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(54) Benævnelse: **Fremgangsmåde til korrigering af et optaget billede, fremgangsmåde til udvælgelse af en tegning, der er skitseret på en side eller på to hosliggende sider af en notesbog, en relativ applikation til en smarttelefon, en indbundet notesbog og en indbundet planlægningskalender.**

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DESCRIPTION

TECHNICAL FIELD

[0001] The disclosure relates to methods of capturing images sketched on a paper support and more particularly to a method of generating a corrected image from a distorted image, a method of capturing a writing or a drawing sketched on a notebook or agenda, a relative app for smartphone, a hardback notebook and a hardback agenda.

BACKGROUND

[0002] Paper notebooks or agendas are still widely diffused for taking notes, despite the ever increasing use of mobile electronic devices. The latters are of practical use when short notes are to be taken with either a physical keyboard or a virtual keyboard displayed on a touchscreen, but the formers are largely preferred for recording hand-written notes or for sketching drawings In order to transmit or store electronically these hand-written notes or drawings, they may be digitally acquired with a scanner or, more commonly, a picture of the hand-written paper pages is taken with a digital camera of a smartphone Scanners may generate digital images of good quality because the pages with hand-writings to be scanned are placed to lie flat on the scanner screen, but scanners generally cannot be used as portable devices.

[0003] On the other side, pictures taken with a digital camera have a poor quality because it is very difficult to place the digital camera in a plane parallel to the plane of the paper pages, especially if two adjacent pages of a notebook or agenda are to be captured at the same time. Generally speaking, pictures taken in this way are affected by severe perspective distortions that should be corrected.

[0004] A method for compensating perspective distortion of objects depicted in a paper sheet taken with a digital camera is disclosed in the European patent application EP1947605. According to this prior document, upon the disclosure of which the preamble of claim 1 is drafted, the method processes an image of a rectangular sheet of paper, having boundary markers at the corners of the sheet, according to the following operations:

- calculating the smallest rectangle that encloses all the boundary markers;
- building a geometric transformation to map the locations of the boundary markers to corresponding locations of the rectangle;
- transforming the captured image upon the geometric transformation.

[0005] This prior method does not allow to correct perspective distortions of a picture of a

drawing sketched over two adjacent pages of a notebook or agenda. In this situation, the two adjacent pages typically do not lie on a same plane and the prior algorithm is unsatisfactory because either:

- the two adjacent pages are taken together and the perspective distortion around the knuckle line of the two adjacent pages is left uncorrected; or
- one page at the time is taken and hand-written notes or drawing extending over the two adjacent pages are not taken as a single picture.

[0006] The document EP1947605, upon the disclosure of which the preamble of claim 1 and of claim 10 is drafted, discloses a method and apparatus for detecting and correcting perspective distortion for document imaging characterized by the presence of special markers that define the corners of the document.

[0007] The document US2005/053304 discloses a method and apparatus for correcting a scanned image of a non-planar original that has a constant cross section in one direction, such as a book, that provides for applying a coordinate system to the scanned image to align the coordinate system to the direction with the constant cross section. The scanned image is imaged onto a target image, or vice versa, using aspect factors or dilation factors.

[0008] The document US2012320427 discloses an image processing method based on the step of obtaining a vanishing point on a curved surface in a two-dimension image.

[0009] The document US7330604 discloses a method for processing a captured image that comprises the steps of distinguishing an imaged document from its background, adjusting the captured image to reduce distortions created from use of a camera and properly orienting the document.

[0010] There is still the need of an algorithm capable of correcting perspective distortion of pictures of two adjacent pages of a notebook or agenda containing hand-written notes or drawings extending over both pages.

SUMMARY

[0011] The inventors have found a method of processing a distorted digital image depicting two adjacent pages of a notebook or agenda, each page having a main marker and a plurality of subordinate markers, all the markers being located at boundaries of the page at least as vertexes of a rectangle having a nominal aspect ratio, adapted to correct perspective distortions due to the fact that the two adjacent pages of the notebook or agenda do not lie in a same plane. The method may be further improved to discriminate whether the distorted picture to be processed represents either a single page or two adjacent pages of a notebook or

agenda, in order to carry out either a first processing algorithm if a single page has been captured or the above method of processing a distorted digital image depicting two adjacent pages.

