

Dimensionality Reduction for Data Visualization and Linear Classification – Robustness vs. Accuracy

HSD 

Martin Becker, Jens Lippel and Thomas Zielke
Faculty of Mechanical and Process Engineering
Hochschule Düsseldorf – University of Applied Sciences, Germany
martin.becker@hs-duesseldorf.de

1 Introduction

- Dimensionality reduction (DR) often serves as a preprocessing step, e.g., for linear classification.
- The DR's purpose is to ensure that the subsequent component can function robustly.
- The robustness of a DR itself is rarely questioned:

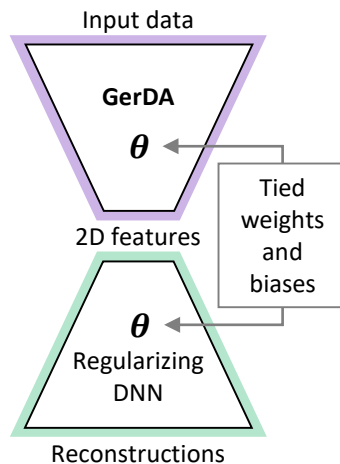
Largely overlooked:
Reproducibility

Mostly studied:
“Outlier robustness”

2 Deep Neural Networks

- We consider 2 related deep neural networks (DNN):

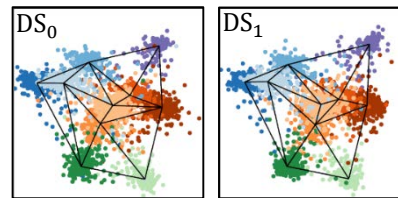
GerDA	Generalized Discriminant Analysis [1]
ReNDA	Regularized Nonlinear Discr. Analysis [2]



- ReNDA** has a deep autoencoder architecture.
- It uses **GerDA** as the encoder DNN.
- The decoder DNN acts as a regularizer.
- ReNDA** has been shown to yield reliably reproducible 2D feature representations [2].

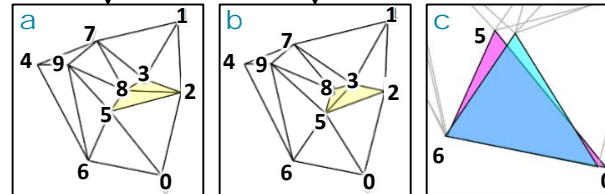
3 Robust Inter-cluster Structure

- Consider 2 random data splits (DS_0) from MNIST into 50k training and 10k validation samples.
- GerDA** results – 2D feature representations:



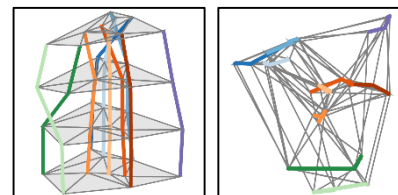
- showing class-related clusters
- similarly aligned

Delaunay triangulation based on class means



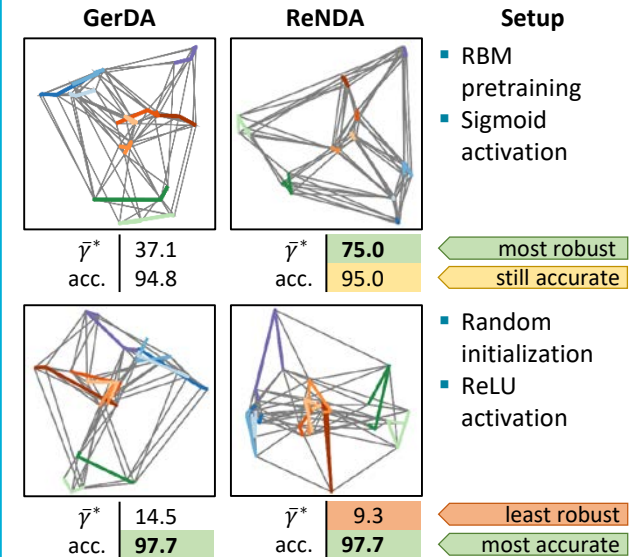
γ	scatter plot similarity $\coloneqq \sqrt{\alpha \cdot \beta}$
α	percentage of common triangles (see a, b)
β	average percental triangle overlap (see c)

- Dealing with more than 2 scatter plots:
 - align as similar as possible
 - state **average scatter plot similarity** $\bar{\gamma}^*$



- visualize by stacking and superimposing the Delaunay triangulations

4 Results and Conclusion



- The results support 2 recent claims:
 - RBM pretraining adds robustness to a DNN [3].
 - Robustness may be at odds with accuracy [4].
- The **ReNDA** results are reproducible and accurate.

5 References

- A. Stuhlsatz et al., “Feature extraction with deep neural networks by a generalized discriminant analysis”, *IEEE Transactions on Neural Networks*, 2012.
- M. Becker et al., “Robust dimensionality reduction for data visualization with deep neural networks”, *Graphical Models*, 2020.
- D. Erhan et al., “Why does unsupervised pre-training help deep learning?”, *Journal of Machine Learning Research*, 2010.
- D. Tsipras et al., “Robustness may be at odds with accuracy”, in *ICLR Conference Proceedings*, 2019.