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The algorithm development for operation of a computer vision system via the OpenCV library

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Abstract

The article is devoted to the effective way of getting images from the information board of the counting register for utility metering. This method is based on the use of the open source library OpenCV. The image processing algorithm has been represented. The method of calibration of the video camera allows us to reduceerror probability in text recognition. Here are some results of the experiment.

Keywords: computer vision; computer vision system; calibration of video camera; counting registers for utility metering.

1. The algorithm development for operation of a computer vision system via the OpenCV library

The use of modern automated remote data collection and transmission systems from energy metering devices allow us to:

- solve the problem of access to the object
- reduce the laboriousness of data accounting and processing
- monitor the accuracy control
- improve the reliability of the data and significantly speed up its receipt.

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The use of automated contactless accounting systems satisfies the requirements of cost effectiveness indicators. One of the most promising ways to obtain information is using computer vision. The solution of computer-based identification problems is based on the creation of artificial intelligence systems that process an image or a sequence of images to highlight sensitive information. The computer-generated system enables to process large amounts of information rather fast and with no loss in quality. The data can be stored and transmitted in a compressed form, thus, the speed of data transmission to the operator is significantly increased.

The computer vision system consists of a microprocessor (the ARM architecture with reduced power consumption) and RAM to store intermediate results and dynamically highlight structures. Low-level interaction with this block is done by using a real-time operating system with open distributed source (Linux). This approach allows us to abstract from the coordinating signals between the transmitter block and the video capture module.

The source data of the computer vision system is analog information from an energy metering device which enters the analytical system from the video sensor. The video sensor matrix is illuminated depending on the light and color rendering of the image. Thus, a video buffer is formed, where each pixel is converted into an analog signal, the saturation of which determines the light space of RGB. It is not practical to work and process such data because of the time spent on transferring data to a logical block. Therefore, the shots of the video stream are converted into the YCbCr color space family. Then subsampling takes place in the form of replacing an analog signal with a digital one by means of transmitting brightness and saturation, it reduces the video data stream. This is done by the digital signal processor of the camcorder.

This paper presents the algorithm for operation of a computer vision system. When writing the program, we used the library of image processing algorithms via computer vision with open source OpenCV [1].

The image is captured from a video camera over a predetermined period of time with the help of the cvCreateCameraCapture () feature and is downloaded for further processing in the program's memory (Figure 1).

Fig. 1. The video camera image.

To highlight the area of interest in the image (tariff scale) the originally uploaded image is translated into gray gradation (Figure 2a) using cvCvtColor () function, and then binarized (Figure 2b) with cvThreshold ().This is necessary for the application of morphological discovery of the image.

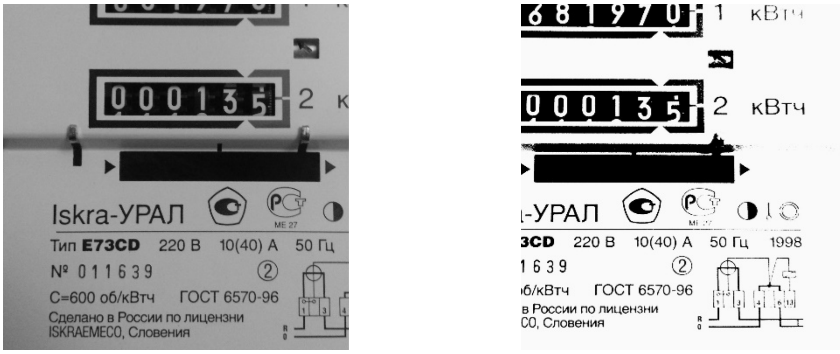

Fig. 2. (a) the grayscale image; (b) the binarized image.

Morphological discovery (Figure 3) is necessary for further highlighting the area of interest in the image. It allows us to get rid of unwanted objects in the image that are not in this area, as well as clearly distinguish the boundaries of the object without thin lines, protrusions, interruptions and errant dots. Morphological discovery is performed using the cvDilate () function.

