Adaptive Parameter Tuning for Morphological Segmentation of Building Facade Images
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1. Introduction

Hypothesis:
- Images are rectified and cropped.
- Facade elements are pseudo-regularly aligned (Haussmannian buildings).
- Our approach applies to directional color gradients.
- Our method is based on: Accumulation of directional color gradients.

Morphological filters:
- ASF
- Robustness to image resolution changes.
- Alternate Sequential Filter (ASF_n)
- Size distribution of the noise is characterized using PS_i = \sum_{\text{pixel}} (\gamma_i - \gamma)
- \gamma_{op} is chosen as the value i for which PS falls down under 25% of its maximum.
- Facade divisions are pseudo-regularly aligned (Haussmannian buildings).

We propose the adaptive tuning of morphological filters.

2. Method

Input images (Fig. a) are assumed rectified and cropped (Fig. b).
- Morphological vertical gradient G_y detects horizontal contours (Fig. c).
- Opening \gamma_{op} is applied to eliminate undesirable details (Fig. d).
- Accumulated vertical gradient P_C (Fig. e) contains peaks at window locations and valleys between them.
- ASF_{\gamma} and h-min filters get a single maximum for each window (Fig. e).
- Watershed on the inverted profile computes facade divisions (Figs. e,f).
- In the filtered profile P_C, minima pass through the wall (Fig. g) while maxima pass through the windows (Fig. h).
- Constrained watershed on the projected horizontal gradient P_{G_y} (Fig. i) takes the extrema of P_C as markers, determines the window line divisions (Fig. j).

Although a vertical splitting is explained, the same technique applies to horizontal splitting, just changing vertical by horizontal and vice versa.

3. Some Segmentation Examples

Our approach applies to pseudo-periodic structures and it is robust to different issues (Figs. j,k,l).
- Good results are obtained, but they depend on a correct parameter tuning.

4. Database

100 rectified and annotated images from the public database: http://vision.mas.ecp.fr/Personnel/teboul/data.php.

5. Adaptive filter tuning

Opening filter (\gamma_{op})
- \gamma_{op} gets rid of noise from gradient images.
- Size distribution of the noise is characterized using PS_i = \sum_{\text{pixel}} (\gamma_i - \gamma)
- \gamma_{op} is chosen as the value i for which PS falls down under 25% of its maximum.
- Robustness to image resolution changes.

Alternate Sequential Filter (ASF_{\gamma}):
- ASF_{\gamma} is a sequence of openings (\gamma_i) and closings (\phi_i) of increasing sizes:
- ASF_{\gamma}(P_C) = \gamma_{op} \phi_1 \gamma_{op} \phi_2 \gamma_{op} \phi_3
- The n leading to the most regular result is selected.
- Regularity: standard deviation \sigma(n) of the segmented facade division sizes.

H-minima filter (h-min)
- h-min removes remaining low contrasted extrema (lower than h).
- h is chosen depending on the extrema dynamic: h \propto \text{range}(ASF_{\gamma}(P_C))

6. Results

We evaluate window localization using Precision, Recall, f_{mean}.
- An exhaustive test for n shows that our tuning method offers the best possible score f_{mean}=0.79 (Fig. s).
- For h, the best possible f_{mean} corresponds to h_v=14\% and h_h=2.5\% in vertical and horizontal profiles, respectively (Fig. t).

Overall performances:
- Precision=0.82, Recall=0.79 and f_{mean}=0.80

7. Conclusions

Our adaptive segmentation method offers robustness to texture, noise, image resolution changes, occlusions, shadows and rectification errors.
- It fails if pseudo-periodic hypothesis is not fulfilled.
- Good performances on Teboul’s public database.
- In the future, ultimate opening will be studied. This operator automatically adapts its size to image structures based on a contrast criterion.

http://cmm.ensmp.fr/~serna/