Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Fault diagnosis of a marine power-generation diesel engine based on the Gramian angular field and a convolutional neural network

Congyue LI, Yihuai HU, Dexin CUI, Jiawei JIANG

Cite this as: Congyue LI, Yihuai HU, Jiawei JIANG, Dexin CUI, 2024. Fault diagnosis of a marine power-generation diesel engine based on the Gramian angular field and a convolutional neural network. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 25(6):470-482. https://doi.org/10.1631/jzus.A2300273

Research problem

Only part of the data in the vibration signal contains critical fault feature information.

Existing methods of signal preprocessing cause some loss of information.

Existing network models have insufficient ability to learn key fault features, thus affecting the accuracy of machinery fault diagnosis.

Method

A combination of spatial domain image fusion and convolutional neural network containing multiple attention mechanisms is used to solve the above problem.

- 1 Gramian Angular Field

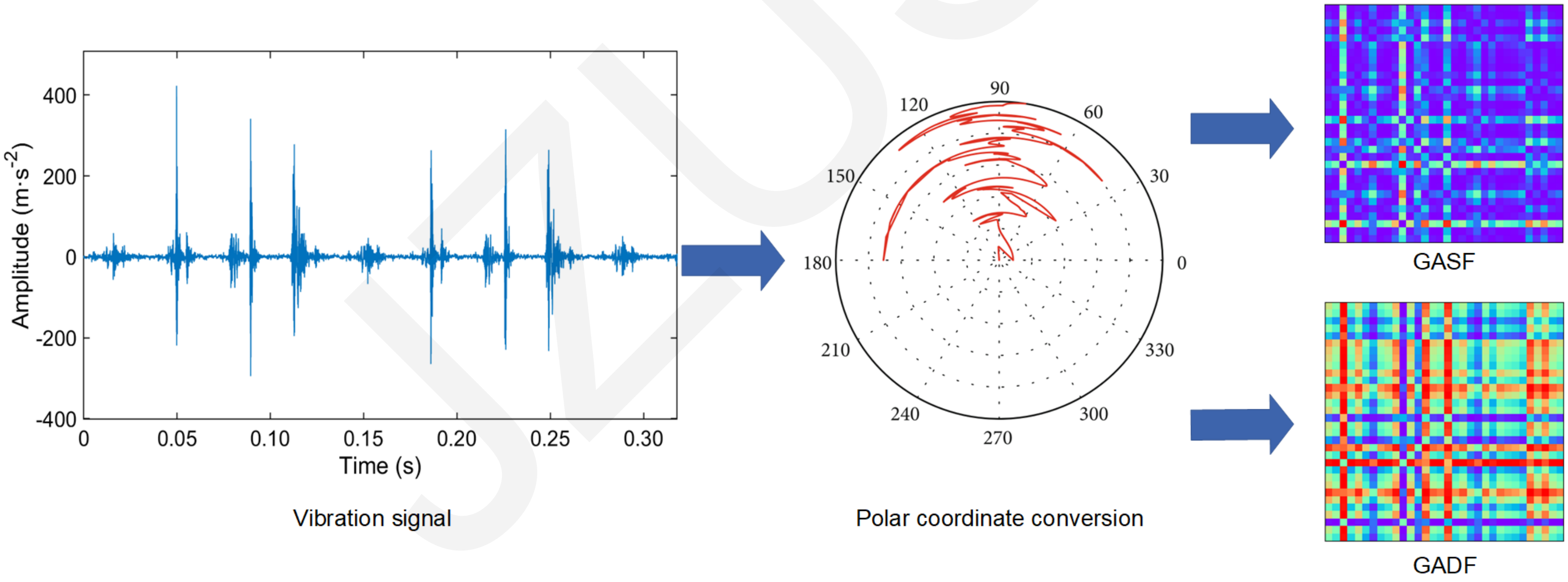

Fig. 1 GAF conversion process

Method

- 2 Image Fusion

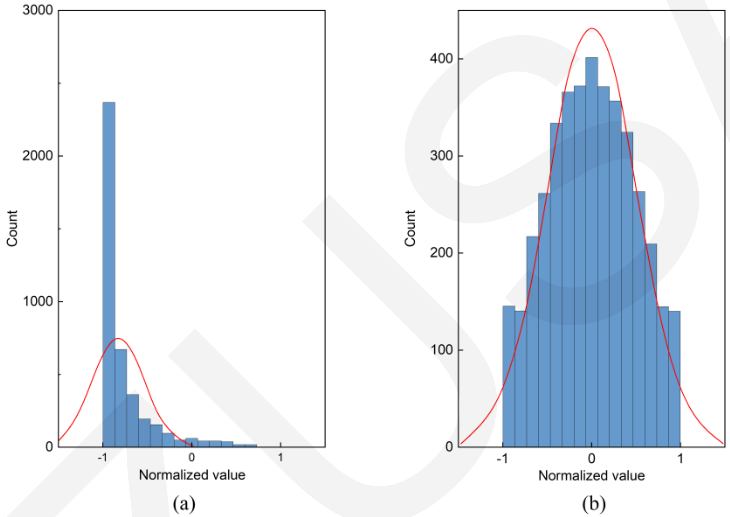

Fig. 2 The density histogram of GASF and GADF: (a) GASF matrix density histogram; (b) GADF matrix density histogram

