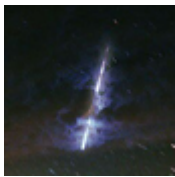


Searching of meteors in astronomical images using Matlab GUI

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The paper deals with the use of computer vision method based on the Hough transformation with using MATLAB and especially its part Image Processing Toolbox. Hough transformation for straight lines enables searching of all straight lines in the digital image. This method is well usable for searching of meteors in astronomical snaps.

1. Principle of Hough Transformation

The principle of Hough transformation for straight lines will be explained using the straight line with slope-intercept form. A straight line is defined by two points $A = (x_1, y_1)$, $B = (x_2, y_2)$, see Fig. 1. Slope-intercept forms for straight lines going through the point A and B are given by the equations

$$y_1 = kx_1 + q \quad (1)$$

$$y_2 = kx_2 + q \quad (2)$$

when k , q are parameters.

These equations are interpreted in the parametric space for parameters k , q :

$$q = kx_1 - y_1 \quad (3)$$

$$q = kx_2 - y_2 \quad (4)$$

The straight lines given by the equations (1) and (2) in the Cartesian coordinated system are given by the equations (3) and (4) in the parametric space. The only common point of both straight lines in the parametric space is the point, which represents the only existing straight line connecting points A and B in the original image space. It is the main principle of Hough transformation for searching of straight lines that all straight lines and their parts in the image space are transformed into the only points in the parametric space.

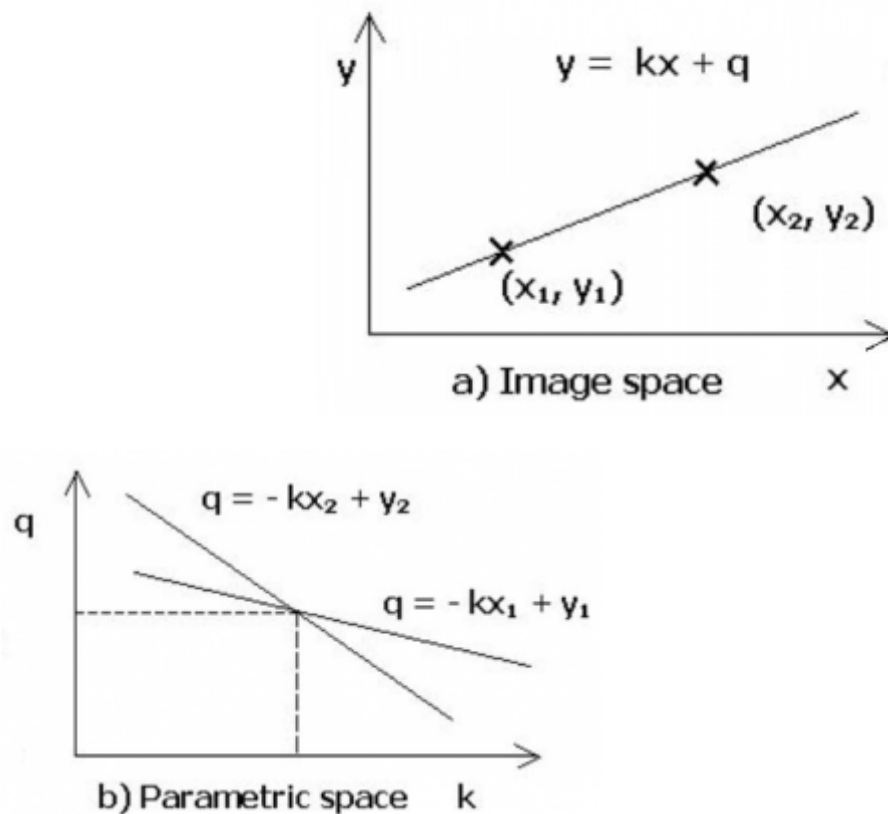


Figure 1: Principle of Hough transformation

All image points are transformed into some points in the parametric space. All values in the parametric space are quantized and the parametric space is divided into elementary cells. Points, which belong to the elements of the straight lines, are accumulated in these cells. At the end of this process the content of all cells is evaluated. If some cell contains a lot of points, it is a big probability that these points lie on the same line.

