Dual Query: Practical Private Query Release for High Dimensional Data

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Private Query Release

Queries

Release answers that preserve privacy

Sensitive Database (Medical Records)

Counting Queries: “What fraction of Patients smoke and have lung cancer?”

Find the Equilibrium with No-Regret Learning

No-Regret Algorithm vs. Best Response

→ converge to Equilibrium

▸ Actions for query player: query class Q
▸ Actions for data player: possible data records \( X \) = \{0, 1\}^d
▸ Payoff on \((q, x)\) is \(q(D) - q(x)\)
▸ Approximate Minimax Equilibrium ⇒ Accurate Answers

Scaling with Number of Attributes

Differential Privacy [DMNS06]

Neighboring Databases \( D \) and \( D' \):

\[Pr[A(D) = r] \lesssim (1 + \epsilon)Pr[A(D') = r]\]

Query Release as a Zero-Sum Game

Query Player Maximizes while Data Player Minimizes

▸ Previous idea: Data player runs no-regret learning
▸ Maintain approximate database \( \hat{D} \), privately find queries with high error, update \( \hat{D} \) [HR10][HLM12]
▸ \( \hat{D} \) is distribution over \( X \) (HUGE! \( 2^d \))
▸ Problem: not scalable for high dimensional data.
Existing work: \( \sim 100 \) attributes [HLM12].

Our Novelty: Switching the Roles

Query player runs no-regret learning

▸ Now: distribution over queries \( Q \), find record minimizing error
Makes High Dimensional Data Possible!

▸ Space linear in \(|Q|\) rather than \(|X|\)
▸ Best response problem for data player is NP-Hard but non-private and succinctly represented, can use existing solvers like CPLEX

Theoretical Accuracy Guarantee

Max additive error over all queries (error 1 trivial):

\[O \left( \frac{\log |Q|}{|D|^{1/3}\epsilon^{1/3}} \right)\]

Experimental Accuracy

Netflix: Average Max Error

Figure 1: Accuracy versus \( \epsilon \) (privacy)

Figure 2: Accuracy versus number of attributes

Synthetic: Average Runtime(secs)

Figure 3: Runtime versus number of attributes

Conclusion and Open Problems

▸ Dual Query: A new private query release mechanism that can handle datasets with dimensionality multiple orders of magnitude larger than what was previously possible.
▸ Open problems:
  ▸ Parameter setting under differential privacy
  ▸ Incorporate sparsity of the dataset
  ▸ Subclass of queries with “easy” best response problem
  ▸ Allow queries to arrive online