

WP 3: Extracting building structures from images

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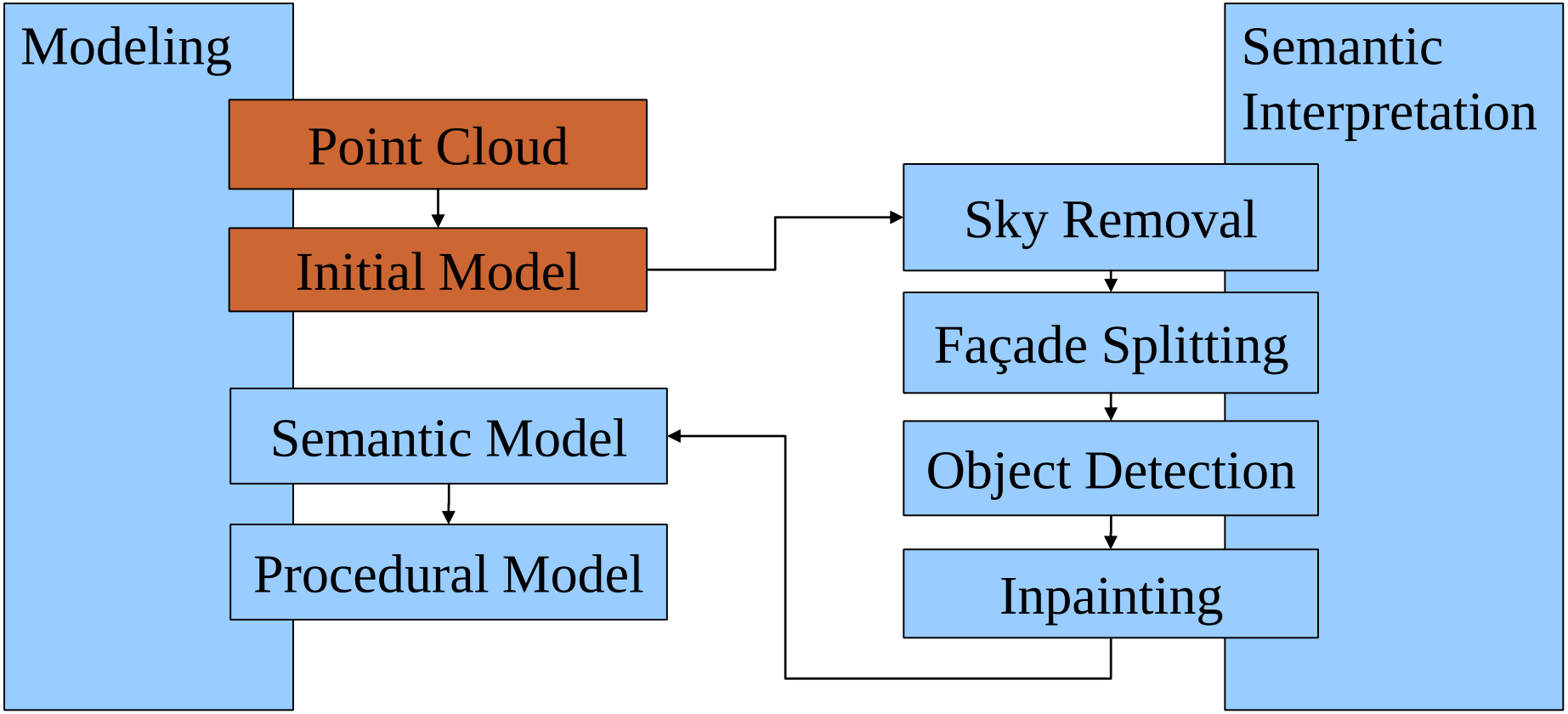
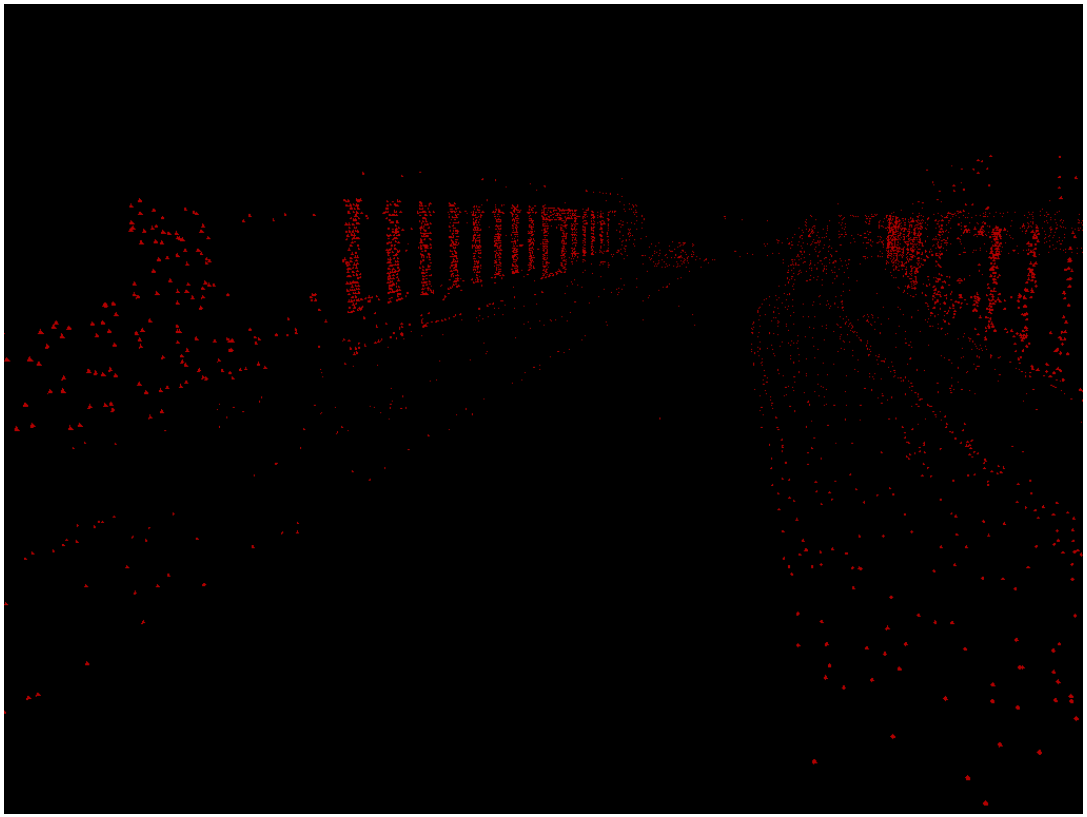
- Goal: Produce a compact 3D representation of a city
  - Façades approximated by planes
  - Add additional value by semantic information



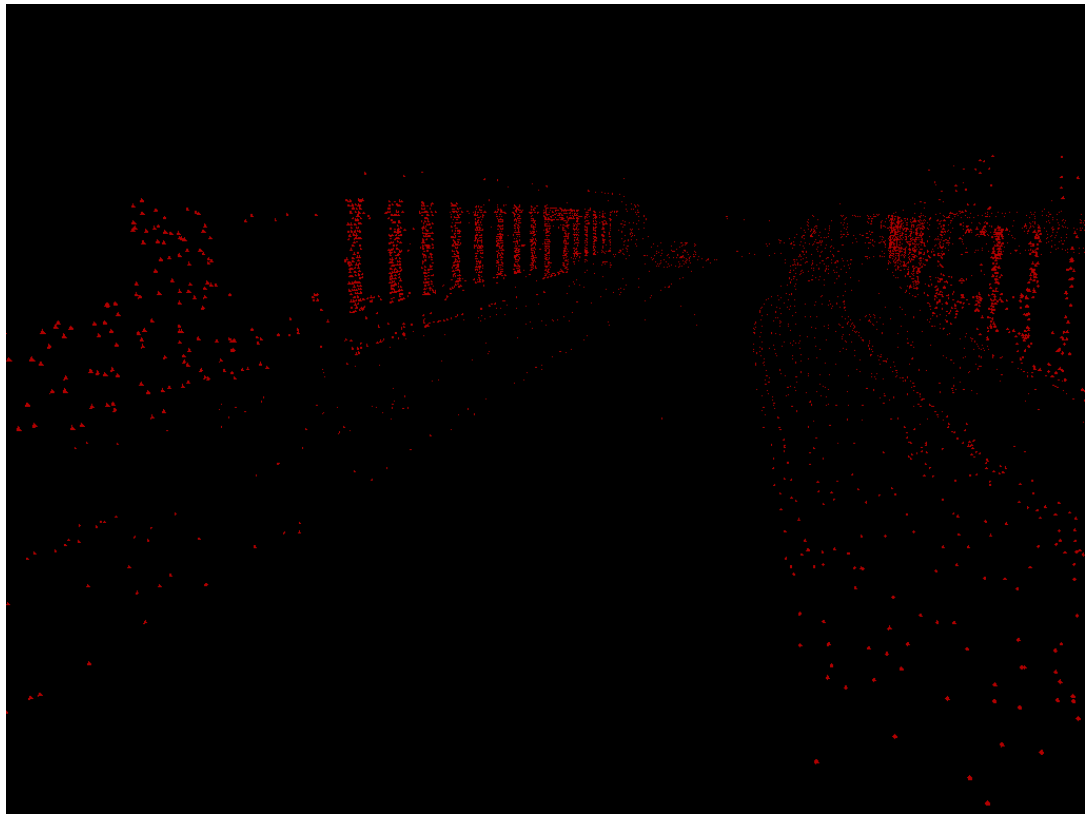
Overview


Modeling
Point Cloud
Initial Model
Semantic Model
Procedural Model
Semantic Interpretation
Sky Removal
Façade Splitting
Object Detection
Inpainting

