

## FAULT DETECTION FOR MOTOR DRIVE CONTROL SYSTEM IN INDUSTRIAL ROBOTS USING CNN-LSTM BASED OBSERVERS

Mrs.B.Laxmi Kalpana<sup>1</sup>, G.Divya<sup>2</sup>, Sunkari Sailakshmi<sup>3</sup>, M.Sowjanya<sup>4</sup>

<sup>1</sup> Assistant Professor, Department of Computer Science and Engineering, Sridevi Women's Engineering College, Hyderabad, India

Email: [kalpana.laxmi@gmail.com](mailto:kalpana.laxmi@gmail.com)

<sup>2,3,4</sup> B.Tech Student, Department of Computer Science and Engineering, Sridevi Women's Engineering College, Hyderabad, India

### Abstract

The complex working conditions and nonlinear characteristics of the motor drive control system of industrial robots make it difficult to detect faults. In this paper, a deep learning-based observer, which combines the convolutional neural network (CNN) and the long short term memory network (LSTM), is employed to approximate the nonlinear driving control system. CNN layers are introduced to extract dynamic features of the data, whereas LSTM layers perform time-sequential prediction of the target system. In terms of application, normal samples are fed into the observer to build an offline prediction model for the target system. The trained CNN-LSTM-based observer is then deployed along with the target system to estimate the system outputs. Online fault detection can be realized by analysing the residuals. Finally, an application of the proposed fault detection method to a brushless DC motor drive system is given to verify the effectiveness of the proposed scheme. Simulation results indicate the impressive fault detection capability of the

presented method for driving control systems of industrial robots.ine learning-based methods.

### INTRODUCTION

In general, fault detection methods for robot driving control systems can be divided into three main groups, including model-based, signal-based and data-driven methods. Model-based fault detection methods are accomplished based on the comparison between the estimated and measured signals, which are highly dependent on accurate design of the system model. However, modelling for nonlinear driving control systems is a challenging task due to the complex mapping between model parameters and physical operation. To address this challenge, advanced machine learning techniques, such as Convolutional Neural Networks (CNNs) and Long Short Term Memory networks (LSTMs), have gained attention for their ability to effectively analyse complex time-series data and detect anomalies. In this study, we propose a novel approach that combines the strengths of CNNs and LSTMs for fault detection in motor drive control systems

within industrial settings. The Convolutional Neural Network (CNN) architecture is well-suited for extracting relevant features from high-dimensional data such as motor sensor readings or control signals. Recently, data-driven methods, which are also known as knowledge-based methods, have been extensively studied due to their powerful modelling ability without any prior known models or parameters. Deep learning technology has now been extensively researched in data-driven fault detection. Based on the historical data set, a deep CNN model was designed to realize thruster failure detection of dynamically positioned vessels. In a CNN-based fault detection and classification method was developed in the semiconductor manufacturing process took full use of raw time series data to train a one-dimensional CNN model, which showed good performance in fault diagnosis. In wavelet analysis was used to transform the raw data into time-frequency images that were regarded as inputs of a CNN model, which turned FDD problems into image pattern recognition issues. While Wen et al. developed a signal-to-image data preprocessing method and proposed a CNN-based fault diagnosis scheme. However, for all these FDD methods, it is expected to be reliable in fault classification

when the training data include multiple fault patterns. That is to say, fault patterns that are not included in the raw data would hardly be classified by the trained model. Although CNN-based models are able to extract patterns of local trends of time-series data, they, fail to capture the sequence pattern information for long temporal dependencies. The LSTM is a deep learning method based on the recurrent neural network (RNN) that overcomes the limitations of the RNN structure by introducing memories and gates. An initial fault detection algorithm for rolling bearings based on the LSTM was designed and verified by experiment results. The high impedance fault detection of solar photovoltaics based on the LSTM. LSTM-based method to detect anomalies for satellite power systems, where the LSTM was conducted to establish a prediction model. To detect vibration signal faults for the rotating machinery, the LSTM method was adopted as a classifier in. Generally, the LSTM networks are suitable for working with temporal correlations, especially long temporal dependencies. One challenge to LSTM networks is how to improve their ability to explore potential correlations for noncontinuous data. Therefore, some literary research tried a hybrid method based on CNN and LSTM to exploit the complementary advantages of

