

Digital processing of space images using global filtering in the frequency area

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Abstract. In modern systems, remote sensing widespread two-dimensional fast Fourier transform (FFT) for processing satellite images and the subsequent image filtering. In this paper we consider the possibility of using combinations of high and low frequency filters to improve global images terrestrial surface.

1 Introduction

Currently, remote sensing of the Earth is closely related to digital image processing, since the obtained aerospace images are presented in digital form in the form of raster images. To improve images, usually used are changes in brightness and contrast, spatial filtering, Fourier transform and subsequent frequency filtering [1]. Consider in this paper the possibility of using a combination of the results of applying high and low pass filters to improve the image.

2 Method description

Let us consider as the initial data the image of Krasnoyarsk and its environs from the LandSat-8 satellite dated April 7, 2016 [2] (Figure 1). For the convenience of calculations, let us set the size of the investigated area as a power of two: 512 * 512 pixels. This image can be represented as a function $f(x,y)$ of the brightness of a pixel with coordinates x and y , taking integer values 0-255 for each red, green, blue channel in the RGB color model. In [1], it is proposed to multiply all the elements of the image $f(x,y)$ by $(-1)^{x+y}$, and then calculate the discrete Fourier transform of this function [3]. In this case, we get a centered Fourier transform $F(u,v)$ in the frequency domain, in which high frequencies (responsible for image contours and sharp transitions) will be in the center of the spectrum, and low frequencies (responsible for image smoothing and color saturation) will be around the edges.

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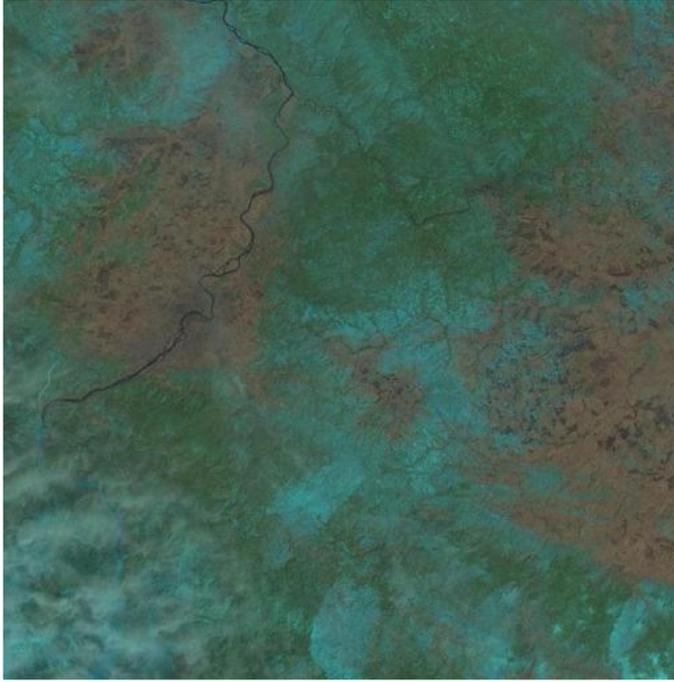


Fig. 1. Satellite image of Krasnoyarsk surface

We apply a global high-pass filter to the obtained function $F(u,v)$, for example, a Gaussian high-pass filter (HPF):

$$H(u,v) = 1 - \exp\left(\frac{-D^2(u,v)}{2 \cdot D_0^2}\right) \quad (1)$$

where $D(u,v)$ is the distance from the center of the Fourier transform to the point with coordinates (u,v) , D_0 is the cutoff frequency. The Gaussian HPF graph is shown in Figure 2.

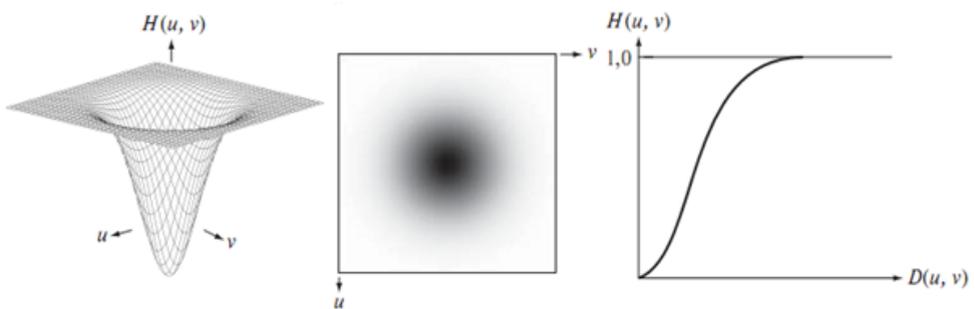


Fig. 2. Graph of a Gaussian HPF function on the left, a grayscale image of the filter in the center, radial filter profiles for different values of D_0 on the right

As a result of filtering, the high frequencies will remain unchanged, and the low frequencies outside the radius D_0 will be zeroed. After that, we calculate the inverse two-dimensional Fourier transform, multiply all the samples of the resulting function by $(-1)^{x+y}$ to cancel centering, and we get the processed image $f_i(x,y)$ (Figure 3 on the left).



