Reproducibility review of: Window Operators for Processing Spatio-Temporal Data Streams on Unmanned Vehicles

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Reviewed paper

> *Tobias Werner and Thomas Brinkhoff: Window Operators for Processing Spatio-Temporal Data Streams on Unmanned Vehicles. AGILE GiScience Ser., 1, 21. https://doi.org/10.5194/agile-giss-1-21-2020, 2020.*

Summary

The reproduction was successful. Based on an updated data and code archive provided by the authors (extending the original anonymous supplement), I was able to deploy a database with the newly implemented functions and insert the test data. All but one data-based figures could be recreated with the provided functions.

Reproducibility reviewer notes

Reproduction

Following the instructions in `readme.txt` I conducted the following steps.

I./II. Database setup and window operators

I started a database locally with Docker using the closely matching tag `11-2.5`:

```
docker run --rm -it --name windowoperators -p 5432:5432 -e POSTGRES_PASSWORD=password postgis/postgis:11-2.5
```

Add `auv` database (using a second terminal and the same image):

```
docker run -it --link windowoperators:postgres --rm postgis/postgis:11-2.5 \
  sh -c 'exec psql -h "$POSTGRES_PORT_5432_TCP_ADDR" -p "$POSTGRES_PORT_5432_TCP_PORT" -U postgres'
```

```
postgres=# CREATE DATABASE auv;
CREATE DATABASE
postgres=# \l
                                    List of databases
       Name       |  Owner   | Encoding |  Collate   |   Ctype    |   Access privileges
------------------+----------+----------+------------+------------+-----------------------
 auv              | postgres | UTF8     | en_US.utf8 | en_US.utf8 |
 postgres         | postgres | UTF8     | en_US.utf8 | en_US.utf8 |
 template0        | postgres | UTF8     | en_US.utf8 | en_US.utf8 | =c/postgres          +
                  |          |          |            |            | postgres=CTc/postgres
 template1        | postgres | UTF8     | en_US.utf8 | en_US.utf8 | =c/postgres          +
                  |          |          |            |            | postgres=CTc/postgres
 template_postgis | postgres | UTF8     | en_US.utf8 | en_US.utf8 |
(5 rows)
```

Then I ran the creation script from the directory of the file `create_windows.sql`:

```
docker run -it --link windowoperators:postgres --rm -v $(pwd):/work postgis/postgis:11-2.5 \
  sh -c 'exec psql -h "$POSTGRES_PORT_5432_TCP_ADDR" -p "$POSTGRES_PORT_5432_TCP_PORT" -U \
          postgres -d auv -a -f /work/create_windows.sql'
Password for user postgres:
-- PostgreSQL version 11.5
-- PostGIS version 2.5.3
-- Load spatial extension
create extension postgis;
CREATE EXTENSION

[..]
```

III. Python environment

The authors provide textual instructions for recreating the Python environment using miniconda and list the used versions. Since no ready-to-use environment definition was available and I am not familiar with miniconda, I created a snapshot using Pipenv using local Python 3.8 installation. The installation of the psycopg2 package from source failed and I installed `psycopg2-binary` in the latest available version instead. The resulting `Pipfile` is as follows:

```
[[source]]
name = "pypi"
url = "https://pypi.org/simple"
verify_ssl = true

[dev-packages]

[packages]
geopandas = "==0.6.1"
psycopg2-binary = "==2.8.5"
matplotlib = "==3.2.2"

[requires]
python_version = "3.8"
```

IV. Data insertion

```
pipenv run python database.py
```

This command starts a counter going up to 35553, which took at least 12 hours (roughly one insertion per second) on my system (8 cores, 40GB RAM, SSD). This seemingly long time to insert a small number of records is due to the implemented operators being triggered on every insertion.

