Blob Matching Optimization

Summary of work and next steps

Samuel Alter | Reveal Global Consulting | 2025-03-28

Agenda

1. Introduction

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2. Work Timeline

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3. Performance Results

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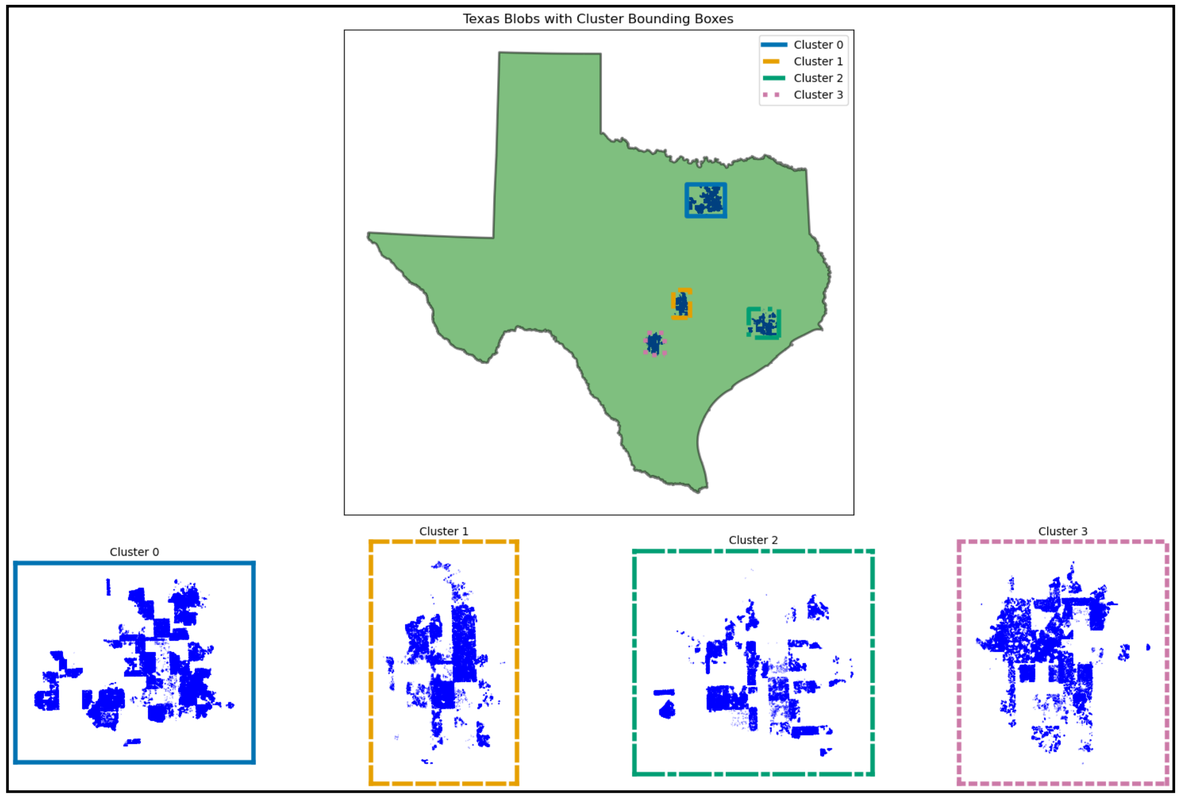
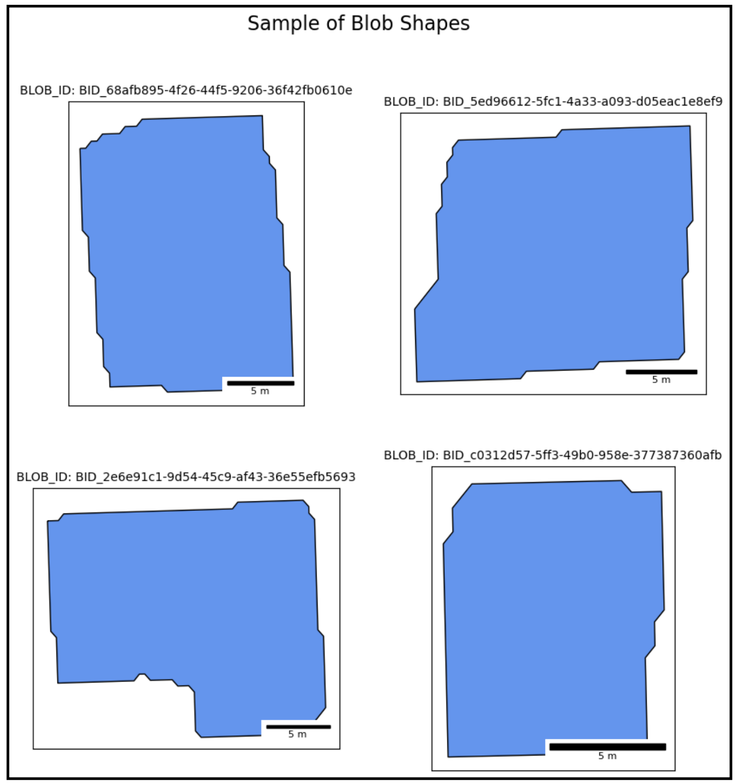
Introduction

Blob Matching





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1. Introduction
2. **Work Timeline**
3. Performance Results
4. Next Steps

Work Timeline

Overview

1. Understand functions

Work Timeline

Overview

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2. Benchmark process

Work Timeline

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1. Understand functions
2. Benchmark process
3. Isolate inefficient areas

Work Timeline

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1. Understand functions
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3. Isolate inefficient areas
4. Optimize the inefficient functions

Work Timeline

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2. Benchmark process
3. Isolate inefficient areas
4. Optimize the inefficient functions
5. Benchmark optimized process

Work Timeline

Details

1. Isolate blob matching functions within `BlobSearchBusinessClass.py`

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2. Bring in supporting functions and scripts

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4. Write benchmarking tools to measure and analyze performance of script

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2. Bring in supporting functions and scripts
3. Refocus with `BlobMatchingBusinessClass.py` script
4. Write benchmarking tools* to measure and analyze performance of script

   *Tools:

   - @Timer decorator
   - @ErrorCatcher decorator
   - Results analysis CLI script

Work Timeline

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1. Isolate blob matching functions within `BlobSearchBusinessClass.py`
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5. Get performance results with limited, 835-row sample dataset and…

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6. …Get performance results with larger, ~6,000-row sample dataset

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1. Isolate blob matching functions within `BlobSearchBusinessClass.py`
2. Bring in supporting functions and scripts
3. Refocus with `BlobMatchingBusinessClass.py` script
4. Write benchmarking tools to measure and analyze performance of script
5. Get performance results with limited, 835-row sample dataset and…
6. …Get performance results with larger, ~6,000-row sample dataset
7. Determine which functions within script are least efficient

Work Timeline

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2. Build benchmarking tools (@Timer/ErrorCatcher, and results analysis script)

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```
'fork'
```

```
mp.set_start_method('spawn', force=True)
```

Work Timeline

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1. Add logging messages throughout script
2. Build benchmarking tools (@Timer/ErrorCatcher, and results analysis script)
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4. **Improvements to execution speed: swap ‘`spawn`’ for ‘`fork`’**

```
'fork'
```

```
mp.set_start_method('spawn', force=True)
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Improvements in Execution Speed

