

# CONTRAST ENHANCEMENT OF COLOUR DIGITAL IMAGES

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Preliminary communication

The main parts of digital images processing are procedures that improve the images quality which does not improve information content, but ensures that the image is visually better and more suitable for display. That is achieved through improved contrast, noise removing, sharpening and colouring pictures. Contrast is the rate of frequency changes in illumination and recording the difference between light and dark elements of the image in the brightness level. Contrast is the difference between two adjacent surfaces' brightness. Absolute value of the brightness of an object is of less importance than the relative brightness (contrast). Objects that have the same objective value of luminance may cause differences in the subjective sense of brightness depending on the contrast. This paper presents the improvement of the digital images quality in colour, which are the result of volcanic activity recording in the infrared region of the electromagnetic energy spectrum, with the application process to improve the contrast of images. High-quality digital images of the volcano were treated in high spatial resolution, which enabled the successful application of MATLAB and the results were very clear, precise and expressive images.

**Keywords:** *contrast; digital image; improving the quality; MATLAB; Plosky Tolbachik; volcano*

## Poboljšanje kontrasta digitalnih snimaka u boji

Prethodno priopćenje

Osnovna područja obrade digitalnih snimaka su postupci poboljšanja kvalitete snimaka, čime se ne popravljaju informacijski sadržaj, već se postiže da slika bude vizualno kvalitetnija i pogodnija za prikaz, što se ostvaruje kroz poboljšanje kontrasta, otklanjanje šuma, izoštravanje i bojanje slike. Kontrast je mjera učestalosti promjene osvijetljenja na snimku i predstavlja razliku između svijetlih i tamnih elemenata snimka u nivou osvijetljenosti. Kontrast predstavlja razliku svjetline dviju susjednih površina. Apsolutna vrijednost svjetline nekog objekta je od manjeg značaja od relativne svjetline (kontrasta). Objekti koji imaju istu objektivnu vrijednost svjetline (luminance), mogu izazvati različit subjektivni osjećaj svjetline (brightness) zavisno od kontrasta. U ovom radu će biti predstavljeno poboljšanje kvaliteta digitalnih snimaka u boji, koji su rezultat snimanja vulkanske aktivnosti u infracrvenom području spektra elektromagnetne energije, uz primjenu postupka poboljšanja kontrasta snimaka. Obradivani su kvalitetni digitalni snimci vulkana visoke prostorne rezolucije, što je omogućilo uspješnu primjenu programskog paketa MATLAB i dobiveni su vrlo jasni, precizni i izražajni slikovni prikazi.

**Ključne riječi:** *digitalni snimak; kontrast; MATLAB; Plosky Tolbachik; poboljšanje kvalitete; vulkan*

## 1 Introduction

Digital image processing is a multidisciplinary field that covers various aspects of optics, electronics, mathematics, photography and computers.

Using colour in image processing is motivated by two main reasons. The first reason is that the colour is a powerful descriptor that simplifies the identification of objects and their separation. Another reason is that people may distinguish much more colour nuances than nuances of grey, which is particularly important when it comes to interactive (controlled by the viewer) image analysis [1].

Colour image processing can be divided into two parts. One is common image processing in colour while the other is so called pseudo colour or the use of colour image processing that essentially has no colour [2].

Although the perception and interpretation of colour is a psychological phenomenon that is still not fully understood, the physical nature of colour can be described by some formal laws based on experimental and theoretical results. Originally, Isaac Newton had described the decomposition of sunlight into the colour spectrum when passing it through a glass prism in 1666. [3].

Humans and some animals see the colour as part of the spectrum that is reflected from the object. Basic features that are used to distinguish one colour from another are: *luminance*, which corresponds to the intensity, the *dominant colour* (hue), which corresponds to the dominant wavelength and *saturation*, which is inversely proportional to the amount of white light that is added to the dominant colour. Another approach is trichromatic theory that means the presentation of colours

based on the characteristics of human vision that each colour is decomposed into three components: red, green, and blue [4].

Almost all the methods that are used to repair the quality of monochrome images can be applied to improve colour images, but their use is not simple. Specifically, in addition to the increase of computational complexity appears the additional problem of colour images perception [5].

Processing of colour images could be made through simultaneous processing of all three components of the image: *R*, *G* and *B*. However, one must take care not to disturb the *colour balance*. Colour balance means the ratio of primary colours, which ensures that the grey items do have a grey colour. When the colour balance is disturbed, grey objects become coloured. Linear transformations, which are used for monochrome images, do not disturb the colour balance if applied only to the two primary components, and the third component is transformed in such a way as to keep the colour balance [6].