[0012] According to an embodiment, it is provided a method of generating a selection image of a writing or a drawing sketched on a page or two adjacent pages of a notebook or agenda, comprising the steps of:

- taking a picture with an image capture device of either a planar page or two adjacent planar pages of a notebook or agenda, capturing thereby a distorted image;
- processing the distorted image with the above method, generating thereby a corrected image;
- discriminating in the corrected image pixels belonging to the markers, pixels belonging to the sketched writing or drawing and pixels belonging to an unwritten portion of the pages of the notebook or agenda;
- selecting from the corrected image the pixels belonging to the sketched writing or drawing.

[0013] These methods may be implemented via software with a PC, a smartphone or a tablet. A hardback notebook and a hardback agenda according to this disclosure comprise at least a planar front cover and a planar back cover for covering opposite sides of the notebook or agenda and a deformable spine cover, and substantially rectangular pages bound to the covers with a binding configured so as, when the notebook or agenda is open, to allow any two planar adjacent pages at which the notebook or agenda is open to lie flat over the covers of the notebook or agenda without substantially being curved, each page of the adjacent pages having a main marker at an outer corner of the page and a plurality of subordinate markers placed at the other corners of the same page, the main markers of the two planar adjacent pages being located at diametrically opposite corners in respect to a middle point of a knuckle line of the pages of the notebook or agenda, all the markers of each page being located at boundaries of the page as vertexes of a first rectangle having a first nominal aspect ratio, the markers of two adjacent planar pages of the planar pages defining a second rectangle having a second aspect ratio. According to an embodiment, the main marker is composed of two paired dark squares at a mutual distance smaller than the width and height of the squares, and each of the subordinate markers is a single dark square, the markers being placed over a light background.

[0014] The claims as filed are integral part of this specification and are herein incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Figure 1 schematically depicts two adjacent pages of a notebook with markers according to an embodiment of this disclosure.

Figure 2 illustrates geometrical points identified for correcting perspective distortion according to an embodiment of the method of this disclosure.

Figure 3 is a flow chart of an embodiment of an algorithm "unwarp pages" for correcting perspective distortion of a drawing spanning over two adjacent pages of a notebook,

Figure 4 is a flow chart of an embodiment according to this disclosure of a method for generating a selection image of a writing or a drawing sketched on one page or two adjacent pages of a notebook or agenda.

Figure 5 is a flow chart of an embodiment of an algorithm according to this disclosure for locating markers printed on the pages of a notebook or agenda.

Figure 6 schematically illustrates how is determined an ellipse having the same second statistical moments of a cluster of pixels.

DETAILED DESCRIPTION

[0016] The algorithm implemented with method of this disclosure for generating a corrected image from a distorted image depicting two adjacent planar pages of a notebook will be illustrated referring to figure 1, that depicts a picture of two planar adjacent pages of a notebook with evident perspective distortions due to the fact that the two pages do not lie in a same plane.

[0017] Each page of the notebook has a main marker, that in the non limiting shown example is composed of two paired dark squares (upper outer corner of the left page and lower outer corner of the right page) printed on a light background Optionally, the centers of the paired dark squares are at a mutual distance smaller than the width and height of the squares. The main markers may be typically placed in correspondence of diametrically opposite outer corners of any two adjacent pages of the notebook. Each page has also a plurality of subordinate markers, that in the non limiting shown example are single dark squares printed on a light background, placed in the other corners so as to define a rectangle having a known pre-established aspect ratio.

