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Approximate Data Profiling

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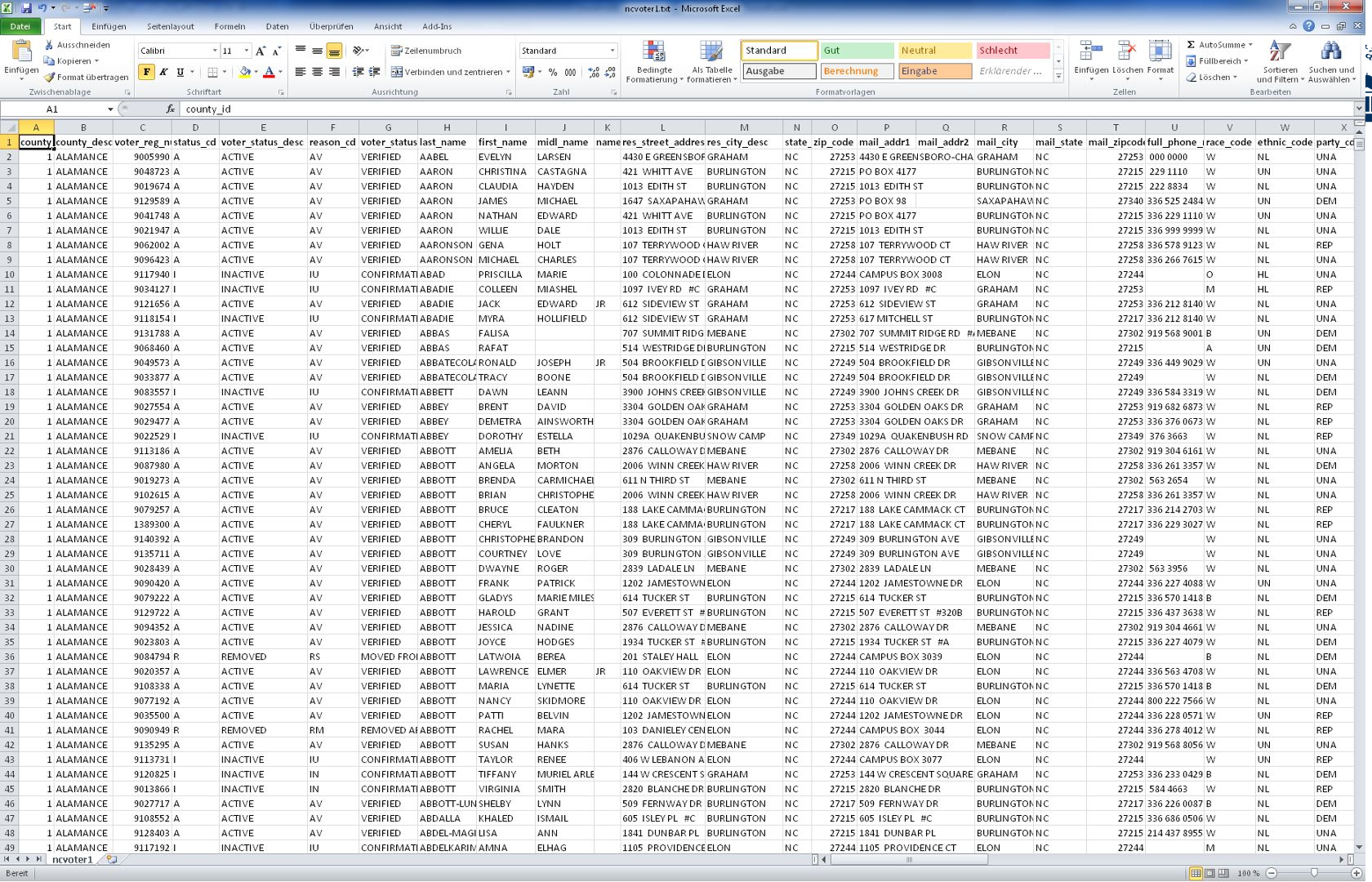
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1 ALAMANCE 9005990 A ACTIVE AV VERIFIED AABEL EVELYN LARSEN 4430 E GREENSBOF GRAHAM NC 27253 4430 E GREENSBORO-CHA GRAHAM NC 27253 000 0000 W NL UNA
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1 ALAMANCE 9129589 A ACTIVE AV VERIFIED AARON JAMES MICHAEL 1647 SAXAPAHAW GRAHAM NC 27253 PO BOX 98 SAXAPAHAW NC 27340 336 525 2484 W UN DEM
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1 ALAMANCE 9131788 A ACTIVE AV VERIFIED ABBAS FALISA 707 SUMMIT RIDG MEBANE NC 27302 707 SUMMIT RIDGE RD #/ MEBANE NC 27302 919 568 9001 B UN DEM
1 ALAMANCE 9068460 A ACTIVE AV VERIFIED ABBAS RAFAT 514 WESTRIDGE DI BURLINGTON NC 27215 514 WESTRIDGE DR BURLINGTON NC 27215 A UN DEM
1 ALAMANCE 9049573 A ACTIVE AV VERIFIED ABBATECOLA RONALD JOSEPH JR 504 BROOKFIELD I GIBSONVILLE NC 27249 504 BROOKFIELD DR GIBSONVILLE NC 27249 336 449 9029 W UN UNA
1 ALAMANCE 9033877 A ACTIVE AV VERIFIED ABBATECOLA TRACY BOONE 504 BROOKFIELD I GIBSONVILLE NC 27249 504 BROOKFIELD DR GIBSONVILLE NC 27249 W NL DEM
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1 ALAMANCE 9022529 I INACTIVE IU CONFIRMATI ABBEY DOROTHY ESTELLA 1029A QUAKENBU SNOW CAMP NC 27349 1029A QUAKENBUSH RD SNOW CAMP NC 27349 376 3663 W NL REP
1 ALAMANCE 9113186 A ACTIVE AV VERIFIED ABBOTT AMELIA BETH 2876 CALLOWAY D MEBANE NC 27302 2876 CALLOWAY DR MEBANE NC 27302 919 304 6161 W NL UNA
1 ALAMANCE 9087980 A ACTIVE AV VERIFIED ABBOTT ANGELA MORTON 2006 WINN CREEK HAW RIVER NC 27258 2006 WINN CREEK DR HAW RIVER NC 27258 336 261 3357 W NL DEM