Time Savings: ~40x

```
% python3.9 ./app/BlobSearch/BlobSearchBusinessClass_original_spawn.py 202407 --geo_hash
"9vgm0d" --p 7
Args: Namespace(yyyymm='202407', city=None, county=None, state=None, full_sat_img_id=None,
geo_hash='9vgm0d', p=7, info=False, override_history_check=False, overwrite=False)
Num Geohashes: 1
BlobSearchBusinessClass PROCESS AREA: City None | County None | State None | FullSatImgID None
| GeoHash 9vgm0d
OVERRIDE_HISTORY_CHECK = False
OVERWRITE              = False
CURR_YYYYMM                          : 202407
PREV_YYYYMM                          : 202406
Number of Geo Hashes                 : 1
Number of Large Geo Hashes           : 1 | ['9vgm0d']
Number of Previous Blobs             : 400
Number of Current Blobs              : 435
Curr Blob BCs (with Invalid)         : 0
Curr Blob BCs (without Invalid)      : 0
Processing 5 Processes with Batch Size 1
Process GeoHashes (5): 100%|##########| 1/1 [00:00<00:00, 444.26iteration/s]
Process GeoHash (1): 1iteration [03:10, 190.15s/iteration]

Before Impute Duplication Removal
NEW BLOB BC MATCHES     : 354
NEW BLOB BC IMPUTED     : 49
NEW BLOB IMPUTED        : 49
MARK INVALID BLOB BC    : 0

After Impute Duplication Removal
NEW BLOB BC MATCHES     : 354
NEW BLOB BC IMPUTED     : 49
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No Blob Business Classes to Mark as Invalid
