



# TabStruct

## Measuring Structural Fidelity of Tabular Data

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 Paper

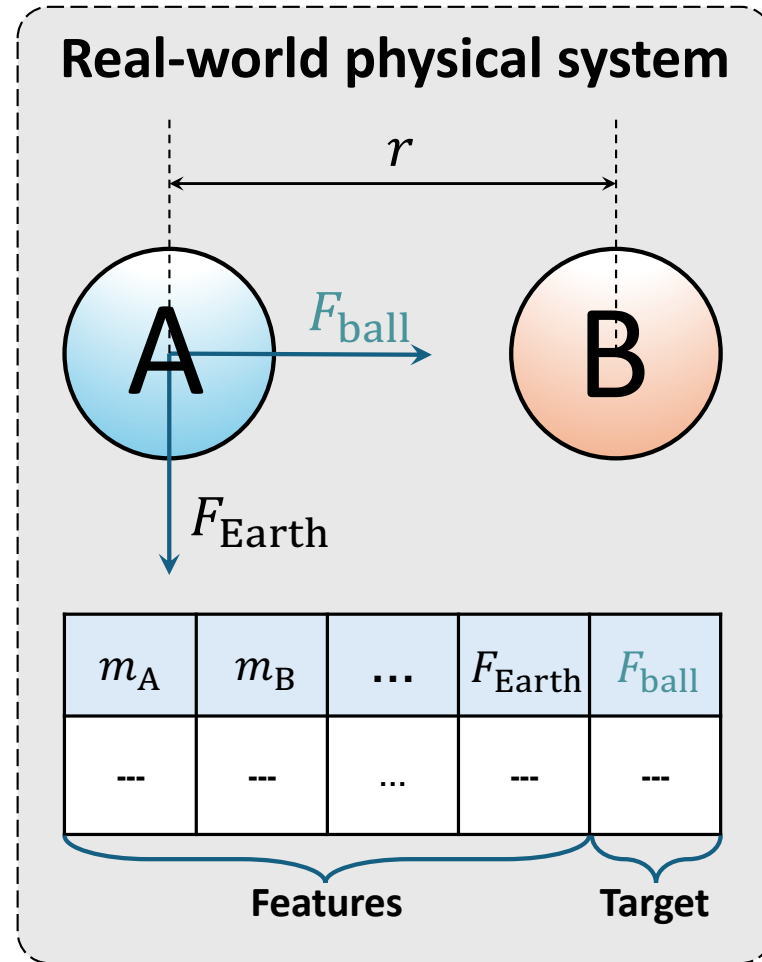


 Code

# Which of the two images is real?



# An example table of gravity system



## Which of the two tables is real?

$m_A$	$m_B$	...	$F_{\text{Earth}}$	$F_{\text{ball}}$
0.3kg	2.2kg	...	3.4N	5.2N
0.5kg	3.4kg	...	2.9N	2.5N
0.6kg	6.4kg	...	1.5N	7.2N

$m_A$	$m_B$	...	$F_{\text{Earth}}$	$F_{\text{ball}}$
0.9kg	1.1kg	...	1.4N	0.7N
0.7kg	2.6kg	...	1.9N	1.8N
0.3kg	3.3kg	...	1.8N	3.0N