## 2 Materials and methods

As an example of a successful improvement of the quality of the digital colour image for a successful image analysis, the paper presents the contrast improvement of volcano Plosky Tolbachik image in the territory of Russia.

Tolbachik is a volcanic complex in the Kamchatka Peninsula in the far east of Russia. It consists of two volcanoes, Plosky Tolbachik (3085 m) and Ostry Tolbachik (3682 m).

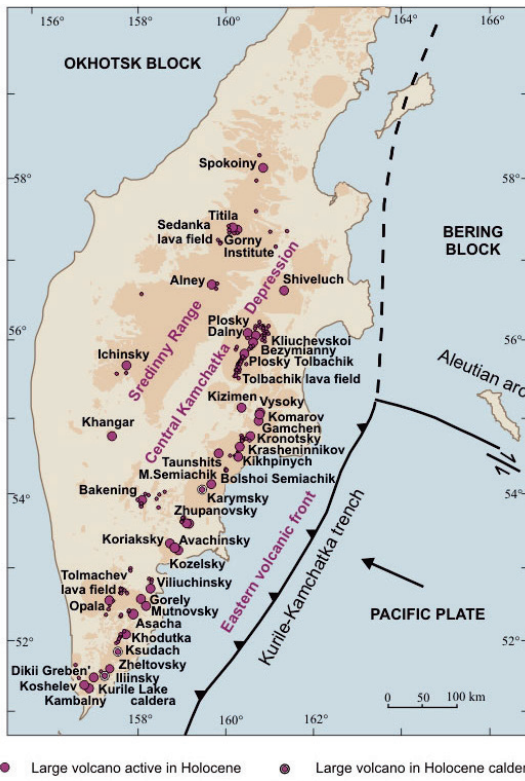


Figure 1 Active volcanoes in the central part of Kamchatka Peninsula [7]

Volcano Plosky Tolbachik in the Russian Kamchatka peninsula erupted on 27 November 2012, after 36 years, throwing out clouds of ash 3000 meters in height.

The shoot of the eruption of the Plosky Tolbachik volcano taken from air is presented in Fig. 2. Fig. 3 shows the original infrared satellite image of the volcano made by NASA satellite. In Fig. 4 we see the areas on which the lava is hot, highlighted by the red colour. Satellite image of the volcano on which are highlighted the streams of lava is presented in Fig. 5.



Figure 2 The eruption of Plosky Tolbachik volcano [8]

Used images were taken during the mission EO-1, on November 2012, and were recorded with sensor ALI (Advanced Land Imager). The Earth Observing-1 Mission (EO-1) satellite is part of NASA's New Millennium Program (NMP). The EO-1 ALI is the first Earth-Observing instrument to be flown under NASA's New Millennium Program (NMP). The ALI employs novel wide-angle optics and a highly integrated multispectral and panchromatic spectrometer.

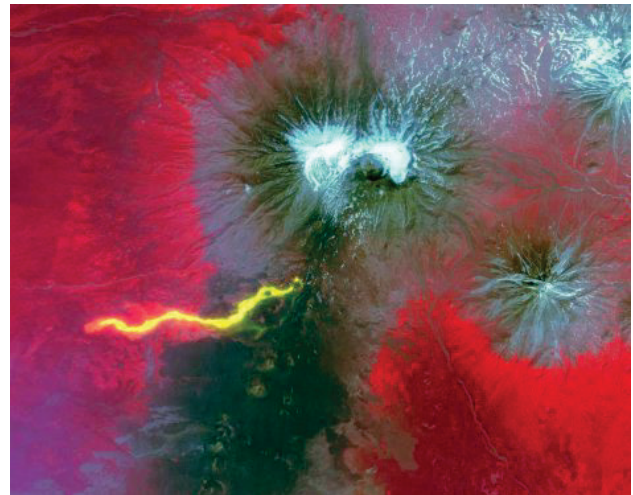


Figure 3 Infrared satellite image of the volcano Plosky Tolbachik [9]



Figure 4 Coloured infrared satellite image of the volcano Plosky Tolbachik [9]

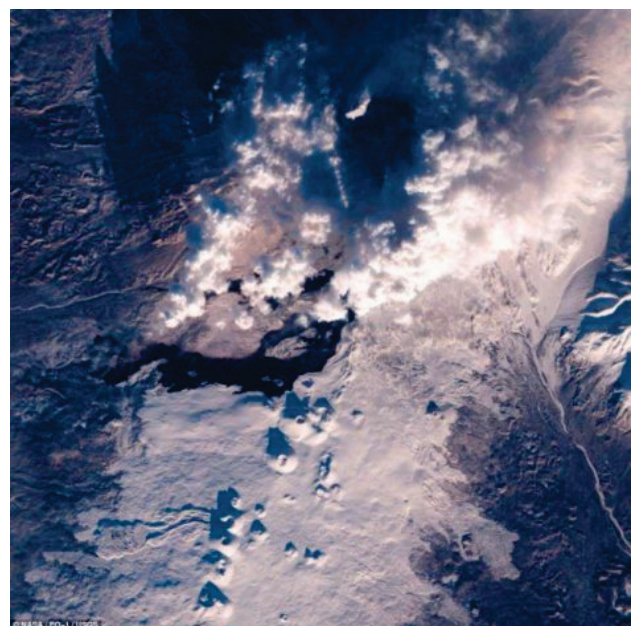


Figure 5 A satellite image of the volcano Plosky Tolbachik with details [9]

