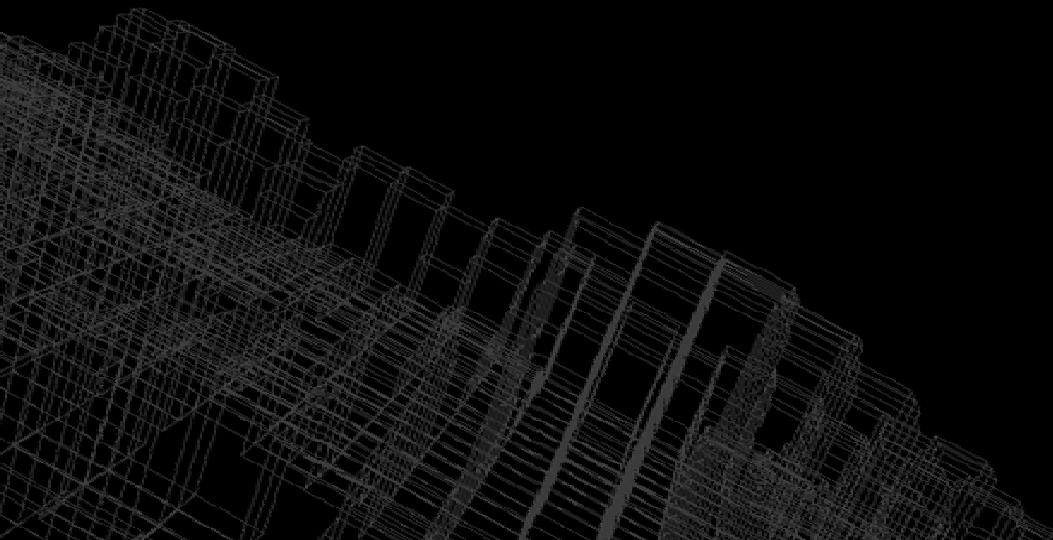


# **Morphological Façade Image Analysis For Building Modeling**

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# Overview

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- Introduction
- Viscous Leveling
- Gradient Projection
- Façade Division
- Window localization
- Conclusions
- Perspectives



# Introduction

TERRANUMERICA

cap  
digital

Aim : to develop a platform for urban modeling

- **Realism** : required for virtual training applications
- **Productivity** Ex. urban models for « superman returns » (2006) took 15 man years [Muller06]

Applications:

Virtual training for emergency response

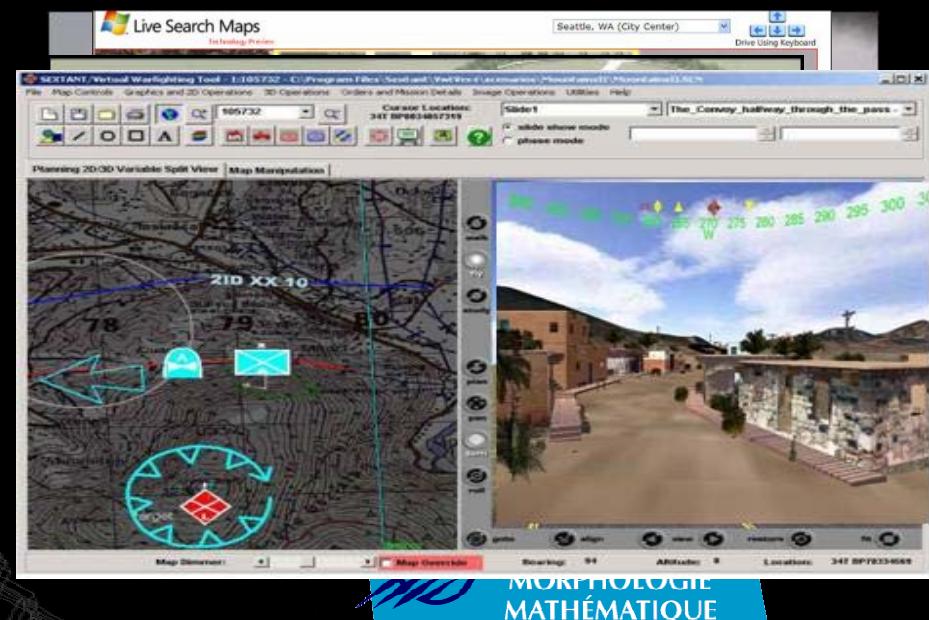
Entertainment industry

Urban planning

Visual impact analysis

Driving simulation

...



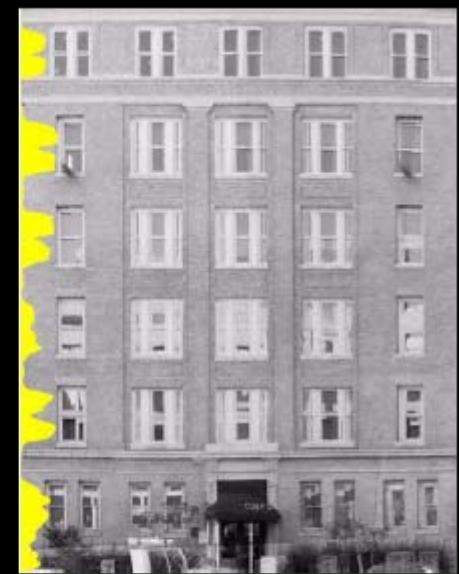
# Introduction

LEE and NEVATIA [Lee04] developed a method for windows detection with a projection of directional edges image. The edges image is accumulated vertically and horizontally. The windows of the same column or row generate peaks in both projection profiles. To locate the windows, they use a threshold to select those peaks.