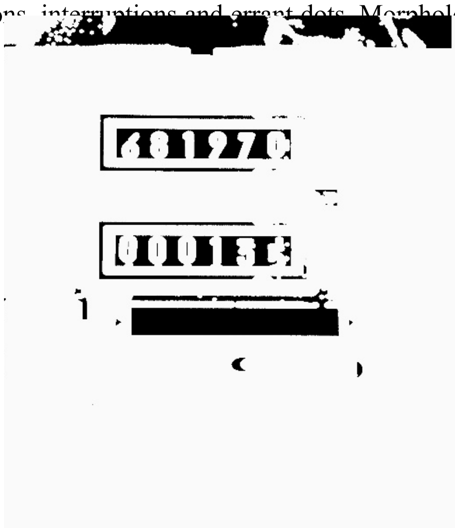

Fig. 3. Morphological discovery.

Selecting the area of interest (Figure 4) is performed using the cvSetImageROI () function. Then the area is divided into parts with the image of individual numbers.

Fig. 4. The image area of interest.

A number is recognized by comparing its contour with the contours of previously prepared templates. The contour search (Figure 5) is performed using the cvFindContours () function. The contours are compared in three parameters: the area of the contour, the perimeter, and the ratio of the area of the contour to the square of the perimeter. When these three parameters of the source image coincide within the confidence interval with the template, the digit is considered recognized and written to the file. This algorithm is used until the entire number is recognized and transmitted to the operator.

Fig. 5. The recognised contours on the first segment.

To carry out the process of image recognition, it is also necessary to calibrate the camera. Here is the camera calibration technique. Camera calibration is necessary to evaluate the parameters of internal, external and lenticular distortion of the camera. Calibrating the camera allows us to correct optical distortions, judge the distance of an object from the camera, and also measure the size of objects in the image. The camera was calibrated in the Matlab application package, using the example of how it was implemented in [2].

Previously prepared calibration templates with the image of a chessboard at different angles, one side of which contains an even number of squares and the other an odd number of squares, are loaded into the Matlab Camera Calibrator (Figure 6). A chessboard image is displayed with green circles that indicate the detected dots. A yellow square indicates a point with coordinates (0;0).

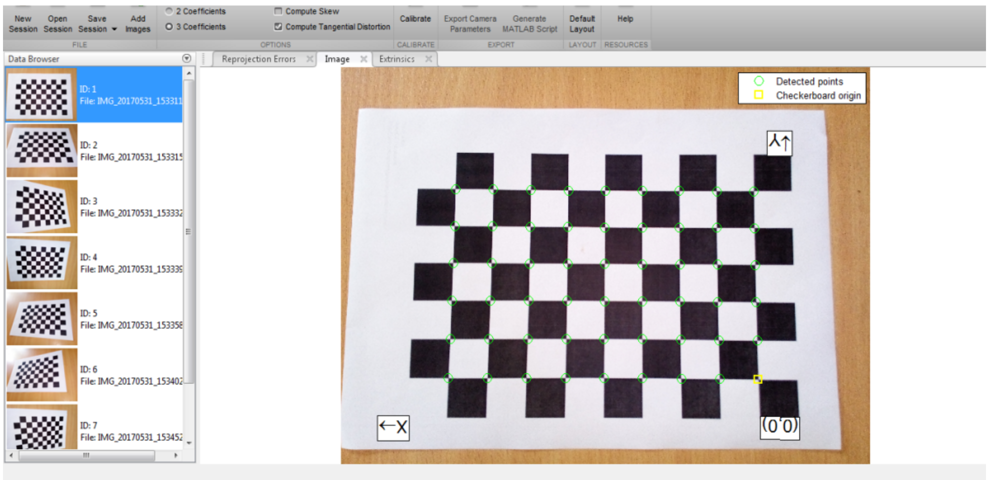

Fig. 6. The calibration template.

For improvingthe calibration, 3 radial distortion factors and tangential distortion calculation were set because of the fact that the lens and the image plane are not parallel.Calibration accuracy is assessed by analyzing reprojection errors and external camera parameters.