# Tabular data evaluation remains vague

## Real-world or synthetic image?



*Images of classic double-decker bus*

## Real-world or synthetic table?

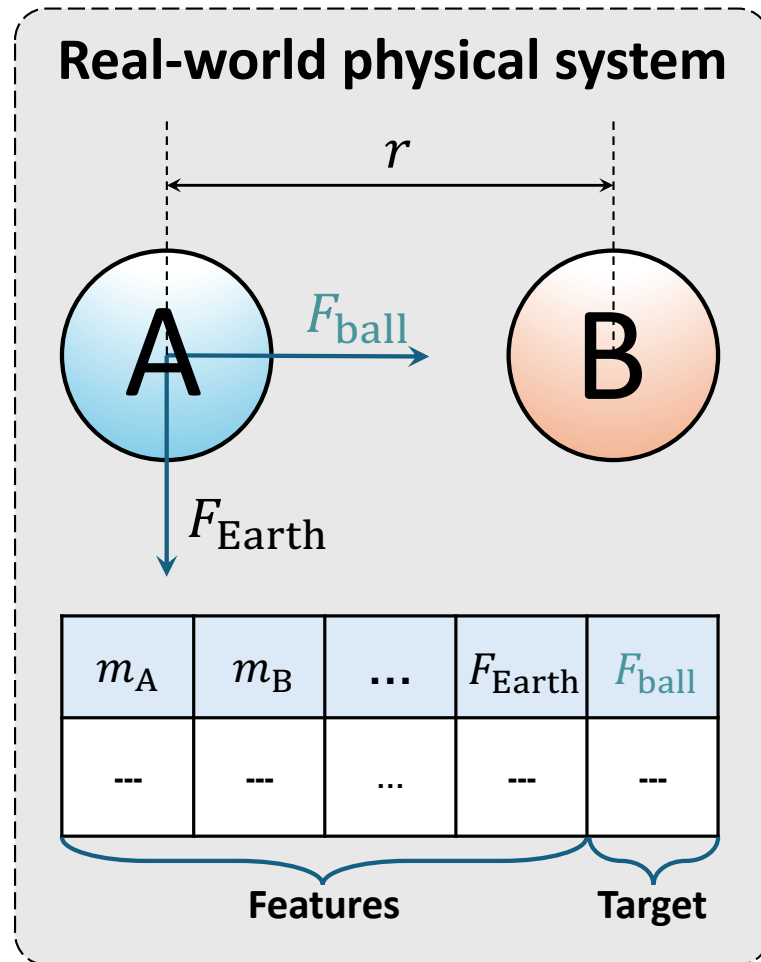
$m_A$	$m_B$	...	$F_{\text{Earth}}$	$F_{\text{ball}}$	$m_A$	$m_B$	...	$F_{\text{Earth}}$	$F_{\text{ball}}$
0.3kg	2.2kg	...	3.4N	5.2N	0.9kg	1.1kg	...	1.4N	0.7N
0.5kg	3.4kg	...	2.9N	2.5N	0.7kg	2.6kg	...	1.9N	1.8N
0.6kg	6.4kg	...	1.5N	7.2N	0.3kg	3.3kg	...	1.8N	3.0N

*Tables of gravity system with two balls*

An illustration of the vague human understanding of tabular data

- Humans (we 😊) are born with cognitive advantages to parse:
  - Sequential data: text, speech, etc.
  - Spatial data: image, etc.
- **Then, what about structured tabular data?**

# Tabular data is fundamentally different



An example table of gravity system

- **Tabular data [1, 2, 3]**
  - data points as rows
  - features as columns
  - one of the **most common** modalities
- **Heterogeneity**
  - features: **different types & semantics**
- **Some negative examples**
  - Flattened images are **not** tabular data
  - Speech is **not** tabular data
  - Textual tables are **not** tabular data

[1] van Breugel, Boris, and Mihaela van der Schaar. "Position: Why Tabular Foundation Models Should Be a Research Priority." Forty-first International Conference on Machine Learning.