**Contrast-Stretching Transformation.** The function of contrast-stretching transformation compresses the input levels lower than  $m$  into a narrow range of dark levels in the output image. Similarly, it compresses the values above  $m$  into a narrow band of light levels in the output. The result is an image of higher contrast [10].

**Contrast-Stretching.** It is very frequent that in the photo taking process we got low contrast photo due to the inadequate scene illumination or small dynamic range of the camera [11]. Contrast stretch operation can then be used in order to enhance the subjective quality of the photo, presented with the expression [12]:

$$v = \begin{cases} \alpha u, & 0 \leq u < a \\ \beta(u - a) + v_a & a \leq u < b \\ \gamma(u - b) + v_b & b \leq u \leq (L - 1) \end{cases} \quad (1)$$

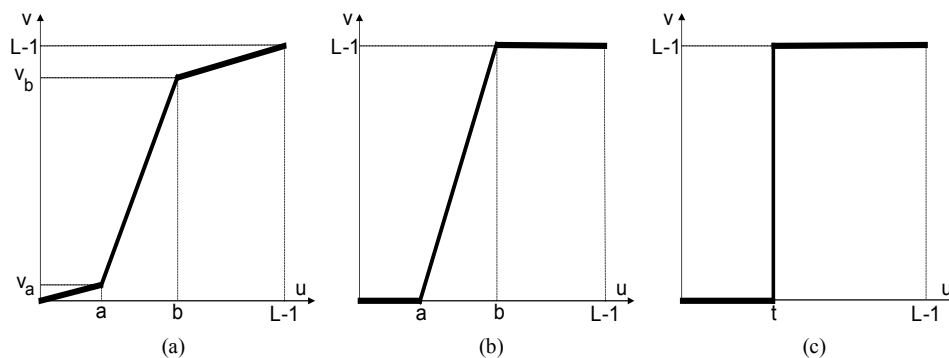


Figure 6 Contrast transformations: (a) Stretching, (b) Trimming, (c) Thresholding [13]

### 3 Results and discussion

The result of the conducted contrast improvement in spatial improvement of the quality of the digital colour image within the realized experiment is shown in Fig. 7.

The conducted contrast improvement is achieved by using the function `stretchlim` - Find limits to contrast stretch image.

Syntax

```
Low_High = stretchlim(I)
Low_High = stretchlim(I,Tol)
Low_High=stretchlim(RGB,Tol)
```

`Low_High = stretchlim(I)` returns `Low_High`, a two-element vector of pixel values that specify lower and upper limits that can be used for contrast stretching image `I`. By default, values in `Low_High` specify the bottom 1 % and the top 1 % of all pixel values. The returned grey values can be used by the `imadjust` function to increase the contrast of an image [14].

This function supports code generation.

`Low_High = stretchlim(I,Tol)` where `Tol` is a two-element vector `[Low_FractHigh_Fract]` that specifies the fraction of the image to saturate low and high pixel values.

If `Tol` is a scalar, `Low_Fract = Tol`, and `High_Fract = 1 - Low_Fract`, which saturates equal fractions at low and high pixel values.

The constants  $a$  and  $b$  are chosen experimentally, or on the basis of the image known statistics, while for parameters  $\alpha$ ,  $\beta$  and  $\gamma$  restrictions  $\alpha < 1$  and  $\beta > 1$  can be applied. Thus, the area of gray level, which usually appears in the image,  $a \leq u < b$ , stretched to the area  $v_a \leq v < v_b$  thereby improving the visual impression. Contrast transformation (1) is shown in Fig. 6a.

**Trimming.** The special case of the contrast stretching appears when the first and the third segment are horizontal, i.e.  $a = g = 0$ , shown in Fig. 6b. This transformation process is called trimming. It is suitable for the noise reduction when the values of the input are in the range  $[a, b]$ .

**Thresholding.** If during the trimming procedure  $a = b = t$  besides  $a = g = 0$ , like in Fig. 6c the output becomes binary. This process of binarization is called thresholding.

