Fingerprinting Relational Databases

Quality Evaluation and Impact on Learning Tasks

Tanja Šarčević

Outline

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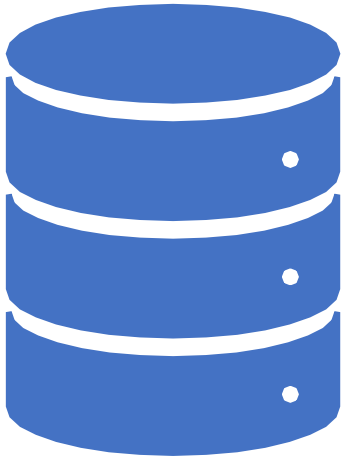
Fingerprinting techniques

Robustness Evaluation

Data Utility Evaluation

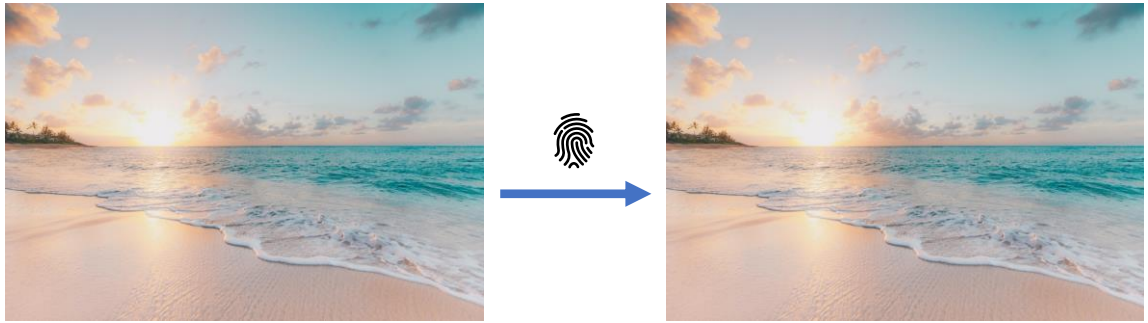
Conclusion and Future Work



Use case: medical data

- Medical data – sensitive and a valuable asset to the hospital
  - The owner wants to share data with researchers
  - The owner wants to have a claim of the ownership and trace the source of an unauthorised publishing
- **Idea**: hide a piece of information in the data before the distribution

Fingerprinting



Age	BloodPress.	Diabetes
32	64	1
31	66	0
50	72	1
48	70	0

Age	BloodPress.	Diabetes
33	64	1
31	**68**	0
50	72	1
47	70	0

Fingerprinting

FINGERPRINT - string of bits containing information about the owner and the recipient of the specific data copy

