real-time interaction and responsive design.

Functionality:

- Manual and media upload input modes
- Display fault prediction and confidence score.

7. **Database Integration:**

Database:

- MongoDB used to store user inputs, prediction logs, and dataset.

API Communication:

- Developed RESTful APIs for smooth frontend-backend communication.

8. **Maintenance and Scalability:**

Quick-Change Mechanism:

Suggested mechanism for pulley replacement to reduce downtime.

Scalability:

- System supports expansion with more input types and extended datasets.

IV. BLOCK DIAGRAM

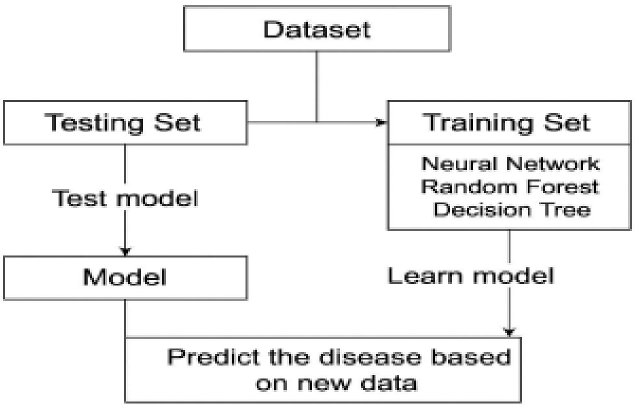

Fig. 2 : Block Diagram

V. TECHNOLOGY STACK

Category	Technology	Purpose
Frontend	React JS	Build interactive user interfaces for web application
Frontend	HTML/CSS	Structuring and styling web pages
Backend	Node.js + Express	Server-side logic and API development
Machine Learning	Python	Core language for building ML and deep learning models
Deep Learning	TensorFlow/Keras	Training CNN and Autoencoder mondels for fault detection
Database	Firebase / AWS	Storing multimedia inputs, user data, and predi-
Cloud & Hosting	OpenCV/Librosa	Hosting web application and deploying ML mo-
Multimedia Analysis	Pandas/Numpy	Image analytics and audio processing for detecting cracks and anomalies

Table 1 : Technology Stack

VI. RESULTS

Fig.3 : Dashboard

Fig.4 : Data Entry

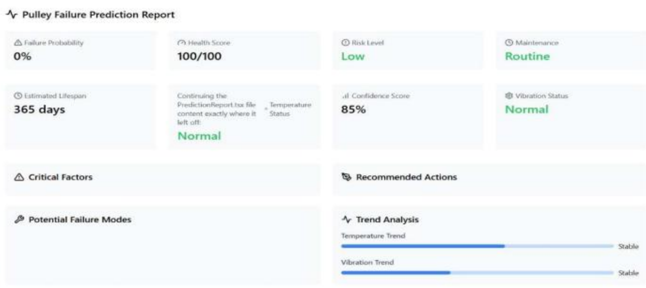

Fig.5 : Prediction Report

VII. CONCLUSION

In conclusion, our project successfully addresses the long-standing issue of unpredictable poly pulley failures in cable belt conveyor systems, a critical concern in industries relying on seamless material transportation. By integrating advanced AI and machine learning technologies, we have developed a predictive maintenance solution capable of identifying early signs of wear, cracks, and potential failure points through multimedia input analysis, including audio, video, and image data.

The solution leverages a powerful combination of convolutional neural networks (CNNs) and autoencoders to process real-time input and historical failure data, enhancing the accuracy of predictions. The application interface allows operators to manually input values or upload visual and audio data, enabling a flexible and user-centric approach to pulley condition monitoring. The implementation of a quick-change pulley mechanism further reduces system downtime, enhances operational safety, and ensures cost-effective maintenance cycles. Overall, this project offers a pioneering approach with significant implications for the mining and manufacturing sectors. By automating the detection and prediction of pulley failures, we not only reduce unplanned downtime and maintenance costs but also improve system reliability and operational efficiency. With scalability and continued testing, this innovation holds strong potential for widespread adoption in industrial environments.

References

[1]. Boucher, R., & CurΘs, R. (2006). The Influence of Conveyor Belt and Pulley Materials on Conveyor System Performance. InternaΘonal Journal of Mining Science and Technology, 16(1), 47-55.

[2]. Spurling, T., & Baxter, G. (2015). Polymer Composite Materials for Conveyor Pulley Systems. Materials Science and Engineering, 30(12), 1310-1321.

[3]. Hagan, T., & Goodwin, A. (2008). Mechanical Design of Cable Belt Conveyor Systems: ImplicaΘons for Poly Pulley Failures. Journal of Engineering and Technology, 45(6), 1023-1032.

[4]. Gupta, S. K., & Khare, R. (2017). InnovaΘons in Conveyor Pulley Design for Mining ApplicaΘons. Journal of Mining Engineering, 38(2), 102-110.

[5]. Smith, P. D., & Thomas, M. J. (2019). PredicΘve Maintenance of Conveyor Systems Using IoT Sensors. InternaΘonal Journal of Engineering and Applied Sciences, 28(5), 137-143.

[6]. Wang, Z., & Li, M. (2013). FaΘgue Behavior of Polymer-Based Conveyor Pulleys: A SimulaΘon Study. InternaΘonal Journal of FaΘgue, 49, 171-179.

[7]. Yadav, S. P., & Sharma, R. (2020). Advanced Materials for Conveyor Pulley Systems: Review and Future Prospects. Materials Science Forum, 1007, 57-67.