Nevertheless, this method is very sensitive to elements that do not belong to the regular alignment in façades, occlusions or textured façades (e.g. façade in bricks, stone or ornaments).



(a) Horizontal projection:  $H_h$



(b) Vertical projection:  $V_v$

Two projection profiles.

# Data: Haussmannien Architecture



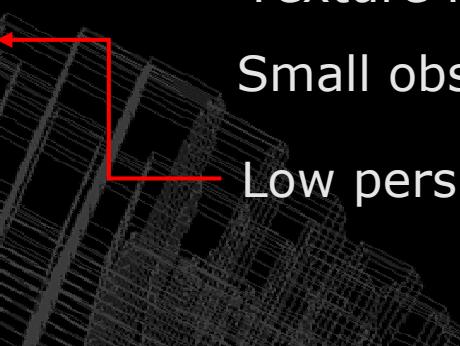
Some problems:

Balconies

Texture Façades



Small obstacles (trees, lamppost)



Low perspective

# Viscous Leveling [Meyer08]

## Leveling

Levelings simplify images while preserving the contours of the remaining objects [Meyer98]

We want to eliminate dark balconies



Reconstruction of dark balconies.

Leakage problem [Salambier96] of connected operators caused by narrow bridges



$f$

$g$ :  
marker a closing image by  
using 13x13 square as  
structuring element

*upper leveling*

Viscous leveling restores the contours and simplifies dark (-) and bright (+) components in a dilated/eroded image  $f$ . Then, the result image is eroded/ dilated as follows:

$$\underset{v}{\Lambda^+} = \varepsilon \underset{v}{\Lambda^+} \delta, \underset{v}{\Lambda^-} = \delta \underset{v}{\Lambda^-} \varepsilon$$



We want to eliminate dark components in vertical and horizontal directions

Reduce balcony information

 $f$ 

$g$ :  
marker a closing image by  
using 13x13 square as  
structuring element

*Leveling**Viscous Leveling*

# Gradient Projection

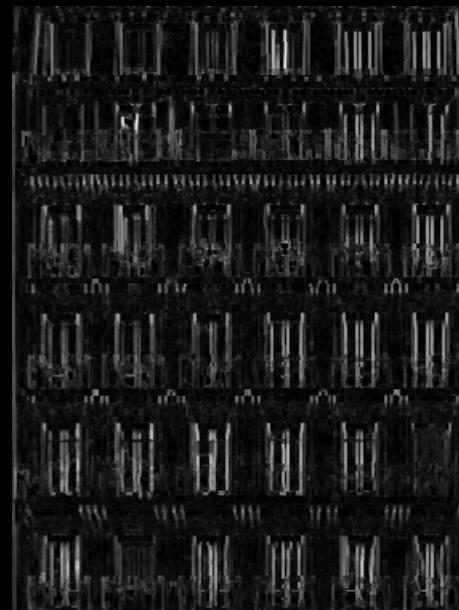
We use a color directional gradient:

- **Color** : Usually, windows color is different from wall color.
- **Directional** : Horizontal profile must only be affected by vertical variations, and vice versa.

Vertical gradient ( $G_v$ ) is generated by using a horizontal structuring element (SE) and horizontal gradient ( $G_h$ ) is generated by using a vertical SE.