2. Realization of Hough Transformation with the Use of Image Processing Toolbox Functions

2.1 Description of Image Processing Toolbox Functions Used for Searching of Meteors

Image Processing Toolbox is the MATLAB toolbox for image processing and analysis. It includes functions enabling following image processing operations: spatial image transformations, morphological operations, neighbourhood and block operations, linear filtering and filter design, transforms, image analysis and enhancement, image registration, deblurring, region of interest operations.

Functions used for meteor searching can be divided into following groups: greyscale transformations, geometric transformations, image smoothing, line detection and edge based segmentation.

Greyscale Transformations are processes, which do not depend on the position of the pixel in the image. Greyscale transformation functions transform the original image with the given brightness into an image with a new brightness by the equation

$$q = T(p) \quad (5)$$

where T is the transformation from the original brightness p into a new brightness q . Greyscale transformations are usually used for contrast enhancement, thresholding and creation the negative image.

Two MATLAB functions were used for the greyscale transformation. It was **rgb2gray** - this function converts the colour image in true colours RGB to the greyscale image. During this operation hue and saturation information is eliminated, but the luminance is retained. The second function is **im2bw**. It is function for conversion of the greyscale image to the binary image. All pixels in the input image with luminance greater then set level are replaced by the pixels with brightness value white (level 1) and the other pixels are replaced by the pixels with brightness value black (level 0) in the output image.

Geometric transformations realize basic geometric operations with image: rotation, change of scale and skewing by the angle. The process of a geometric transformation itself consists of two basic steps. First is the **pixel co-ordinate transformation**, which maps the co-ordinates of the input image pixel to the point in the output image. The second step is to find the point in the digital raster, which matches the transformed point and determines its brightness value. The brightness is usually computed as an **interpolation** of the brightnesses of several points in the neighbourhood.

The MATLAB function **imrotate** realizes rotation of the image by angle degrees in counter clockwise direction around its centre point.

Image smoothing is an image pre-processing method, which uses a small neighbourhood of a pixel in an input image to produce a new brightness value in the output image. Smoothing suppresses noise in the image. The disadvantage of smoothing is that smoothing blurs all sharp edges and it can cause the loss of image information. However, some smoothing methods are edge preserving. **Median filtering** is a non-linear smoothing method that reduces the blurring of edges. The current image point is replaced by the median of the brightnesses in its neighbourhood. Median smoothing eliminates impulse noise.

The MATLAB function **medfilt2** performs median filtering in two-dimensional matrixes. It is usually used for reduction of "salt and pepper" noise in the image.

Edge detector is a general tool for finding of lines in the image. It is independent of the content of the image. The MATLAB function **imfilter** is based on the local convolution in the image with convolution kernels, which serve as line patterns. It is used as a line finding operator.

2.2 Straight lines detection

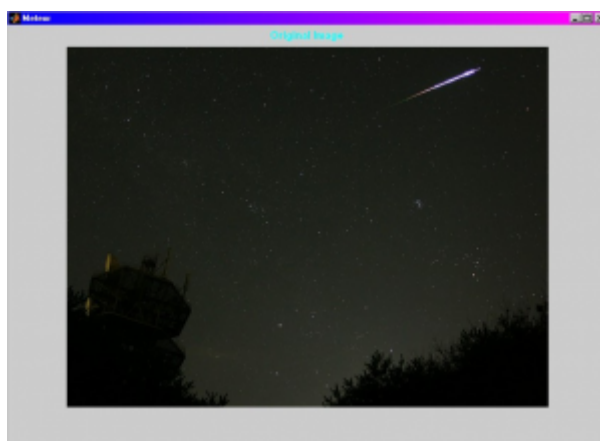
Hough transformation, which was described in the paragraph 1, was used as own straight lines detection function. All described MATLAB functions in the paragraph 2.1 were used as parts of other new created functions.