1 ALAMANCE 9019273 A ACTIVE AV VERIFIED ABBOTT BRENDA CARMICHAEI 611 N THIRD ST MEBANE NC 27302 611 N THIRD ST MEBANE NC 27302 563 2654 W NL UNA
1 ALAMANCE 9102615 A ACTIVE AV VERIFIED ABBOTT BRIAN CHRISTOPHE 2006 WINN CREEK HAW RIVER NC 27258 2006 WINN CREEK DR HAW RIVER NC 27258 336 261 3357 W NL UNA
1 ALAMANCE 9079257 A ACTIVE AV VERIFIED ABBOTT BRUCE CLEATON 188 LAKE CAMMA BURLINGTON NC 27217 188 LAKE CAMMACK CT BURLINGTON NC 27217 336 214 2703 W NL REP
1 ALAMANCE 1389300 A ACTIVE AV VERIFIED ABBOTT CHERYL FAULKNER 188 LAKE CAMMA BURLINGTON NC 27217 188 LAKE CAMMACK CT BURLINGTON NC 27217 336 229 3027 W NL REP
1 ALAMANCE 9140392 A ACTIVE AV VERIFIED ABBOTT CHRISTOPHE BRANDON 309 BURLINGTON GIBSONVILLE NC 27249 309 BURLINGTON AVE GIBSONVILLE NC 27249 W NL UNA
1 ALAMANCE 9135711 A ACTIVE AV VERIFIED ABBOTT COURTNEY LOVE 309 BURLINGTON GIBSONVILLE NC 27249 309 BURLINGTON AVE GIBSONVILLE NC 27249 W NL UNA
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1 ALAMANCE 9090420 A ACTIVE AV VERIFIED ABBOTT FRANK PATRICK 1202 JAMESTOWN ELON NC 27244 1202 JAMESTOWNE DR ELON NC 27244 336 227 4088 W UN UNA
1 ALAMANCE 9079222 A ACTIVE AV VERIFIED ABBOTT GLADYS MARIE MILES 614 TUCKER ST BURLINGTON NC 27215 614 TUCKER ST BURLINGTON NC 27215 336 570 1418 B NL DEM
1 ALAMANCE 9129722 A ACTIVE AV VERIFIED ABBOTT HAROLD GRANT 507 EVERETT ST # BURLINGTON NC 27215 507 EVERETT ST #320B BURLINGTON NC 27215 336 437 3638 W NL REP
1 ALAMANCE 9094352 A ACTIVE AV VERIFIED ABBOTT JESSICA NADINE 2876 CALLOWAY D MEBANE NC 27302 2876 CALLOWAY DR MEBANE NC 27302 919 304 4661 W NL UNA
1 ALAMANCE 9023803 A ACTIVE AV VERIFIED ABBOTT JOYCE HODGES 1934 TUCKER ST # BURLINGTON NC 27215 1934 TUCKER ST #A BURLINGTON NC 27215 336 227 4079 W NL DEM