If `Tol = 0`, `Low_High = [min(I(:)); max(I(:))]`.

If you omit the `Tol` argument, `[Low_FractHigh_Fract]` defaults to `[0,01 0,99]`, saturating 2 %.

If `Tol` is too big, such that no pixels would be left after saturating low and high pixel values, `stretchlim` returns `[0 1]`.

`Low_High = stretchlim(RGB,Tol)` returns a 2-by-3 matrix of intensity pairs to saturate each plane of the RGB image. `Tol` specifies the same fractions of saturation for each plane.

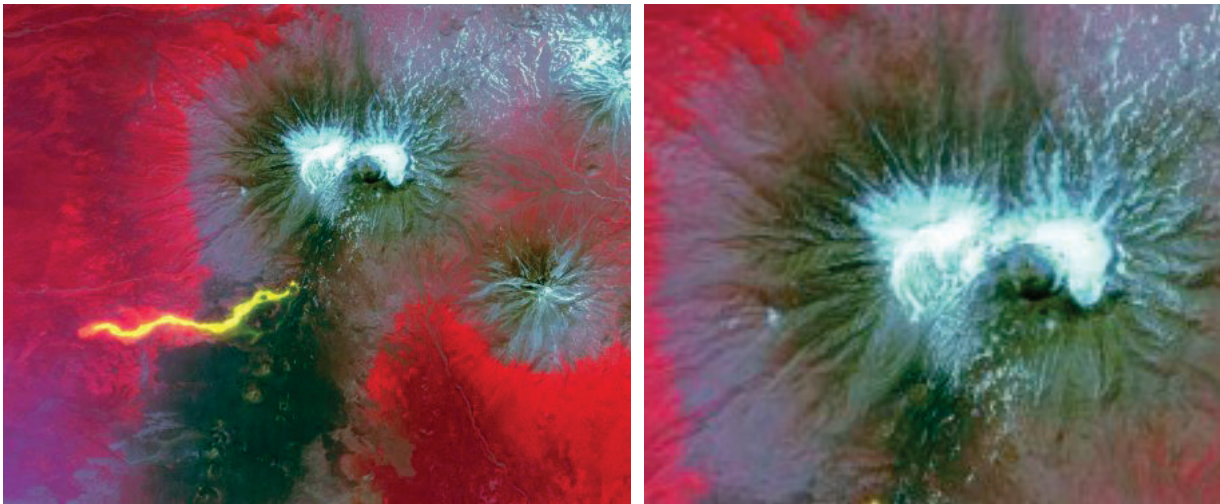
The input images `I` or `RGB` can be of class `uint8`, `uint16`, `int16`, `double`, or `single`. The output limits returned, `Low_High`, are of class `double` and have values between 0 and 1 [15].

Contrast improvement of an RGB image can also be successfully done by using the function `imadjust`.

`RGB2 = imadjust(RGB1,_)` performs the adjustment on each plane (red, green, and blue) of the RGB image `RGB`. If `low_in`, `high_in`, `low_out`, `high_out`, and `gamma` are scalars, `imadjust` applies the same mapping to the red, green, and blue components of the image.

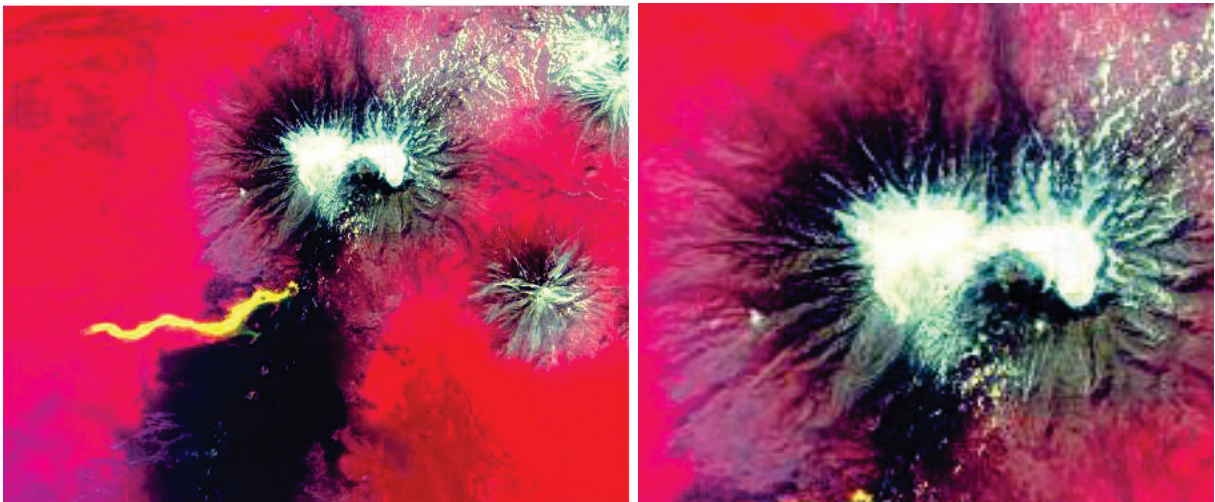
The procedure of the conducted contrast realized in the framework of the experiment is as follows:

```
RGB = imread('vulkan1.jpg');
RGB1 = imadjust(RGB,[0.2 0.3 0; 0.6 0.7 1],[]);
RGB1 = imadjust(RGB,stretchlim(RGB), [0.99 0.01]);
```



