Dataset and quality of data for AI

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Research Challenges in Coupling Artificial Intelligence and Network Management

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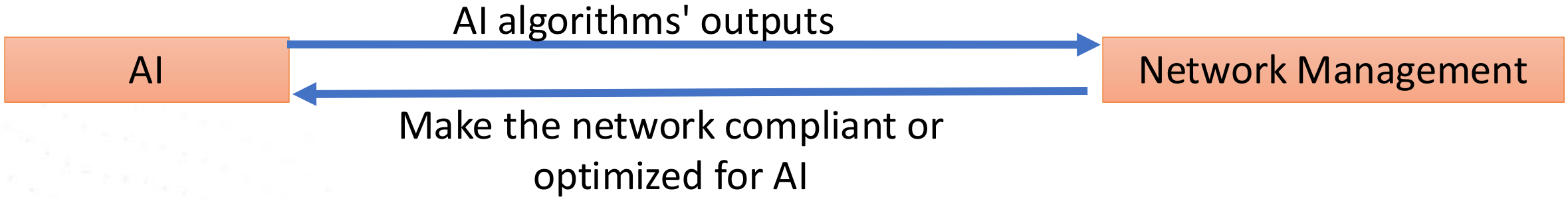
How was this document was built and structured?

- Coupling Network Management and AI



- The document is about challenges
  - Identify and classify challenges
  - No exhaustivity claimed
  - No solution provided (only examples for illustration purposes)
  - Current SotA overview and gap analysis

Sdsqd

"Data challenges" highlights

- Network data as input for ML algorithms
  - Data for AI-based NM solutions: data definition, mapping to a problem, representation, encoding, external parameters
  - Data collection: integrate AI-based solutions requirements into the collection process requirements
  - Usable data: lack of datasets for training and validation --> administrative, legal and ethical issues... and **quality problems**

Make AI more acceptable for networking

- Favor the most simple algorithms -> help in their explainability
  - Only use most sophisticated algorithms if there is a real added value

- Better to well tune a given algorithm rather than just select one after benchmarking multiple ones blindly
  - Starting with features also (much network data is neither images nor text…)

- Make the ML models robust and generalizable

  --> start with challenges related to data: we need high quality datasets

Always discussing that without significant progress

Data quality

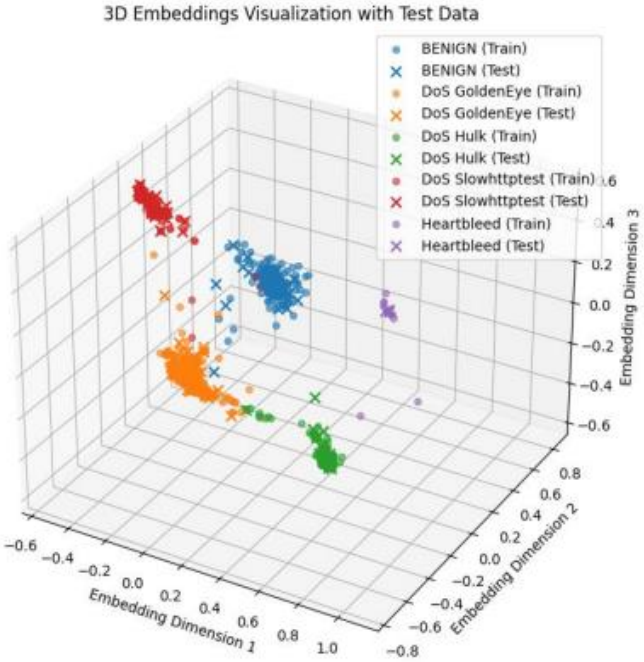
- Inherent problems
  - Hard to get access real data for privacy and legal reasons
  - Hard to label them properly
  - → (Small and) unrealistic datasets

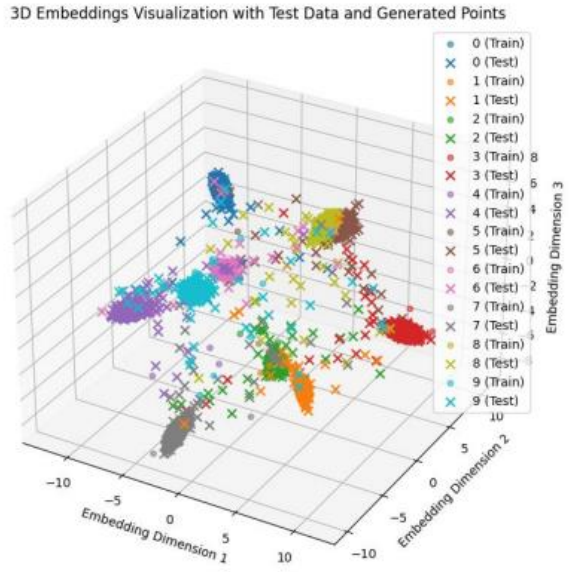
- But necessity to compare and reproduce results
  - Can we generate good data (with simulators or digital twins…)?
  - How good or realistic is a dataset?
- Regulations will also adds constraints (e.g. European AI act)

- Example: How bad is it for network intrusion?
  - CIC-IDS datasets have been extensively used since 2018
  - Easy to classify attacks in these datasets: Random Forest reaches 0.97 F1-score
    - Is it worth to get 0.99 with DL?
    - “Undetected” overfitting issue due to lack of data variability

Data quality measure

- Complexity of data, volume, neuron coverage...
- Feature-based, linearity, neighborhood measures (How Complex Is Your Classification Problem? A Survey on Measuring Classification Complexity. ACM Comput. Surv. 2020)



