

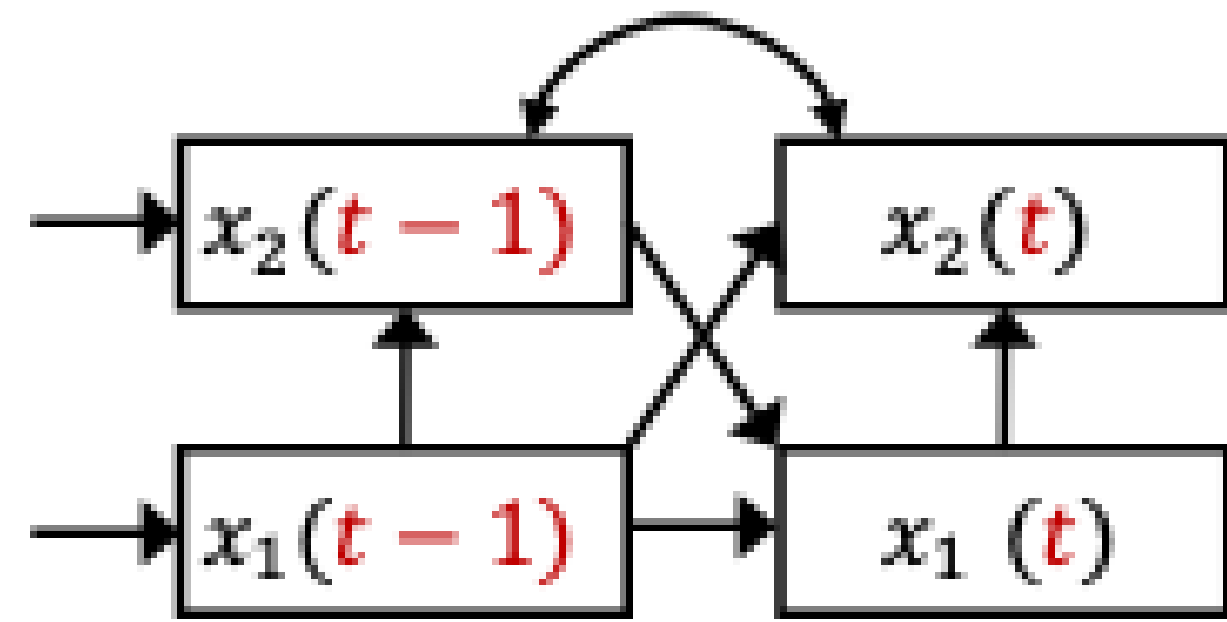
Causal Discovery

因果探索

- ・非線形・未観測共通原因・背景知識・時系列・連続変数
(Maeda & Shimizu, Behaviormetrika, 2024)

$$x_i(t) = \sum_{j, \tau: x_j \text{の親}} f_{ij}^{(\tau)}(x_j(t-\tau)) + \sum_{k, \omega: x_i \text{の親}} g_{ik}^{(\omega)}(u_k(t-\omega)) + e_i(t)$$

観測変数間だけでなく
親変数と誤差変数の独立性を利用



向き・交絡の「存在」が識別可能

ソフトウェア

Python package: Causal-learn

(Zheng et al., 2024, Journal of Machine Learning Research
Machine Learning Open Source Software)

Github: <https://github.com/py-why/causal-learn>

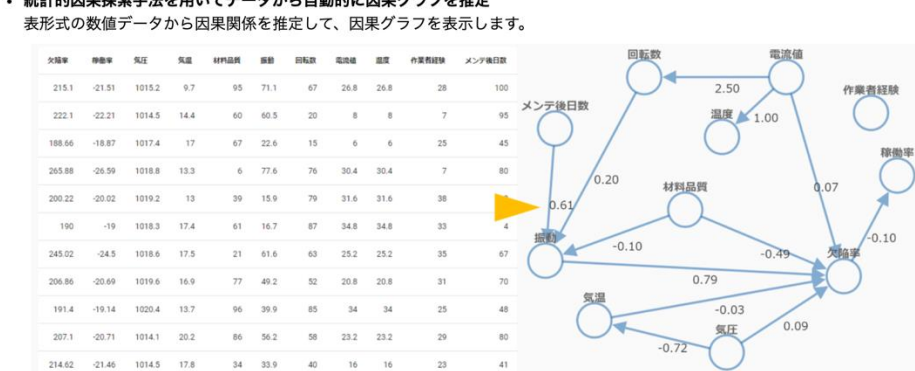
これまで作成のLINGAM Package (Ikeuchi et al., 2023)

Github: <https://github.com/cdt15/lingam>

と合わせて、約45,000DL/月

参考: Causalas (SCREEN アドバンスドシステムソリューションズ)
を監修 (清水)