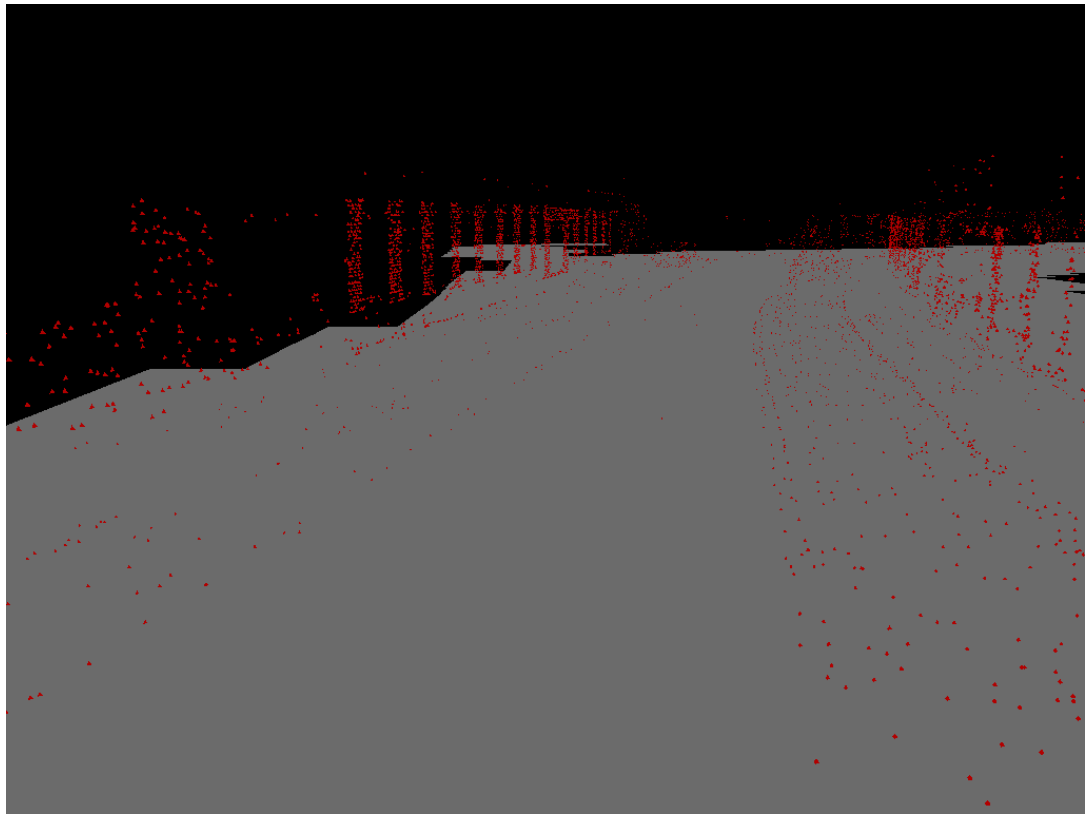
- Initial point cloud
  - Based on visual features



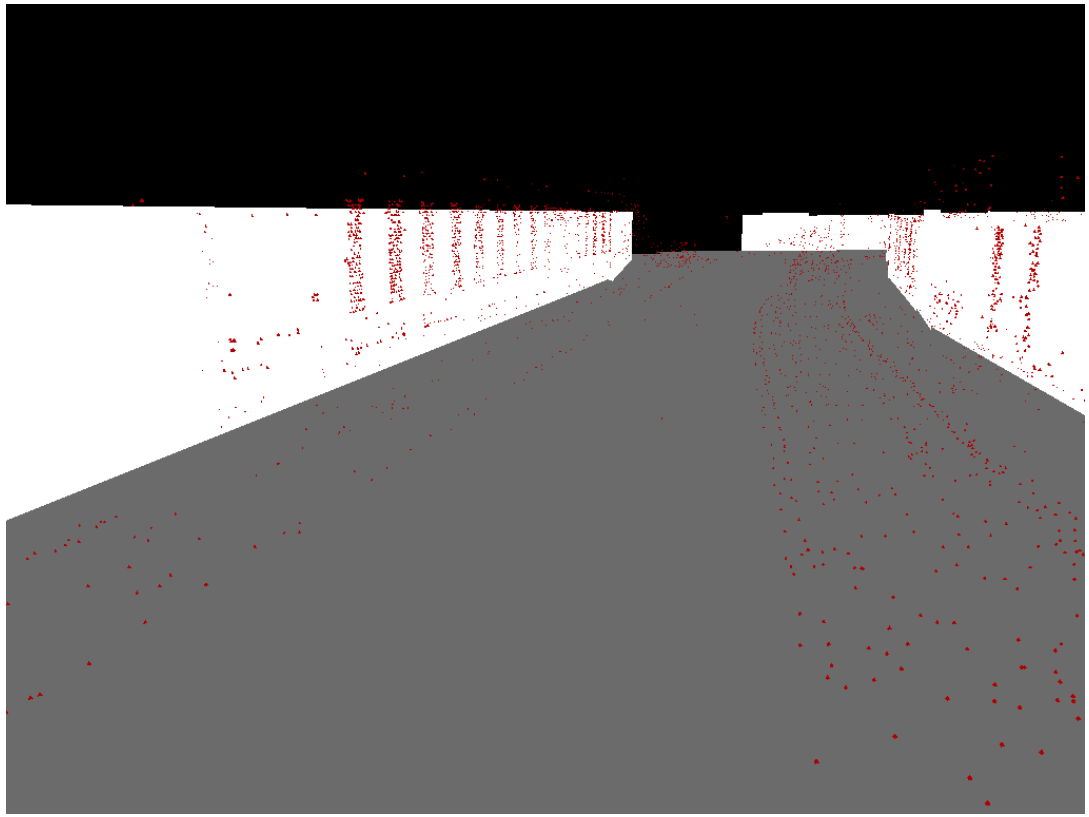
- Ground plane estimation
  - Lowest point used as initial estimate
  - Refined with locally-weighted mean filtering



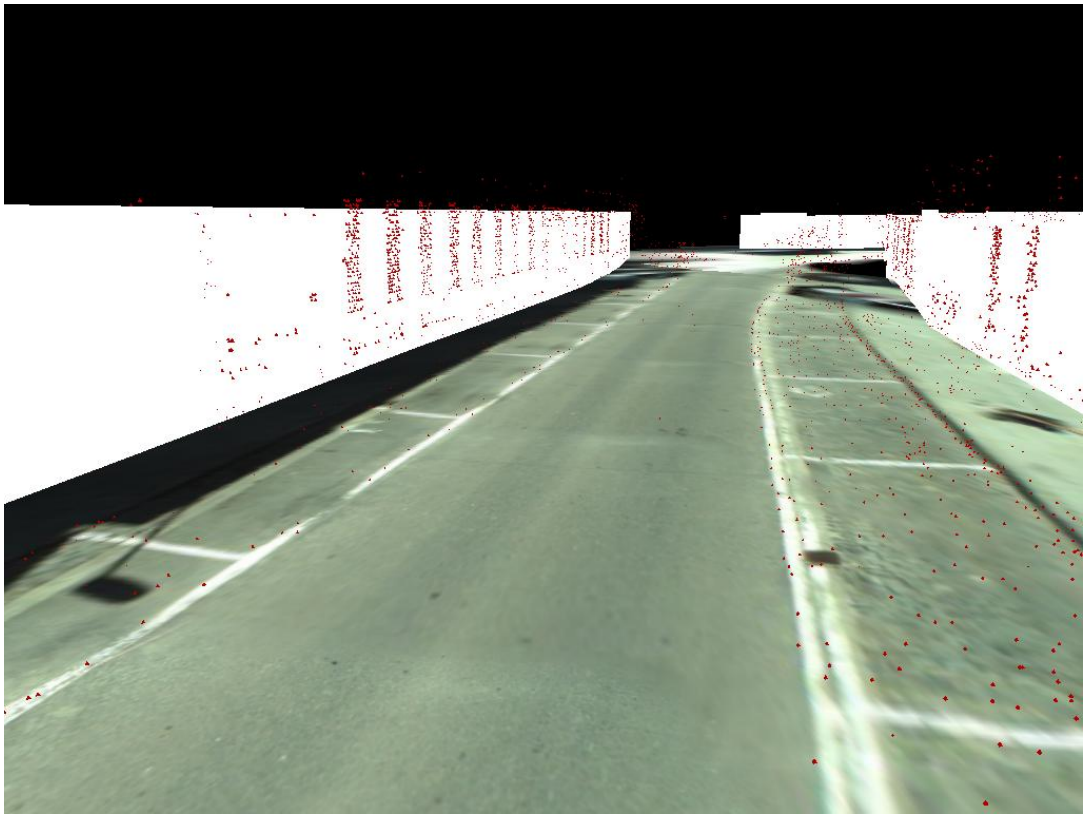
- Wall plane estimation
  - Perpendicular to ground plane
  - Local RANSAC-based estimator
  - Local planes conjoined



