Spectral Based Approach of Subpixel Image Formation

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Abstract **The paper deals with modern problems of digital remote sensing and the possible ways to improve the spatial resolution. New ways of data capturing that allow the use of sub-pixel technology to take pictures of a higher spatial resolution are describe. Theoretical and experimental results show that the proposed methods increase resolution of satellite images.**

Keywords **image processing, spatial resolution, sub-pixel image processing, inverse problems.**

I. INTRODUCTION

Quality improvement of satellite images is one of the most important tasks for remote sensing. The most important parameter of satellite images which defines quality is spatial resolution which depends on quantity of pixel per image and its geometric projections to the Earth surface. Decreasing of pixel's size is limited by current state of technology and data processing algorithms.

Decreasing of pixel's size requires improvement of photosensitivity and increasing frequency bands for synchronization and data signals. But this approach makes significant load for onboard processing unit.

Solution for such problem is using subpixel data forming and processing which allows produce hi-resolution digital image by series of low-resolution images taken with some spatial shift.

II. MAIN PART

Subpixel image processing gives improvement of spatial resolution with the same sensor without changing of pixel's geometry. It can be made by positioning of several image sensors shifted for subpixel distant relative each other [1].

The series of low resolution subimages can be taken with:

а) subpixel scanning scene projection by several image sensors,

б) optical shielding mask posed before image sensor (in focal plane) and defocused image on the image sensor [2],

в) different degrees of defocusing on different image sensors without applying optical mask.

If consider typical image sensor it contains pixels with some shape, usually square. This pixel's shape contributes a lot to the pulse responce of image system called as point spread function and determines system's low frequency property if consider spatial spectrum domain. So the model of digital image forming process will look as preaplying low frequence spatial filter followed by spatial discretization (1). This low frequency filter limits potential spatial resolution even spatial discretization is done with fine pitch.

$$\boldsymbol{I}(\boldsymbol{k},\boldsymbol{l}) = D\{I(x,y) \oplus h(x,y)\} \qquad (1)$$

Where: $\oplus$ - convolution; $D\{\cdot\}$ - discretization operator; $I(x,y)$ - initial image; $h(x,y)$ - aperture of pixel; x, y - linear coordinates; k, l - discrette coordinates.

Based on described image forming model becomes obvious relation between potential spatial resolution and properties of low-frequency filter caused by pixel's aperture. This means that two shifted image sensors cannot produce the image with improved spatial resolution in twice because of low-pass filtering.

The improvement can be achieved with applying inverse filtering which compensate the influence caused by pixel's aperture. As this inverse filtering have high frequency properties than to stabilize it against noise need to use regularization methods like Tikhonov regularization [3].

Then Image forming process looks

$$\boldsymbol{I}(\boldsymbol{k},\boldsymbol{l}) = D\{I(x,y) \oplus h(x,y)\} + D\{I(x+\Delta x, y+\Delta y) \oplus h(x,y)\} \qquad (2)$$

where $\Delta x, \Delta y$ - spatial shift for subpixel distant.

And with applying correction in frequency domain the restored image $\bar{\boldsymbol{I}}(\boldsymbol{k},\boldsymbol{l})$ is:

$$\bar{\boldsymbol{I}}(\boldsymbol{k},\boldsymbol{l}) = R^{-1}\{\boldsymbol{I}(\boldsymbol{k},\boldsymbol{l})\} \qquad (3)$$

Where $R^{-1}\{\cdot\}$ - regularized inverse filtering operator.

III. CONCLUSIONS

The analysis of image forming process by image sensors array shows that pixel's aperture works as lowpass spatial filter and degrades spatial resolution even used several image sensors shifted for subpixel distance. Proposed approach uses constructive placement of image sensor and dataprocessing based on inverse filtering as well. This gives benefit in comparision to existing modern approaches based on image sensors placement or masks.

IV. REFERENCES

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