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A Deep Learning Combination Model to Predict TBM Disc-cutter Wear Status

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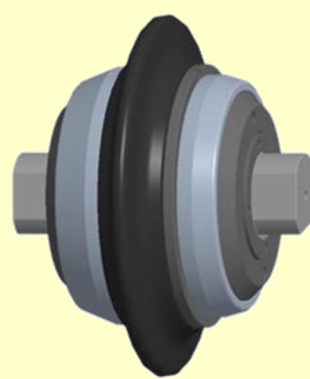
Introduction

- The disc-cutters mounted on the TBM cutter-head undertakes almost all the rock-breaking tasks and is the key core component of the TBM. In the process of rock-breaking, there will be violent contact between the disc-cutters and the rock, so that the disc-cutters are very prone to wear failure and cannot work normally.
- At present, engineers still use the method of regularly checking the status of the disc-cutters.
- This paper combines LSTM with CNN, and proposes a combined LSTM-CNN model.

Model Training

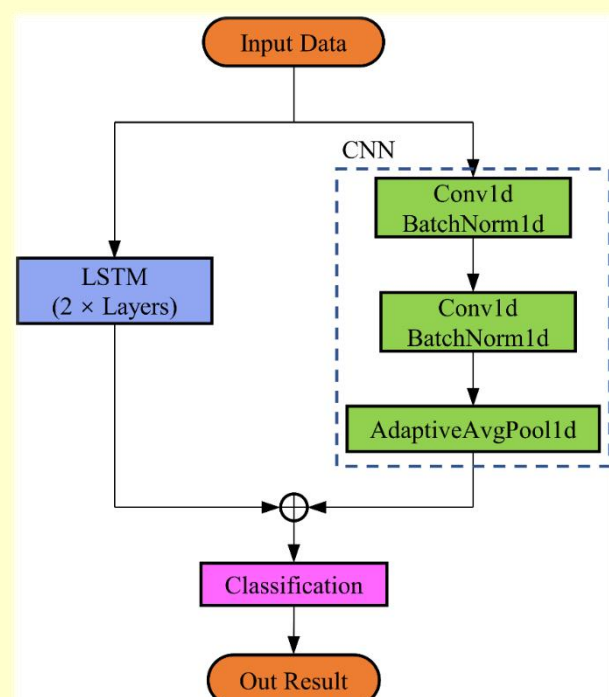


Vibration test bench



Disc-cutter

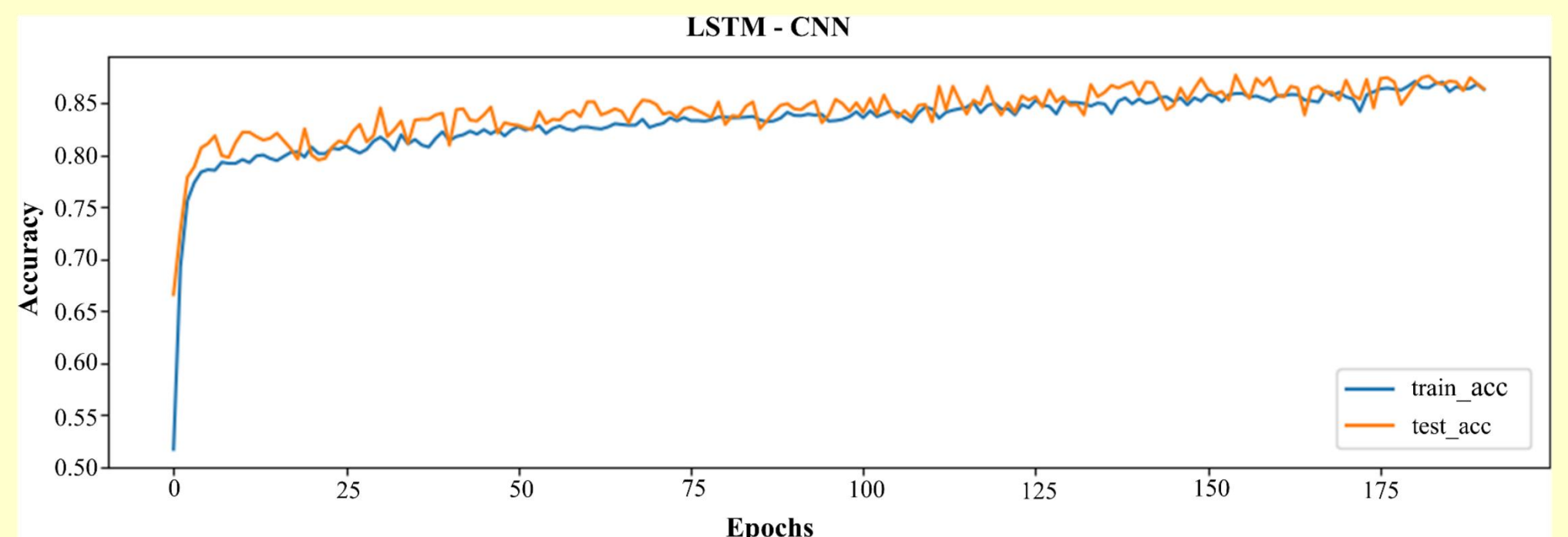
- The rock-breaking vibration test of disc-cutters was completed by the linear cutting test bench.
- The disc-cutters are 19 inch single cut cutters.
- The kind of rock samples used in the vibration test is granite.



Model construction

LSTM - CNN				
		Normal	Uniform-wear	Angled-wear
Actual label	Normal	0.793	0.106	0.101
	Uniform-wear	0.079	0.875	0.046
	Angled-wear	0.027	0.015	0.959

Training result



Accuracy curve

- The input data goes into the LSTM part and the CNN part respectively. The output of the two parts is added to form a new feature. The classification layer is a single Linear layer.
- On the whole, the LSTM-CNN model can distinguish the three kinds of wear status well.

Summary

As the core component of the Tunnel Boring Machine (TBM) rock-breaking function, disc-cutters directly affect the service life and construction efficiency of the TBM. Accurately predicting the wear status of disc-cutters is critical to efficient reel replacement decisions.

To solve this problem, a combined method LSTM-CNN based on long short-term memory (LSTM) network and convolutional neural network (CNN) is proposed, which predicts the wear status of the disc-cutters based on vibration dataset. The high-sensitivity vibration sensor is used to collect signals in the rock-breaking test, and then the deep learning model is used to eliminate interference signals to extract effective features, and the prediction of the three kinds of disc-cutters wear status (normal, uniform-wear failure and angled-wear failure) is realized.