Thesis Committee Meeting

Ananth Mahadevan

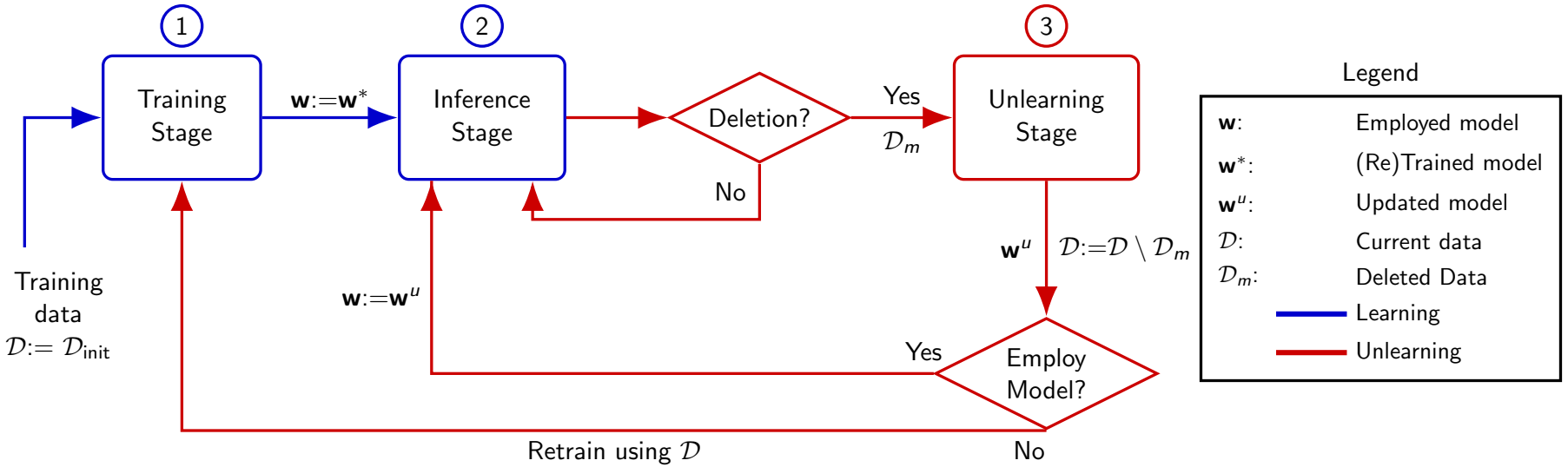
February 21, 2024

Overview

Published Articles

1. Certifiable Unlearning for logistic regression: An experimental study, MAKE 2022 [1]
2. Scalably Using Node Attributes and Graph Structure for Node Classification, Entropy 2022 [4]
3. Robustness of Sketched Linear Classifiers to Adversarial Attacks, CIKM 2022 [3]
4. Reception Reader: Exploring Text Reuse in Early Modern British Publications, JOHD 2023 [6]

Machine Unlearning



Unlearning

Task of updating a ML model after partial deletion of training data

Qualities of an approximate unlearning method:

- **Certifiability**: How similar are $\mathbf{w}^u$ and $\mathbf{w}^*$?
- **Effectiveness**: How well does $\mathbf{w}^u$ perform?
- **Efficiency**: How much time to produce $\mathbf{w}^u$?

Experimental Setup

Item	Values
Parameters	Noise (σ) & Efficiency (τ)
Metrics	`AccDis`, `AccErr` & Speedup($\times$)
Methods	INFLUENCE, FISHER & DELTAGRAD

Metric	Quality
`AccDis` $\uparrow$	Certifiability$\downarrow$
`AccErr` $\uparrow$	Effectiveness$\downarrow$

Parameter	Effect
$\tau\uparrow$	Efficiency$\uparrow$ Certifiability$\downarrow$ Effectiveness$\downarrow$
$\sigma\uparrow$	Certifiability$\uparrow$ Effectiveness$\downarrow$