1 ALAMANCE 9084794 R REMOVED RS MOVED FROI ABBOTT LATWOIA BEREA 201 STALEY HALL ELON NC 27244 CAMPUS BOX 3039 ELON NC 27244 B NL DEM
1 ALAMANCE 9020357 A ACTIVE AV VERIFIED ABBOTT LAWRENCE ELMER JR 110 OAKVIEW DR ELON NC 27244 110 OAKVIEW DR ELON NC 27244 336 563 4708 W NL UNA
1 ALAMANCE 9108338 A ACTIVE AV VERIFIED ABBOTT MARIA LYNETTE 614 TUCKER ST BURLINGTON NC 27215 614 TUCKER ST BURLINGTON NC 27215 336 570 1418 B NL DEM
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1 ALAMANCE 9035500 A ACTIVE AV VERIFIED ABBOTT PATTI BELVIN 1202 JAMESTOWN ELON NC 27244 1202 JAMESTOWNE DR ELON NC 27244 336 228 0571 W UN REP
1 ALAMANCE 9090949 R REMOVED RM REMOVED AF ABBOTT RACHEL MARA 103 DANIELEY CEN ELON NC 27244 CAMPUS BOX 3044 ELON NC 27244 336 278 4012 W NL REP
1 ALAMANCE 9135295 A ACTIVE AV VERIFIED ABBOTT SUSAN HANKS 2876 CALLOWAY D MEBANE NC 27302 2876 CALLOWAY DR MEBANE NC 27302 919 568 8056 W UN UNA
1 ALAMANCE 9113731 I INACTIVE IU CONFIRMATI ABBOTT TAYLOR RENEE 406 W LEBANON A ELON NC 27244 CAMPUS BOX 3077 ELON NC 27244 W UN REP
1 ALAMANCE 9120825 I INACTIVE IN CONFIRMATI ABBOTT TIFFANY MURIEL ARLE 144 W CRESCENT S GRAHAM NC 27253 144 W CRESCENT SQUARE GRAHAM NC 27253 336 233 0429 B NL DEM
1 ALAMANCE 9013866 I INACTIVE IN CONFIRMATI ABBOTT VIRGINIA SMITH 2820 BLANCHE DR BURLINGTON NC 27215 2820 BLANCHE DR BURLINGTON NC 27215 584 4663 W NL REP
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1 ALAMANCE 9128403 A ACTIVE AV VERIFIED ABDEL-MAGI LISA ANN 1841 DUNBAR PL BURLINGTON NC 27215 1841 DUNBAR PL BURLINGTON NC 27215 214 437 8955 W NL UNA
1 ALAMANCE 9117192 I INACTIVE IU CONFIRMATI ABDELKARIM AMNA ELHAG 1105 PROVIDENCE ELON NC 27244 1105 PROVIDENCE CT ELON NC 27244 M NL UNA
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Introduction: Data Profiling