プログラミングしなくともクリックで
因果探索を実行可能



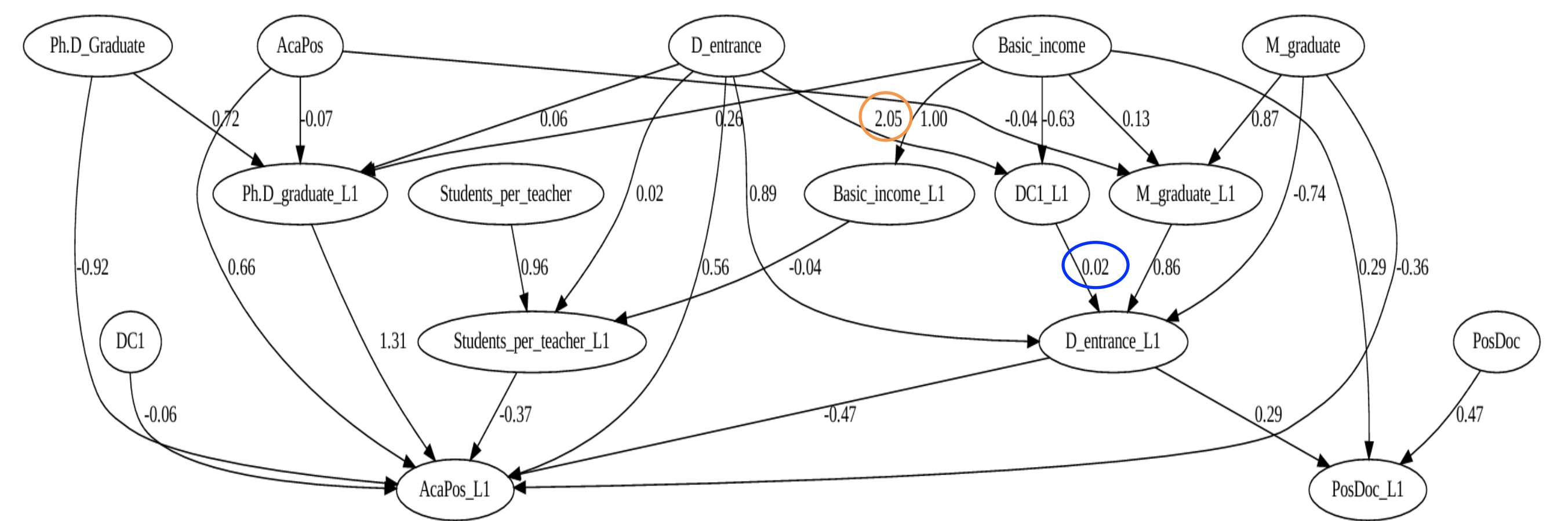
Applications of Causal Discovery

因果探索の事例・活用

- ・各政策要因による博士課程進学者数への
因果メカニズムの定量的理解へ
(高山ら, 2024, 研究・イノベーション学会 年次学術大会にて発表)