V. Evaluate results and plot figures

Connecting to the database, I see the following tables/values:

```
postgres=# \c auv
You are now connected to database "auv" as user "postgres".
auv=# \dt
                     List of relations
 Schema |               Name                | Type  |  Owner
--------+-----------------------------------+-------+----------
 public | area                              | table | postgres
 public | area_window_result                | table | postgres
 public | jumping_distance_window_result    | table | postgres
 public | location_stream                   | table | postgres
 public | session_distance_window_result    | table | postgres
 public | sliding_distance_window_result    | table | postgres
 public | sliding_window_result             | table | postgres
 public | spatial_ref_sys                   | table | postgres
 public | tilting_distance_window_result    | table | postgres
 public | tilting_waypoint_window_result    | table | postgres
 public | tilting_window_params             | table | postgres
 public | tilting_window_result             | table | postgres
 public | waypoints                         | table | postgres
(13 rows)

auv=# SELECT * FROM area_window_result LIMIT 5;
         time          |                        geom
-----------------------+----------------------------------------------------
 2019-03-01 12:40:25.8 | 0101000020787F00003A61D1BF763D1A4143FD6A8190C55641
 2019-03-01 12:40:26   | 0101000020787F0000C9D4A7D3753D1A411553938C90C55641
 2019-03-01 12:40:26.2 | 0101000020787F0000DE687EE7743D1A415EAABB9790C55641
 2019-03-01 12:40:26.4 | 0101000020787F0000731D55FB733D1A411C03E4A290C55641
 2019-03-01 12:40:26.6 | 0101000020787F00008AF22B0F733D1A414F5D0CAE90C55641
(5 rows)

auv=# SELECT schemaname,relname,n_live_tup
auv-#   FROM pg_stat_user_tables
auv-#   ORDER BY n_live_tup DESC;
 schemaname |             relname              | n_live_tup
------------+----------------------------------+------------
 public     | tilting_distance_window_result |      35554
 public     | location_stream                  |      35554
 public     | session_distance_window_result |      35554
 public     | tilting_window_result            |      35554
 public     | tilting_waypoint_window_result |      35553
 public     | area_window_result               |      29266
 public     | spatial_ref_sys                  |       5757
 public     | sliding_distance_window_result |       1364
```

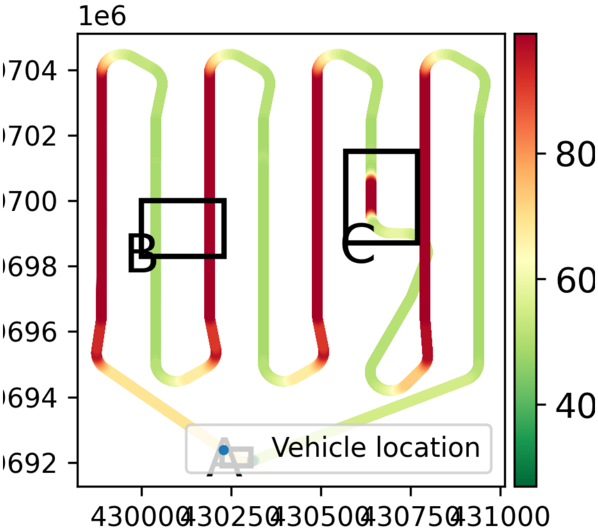
```
 public      | jumping_distance_window_result |        543
 public      | waypoints                      |         57
 public      | sliding_window_result          |         16
 public      | tilting_window_params          |          1
 public      | area                           |          1
(13 rows)
```

There are 8 `_result` tables, with different number of rows, as can be expected due to the different operators.