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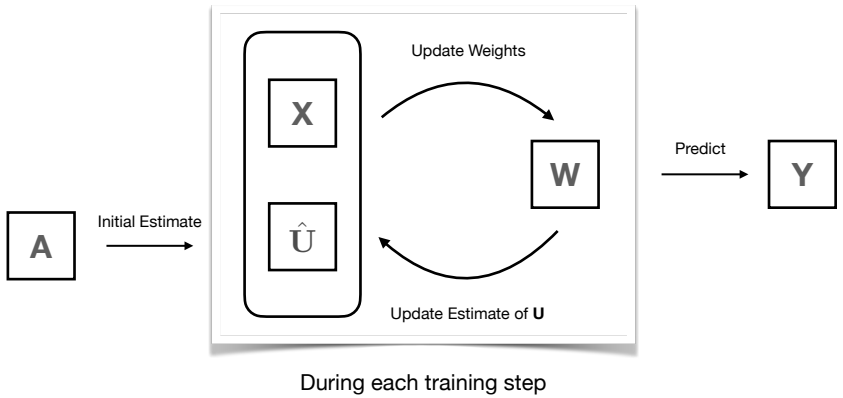
Scaling Node Classification [4]



- Improves running time of node classification method JANE [5]
- Developed mini-batching training algorithm to improve GPU utilization
- Scaled experiments to graphs with more than a million nodes

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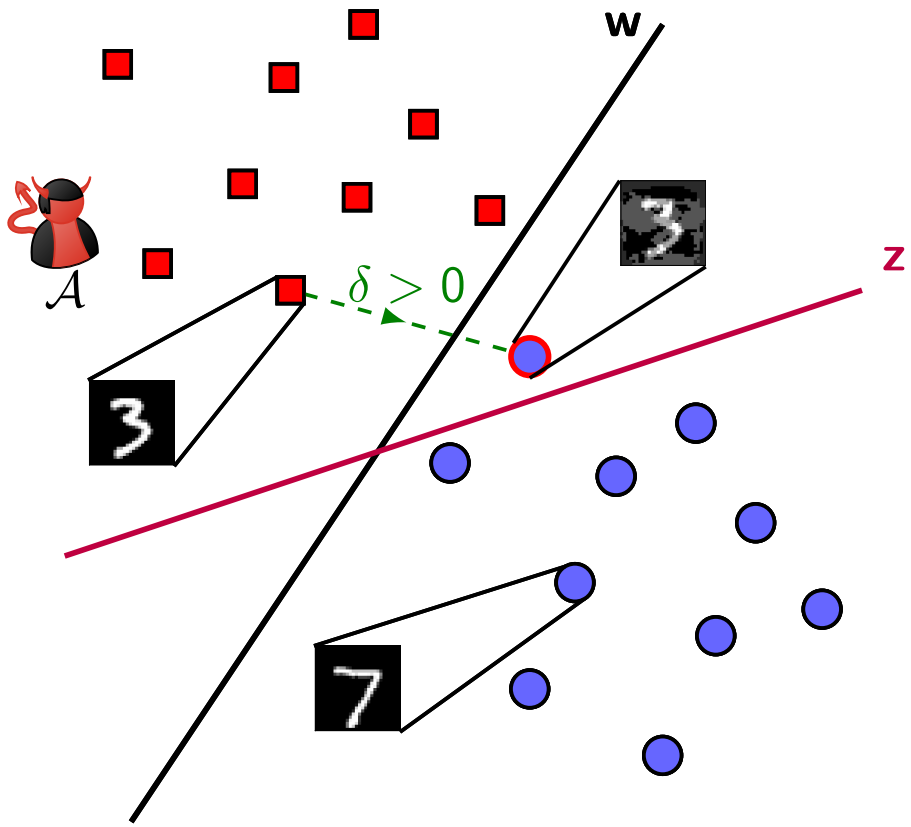
Robustness of Sketched Linear Classifiers [1]

- **w**: Linear Classifier
- **z**: WM-Sketch Classifier [7]
- $\mathcal{A}$: Adversary
- δ: FGSM perturbation



Robustness of Sketched Linear Classifiers [1]

$\mathcal{A}$ crafts a perturbation based on its Knowledge and Observability of the target.

- Knowledge: Is the target a WM-Sketch?
- Observability: Does $\mathcal{A}$ have access to count sketch R?

$\mathcal{A}$	Knowledge	Observability
White-Box	✓	✓
Grey-Box	✓	✗
Black-Box	✗	✗

Research Question

How does the performance of a given WM-Sketch worsen in the presence of these adversaries?

