

Editing Watertight Manifold Polyhedra using Face Shifts with Automatic Topological Updates and Edge Flips

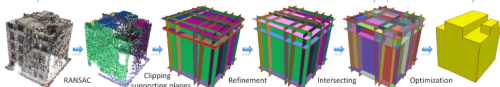
Florent GENIET, Bruno VALLET,
Mathieu BREDIF

Univ Gustave Eiffel, ENSG, IGN, LASTIG
January 22, 2024

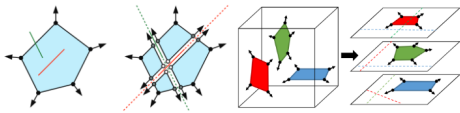
Context : State of the art

Problem : Create a **Building reconstruction** method **cheap**, with **high fidelity** and **robust to data defaults**.

Automatic methods : fast/cheap, but lack of robustness on data defaults.

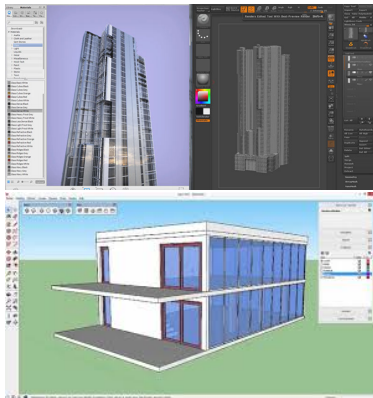


Nan, Liangliang & Wonka, Peter. (2017). PolyFit: Polygonal Surface Reconstruction from Point Clouds



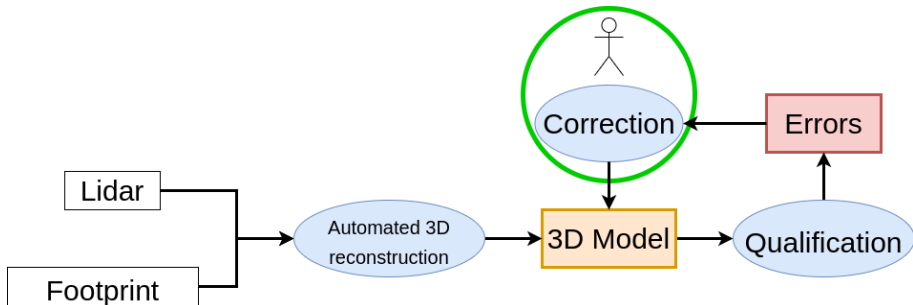
Jean-Philippe Bauchet, Florent Lafarge. Kinetic Shape Reconstruction. ACM Transactions on Graphics, 2020.

Manual methods : slow/expensive, but high fidelity and high robustness to data defaults