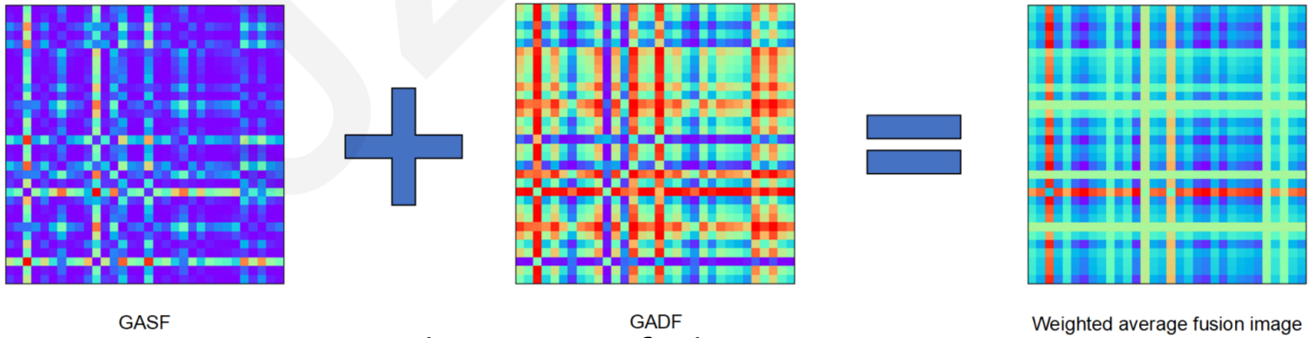

Fig. 3 Image-fusion process

Method

- 3 Improvements in Attention Mechanisms

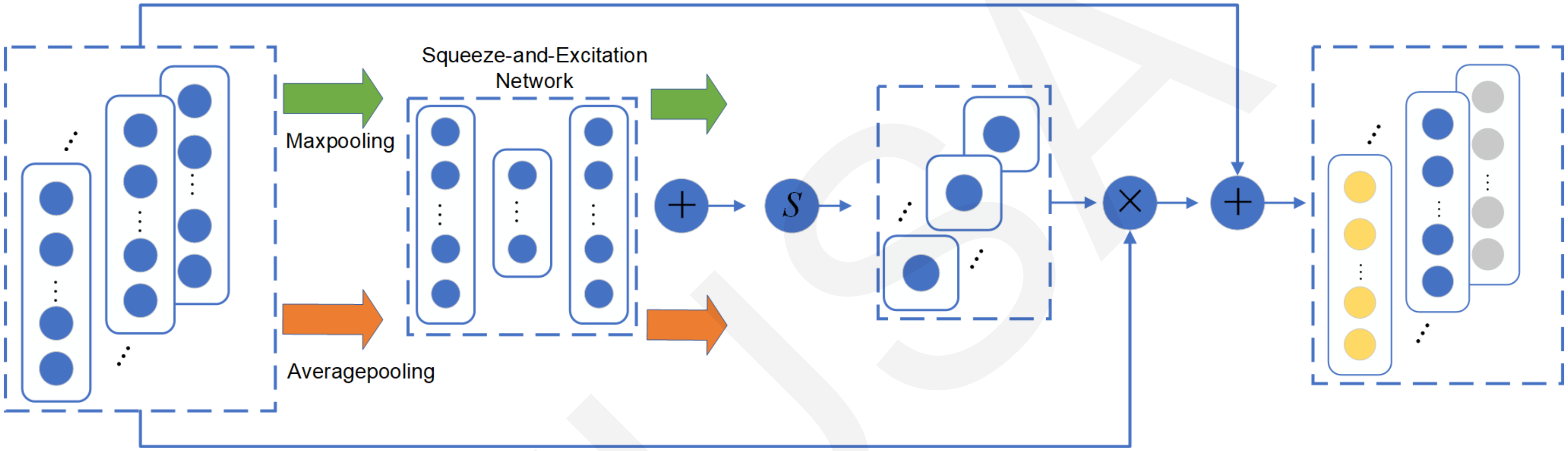

Fig. 4 Channel attention mechanism

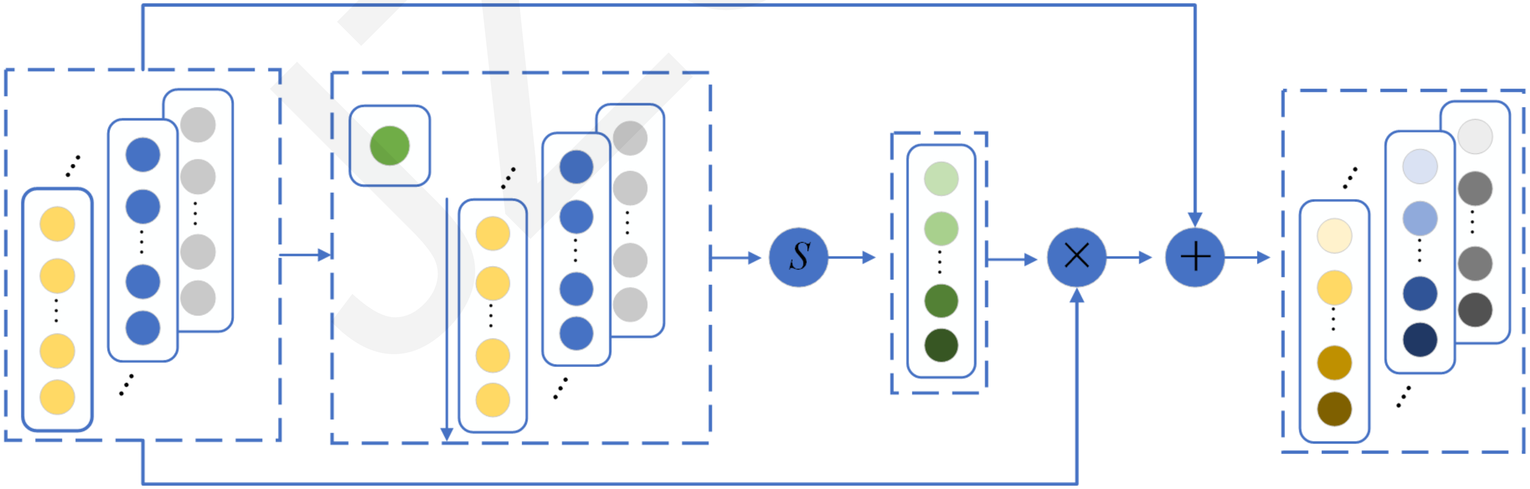

Fig. 5. Temporal attention mechanism

Method

● 4 The CNN Structure and Main Parameters

Name	Structure parameters	Output size
Image input	64×64×3	64×64×3
Conv_1	32@2×2, Stride= [1], Padding= [2]	67×67×32
Batchnorm_1	-	67×67×32
Maxpool_1	3×3, Stride= [2], padding= [0]	33×33×32
Multi-attention mechanism_1	64@1×1×1 (Time attention mechanism)	33×33×32
Relu_1	ReLu	33×33×32
Conv_2	32@3×3, Stride= [1], Padding= [2]	35×35×32
Batchnorm_2	-	35×35×32
Maxpool_2	3×3, Stride= [2], Padding= [0]	17×17×32
Multi-attention mechanism_2	128@1×1×1 (Time attention mechanism)	17×17×32
Relu_2	ReLu	17×17×32
Fc_1	-	1×1×100
Relu_3	ReLu	1×1×100
Dropout	0.5	1×1×100
Fc_2	-	1×1×7
Softmax	-	1×1×7
Class output	-	1×1×7