$G_h$



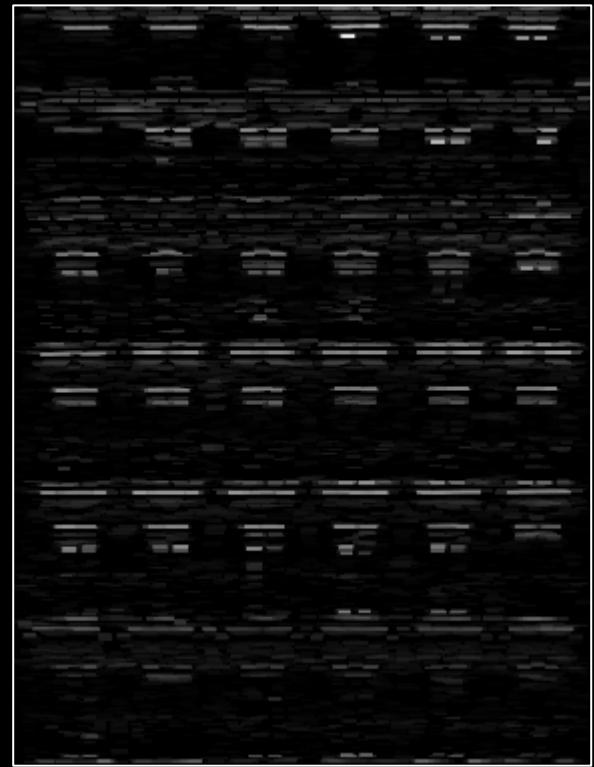
$G_v$

# Gradient Filtering + Gradient Projection

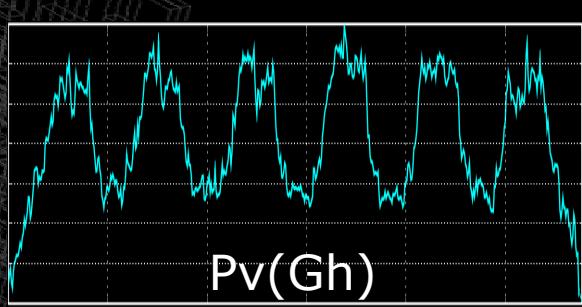
$G_h$



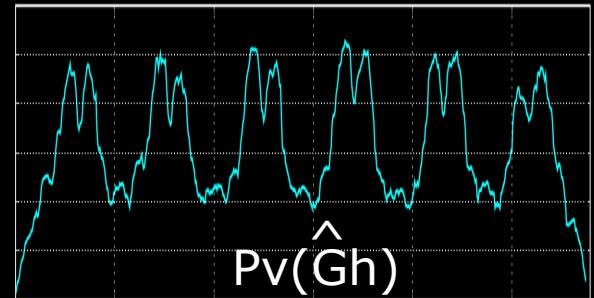
$\hat{G}_h$



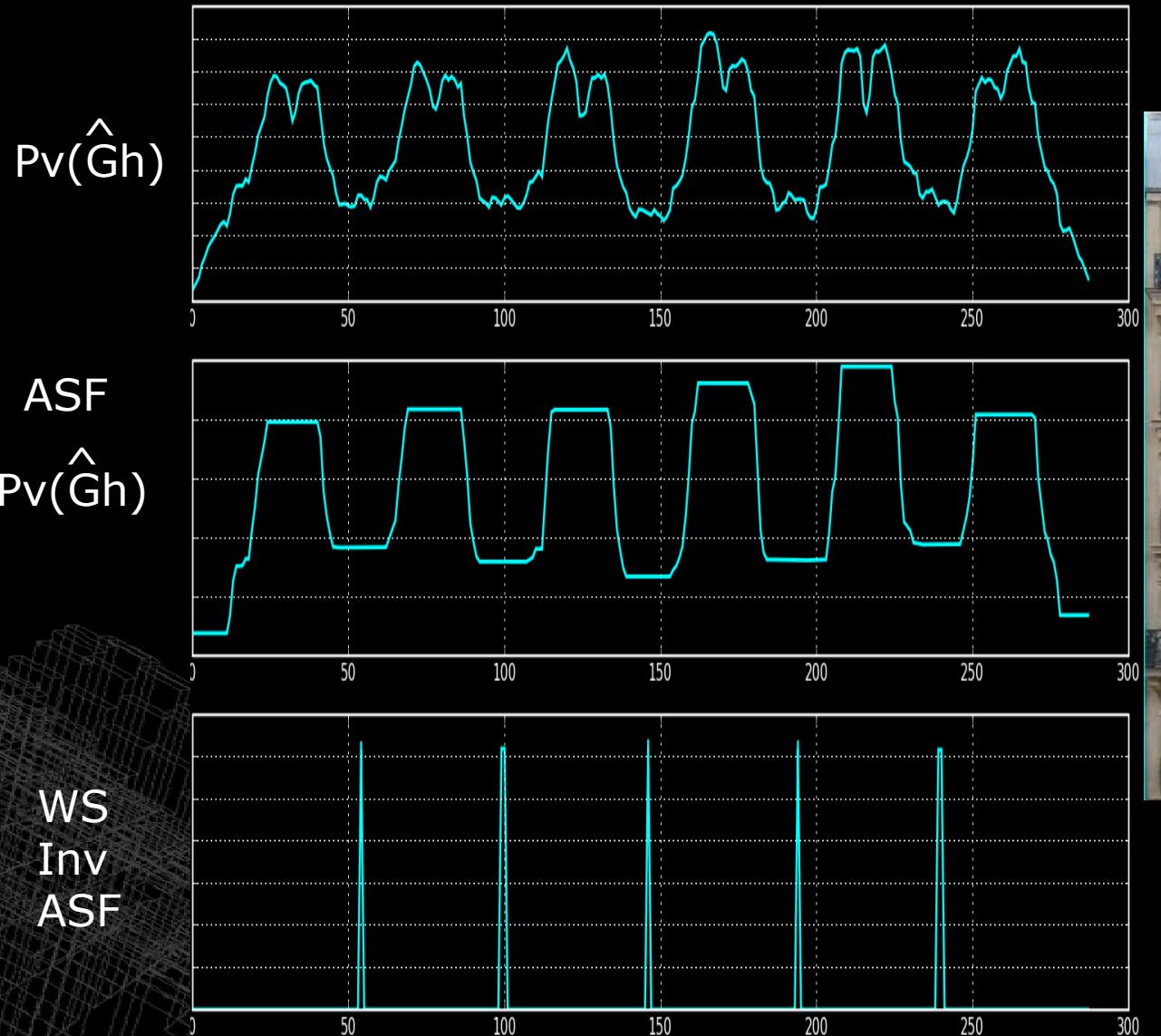
To reduce **noise** caused by **small structures** we apply a directional morphological **opening**. The directional opening is applied in the same direction of gradient



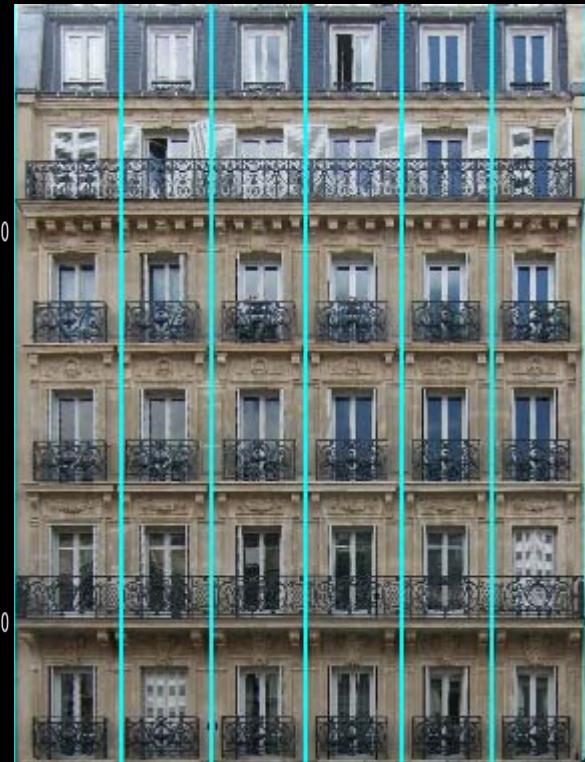
We accumulate on columns  $G_h$ , providing vertical projection  $Pv(G_h)$ .