both techniques. Li et al. proposed a hybrid CNN-LSTM network for predicting the concentration. Similarly, a hybrid CNN-LSTM framework was developed to forecast the short-term individual household electric load. In a deep learning model based on CNN and LSTM networks was established for fault classification of vibration data of a helicopter gearbox mockup system. The final results indicated the promising performance of the CNN-LSTM networks. However, to our best knowledge, the hybrid deep learning framework employed for fault detection of industrial robot driving control systems has rarely been found in the literature.

**LITERATURE REVIEW "Fault Detection and Diagnosis in Motor Drive Systems Using Deep Learning Techniques: A Comparative Study"** This paper presents a comparative study of various deep learning techniques, including CNN, LSTM, and their combinations, for fault detection and diagnosis in motor drive systems. The study evaluates the performance of different architectures on benchmark datasets and discusses the strengths and limitations of each approach. Many approaches have been used to detect the faults in an induction motor. These use the current spectrum analysis, vibration analysis and other techniques for the detection of the various faults in the motors.

The faults in the induction motor were detected by the monitoring of the current and the vibration of the induction motor. The mechanical faults are detected such as bearing damage through vibration spectrum analysis and electrical faults such as single phasing, unbalanced supply by current analysis. In another approach the bearing faults were detected by the use of stator current spectrum analysis and a fault model was developed which considered the air gap length variations and changes in the load torque. In another approach, a broken rotor bar fault was detected using wavelet transform.

**"Robust Fault Detection in Motor Drive Systems Using Attention Mechanisms in CNN-LSTM Networks"** This work introduces attention mechanisms in CNN-LSTM networks for robust fault detection in motor drive systems. By dynamically weighting the importance of input features over time, the proposed attention-based approach enhances the network's ability to focus on relevant information and improve fault diagnosis accuracy, particularly in complex and noisy industrial environments. A Wavelet and adaptive threshold based fault diagnosis technique for a three-phase induction motor stator inter-turn faults was developed and the severity of the fault can be detected easily. In another report, the effects of motor eccentricity on the

generation of characteristic frequencies and principal slot harmonics in the real and simulated motors were investigated by the use of MCSA and monitoring of magnetic flux density outside the motor. Various strategies have been applied for the speed control of the induction motor.

**“Feature Learning for Fault Detection in Motor Drive Systems: A CNNLSTM Approach”** This study investigates the effectiveness of feature learning techniques based on CNN-LSTM networks for fault detection in motor drive systems. It explores different strategies for feature extraction and representation learning from raw sensor data and evaluates their impact on fault classification performance.

### EXISTING SYSTEM

In Existing system" typically refers to the current state or setup of a particular process, organization, or technology. It refers to the way things are currently being done or the infrastructure that is already in place. This term is often used in discussions about making changes, improvements, or upgrades to a system. Understanding the existing system is crucial for planning and implementing changes effectively, as it provides a baseline from which to measure progress and assess the impact of any modifications. In existing system we are using the support vector machine algorithm

SVM where it cannot provide the early detection and reliability.

### Drawback in Existing System

- Less accuracy
- Limited Performance
- Difficulty in Handling Streaming

### Proposed System

- On basis of the existing system we are proposing the CNN, LSTM, Feature Extraction and Preprocessing networks in proposed systems. This provides early fault detection and reliability which maintains the adaptability and safety.
- Preprocessing: Image Pre-processing is a common name for operations with images at the lowest level of abstraction. Its input and output are intensity images. The aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing.
- Feature extraction: Feature analysis argues that we observe individual characteristics, or features, of every object and pattern we encounter. Recognition-by-components theory maintains that we sort objects into their component parts as a way of

recognizing them. These components are understood as three-dimensional shapes called geons.