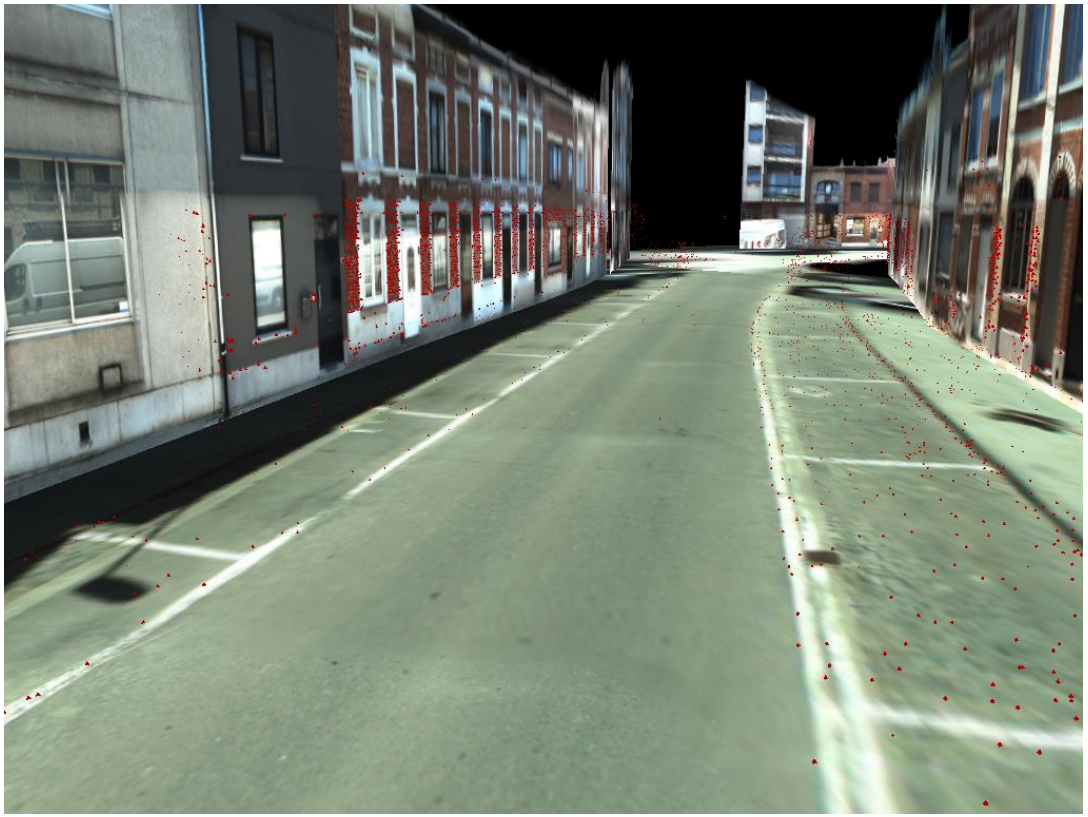
- Ground texturing
  - Projected from frontal camera
  - Blended with Hamming window



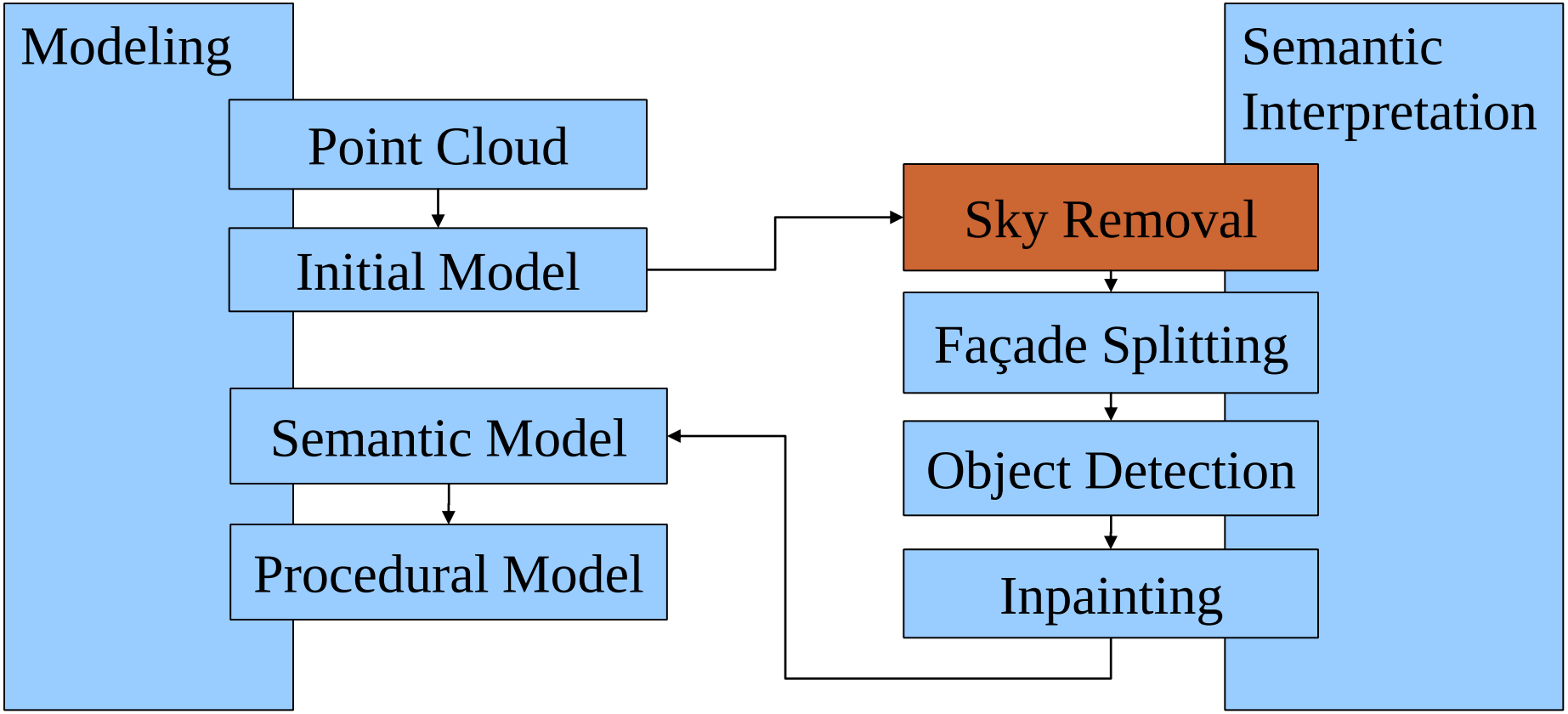
- Wall texturing
  - Composited images projected from several viewpoints onto common plane



- Initial 3D model
  - Rendered with OGRE



Overview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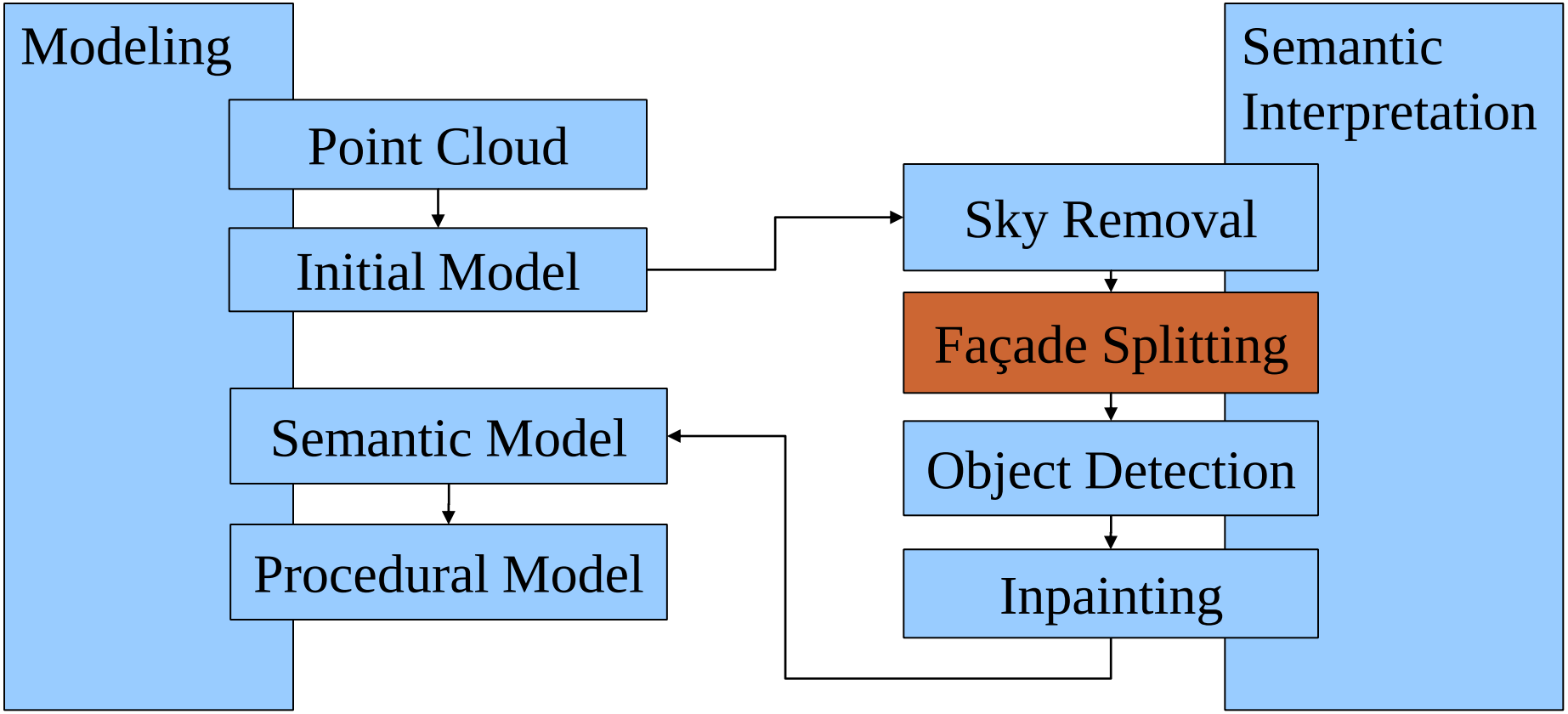
- Connected components from top of image
- Threshold in RGB colorspace



