MANHOLE COVER LOCALIZATION IN AERIAL IMAGES WITH A DEEP LEARNING APPROACH

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CONTEXT

- Urban expansion leads to more buried wastewater networks, often poorly documented.
- Very high reolution areal images may be used to identify and pinpoint the aerial elements of these networks
- Deep Learning, Convolutional Neural Network
- Challenge: detect small objects i.e manhole covers (80 cm); in low contrast settings and cluttered backgrounds

Objective: An automatic recognition and localization method for manhole covers.

Figure 1: *Extract of the 5cm resolution image used for validation.*

REFERENCES

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MATERIALS AND METHODS

The method is developed and applied on two towns located in the south of France: Gigean and Prades-Le-Lez.

Data:

2 RGB Images, 5cm/pixel:
- Training dataset: 605 manhole covers from Prades Le Lez
- Validation dataset: 101 manhole covers from Gigean
The thumbnails are 40*40 pixels size (Figure 2)
Classification into 2 categories: "Manhole covers" and "others"
Data augmentation with the Keras library [1]

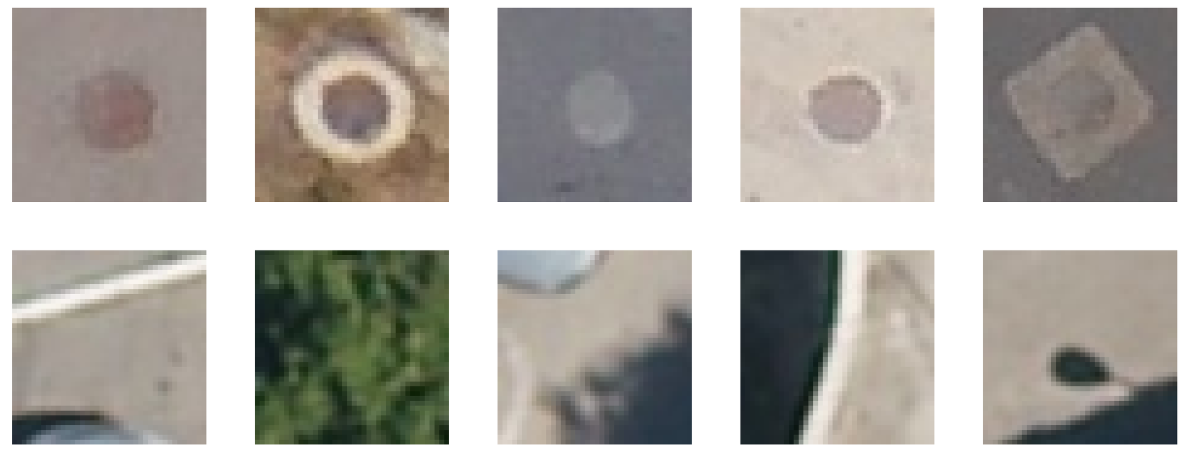
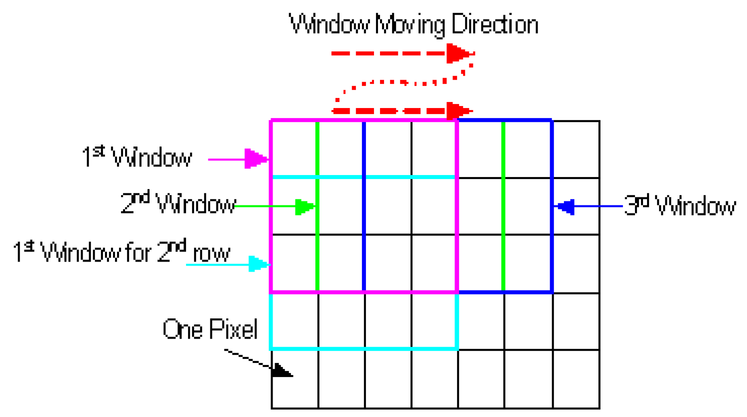


Figure 2: *Example of thumbnails: up, manhole covers, down, others.*

Method:

Convolutionnal Neural Network

Customized Alexnet [2] (Figure 3)
Extract thumbnails from images using a sliding window:



Boosting the network:

After application on Prades-Le-Lez:
Add all false positives to the other objects' category and train the network again. [3]

Cleaning the database:

Remove all the thumbnails that have a dominant feature that is not related to manhole covers from training database.