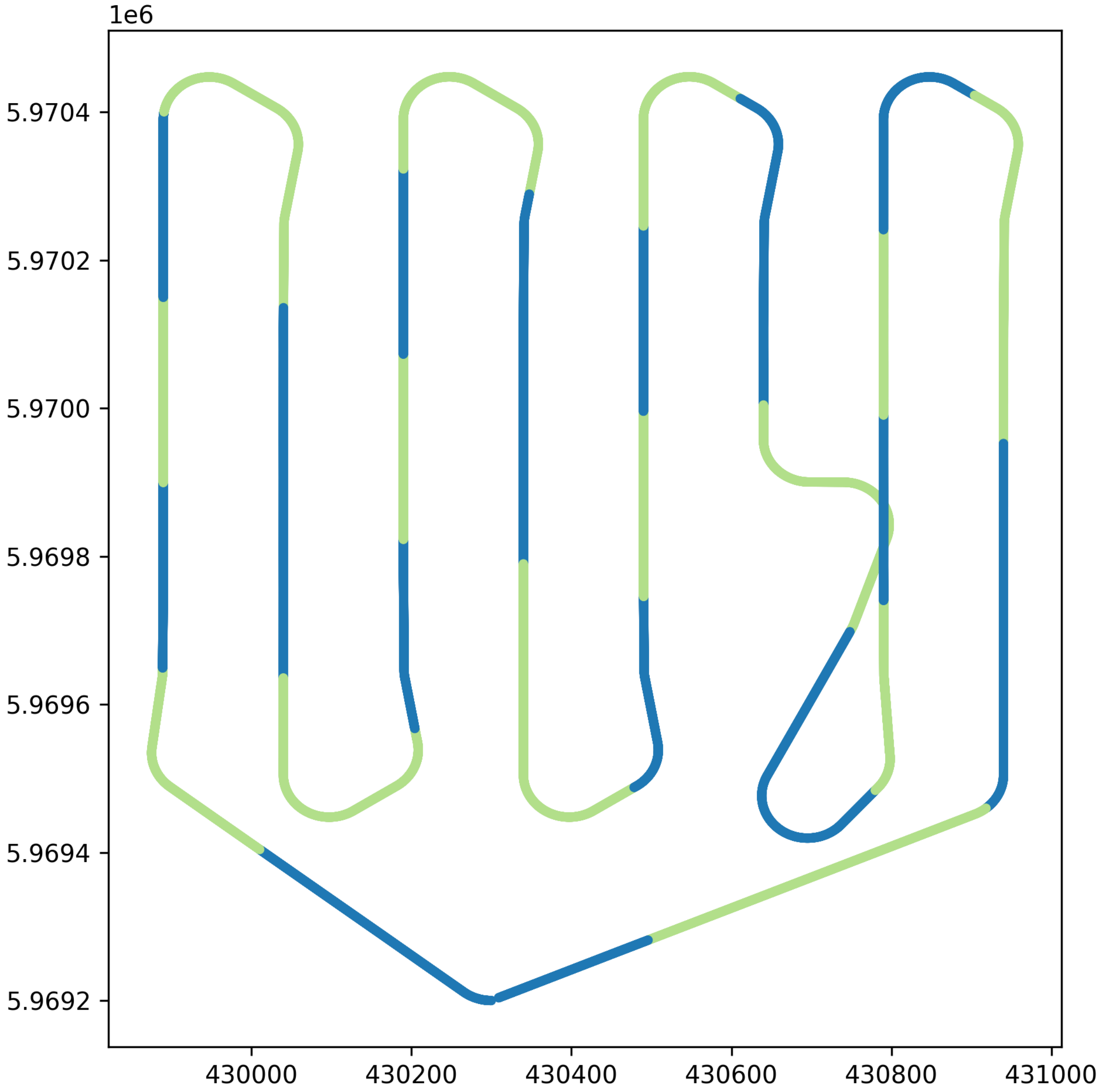
Plots

The following plots were created with these function calls (prepending `pipenv run` to set the computing environment). Where a file save command was missing, the plots were saved to files manually. *Fig. 14 seems to be a data-based plot but the code is missing.*