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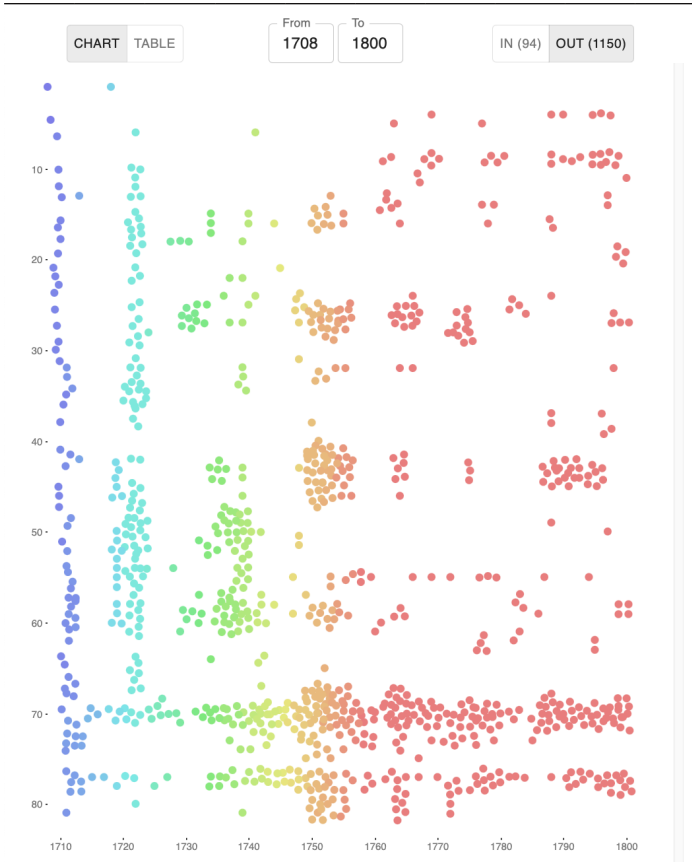
Reception Reader Interface



Gale Primary Sources Help Citation Feedback @ReceptionReader Cookies

Shaftesbury, Anthony Ashley Cooper (1671-1713)
1708 - A letter concerning enthusiasm

concerning ENTHUSIASM. 27

Nation expreſſes it) it is neceſſary a People ſhou'd have a *Publick Leading* in Religion. For to deny the Magiſtrate a Worſhip, or take away a National Church, is as mere Enthuſiaſm as the Notion which ſets up Perſecution. For why ſhou'd there not be publick Walks, as well as private Gardens? Why not publick Librarys, as well as private Education and Home-Tutors? But to preſcribe bounds to Fancy and Speculation, to regulate Mens Apprehenſions and religious Beliefs or Fears, to ſuppreſs by Violence the natural Paſſion of Enthuſiaſm, or to endeavour to aſcertain it, or reduce it to one Species, or bring it under any one Modification, is in truth no better Senſe, nor deſerves a better Character, than what the Comedian declares of the like Project in the Affair of Love——

D 2 *Nihil*

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Astell, Mary (1668-1731)
1722 - An enquiry after wit: wherein the trifling ar...

AN ENQUIRY AFTER WIT.

well'd againſt *Enthuſiaſm*, as the Title imports? I wiſh it may prove ſo, for the *poor Gentleman's* ſake; for if it be otherwiſe, the Wit of his *Letter* will be no equivalent for the Profaneneſs: Let us ſee then his account of *Enthuſiaſm*. By p. 27. one wou'd take it to be nothing elſe but *Perſecution*, from whatever hand it comes, whether the Magiſtrate perſecutes the People, or they the Magiſtrate: *For*, ſays the Letter, *to deny the Magiſtrate a Worſhip, or take away a National Church, is as mere Enthuſiaſm as the Notion which ſets up Perſecution.* Whence it follows, that whatever Privilege the *good People* may claim, *Magiſtrates* muſt not pretend to be *out of the hearing* of a Deity. Their P. 28. Underſtandings ought to be ſuperior to thoſe *odd and contrary Storys*, which (as it ſeems) *puzzle* little Wits. They ſhou'd *Know* that there is a GOD; for if they Diſbelieve or Doubt, it will be the moſt *Ridiculous Formality in the World* to Worſhip one. Magiſtrates, in a word, muſt neither be Atheiſts nor Deiſts, for theſe *good People* have no manner of occaſion for a *Worſhip*, or a *National Church*, 'twou'd be highly Ridiculous in them to pretend to any: Whereas, according to the *Letter*, a Church and a Worſhip are ſo abſolutely neceſſary to the Magiſtrate, that he can't be without them, if he means to guard againſt *Enthuſiaſm*.