文部科学省 科学技術・学術政策研究所 NISTEP との共同研究

公開データを基に大学別のデータセットを構築
国立86大学 x 11か年度



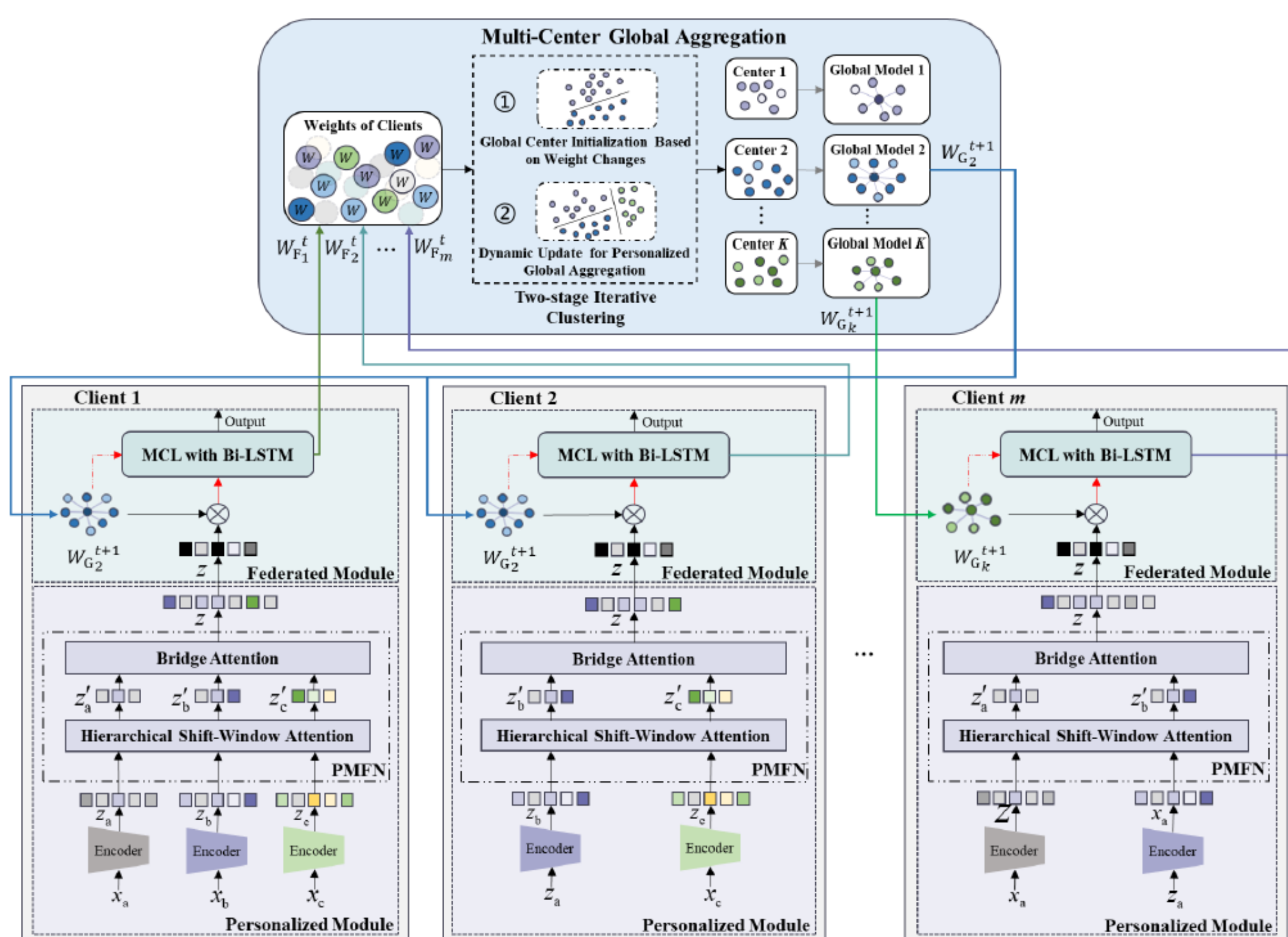
【重点支援3の16大学】

変数名	内容
M_graduate	修士課程等修了者数
D_entrance	博士課程進学者数
Ph.D_graduate	博士課程修了者数
PosDoc	博士課程修了直後のポスドク就職者数
AcaPos	博士課程修了直後の大学教員就職者数
Basic_income	運営費交付金収益額
Students_per_teacher	教員一人当たり学生数
DC1	DC1採択者数

Multi-Modal Analysis

マルチモーダル分析

X. Zhou et al., "Personalized Federated Learning with Model-Contrastive Learning for Multi-Modal User Modeling in Human-Centric Metaverse," **IEEE Journal on Selected Areas in Communications**, 2024. DOI: 10.1109/JSAC.2023.3345431



➤ A newly designed **Personalized Federated Learning** framework, including a multi-center global aggregation structure facilitated by a **two-stage iterative clustering** scheme and a hierarchical local training structure integrated with a **model-contrastive learning** scheme

➤ A **Personalized Multi-Modal Fusion Network**, in which a **hierarchical shift-window attention mechanism** is improved to fuse the high-dimensional inputs from users' multi-modal data while effectively reduce the feature dimensions, and a **bridge attention mechanism** is introduced to greatly reduce the computational cost for more efficient cross-modal fusion from heterogeneous data