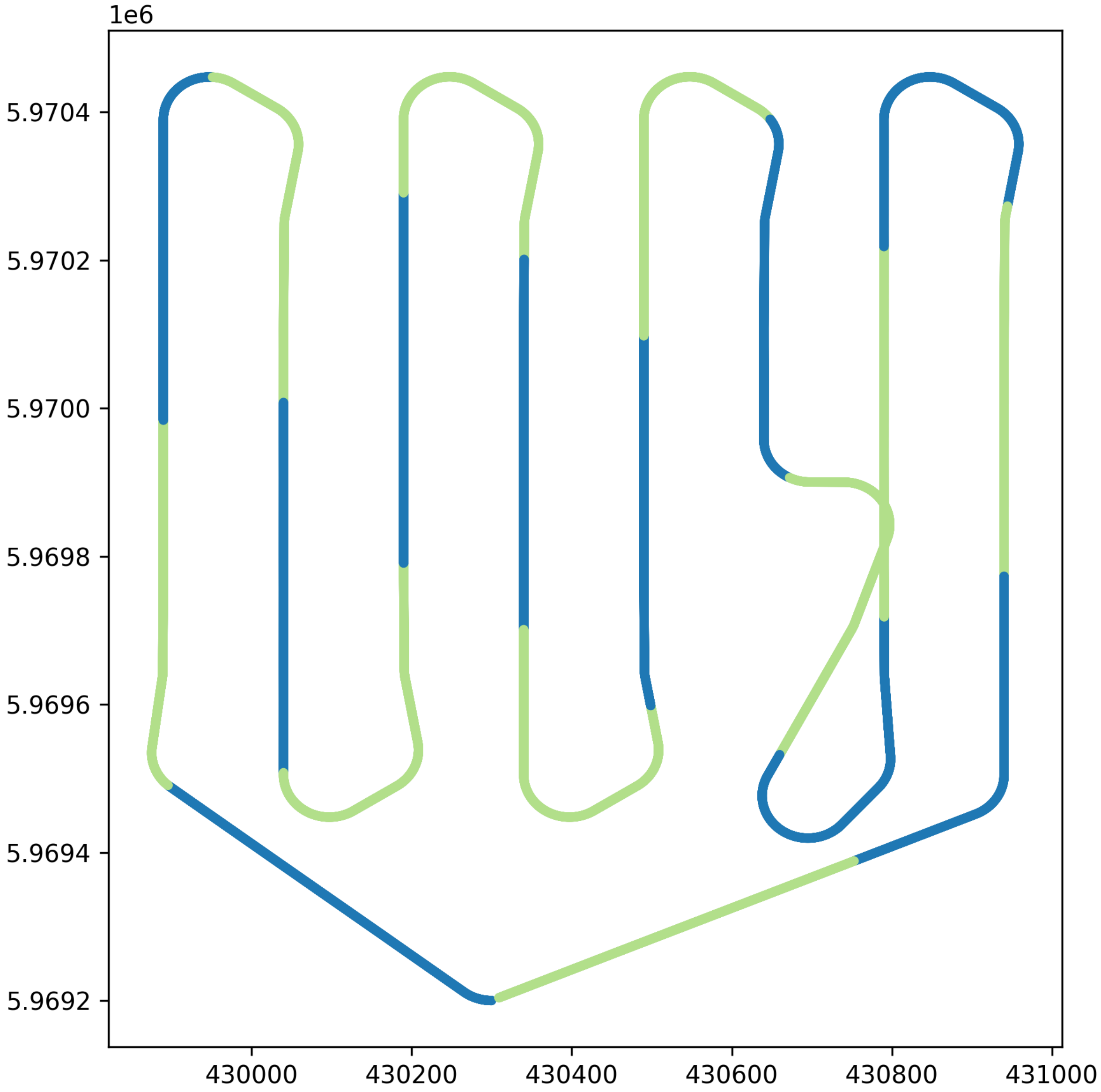
Plot density track (Fig. 2), `pipenv run python plot_density_track.py`



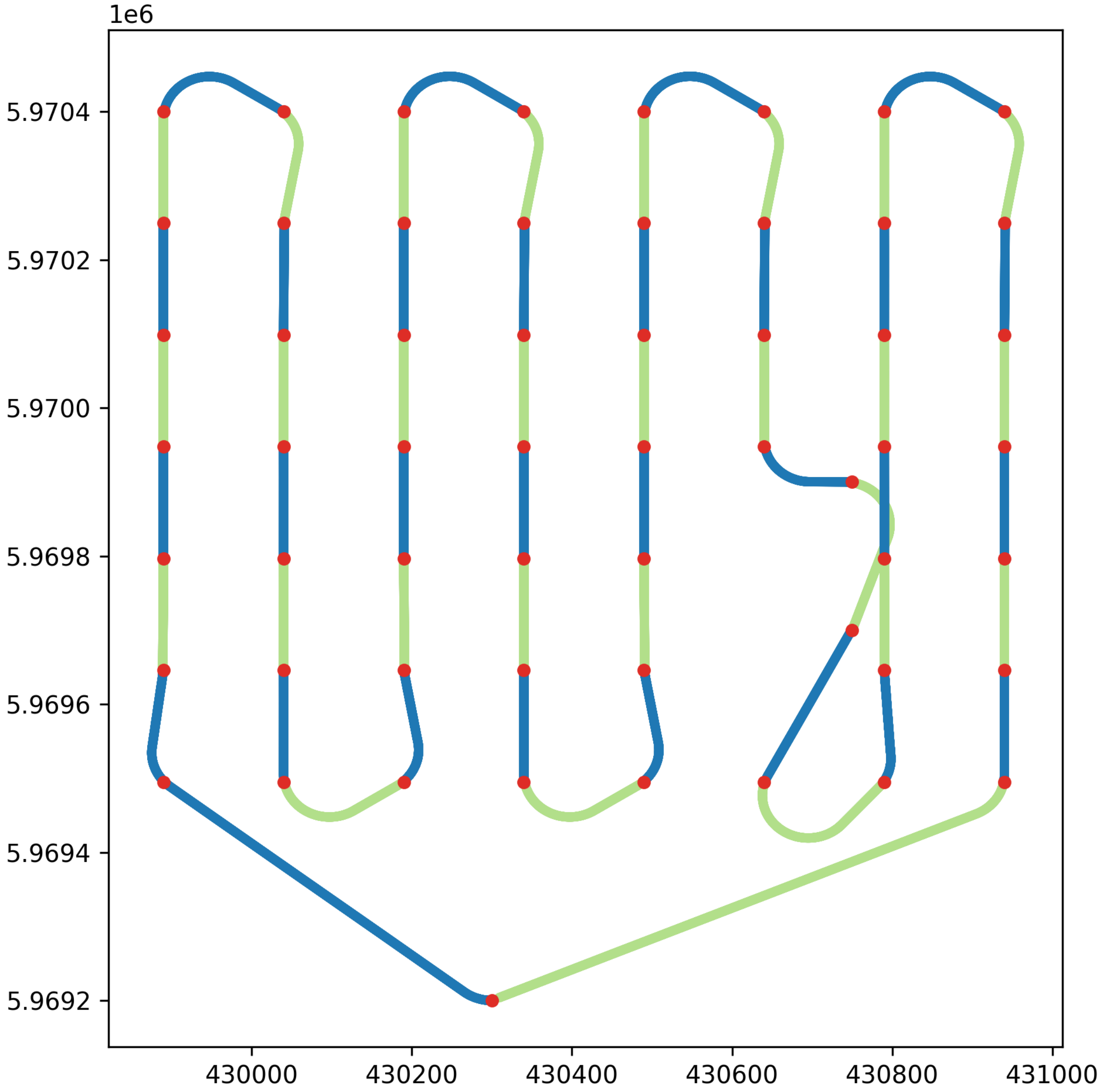
Plot tilting window (Fig. 9), `pipenv run python plot_tilting_window.py`