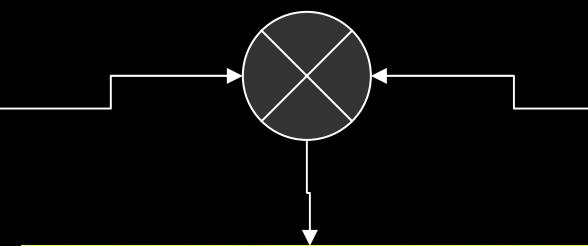
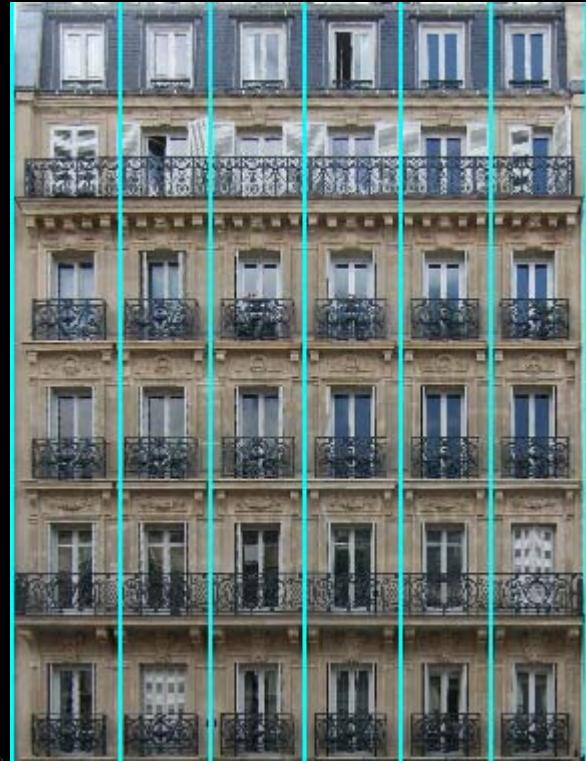
# Façade Division



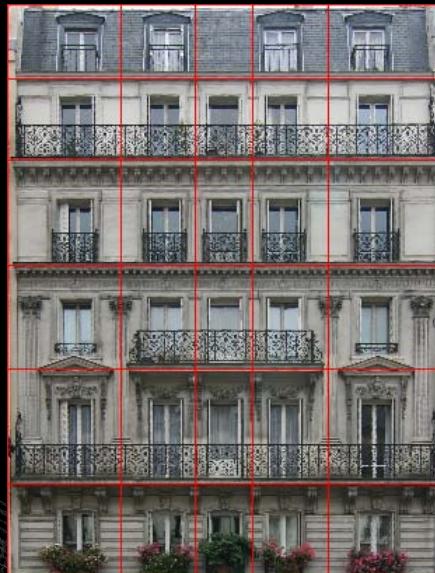
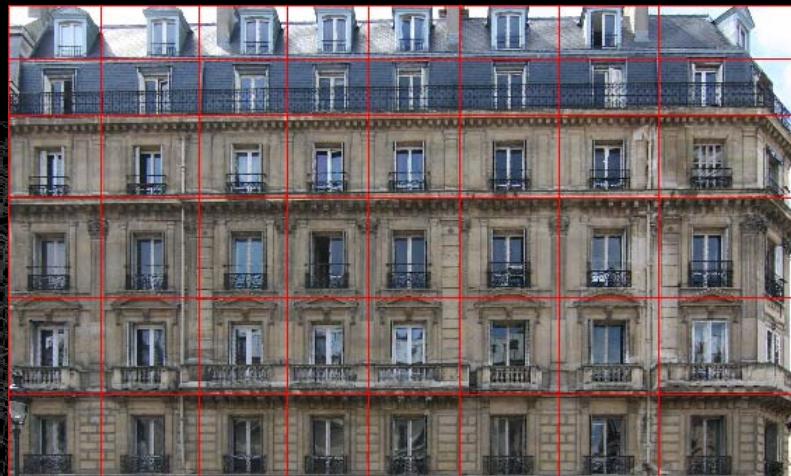
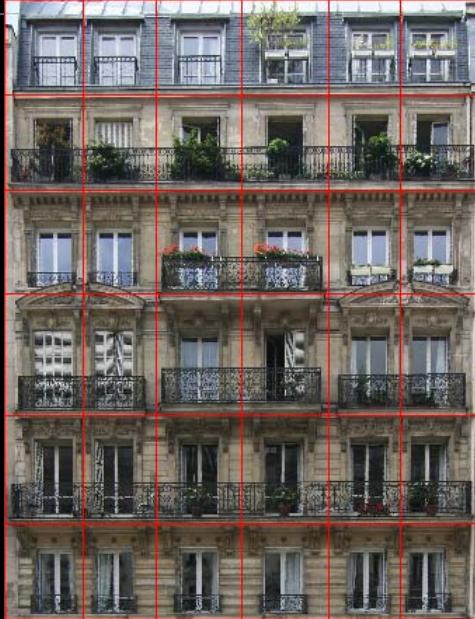
# Vertical Division