AGAIN,

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Historical Text Reuse

- 250k scanned English documents from 18th century
- Fuzzy string matching using BLAST to find reuses
- De-fragmenting and clustering of reuse pairs
- Front-end for navigation

In Progress

1. Cost-Aware Retraining for Machine Learning
   - Rejections from ICML 2023 and EuroSys 2023
   - Submitted pre-print to Arxiv [2]
   - Re-submitted to Knowledge-Based Systems Journal
2. Data Science Pipeline for Historical Text Reuse
   - Manuscript under preparation
   - Planned submission to VLDB 2024 Scalable Data Science track
3. Scalable Constraint-Based Diversity Sampling
   - Improved running time of Fair Max-Min Diversification [8]
   - Plan to develop approximate distributed sampling algorithm and code library

Cost-Aware Retraining for ML

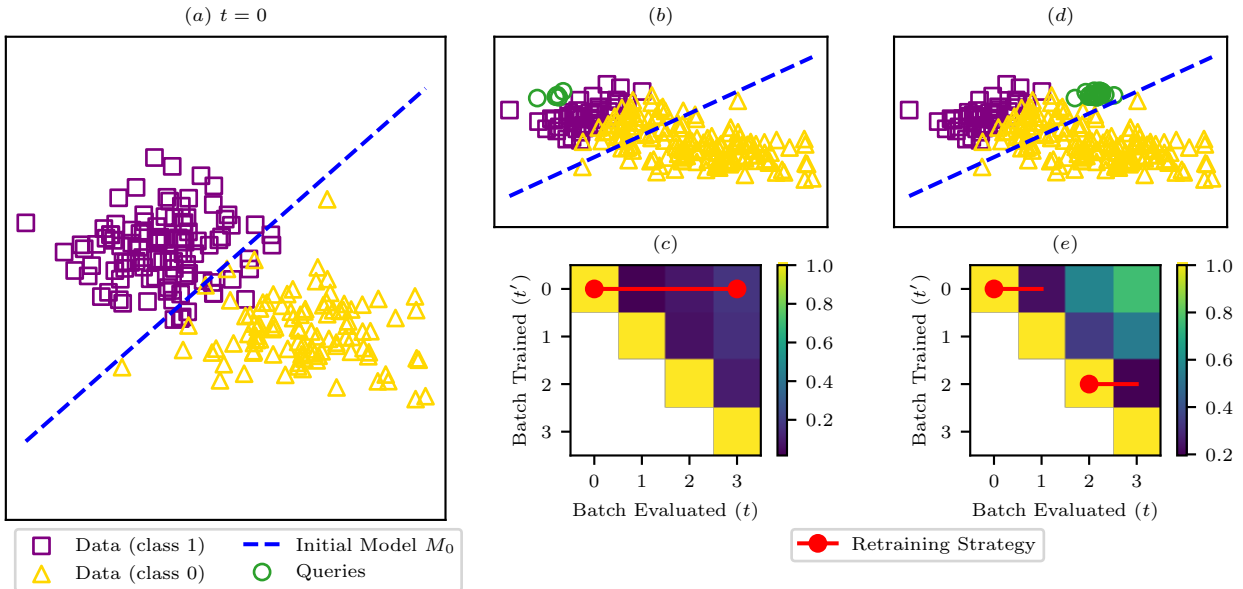

Figure: Example scenario. (a) Initial data and model M_0. (b) Queries are far from misclassification. (d) Queries are closer to misclassifications. (c) and (e): Cost matrix and ORACLE retraining strategies with retraining cost fixed to $\kappa = 1$ for (b) and (d) respectively.

