Correction of Digital Images Distortion

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Abstract —The problem of digital images distortion is considered in the article. Authors investigated the factors that influence on digital image aberrations. These appear mainly due to the optical system errors. The image acquisition conditions were investigated as well. To determine values of distortion as a test object square grid is used. The focus distance of camera affects on distortion value. To determine the value of distortion the program has been developed. Using this program it was found out that for every camera the optimal focus distance with minimal distortion can be determined. The distortions correction techniques are developed on base of well-known image processing methods and on methods worked out by the authors. To find coordinates of grid nodes authors worked out the technique using information of the central part of test object's image. The common case of mutual position of camera lens and object plane is solved using method of projective geometry based on the harmonic properties of the full quadrangle. When they are parallel to each other, coordinates of nodes are determined using method of line detection developed by authors.

Keywords— digital image processing; distortion of digital images; optical aberrations; camera calibration; line detection, edges detection.

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I. INTRODUCTION

Processing of digital images is the basis of many tasks of modern complexes equipped with technical vision. The relevance of image processing techniques, development of methods improving their accuracy is continued with new way to obtain visual information. Increasing speed of data processing and expanding of digital images usage affects also. In information security biometric identification and authentication systems are based on human physiological characteristics and used as protection of unauthorized access [1, 2].

Appearance and possibility to use inexpensive photo and video systems as a part of security access systems [3-5] increase the demand for them. This is one of factors for accumulation of visual information for further analysis. A new source of visual information is unmanned aerial vehicles which are actively used and developed. All of them are based on obtaining information on the basis of optical systems, which, as a rule, have hardware errors .

The resulting images may have a radial or tangential distortion. Methods and algorithms for images improving are relevant and continue to develop actively [6]. Algorithm to automatically correct wide-angle lens distortion is described in article [7], in article [8] image quality improved using contour stencils.

II. DEFINITION AND CORRECTION OF DISTORTION OF DIGITAL IMAGES.

As a rule, to determine the distortion of optical systems, specially created objects of known shape are used, analyzing that images values of distortion are determined [9, 10]. As the object to determine the distortion, we chose a square grid, the image of which was obtained by means of different input devices and processed by developed software [11].

The main difficulty of processing the grid image was to determine the points of the grid nodes. There are many well-known techniques and algorithms of edges detection [12]. This problem continues developing and improving [13-15].

After stage of computational experiments, an algorithm has been developed. The main advantage of this algorithm is that user can obtain ordered set of points. The results of this algorithm are the determined values of total distortion and new coordinates of nodes after correction (Fig. 1). To determine nodes of grid we consider two variants. The first variant when optical axis of lens is perpendicular to image plane (Fig.2A). Another one is when there is some angle between lens axis and object plane (Fig.2B). For both of them methods to compute coordinates of grid nodes have been worked out.

The central part of the image has minimal distortion. Based on the coordinates of the central quadrilateral of grid, the coordinates of the ideal grid are calculated. For the first case coordinates of nodes are determined as point of intersection of approximated lines. In the second case the coordinates of grid are determined on the basis of the

harmonic properties of the complete quadrangle located in the central part of the image.