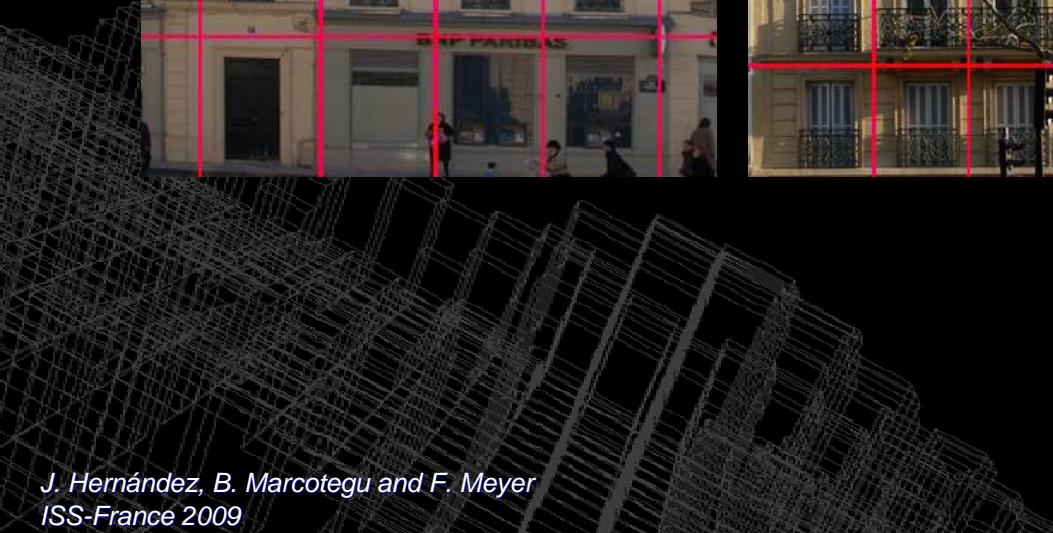
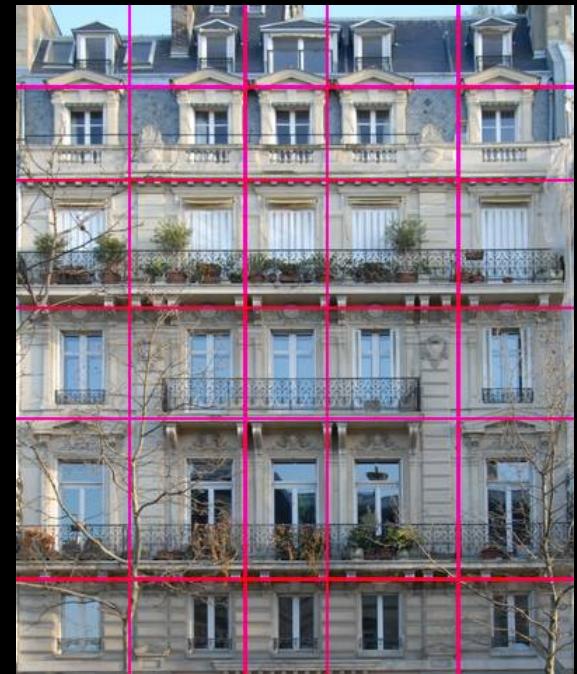
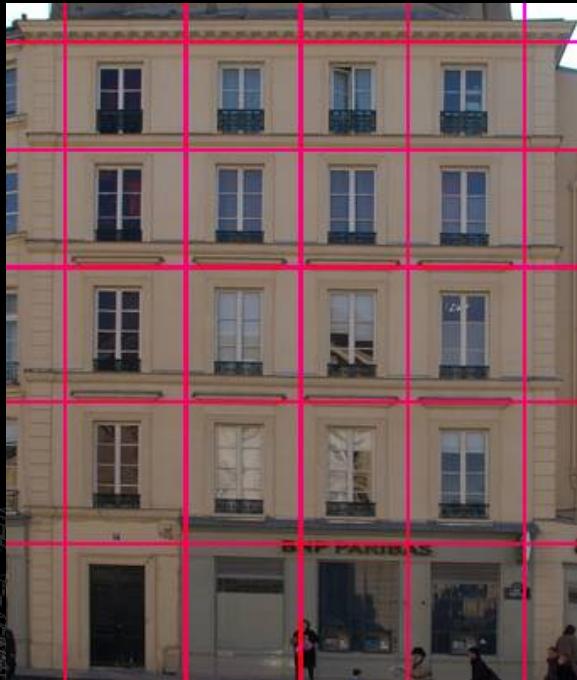
# Façade Division



