

fn truncate_id_bound

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

Proves soundness of `truncate_id_bound` in `mod.rs` at commit `f5bb719` (outdated¹). `truncate_id_bound` returns an upper bound on dataset distances in terms of the symmetric distance metric.

1 Hoare Triple

Precondition

Caller Verified

- `id_bound.by = truncate.by`

Function

```
1 def truncate_id_bound(
2     id_bound: Bound,
3     truncation: Bound,
4     total_ids: Option[int],
5 ) -> Bound:
6     # Once truncated, max contributions when grouped by "over" are bounded
7     row_bound = Bound.by(truncation.by)
8
9     # In each group, the worst-case row contributions is the
10    # the number of ids contributed (known from id_bound)
11    # times the number of rows contributed under each id (known from truncation),
12    num_ids, num_rows = id_bound.per_group, truncation.per_group
13    if num_ids is not None and num_rows is not None:
14        row_bound = row_bound.with_per_group(num_ids.inf_mul(num_rows)) #
15
16    # Worst case number of groups contributed is the
17    # total number of ids contributed (total_ids)
18    # times the number of groups contributed under each id (known from truncation).
19    num_groups_via_truncation = None #
20    if total_ids is not None and truncation.num_groups is not None:
21        num_groups_via_truncation = total_ids.inf_mul(truncation.num_groups)
22
23    # Alternatively, the number of groups contributed may be known outright from id_bound.
24    # Use the smaller of the two if both are known.
25    num_groups = option_min(num_groups_via_truncation, id_bound.num_groups)
26    if num_groups is not None:
27        row_bound = row_bound.with_num_groups(num_groups) #
28
29 return row_bound
```

¹See new changes with git diff f5bb719..9bdaf70 rust/src/transformations/make_stable_lazyframe/truncate/mod.rs

Postcondition

Theorem 1.1 (Postcondition). Let g vary over groups when partitioned by `id_bound.by`. If for any two datasets x, x' we have that

$$\begin{aligned} \|d_{\text{SymId}}(\text{function}(x)_g, \text{function}(x')_g)\|_\infty &\leq \text{id_bound.per_group}, \\ \|d_{\text{SymId}}(\text{function}(x)_g, \text{function}(x')_g)\|_0 &\leq \text{id_bound.num_groups}, \\ d_{\text{SymId}}(\text{function}(x), \text{function}(x')) &\leq \text{total_ids}, \end{aligned}$$

and `function` truncates a dataset such that,

$$\begin{aligned} \max_{id} \|d_{\text{Sym}}(\text{function}(x)_{id,g}, \text{function}(x')_{id,g})\|_\infty &\leq \text{truncation.per_group}, \\ \max_{id} \|d_{\text{Sym}}(\text{function}(x)_{id,g}, \text{function}(x')_{id,g})\|_0 &\leq \text{truncation.num_groups}, \end{aligned}$$

then we have that

$$\begin{aligned} \|d_{\text{Sym}}(\text{function}(x)_g, \text{function}(x')_g)\|_\infty &\leq \text{row_bound.per_group}, \\ \|d_{\text{Sym}}(\text{function}(x)_g, \text{function}(x')_g)\|_0 &\leq \text{row_bound.num_groups}, \end{aligned}$$

where `row_bound` denotes the return value.

Proof. Assume the preconditions are met, as well as the conditions of the postcondition.

We first prove the per-group bound.

$$\begin{aligned} &\|d_{\text{Sym}}(\text{function}(x)_g, \text{function}(x')_g)\|_\infty \\ &\leq \|d_{\text{SymId}}(\text{function}(x)_g, \text{function}(x')_g)\|_\infty \cdot \max_{id} \|d_{\text{Sym}}(\text{function}(x)_{id,g}, \text{function}(x')_{id,g})\|_\infty \\ &\leq \text{id_bound.per_group} \cdot \text{truncation.per_group} \\ &= \text{row_bound.per_group} \quad \text{by line 14} \end{aligned}$$

We now prove the number of groups bound. There are two ways to bound the number of contributed groups. We first reason by the total number of identifiers.

$$\begin{aligned} &\|d_{\text{Sym}}(\text{function}(x)_g, \text{function}(x')_g)\|_0 \\ &\leq d_{\text{SymId}}(\text{function}(x), \text{function}(x')) \cdot \max_{id} \|d_{\text{Sym}}(\text{function}(x)_{id,g}, \text{function}(x')_{id,g})\|_0 \\ &\leq \text{total_ids} \cdot \text{truncation.num_groups} \\ &= \text{num_groups_via_truncation} \quad \text{by line 19} \end{aligned}$$

We can also directly bound the number of contributed groups by `id_bound.num_groups`:

$$\begin{aligned} &\|d_{\text{Sym}}(\text{function}(x)_g, \text{function}(x')_g)\|_0 \\ &= \|d_{\text{SymId}}(\text{function}(x)_g, \text{function}(x')_g)\|_0 \\ &\leq \text{id_bound.num_groups} \end{aligned}$$

This is a valid upper bound on the number of contributed groups, because truncation is applied independently to each group.

Therefore, we take the minimum of the two upper bounds.

$$\begin{aligned} &\|d_{\text{Sym}}(\text{function}(x)_g, \text{function}(x')_g)\|_0 \\ &\min(\text{num_groups_via_truncation}, \text{id_bound.num_groups}) \\ &= \text{row_bound.num_groups} \quad \text{by line 27} \end{aligned}$$

In the implementation, any of the input bounds could be missing. When a bound is missing, any output bounds that require it are not claimed. \square