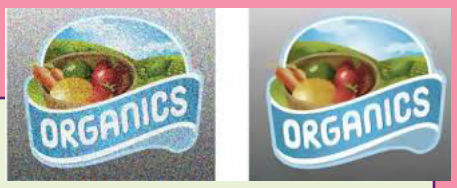
MATH MATTERS

Apply It.

The math behind... Noise Removal of Images



Technical terms used:

denoising, curvature motion, level set method, geometric flow

Uses and applications:

In every digital photograph, there is noise (fine scale fluctuations of pixels) caused by mechanical or electrical imperfections, which may make interpretation of the image difficult. Using computer algorithms, the image can be corrected by preserving relevant data and removing corrupted noise, resulting in a clearer photo.

How it works:

Given a noisy image, we wish to apply an algorithm which eliminates the imperfections and enhances the relevant patterns. The data in a photo can be thought of as a landscape with heights that define the hue. The noisy areas in the photo appear in this landscape as sharp peaks with high curvature. It turns out one can use a geometrically driven flow called curvature motion as a simple and effective way to denoise the image. Heuristically, curvature motion smooths and flattens all the bumps in the landscape as the flow evolves. The utility of curvature motion can be heuristically understood from the following two facts. First, curvature motion propagates information in normal directions to edges, which implies that edges/lines of the image remain sharp on the large scale. Second, high curvature regions evolve the fastest, so areas with noise will quickly smooth/vanish. Thus, given an image, one employs algorithms such as level set methods in order to evolve the data by curvature motion. When noise removal is optimal, the flow halts with the use of advanced stopping techniques (if one continues smoothing, then eventually the whole image will become monochromatic).

Interesting fact:

The use of ultrasound imaging is ubiquitous in the medical community, ranging from prenatal care to tumor detection. So-called speckle noise inhibits both human and software interpretation abilities. The use of noise reduction software allows for proper analysis of the data for accurate medical diagnosis.

References:

R Malladi and J. A. Sethian, Image processing via level set curvature flow. Proc. Natl. Acad. Sci. U.S.A. 92,7046-7050 (1995).

K. Z. Abd-Elmoniem, A.B.M. Youssef, and Y.M. Kadah. Real-time speckle reduction and coherence enhancement in ultrasound imaging via nonlinear anisotropic diffusion. IEEE Transactions on Biomedical Engineering 49, 997-1014 (2002).

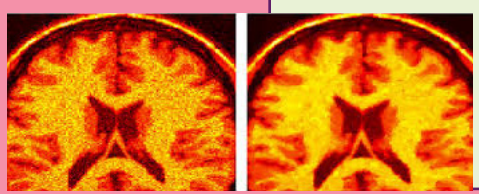


Image courtesy of Luca Calatroni, Cambridge Image Analysis, University of Cambridge, UK

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