# Facade Division : Rue Soufflot Results



## Some Results



# Window Position

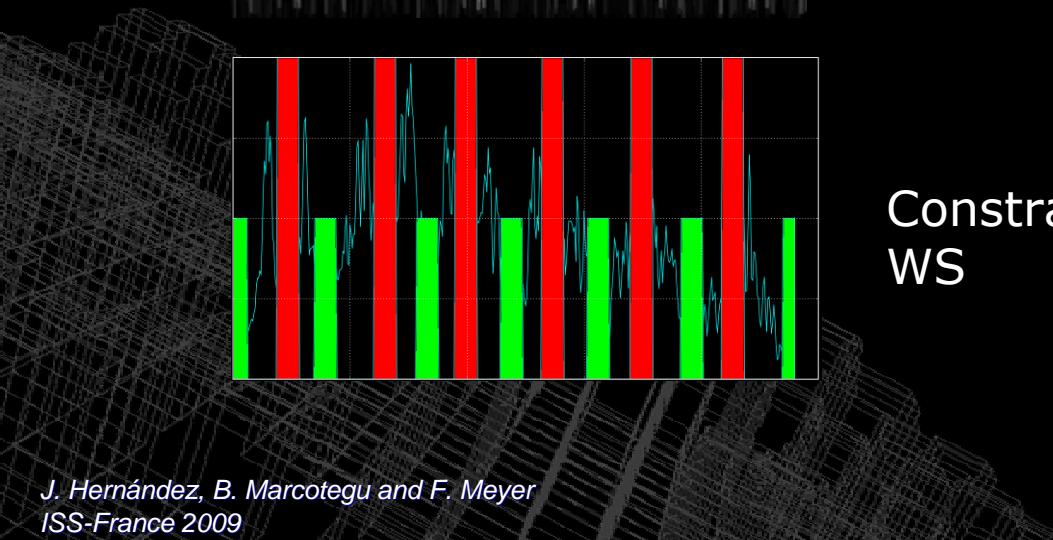


Windows and wall markers

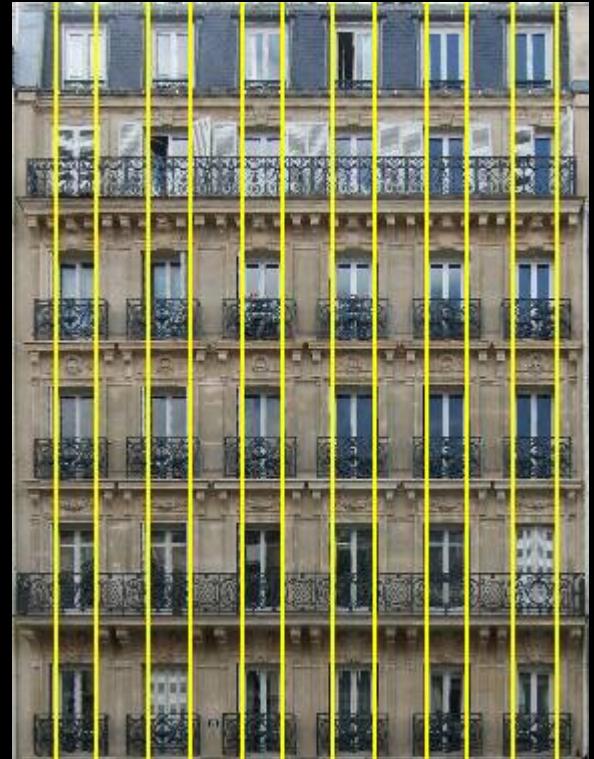


# Window Positions

$\hat{G}_v$

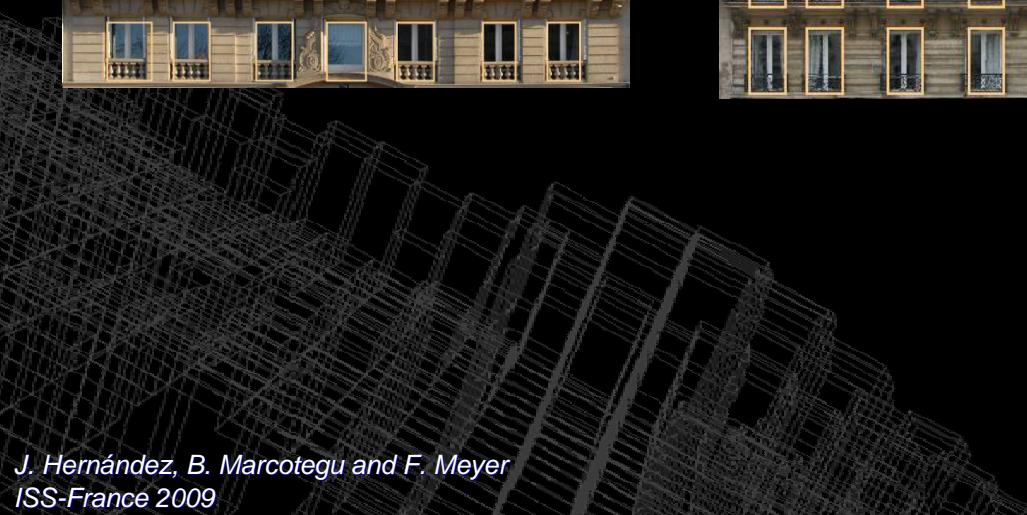


Constrained  
WS



# Some Results

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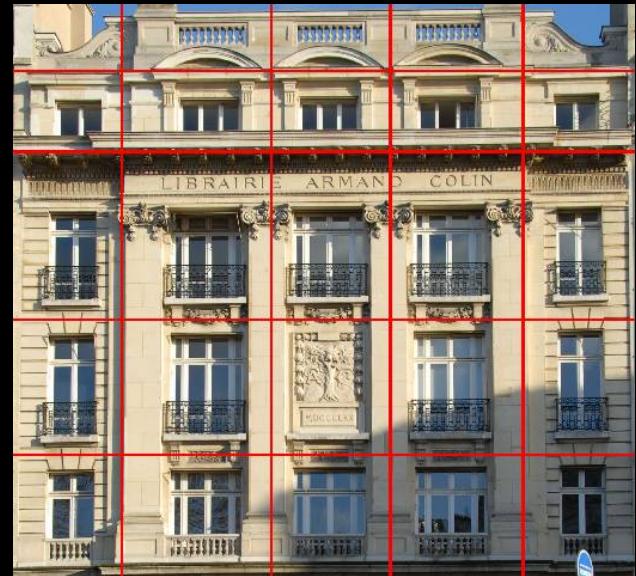
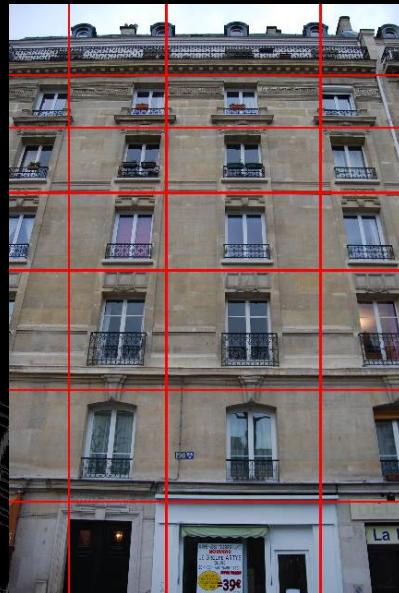