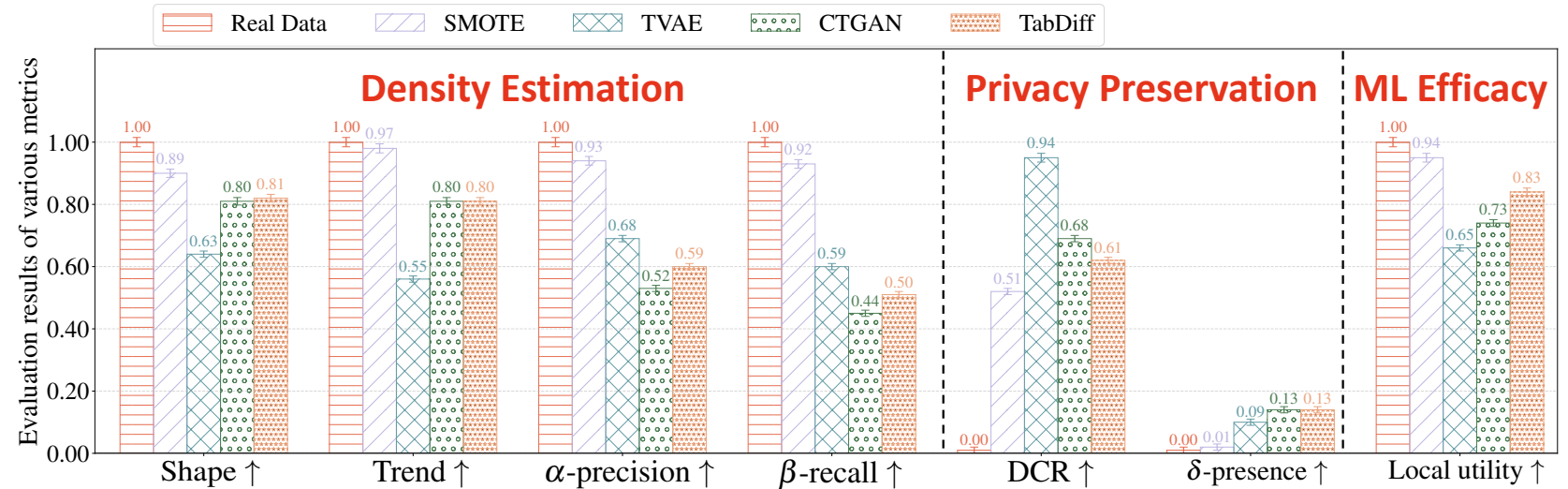
[2] Borisov, Vadim, et al. "Deep neural networks and tabular data: A survey." IEEE transactions on neural networks and learning systems (2022).

[3] Hollmann, Noah, et al. "Accurate predictions on small data with a tabular foundation model." Nature 637.8045 (2025): 319-326.

# Conventional evaluation dimensions are insufficient

## Conventional metrics:

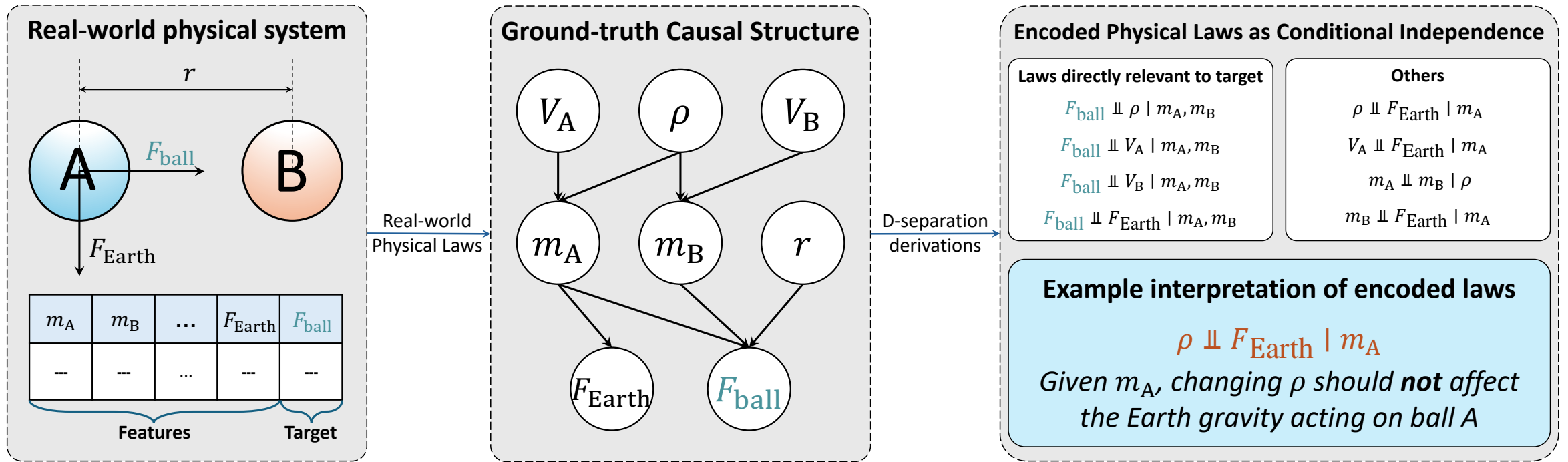
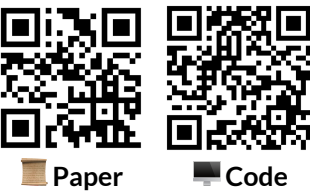
*Interpolation is all you need, as SMOTE yields synthetic data whose evaluations most closely match real data*



