INSPECTRE: Privately Estimating the Unseen

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Property Estimation

- p: unknown discrete distribution
- $f(p)$: some property of distribution, e.g. entropy.
- α: accuracy
- **Input:** i.i.d. samples X_1^n from p
- **Output:** $\hat{f} : X_1^n \to \mathbb{R}$ such that w.p. at least 2/3,

$$\left|\hat{f}(X_1^n) - f(p)\right| < \alpha$$

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Privacy should be concerned.

Data may contain sensitive information.

- In medical studies, data may contain health records or disease history.
- In map application, position information indicates users' residence.

Differential Privacy: $\hat{f}$ is ϵ-differentially private (DP) if for any X_1^n and Y_1^n, with $d_{ham}(X_1^n, Y_1^n) \leq 1$, for all measurable S,

$$\frac{\Pr\left(f(X_1^n) \in S\right)}{\Pr\left(f(Y_1^n) \in S\right)} \leq e^{\epsilon}.$$

Private Property Estimation

Given i.i.d. samples from an unknown distribution p, the goals are:

- *Accuracy*: estimate $f(p)$ up to $\pm\alpha$ with probability $> \frac{2}{3}$.
- *Privacy*: estimator must satisfy ϵ-differential privacy.

We are interested in the following properties:

- **Entropy**, $H(p)$: the Shannon entropy.
- **Support Coverage**, $S_m(p)$: expected number of distinct symbols in m draws from p.
- **Support Size**, $S(p)$: $\#$ symbols with non-zero probability.

Main Theorem

Informally, our upper bounds show that the cost of privacy in these settings is often **negligible** compared to the non-private statistical task. Furthermore, our upper bounds are **almost tight** in all parameters.

Laplace Mechanism

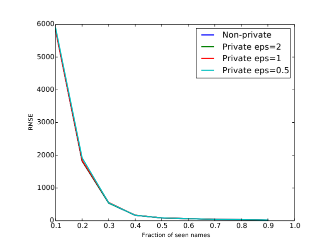
Our algorithms use *Laplace Mechanism*.

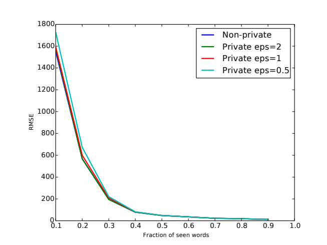
- Compute a non-private estimate of the property;
- Privatize this estimator by adding Laplace noise $X \sim Lap(\Delta_{n,\hat{f}}/\epsilon)$.

We find estimators with **low sensitivity** for all these problems.

Evaluation on real data

- Support coverage estimation
- Comparison on performance of private and non-private estimator
- The dataset: 2000 US Census data, and Hamlet





The End

Details in paper online!

https://arxiv.org/abs/1803.00008