Total Time: 196.3545618057251 seconds


Total Time: 196.35533475875854 seconds
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No Blob Business Classes to Mark as Invalid
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Total Time: 4.780802965164185 seconds
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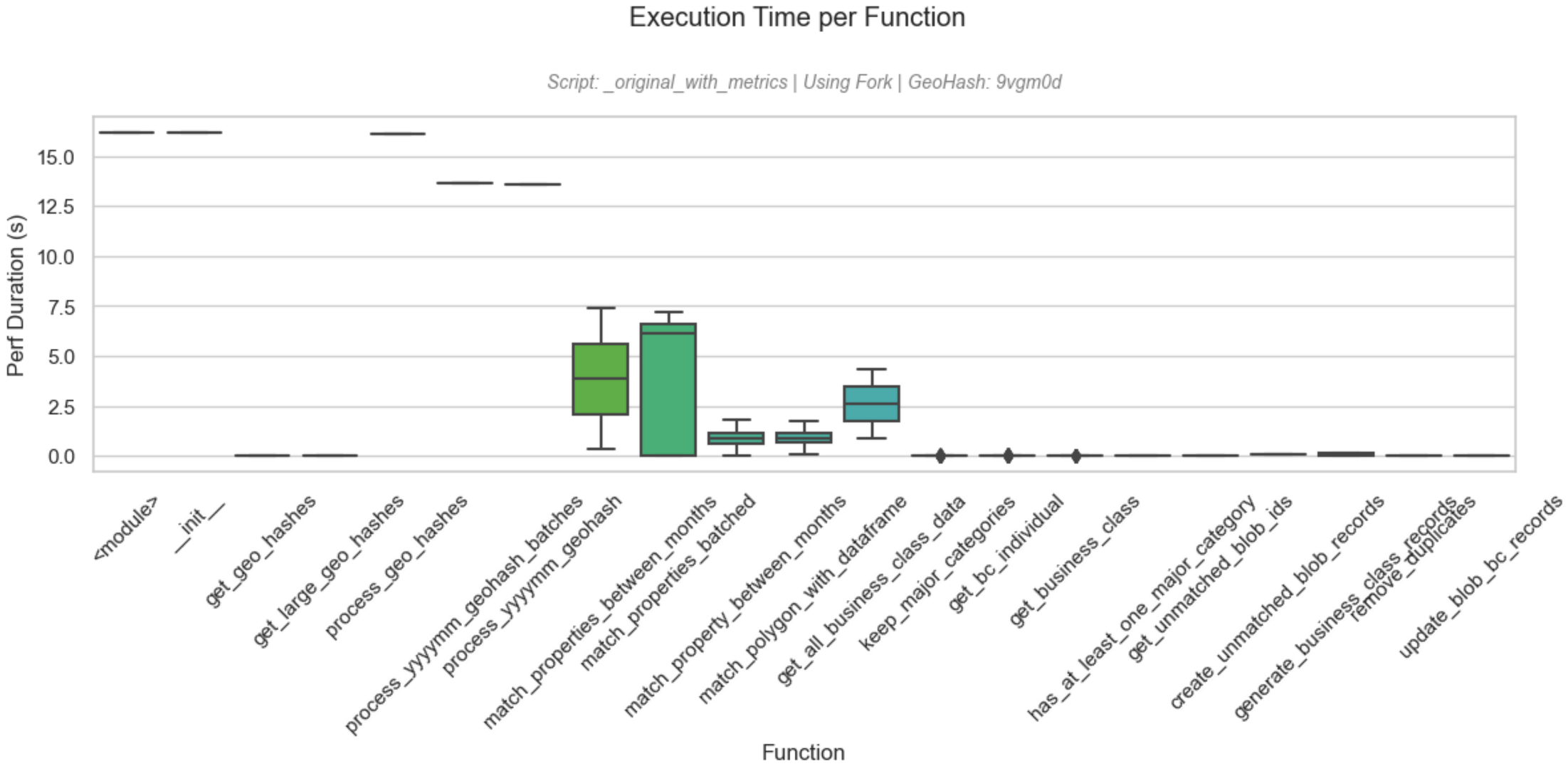
Performance Results

835-row dataset



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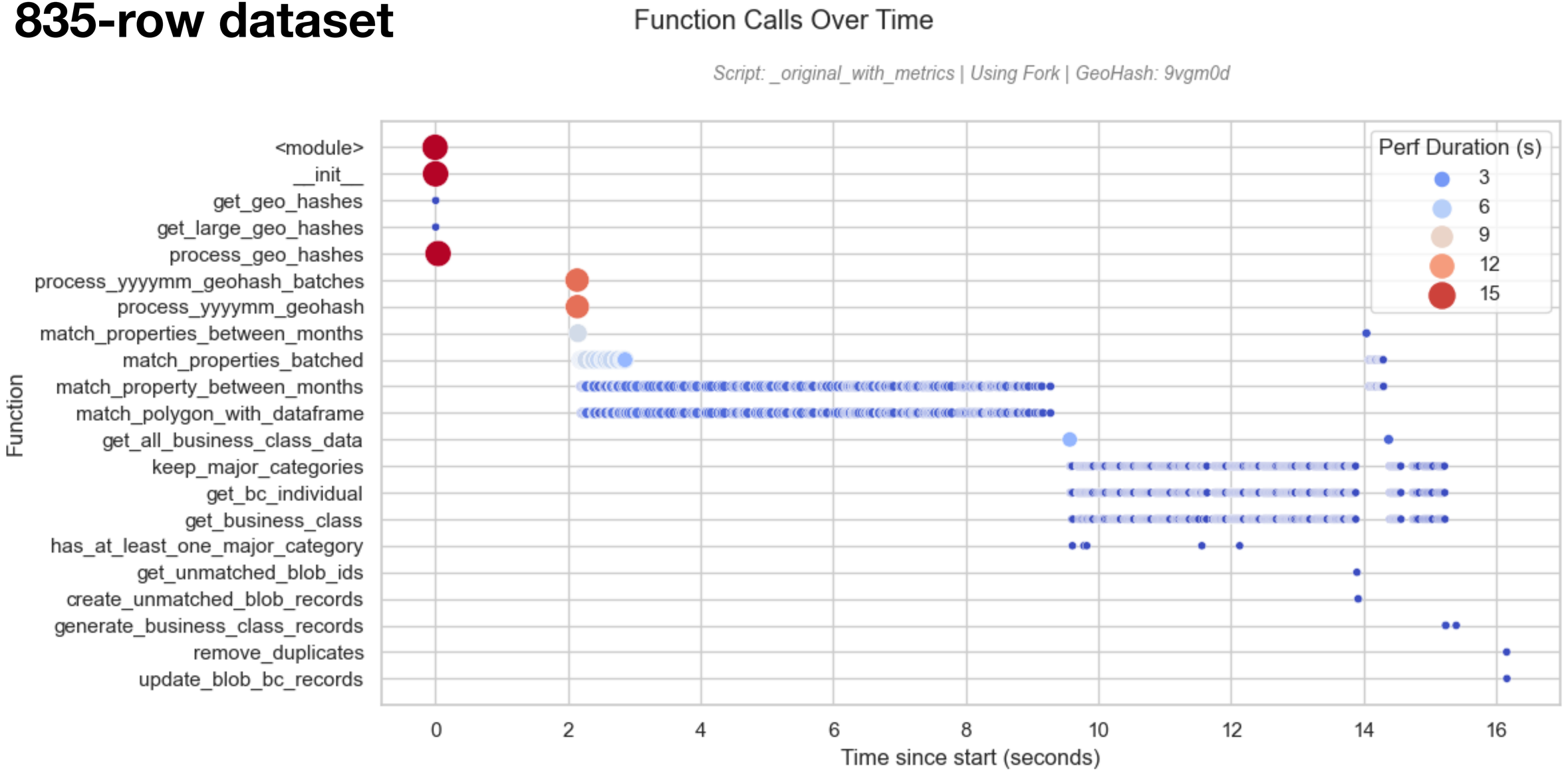

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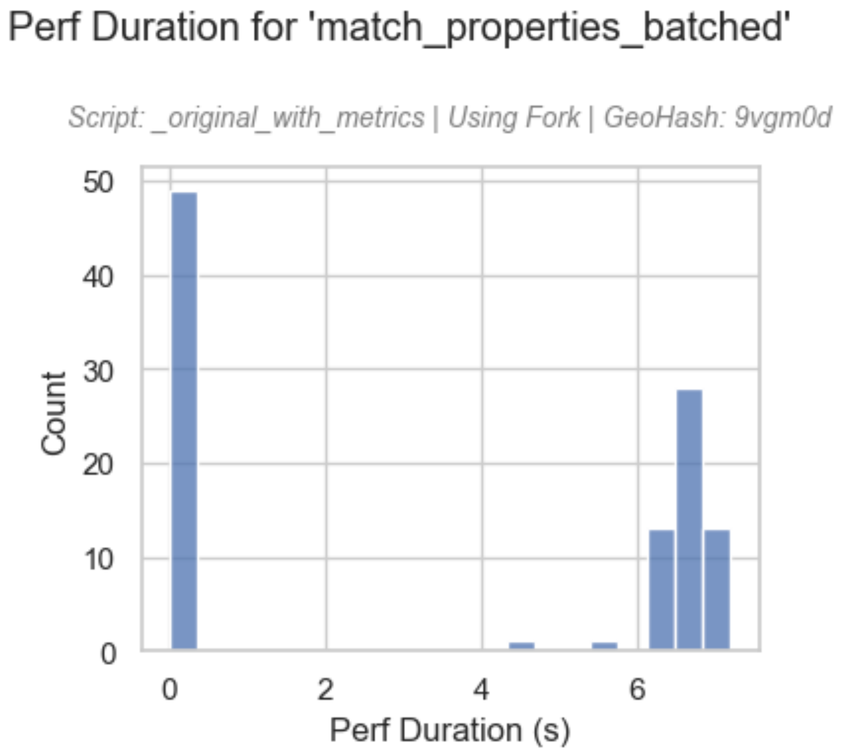

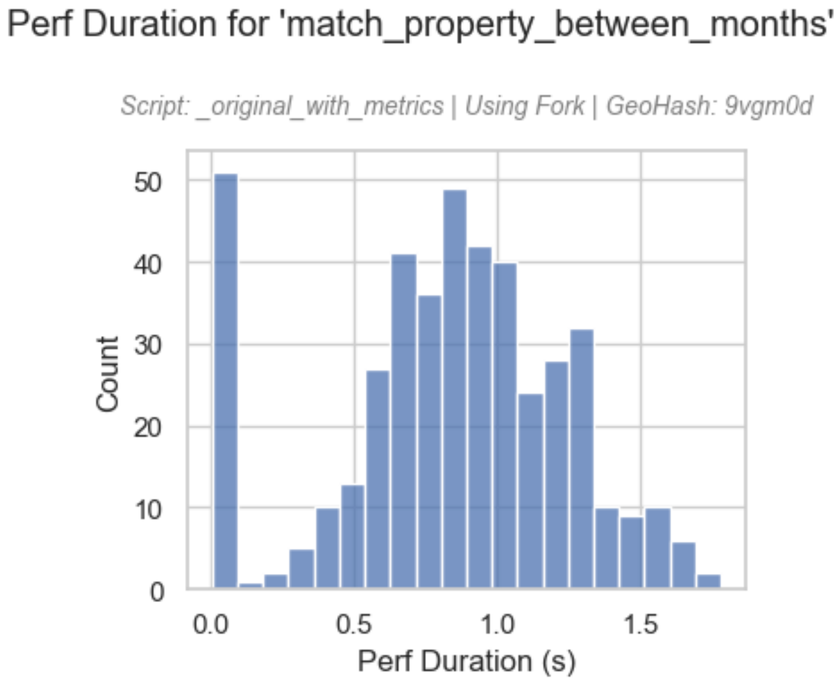

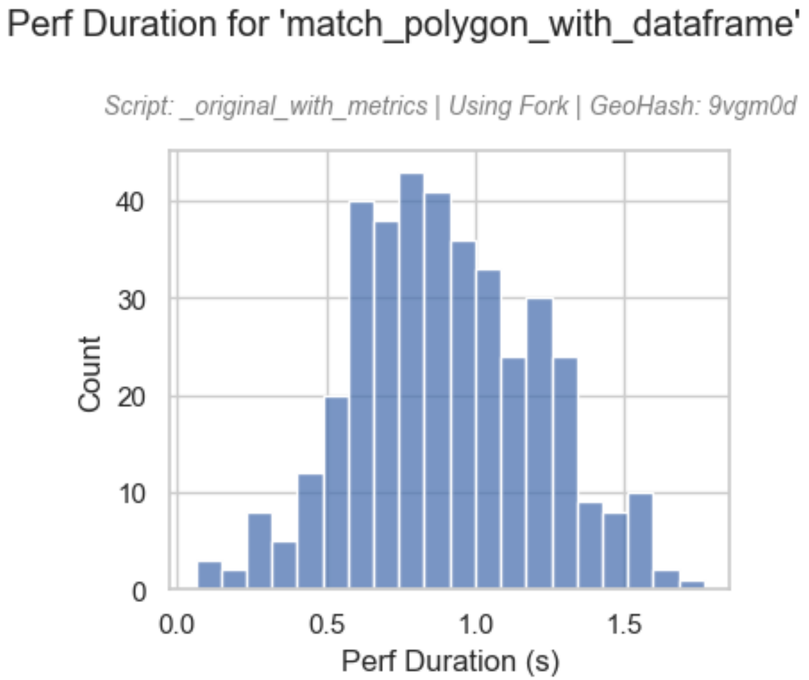

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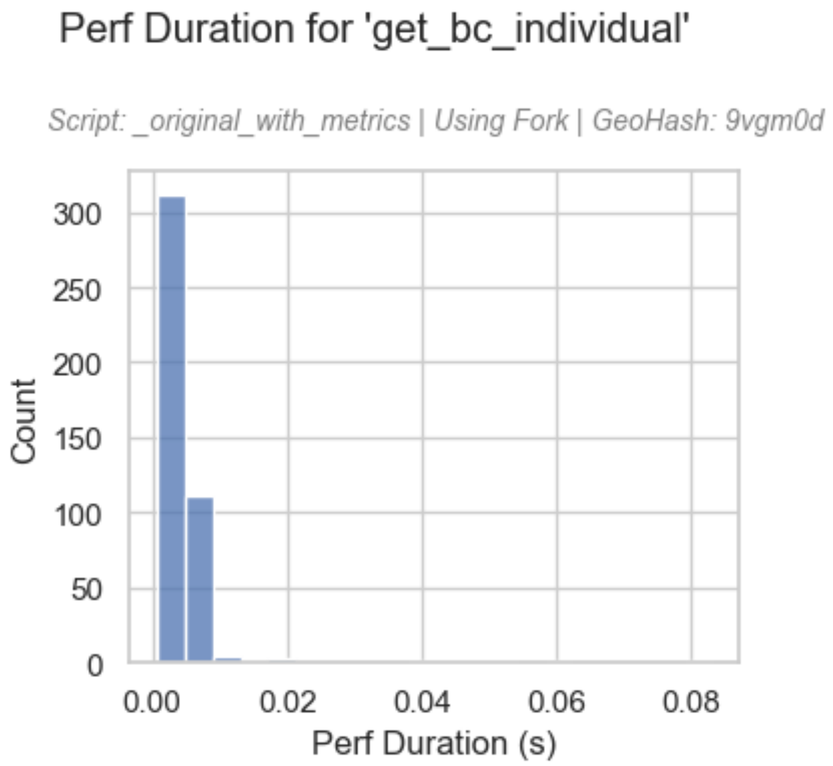

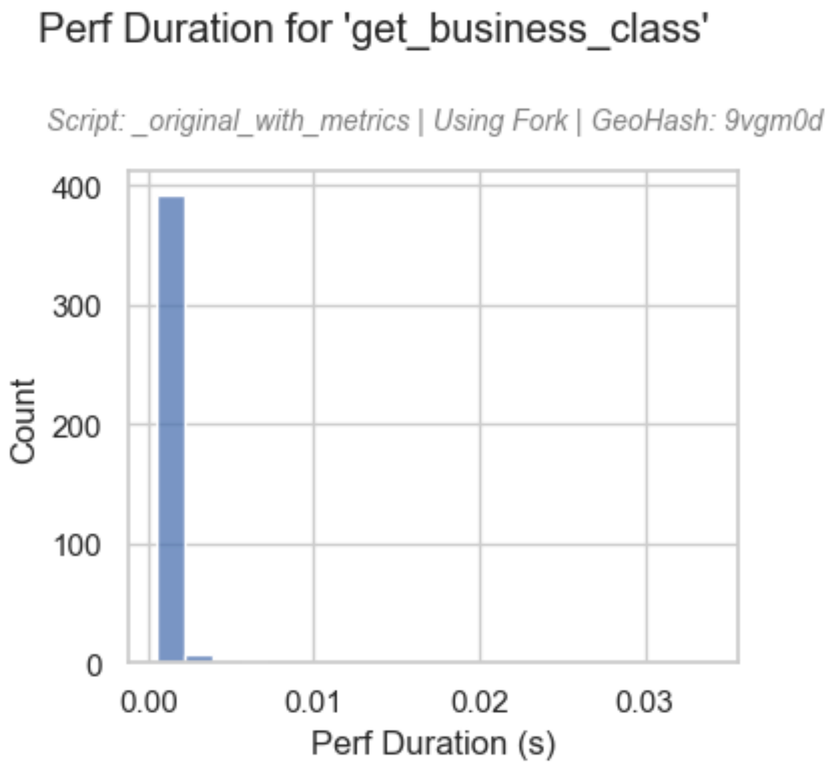

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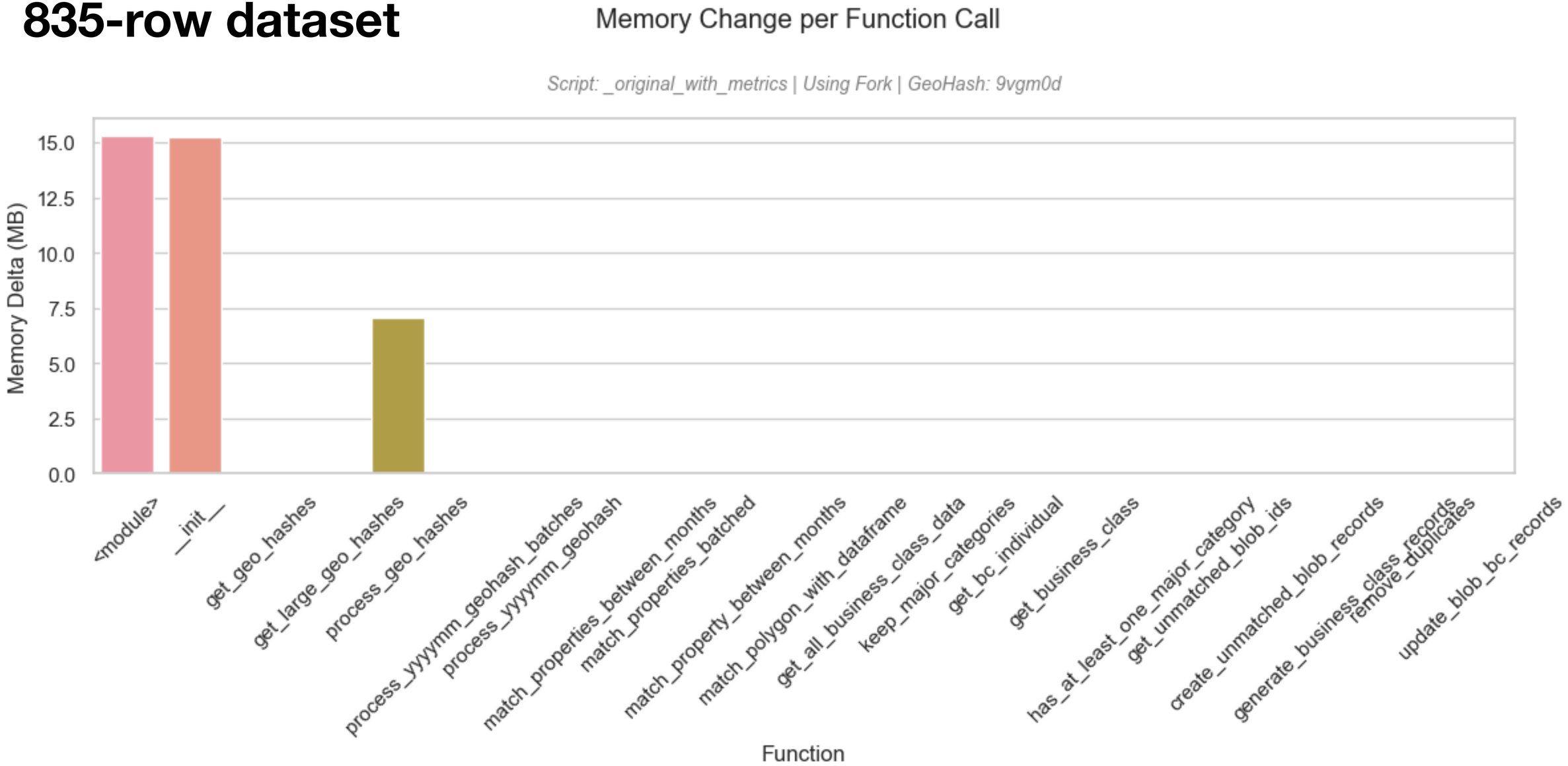

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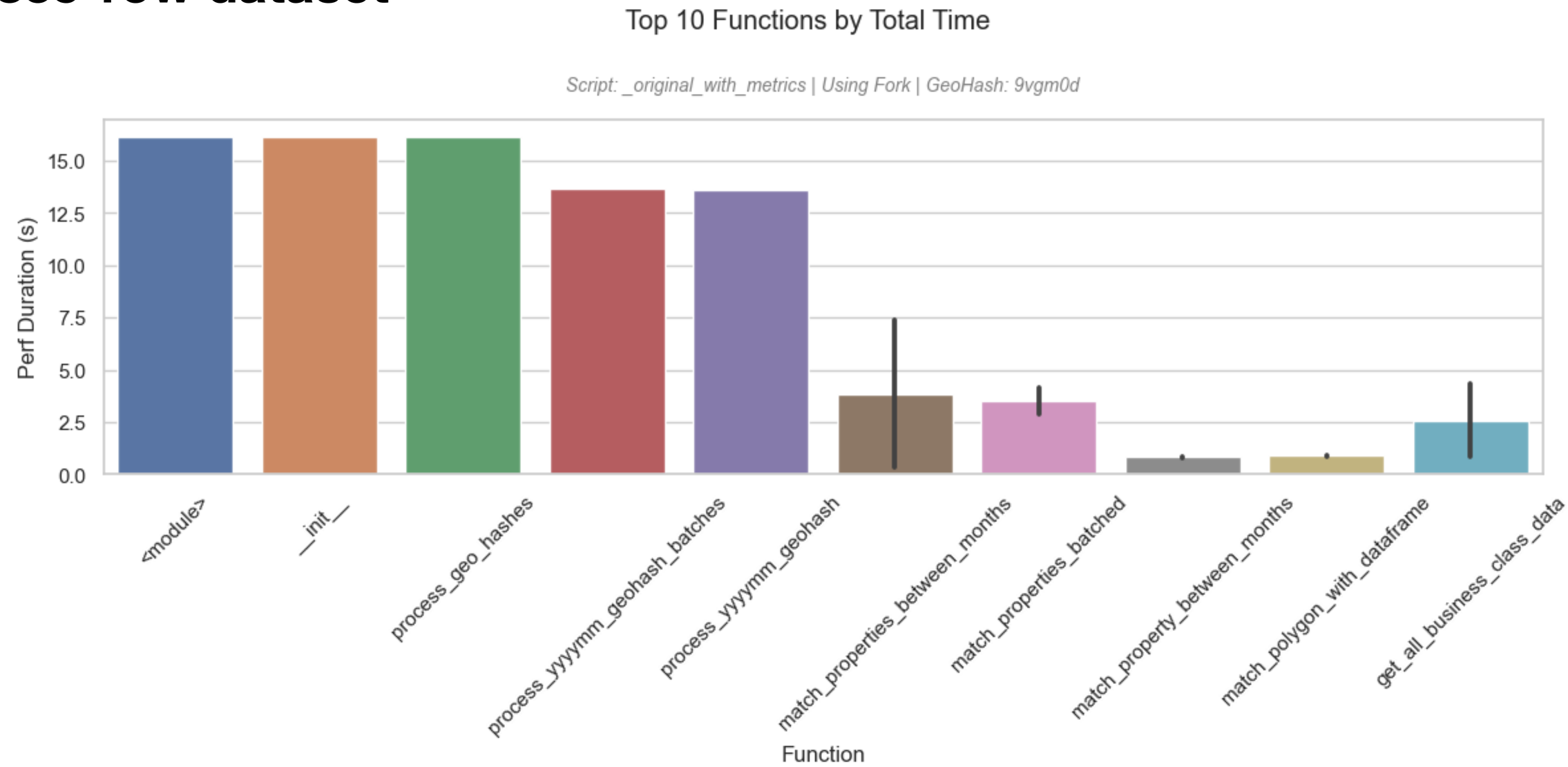


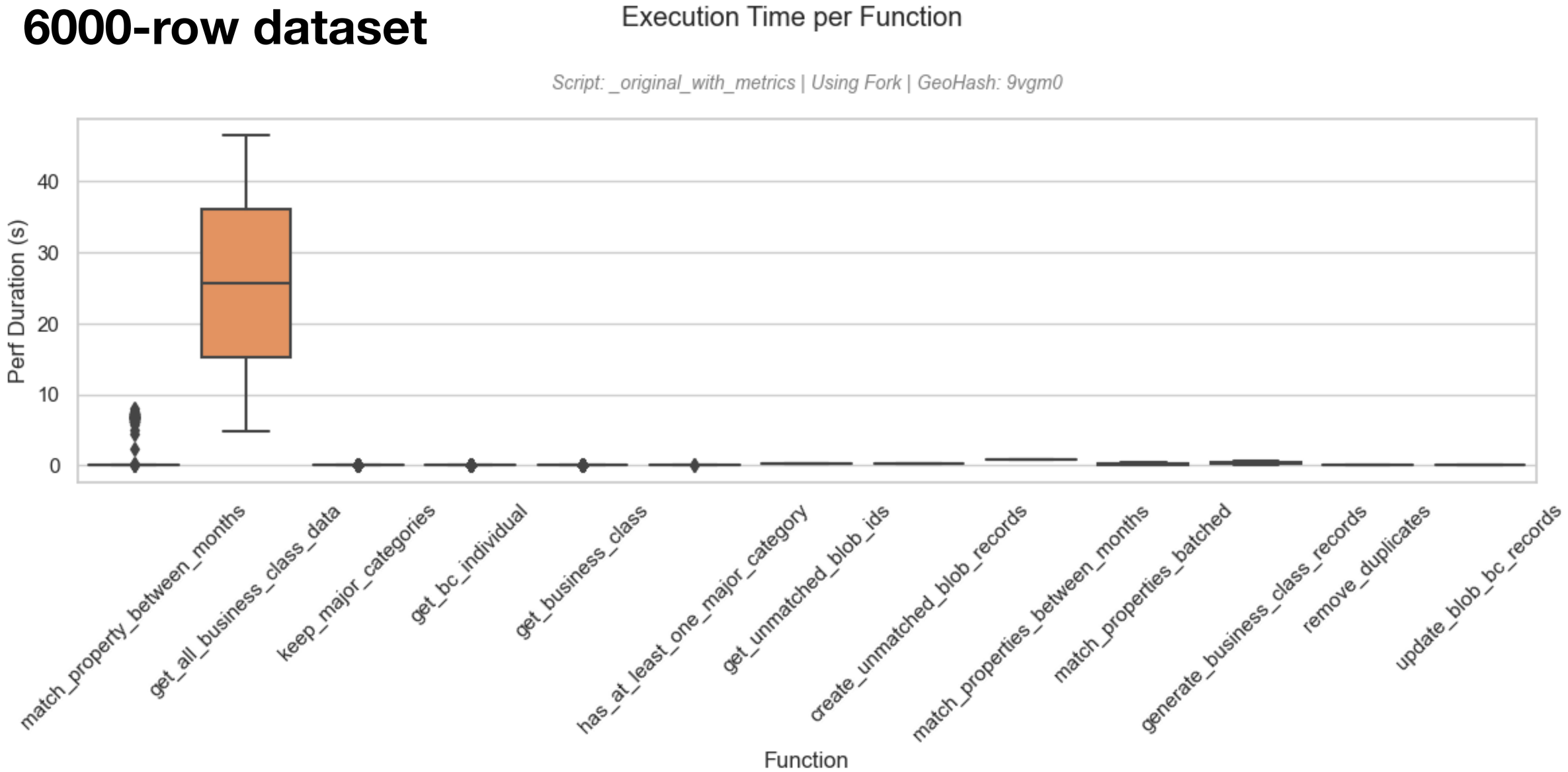
Performance Results

835-row dataset

Function	Perf Duration (s)_count	Perf Duration (s)_sum	Perf Duration (s)_mean	Perf Duration (s)_max	CPU Delta_mean	Memory Delta (MB)_mean
match_properties_batched	105	370.4236	3.5278	7.1972	0.00	0.0000
match_property_between_months	438	364.2335	0.8316	1.7845	0.00	0.0000