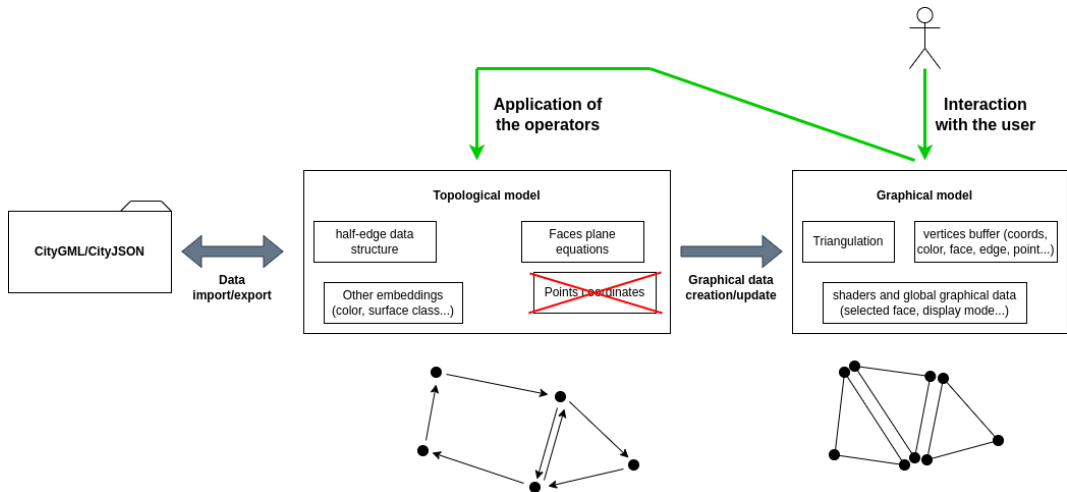


Context : Creation of a semi-automatic reconstruction pipeline

Manual correction method : we want to correct **both the geometry and the topology** of the objects.



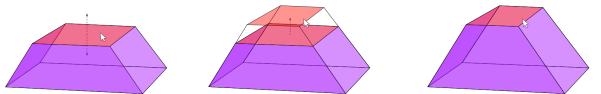
Polyedral modeler overview



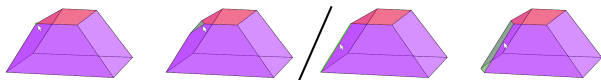
Operators

Operators

■ Face Shift



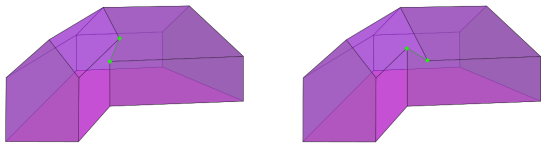
■ Face creation



From an vertex

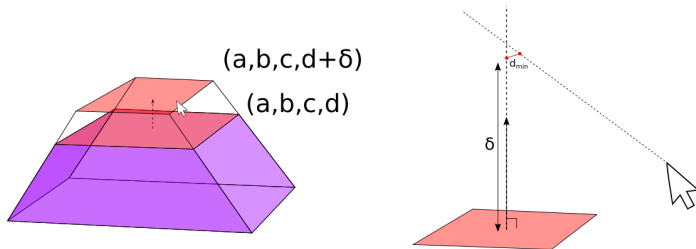
From an edge

■ Edge Flip



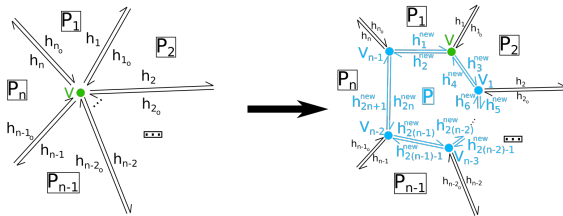
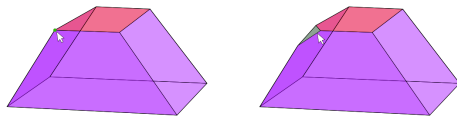
Shift operator

There is no need for topological modification ! We just modify the plane equation of the face : **translation along the normal of the face.**

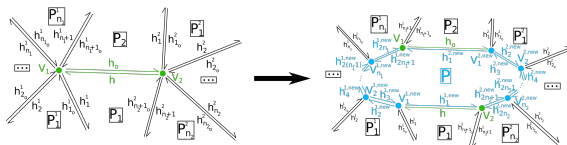
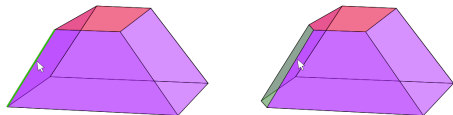


