CART'EAUX WATER MAP'

AUTOMATIC MAPPING PROCEDURE FOR WASTEWATER NETWORKS USING MACHINE LEARNING AND DATA MINING

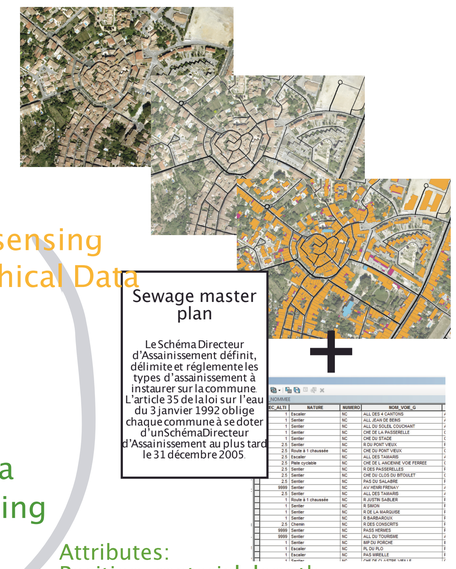
In France, municipalities must establish a detailed description of wastewater collection and transport systems. If general maps and characteristics of the wastewater networks should – a priori – be available, the information remains quite fragmented (different formats and databases, held by many stakeholders...).

The Cart'Eaux project aims at developing a methodology to gather various types of data to produce a regular and complete mapping of urban sewage systems. This includes the use of remote sensing, deep learning, data mining, text analysis. Several statistically possible networks are generated including an uncertainty associated to each piece of information, that will be taken into account in the final hydraulic modelling.

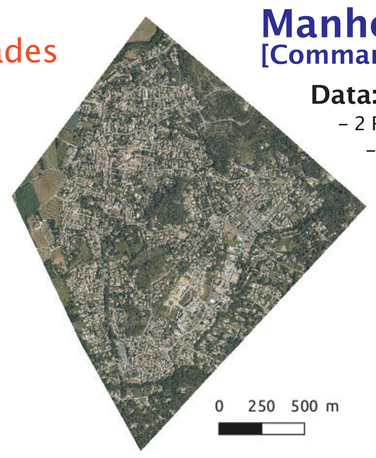
In the following, results are expressed in terms of precision and recall.

$$\text{Precision} = \frac{TP}{TP+FP} \qquad \text{Recall} = \frac{TP}{TP+FN}$$

TP=True Positive: correctly detected manholes
FP=False Positive: object badly detected as manholes
FN=False Negative: undetected manholes

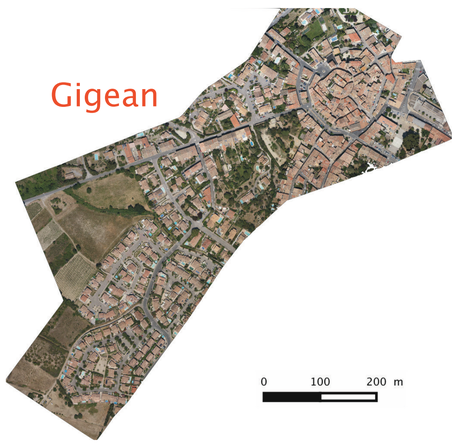


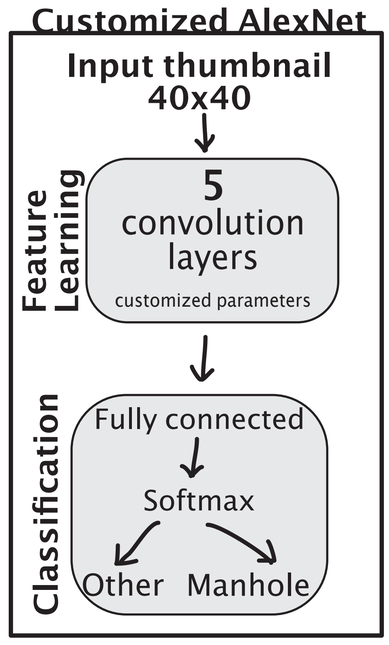
Manhole cover localization: deep learning
[Commandré et al. 2017a; Pasquet et al. 2016]



Data:

- 2 RGB images 5 cm/pixel: "Prades" and "Gigean"
- Training dataset: 605 manhole covers in Prades (=>augmentation data up to 18405 "manhole" and 458915 "other")
- Validation dataset: 100 manhole covers in Gigean



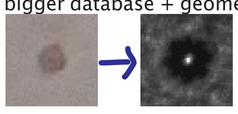


Results

TRUE POSITIVE
FALSE POSITIVE
FALSE NEGATIVE

Precision = 72%
Recall = 54%

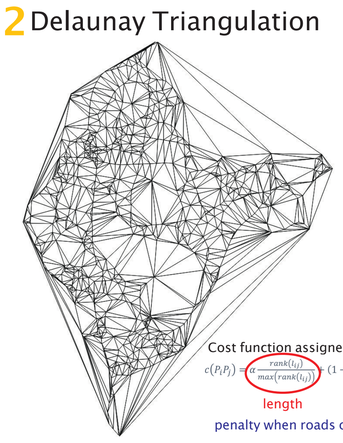
Perspectives:
bigger database + geometric filter



Mapping of wastewater network
[Commandré et al 2017b]

1 Detected Manholes

2 Delaunay Triangulation



3 Minimum Spanning Tree

Kruskal's algorithm (1956)

