Image Filtering Algorithm for Enhanced Noise Removal and Feature Preservation

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SUMMARY

UCLA researchers in the Department of Chemistry & Biochemistry have developed a novel image filtering algorithm that removes image noise while preserving image features with unprecedented fidelity.

BACKGROUND

Traditional image processing techniques use filtering algorithms based either on spatial smoothing (averaging) of pixel intensities or on distinguishing the true image signal from noise in a mathematically transformed domain (e.g. sorting image data by frequency content rather than by location). However, both of these approaches rely on imperfect assumptions about the statistical distribution of noise. Consequently, these methods often blur the image by suppressing certain spatial variations in intensity or by mistakenly discarding certain shapes as noise. The end result of these filtering techniques is noise reduction at the expense of diminished image quality.

INNOVATION

UCLA researchers have developed an advanced image filtering algorithm that effectively removes image noise while preserving image features with unprecedented fidelity. This efficient de-noising algorithm employs a nonlinear filter based on *multilayer perceptrons (*MLPs) to groups of similar-looking image patches across multiple copies of the original image. This filtering technique outperforms current state-of-the-art noise removal algorithms including those based on collaborative filtering and total variation.

APPLICATIONS

- ▶ Medical image filtering, including the following modalities:
- ▶ Magnetic resonance imaging (MRI), especially noisy images such as ^{23}Na (sodium) MRI and ^{31}P (phosphorous) MRI as well as time-course analysis such as functional MRI (fMRI).
- ▶ Computed tomography (CT)
- ▶ Positron emission tomography (PET)
- ▶ X-ray imaging
- ▶ Medical ultrasound imaging
- ▶ Optical (e.g. endoscopic & laparoscopic) imaging
- ▶ Electron microscopy
- ▶ Image filtering for digital photography (commercial and consumer), such as photography in dark environments or short exposure times
- ▶ Image restoration for video editing
- ▶ Image filtering for machine vision & artificial intelligence
- ▶ Automated face & object recognition algorithms
- ▶ Security and defense-related camera systems
- ▶ Self-driving vehicles
- ▶ Efficient image compression & de-compression

ADVANTAGES

- ▶ Superior noise removal & feature preservation vs. current state-of-the-art image filtering methods
- ▶ Applicable to any imaging modality: can be used to reduce scan time or dose to the patient (or sample)
- ▶ Does not require knowledge or modeling of noise distribution

CONTACT

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INVENTORS

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OTHER INFORMATION

KEYWORDS

feature similarity index (FSIM), Image filtering, image restoration, image de-noising, signal processing, signal-to-noise ratio, noise removal, domain transformation, collaborative filtering (BM3D, BM4D), total variation filtering, nonlinear filtering, multi-layer perceptrons (MLP)

CATEGORIZED AS

- ▶ **Computer**
  - ▶ Software
- ▶ **Imaging**
  - ▶ Medical
  - ▶ Security
  - ▶ Software
- ▶ **Medical**
  - ▶ Imaging
- ▶ **Security and Defense**
  - ▶ Screening/Imaging

RELATED CASES

2015-240-0

- Works well for both low- and high-noise images
- Handles both additive and multiplicative noise
- Computationally efficient
- Accounts for spatial correlations in pixel intensity within the image

STATE OF DEVELOPMENT

The described signal filtering algorithm has been implemented and tested on a set of MRI scans taken at UCLA. For all levels of initial image noise, images filtered using this novel algorithm were found superior to those filtered using other state-of-the-art de-noising methods, as quantified using the peak signal-to-noise ratio and the feature similarity index. Denoising of ^{23}Na MRI images acquired at NYU (New York University) was also performed and demonstrated unprecedented performance for noise removal and feature preservation in extreme noise conditions.

The ^{23}Na MRI images are unpublished yet, but available by request to the PI: louis.bouchard@gmail.com

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,953,246	04/24/2018	2015-240

RELATED MATERIALS

- Khalid Youssef, Nanette N. Jarenwattananon and Louis-S. Bouchard, Feature-Preserving Noise Removal, IEEE Trans. Med. Imag.

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Reducing Computational Complexity of Training Algorithms for Artificial Neural Networks
- Biologically Applicable Water-Soluble Heterogeneous Catalysts For Parahydrogen-Induced Polarization

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