match_polygon_with_dataframe	389	349.6549	0.8989	1.7670	0.00	0.0000
<module>	1	16.1637	16.1637	16.1637	78.40	15.3354
__init__	1	16.1550	16.1550	16.1550	65.40	15.2699
process_geo_hashes	1	16.1157	16.1157	16.1157	-14.90	7.0451
process_yyyymm_geohash_batches	1	13.6529	13.6529	13.6529	-1.30	0.0000
process_yyyymm_geohash	1	13.5878	13.5878	13.5878	0.00	0.0000
match_properties_between_months	2	7.7221	3.8611	7.3957	0.00	0.0000
get_all_business_class_data	2	5.1677	2.5839	4.3149	0.00	0.0000
get_bc_individual	438	2.0380	0.0047	0.0831	-0.05	0.0000
keep_major_categories	438	0.6930	0.0016	0.0566	0.00	0.0000
get_business_class	403	0.4381	0.0011	0.0340	-0.05	0.0000
generate_business_class_records	2	0.1697	0.0848	0.1554	0.00	0.0000
create_unmatched_blob_records	1	0.1089	0.1089	0.1089	0.00	0.0000
get_unmatched_blob_ids	1	0.0162	0.0162	0.0162	0.00	0.0000
has_at_least_one_major_category	5	0.0045	0.0009	0.0012	0.00	0.0000
remove_duplicates	1	0.0019	0.0019	0.0019	75.10	0.0000
update_blob_bc_records	1	0.0003	0.0003	0.0003	6.80	0.0000
get_geo_hashes	1	0.0002	0.0002	0.0002	29.80	0.0000
get_large_geo_hashes	1	0.0001	0.0001	0.0001	-0.20	0.0000

Performance Results

6000-row dataset



Performance Results

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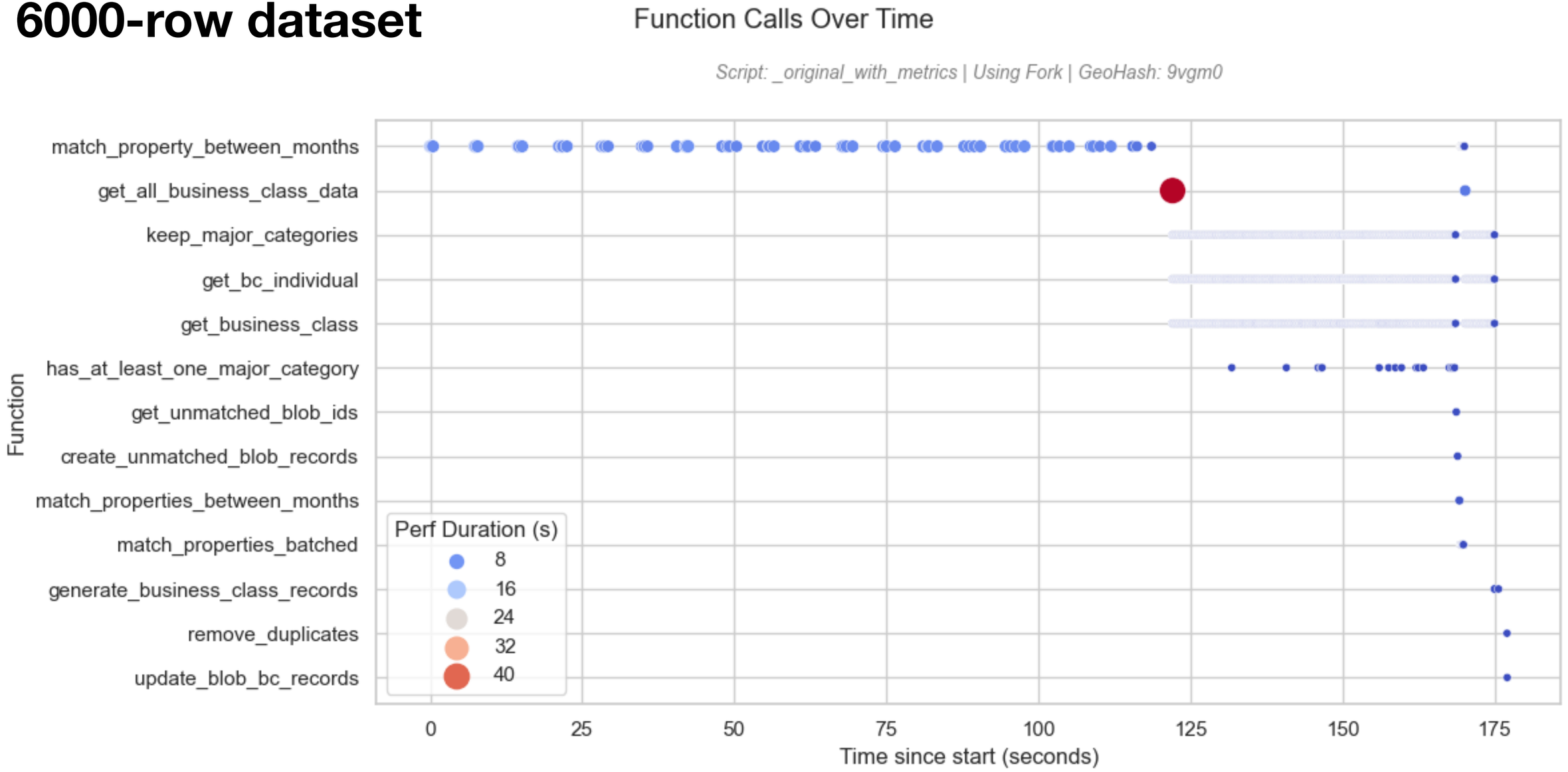
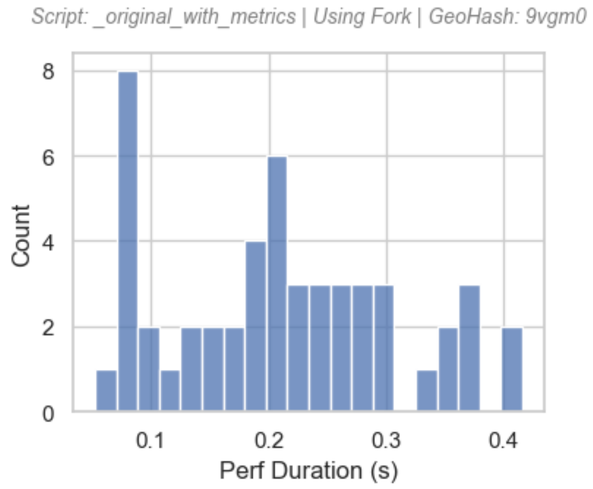


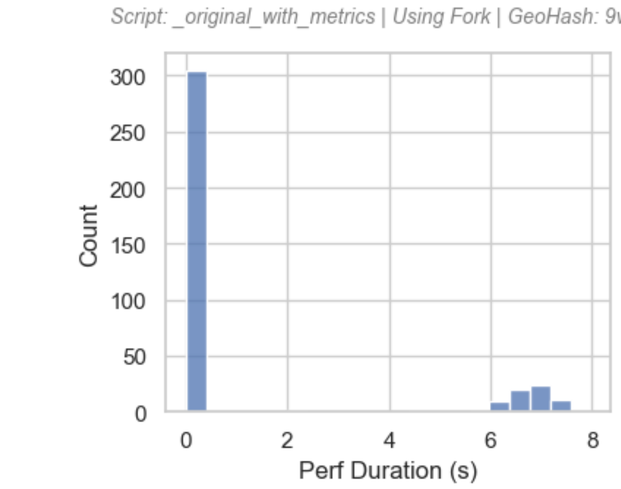
Performance Results

6000-row dataset