Evaluation results under conventional dimensions [1]

- **Conventional evaluation dimensions**
  - Density Estimation: discrepancy between **statistics**
  - Privacy Preservation: risk of **privacy** leakage
  - ML Efficacy: **utility** in downstream predictive tasks

[1] Jiang, Xiangjian, et al. "TabStruct: Measuring Structural Fidelity of Tabular Data." The Twelfth International Conference on Learning Representations (ICLR 2026 Oral).



A physical system and its underlying causal structure [1]

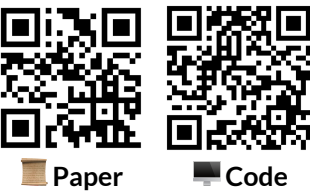
- **Structural Causal Models (SCM)** underpin tabular generative process
  - This has been noticed and pioneered in prior studies [2, 3]
  - **Conditional independence (CI)** describes such inter-feature causal interactions

[1] Jiang, Xiangjian, et al. "TabStruct: Measuring Structural Fidelity of Tabular Data." The Twelfth International Conference on Learning Representations (ICLR 2026 Oral).

[2] Hollmann, Noah, et al. "Accurate predictions on small data with a tabular foundation model." Nature 637.8045 (2025): 319-326.

[3] Zhang, Xiyuan, et al. "Mitra: Mixed synthetic priors for enhancing tabular foundation models." arXiv preprint arXiv:2510.21204 (2025).

# Let's evaluate the causal structures!



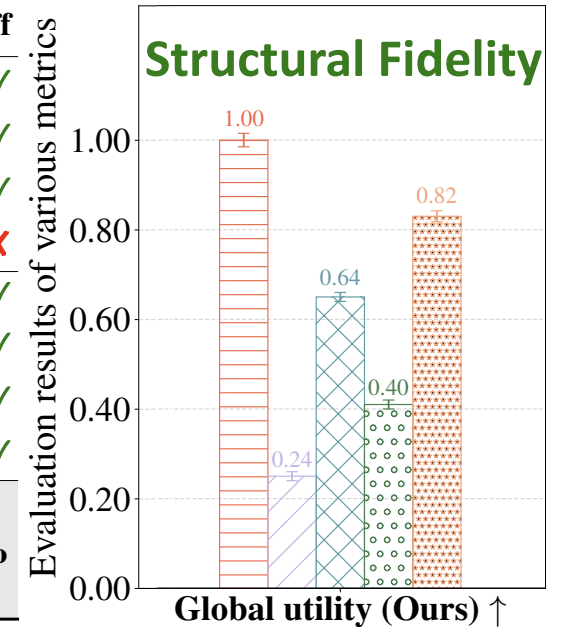
Paper Code

## Our proposed metric:

Interpolation is **not** all you need, as the generators violate many physical laws

e.g., Given  $m_A$ , changing  $\rho$  **affects** the Earth gravity acting on ball A  
(violating  $\rho \perp F_{\text{Earth}} \mid m_A$ )

GT conditional independence		Real Data	SMOTE	TVAE	CTGAN	TabDiff
Local structure	$F_{\text{ball}} \perp \rho \mid m_A, m_B$	✓	✓	✓	✓	✓
	$F_{\text{ball}} \perp V_A \mid m_A, m_B$	✓	✓	✓	✓	✓
	$F_{\text{ball}} \perp V_B \mid m_A, m_B$	✓	✓	✗	✓	✓
	$F_{\text{ball}} \perp F_{\text{Earth}} \mid m_A, m_B$	✓	✓	✓	✗	✗
Global structure	$\rho \perp F_{\text{Earth}} \mid m_A$	✓	✗	✗	✓	✓
	$V_A \perp F_{\text{Earth}} \mid m_A$	✓	✗	✓	✓	✓
	$m_A \perp m_B \mid \rho$	✓	✗	✓	✗	✓
	$m_B \perp F_{\text{Earth}} \mid m_A$	✓	✗	✓	✗	✓
<b>Obey physical laws (Global CI score)</b>		<b>100.0%</b>	<b>50.0%</b>	<b>75.0%</b>	<b>62.5%</b>	<b>87.5%</b>

