Advanced Testing of Deep Learning Models: Towards Robust AI

Summer Semester - 2024

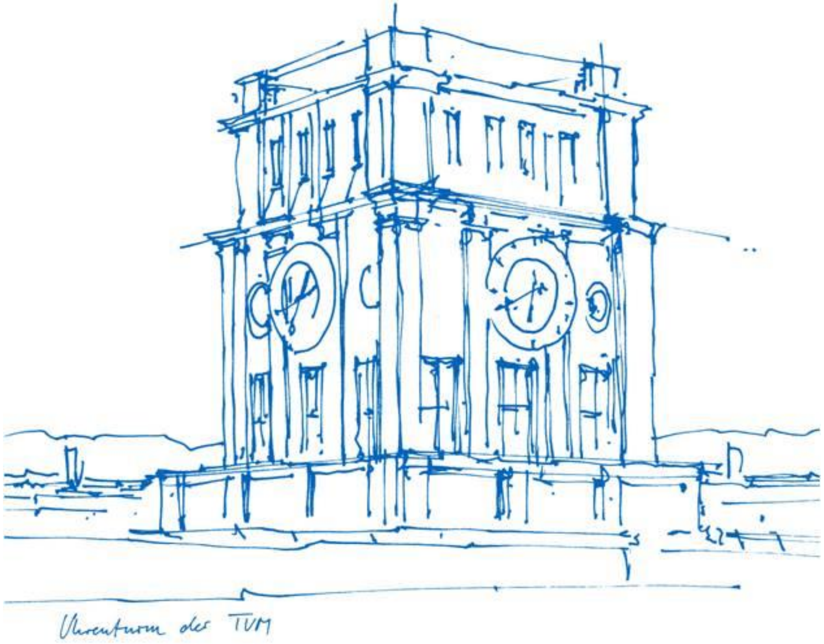
Vivek V. Vekariya

Prof. Dr. Alexander Pretschner

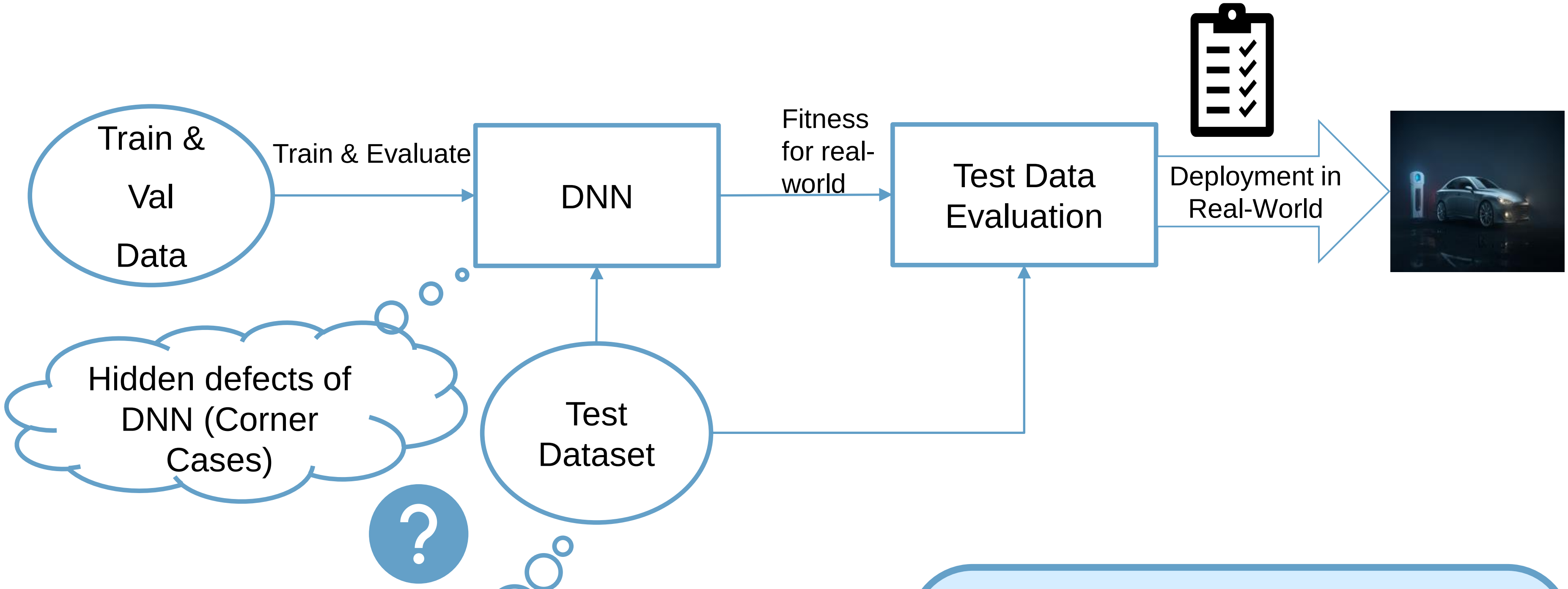
Lehrstuhl für Software and Systems Engineering