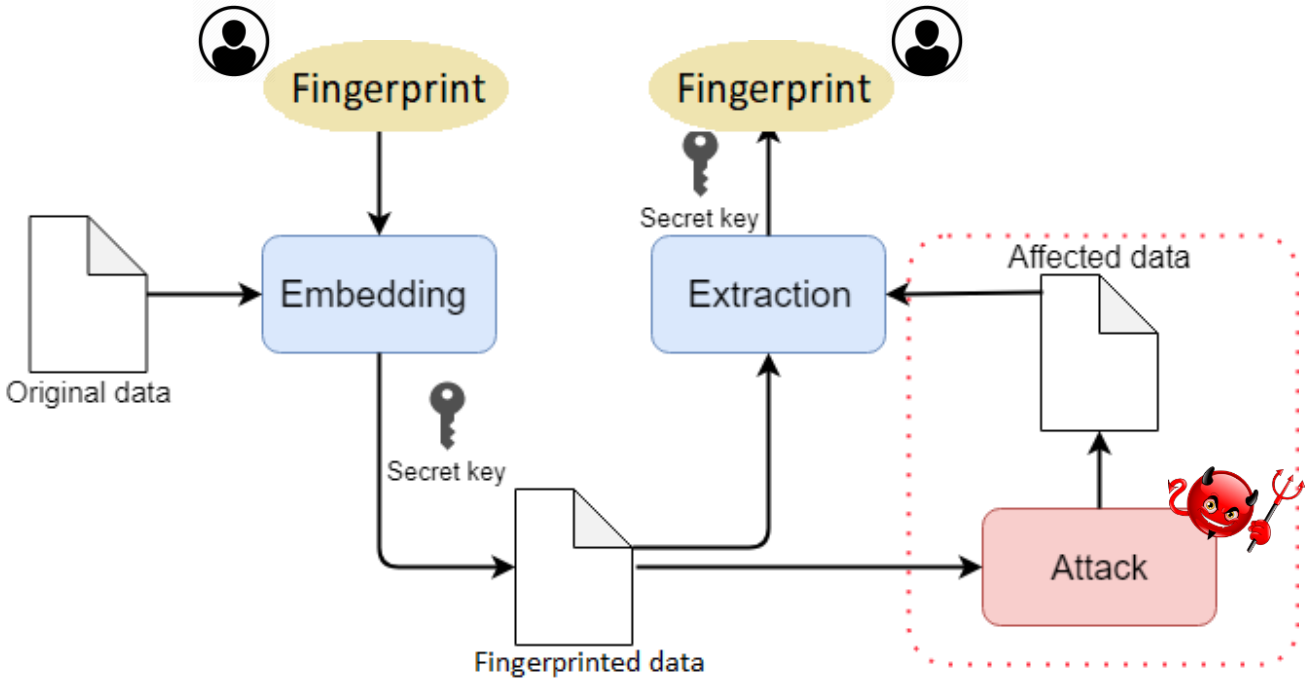
FINGERPRINTING - an information hiding technique that embeds the fingerprint into the data

Fingerprinting

Requirements of the fingerprint:

1) recognizable by the owner
2) not detectable and consequently removable by the recipients
3) robust to attacks
4) does not change the utility of the data too much

Fingerprinting Schemes: workflow



Fingerprinting Schemes: Numerical data

AK (Agrawal and Kiernan) Scheme:

- Pseudorandom choice of a row, a column and a least significant bit of a value to be marked

Age	BloodPress.	Diabetes
33	64	1
31	66	0
50	71	1
48	70	0

Block Scheme:

- The data is first divided into blocks
- Pseudorandom choice of the value to be marked within every block

Age	BloodPress.	Diabetes
32	64	1
33	66	0
49	72	1
48	70	0

Two-level Scheme:

- 1st layer: Pseudorandomly selects the values to be marked; this pattern identifies the owner
- 2nd layer: Pseudorandomly selects the values to be marked; this pattern identifies the recipient

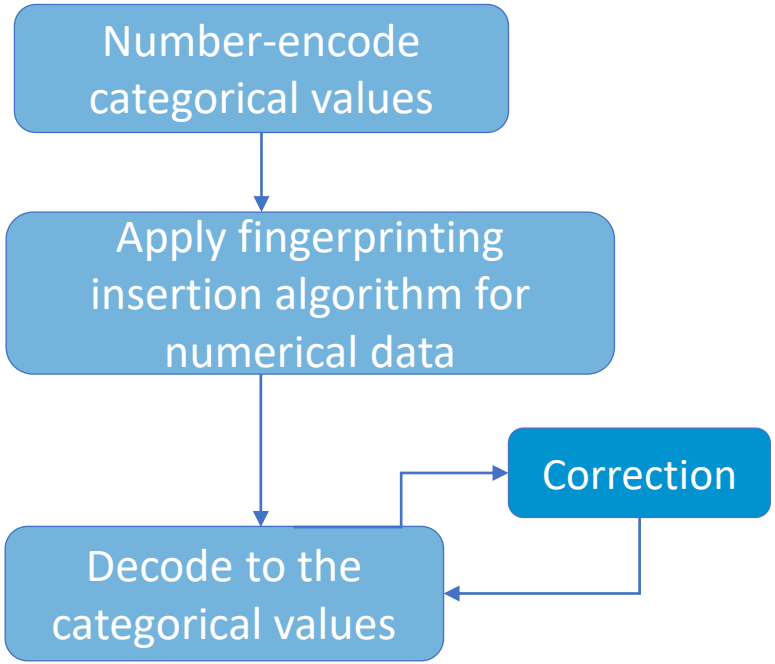
Age	BloodPress.	Diabetes
31	64	1
31	69	0
50	72	1
45	70	0

Numerical vs. Categorical Data

- Decimal:
  32.3 → 32.7 ☺
- Integer:
  32 → 34 ☺
- Non-numerical:
  France → Germany ?

