Secure Federated Feature Selection

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BACKGROUND: we propose the first secure federated χ2 -test protocol FED-χ2 . To minimize both the privacy leakage and the communication cost, we recast χ2 -test to the second moment estimation problem and thus can take advantage of stable projection to encode the local information in a short vector. As such encodings can be aggregated with only summation, secure aggregation can be naturally applied to hide the individual updates. We formally prove the security guarantee of FED-χ2 that the joint distribution is hidden in a subspace with exponential possible distributions. Our evaluation results show that FED-χ2 achieves negligible accuracy drops with small client-side computation overhead. In several real-world case studies, the performance of FED-χ2 is comparable to the centralized χ2 -test.

BUILDING BLOCK: STABLE PROECTION

Function ENCODE(P, u_i):
  return $\mathbf{P} \times \mathbf{u}_i$
Function GEOMETRICMEANESTIMATOR(e):
  ▷ ℓ: Encoding size.
  $\hat{d}_{(2),gm} \leftarrow \frac{\prod_{k=1}^{\ell} |\mathbf{e}_k|^{2/\ell}}{(\frac{2}{\pi}\Gamma(\frac{2}{\ell})\Gamma(1-\frac{1}{\ell})\sin(\frac{\pi}{\ell}))^{\ell}}$
  return $\hat{d}_{(2),gm}$
Function DECODE(e):
  return GEOMETRICMEANESTIMATOR(e)

METHODOLOGY

STEP 1: Recast χ2 –test as a second frequency moments estimation problem.

STEP 2: Encode the second frequency moments information using stable projection.

STEP 3: Use secure aggregation to sum the clients' updates.

we propose the first secure federated χ2-test protocol FED-χ2.

Algorithm 2: FED-χ^2: secure federated χ^2-test. SECUREAGG is a remote procedure that receives inputs from the clients and returns the summation to the server. INITSECUREAGG is the corresponding setup protocol deciding the communication graph and other hyper-parameters.

Round 1: Reveal the marginal distribution
  INITSECUREAGG(n)   // n is the client number.
  for $x \in [m_x]$ **do** v_x = SECUREAGG($\{v_x^{(i)}\}_{i\in[n]}$)
  for $y \in [m_y]$ **do** v_y = SECUREAGG($\{v_y^{(i)}\}_{i\in[n]}$)
  Server
    Calculate $v = \sum_x v_x$ and broadcast v, $\{v_x\}$ and $\{v_y\}$ to all the clients.
Round 2: Approximate the statistics
  Server
    Sample the projection matrix $\mathbf{P}$ from $\mathcal{Q}_{2,0,1}^{\ell\times m}$
    Broadcast the projection matrices to the clients
  Client $c_i, i \in [n]$
    Calculate $\bar{v}_{xy} = \frac{v_x v_y}{v}$
    Prepare $\mathbf{u}_i$ s.t. $\mathbf{u}_i[\mathbb{I}(x,y)] = \frac{v_{xy}^{(i)} - \bar{v}_{xy}/n}{\sqrt{\bar{v}_{xy}}}$
    Calculate $\mathbf{e}_i$ = ENCODE(P, u_i)
  $\mathbf{e}$ = SECUREAGG($\{e_i\}_{i\in[n]}$)
  Server
    $\hat{s}_{\chi^2}$ = DECODE(e)

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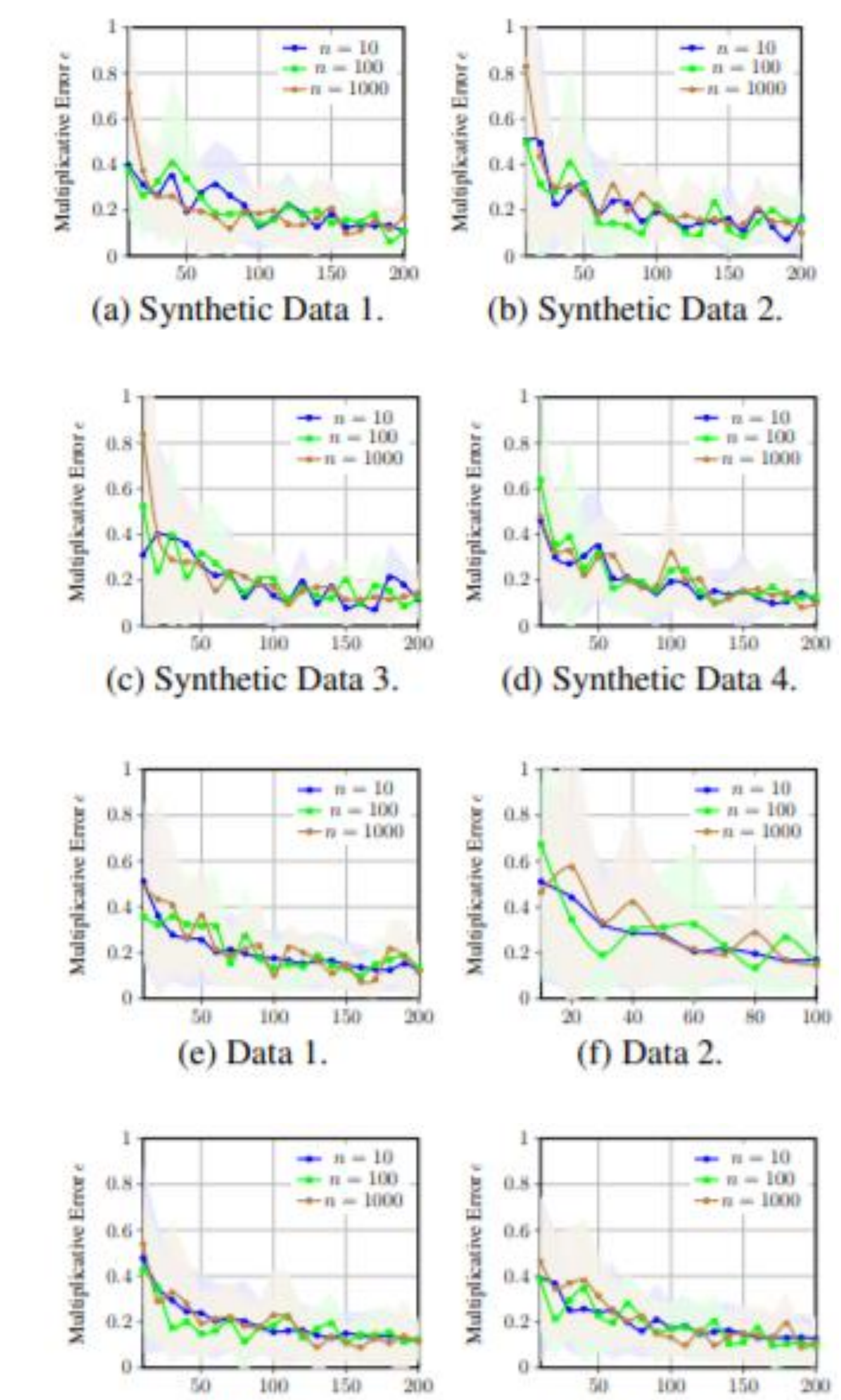
Experiment



(a) Synthetic Data 1.
(b) Synthetic Data 2.
(c) Synthetic Data 3.
(d) Synthetic Data 4.
(e) Data 1.
(f) Data 2.
(g) Data 3.
(h) Data 4.

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