Overview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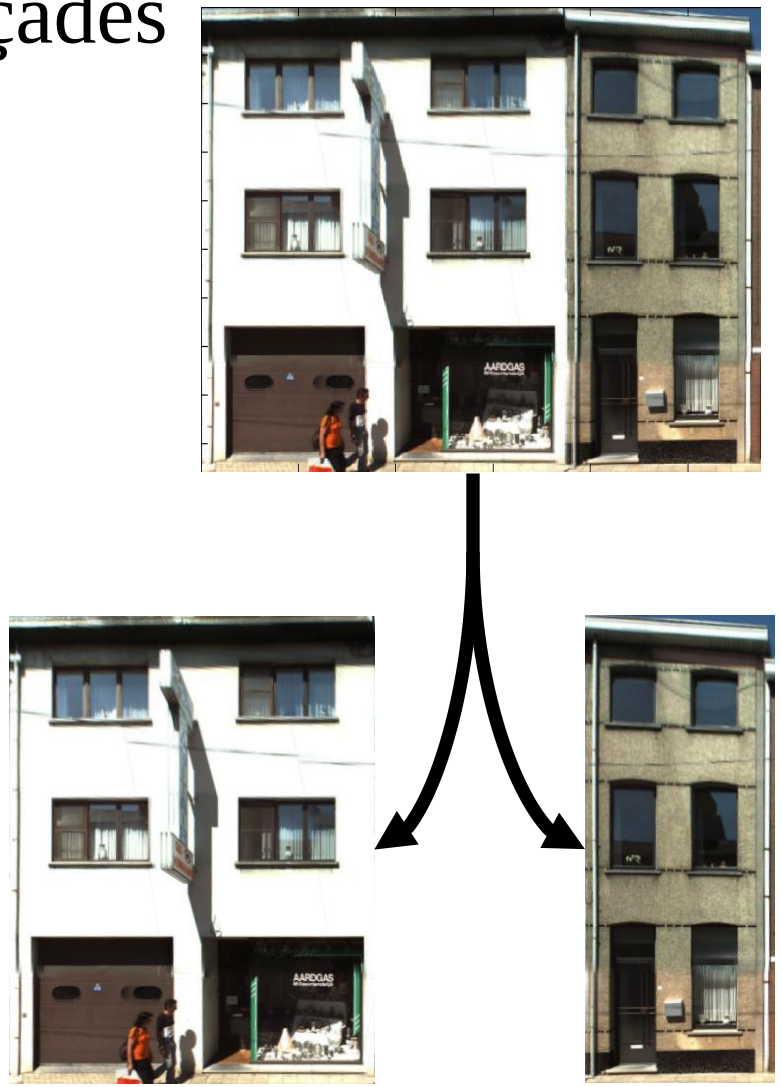
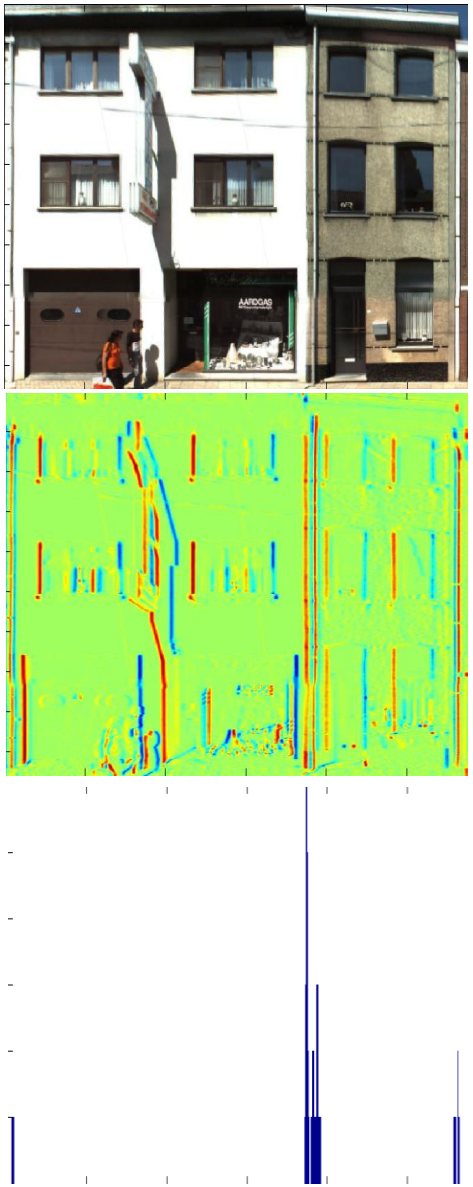
- Single plane may contain façades from several buildings
- Want to achieve semantic segmentation of façades



- Method
  - Compute vertical edge image
  - Find sufficiently long, clear edges as candidate splits
  - Perform local non-maximum suppression



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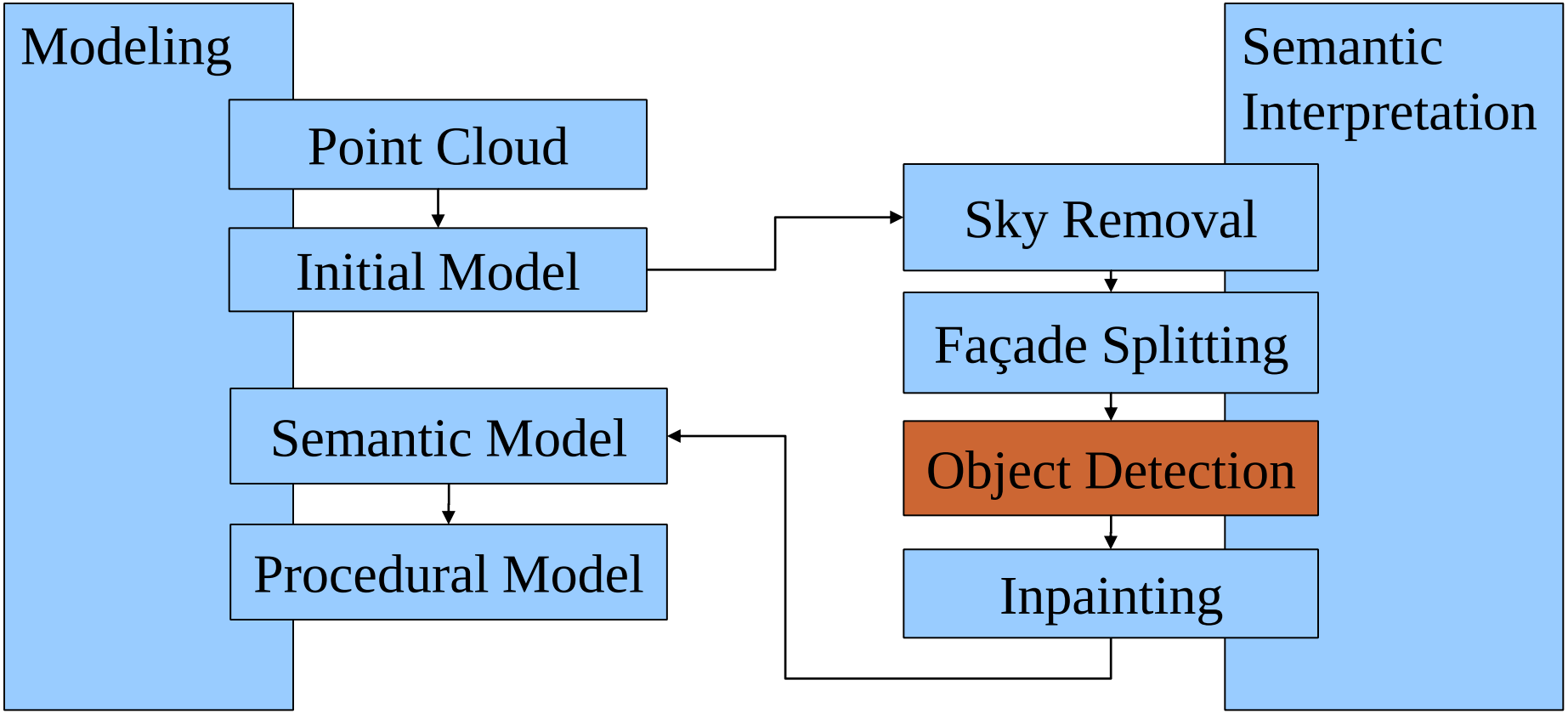
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- Improve the model by detecting specific structures within a façade
  - **Windows**, Doors, Garages, Steps
- Need automatic detection of these parts