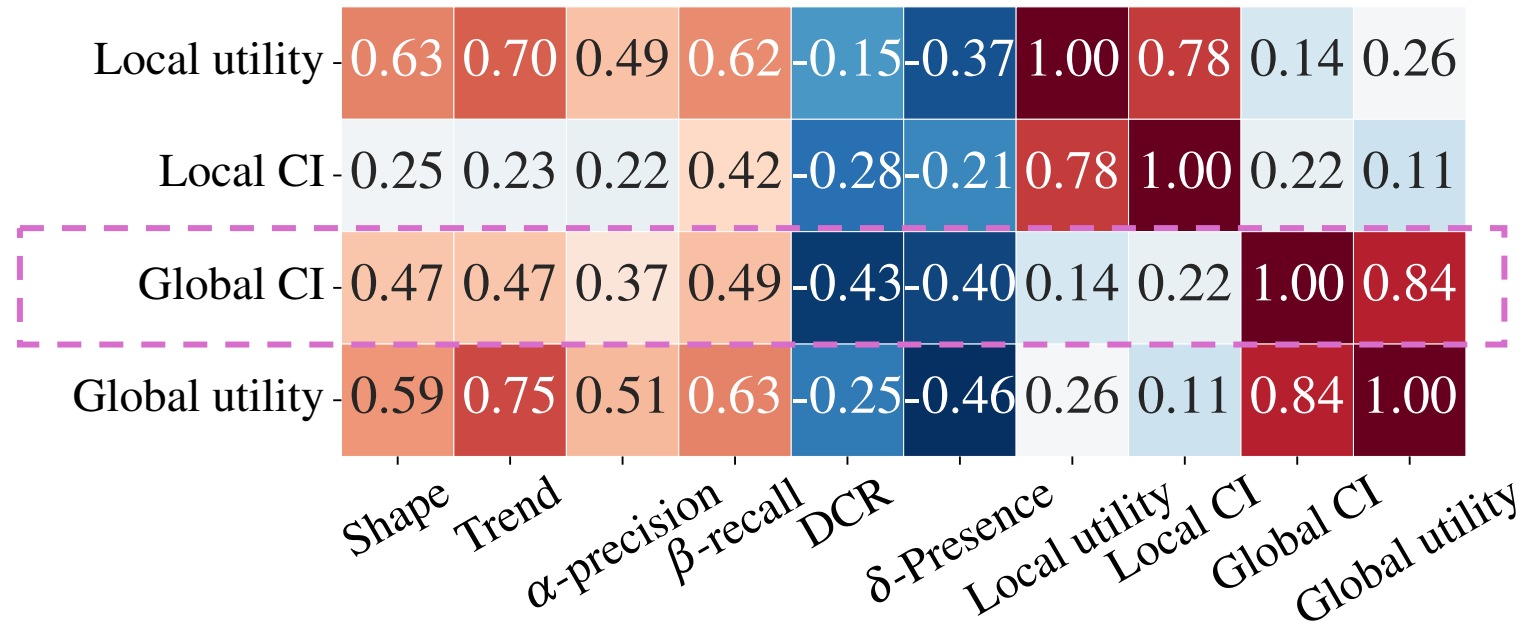


Evaluation results with the proposed structural fidelity metric [1]

- **Global CI**: golden standard, but **inapplicable** in many real-world datasets
- **Global Utility (Ours)**: empirically effective measure on **any dataset**