[0018] It is simpler to detect the markers shown in figure 1 and to discriminate them from handwritten notes or drawings, and for this reason they are realized with dark squares. According to a less preferred embodiment, the main marker and the subordinate markers of each page have a different shape or are made of different symbols, such as for example in the

prior document EP1947605. Nevertheless, in this last case, it is harder to locate them and they may be more easily erroneously recognized as part of a sketched drawing if users do not take care of writing away from them.

[0019] Typically, the pages of the notebook are bound with a binding that allows them to lie flat over the paired covers of the notebook, so as it is easy to make hand-written notes or to sketch drawings that extend over both adjacent pages. When taking a picture of both pages holding the notebook with one hand and a digital image capturing device (such as a smartphone) with the other hand, the two adjacent pages do not lie in the same plane and a distorted image as in figure 1 is captured.

[0020] According to the method of this disclosure, the first operation to be carried out for correcting perspective distortion of the distorted image consists in locating the positions of the subordinate markers and of the main marker in each page. Any skilled person will realize that there are numerous known ways of accomplishing this task, such as for example with a pattern recognition algorithm.

[0021] An innovative algorithm specifically designed for locating dark squares printed over a light background is disclosed hereinafter. According to a particularly effective embodiment of the method of this disclosure, the operation of locating the positions of the markers is carried out with this innovative algorithm.

[0022] Once the markers of both adjacent pages are recognized, according to the method of this disclosure certain reference lines, determined by the markers, are identified, namely:

- the upper edge lines 3, 4; the line 3 passes through a marker placed at the top left angle of the left page (hereinafter referred as the "upper outer marker" of the left page) and through a marker placed at the top right angle of the left page (hereinafter referred as the "upper inner marker" of the left page); the line 4 passes through a marker placed at the top right angle of the right page (hereinafter referred as the "upper outer marker" of the right page) and through a marker placed at the top left angle of the right page (hereinafter referred as the "upper inner marker" of the right page); the two upper edge lines, passing through the respective upper outer marker and the respective upper inner marker, cross each other at an upper cross-point 7;
- the lower edge lines 5, 6; the line 5 passes through a marker placed at the bottom left angle (hereinafter, the "lower outer marker") of the left page and through a marker placed at the bottom right angle of the left page (hereinafter referred as the "lower inner marker" of the left page); the line 6 passes through a marker placed at the bottom right angle of the right page (hereinafter referred as the "lower outer marker" of the right page) and through a marker placed at the bottom left angle of the right page (hereinafter referred as the "upper inner marker" of the right page); the two lower edge lines, passing through the respective lower outer marker and the respective lower inner marker, cross each other at a lower cross-point 8;

- the upper side line 1;

- the lower side line 2;
- the knuckle line passing through the cross-points 7 and 8, that crosses the upper side line 1 and the lower side line 2 at the upper target point 9 and at the lower target point 10, respectively.

[0023] In order to better understand how the algorithm for correcting perspective distortion works, let us refer to the geometric representation of figure 2 that corresponds to the picture of figure 1, wherein:

- A and F are the upper outer markers;
- C and E are the lower outer markers;
- B is the upper cross-point of the upper edge lines AB and FB;
- D is the lower cross-point of the lower edge lines CD and ED;
- AF is the upper side line;
- CE is the lower side line;
- BD (or GH) identifies the knuckle line;
- G is the upper target point at which the knuckle line crosses the upper side line;
- H is the lower target point at which the knuckle line crosses the lower side line;
- AC and EF are the outer edge lines passing through the respective upper outer marker and lower outer marker.

[0024] The captured pages are substantially planar, thus it may be fairly assumed that the outer edge lines AC and EF are substantially parallel to each other and are parallel to the knuckle line BD.

