DATABASE AND GRAPH-BASED ANALYSIS EPA-SWMM URBAN FLOOD MODELLING

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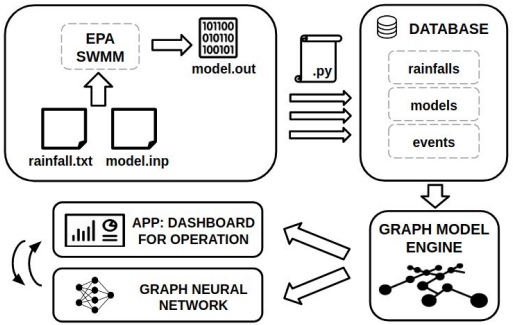
- **Abstract:** This work illustrates the steps on the development of a graph-based approach for the analysis of a high-resolution urban 1D hydrological-hydraulic model. Current tools focus on a processed file generated by EPA-SWMM (.RPT), this tool works on the unprocessed binary output file (.OUT). A database with the data and results of the EPA-SWMM model is build in PostgreSQL. The results of the model are used to build a graph network of the hydraulic system, allowing a deeper analysis over the sub-basins of each node.

- Keywords: hydroinformatics, urban flooding, surrogate modelling, database, graphs.

METHODS

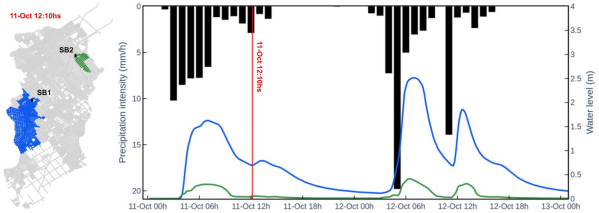
General workflow



1. A Python script processes the three files and loads the data on the database,
2. The database was designed scalable and flexible.
3. The main engine is a Python class capable of building graphs and subgraphs for any event, at any elapsed time.
4. **Next steps:**
   a. Build an app with a user friendly interface for operational tasks and decision making support.
   b. Develop a Graph Neural Network for water levels estimation. A priori, the approach will be a *graph classification* problem.

RESULTS

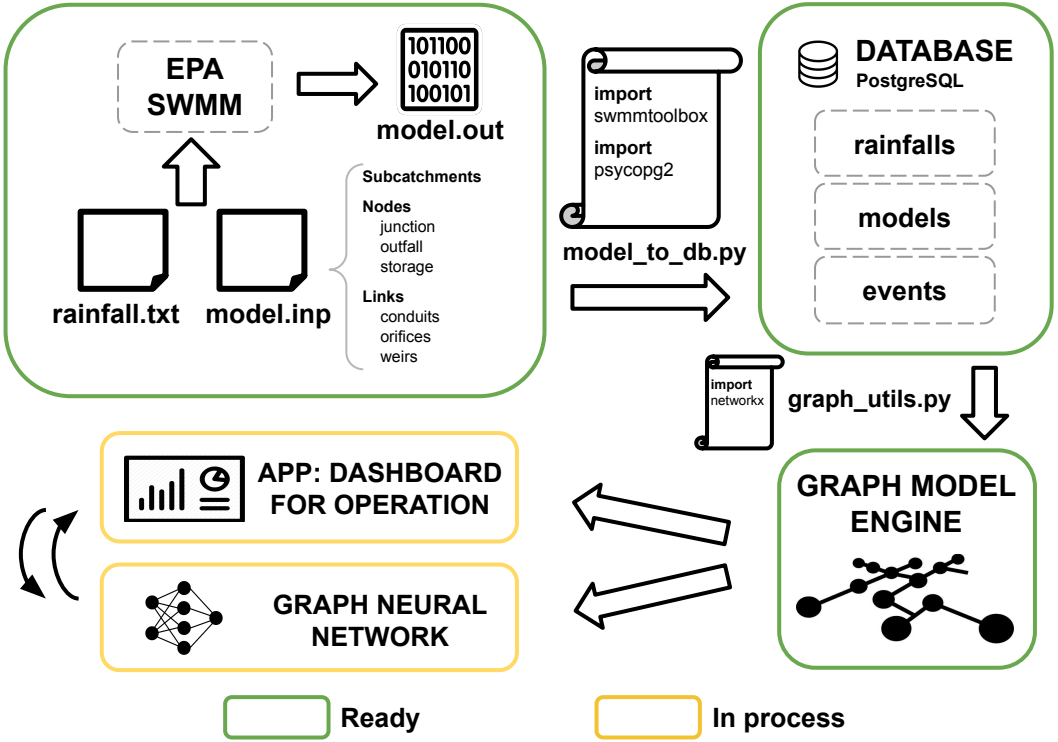
- The software is capable of fully pre-process and load the data generated by the EPA-SWMM into the database.
- The database models de data and provides the SQL interface for querying and comparing the events results.
- The engine uses the graph as an intermediate step, to provide a richer and more complex querying alternative.
- An interesting feature of the engine is the possibility of building subgraphs: graphs of independent internal subcatchments. These subgraphs also provide aggregated data, on the outlet node, of the variables of the chosen subcatchment.



