

impl TopKMeasure for MaxDivergence

Tudor Cebere

Michael Shoemate

October 30, 2025

This proof resides in “`contrib`” because it has not completed the vetting process.

This document proves soundness of `TopKMeasure` for `MaxDivergence` in `mod.rs` at commit `e62b0aa2` (outdated¹).

1 Hoare Triple

Precondition

Compiler-verified

- Associated Const `REPLACEMENT = false`
- Method `privacy_map`
Types consistent with pseudocode.

Caller-verified

- Method `privacy_map`
 - `d_in` is non-null and positive.
 - `scale` is non-null and positive.

Pseudocode

```
1 # MaxDivergence
2 REPLACEMENT = False
3
4 def privacy_map(d_in: f64, scale: f64) -> f64:
5     return d_in.inf_div(scale)
```

Postcondition

Theorem 1.1. The implementation is consistent with the associated items in the `TopKMeasure` trait.

- Method `privacy_map`: For any x, x' where $d_{in} \geq d_{Range}(x, x')$, return $d_{out} \geq D_{self}(f(x), f(x'))$, where $f(x) = \text{noisy_top_k}(x = x, k = 1, \text{scale} = \text{scale}, \text{replacement} = \text{Self} :: \text{REPLACEMENT})$.

Proof. Since `Self::REPLACEMENT` is false, then by the postcondition of `noisy_top_k`, `noisy_top_k` returns a sample from \mathcal{M}_{PF} . In the case that scores are not monotonic, by [1] Theorem 1, \mathcal{M}_{PF} satisfies ϵ -DP, because the range distance is equal to $2 \cdot \Delta$. Otherwise in the case that scores are monotonic, by [1] Remark 1, \mathcal{M}_{PF} satisfies $\epsilon/2$ -DP, but the range distance is equal to Δ , thus satisfying ϵ -DP. \square

¹See new changes with `git diff e62b0aa2..e644840 rust/src/measurement/noisy_top_k/mod.rs`

References

- [1] Ryan McKenna and Daniel Sheldon. Permute-and-flip: A new mechanism for differentially private selection, 2020.