Intraclass variation

Interclass similarity

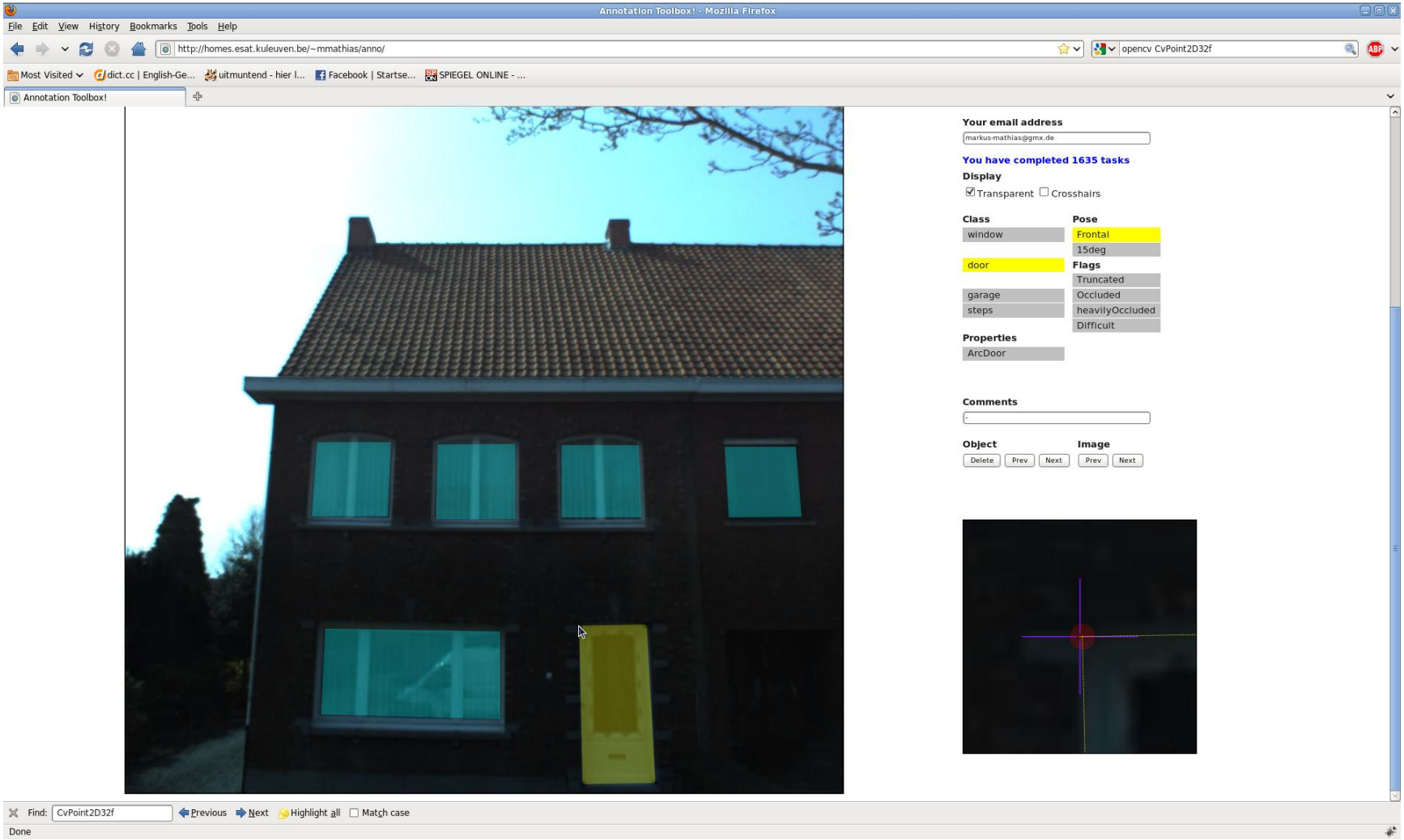


- Can we learn a structure's appearance?
- Can train a classifier, but we first need ground truth annotations

- Gathering sufficient annotations is nontrivial
  - Many variations of each structure
  - Different interpretations of what to annotate
  - Low quality annotations can damage classifier
  - Creation of Annotation Guide



- The annotation tool

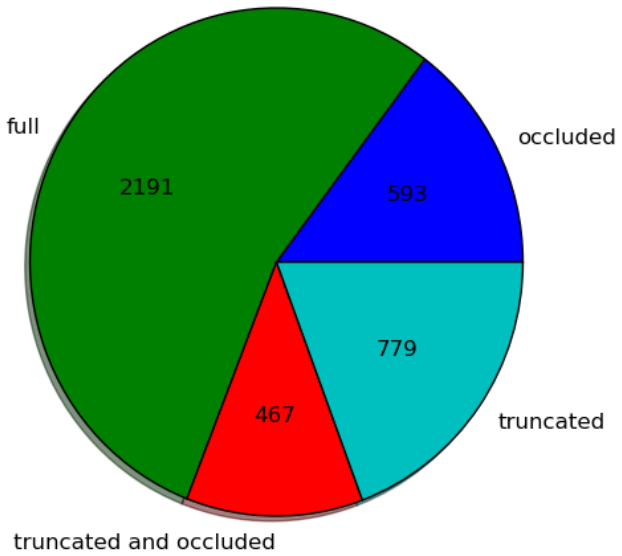


- Several rounds of annotations:
  - Initial Annotation (Polygons)
  - Quality Verification
  - Frame annotation (Rectangles)
  - Quality Verification



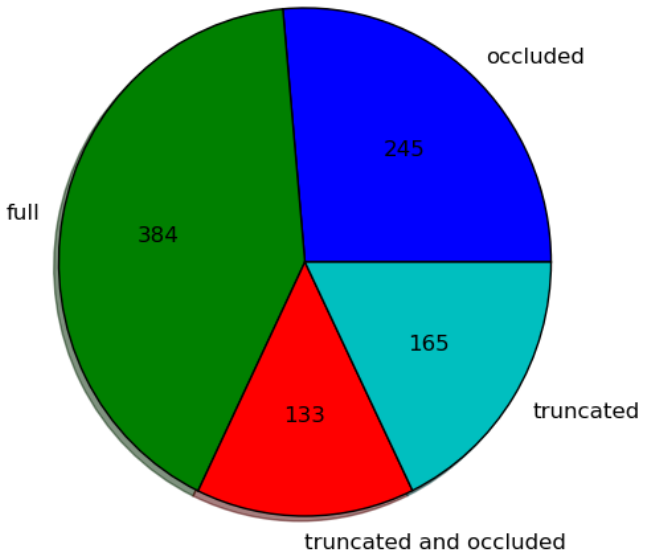
- Large database of annotated images
- Statistics:

Windows



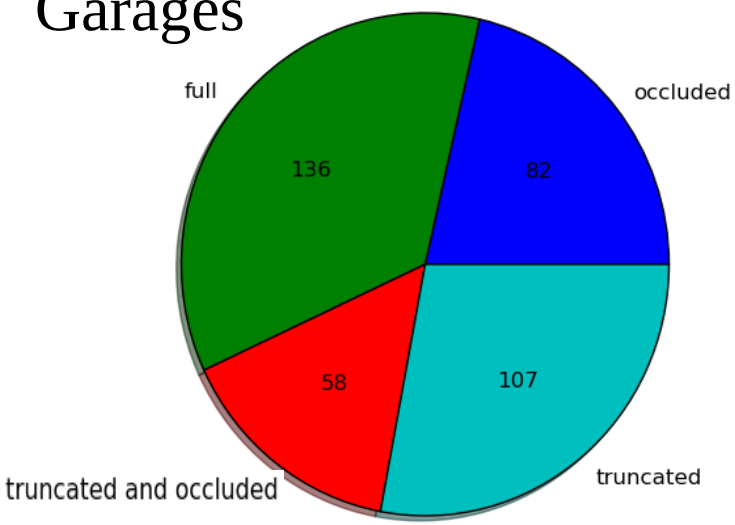
Total: 4030

Doors



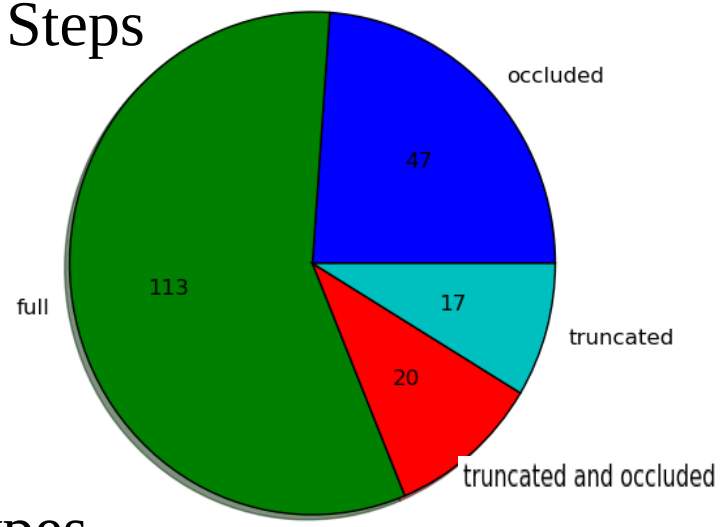
Total: 927

Garages



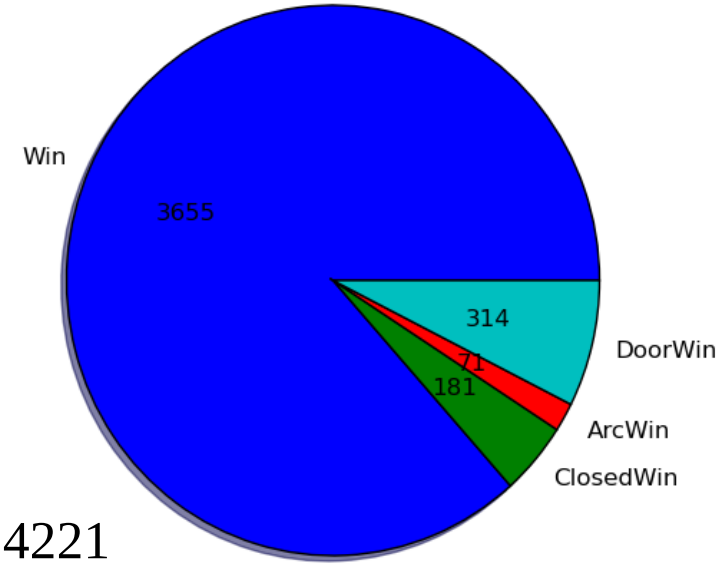
Total: 383

Steps



Total: 215

Window Types



Total: 4221

- Detector:
  - Multiclass Multilabel Adaboost detector [1]
  - Cascaded [2]
  - “Remove confusing samples” option in order to prevent over-fitting [3]

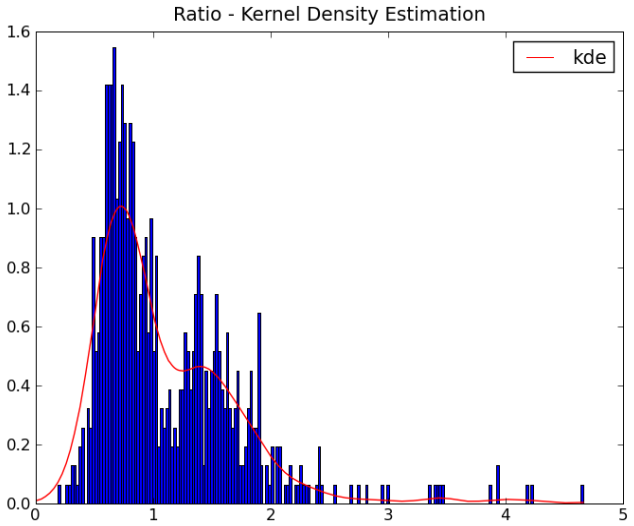
[1] Schapire, Singer “BoosTexter: A Boosting-based System for Text Categorization” (2000)

[2] Viola, Jones "Robust Real-time Object Detection” (2001)

[3] Vezhnevets, Barinova "Avoiding Boosting Overfitting by Removing Confusing Samples” (2007)

- Detector: trained for subclasses of windows:
  - Arc window, shutters closed window, normal window, vertical and horizontal window
- Optimization step:
  - local: symmetry, ratio, size, line crossings
  - global: alignment, position