Face creation operator

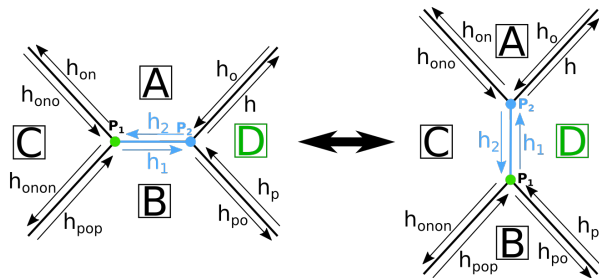
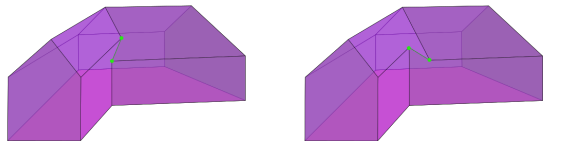
Creation from a vertex



Creation from an edge



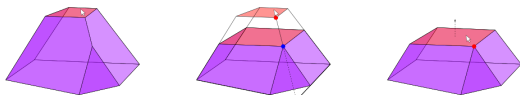
Flip operator



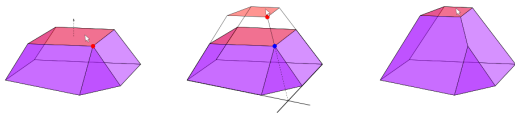
Topological Events Resolutions

Topological Event Resolutions

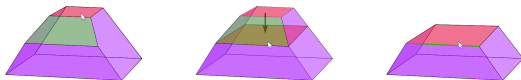
■ Edge Collapse



■ Vertex Splitting

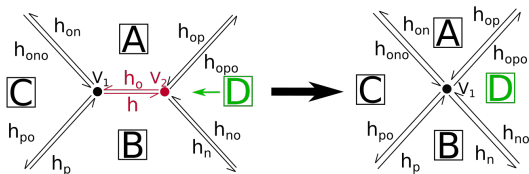
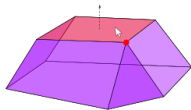
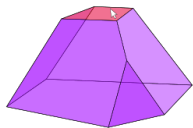


■ Face Collapse



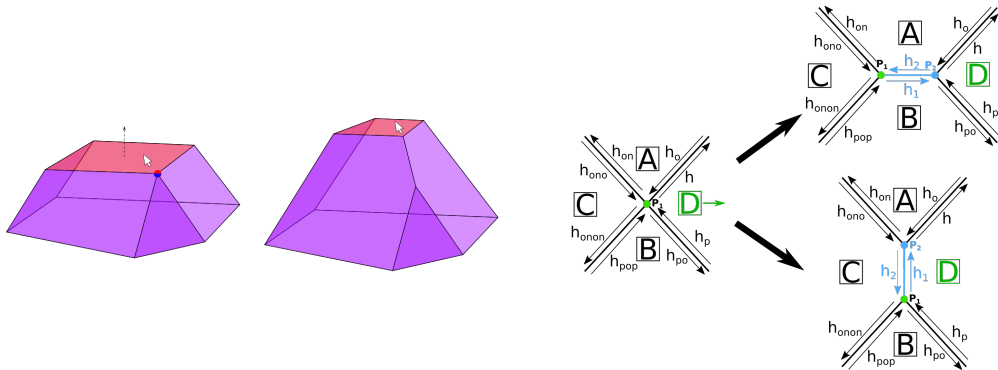
Edge Collapse

Happens when two ends of an edge collides.
Topological changes : **an edge** is transformed into a **vertex**.



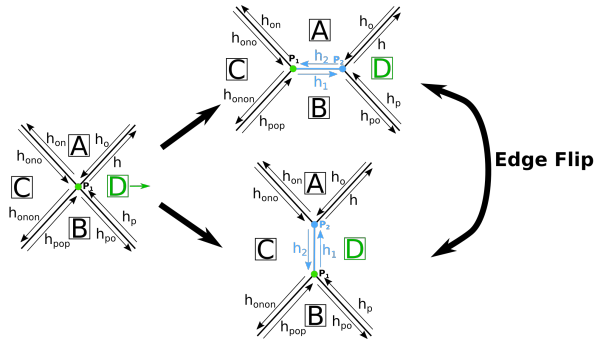
Vertex Splitting

Happens when a face adjacent to a vertex **adjacent to 4 or more faces** is shifted.
Topological changes : a **vertex** is transformed into an **edge**.



