Automatic And Robust Chain For Urban Reconstruction From Satellite Imagery

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LuxCarta focuses on the creation and delivery of geodata for the global telecom, navigation and other vertical markets.

**EXPERTISE**
- Remote Sensing
- Photogrammetry
- Elevation Models
- 3D Models

**R&D PRODUCTION**
- Data production automation
- Automatic correlation
- Machine learning

**PRODUCT INNOVATION**
- Population maps
- 2.5D clutter height
- 3D building\tree model

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Goal

Automatically produce 3D databases from stereo imagery

- Stereo-pairs
- Geodata
- Parameters

Input Data

Automatic Chain

3D Database

- DTM
- DSM
- Ortho-image
- 3D Building\tree

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Plan

- Overview of the Automatic Chain
- Height Computation
- Building/tree extraction
- Conclusion
3D building/tree extraction consists of:

- **Input**
  - Import
  - Input data

- **Height Computation**
  - ITP & GCP collection
  - Epipolar reprojection

- **Classification**
  - Disparity map computation
  - Disparity to DSM
  - Epipolar reprojection
  - Building/tree post processing

- **Output**
  - Texturing
  - Export

**Robust:**
- Multiple Data: PairS stereo imagery
- Mix the Algorithm: Traditional/Deep Learning
Automatic Detection of **Ground Control Point** based on feature detection and matching

→ DL Classification of buildings and trees allows to valid in most cases the GCP detection.
Computation DSMs

Semi Global Machine:
- An algorithm to compute a disparity map from epipolar images

SGM improved by us with:
- Possible use of an input disparity map, to reduce the search range
- Adaptive penalty coefficients for a better deal with pixelwise ambiguity
- Filter to align the edge in the disparity map and the source image
- Filter by information cross to reduce the bad matches: mirror effect, right-left inversion
- CPU Multi-Thread/GPU

DSM Fusion:
- Fill all the non informed values
- Remove the artefacts
- Increase the elevation accuracy
Fusion DSMs
Computation DTM

Original approach based on the study the profile of the DSM

- DSM
- Classification
- Surface Reconstruction

→ DL Classification of buildings and trees allows to valid Classification done using DSM
Our Work in the last years:

- **Towards large-scale city reconstruction from satellites**
  Duan Liuyun and Lafarge Florent

- **KIPPI: KInetic Polygonal Partitioning of Images**
  Bauchet Jean-Philippe and Lafarge Florent
  IEEE Conference on Computer Vision and Pattern Recognition, 2018
Classification:
- based on UNET model:

*Large-scale semantic classification: outcome of the first year of Inria aerial image labeling benchmark.*
Bohao Huang, Kangkang Lu, Nicolas Audebert, Andrew Khalel, Yuliya Tarabalka, et al..

Polygonization:
- based on constraints:
  - angles
  - shapes

*Fig. 1: U-net architecture designed by AMML.*
Our Methodology: Build a Generic Model

Data Set → Preprocessing → Patch Generation → Data Augmentation → Deep Learning → Model

+Ground Truth
Our Methodology: Test Model

1. Data Set
2. Preprocessing
3. Data Augmentation
4. Apply the Generic Model
5. Classification
Fine Tune the Generic Model if the Test Failed

Area of “fine tuning”
Fine Tune the Generic Model if the Test Failed

Area of “fine tuning”

Manual digitalization of 3D features (buildings for example)
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Learning from the Generic Model and Test

Polygonization

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Fine Tune the Generic Model if the Test Failed

Area of “fine tuning”

- Manual digitalization of 3D features (buildings for example)
- Automatic height assignment from DSM
- Vectorization

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3D Results
Using **only 1-3 km\(^2\)** for the fine tuning that takes around **2 minutes of learning** to **classify an area 2000 km\(^2\)**

- We have tested ten of thousands km\(^2\) on different areas: USA, Canada, Australia, ...
- In Average, 80% Polygons no need of manual correction according to the quality asked by our customer
Conclusions & Perspectives

Conclusions:
- Automatic And Robust Chain For 3D Urban Reconstruction
- Deep Learning has allowed to surpass the bottleneck of extracting the buildings\trees in an **automatic way**
- Our chain is **robust** by applying multiple data sources and combining non-learning and learning algorithms
- Our automatic chain has reduced drastically the delivery time for huge areas

Perspectives:
- Aim at replacing all the manual interactions:
  - Remove the fine tuning operation, etc...
- Add other classification as: roads, rivers, lakes, ...
- Deep Learning based dense matching
Questions ?

Thank you for your attention !!!
Any questions ?