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Link between roughness and squeal: prediction by deep learning approach

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It is well known that the problem of squeal is strongly linked to contact conditions and in particular to the associated surface condition. The current approach to be predictive consists in carrying out simulations including more and more complicated models. The pitfall of this approach lies in the consequent development time of the models and the CP time resolution.
In this paper, an alternative is proposed: it consists in using of deep learning algorithms and convolutional neural network architecture. In the end, the method used shows all its robustness with a failure rate of less than 4%.

Keywords: roughness, deep learning, brake system, convolutional neural network, contact

1. Introduction

One major issue that automotive and railway industries have been facing is the squeal like sound which is produced from braking and this issue has resulted in loss of comfort and satisfaction of the customers. This noise does not technically disrupt the braking systems performance, however customers who have complained from these annoying noises tend to replace parts, which imposes huge costs on after-sales service companies. In recent years, different laboratories have been looking at the problem and have been working on the answer [1,2, etc.]. Today, the usual approach is to model the braking system [3,4, etc.], but these approaches are far from reality because of the multi-scale nature of the contact (tribology, system scale, etc.) which has a crucial importance on squealing.

2. Methods

In order to have a predictive tool for any surface, we develop a specific deep learning algorithm. The database is built from the enriched model [4] run on a large set of cases. Finally, in order to evaluate the relevance of the model, we will test it with numerical and experimental data.

- The 2D Convolutional Neural Networks architecture is shown in Figure1. In this architecture, the inputs are in the form of 2D matrice of roughness in order to training the model. This network tries to find a relation between inputs and outputs by applying different filters on inputs.

- In figure 2, we see the accuracy curve of the model, which shows that the model has acceptable accuracy.

- Type of learning: Supervised Learning

- Algorithms: Machine learning and Deep learning

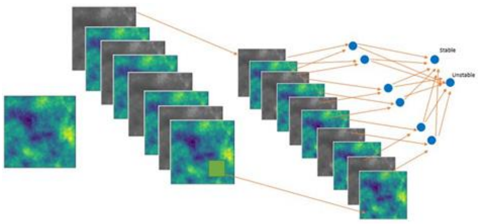

Figure1. Visualization of convolutional Neural Network Structure

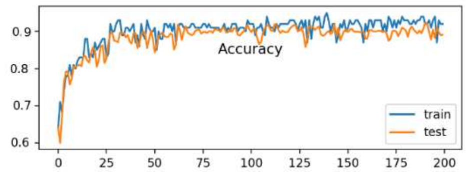

Figure2. Accuracy

3. Discussion

In this study, we showed that deep learning can be effectively used by analyzing the roughness of the contact surfaces to identify the surfaces which are at risk of squealing. One of the advantages of this method is reducing computation time. After only one training, the model can be applied to the other cases and we will have the output within one or two seconds, while in finite element methods, we need one hour per calculation. In addition, this new method of creating models is quite simple and user friendly. User can easily work with the model by a simple data entry, without having knowledge of deep learning. Also, by developing, improving, and incorporating the physics of perceived mechanical science problems into the functions of deep learning libraries, this powerful tool can be highly optimized and tailored to engineering needs. Using this method reduces the time of calculation and increases the accuracy. The error percentage in this method is less than 4%.

4. References

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