Image enhancement algorithms in FLOSS: sharpening

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Getting supplementary data on LVEE

wget -m --limit-rate=100k http://192.168.1.107/share/
Sources of image fuzziness

- Focusing error;
- Lenses low quality or softness;
- Flatbed scanners peculiarities;
- Camera shake due to hands trembling or other reasons of motion.
FLOSS projects to be considered

- GIMP (GPL3+);
- ImageMagick (Apache 2.0);
- G'MIC (CeCILL License) – GIMP plugin and standalone program;
- Krita (GPL2).
USM (unsharp mask)

- Algorithmically: mixing an image with the result of its gaussian blur;
- Present in any editor declaring image processing capabilities (GIMP, ImageMagick, G'MIC, Krita, even optical printing from film negatives!);
- Parameters of USM in different software differ.
USM (unsharp mask)

• Pro:
  – Present everywhere;
  – It is possible to apply threshold value to leave smooth area untouched (otherwise noise will be enhanced too);

• Contra:
  – Low selectivity, a morphology of the image is not taken into account;
  – USM relies on visual enhancement, no compensation of real blurring effects is applied;
  – Artifacts may be produced on severe sharpening levels.
Example: USM

Source

Result
Morphology-based algorithms

• Searching for contours and their enhancement.
  - Laplacian of gaussian (ImageMagick):
    
    ```
    convert 1.png -define convolve:scale='100,100\%\' -morphology Convolve 'Log:0x2' 1_sharpen.png
    http://www.imagemagick.org/Usage/convolve/#sharpen
    ```
  - *Erosion sharpening* (GIMP plugin)
    
    The image is mixed with results of „dilate“ and „erode“ operations with some weight coefficients.

• *Pro*: More selective in respect to USM.
• *Contra*: Threshold is usually not applicable, preliminary denoising should be applied.
Example: erosion sharpening
Wavelet sharpen

- Contours are selected using wavelets and enhanced (some components of the image wavelet decomposition are enhanced);
- Implemented as GIMP plugin;

**Pro:**
- One of the most effective methods of image sharpening;
- May be combined with wavelet denoising.

**Contra:**
- No threshold usage is available, so preliminary denoising should be applied.
Example: *wavelet sharpen*
PSF-based algorithms

- Image blurring = 
  = stochastic (e.g. noise, accidental defects) + deterministic (motion blur, focusing error);

- If deterministic blurring prevails and point spread function (PSF) is known, one can restore initial image exactly (but borders);

Problems:
- PSF usually unknown;
- Noise.

http://en.wikipedia.org/wiki/File:Convolution_Illustrated_eng.png
PSF estimation


PSF-based algorithms

• **Pro:**
  – Try to compensate physical effects leading to fuzziness;
  – Can help to extract information from the image where other methods cannot (e.g. vehicle number blurred by motion and so on);

• **Contra:**
  – Require a lot of computational resources;
  – Often produce images with artifacts (ripple).
Example: *Refocus*

Source

Result
Conclusions

• FLOSS projects deliver a lot of powerful theoretically substantiated algorithms for image sharpening, based both on visual sharpness enhancement as well as on compensation of physical reasons leading to fuzziness;

• Image sharpening algorithms substantially differ in different programs (mostly as plugins or scripts). The most of them are implemented as GIMP plugin (especially taking into account G'MIC);

Basing on personal experience, author recommends wavelet algorithm usage in the majority of cases.
Yet another example :)
And yet another ;)

Source  Wavelet  Deconvolution sharpening