Cost function assigned to each link ij:

$$c(P_iP_j) = \alpha \frac{rank(l_{ij})}{max(rank(l_{ij}))} + (1-\alpha)\delta \frac{rank(|s_{ij}-s_m|)}{max(rank(|s_{ij}-s_m|))} + \beta + \gamma$$

length — slope

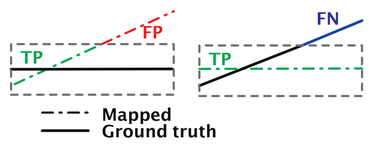
penalty when roads or buildings are crossed

Results

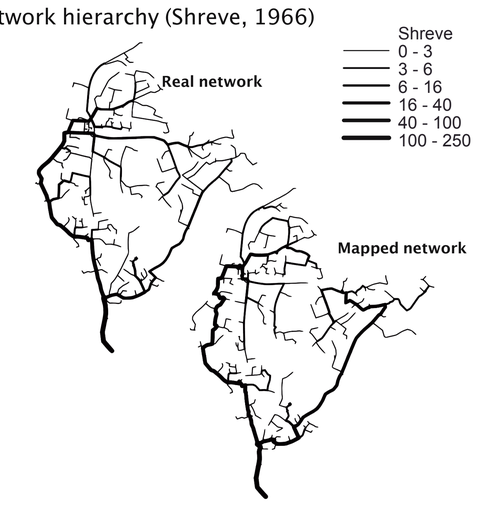
The mapped network from all actual nodes is validated against the real network using:

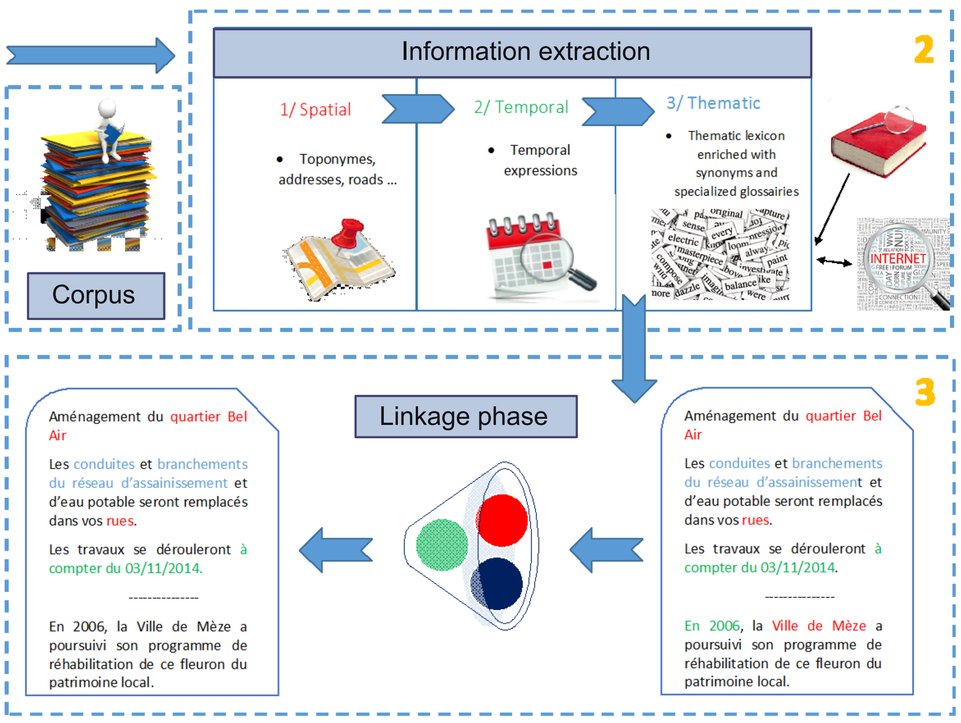
1/ positional errors (Heipke et al., 1997):

Precision (correctness) = 90%
Recall (completness) = 93%



2/ network hierarchy (Shreve, 1966)





Data mining and Text analysis to retrieve meaningful information
[Chahinian et al 2016]

Step 1: the web is scoured for informative documents which are saved in text format
Step 2: information extraction
- spatial (Unitex software)
- temporal (Heideltime software)
- thematic (lexicon of buried network terms)

Step 3: linkage

Results:

	Spatial	Temporal	Thematic
Recall	70%	91%	91%
Precision	89%	91%	96%

References:
Commandré B., En-Nejjary D., Pibre L., Chaumont M.,Delenne C., and Chahinian N. 2017. Manhole cover localization on aerial images with a deep learning approach in proceedings ISPRS Hannover Workshop 2017, Hannover, Germany, pp. 1-6.
Commandré B., Chahinian N., Bailly J.-S., Chaumont M., Subsol G., Rodriguez F., Derras M., Deruelle L., Delenne C. 2017. Automatic reconstruction of urban wastewater and stormwater networks based on uncertain manhole cover locations. In ICUD, pages 2345-2352Heipke C., Mayer H., Wiedemann C. 1997 Evaluation of Automatic Road Extraction. International Archives of Photogrammetry and Remote Sensing, 47-56.
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Pasquet J., Desert T., Bartoli O., Chaumont M., Delenne C., Subsol G., Derras M., Chahinian N. 2016. Detection of manhole covers in high-resolution aerial images of urban areas by combining two methods. IEEE Journal of selected topics in applied earth observations and remote sensing, 9(5):1802 - 1807.

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