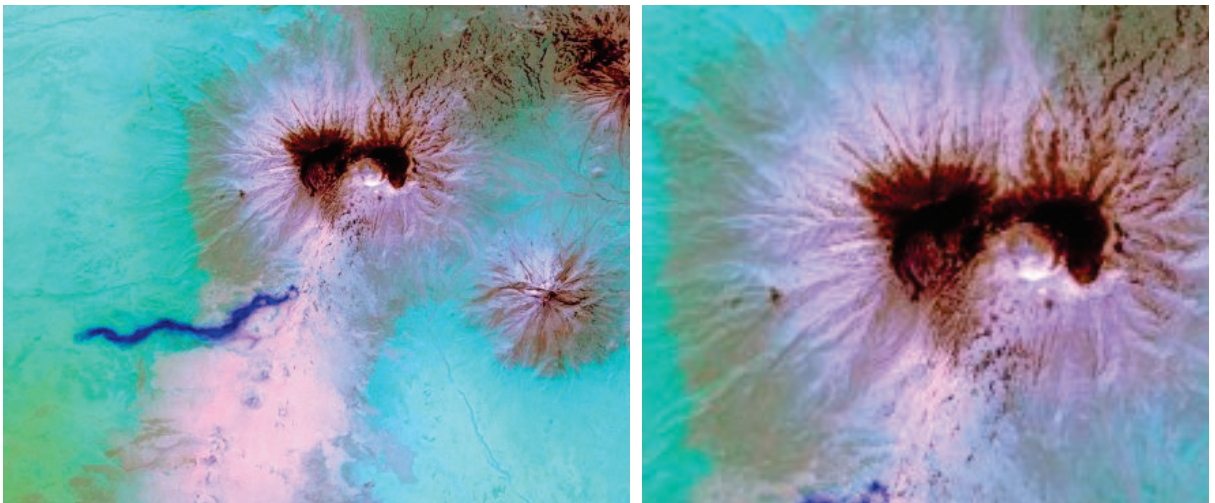
(a)

```
RGB = imread('vulkan1.jpg');  
RGB1 = imadjust(RGB,[0.2 0.3 0; 0.6 0.7 1],[,]);  
figure,imshow(RGB1);
```



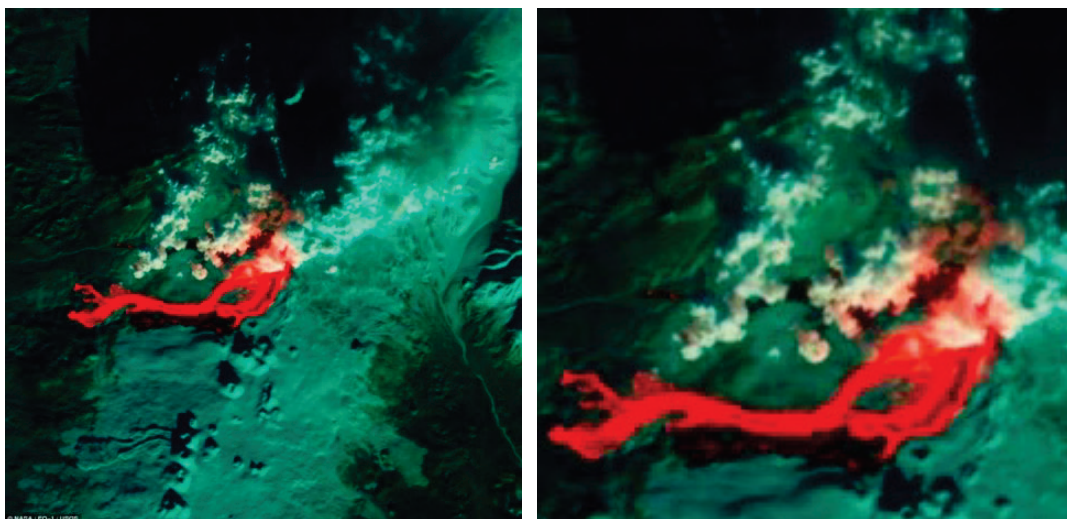
(b)

```
RGB = imread('vulkan1.jpg');  
RGB1 = imadjust(RGB,stretchlim(RGB), [0.99 0.01]);  
figure,imshow(RGB1);
```