Fingerprinting categorical data: Approach #1

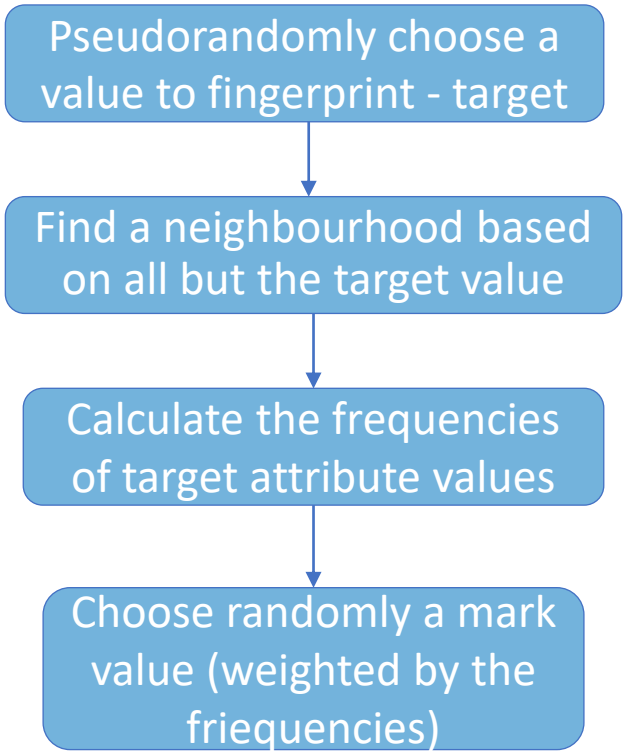
Insertion



- London, Paris, Vienna
- Encoding: 0,1,2 (00,01,**10**)
- Fingerprinting: 10 -> 11
- Decoding: 11 -> ??

- Correction: 11 mod 3 = 00
- Decoding: 00 -> London

Fingerprinting categorical data: Approach #2



- Addressing the problem of semantic relations between categorical attributes that can be disturbed by fingerprinting
- *gender*: male, *pregnant*: yes
- The fingerprinted value will be a value that is likely to occur in a combination with other values from the row