Vertex Splitting

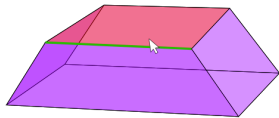
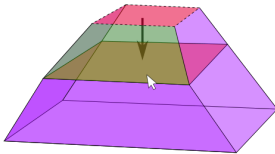
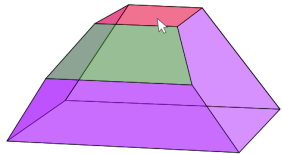
If the 2 splits are possible : choose the one creating the shortest edge.
The user can switch from a solution to the user using the edge flip.



Face Collapse

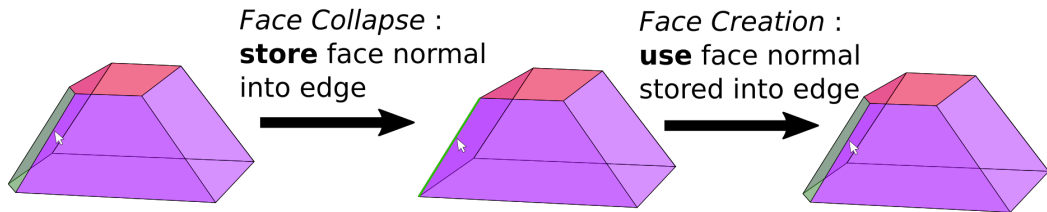
Happens **after an edge collapse**, if one of the faces adjacent to the collapsed edge only has **two edges on its exterior border**.

Topological changes : **a face is transformed into an edge**.



Face Collapse

The normal of the plane of the deleted face is stored in the newly created edge.



Conclusion

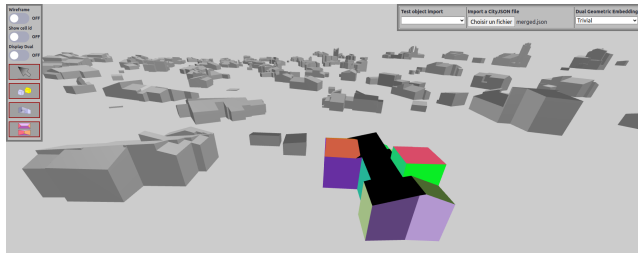


Figure: Import of a cityJSON file, with **95% of successful imports**

Future works :

- Increase **Robustness**
- **New operators** implementations (Face rotation, face cut...)
- Add **other data sources** display (LIDAR, Ortho-images...)

Conclusion

Our application is available on GitHub, and is deployed on GitHub Pages



Our repo : [https://github.com/
LelouchLiBritania/3D-Viewer.git](https://github.com/LelouchLiBritania/3D-Viewer.git)



Our demo :
[https://lelouchlibritania.github.io/
3D-Viewer/](https://lelouchlibritania.github.io/3D-Viewer/)

Thank you for your attention !!

References :

- Aurenhammer, F., Walzl, G., 2016. Straight Skeletons and Mitered Offsets of Nonconvex Polytopes. *Discrete Computational Geometry*, 56(3), 743–801. doi.org/10.1007/s00454-016-9811-5.
- Bauchet, J.-P., Lafarge, F., 2020. Kinetic Shape Reconstruction. *ACM Transactions on Graphics*. doi.org/10.1145/3376918.
- Groger, G., Kolbe, T. H., Czerwinski, A., Nagel, C., 2008. OpenGIS® City Geography Markup Language (CityGML) Encoding Standard. Version 1.0.0. Report, Open Geospatial Consortium. Accepted: 2019-10-28T20:43:28Z.
- Huang, J., Stoter, J., Peters, R., Nan, L., 2022. City3D: Large-Scale Building Reconstruction from Airborne LiDAR Point Clouds. *Remote Sensing*, 14(9), 2254. doi.org/10.3390/rs14092254. Number: 9 Publisher: Multidisciplinary Digital Publishing Institute.