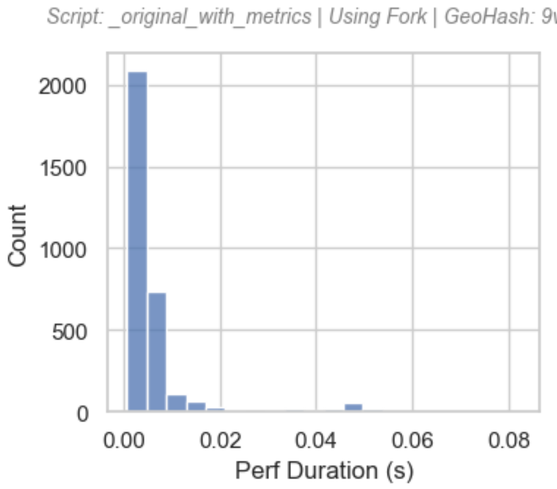
Perf Duration for 'match_properties_batched'



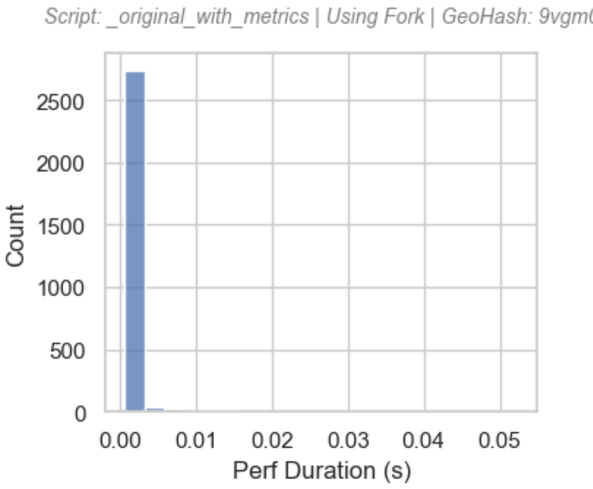
Perf Duration for 'match_property_between_months'



Perf Duration for 'get_bc_individual'



Perf Duration for 'get_business_class'



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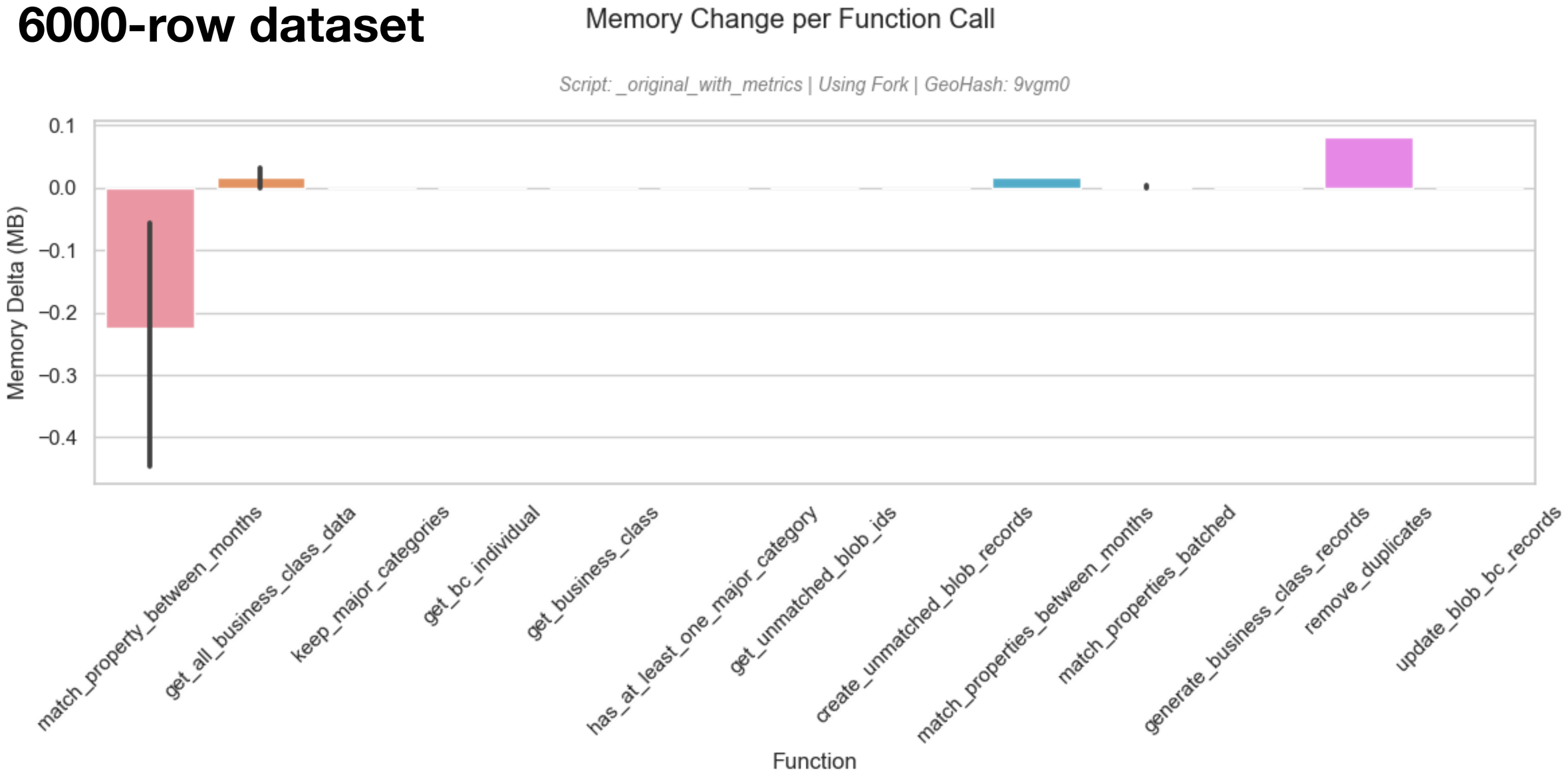
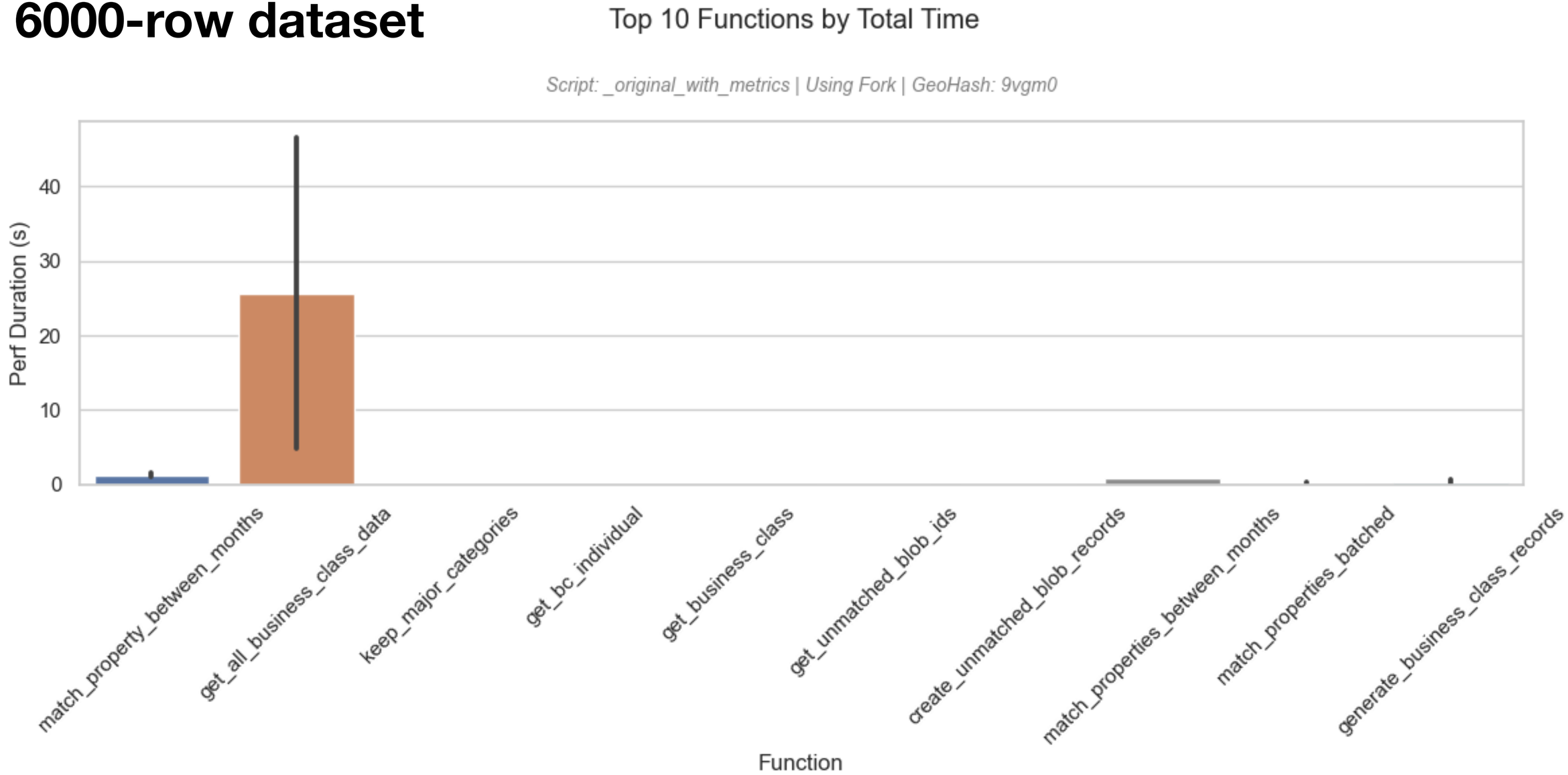


Performance Results

6000-row dataset



Performance Results

6000-row dataset

Function	Perf Duration (s)_count	Perf Duration (s)_sum	Perf Duration (s)_mean	Perf Duration (s)_max	CPU Delta_mean	Memory Delta (MB)_mean
match_property_between_months	376	480.7318	1.2785	7.9774	-0.0011	-0.2240
get_all_business_class_data	2	51.3464	25.6732	46.5252	0.0000	0.0164
get_bc_individual	3180	21.3697	0.0067	0.0824	0.0017	0.0000
match_properties_batched	51	10.7770	0.2113	0.4164	0.0039	0.0019
keep_major_categories	3180	6.7290	0.0021	0.0677	-0.0015	0.0000
get_business_class	2875	5.2438	0.0018	0.0524	0.0000	0.0000
match_properties_between_months	1	0.9452	0.9452	0.9452	0.0000	0.0164
generate_business_class_records	2	0.7380	0.3690	0.6396	0.0000	0.0000
create_unmatched_blob_records	1	0.2242	0.2242	0.2242	0.0000	0.0000
get_unmatched_blob_ids	1	0.2112	0.2112	0.2112	0.0000	0.0000
has_at_least_one_major_category	16	0.0232	0.0015	0.0066	0.0000	0.0000