Technische Universität München

08.02.2024



The world of AI testing



1. Hand Picked Test set
2. Inadequate test dataset
3. Statistical measure about the quality of test dataset?

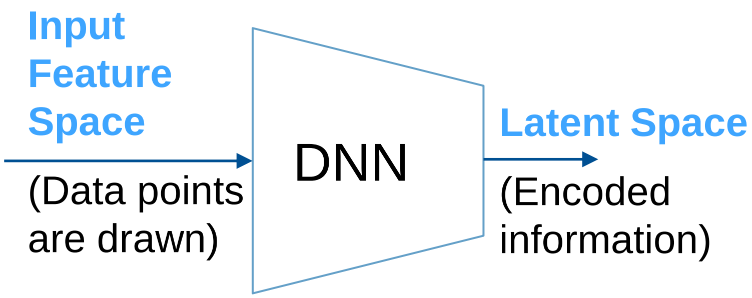
- **DNN Testing**

  How to identify corner cases?

- **Dataset Quality Evaluation**

  How to evaluate dataset quality for safety assured performance?

Exploring Latent Space Coverage



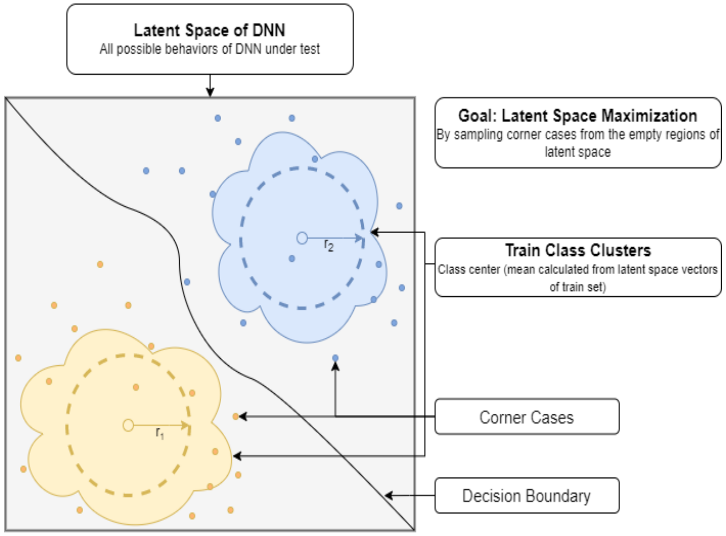
Input Feature Space

(Data points are drawn)

DNN

Latent Space

(Encoded information)

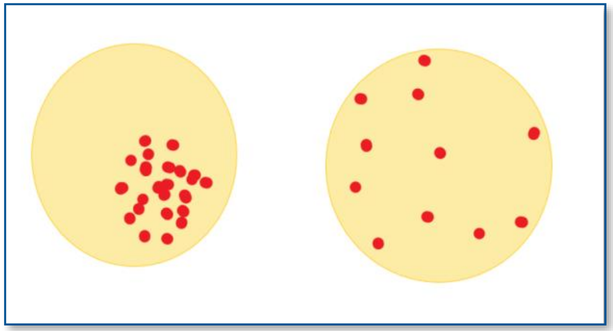

Latent Space of DNN
All possible behaviors of DNN under test
Goal: Latent Space Maximization
By sampling corner cases from the empty regions of latent space
Train Class Clusters
Class center (mean calculated from latent space vectors of train set)
r_2
r_1
Corner Cases
Decision Boundary

- **Dataset Quality Aspects:**
  - Robust test dataset: e.g. Accuracy- 0%
  - Diverse test dataset: Test more underlying faults
- **Latent Space Coverage:**

➢ Coverage, Density & Sparsity Estimation

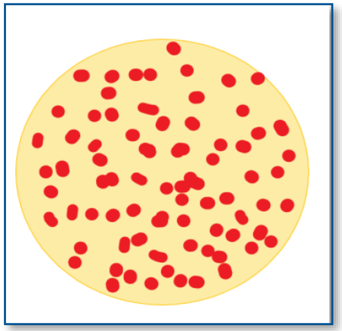
  - Verify training policies
  - Estimate potential data collection gap