"Data profiling is the process of examining the data available from an existing information source (e.g. a database or a file) and collecting statistics or informative summaries about that data" [0]

- Metadata is essential
  - For data integration, query optimization, data cleaning, …
- Metadata is often incomplete, outdated or completely unavailable
- → discover useful metadata, given just the (relational) dataset
- Our Focus: Unique Column Combinations (UCCs), Functional Dependencies (FDs) and Inclusion Dependencies (INDs)

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[0] https://en.wikipedia.org/wiki/Data_profiling

Introduction: Unique Column Combinations (UCCs)

ID	Student ID	First Name	Last Name	Birthday
1	457825	John	Doe	14.02.1966
2	127894	John	Doe	13.11.1990
3	487992	Jim	Smith	17.04.1993
…	…	…	…	…

Unique Column Combination R.X:

For a set of attributes X in Relation R, X is a UCC, if for all t ∈ R there exists no t' ∈ R, so that t[X] = t'[X].

Example UCCs:

- {ID}
- {Student ID}
- {First Name, Last Name, Birthday}

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Introduction: Functional Dependencies (FDs)

ID	Company	Street	Zip-Code	City
…	…	…	12307	Berlin
…	…	…	12307	Berlin
…	…	…	12359	Berlin
			23966	Wismar

ID	First Name	Last Name	Birthday
1	John	Doe	14.02.1966
2	John	Doe	13.11.1990
3	Jim	Smith	17.04.1993

Functional Dependency X → A:

For sets of attributes X and A, the FD X → A holds if:
$t_1[X] = t_2[X] \Rightarrow t_1[A] = t_2[A]$.

Example FDs:

- Zip-Code → City
- First Name, Last Name, Birthday → ID

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Introduction: Inclusion Dependencies (INDs)

Object	Density	Semi-major Axis
Mercury	…	…
Venus	…	…
Earth	…	…
Saturn	…	…

Name	Satellite of	Distance [km]
…	Saturn	…
…	Saturn	…
…	Earth	…

Inclusion Dependency X ⊆ Y:

For sets of attributes $R_1.X=\{X_1,...,X_n\}$ and $R_2.Y=\{Y_1,...,Y_n\}$ the IND $R_1.X \subseteq R_2.Y$ holds if $\Pi_X(R_1) \subseteq \Pi_Y(R_2)$

Example INDs:

- Satellite of ⊆ Object

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Data Profiling Algorithms: Basic Strategies

Automatic discovery algorithms

- Typically discover minimal FDs/UCCs and maximal INDs
- Search space is still exponentially large
- → Employ pruning strategies

Examples for pruning:

- If {A,B} is no UCC, then neither {A} nor {B} can be UCCs
- If AB ↛ C then we also know that A ↛ C and B ↛ C

Data Profiling: Using Sampling

Motivation

- Runtime: even with state of the art algorithms, the discovery of dependencies can be infeasible for very large datasets
- Privacy: for data protection reasons, we may not access all data
- Cost: to collect or purchase all data might be too expensive
- Data quality: our database may be incomplete

Problem Statement

- Discover dependencies on a subset / sample

Research questions

- How close can we get to the true dependencies?
- What properties must our subset / sample have, so that we get reliable results?
- What is the tradeoff between sample size and correctness of results?