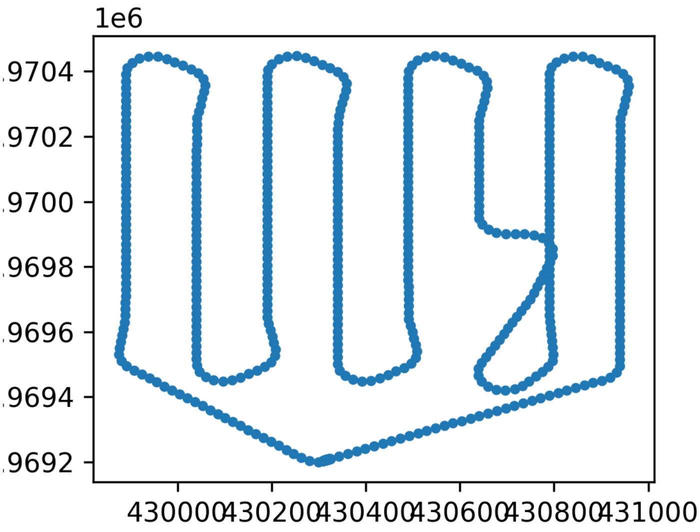
Plot tilting distance window (Fig. 11), `pipenv run python plot_tilting_distance_window.py`



Plot tilting waypoint window (Fig. 13), `pipenv run python plot_tilting_waypoint_window.py`



Plot jumping distance window (Fig. 15), `pipenv run python plot_jumping_distance_window.py`



GStream tool

I can confirm the authors' SQLite package extension compiles following the commands in `travis.yml`: there is a file `libstreams.so` afterwards. Running `GStream/test/src []$ python gstream_test.py` runs 7 tests and results in a message "OK". Since the SQLite extension was included for the sake of completeness but was not used in the evaluation of the article, I did not inspect this tool further.

Conclusion

An excellent example of a reproducible computational workflow, with only some potential to improve automation and documentation for third parties.

Comments to the authors

The given repository is an excellent attempt at trying to make a workflow reproducible. The documentation is good, though steps could be automated a little bit further. I have the following concrete recommendations:

- Provide a reusable snapshot of the environment (`environment.yml`)
- Document expected execution times clearly, with the hardware environment they were based on; ideally, provide a small sample dataset that demonstrates the functionality of the code within a few minutes, and document the expected numerical outcomes
- Document how to determine if the created tables are "correct" (how many rows, what summary statistics to expect)
- Use (and provide) a script for the database creation process (do not assume the person evaluating your work knows SQL)
- Save all plots to files, so display properties can be controlled better

Comments on first supplement

The original data and code supplement did not include the code for creating the figures, and lacked a documentation of all steps, e.g., it was unclear how to evaluate the results sets in the window tables. This supplement is still available online at https://figshare.com/s/cc758d056c8c6f193e52. The instructions or code to create the figures from the paper were missing.