remove_duplicates	1	0.0114	0.0114	0.0114	72.9000	0.0819
update_blob_bc_records	1	0.0006	0.0006	0.0006	67.0000	0.0000

Agenda

1. Introduction
2. Work Timeline
3. Performance Results
4. **Next Steps**

Next Steps

Key Expensive Functions

1. `match_properties_batched`
2. `match_property_between_months`
    2.1. `match_polygon_with_dataframe`
3. `process_yyyymm_geohash_batches`
4. `process_yyyymm_geohash`
5. `process_geo_hashes`
6. `__init__`

Next Steps

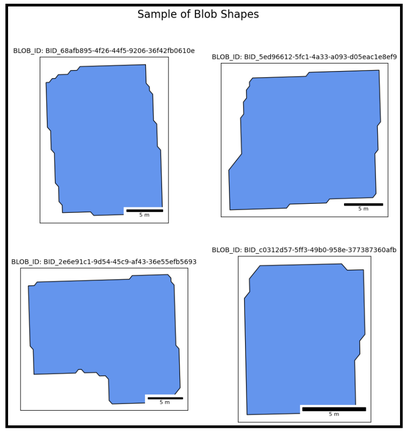
Observations and Recommendations

- Blob shapes are complicated

Next Steps

Observations and Recommendations

- Blob shapes are complicated



Next Steps

Observations and Recommendations

- Blob shapes are complicated
- Repeated communications with external database is slow

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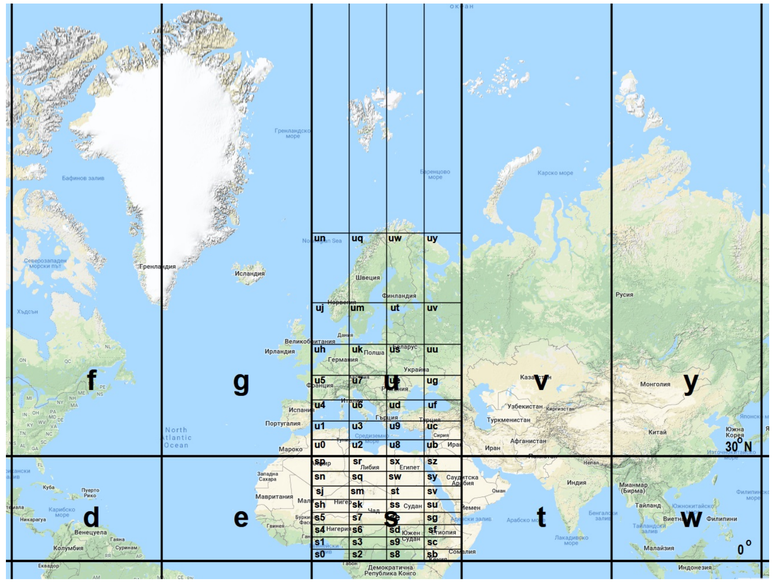
Observations and Recommendations

- Blob shapes are complicated
- Repeated communications with external database is slow
- Geohash is a fine geospatial index, but neighbor-finding is not as strong…

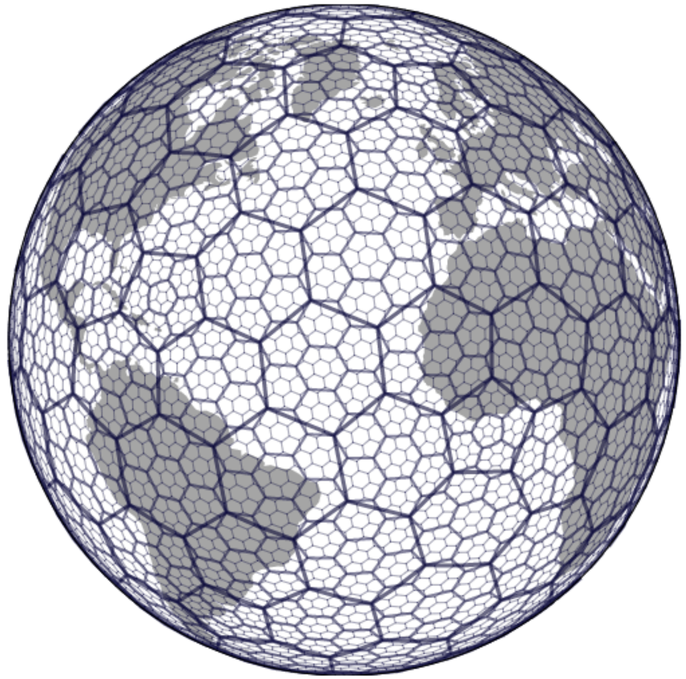


http://petrov.free.bg/academic/publication/geohash-eas-modified-geohash-geocoding-system-equal-area-spaces/fig_6.jpg

Next Steps

Observations and Recommendations

- Blob shapes are complicated
- Repeated communications with external database is slow
- Geohash is a fine geospatial index, but neighbor-finding is not as strong…