Robust Estimation

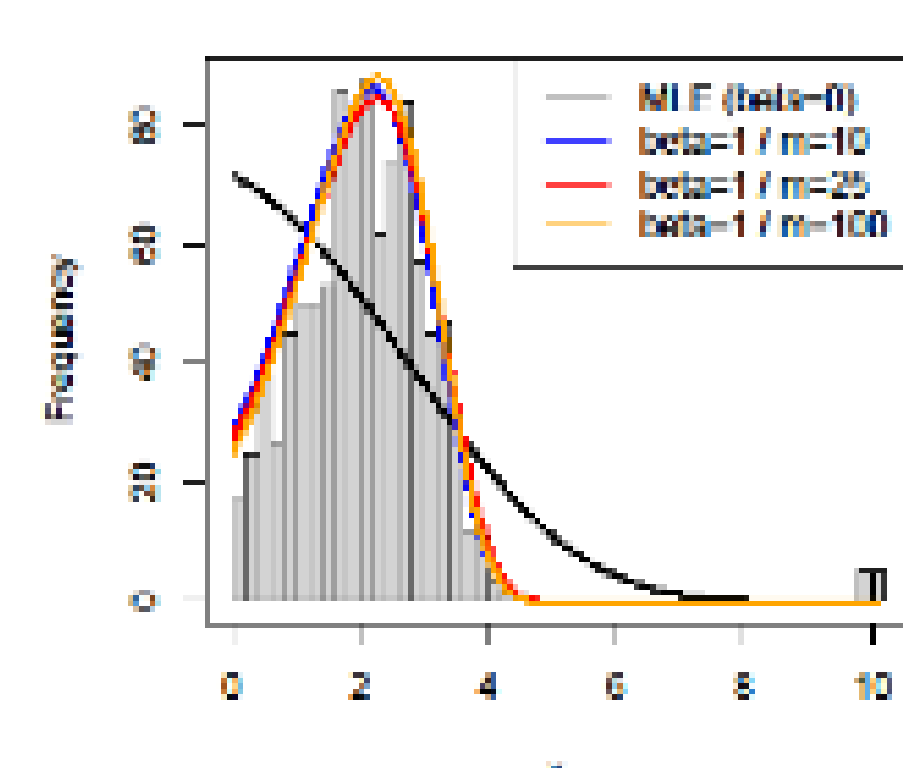
ロバスト推定

Akifumi Okuno. "Minimizing robust density power-based divergences for general parametric density models" accepted to AISM.

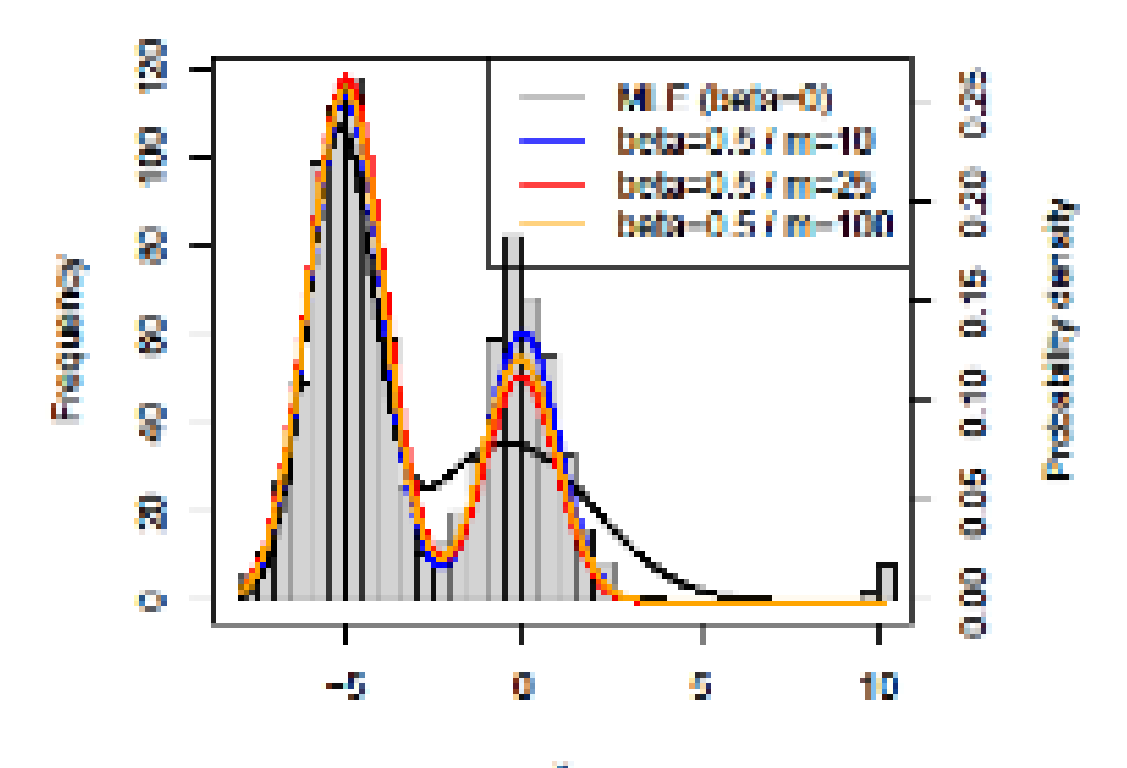
As an extension of KL-divergence, density-power divergence (DPD):

$$d_{\beta}(\hat{Q}, P_{\theta}) := -\frac{1}{\beta} n^{-1} \sum p_{\theta}(x_i)^{\beta} + \frac{1}{1+\beta} \int p_{\theta}(x)^{1+\beta} dx$$

is robust against outliers, but previous works optimized DPD only for simple probabilistic density models (e.g., normal density) whose integral can be analytically calculated. Okuno (AISM2024) proposes a stochastic algorithm to optimize DPD for **general parametric models** without explicitly computing integrals.



Gompertz density (Skew)



Gaussian mixture (multimodal)



We provide R package "sgdpd":
<https://github.com/oknakfm/sgdpd>

日本語での解説: <https://doi.org/10.51094/jxiv.642>