Searching of meteors was realized by the use of the menu in the Fig. 2. This menu was created on the basis of GUI and enables to choose desirable function, to look over database with results of all processed images and to enter a new image.

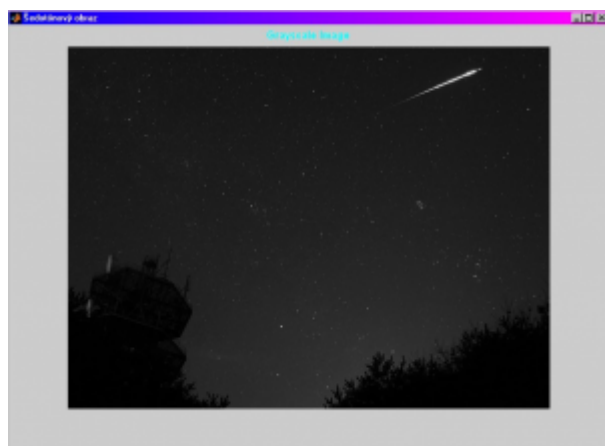


Figure 2: User menu for meteor searching

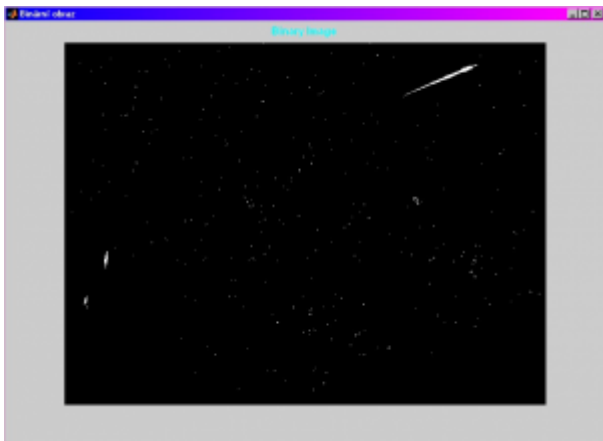
The process of straight lines detection itself is shown in the following images.



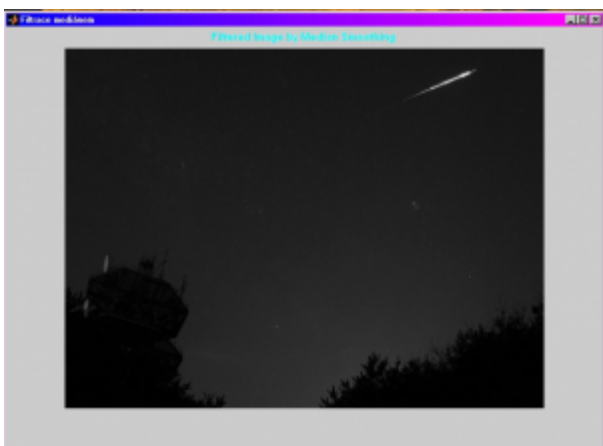
(a)



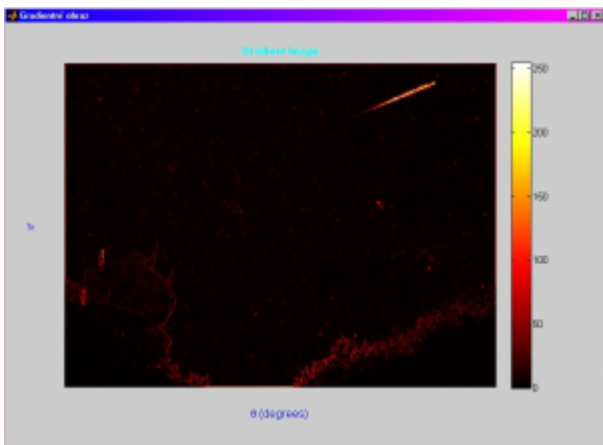
(b)