[0025] According to an embodiment of the algorithm of this disclosure, a central fixed transformation point O is determined as the point belonging to the knuckle line GH at which the ratio between its distance OD from the lower cross-point D and its distance OH from the lower target point H equals the ratio between its distance OB from the upper cross-point B and its distance OG from the upper target point G,

$$OD/OH = OB/OG.$$

[0026] The algorithm determines for each captured page, a respective outer fixed transformation point X1 or X2 belonging to the respective outer edge line AC or FE as the point at which the ratio between its distance X1C or X2E from the lower outer marker C or E and its distance X1A or X2F from the upper outer marker A or F equals the ratio between the distance OD of the central fixed transformation point O from the lower cross-point D and the distance OB of the central fixed transformation point O from the upper cross-point B,

$$X1C/X1A = OD/OB = X2E/X2F;$$

and determines a respective fixed transformation segment OX1 or OX2 joining the central fixed transformation point O with the respective outer fixed transformation point X1 or X2.

[0027] For each captured pixel P laying in a page area comprised between the respective fixed transformation segment OX1 or OX2 and the respective upper/lower edge line, a corresponding intermediate pixel P1 is determined according to an image stretching algorithm that keeps unchanged all points of the outer edge line AC or FE and all points of the fixed transformation segment OX1 or OX2, and that maps points laying in the page area so as to elongate the knuckle line to bring the upper/lower cross-point (B or D) into the upper/lower target point (G or H) and so as to transform the upper/lower edge line (AB or CD) into the upper/lower side line (AF or CE).

[0028] In general, any image stretching algorithm could be used for this operation. The applicant has found that a particularly effective image stretching algorithm that provides outstanding results, and that comprises the following steps:

- determining a parallel line K1O1 to the knuckle line passing through a captured pixel P, crossing the respective fixed transformation segment OX1 at a relative fixed point O1, crossing the respective upper/lower edge line at a relative upper/lower point K1 or L1, and crossing the respective upper/lower side line at a relative upper/lower target point K or L; and
- determining the corresponding intermediate pixel P1 so as the ratio between its distance P1O1 from the relative fixed point O1 and the distance PO1 of the captured pixel P from the relative fixed point O1 equals the ratio between the distance of the relative upper/lower target point from the relative fixed point O1 and the distance of the relative upper/lower point from the relative fixed point O1,
  $P1O1/PO1 = KO1/K1O1$.

[0029] Whatever the image stretching algorithm is used, it is obtained an intermediate image composed of the intermediate pixels P1 and having a guiding trapezoid, the bases of which are the outer lines AC and FE and the sides of which are the side lines AF and CE.

[0030] Finally, a corrected image corresponding to the originally taken distorted image is obtained by determining locations of corrected pixels of the corrected image by processing pixels of the intermediate image with a perspective correction algorithm adapted to transform the guiding trapezoid into a rectangle having the pre-established nominal aspect ratio, keeping as a reference a base of the guiding trapezoid. Perspective correction algorithms adapted to transform a trapezoid into a rectangle of a pre-established aspect ratio are well known in the art. Merely as an example, it is possible to mention the perspective correction algorithm developed by ABBYY Production LLC and illustrated at the following web-page:
http://www.abbyy.com/mobile_imaging_sdk/description/#function26
for transforming a trapezoidal shape into a rectangular shape, though the skilled person may readily identify numerous other alternative algorithms capable of performing the same operation.

[0031] Optionally, in order to simplify calculations involved in the above image stretching algorithm according to this disclosure, the distorted image is rotated in order to orient vertically the knuckle line and the outer edge lines before executing the image stretching algorithm, then an inverse rotation is applied after having executed the image stretching algorithm. All steps carried out according to this embodiment are summarized in the flow chart of figure 3.

[0032] The method of this disclosure may be further improved to manage distorted images representing pictures of two adjacent pages or of a single page of a notebook or agenda, recognizing whether the user has taken a "portrait picture" (a single page) or a "landscape picture" (two adjacent pages).

