Chair of Computational Modeling and Simulation
TUM School of Engineering and Design
Technical University of Munich

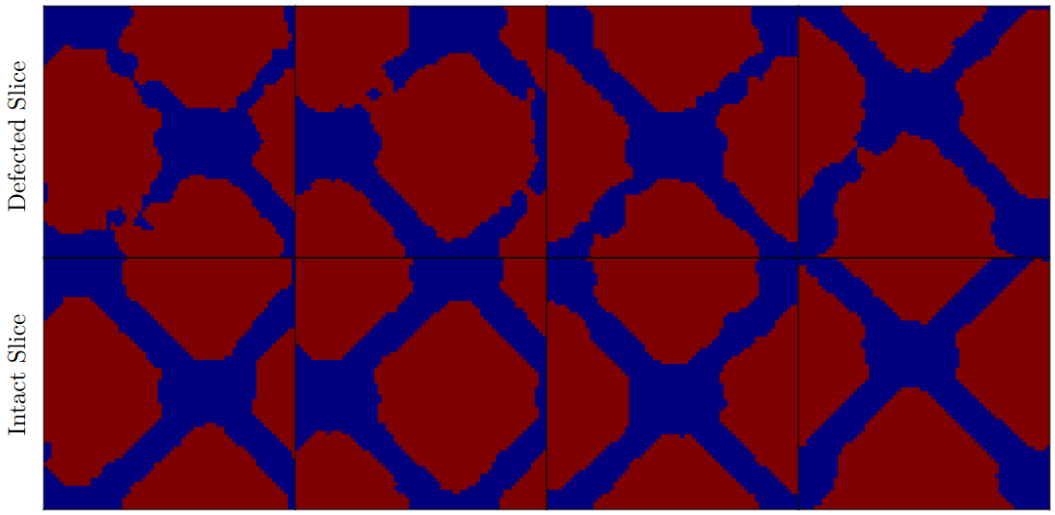
Modeling:
Mathematics:
Programming:
Science:

Software Lab:

Anomaly Detection with Generative Deep Learning

Description

Generative Deep Learning [1] is able to emulate distributions. In other words, new samples are generated from a distribution of a dataset. A simple approach are variational autoencoders, which map from a sample to itself via a reduced latent vector. Sampling this latent vector creates novel samples. A more advanced approach are generative adversarial networks, composed of a generator and a discriminator network. By letting the two networks compete against each other, a generator capable of providing new data points is created. A combination of the two are so-called variational autoencoder generative adversarial networks.
These networks can be employed for anomaly detection of data points not belonging to the original distribution [2,3]. This is, for example, useful in automatic quality monitoring of additively manufactured specimens, as shown below. By providing a trained generative neural network with an anomalous sample, a spatial reconstruction error between the sample and the reconstructed sample can be formulated. For autoencoders, this reconstruction is simply the output, while for generative adversarial networks, an additional optimization has to be performed. In order to test if the network is capable of expressing the sample, the input of the network is optimized to reduce the mismatch between prediction and anomalous sample. In both cases, the inability of the generative method to match the anomalous sample serves as an anomaly detector. This is to be investigated with simple distributions, such as circular holes in two-dimensional domains.



Task

Apply generative deep learning to learning material distributions enabling anomaly detection through reconstruction errors

- Perform a literature review to learn and understand most prominent generative algorithms.
- Implement a (variational) autoencoder and learn simple 1D and 2D material distributions.
- Implement a generative adversarial network and learn simple 1D and 2D material distributions.
- Implement a variational autoencoder generative adversarial network and learn simple 1D and 2D material distributions.
- Test the implemented methods on material coming from different material distributions. The reconstruction errors arising from the inability to match the material from the different distribution serve as spatial anomaly measure. Compare the methods.

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References

[1] Generative Deep Learning – Teaching Machines to Paint, Write, Compose, and Play, Foster, D. (2023)

[2] Deep Learning in Computational Mechanics: a review, Herrmann, L., Kollmannsberger, S. (2024)

[3] Deep Learning for Anomaly Detection: a review, Pang, G., Shen, C., Cao, L., Hengel, A. V. D. (2022)