

Introduction

Task:

Adding an **artistic effect** to a natural image



Input image



Processed image

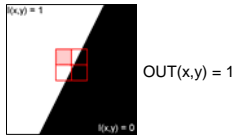
Approach:

Smoothing texture while **preserving edges** and corners

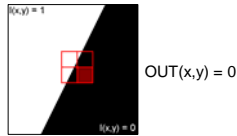
Kuwahara Filter and Extensions

• Kuwahara filter

- » Local averaging
- » Minimum Standard Deviation Criterion



Central pixel on the **white side** of the edge



Central pixel on the **white side** of the edge

- » Only the **most homogeneous region** is considered
- » Artifacts due to the Gibbs phenomenon



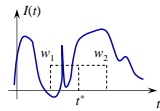
• Extensions

- » Different number and shape of the subregions
- » Weighted local averages
- » Value and Criterion Filter Structure (VCFS)
- » Connections with PDE theory and mathematical morphology

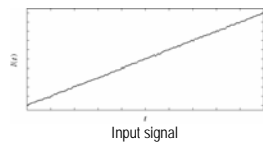
Ill-posedness of VCFS

• 1D Kuwahara filtering

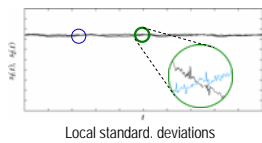
Two sub-windows $w_1(t)$ and $w_2(t)$



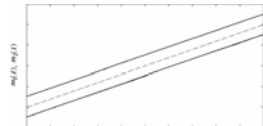
• Linear noisy input signal $I(t) = t$



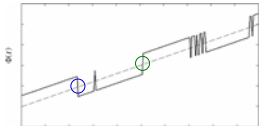
Input signal



Local standard deviations

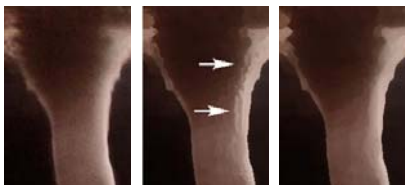
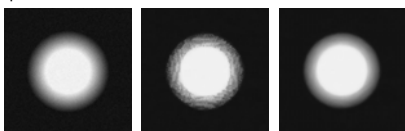


Local averages



Final output

• 2D examples



Input images

Kuwahara filtering

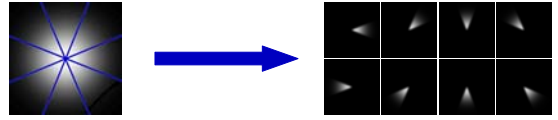
Proposed approach

Proposed Approach

» Different **weighting functions**

» **Well-posed** combination criterion instead of minimum standard deviation

• Weighting functions $w_i =$ sectors of a Gaussian



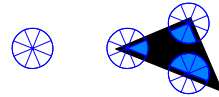
• Weighted local averages and standard deviations computed as **convolutions**

$$m_i = I * w_i, \quad s_i^2 = I^2 * w_i - m_i^2$$

• Well posed **combination criteria**

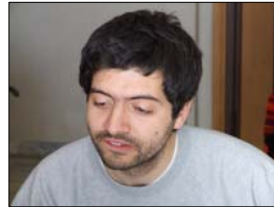
$$\Phi = \frac{\sum_i s_i^{-q} m_i}{\sum_i s_i^{-q}}$$

- » $q = 0 \Rightarrow$ Gaussian smoothing
- » $q \rightarrow \infty \Rightarrow$ Minimum Standard Deviation Criterion

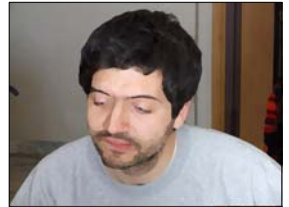


» **Automatic selection** of the interesting sectors

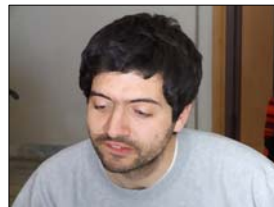
Results and Comparison



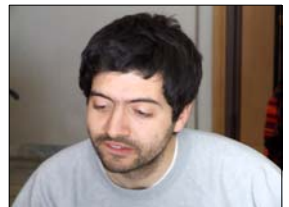
Input image



Proposed approach



Kuwahara Filter



Area open-closing



Input image



Proposed approach



Structural closing



Bilateral filtering

Larger set of examples available on

<http://www.cs.rug.nl/~imaging/artisticsmoothing>

Summary and Conclusions

- **Ill-posedness** of VCFS
- A **well-posed** selection criterion is proposed
- **Adaptive choice** of the most appropriate sectors
- **Wide set** of experimental results and comparison with existing techniques
- **Robustness** to noise and **blurring**

References

- Giuseppe Papari, Nicolai Petkov, Patrizio Campisi, "Artistic Edge and Corner Preserving Smoothing", *IEEE Transactions on Image Processing*, 29(10), 2449-2462, 2007
- Giuseppe Papari, Nicolai Petkov, Patrizio Campisi, "Edge and Corner Preserving Smoothing for Artistic Imaging", *Proceedings SPIE 2007 Image processing: Algorithm and Systems*, San Jose, CA, January 28 - February 1st, 2007