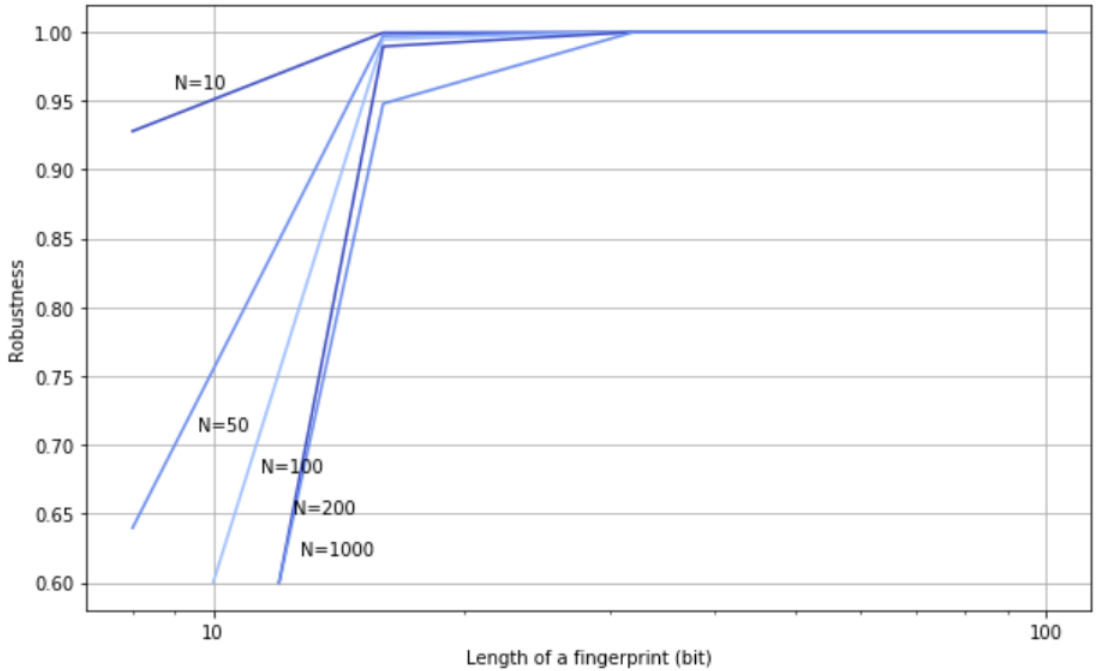
Robustness Evaluation: Attacks

- Malicious operations on the fingerprinted dataset with the goal of
  - disabling the extraction of the correct fingerprint or
  - disabling association of a fingerprint with the correct recipient
- **Subset Attack**
- **Superset Attack**
- **Bit-flipping Attack**
- **Additive Attack**

- **Misdiagnosis False Hit Rate**: measures the likelihood of extracting a valid fingerprint from non-fingerprinted data