Classification:

A thumbnail is retained if the probability of representing a manhole is greater than 90%.

Validation:

Comparison with ground truth data [4]:

$$a_0 = \frac{area(B_p \cap B_{gt})}{area(B_p \cup B_{gt})}$$

B_p = Bounding box detected by the network
B_{gt} = Ground truth bounding box
True detection if $a_0 > 50\%$

Application:

Four networks tested:

1. Original Alexnet network
2. Fifth iteration boosted network
3. Fifth iteration boosted network with cleaned database
4. Customized network with cleaned database

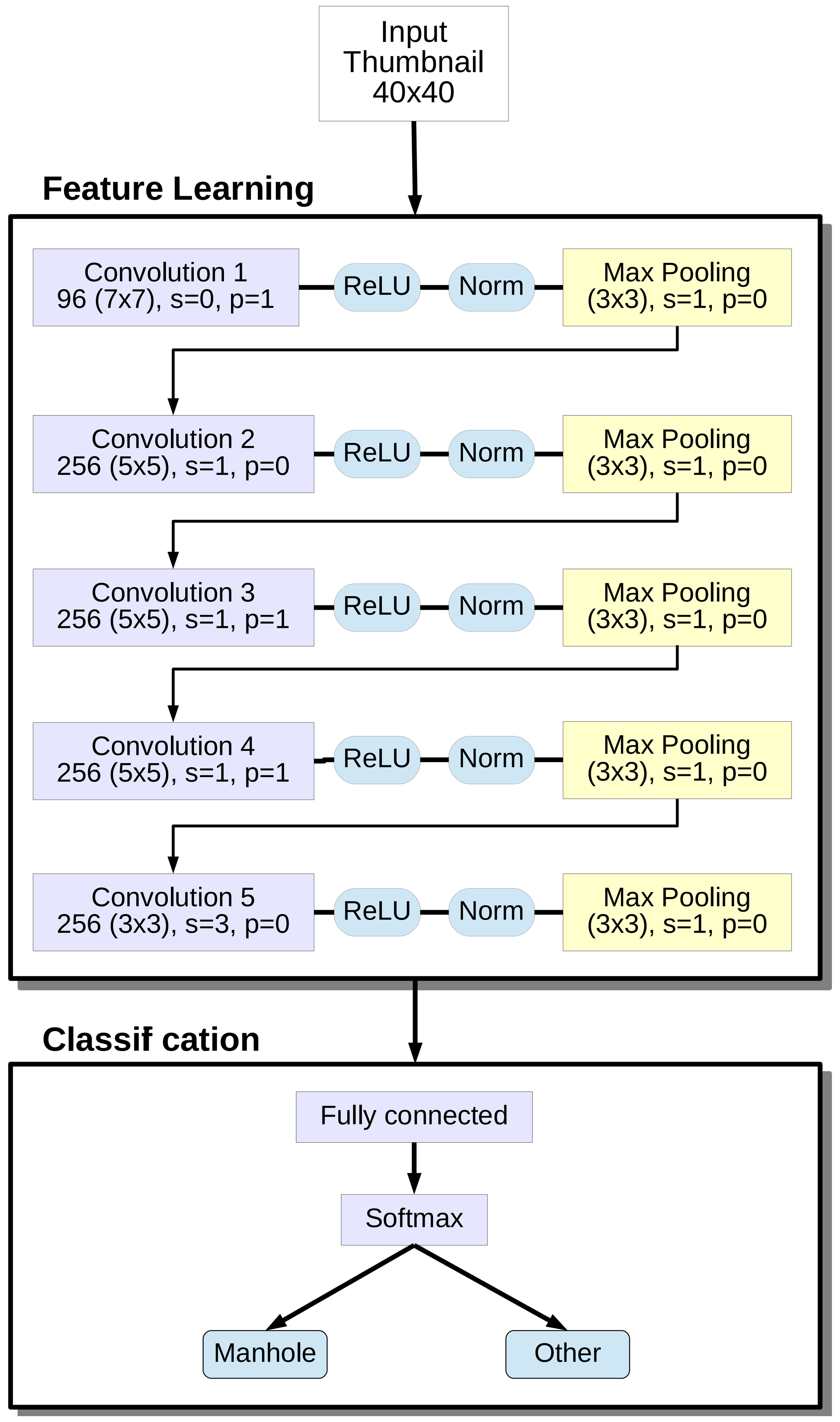


Figure 3: *Customized AlexNet architecture*

The results are assessed in terms of precision and recall:

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

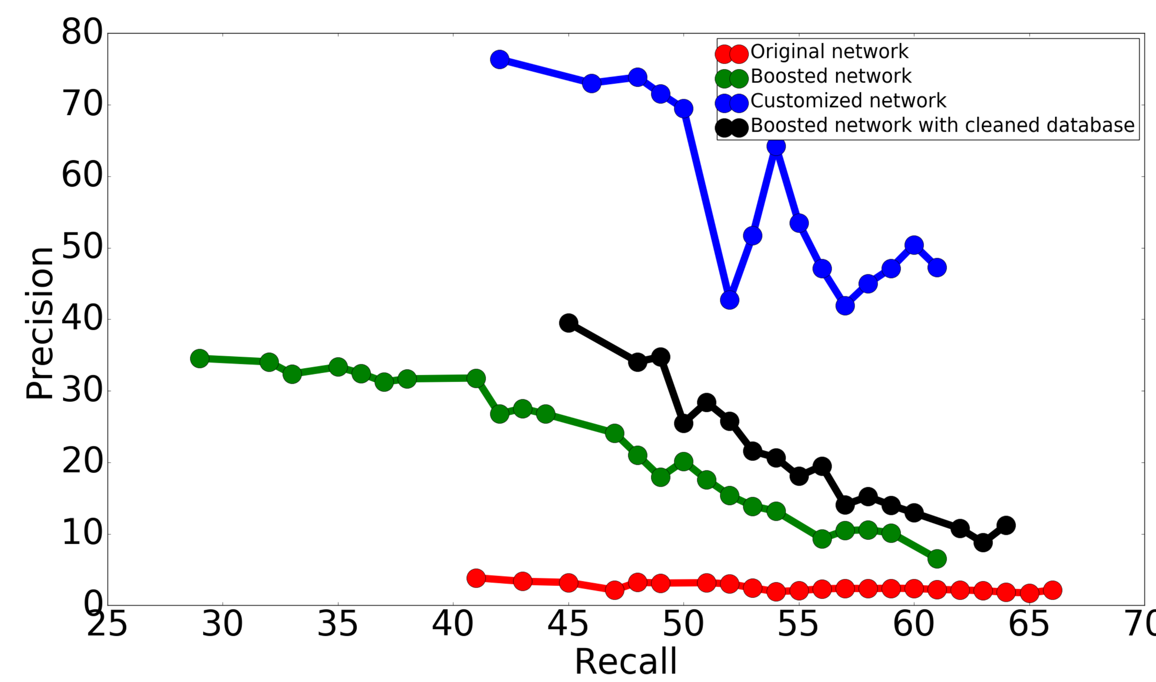
TP = Number of correctly classified manhole covers
FP = Number of thumbnails wrongly classified
FN = Number of undetected manhole covers

RESULTS

Figure 4: *Sample of the results obtained with the customized network and the cleaned database.*

Green square: correctly detected manhole covers
Red square: false detection
Blue square: undetected manhole covers

Customized network yields better results as shown by the ROC curves:



CONCLUSION AND PERSPECTIVES

An automated procedure was put forward to identify and localize manhole covers using aerial RGB images.
Preliminary results: recall is higher than 50% for an average precision of 60%.

Perspectives:

- Combine a circular filter [5] and convolutionnal neural network to reduce false positives.
- Add a third category - inlet gates - to the classification in order to optimize the learning phase and extract more precise features.