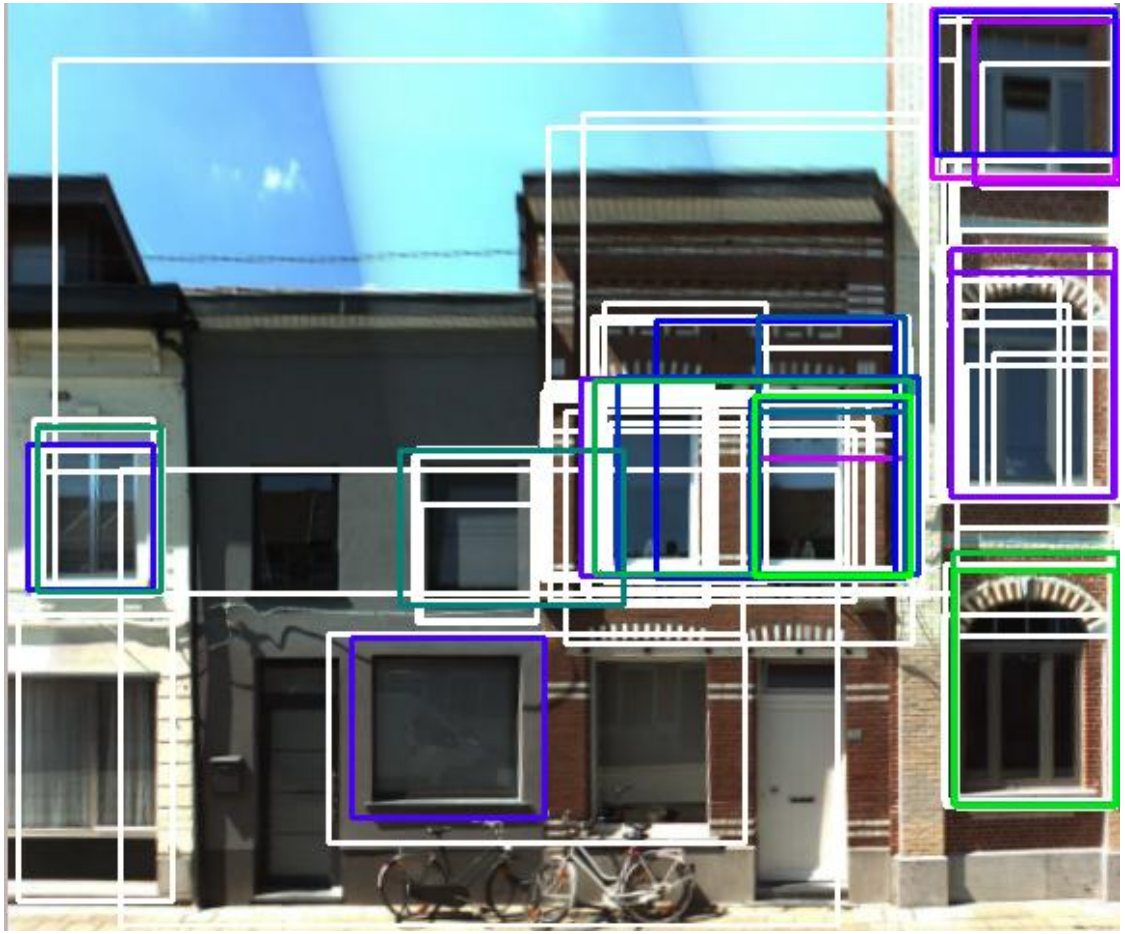




- Original Image



- Multiclass Detector Result



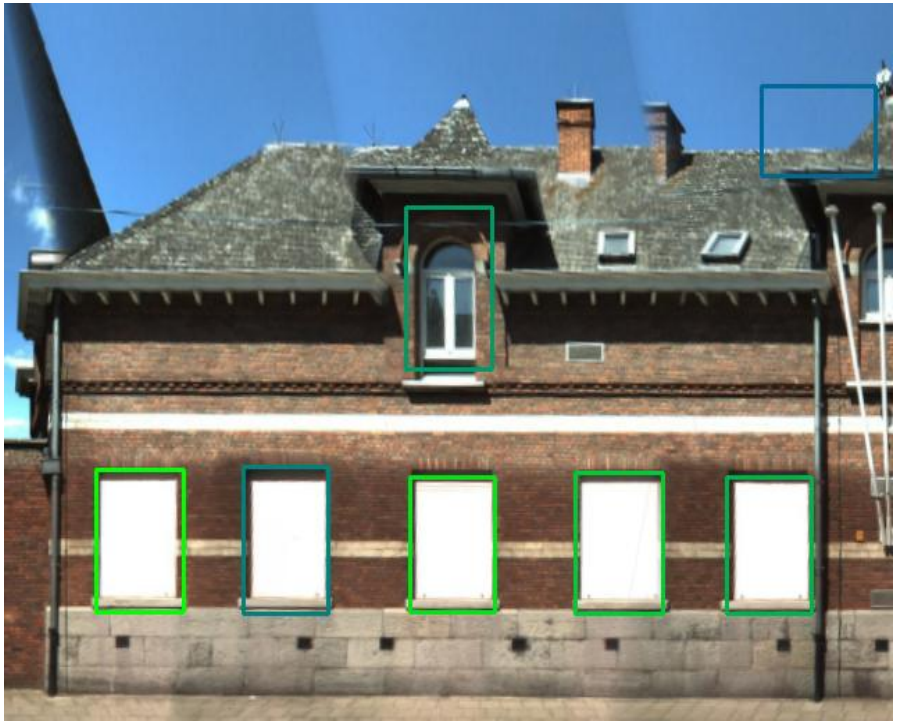
- Pruning of overlapping rectangles



- Optimization result



- Optimization result





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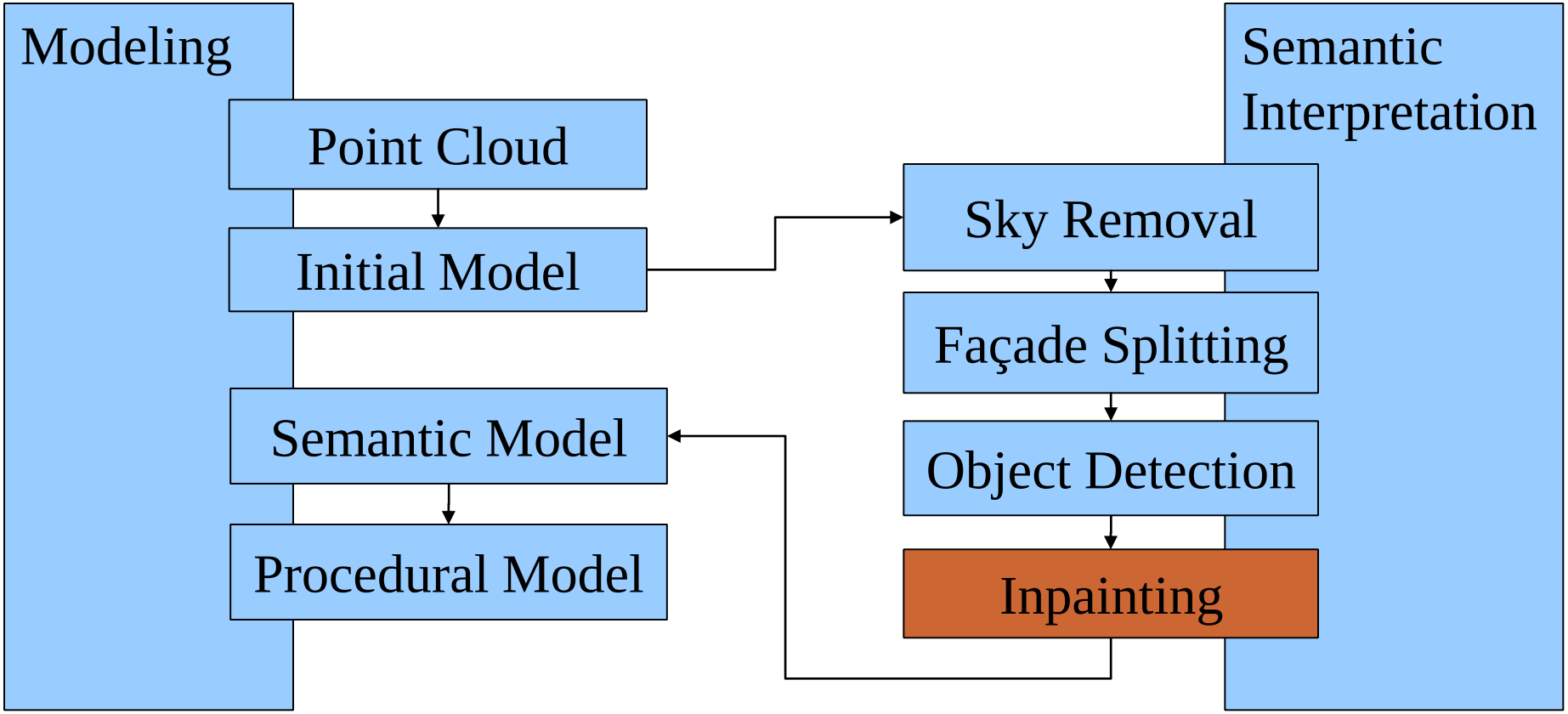
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- Goal: remove occlusions from the façade



- Process:
  - Identify occlusion regions in image
    - Special detectors (Pedestrian)
    - Stereo depths
    - Manual annotation
  - Fill in texture



- Process:
  - Identify occlusion regions in image
  - Fill in texture
    - Proceed along edge of region
    - Insert patches based on confidence, patch similarity (See [4])



[4]A. Criminisi, P. Perez, K. Toyama. Object Removal by Exemplar-based Inpainting. 2003.

- Example result
  - Most obvious linear structures preserved
  - Slight artifacts



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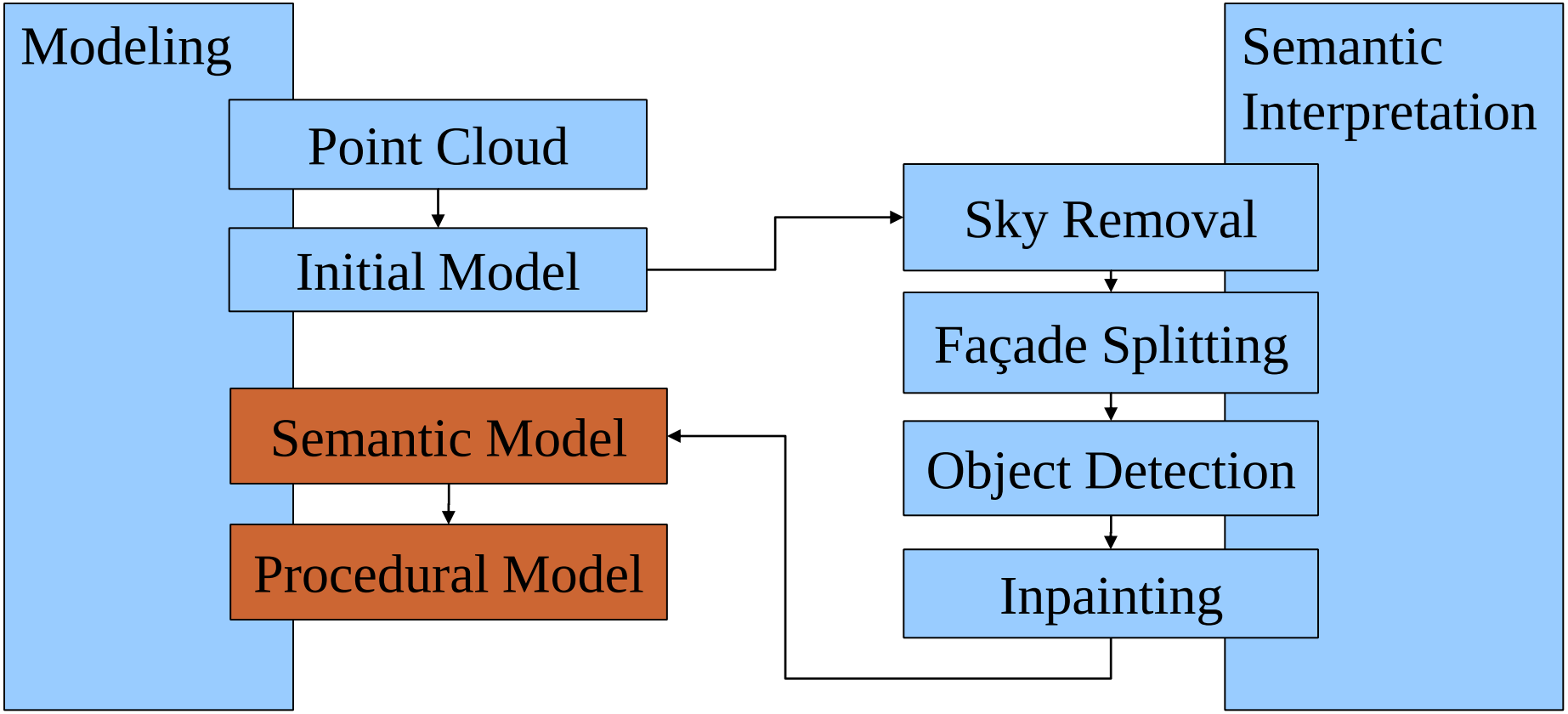
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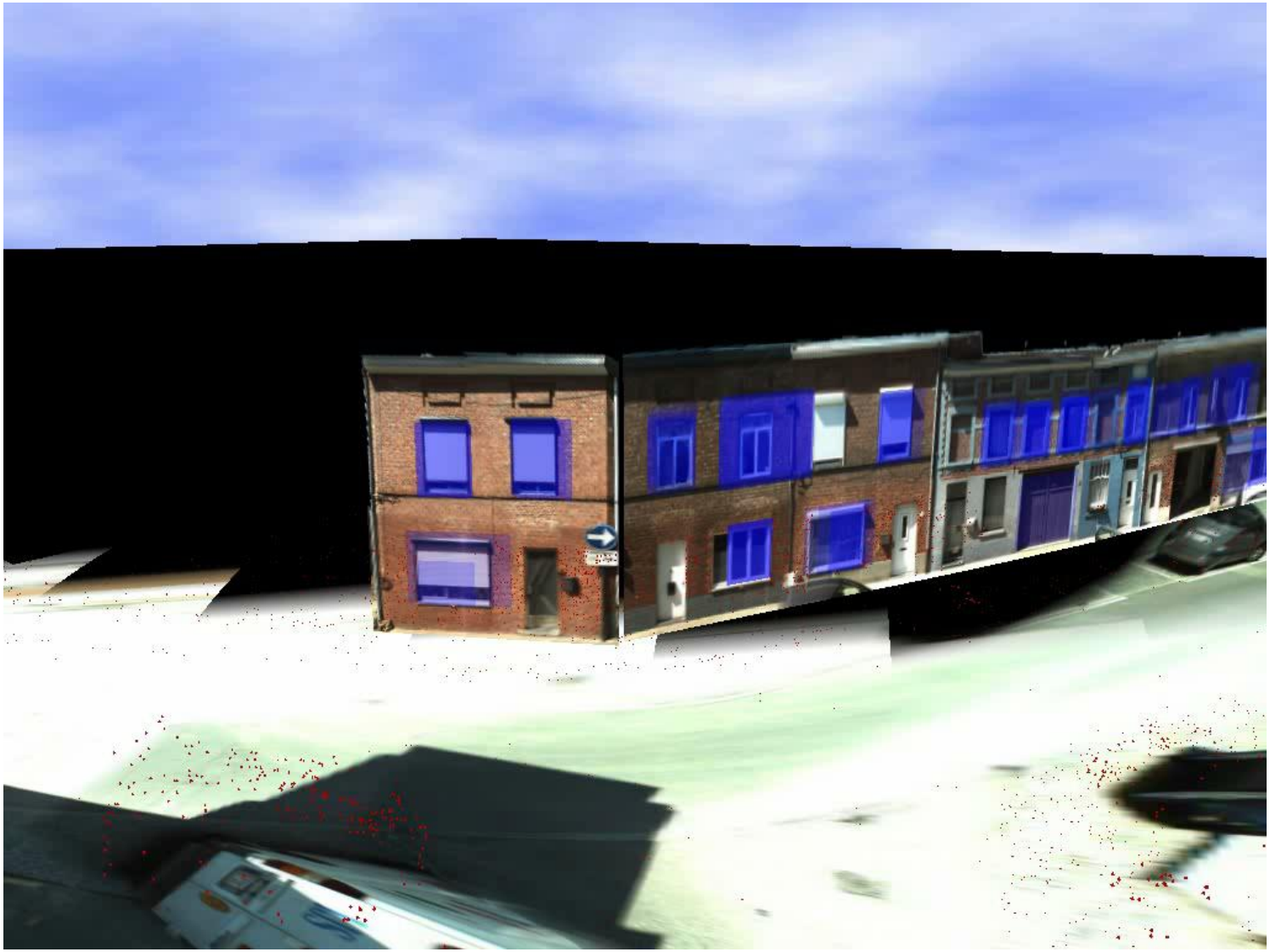
Semantic Model