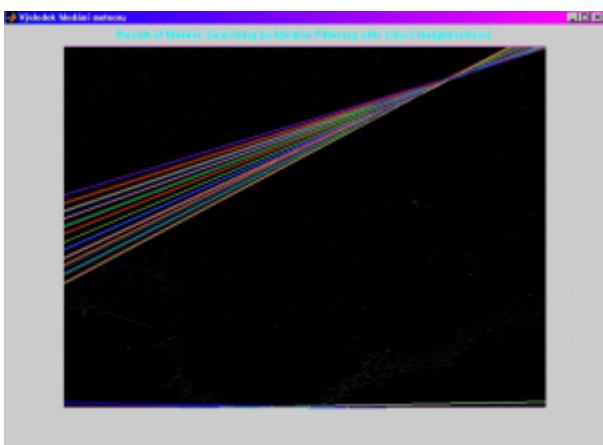
(c)



(d)



(e)



(f)

Figure 3: Process of the straight lines detection a) original image, b) greyscale image, c) binary image, d) filtered image by median smoothing, e) gradient image after edge detection, f) resulting image with searched meteor

3. Results of Meteor Searching

Some results of meteor searching in astronomical snaps are shown in the following figures.

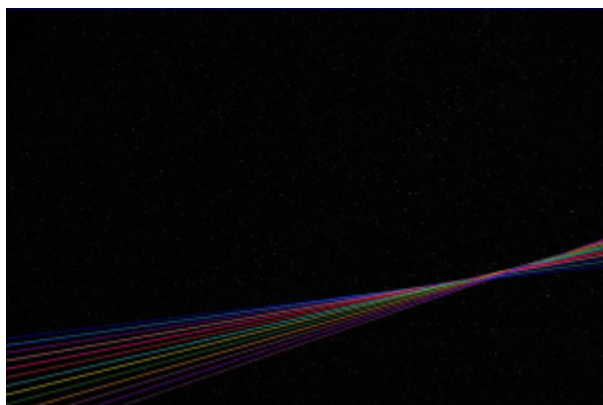


Figure 4: Very bright meteor and result of its searching

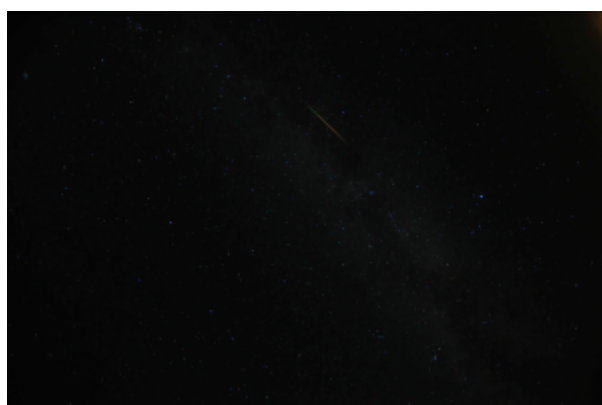