Approximate Data Profiling: Related Work

State of the art dependency discovery algorithms on full data sets:

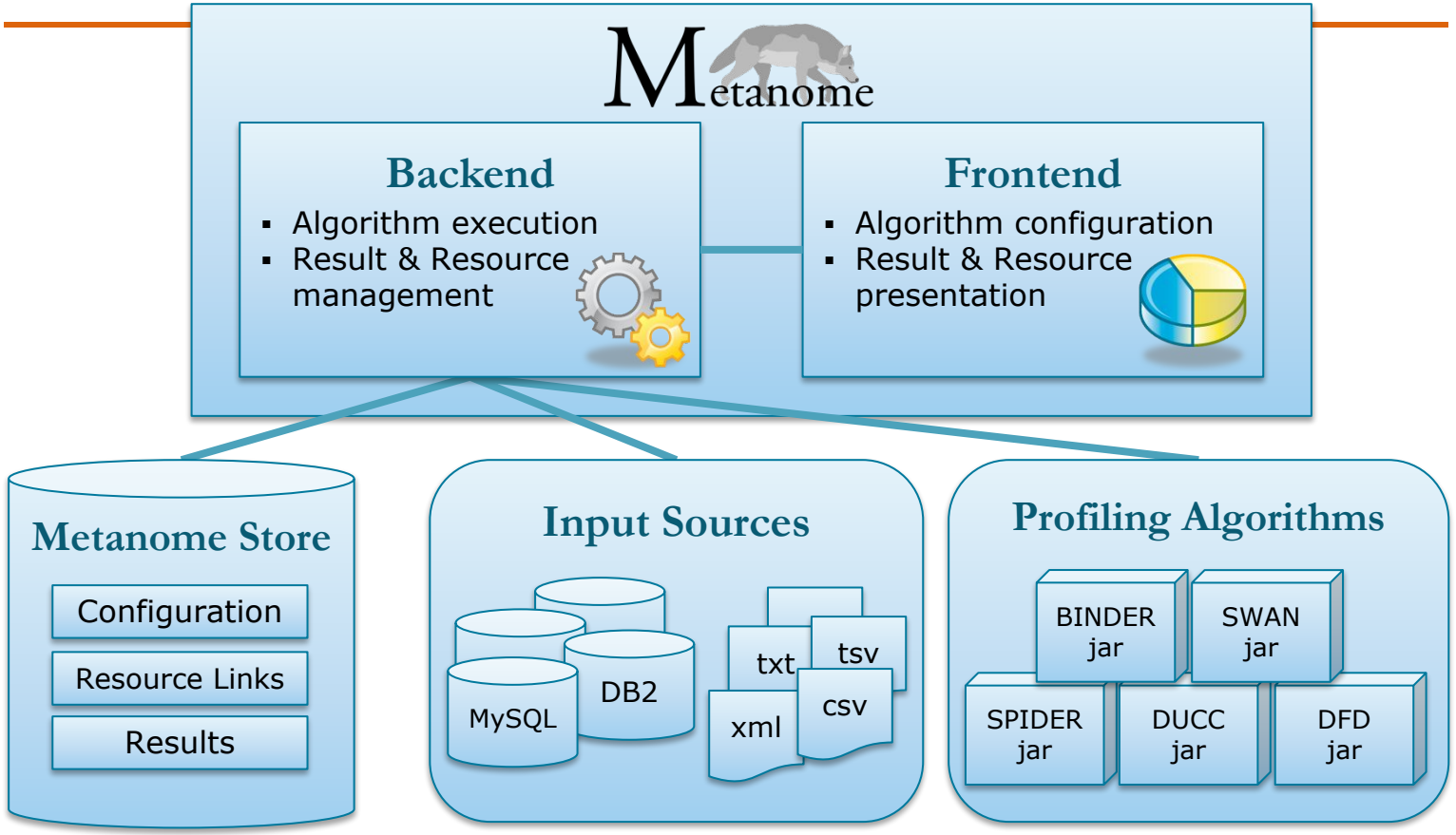
- Functional Dependencies: HyFD [1]
- Inclusion Dependencies: BINDER [2]
- Unique Column Combinations: HyUCC [3]