Exploring Latent Space Coverage



Dense and Sparse test data points
in Latent Space

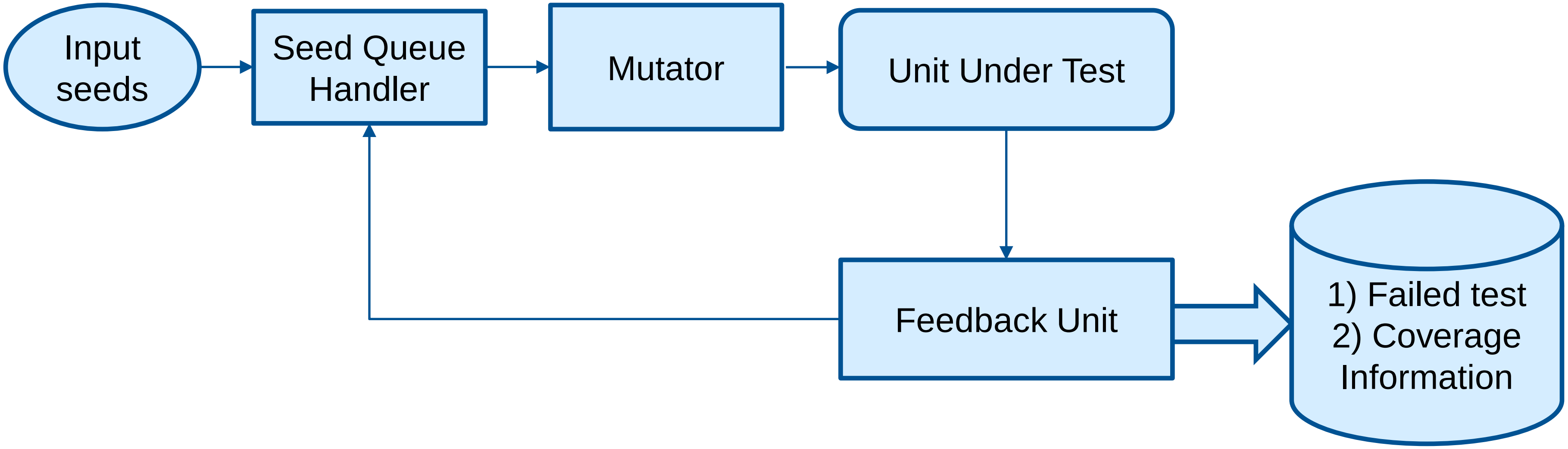
Is this a true maximization of latent space coverage?



Ideal test data points in
latent space

- **Directly using Latent space vectors:**
  - GANs & VAEs
- **Corner Case Identification:**
  - Coverage-guided Fuzz Testing
  - Latent Space based Testing
  - Metamorphic Relation Testing

Coverage-Guided Fuzzing



Learning Outcomes

- **Implementation, testing & evaluation** of state-of-the-art Classification & 2D Object Detectors DNNs
- Corner Case data generation using fuzzing and latent space properties
- GANs & VAEs for latent space coverage maximization
- Adversarial Attacks for state-of-the-art Classifiers and 2D Object Detectors

Prerequisites

Required

- Python (of course ☺)
- Deep Learning Frameworks (PyTorch, Keras, TensorFlow)
- Linux / Windows

Good to have

- Insights of 2D Object Detector Networks (SSD, Yolo, RCNN)
- Understanding of latent space and vector space modelling
- Passion for Safe AI

….But every smart work requires sincere dedication & commitment!

Agenda

- **Pre-course Meeting:** 05.02.2024 and 08.02.2024
- **Apply with additional documents: till 15.02.2024**
- **Acceptance Notification:** 23.02.2024
- **Kick–off Meeting - 1:** 18.04.2024 (Do.)
- **Project Discussions & Allocation:** 25.04.2024 (Do.)
- ***Weekly Follow-ups***
- **Mid-term Presentations:** 30.05/06.06.2024 (Preliminary-Do.)
- **Final Presentations:** July.2024 (Preliminary-Do.)

Evaluation

- *We work in TEAMs & get evaluated based on TEAM*
- ***Peer Reviews** for code and merge requests (Let’s Learn Together)*
- **Evaluation Criteria & Deliverables:**
  - Code & results (5/10)
  - Team & Individual reports (3/10)
  - Final Presentation (2/10)
  - Bonus: innovative ideas & extensive evaluation of the approaches

Interested?

1. Give your 1st priority to this course in the matching system
2. Tell us more about you (motivation, CV, transcripts & Gitlab link) by filling out:

   TUM_I4_student_wiki

Thank you for your attention ☺

Vivek V. Vekariya

Garching bei München