Figure 5: Feeble meteor and result of its searching

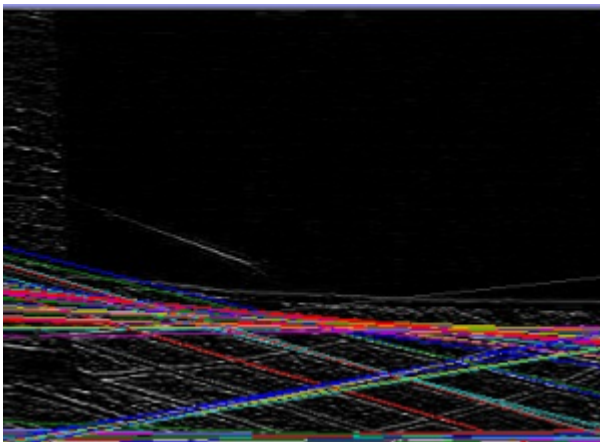
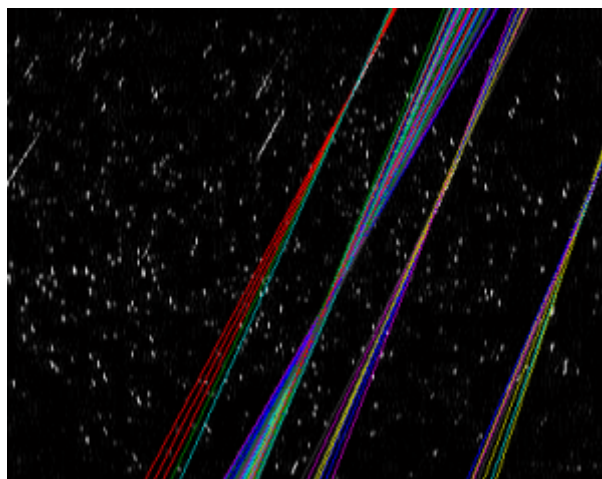
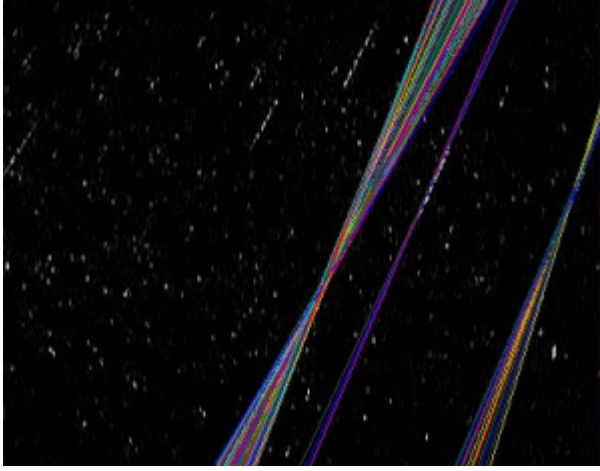


Figure 6: Unsuccessful searching of meteor



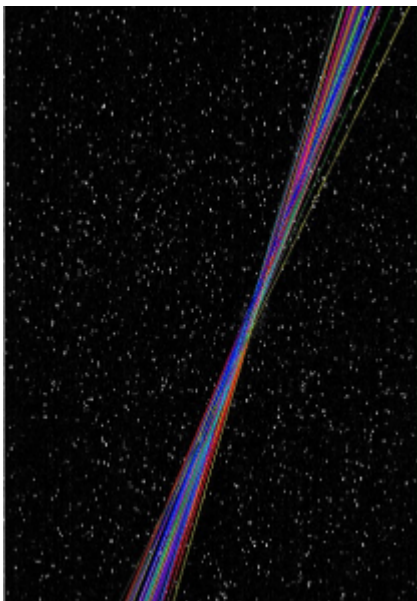
(a)



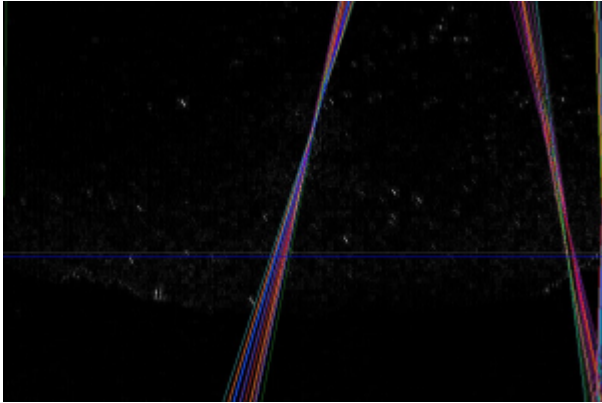
(b)

Figure 7: Results of searching of meteors in the meteor shower by the use of median filtering with a) 2-by-2 neighbourhood and b) 3-by3 neighbourhood

Special cases of meteors are shown in the following images.