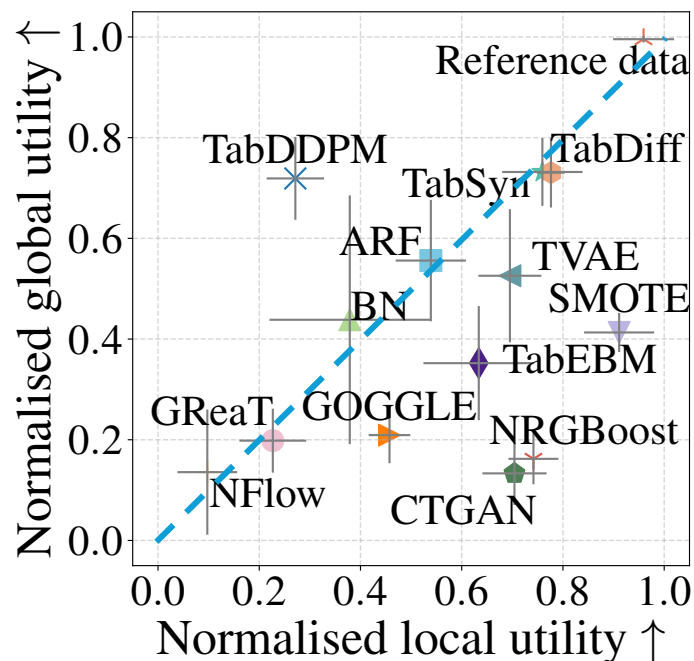
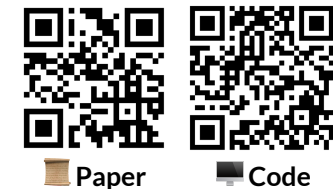
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# Global utility provides a valid and novel lens



Spearman's rank correlation heatmap based on metric values on six SCM datasets

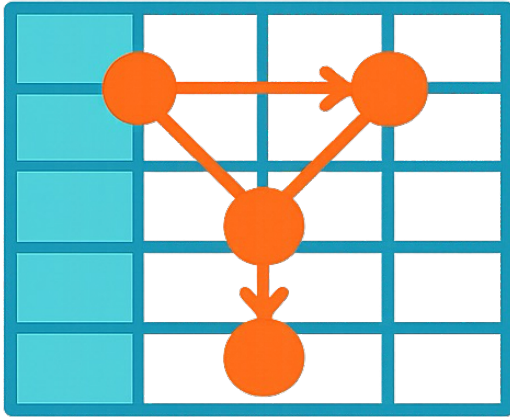
- Global utility is an **effective metric** for global structural fidelity
- More insights **available in paper**



Mean normalised local utility vs. global utility on 23 real-world datasets

- Tabular generative models should capture the **global causal structures**
- More insights **available in paper**

# Out-of-box support for tabular generative tasks

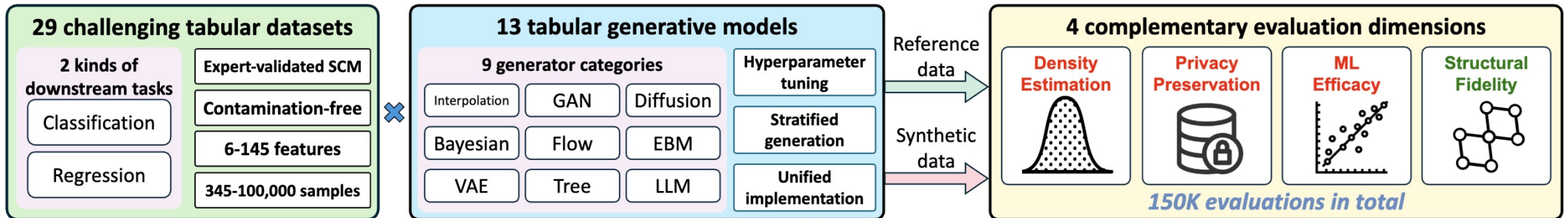


## TabStruct

Structural Fidelity of Tabular Data



## Code



An overview of TabStruct, an evaluation benchmark for tabular generative models [1]

[1] Jiang, Xiangjian, et al. "TabStruct: Measuring Structural Fidelity of Tabular Data." The Twelfth International Conference on Learning Representations (ICLR 2026 Oral).

# THANKS !

For more details, check our paper and code!



 Paper



 Code

Or come for a chat at  
**Poster Session 2**

Reach out to [xj265@cam.ac.uk](mailto:xj265@cam.ac.uk)



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**Nikola  
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**Mateja  
Jamnik**