

Interactive Level-Set Tools for Photo Editing

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1 Introduction

This sketch presents a suite of interactive image-editing tools based on properties of and manipulation of image level sets. This suite includes level-set smoothing, level-set constrained sharpening, and level-set “nudging” (image distortion).

The smoothing tool preserves edge sharpness while smoothing noise and jagged contours. The sharpening tool, constrained by local level-curve properties, is less sensitive to noise than standard techniques. The nudging tool allows incremental movement of image content without the artifacts and overhead of global mesh-based distortion techniques.

All of these tools use partial differential equations to change the image content, but unlike existing approaches using PDEs, the location and duration of application are controlled interactively with immediate feedback to the user.

2 Tools

A *level set* is the set of all points in an image sharing a specific value. Although discrete pixels may not share values locally, we may assume continuity of the image intensity function and infer the existence of intermediate values. Thus, these level sets form closed curves in the image plane.

In this way, one can think of the image not as an array of pixels but as a *topographic map*. Properties of the local contour can be used to drive or control other operations. Moreover, we can directly manipulate the contours themselves—smooth them, move them as desired, etc.

The interactive level-set smoothing tool is based on established techniques for level-set smoothing [Sethian 1996; Alvarez et al. 92; Morse and Schwartzald 2001], with the following contributions:

- Interactive user control of the target area and the amount of smoothing performed,
- Automatic parameter estimation based on local image characteristics (no trial-and-error tweaking of the smoothing parameters), and
- Time-varying adjustment of smoothing parameters based on the duration of the user’s application of the tool.

The interactive level-set nudging tool is also based on established techniques for manipulating level sets [Sethian 1996], but unlike prior applications, specification of the local motion vector field is controlled by the user. Unlike mesh-based deformation approaches, the effect on the image is *local* and *direct*. Thus, subtle movement of image content can be interleaved with smoothing, sharpening, or any other desired interactive operations. This sets it apart from the range of existing mesh-based deformation tools currently available.

Unlike the smoothing and nudging tools, the level-set constrained sharpening tool does not directly manipulate level-set contours. Rather, it uses the local level-set curvature as a constraint to prevent oversharpening (accentuation of noise and corners). In this way, it responds better in the presence of noise than current interactive sharpening techniques.



Figure 1: Nudging tool used to produce a distorted-mirror effect



Figure 2: Simulated weight loss using nudging and smoothing

3 Conclusion

These tools demonstrate the power of locally-applied PDEs under user control. In addition to the operations incorporated into this suite of tools, there are many other PDE-based algorithms for image enhancement [Sapiro 2001, for an excellent survey], which we believe might be successfully incorporated into locally-applied interactive tools.

References

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