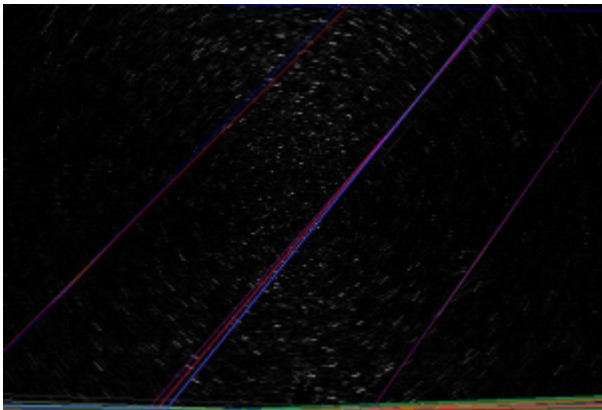


(a)



(b)

Figure 8: False meteors a) satellite Iridium, b) high voltage pylon



(a)



(b)

Figure 9: Triplets a) all three meteors in triplets were found b) only two brighter meteors were found

Following images show the use of individual functions from the push-button menu.

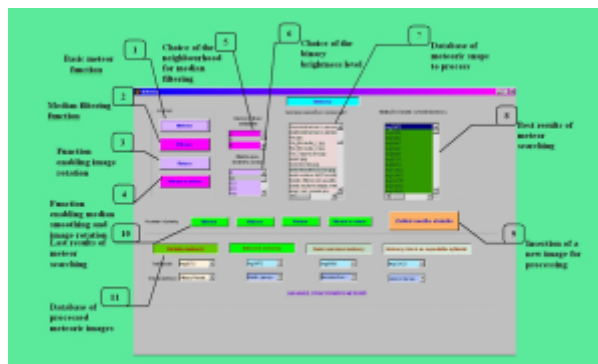
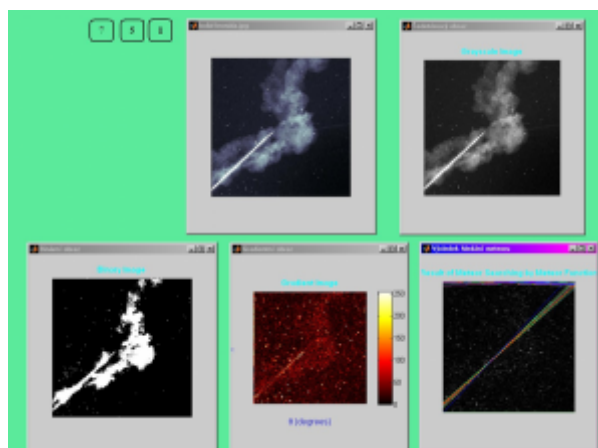