# Conclusions

Automatic façade division based on:

- projection of directional color gradients
- morphological filtering and segmentation

Automatic localization of windows.

Good results on façade with low perspective distortion, textured images and small obstacles.

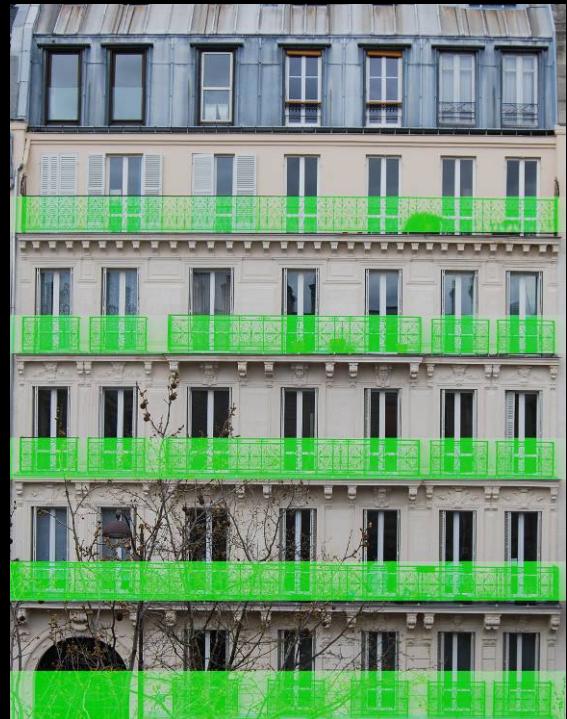


# Perspectives

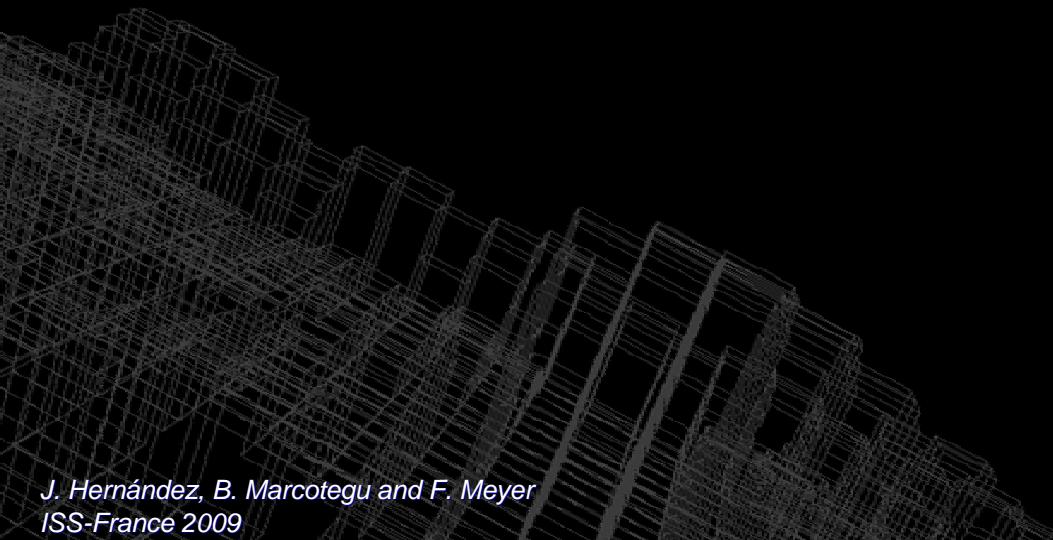
Localization of balconies

Detection of ornaments

Database creation of Haussmann structures (windows, balconies,...)