Sampling/Sketching has already been applied to reduce runtime:

- AIDFD [4]
- FAIDA [5]

[1] Papenbrock, Thorsten, and Felix Naumann. "A hybrid approach to functional dependency discovery." Proceedings of the 2016 International Conference on Management of Data. 2016.
[2] Papenbrock, Thorsten, et al. "Divide & conquer-based inclusion dependency discovery." Proceedings of the VLDB Endowment 8.7 (2015): 774-785.
[3] Papenbrock, Thorsten, and Felix Naumann. "A hybrid approach for efficient unique column combination discovery." Datenbanksysteme für Business, Technologie und Web (BTW 2017) (2017).
[4] Bleifuß, Tobias, et al. "Approximate discovery of functional dependencies for large datasets." Proceedings of the 25th ACM International on Conference on Information and Knowledge Management. 2016.
[5] Kruse, Sebastian, et al. "Fast approximate discovery of inclusion dependencies." Datenbanksysteme für Business, Technologie und Web (BTW 2017) (2017).

Metanome


Metanome
Backend
Algorithm execution
Result & Resource management
Frontend
Algorithm configuration
Result & Resource presentation
Metanome Store
Configuration
Resource Links
Results
Input Sources
MySQL
DB2
txt
tsv
xml
csv
Profiling Algorithms
BINDER jar
SWAN jar
SPIDER jar
DUCC jar
DFD jar

Metanome

http://www.metanome.de

https://owncloud.hpi.de/s/WSmgz18Z6yceG7h

Metanome Resources

Repositories:

- Metanome https://github.com/HPI-Information-Systems/metanome
- Algorithms https://github.com/HPI-Information-Systems/metanome-algorithms
- Metanome-CLI https://github.com/sekruse/metanome-cli

Datasets:

- UCC/FD discovery: https://hpi.de/naumann/projects/repeatability/data-profiling/fds.html#c168191
- IND discovery: https://hpi.de/naumann/projects/repeatability/data-profiling/metanome-ind-algorithms.html

Goals and grading

Goals

- Learn about the research area data profiling
- Read papers and understand them
- Craft a novel solution to the problem of sample-based profiling
- Run experiments and evaluate results
- Present results in written and oral form

Grading

- Approach (35%)
- Written report (35%)
- Presentations and discussions in the seminar (30%)

Requirements

You **bring**:

- Java (at least basic skills or willing to learn)

You want to **learn** about:

- Data Profiling
- Algorithmic problems and how to solve them
- Experimental evaluation on large datasets

You do **not** need to bring:

- Prior knowledge about Data Profiling

You should **agree** to:

- Publish the results as open-source

Seminar Roadmap (preliminary)

Week of Oct 24
- Technical introduction
- Introduce Metanome and algorithms repository

Week of Oct 31
- Present related work (1 previously assigned paper)
- Report initial execution of related work (modify input data)
- Potentially: Initial ideas for a sampling-based variant

Week of Nov 7
- Discuss metrics for evaluation
- Discuss initial ideas / general approaches

Week of Nov 14
- Implement evaluation metrics and evaluate related work on sample

Around Christmas
- Milestone: Technical Evaluation
- Present preliminary results

Beginning of February
- Final presentation (chair is invited)

10.02.2023
- Deadline paper-style submission (max 12 pages)
- If preferred, we can postpone the deadline until after the exam periods

Every week we offer to meet for status updates, questions and feedback

Register for the seminar

Structure:

- Work in teams of **two** students

Register:

- Email to tobias.bleifuss@hpi.de until **October 25**
- Use subject: **Approximate Data Profiling seminar registration**
- Optionally, include topics that are interesting for you
- Optionally, include team partner (if you already have one)
- Optionally, include another time slot that fits your schedule better