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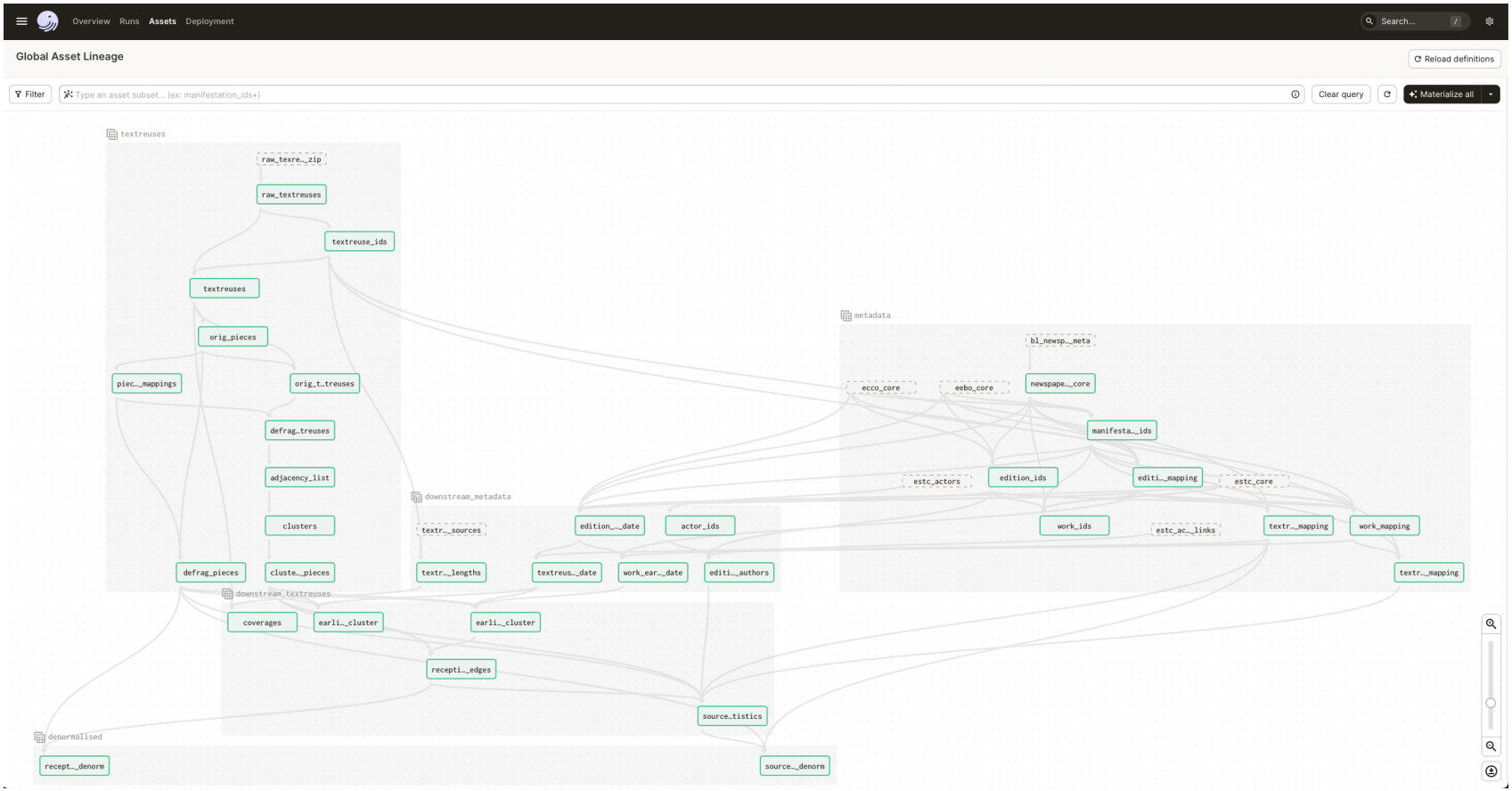
Dagster ETL pipeline



Experiments

- Benchmarking query performance on
  1. Spark
  2. MariaDB Aria
  3. MariaDB Columnstore
- Evaluating different metrics
  1. Query Latency
  2. Storage size
  3. Cost in CSC BU
- Different levels of normalisation

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Scaling up Fair-MMD

Completed

- Reimplementation of FMMD-S algorithm from [8]
- Parallelizes sections of code and efficient memory management
- 100× speedup on largest experiment from [8]
- Scaled up to 4M points dataset and 3000 samples with edge-case constraints

Next Steps

- Distributed algorithm with gurantees
- Approximate distance measures
- Heuristic based ILP solver

Discipline Specific Credits

Completed Credits

29/30 credits completed excluding PhD Seminar (3-5 credits)