Method

- 5 CNN Performance

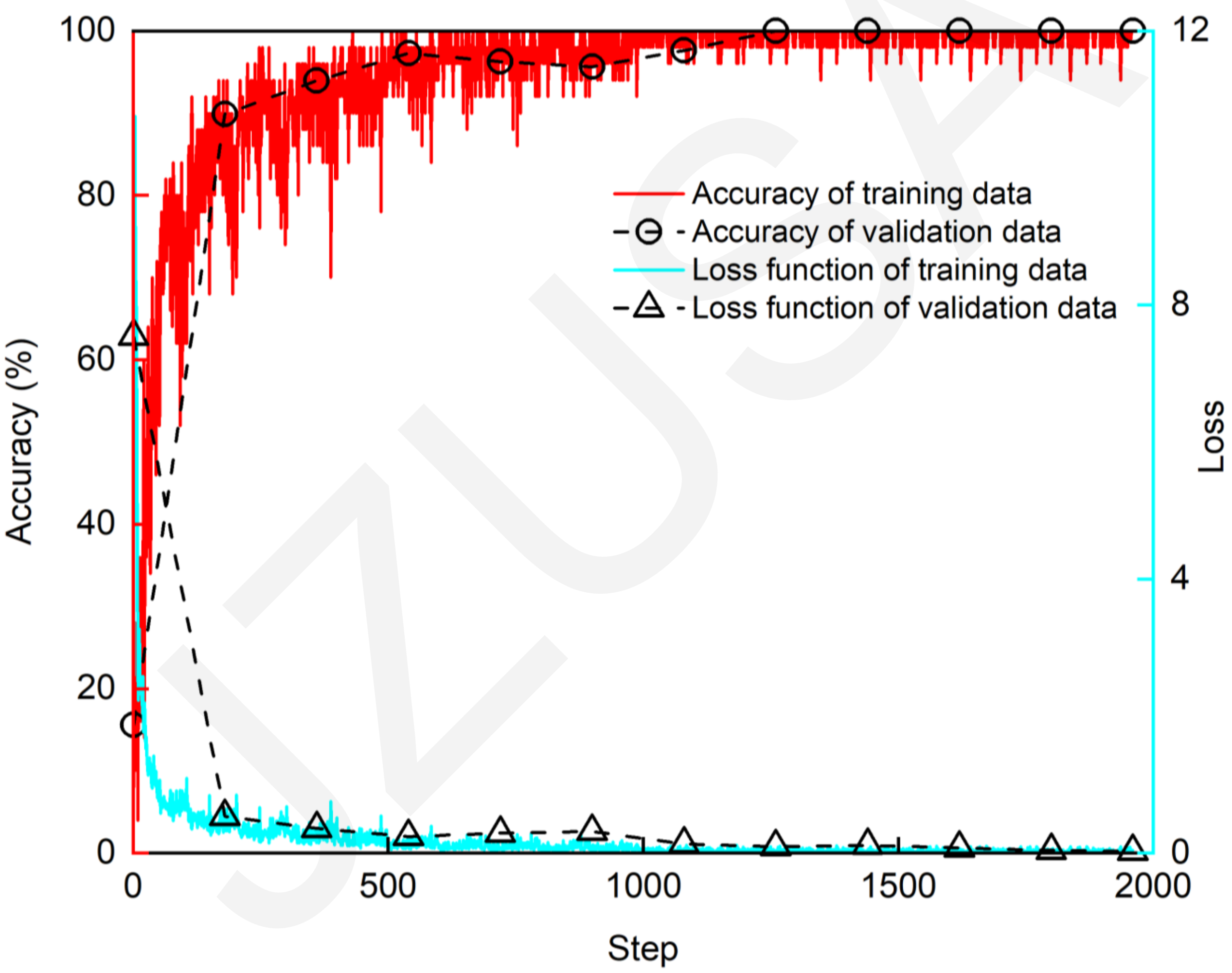

Fig. 12 The CNN model training and validation process

Conclusions

1. Using a multi-attention mechanism, interference information such as noise can be suppressed, and the CNN feature-extraction capability can be optimized. With strong noise, the diagnostic accuracy of the model with a multi-attention mechanism is 14.8% better than the model without the mechanism.

2. The average accuracy is above 94% with all SNRs. The proposed method has better noise immunity and stability than the four other methods.

3. Fused images provide more adequate feature information for the neural network, which improves fault-identification accuracy.

4. The variable-load experiments illustrate that the accuracy of the proposed model can be maintained above 89%, proving that it has good stability.