The histogram (Figure 7) displays the reprojection error in pixels of each image, along with the overall average error. As a rule, reprojection error of less than one pixel is acceptable.

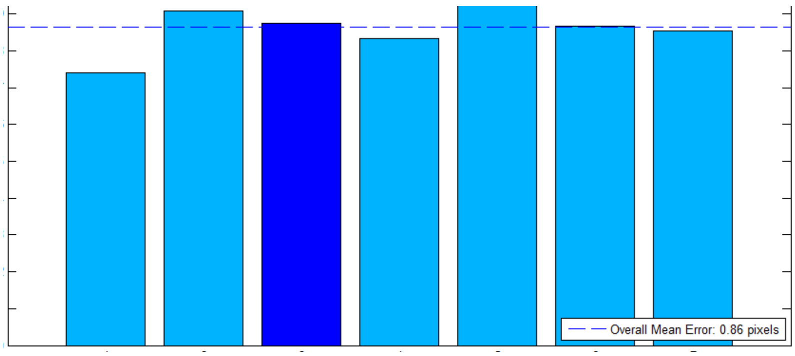

Fig. 7. The histogram of the reprojection error.

The external parameters of the camera are displayed in 3D, which determines the approximate location of the camera lens (Figure 8).

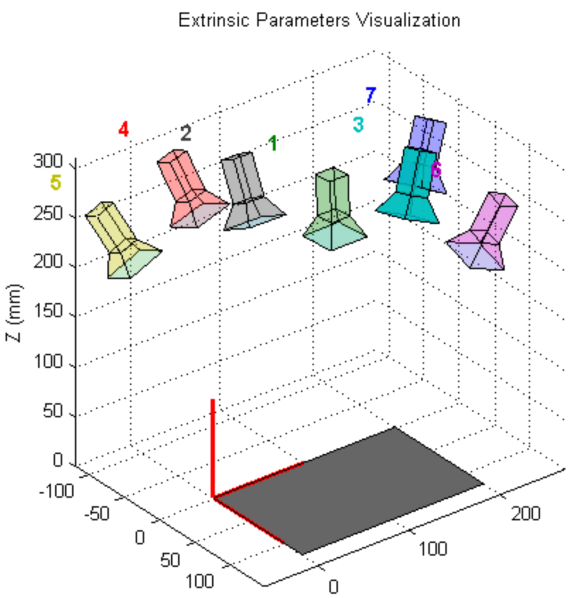

Fig. 8. Visualization of external parameters.

Our next step is to display the values of the internal and external parameters of the camera, as well as distortion coefficients for their further use (Figure 9).

▲	Value	Min	Max
lDistortion	[0.1667 -0.5689 0.5937]	-0.5689	0.5937
entialDistortion	[0.0032 -0.0025]	-0.0025	0.0032
dPoints	*54x2 double*	0	200
dUnits	'mm'		
ateSkew	0		
RadialDistortionCoefficients	3	3	3
ateTangentialDistortion	1		
lationVectors	*7x3 double*	22.3557	345.69...
jectionErrors	*54x2x7 double*	-2.4468	2.5070
Patterns	7	7	7
sicMatrix	[2.6724e+03 0 0;0 2.6592e+03 0;1.6552e+03 1.2886e+03 1]	0	2.6724...
ReprojectionError	0.8645	0.8645	0.8645
ionMatrices	*3x3x7 double*	-1.0000	0.9967

Fig. 9. Camera parameters.

Based on the foregoing, the experiment has been conducted. The calibrated camera was installed on the electric energy meter in such a way that the numerical display was placed in the center of the obtained images. Under equal ambient lighting conditions, 50 images were obtained with different numerical values of the readings. Of these obtained images with information on energy consumption, 49 images were correctly recognized.

Thus, the proposed method of image processing and their recognition is applicable, the reliability of the information according to the results of the experiment is 98%. The construction of such computer vision systems is possible using this algorithm and allows us to automate the process of collecting and transmitting data from energy meters.

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