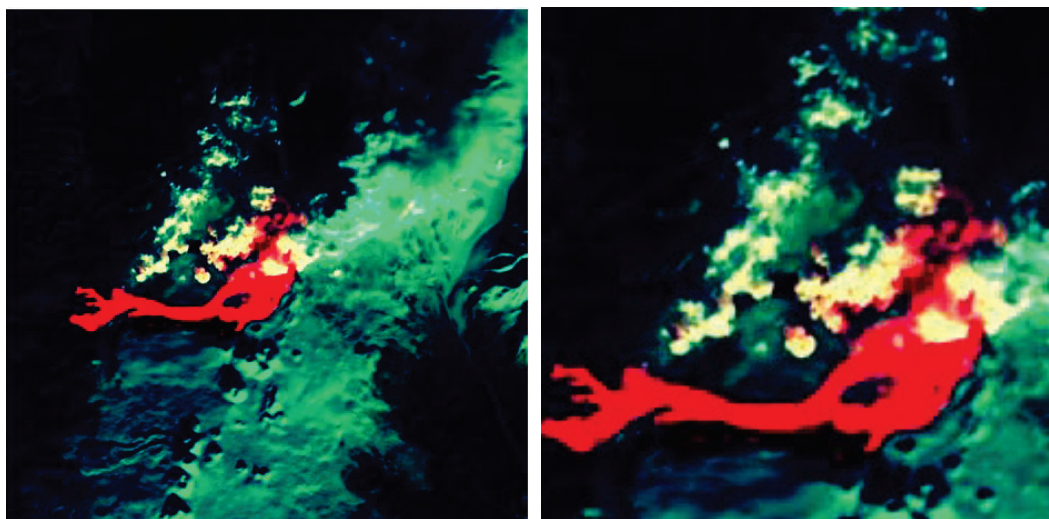
(c)

**Figure 7** (a) The original images of the volcano (left), zoomed part of the left image (right); (b) Image with improved contrast using function imadjust (left), zoomed part of the left image (right); (c) Image with improved contrast using function stretchlim (left), zoomed part of the left image (right)



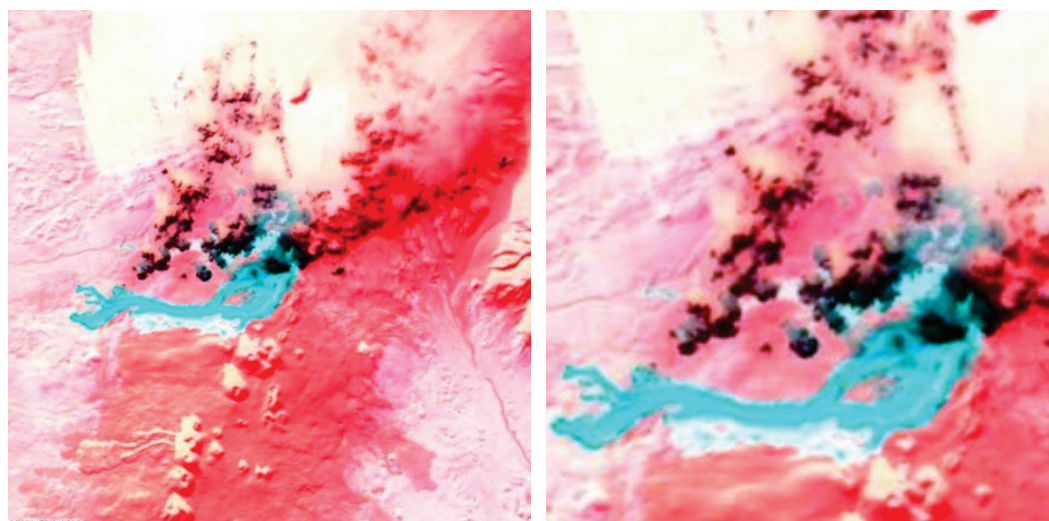
(a)

```
RGB = imread('vulkan2.jpg');
RGB2 = imadjust(RGB,[0.2 0.3 0; 0.6 0.7 1],[,]);figure,imshow(RGB2)
```