Figure 10: Push-button menu with describing its functions



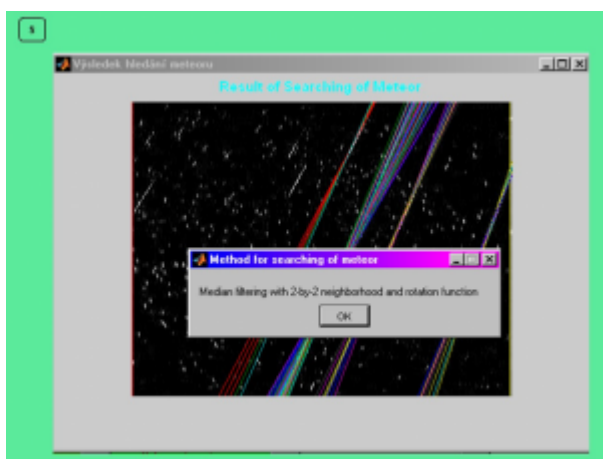
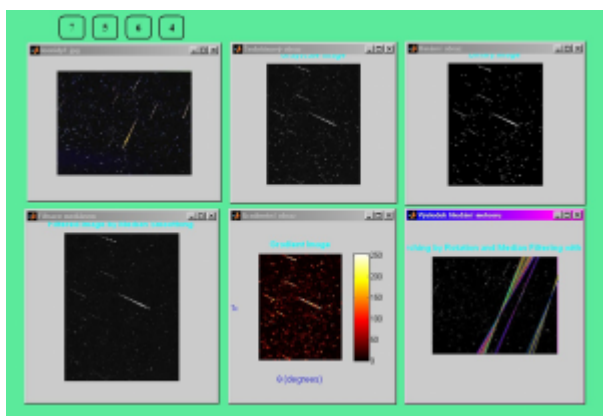
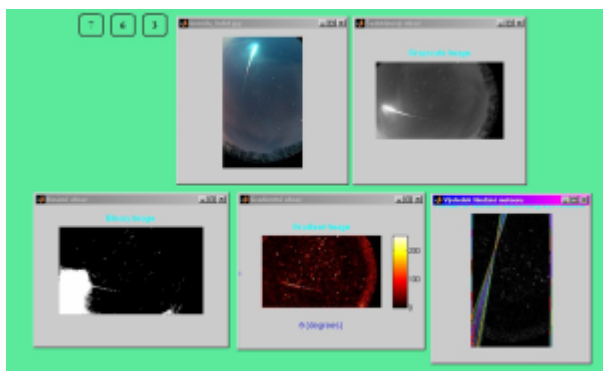
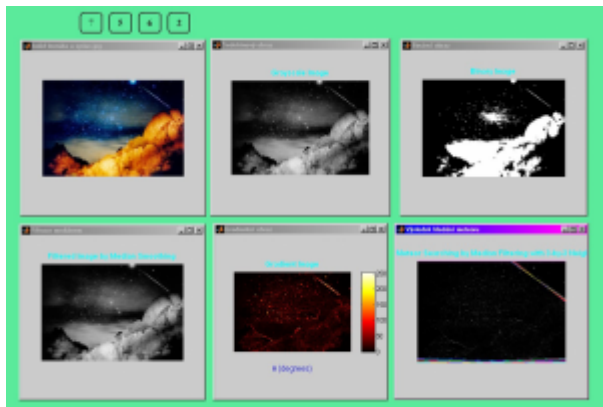




Figure 11: Results of the use of individual buttons from the push-button menu (in the real order)

4. Conclusion

About two hundred meteoric snaps were tested and 80 % meteors were successfully detected by the described method. Remaining 20 % meteors were not found for various reasons. As the most important cause of the unsuccessful searching of some meteors it appears to be a very bright background of the meteor (typically daily sky with the sun or night sky with a lot of stars), further very feeble brightness of meteor and particularly other lines in the image. It is a big disadvantage of Hough transformation that it searches for all straight lines in the image, not only for meteors. The improvement of line detection methods, which serve as pre-processing for Hough transformation, appears as the best way to increase the number of found meteors.

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References

1. Hlaváč, V., Šonka, M.: Počítačové vidění. Grada, Praha, 1992
2. Klíma, M., Bernas, M., Hozman, J., Dvořák, P.: Zpracování obrazové informace. Vydavatelství ČVUT, Praha, 1996
3. Sonka, M., Hlavac, V., Boyle, R.: Image Processing, Analysis and Machine Vision. Third Edition, Cengage Learning, Stamford, 2008
4. Svoboda, T., Kybic, J., Hlavac, V.: Image Processing, Analysis and Machine Vision, A MATLAB Companion. Thomson, Toronto, 2008

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