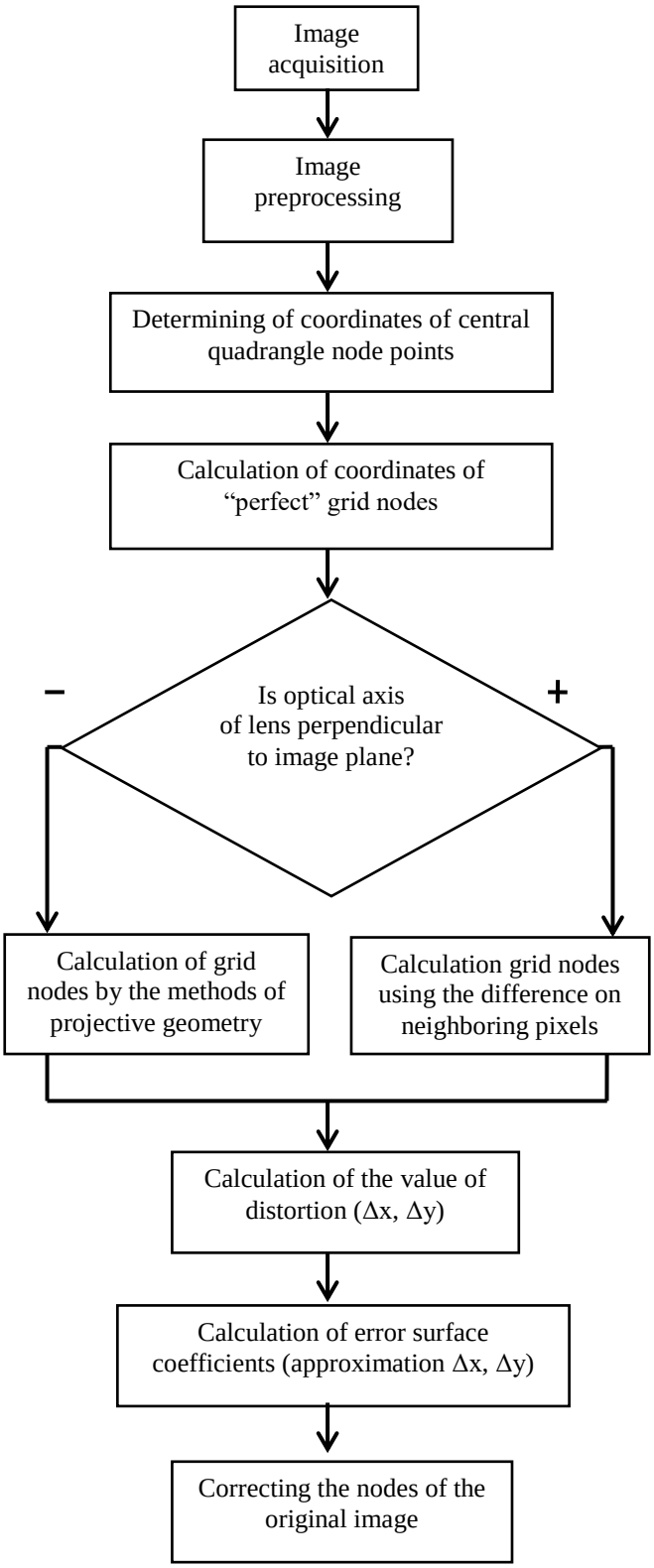


Fig. 1. Algorithm of distortion correction

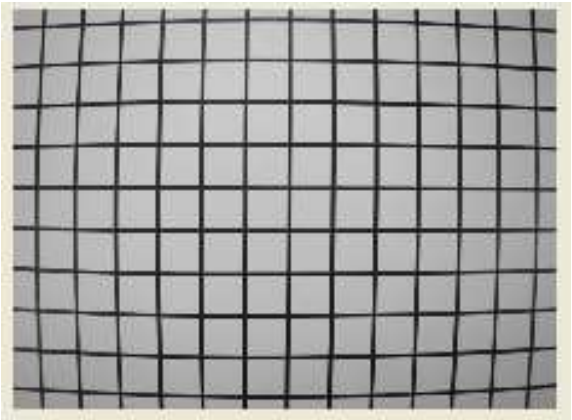
Vertexes of the central quadrangle are calculated, and the points of intersection of the line KL and the diagonal BD is the point F (Fig. 3).

This method allows finding all intersection points of lines, and then the program chooses points belonging to frame of image which is shown as blue rectangle in Fig.3.

Comparing the coordinates of the ideal and real grids, distortion values are determined.

Based on the obtained data on distortion values, a mathematical model of the error surface is created, which makes it possible to automate the correction and significantly reduce the distortion in digital images (Fig. 4).

A



B

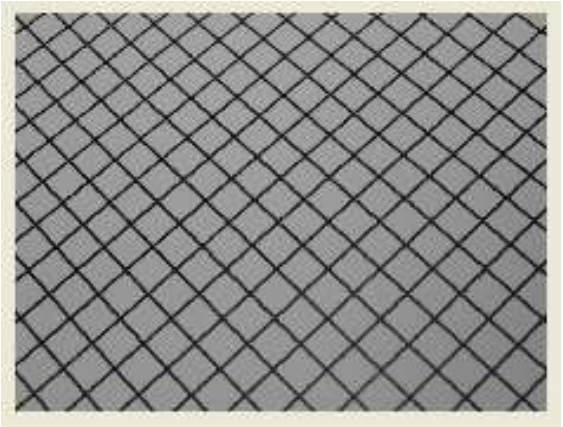
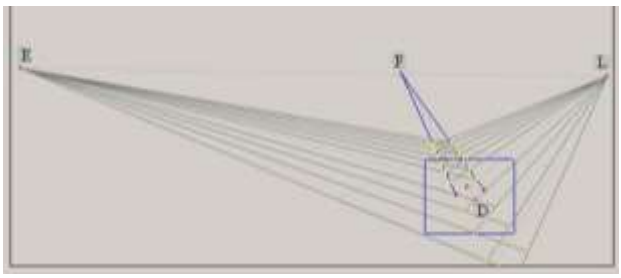