Fig. 3. The result of applying a Gaussian LPF on the left, a Gaussian HPF with $D_0 = 1$ on the right

Then to the function $F(u,v)$ a global low-pass filter, for example, a Gaussian low-pass filter (LPF):

$$H(u,v) = \exp\left(\frac{-D^2(u,v)}{2 \cdot D_0^2}\right) \quad (2)$$

where $D(u,v)$ is the distance from the center of the Fourier transform to the point with coordinates (u,v) , D_0 is the cutoff frequency. The Gaussian LPF graph is shown in Figure 4.

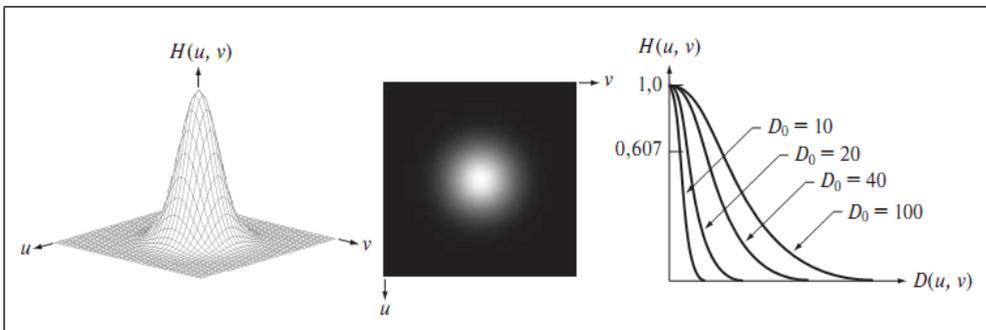


Fig. 4. Graph of a Gaussian LPF function on the left, a grayscale image of the filter in the center, radial filter profiles for different values of D_0 on the right

As a result of filtering, the low frequencies will remain unchanged, and the high frequencies outside the D_0 radius will be zeroed. After that, in the same way, we calculate the inverse two-dimensional Fourier transform, multiply all the samples of the resulting

function by $(-1)^{x+y}$ to cancel centering, and we get the processed image $f_2(x,y)$ (Figure 3 on the right).

Then we perform the step of combining the resulting images. For each pixel of the new image $f_3(x,y)$, recalculate the brightness value using the formula

$$f_3(x,y) = a \cdot f_1(x,y) + b \cdot f_2(x,y) \quad (3)$$

where $a, b \geq 0, a + b = 1$. In this case $a = b = 0.5$.

3 Obtained results

The final filtering result is shown in Figure 5.

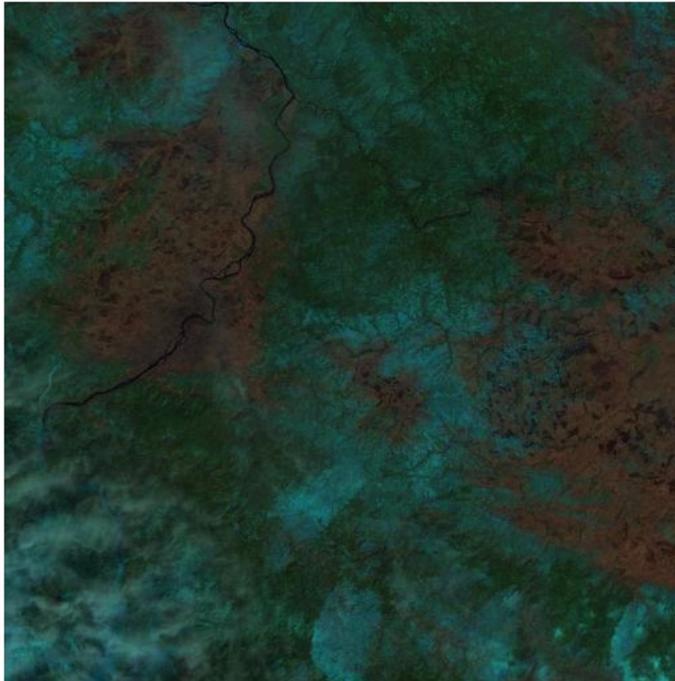


Fig. 5. Global high-pass filtering result

The contours of objects have become noticeably outlined in the image, the color saturation has increased.

4 Conclusion

On the example of a satellite image of Krasnoyarsk and its environs, a method of using a combination of global high- and low-frequency filtering to improve the image is shown. As a result of processing, image details become more visible and colors brighter.

Acknowledgments

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References

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