Completed Courses:

- Network Analysis 5cr
- Security and Privacy in ML 5cr
- Advanced Latex Course 5cr
- Probabilistic Graphical Models 5cr
- Advanced Course in Machine Learning 5cr
- Transaction Management and Query Optimization 5cr
- Research Ethics 2 cr

Transferrable Skills

Completed Courses 3cr:

- Scientific Writing 2cr
- Principles of Peer Review 1cr

Planned Credits 7cr:

- Conference Presentation 2cr
- Poster Presentation and Data Visualization 2cr
- International Conference participation 2cr
- Grant Writing 1cr

Conferences

- VLDB 2022: Participation
- CIKM 2022: Presentation (virtual)
- MLSys 2023: Participation
- AI Day 2022: Poster Presentation
- Meaning of Meaning Workshop 2023: Presentation

Teaching and Supervision

- TA: Netowork Analysis 2023
- Master Thesis Instruction: Anniina R Sainio (Completed)
- Master Thesis Instruction: Andreas Maniatas (Ongoing)

Plans for 2023-2024

1. Research
   - Present - Nov 2023: Submit "Data Science Pipeline for Historical Text Reuse" to VLDB
   - Jan - Mar 2024: Complete scalable sampling project
2. Studies
   - Complete remaining transferrable course credits
   - Finalize all credits with Pirio
3. Thesis
   - Mar 2024 - May 2024: Thesis Writing
   - June 2024: Pre-examination

References I

[1] Ananth Mahadevan and Michael Mathioudakis. Certifiable unlearning pipelines for logistic regression: An experimental study. *Machine Learning and Knowledge Extraction*, 4(3):591–620, 2022.

[2] Ananth Mahadevan and Michael Mathioudakis. Cost-effective retraining of machine learning models, 2023.

[3] Ananth Mahadevan, Arpit Merchant, Yanhao Wang, and Michael Mathioudakis. Robustness of sketched linear classifiers to adversarial attacks. In *Proceedings of the 31st ACM International Conference on Information & Knowledge Management*, CIKM '22, pages 4319–4323, New York, NY, USA, 2022. Association for Computing Machinery.

References II

[4] Arpit Merchant, Ananth Mahadevan, and Michael Mathioudakis. Scalably using node attributes and graph structure for node classification. *Entropy*, 24(7), 2022.

[5] Arpit Merchant and Michael Mathioudakis. Joint use of node attributes and proximity for node classification. In Rosa Maria Benito, Chantal Cherifi, Hocine Cherifi, Esteban Moro, Luis M. Rocha, and Marta Sales-Pardo, editors, *Complex Networks & Their Applications X*, pages 511–522, Cham, 2022. Springer International Publishing.

[6] David Rosson, Eetu Mäkelä, Ville Vaara, Ananth Mahadevan, Yann Ryan, and Mikko Tolonen. Reception reader: Exploring text reuse in early modern british publications. *Journal of Open Humanities Data*, Apr 2023.

References III

[7] Kai Sheng Tai, Vatsal Sharan, Peter Bailis, and Gregory Valiant. Sketching linear classifiers over data streams. In *Proceedings of the 2018 International Conference on Management of Data*, SIGMOD '18, page 757–772, New York, NY, USA, 2018. Association for Computing Machinery.

[8] Yanhao Wang, Michael Mathioudakis, Jia Li, and Francesco Fabbri. *Max-Min Diversification with Fairness Constraints: Exact and Approximation Algorithms*, pages 91–99.

Thesis inclusion of works

Minimum Works in Thesis

1. Certifiable Unlearning
2. Robustness of Sketched models
3. Cost-Aware Retraining
4. ETL pipeline for historical text reuse data

Additional works

1. Scaling up JANE
2. Scalable Diversity Sampling
3. Reception Reader Interface
4. Humanities Text Reuse use-case

Structure of Thesis

Tentative Organization of Works:

1. Maintaining ML models
   - Certifiable Unlearning [1]
   - Cost-Aware Retraining [2]
   - Robustness of Sketched models [3]
2. Scalable ML Pipelines
   - JANE for node-classification [4]
   - Scalable Diversity Sampling
   - Scalable Historical Text Reuse
     - ETL pipeline paper
     - Reception Reader interface [6]
     - Humanities use-case paper