CapstoneVisionSegmentation: Room Segmentation Method Based on Computer Vision

Summary of the Method

As part of this work, we propose CapstoneVisionSegmentation, a room segmentation method based on computer vision and image processing techniques applied to vector representations derived from architectural plans. The primary objective is to automatically identify room boundaries from GeoJSON geometric data, without relying on supervised learning models.

General Principle

CapstoneVisionSegmentation relies on an intermediate transformation from vector data to raster images, by generating binary images from the vector data representing building walls. Image segmentation techniques are then used (OpenCV package) to extract room contours as closed regions, which are subsequently converted into georeferenced polygons.

Method description

**1. Preprocessing of Vector Data**

The input files consist of heterogeneous geometries (Polygons, MultiPolygons, LineStrings), often noisy or incomplete. A standardization process is applied, consisting of:

* Filtering out irrelevant entities to retain only linear primitives describing walls.
* Standardizing entities into elementary segments, enabling faithful conversion into the raster space.
* Rescaling and re-centering coordinates to ensure consistent metric resolution in the resulting image.

**2. Generation of Binary Images**

The conversion of vector segments into binary raster images constitutes a critical step of the method. Each segment is drawn as a line in a black-and-white image according to the following parameters:

* Line thickness: simulates wall width in pixels. A default value of 3 pixels is used but can be adjusted according to the quality of the input plan.
* Image resolution (DPI): defines the number of pixels per meter. We use a dpi\_choice of 50 (one pixel = 2 cm²), ensuring a balance between precision and processing efficiency.
* Dilation method: a Gaussian filter is applied during dilation to maintain consistency, especially on oblique and curved segments.

-> ***Image 1***

**3. Morphological Segmentation and Contour Detection**

Once the binary image is generated, closed areas are detected using morphological processing:

* A morphological closing operation (cv2.morphologyEx with MORPH\_CLOSE) ensures continuity of walls and fills small gaps.
* Contours are extracted using cv2.findContours() with the RETR\_CCOMP mode, providing contour hierarchy.
* Hierarchy management is essential to accurately calculate net areas by subtracting holes from parent contours.

**4. Filtering Walls and Selecting Rooms**

To differentiate rooms from walls or artifacts, filtering is based on geometric criteria:

* Minimum area: rooms must have a surface area of at least 1 m², corresponding to 2500 pixels at 50 dpi.
* Mean thickness: calculated as surface/perimeter ratio. Any object with a thickness less than 0.4 m is classified as a wall.
* The longest contour, usually representing the outer building boundary, is also removed from the analysis.

**5. Georeferencing and Polygon Conversion**

Selected contours are converted into georeferenced polygons using the metadata calculated during binary image generation:

* Pixel coordinates are transformed back into metric coordinates.
* Each polygon is enriched with properties such as real surface area (in m²) and a unique identifier.
* Final results are exported in GeoJSON format for spatial analysis and modeling.

***-> Image 3 out of 4***

**6. Visual Results and Validation**

To qualitatively assess segmentation, a colorized image of the detected contours is generated:

* Each room is filled with a distinct random color.
* The visual overlay of contours allows for validation of spatial coherence.

The method demonstrates robustness against typical imperfections in raw vector data (missing segments, open walls, etc.).

***-> Image 2***

Model Parameters

The parameters used in CapstoneVisionSegmentation are as follows:

* **dpi\_choice = 50** — 50 pixels per meter (1 pixel ≈ 2 cm).
* **thickness\_choice = 3** — wall line thickness in pixels.
* **epaisseur\_min\_m = 0.4** — minimum average thickness to classify a contour as a room (in meters).
* **surface\_min\_m2 = 1** — minimum area threshold for detected rooms (in square meters).
* **dilation method = ‘gaussian'** — ensures smooth wall rendering and consistent dilation.

Discussion

CapstoneVisionSegmentation offers a robust and lightweight alternative to traditional vector-based approaches. By leveraging computer vision techniques, the method overcomes strict vector topology requirements. It adapts to noisy and heterogeneous data typically found in degraded CAD or BIM exports, while ensuring reliable segmentation of interior spaces.

Unlike deep learning-based approaches, this method requires no training data and guarantees interpretability and reproducibility. Moreover, the integration of contour hierarchy enhances the ability to handle complex room structures, such as those containing holes or nested spaces.

However, the method relies on the accurate geometric representation of physical barriers (such as walls and doors). It cannot distinguish between adjacent rooms when there are no physical separations explicitly modeled in the vector data. For example, if doors or openings are omitted from the input plans, rooms may be incorrectly merged into a single space during the contour detection process.