Color Gradient Map-Oriented Anisotropic Diffusion Filtering

Leandro Coser[1], Antonio C. Sobieranski[1], Adiel Mittmann[1], Eros Comunello[2], Aldo von Wangenheim[1]

[1]LAPIX – Federal University of Santa Catarina – Florianópolis – Brazil

[2]UNIVALI – Universidade do Vale do Itajaí – São José – Brazil

{leandro.coser,asobieranski,adiel,eros,awangenh}@inf.ufsc.br

www.lapix.ufsc.br

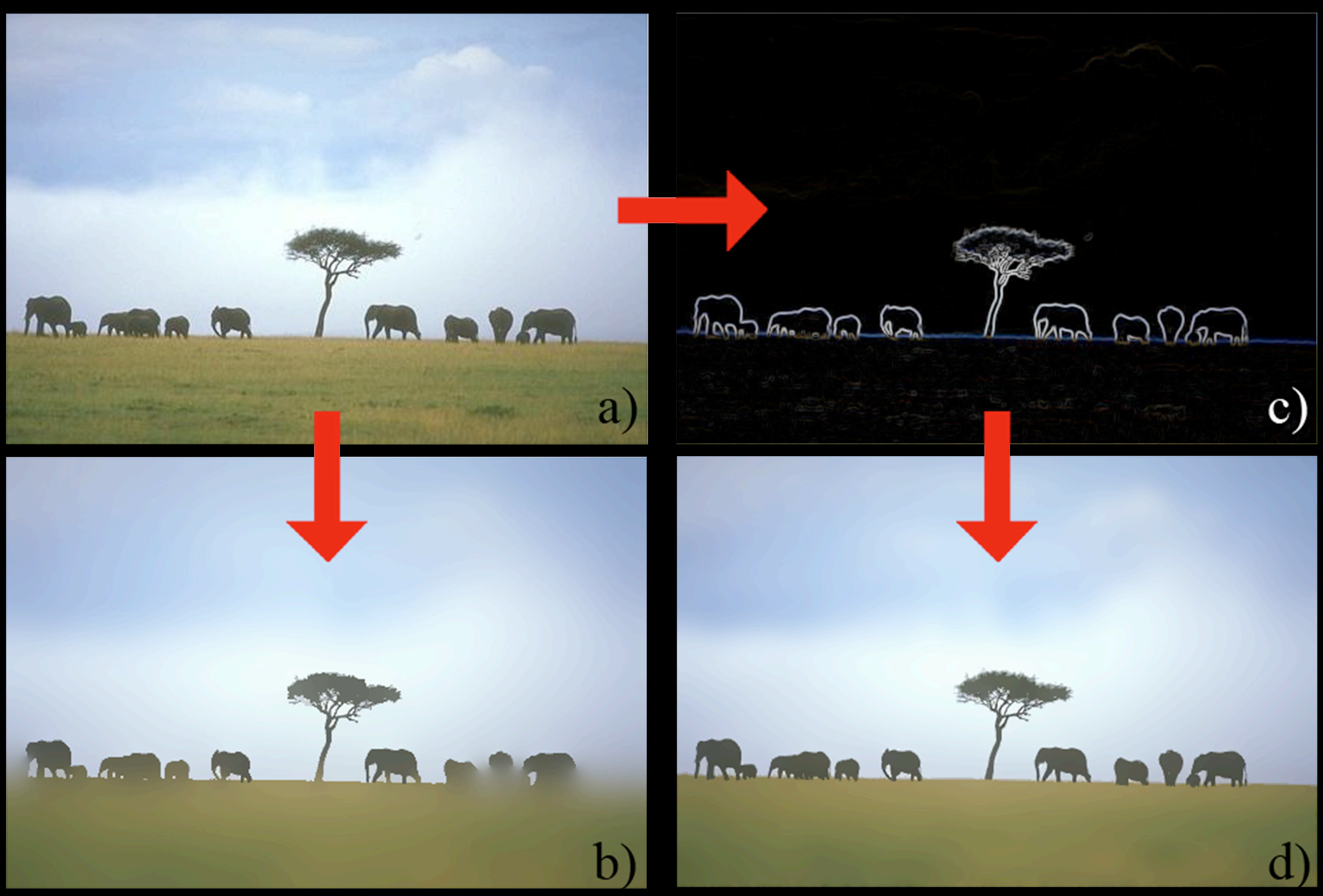

Figure 1. Traditional (a → b) and gradient map-oriented (a → c → d) filtering.

Figure 2. On the left, original images; on the right, results obtained by our approach.

Introduction

- The anisotropic diffusion filter [1, 2] is a powerful image processing technique for noise removal. It works by performing smoothing on the image while preserving boundaries between regions.
- When the filter is applied over many iterations, however, even edges that were clear in the original image become blurred.
- We propose that the anisotropic diffusion filter be oriented by a gradient map based on the original image. Because this map is static, i.e., it does not change over time, well-defined edges are not lost even when the filter is applied many times over.

Orienting the Anisotropic Diffusion Filter

- In order to guide the anisotropic diffusion filter, a gradient map G is calculated by means of a convolution using the following masks:

$$I_y = \frac{1}{4}\begin{pmatrix} -b & a & b \\ 0 & 0 & 0 \\ b & a & b \end{pmatrix} \quad \text{and} \quad I_x = \frac{1}{4}\begin{pmatrix} -b & 0 & b \\ -a & 0 & a \\ -b & 0 & b \end{pmatrix}.$$

- Here, $a = 2(\sqrt{2} - 1)$ and $b = (2 - \sqrt{2})$.
- The modulus of the vector formed by the two components is used as an estimation for the gradient for each channel.

- The basic diffusion equation [3] for an image *I(x, y)* with *M* channels and a signal that is initialized with *u(x, y, 0) = I(x, y)* is

$$\partial_t u_i = \operatorname{div}\left(D\left(\sum_{k=1}^{M} \nabla u_k \nabla u_k^T \right) \nabla u_i \right).$$

- We propose that this equation be changed to accommodate the gradient map G in the following way:

$$\partial_t u_i = \operatorname{div}\left(D\left(G_i \sum_{k=1}^{M} \nabla u_k \nabla u_k^T \right) \nabla u_i \right).$$

- Figure 1 shows an overview of the whole process.
- Figure 2 contains two images and their filtered versions. While internal regions were greatly smoothed, edges remain clear.

Conclusions

- The anisotropic diffusion filter can be improved by using a color gradient map that remains unchanged over iterations.
- With this approach, we ensure the preservation of edges that are well defined in the original image.

References

[1] J. Weickert. *Anisotropic diffusion in image processing.* Teubner-Verlag, 1998.

[2] J. Weickert. Applications of nonlinear diffusion in image processing and computer vision. *Acta Math Univ Comenianae,* 70:33–50, 2001.

[3] T. Brox. *From pixels to regions: partial differential equations in image analysis.* PhD thesis, Saarland University, 2005.