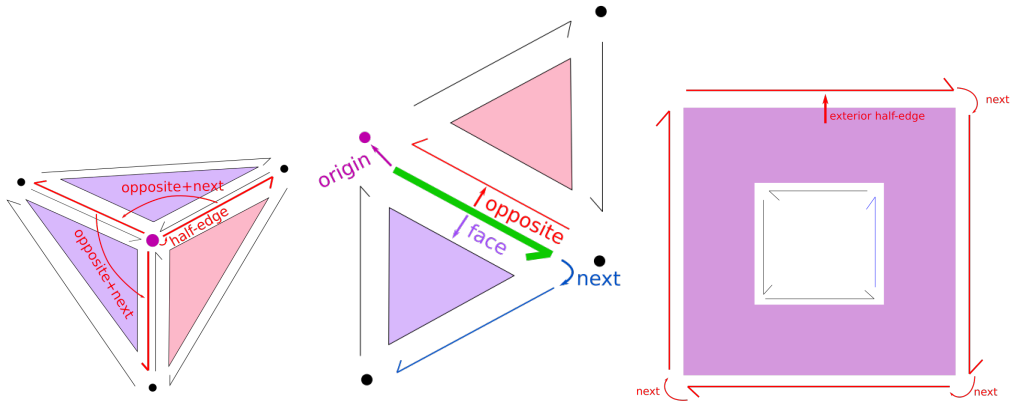
References

- Nan, L., Wonka, P., 2017. PolyFit: Polygonal Surface Reconstruction from Point Clouds. 2017 IEEE International Conference on Computer Vision (ICCV), IEEE, Venice, 2372–2380.
- Keller, E., 2011. Introducing ZBrush 4. John Wiley Sons. Ledoux, H., Arroyo Ohori, K., Kumar, K., Dukai, B., Labetski, A., Vitalis, S., 2019. CityJSON: a compact and easy-to-use encoding of the CityGML data model. Open Geospatial Data, Software and Standards, doi.org/10.1186/s40965-019-0064-0.
- Line Segment Intersection, 2008. M. de Berg, O. Cheong, M. van Kreveld, M. Overmars (eds), Computational Geometry: Algorithms and Applications, Springer, Berlin, Heidelberg, 1943.
- Ying, S., Li, L., Guo, R., 2011. Building 3D cadastral system based on 2D survey plans with SketchUp. Geo-spatial Information Science, 14(2), 129–136. doi.org/10.1007/s11806-011-0483-2. Publisher: Taylor Francis

Topological data structure

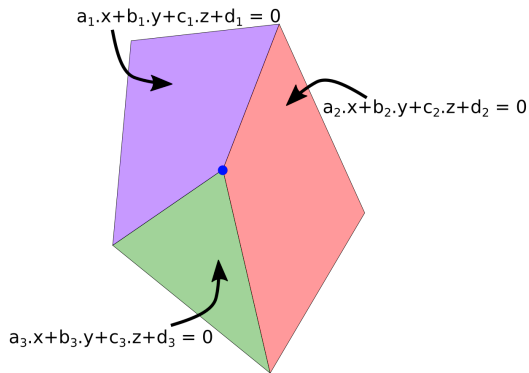
Topological data structure

Our data model is based on the **half-edge data structure**



Topological data structure

The **geometrical data** is embedded in the faces, as plane equation coefficients.



The point coordinates are the solution of the equation system :

$$\begin{cases} a_1x + b_1y + c_1z + d_1 = 0 \\ a_2x + b_2y + c_2z + d_2 = 0 \\ a_3x + b_3y + c_3z + d_3 = 0 \\ \dots \end{cases}$$