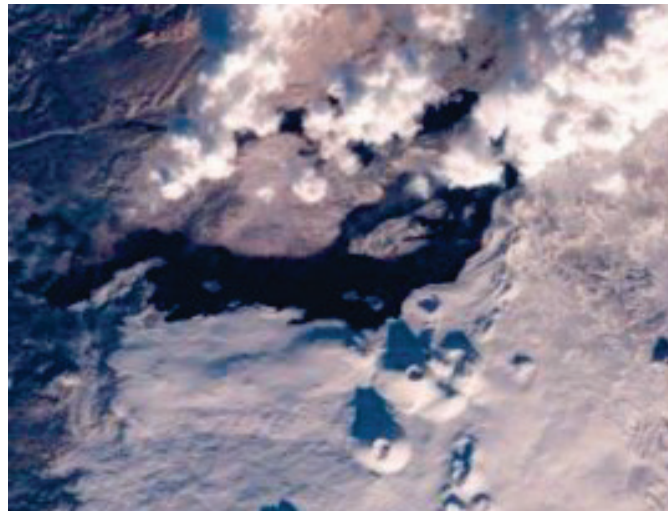
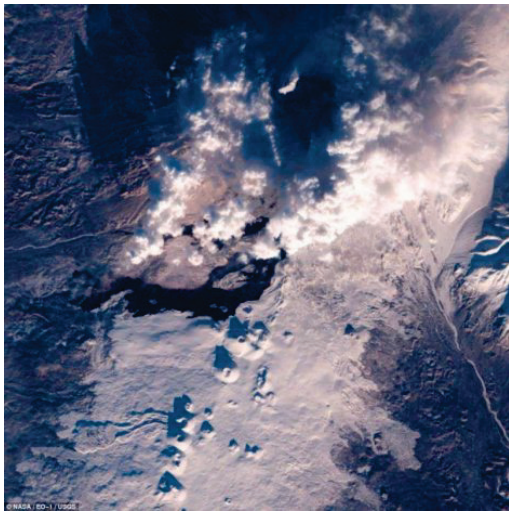
(b)

```
RGB = imread('vulkan2.jpg');
RGB2 = imadjust(RGB, stretchlim(RGB), [0.99 0.01]);
figure, imshow(RGB2);
```



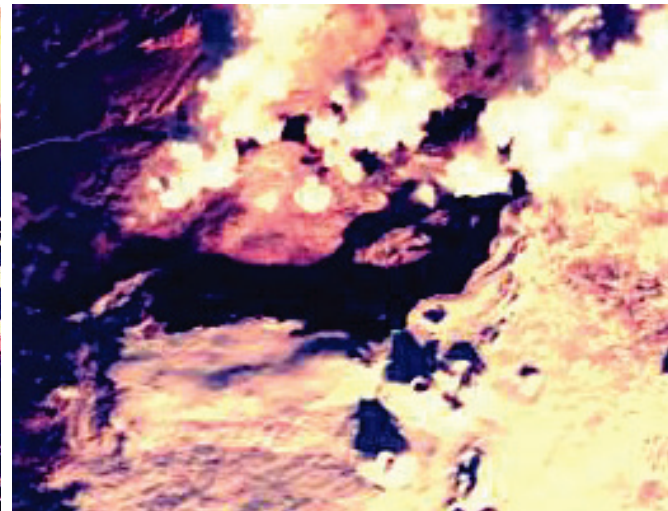
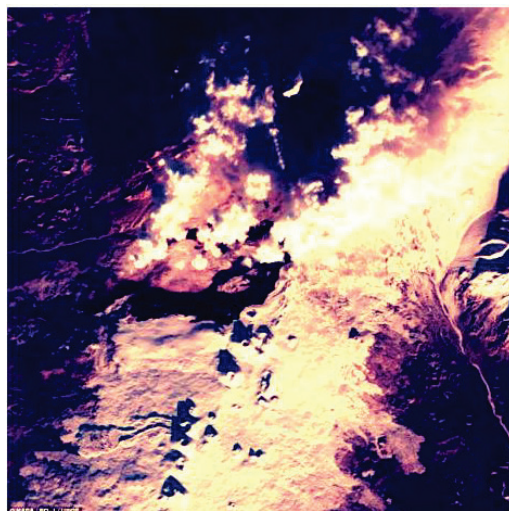
(a)

**Figure 8** (a) The original images of the volcano (left), zoomed part of the left image (right); (b) Image with improved contrast using function imadjust (left), zoomed part of the left image (right); (c) Image with improved contrast using function stretchlim (left), zoomed part of the left image (right)