Semantic Model



- Create models from set of rules separate from evaluation engine
- Generating large scenes with only a few amount of rules
- Used for plant modeling, façades and even entire cities including street network, building, façades, trees
- Focus so far mostly on artificial cities for movies, games etc.





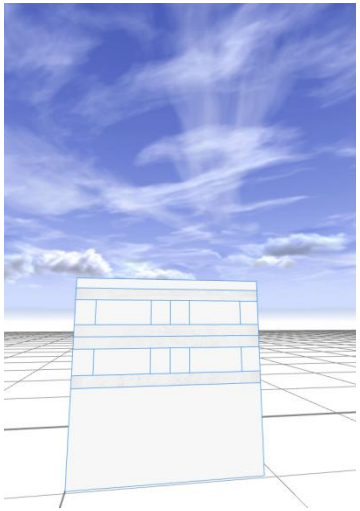


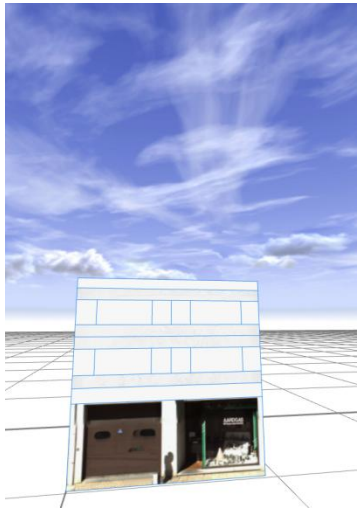


Images courtesy of www.procedural.com

Modeling: Procedural Generation











```
Init--> extrude(height) Building

Building --> comp(f) { front : Frontfacade}

Frontfacade -->
   split(y){ groundfloor_height : Floor(0)
       | ~floor_height : Floor(1)
       |~floor_height:Floor(2)
       | 0.5 : LedgeAsset }
```

```
Floor(floorindex) -->
   case floorindex == 0 :
       split(y){ Texture | TopLedge(0)}
   else :
       split(y){~wall_height : BottomLedge(floorindex)
       | ~window_height : Tile
       | ~wall_height : TopLedge}

Tile -->
split(x){ ~1 : Wall
       |  window_width : WindowTile
       | ~1 : Wall(3) }
```

Modeling: Procedural Generation



Modeling: Procedural Generation



Modeling: Procedural Generation



Modeling: Procedural Generation



Modeling: Procedural Generation

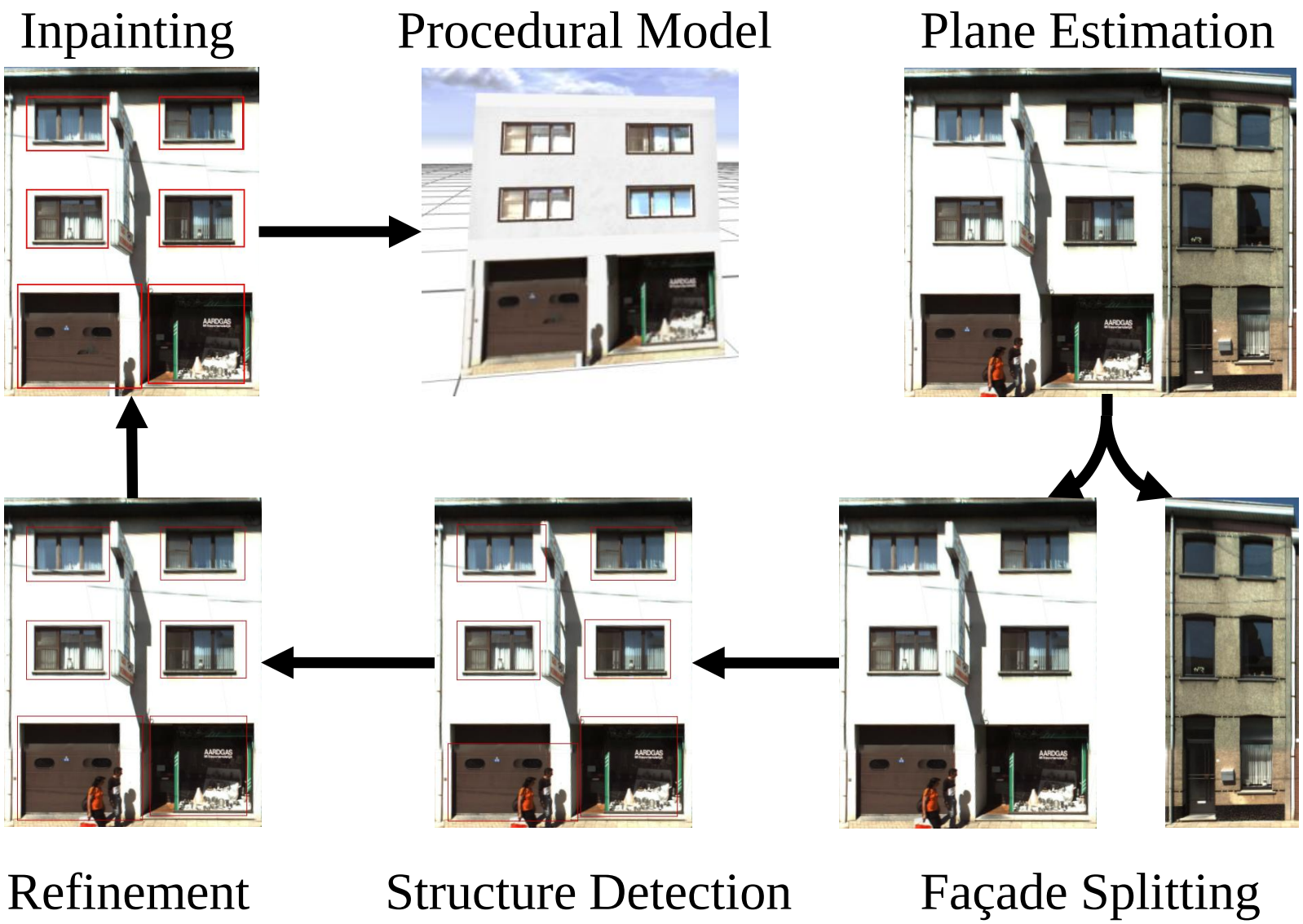


Modeling: Procedural Generation



Modeling: Procedural Generation




Inpainting
Procedural Model
Plane Estimation
Refinement
Structure Detection
Façade Splitting