### Algorithm

- CNN: A more detailed overview of what CNNs do would be that you take the image, pass it through a series of convolutional, nonlinear, pooling (down sampling), and fully connected layers, and get an output. As we said earlier, the output can be a single class or a probability of classes that best describes the image.

### Advantages

- Improved Accuracy
- Early Detection
- Continuous improvement

### CONCLUSION

A CNN-LSTM hybrid deep learning network is designed as a nonlinear observer for driving control systems of industrial robots in this paper. With the assistance of the strengths of CNN and LSTM, the proposed method enhances the modelling performance of the target system by connecting an LSTM network to a CNN network. Then anomaly detection of two common fault patterns can be realized via analyzing the residuals. The superiority of

this approach can be concluded as three aspects compared with conventional methods. Firstly, the hybrid framework focuses on both spatial features and temporal correlation of the target system, which is demonstrated by the predictions for different cases. Secondly, the CNN-LSTM network is equipped with a powerful approximate ability to nonlinear systems, which ensures the accurate evaluation of the target system based on the trained model. Moreover, the fault detection scheme based on residuals utilizes Z-Score and PSNR to enhance the detection efficiency. The case study results reveal that the designed CNN-LSTM model is an effective and promising way of fault detection for the target system. This study focuses only on the prediction of the rotation speed. In future work, estimation for other parameters, such as phase current and electromagnetic torque can be applied to make a weight-based decision. Additionally, the validation of the proposed scheme for different fault patterns on a semi-physical platform will be conducted in the future.

### REFERENCES

- Erjun, Y., H. Mingliang, and L. peng, "Design of high-precision and high-reliability aircraft stepper motor drive servo control system,"

- in Proc. IET Conference, 2021, pp. 22-27
- Ghosh, S.S., S. Chattopadhyay, and A, “Das Harmonics Monitoring for Winding Fault Diagnosis of Brushless DC motor,” in Proc. IET Conference, 2021, pp. 164- 169.
  - Zhang, X., et al. “Research on the control strategy of five-phase fault-tolerant servo system for aerospace,” in Proc. IET Conference, 2021, pp. 1090-1094.
  - Y. Zhao, X. Liu, H. Yu, and J. Yu, “Model-free adaptive discrete-time integral terminal sliding mode control for PMSM drive system with disturbance observer,” IET Electric Power Applications, vol. 63, no. 10, pp. 1756-1765, Oct. 2020.
  - Webert, Heiko, Tamara, Lukas Kaupp, and Stephan Simons, “Fault Handling in Industry 4.0: Definition, Process and Applications,” Sensors, vol. 22, no. 6, pp. 2205, 2022.
  - Purbowaskito, Widagdo, Po-Yan Wu, and Chen-Yang Lan, “Permanent Magnet Synchronous Motor Driving Mechanical Transmission Fault Detection and Identification: A Model-Based Diagnosis Approach,” Electronics, vol. 11, no. 9, pp. 1356, 2022.
  - H. Badihi, Y. Zhang, B. Jiang, P. Pillay and S. Rakheja, “A Comprehensive Review on Signal-Based and Model-Based Condition Monitoring of Wind Turbines: Fault Diagnosis and Lifetime Prognosis,” in Proc. of the IEEE, vol. 110, no. 6, pp. 754- 806, June 2022, doi: 10.1109/JPROC.2022.3171691.
  - H. Chen, B. Jiang, S. X. Ding and B. Huang, “Data-Driven Fault Diagnosis for Traction Systems in High-Speed Trains: A Survey, Challenges, and Perspectives,” IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 3, pp. 1700- 1716, March 2022, doi: 10.1109/TITS.2020.3029946