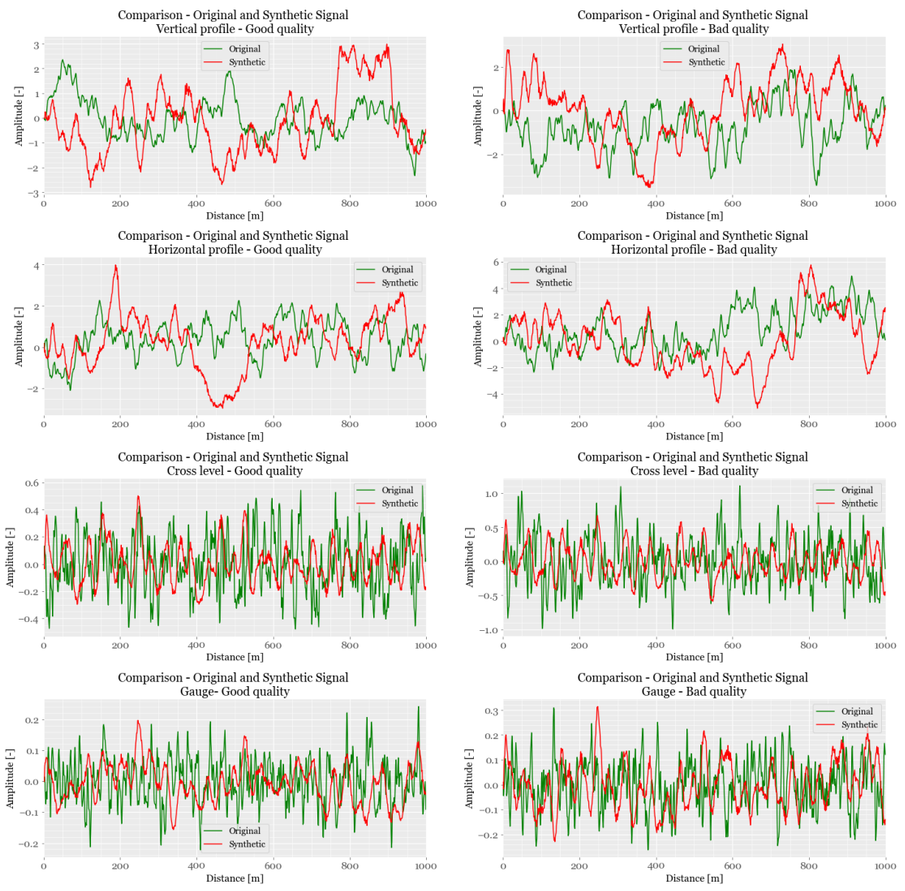
Master Thesis

Modelling and Synthesis of Track Irregularities for Data Augmentation using Advanced Schemes of Generative Adversarial Networks

In recent years, the world of Artificial Intelligence (AI) and more punctually Machine Learning (ML) has shed light on Generative Adversarial Networks (GANs). This algorithm is usually composed of two networks, a generator, and a discriminator. These will engage in an adversarial training where each will adjust its own parameters to perform better at a min-max optimization problem.

Photo: Guillermo Osio Arruti

Through this process, the generator gradually improves its generative process to synthesize more realistic data that the discriminator will no longer be able to distinguish as fake. These types of networks have been used mostly for image generation, or related applications. However, this work proposes to investigate, implement, and analyze the use of these networks in an untested field: the expansion of a data set composed of geometrical Track Irregularities (TI) structured as time-series.



Synthetic data generation using WGAN-GP: Comparison between real and synthetic signals for all eight evaluated geometrical track irregularities

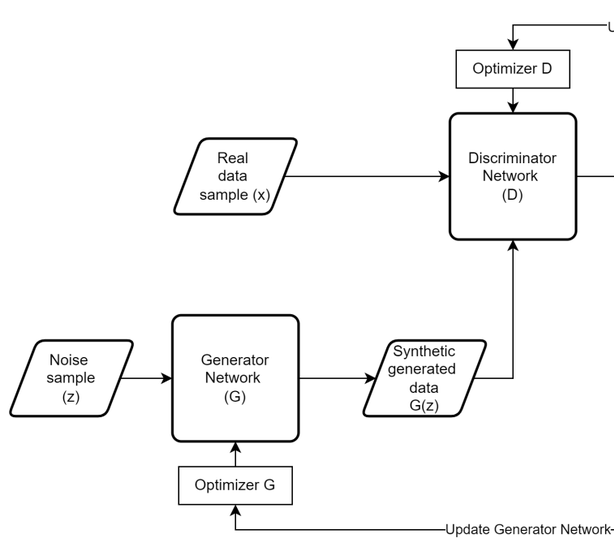


Diagram showing the basic structure of Generative Adversarial Networks

Application of Data Augmentation as a part of the CONMORAIL Project.
Taken and modified from CONMORAIL – DFG Research Project Proposal

This Data Augmentation (DA) process will address the data scarcity and imbalanced data set problematic for the further implementation of a Fault Detection and Isolation (FDI) system for railway tracks. The use of ML algorithms depends not only on the amount of data you have at hand, but also on its quality. The time-series-like TI signals generated here must therefore comply with certain spatial and frequency criteria. Since the scope and purpose of this implementation of GAN is not only exploratory, but also in search of immediate application, data quality analysis is also a major focus of this work.

Master Thesis by Guillermo Osio Arruti

Examiner: Prof. Dr.-Ing Ullrich Martin

Supervising Tutor: M. Eng. Héctor Alberto Fernández Bobadilla

Processing Period 08 2022 - 02 2023

Vorgelegt an der
Universität Stuttgart

Institut für Eisenbahn- und Verkehrswesen

E-2023/02