Railway Track Fault Detection

Project Work

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Spring Semester 2022

Abstract

Following project is a continuation of the Mathematic Modeling Practice subject. During the first semester a set of convolutional networks were built to compare on the task of classifying different railway track faults. The project was followed up by contacting MÁV Central Rail And Track Inspection Ltd. who has provided sample dataset for further research and study purposes. This dataset is limited in terms of track failures however it provides the opportunity to apply anomaly detection models. The sample contains video footage of a short section of a single track of approx. 3 minutes, with a few seconds of rail sections covered with grass and/or containing double tracks. The latter two is considered as outlier from the dataset. A set of autoencoder models built to detect these outliers in the sample. The autoencoder is based on the convolutional models of VGG19, ResNet50 and EfficientNetV2L. Different anomaly detection methods were applied, an approach based on the calculation of a loss measure between the input and the output of the autoencoder and IsolationForest algorithm applied on the feature space of the inputs generated by the encoder part.

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1 Introduction

1.1 Previous work

Current research started as part of the studies on the Mathematics Expert in Data Analytics and Machine Learning postgraduate specialization program [1] held by the AI Research Group of Eötvös Loránd University [2]. During the one year program a thesis work has to be created that is often preceeded by a modeling practice in the first semester. This project follows the same approach as railway track fault detection models were already built in the first semester. However the characteristics of the dataset used at that time did not allow a successful application of a model however valuable experience is gained together with a boost of motivation to follow up the topic and deepen the knowledge in the mentioned problem.

1.2 Available results

The work of the first semester can be found at [3]. Following is a short summary of the results obtained.

During the first semester basic convolutional neural networks were built with a classification head to identify images with defective railway tracks. LeNet-5, AlexNet, VGG16 and ResNet50 were applied, partially utilizing transfer learning as well (indicated with *_p in the following Figures).

The dataset was taken from the Kaggle webpage [4] consisting of a limited number of images with defective and non-defective railway tracks. The images combine a high variety of failures with very limited examples leading to a very specific dataset where the provided validation and test split is not representing the initial set of images.

The results of the modeling is shown on Figure 1, where the performance of different bootstrapped models on the splits of the dataset is given.

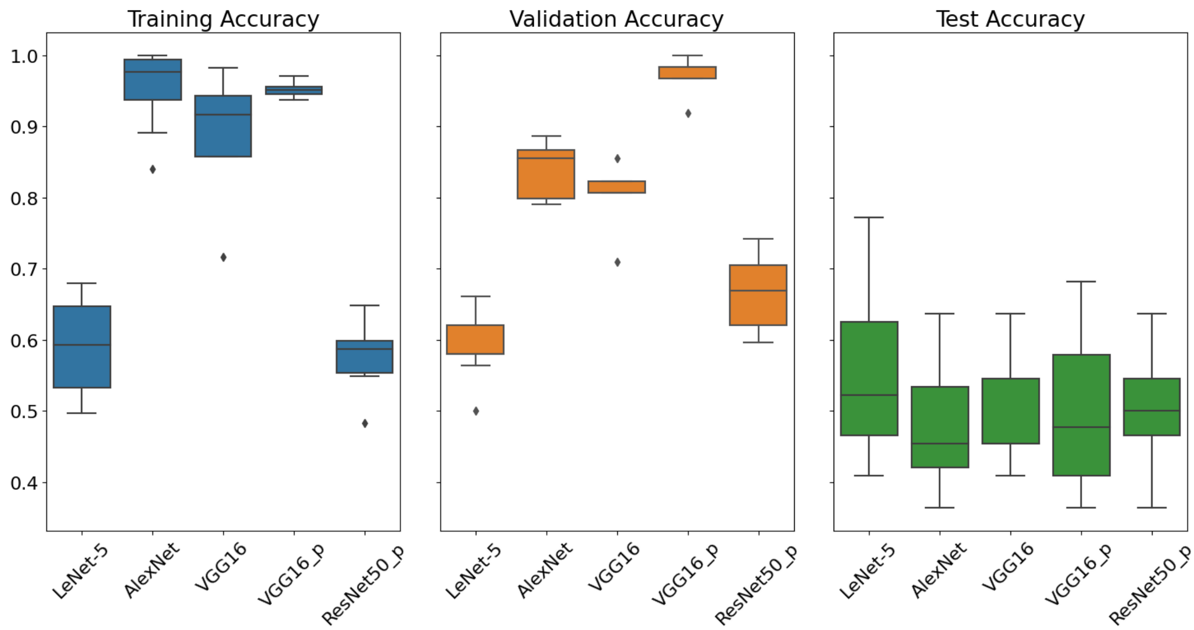

Figure 1: Results of first classification approach on the Kaggle dataset

Most of the models were successfully learned the features of the training and validation datasets, however on the test dataset all failed to classify the images in an acceptable level, mostly achieveing the level of a random classifier only. This lead to the realization that the low number of images compared with the high variety of the track failures will result in a situation where the model can easily learn the specifics of the training and validation dataset preventing of any generalization to the test dataset.

As a followup a search for a more extended dataset and more refined models were started.

1.3 Data provided by MÁV KFV Kft.

The company MÁV Central Rail And Track Inspection Ltd. (MÁV KFV Kft.) [5] was approached as they are proficient in railway track inspection and have the equipment and data that could be used for building such classifier model.

Currently MÁV KFV Kft. operates two vehicles for rail inspection purposes, the SDS and FMK-008 shown on Figure 2, both equipped with different measurement and inspection systems. Fortunately both of them is equipped with video recording, however with different systems. After a first view on the video files the system of the SDS vehicle is selected for a first modelling approach.

SDS

FMK-008

Figure 2: Railway inspection vehicles of MÁV KFV Kft.

This system records both rails from two angles resulting in four video footages parallel. A single footage was selected as it provides a static positioning relative to the tracks with good protection against changes of the lightning of the surroundings. The video system records with a resolution of 720x288 (width x height) with RGB channels at an 50 fps rate. Some examples of the images extracted from the video is shown on Figure 3.

Normal rail

Normal rail

Normal rail

Rails covered with grass

Double rails

Figure 3: Sample images from the dataset

2 The sample dataset

3 Description of the model

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References

[1] *AI&ML Training – AI Research Group*. en-US. URL: https://ai.elte.hu/training/ (visited on 05/23/2023).

[2] *AI Research Group – Artificial Intelligence & Data Science*. en-US. URL: https://ai.elte.hu/ (visited on 05/23/2023).

[3] Tamás Demus. *Mathemathical Modeling Practice - Railway track defect detection*. original-date: 2022-12-02T20:47:30Z. Dec. 2022. URL: https://github.com/demustamas/Mathemathical-Modeling-Practice (visited on 05/23/2023).

[4] *Railway Track Fault Detection | Kaggle*. URL: https://www.kaggle.com/datasets/salmaneunus/railway-track-fault-detection (visited on 12/22/2022).

[5] *MÁV Központi Felépítményvizsgáló Kft.* URL: http://www.mavkfv.hu/index.php?lngchg=en&f= (visited on 05/23/2023).