Fig. 2. Images on different position of camera lens and object plane

A



B

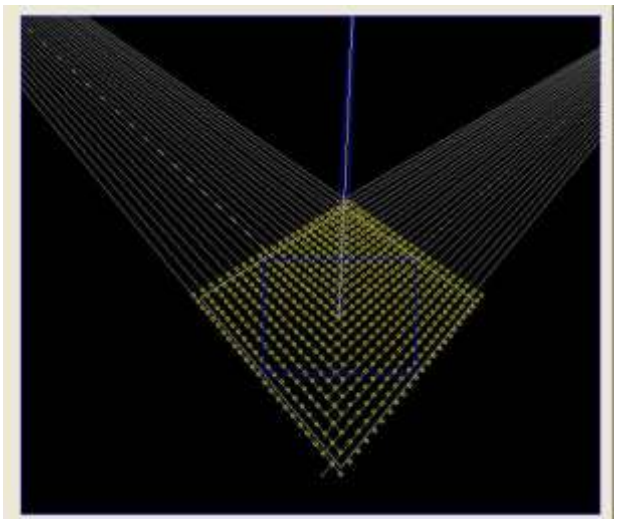
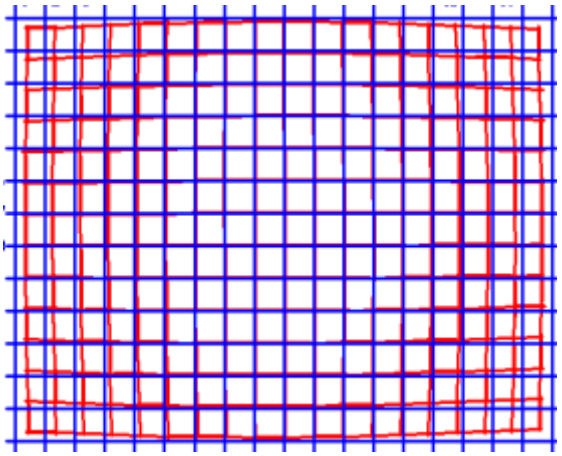
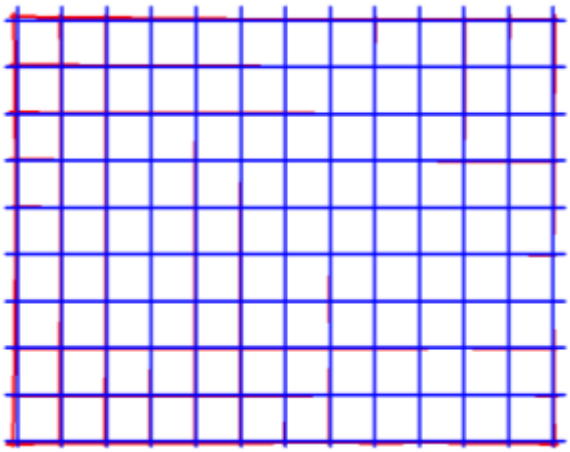


Fig. 3. A - Computing of central quadrangle vertexes
B – Computing coordinates of other nodes

A



B



C

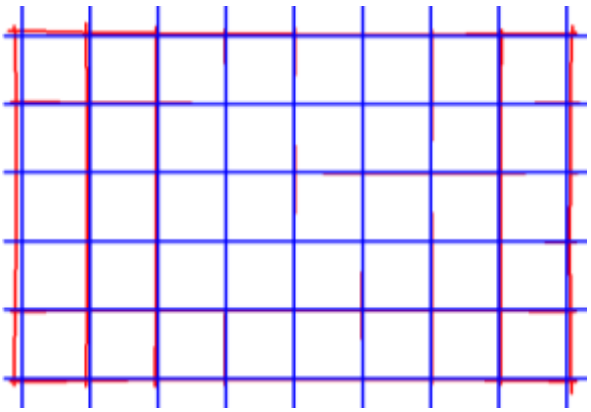


Fig. 4. Lines of square grid on diferent kinds of distortions:
A - distortion of barrel shape with a focus of 5.2 mm,
B - the distortion is minimal at a focus of 7.1 mm,
C - distortion of the cushion shape at a focus of 12.9 mm.
Red lines - lines of the real grid
Blue lines - grid lines after correction

III. CONCLUSION

As a result of the experiments [16], it was revealed that the conditions for shooting to reduce the aberration should be carefully selected.

The fact that the focal length is significantly affected on of optical aberrations is confirmed. In addition, the processing of experimental data by the developed program made it possible to reveal that for each input device it is possible to determine the optimum value of the focal length at which the distortion is minimal.

This is due to the fact that the change of the focal length affects on distortion: from the "barrel" shape at small values the focal length distance to the "pincushion" shape with increasing the value of the focal length.

To solve the problem of determining the grid nodes, image processing methods, methods of projective geometry and approximation were used [17, 18].

The proposed algorithm and methods for determining grid nodes, correcting distortions developed by the authors allow improving the quality of digital images, accuracy of determining lines and other characteristics for more efficient use in recognition systems and geometric modeling.

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