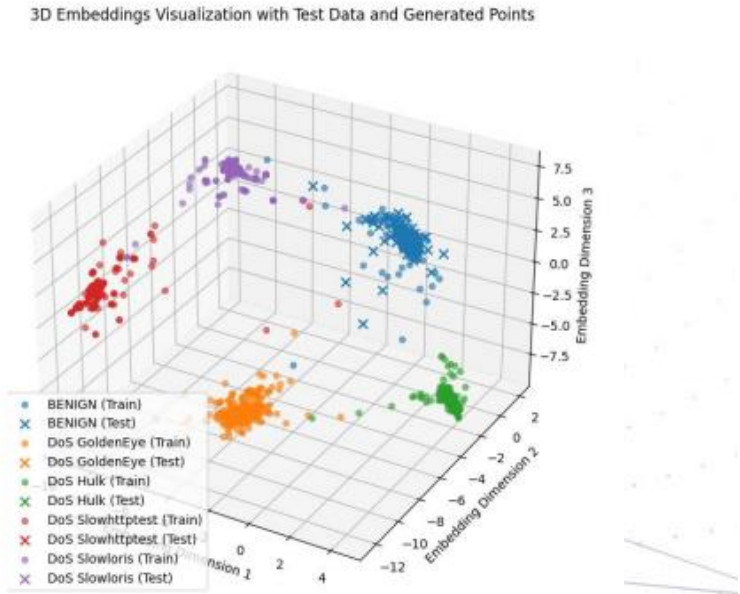


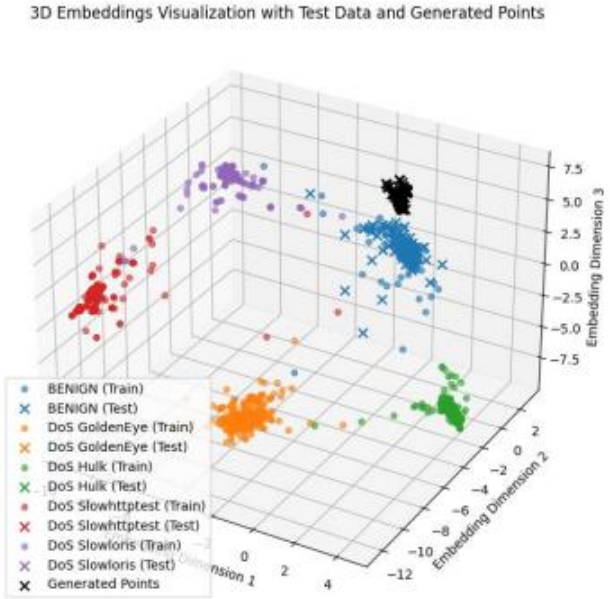
Measures	IDS	CIFAR-10
F1	0.0177	0.8029
F2	0.0000	0.8524
F3	0.0000	0.9998
F4	0.0078	0.2660

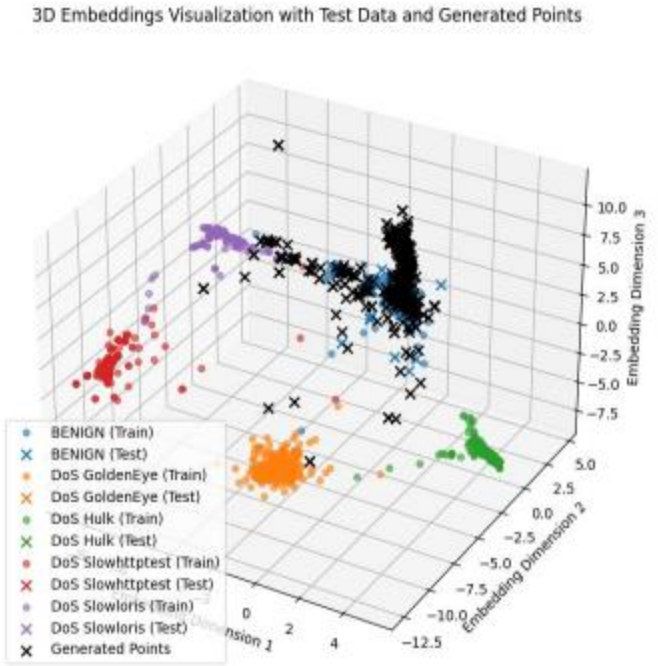
- Those are purely data-related metrics, ok for a classification problems like IDS but not easy to map to other more complex objectives (actions, configurations, etc.)
  - Network-specific quality metric based on the final objective?
  - Guide the collection/generation of new dataset through these metrics?

How to generate data

- Many AI methods exists (e.g. GNN, Evolutionary Algorithm)
- But these are data-centered methods –-> generated data cannot be realistic (e.g. even not compliant with protocol specification)
- Our approach (my research group): do not generate data directly, generate environment to generate data







Without tc

With tc

Research questions

- Assessment of the (re)usability and quality of data **according to a specific goal** ?
  - Derive existing metrics and methodology
  - Avalanche effect on degrading "raw" quality to the final objective
  - Characterize existing and future datasets in a systematic way

- Generation of data
  - For training + For testing --> different requirements
  - **Automation of data generation to be enough realistic** (again this depends on how data will be used)

- Relationship with NDTs to be fed with "high quality" data or to generate data...

- Discussion at IETF 121 meeting https://datatracker.ietf.org/meeting/121/session/nmrg
- To be continued with interested people