**Thank you  
for your  
attention**



## References

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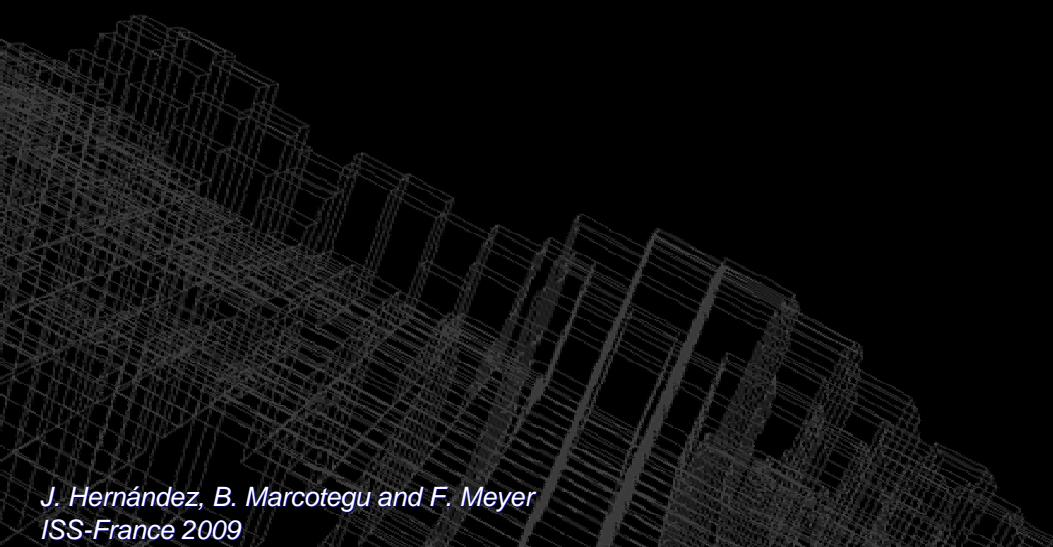
[Muller06] P. Muller, P. Wonka, S. Haegler , A. Ulmer and L. Van Gool; Procedural modeling of buildings; ACM Transaction on Graphics; 2006.

[Lee04] S. Lee and R. Nevatia; Extraction and Integration of Window in a 3D Building Model from Ground View Images; IEEE CVPR; 2004.

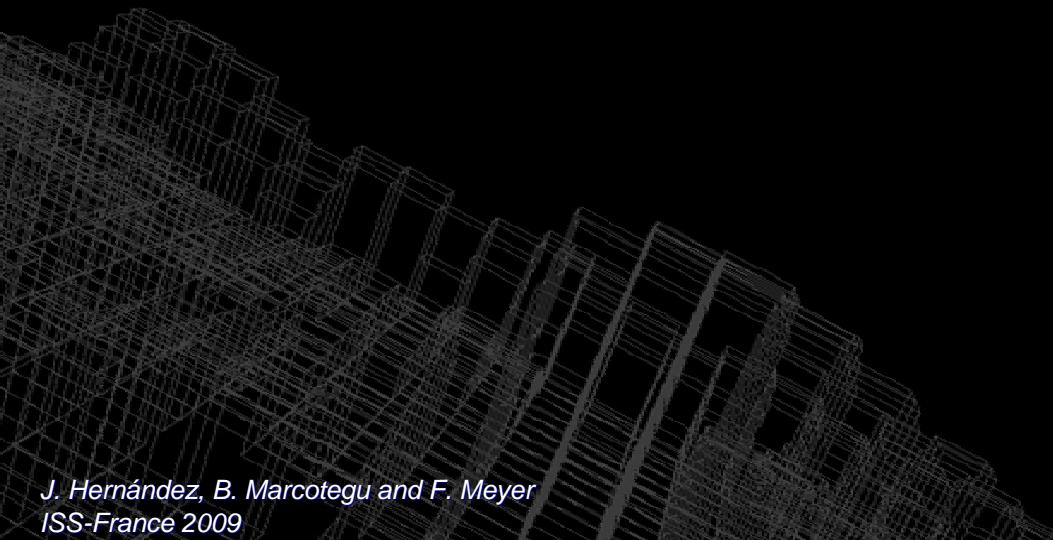
[Salembier96] P. Salembier and A. Oliveras; Practical Extensions of Connected Operator; ISMM; 1996.

[Meyer98] F. Meyer; From connected operators to levelings; ISMM; 1998

[Meyer08] F. Meyer; Nivellements Visqueux; CMM-ParisTech; 2008



# Diapo au cas où



# Perspectives

- Localization of balconies and windows

N° 19

Horizontal localization  
of balconies



# Perspectives

- Localization of balconies and windows

N° 23

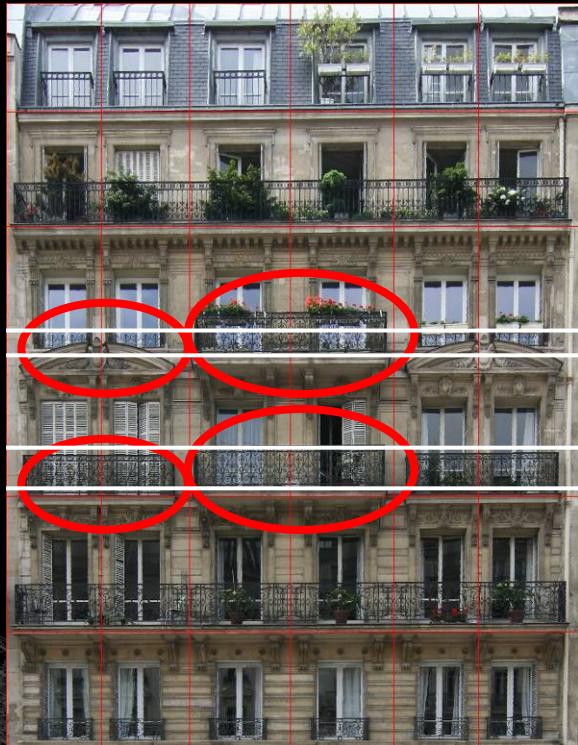
Horizontal localization  
of balconies



# Perspectives

- Localization of balconies and windows

N° 13



Horizontal localization  
of balconies



Two different heights

Two different depths



# Perspectives

- Localization of balconies and windows

Horizontal localization  
of balconies