- …as other alternative options



https://viennadatasciencegroup.at/post/2019-11-21-h3spark/featured.png

Next Steps

Observations and Recommendations

- Geopandas is a fine tool for spatial join processes…

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- Geopandas is a fine tool for spatial join processes…
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https://www.casd.eu/en/data-tech-webinaire-parquet-duckdb/duckdb-logo-2/

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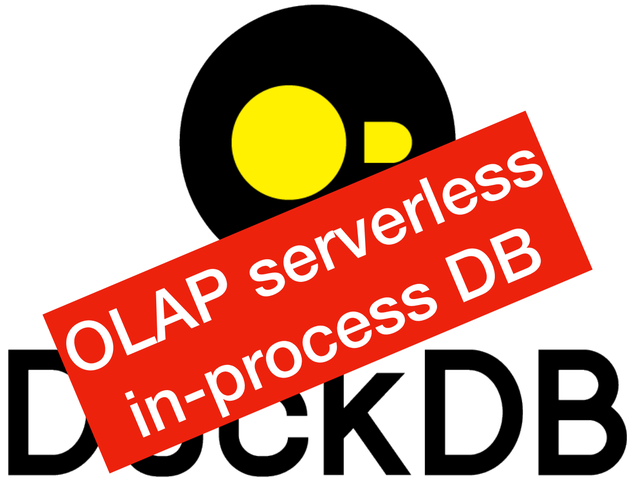

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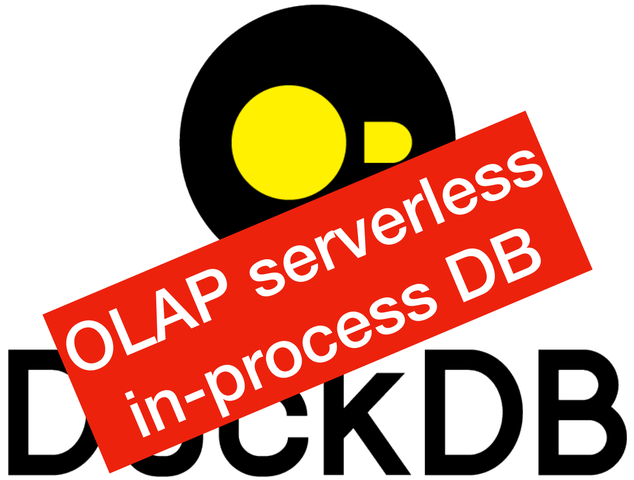

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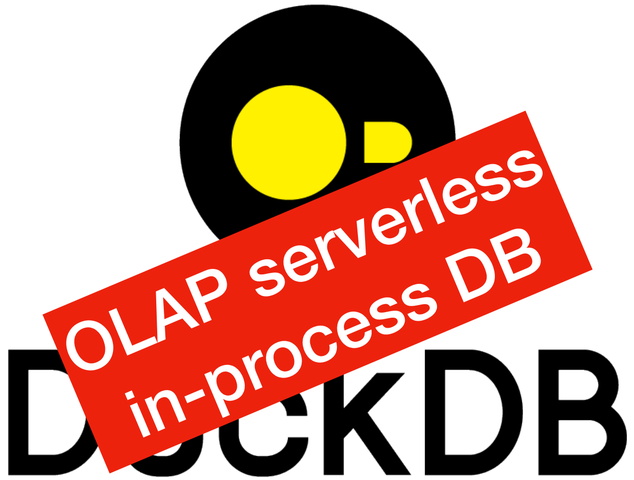

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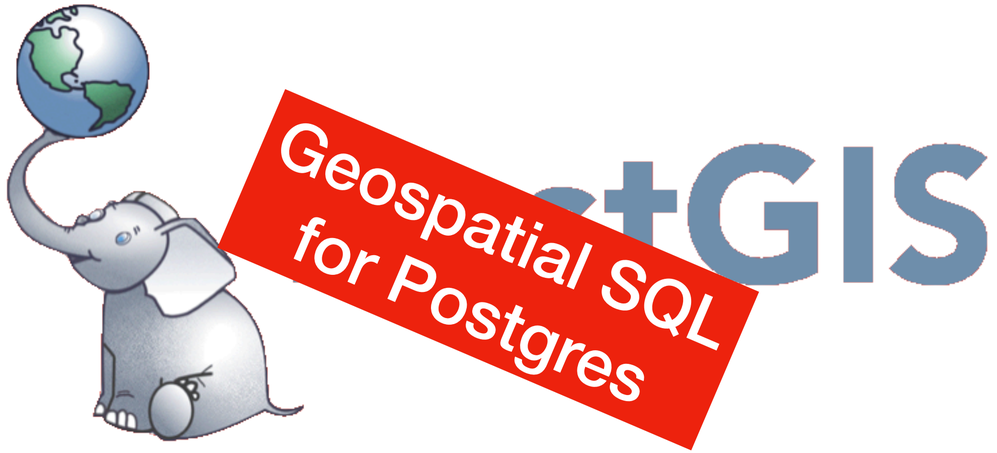

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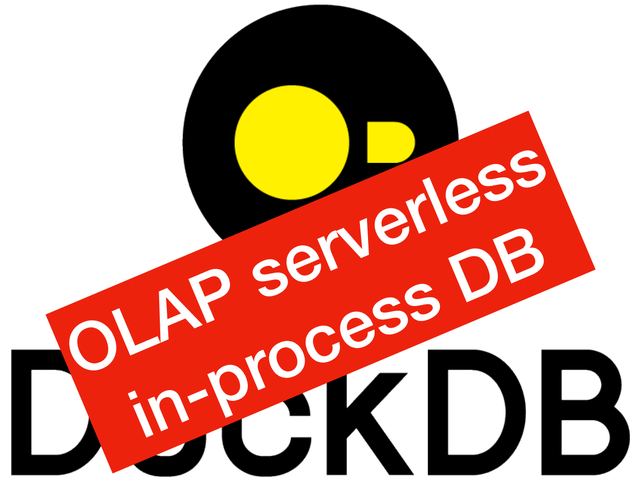
https://sedona.apache.org/latest-snapshot/api/rdocs/logo.png



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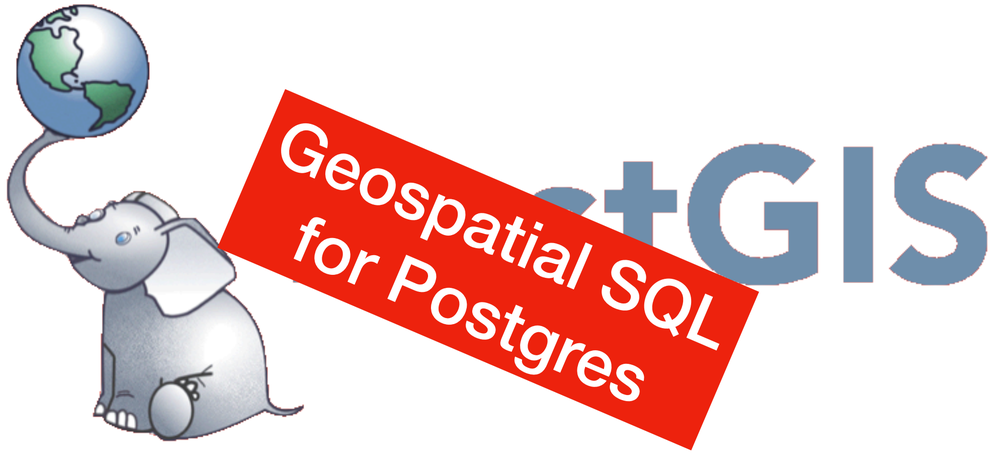

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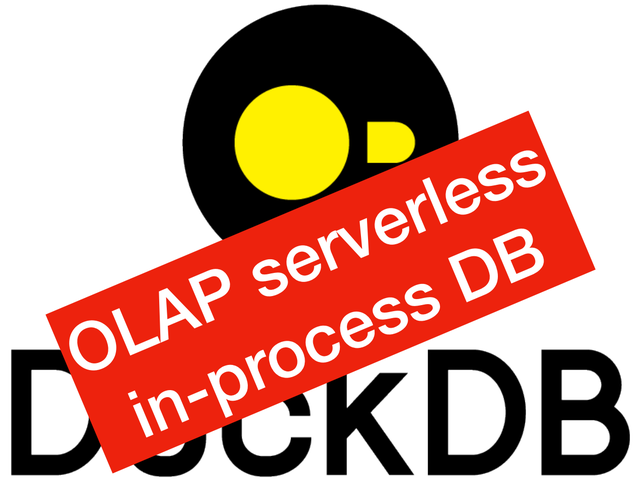

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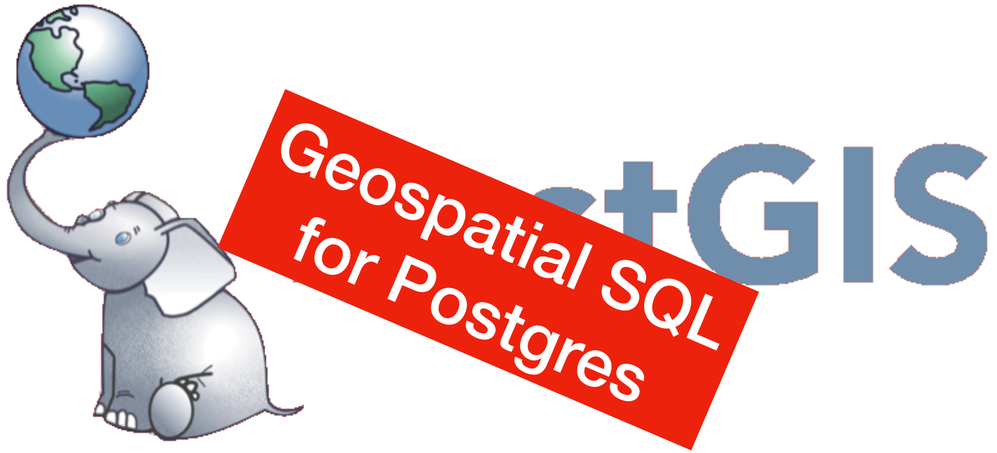

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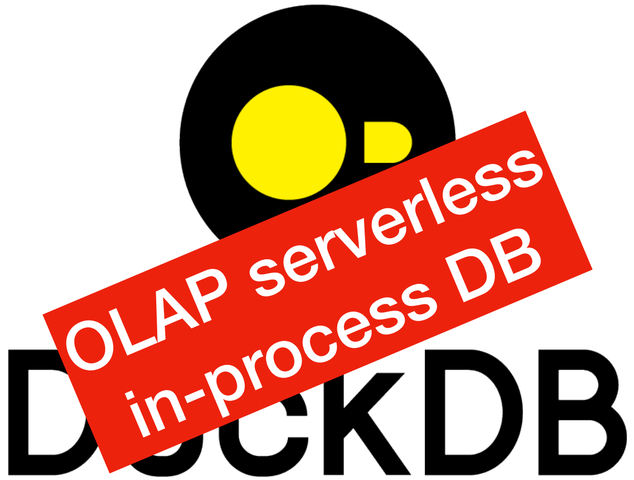