CONCLUSIONS

- The graph approach as a surrogate model was successful. The complexity and high dimensionality of the basin is efficiently represented by a graph.
- By the present time, we are not able to exploit every feature of pure graphs, because of the physical limitations of the basin. Although we believe some research could be done.
- The flexibility for querying the model is very interesting for daily operational tasks. This can be leveraged by incorporating more sensors for real-time data.
- Performance is the main issue. Processing the binary file takes too long (24hs for ~20k nodes). We are evaluating a distributed processing solution and a direct streaming of results form the EPA-SWMM to the database.

- **Next steps:**
  - Development of the App.
  - Modifications on the main engine for a fluent communication with the Pytorch framework. The neural network is being built with the library Pytorch Geometric.
  - Implementation of the graph neural network.
    - The first approach will be a convolutional network, without time as a dimension, so that the model can feed the model with *any* subgraph.


EPA SWMM
101100
010110
100101
model.out
rainfall.txt
model.inp
Subcatchments
Nodes
junction
outfall
storage
Links
conduits
orifices
weirs
import swmmtoolbox
import psycopg2
model_to_db.py
DATABASE
PostgreSQL
rainfalls
models
events
import networkx
graph_utils.py
GRAPH MODEL ENGINE
APP: DASHBOARD FOR OPERATION
GRAPH NEURAL NETWORK
Ready
In process

DATABASE DESIGN AND GRAPH-BASED ANALYSIS FOR SWMM URBAN MODELLING

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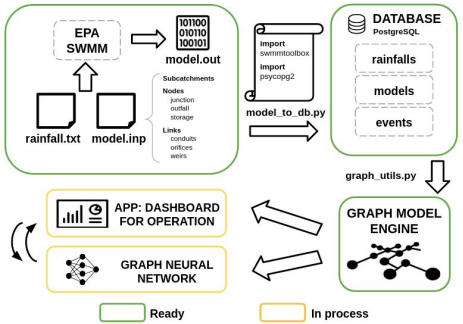
- **Abstract:** This work illustrates the steps on the development of a graph-based approach for the analysis of a high-resolution urban 1D hydrological-hydraulic model. The basin of San Juan - Jimenez (SJJ, Buenos Aires, Argentina) is used as a test case, where the model was previously calibrated and validated. A database with the data (.INP file) and results (.OUT file) of the EPA-SWMM model is built in PostgreSQL. The database is used to build a graph network of the hydraulic system, allowing a deeper analysis over the sub-basins of each node.

- **Keywords**: hydroinformatics, urban flooding, surrogate modelling, database, graphs.

METHODS

- A Python script processes the three EPA-SWMM files and loads the data into the PostgreSQL database.
- The database design admits the integration of multiple models, rainfalls and events for a more efficient storage.
- The main engine is a *Python Class* responsible for building graphs (basin) and subgraphs (sub-basins) for any event, at any elapsed time of the simulation.
- This graph consists of SWMM-nodes connected by SWMM-links, storing every hydraulic and hydrological properties of each element at any elapsed time.

Figure 1: General workflow



RESULTS

- The sub-graphs generated are composed by the predecessor tree and the chosen node as outlet of the sub-basin, with aggregated data such as accumulated precipitation, mean impervious area and the area associated to the sub-basin, etc.

	SB1	SB2
Sub-basin Area [Ha]	751	99
Impervious Area [%]	47	68

Table 1: Attributes of two sub-basins.

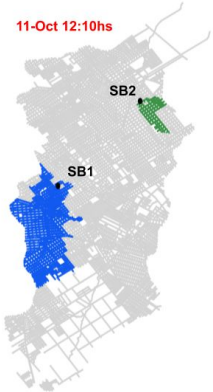
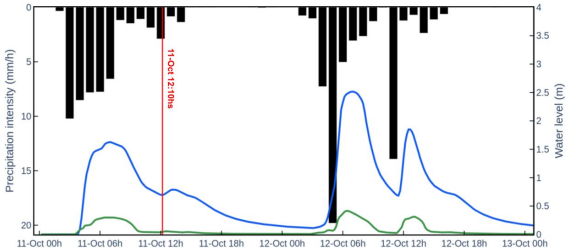


Figure 2: SJJ basin (right).

Figure 3: Water level of two different nodes for a given elapsed-time (below).



CONCLUSIONS

- The query time of the .OUT file was reduced 500 times: from 5 seconds directly from the binary file (swmmtoolbox library), to 10 milliseconds querying from the database.
- Performance is the main issue. Processing the binary file takes too long (24hs for ~19.000 nodes, 25.000 links and 18.000 subcatchments). It is being evaluated a distributed processing solution and a direct streaming of results from the EPA-SWMM to the database.
- The flexibility for querying the model is very interesting for daily operational tasks and decision-making support.
- The graph approach as a way of representation of sub-basins characteristics is successful. The complexity and high dimensionality of the basin is efficiently represented by a graph; nodes, edges and their attributes.

REFERENCES

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