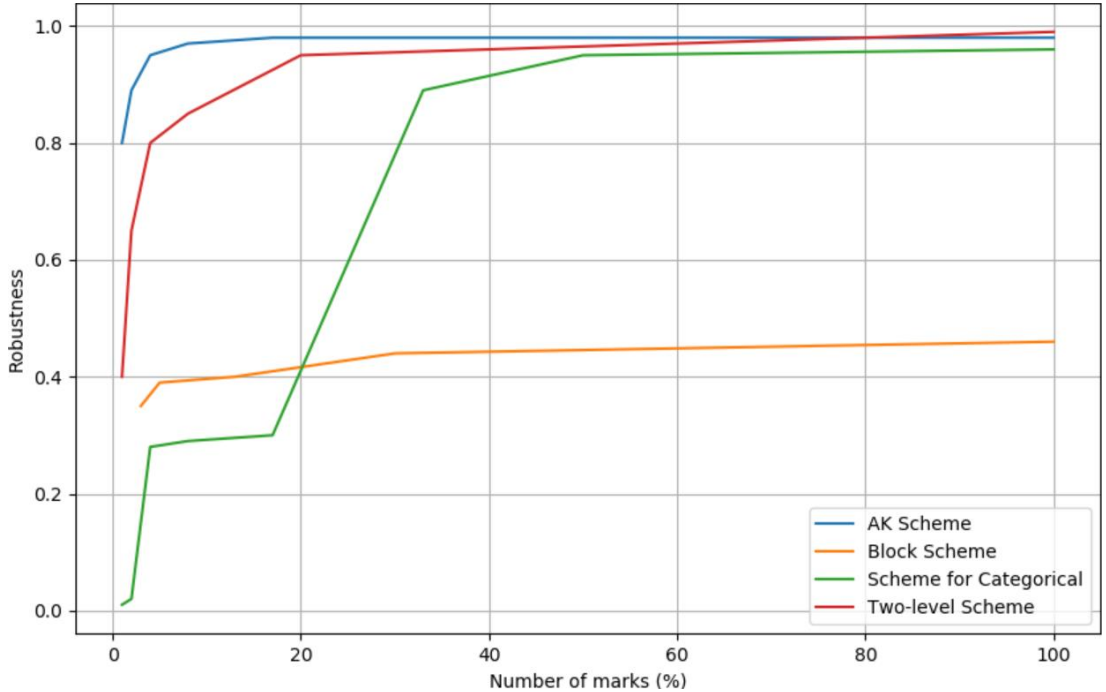
Robustness Evaluation

Misdiagnosis false hit



Robustness Evaluation

Subset Attack



Utility Evaluation

Mean and Variance

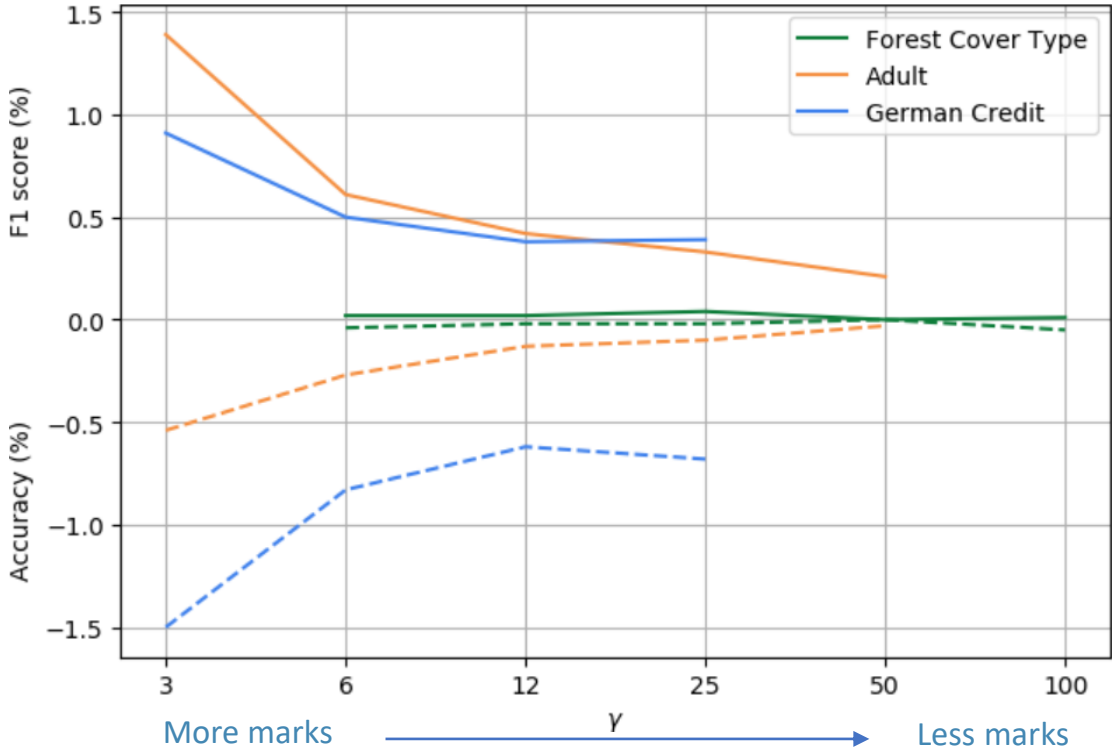
Less marks → More marks

Attribute	Variance	β	30		25		15		10	
		ξ	4	8	4	8	4	8	4	8
Elevation	78391		0	+13	+1	+15	+1	+48	+1	+178
Aspect	12525		0	+7	0	+12	0	+35	0	+127
Slope	56		0	+12	0	+18	0	+48	0	0
HD-Hydrology	45177		0	+6	+1	+4	+1	+13	+2	0
VD-Hydrology	3398		0	+10	0	+15	0	+38	0	+87
HD-Roadways	2431276		0	+3	0	+3	0	+44	-2	0
Hillshade-9am	717		0	+11	0	+15	0	+41	0	+8
Hillshade-noon	391		0	+11	0	+16	0	+45	0	+200
Hillshade-3pm	1465		0	0	0	+13	0	+35	0	+160
HD-Fire-Points	1753493		0	0	0	-4	0	+54	0	+68

Number of Least Significant Bits being marked

Utility Evaluation

ML Classification



Conclusion and Future Work

Number of marks

↑	ω	ξ	L
Misdiagnosis false hit	↑		↑
Subset Attack	↑		↓
Bit-flipping Attack	↑	↑	↓
Additive Attack	↑	↓	
Utility	↓	↓	

- **Trade-off:** robustness of the scheme and the utility of fingerprinted data

Future work

- Fingerprinting scheme for categorical data
  - Further analysis on robustnes of the neighbourhood-search approach
  - Blind scheme for fingerprinting relational data with categorical values


Thank you for
your attention