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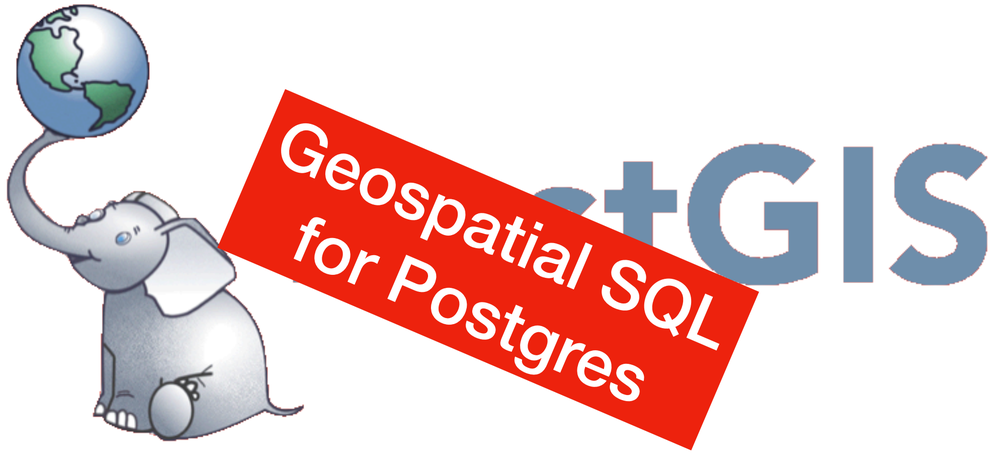
https://wherobots.com/



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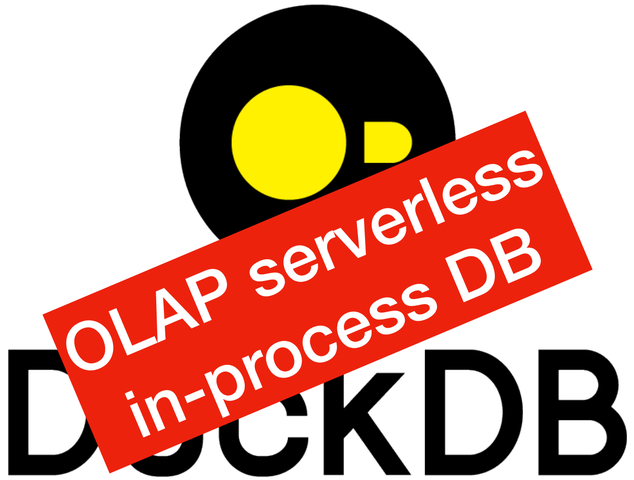

OLAP serverless in-process DB

https://www.casd.eu/en/data-tech-webinaire-parquet-duckdb/duckdb-logo-2/

Distributed geospatial processing on Spark

https://sedona.apache.org/latest-snapshot/api/rdocs/logo.png

Cloud-native geospatial data platform

Geospatial SQL for Postgres

PostGIS

https://postgis.net/

Next Steps

Observations and Recommendations

- Geopandas is a fine tool for spatial join processes…
- …but at the scale we're working at, other tools merit experimentation
- Make sure to use combination of:

Next Steps

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- Make sure to use combination of:
  - Partitioning of data

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- Geopandas is a fine tool for spatial join processes…
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Observations and Recommendations

- Geopandas is a fine tool for spatial join processes…
- …but at the scale we're working at, other tools merit experimentation
- Make sure to use combination of:
  - Partitioning of data
  - Pre-filtering
  - `.parquet` and other optimized data formats

Thanks!

https://github.com/sralter/pymaap