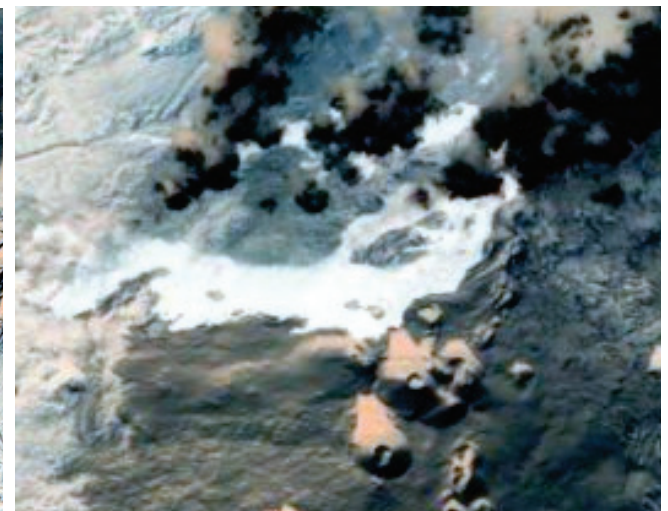
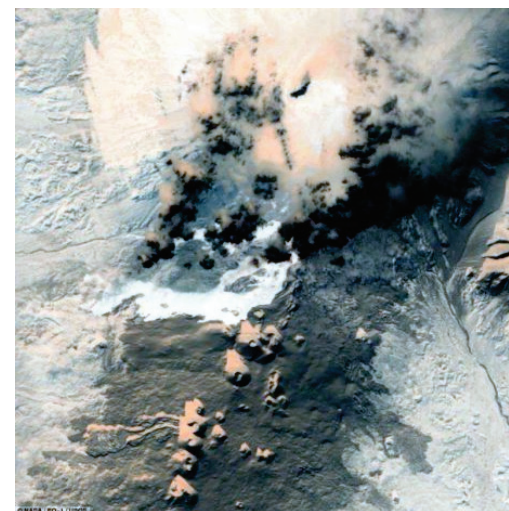
(a)

```
RGB = imread('vulkan3.jpg');  
RGB3 = imadjust(RGB,[0.2 0.3 0; 0.6 0.7 1],[,]);  
figure,imshow(RGB3);
```



(b)

```
RGB = imread('vulkan3.jpg');  
RGB3 = imadjust(RGB, stretchlim(RGB), [0.99 0.01]);  
figure, imshow(RGB3);
```



(a)

**Figure 9**(a) The original images of the volcano (left), zoomed part of the left image (right); (b) Image with improved contrast using function imadjust (left), zoomed part of the left image (right); (c) Image with improved contrast using function stretchlim (left), zoomed part of the left image (right)

In the images of the volcano which were processed by the contrast enhancement, it is much easier to detect the volcano activity and the changes around the volcano. In the infrared images of NASA satellites for earth observation EO-1 it can be seen how the opening of a volcano spews lava, which resembles the fire river. Intense red highlighted areas represent hot lava, and green areas are colder parts of the Kamchatka Peninsula. This image shows prominent lava flows - this time in the form of Dark River flowing from the mouth of the volcano, which ejects clouds of ash into the air, a week after the eruption.

Infrared images of the volcano Tolbachik are of extremely high quality thanks to the use of artificial colours, which are used to mark different temperature zones. Intense red highlighted areas with hot lava, and green areas with colder parts of the Kamchatka Peninsula.

#### 4 Conclusion

In the process of improving the colour quality of digital images, which precedes processing and analysis of images, an important role is played by the process of enhancing of the contrast images. High-quality digital images of the volcano with high spatial resolution have been treated in this paper, which was enabled by successful implementation of MATLAB.

For the maximum improvement of the image contrast of the RGB image using the function image adjust, next values of pixel intensity were used: for Low In we used 0,2 (blue) 0,3 (green) and 0 (red), and for High In the values were 0,6 (blue) 0,7 (green) and 1 (red). These values of the pixel intensity are the values of the original image, which the function image adjust translates into pixel intensity values in the range from 0 to 1.

For the maximum improvement of the image contrast of the RGB image using the function stretchlim, next values of pixel intensity were used: for Low Fract we used 0,99, and for High Fract we used 0,01.

Improving the quality of colour images using MATLAB program, which is designed for solving tasks and the necessary analysis in the field of mathematics, has proved very successful, and was achieved through image contrast correction.

Through the process of contrast of images improvement there were obtained very clear, precise and expressive visual presentations due to highlighting the edges of objects and line elements. On enhanced infrared image of the volcano Tolbachik it is easy to detect, recognize and distinguish areas with hot lava from other colder parts of the Kamchatka Peninsula.

Visually and qualitatively improved images are now ready for further digital analysis in order to obtain and interpret information necessary to monitor the state of the volcano and its surroundings and to take all necessary measures for the protection and recovery.

Results of the volcano digital image quality improvement, which were obtained in this paper show that the methodological procedures of remote sensing can be successfully used during the processing of the

images in the field of monitoring of numerous natural phenomena.

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