[0033] Since each page contains only one main marker, according to an embodiment of the method of this disclosure, the number of main markers captured in the distorted image to be corrected are counted. If two main markers are detected, the algorithm continues as illustrated above, otherwise if only one main marker is detected in the distorted image, the intermediate image of a single captured page of said notebook or agenda is obtained by:

- determining relative positions, in respect to the main marker, of subordinate markers belonging to the captured page and determining the upper edge line joining two upper markers of the markers of the captured page, the lower edge line joining two lower markers of the markers of the captured page, the outer edge line joining two outer markers of the markers of the captured page, the inner edge line joining two inner markers of the markers of the captured page, wherein the outer edge line crosses the lower edge line and the upper edge line in correspondence of the lower outer marker and of the upper outer marker, respectively; and
- determining the intermediate image as the image containing captured pixels of the distorted image, and determining the guiding trapezoid composed of the upper edge line, of the lower edge line, of the outer edge line and of the inner edge line.

[0034] Finally, a perspective correction algorithm for transforming a trapezoidal shape into a rectangular shape is applied for generating the corrected image.

[0035] Once the corrected image has been obtained, it is possible to generate a selection image (hereinafter referred to as "Crop" operation) of the writing or drawing made on the notebook or agenda by filtering out background pixels belonging to unwritten areas or to the markers.

[0036] As an option, it is possible to carry out other operations for enhancing the quality of the selected writing or drawing, such as tuning brightness and contrast, adjusting colors, removing noise. Numerous algorithms adapted to perform these operations are available, such as for example the algorithms developed by ABBYY Production LLC and illustrated at the following web page:
http://www.abbyy.com/mobile_imaging_sdk/description/

[0037] A flow chart of another embodiment of the method of this disclosure for correcting distorted images that may represent a single planar page or two adjacent planar pages is depicted in figure 4. The algorithm for generating a corrected image from a distorted image representing one or two pages is called "Unwarp Pages" in the flow chart. According to figure 4, the "Unwarp Pages" algorithm may not be executed if users decide to ignore the detection of markers or if detection of markers has not been possible. The various operations mentioned in the flow chart of figure 4 are listed below:

1.1. **Detect Markers & detect orientation** - searches markers on the image and detects page orientation - landscape (two-pages) or portrait (one-page). A particularly effective way of executing this operation according to this disclosure will be illustrated in detail hereinafter.

1.2. **Crop** - determines the edges of a document relative to the background, so that the background could be cropped. Provides coordinates of the area that should be cropped (four corners of the quadrangle). [http://www.abbyy.com/mobile_imaging_sdk/description/#function15]

1.3. **Unwarp Pages** - corrects image in such way that result image would look as a double-page spread with pages in plane.

1.4. **Alignment & perspective correction & crop**

1.4.1. Perspective correction - Corrects perspective distortions (from trapezoidal shape to rectangular) [http://www.abbyy.com/mobile_imaging_sdk/description/#function26]

1.4.2. Alignment & Crop - see 1.2.

1.5. **Auto contrast** - automatic tuning of brightness and contrast [http://www.abbyy.com/mobile_imaging_sdk/description/#function13]

1.6. **Color filter** - combines a group of functions for processing color documents The operations are applied in the following order: automatic adjustment of brightness and contrast, the document background is turned white [http://www.abbyy.com/mobile_imaging_sdk/description/#function6]

1.7. **Spy shot** - combines a group of functions for processing blurry, out-of-focus, and dark pictures. The operations are applied in the following order: noise removal, reduction of brightness, adjustment of brightness and contrast. [http://www.abbyy.com/mobile_imaging_sdk/description/#function9]

[0038] A particularly effective algorithm for locating in the distorted image all the markers when the main marker is made of two paired dark squares and each of the subordinate markers is composed of a single dark square over a light background, is described hereinbelow referring to the flow chart of figure 5 and to the ellipses depicted in figure 6.

[0039] This algorithm is intended to detection of the markers captured in the distorted image and comprises of the following steps:

1.1. The input image (i.e. the distorted image) may be subjected to preprocessing in order to maximize the contrast of markers to the background. This step may be useful for simplifying the operation of locating the markers. Preprocessing may include adaptive illumination correction and image intensity correction, for example using the image histogram. Adaptive illumination correction may be performed by pointwise calculating the local average intensity value and performing a subsequent image intensity alignment in respect to this value. Further image intensity correction may be performed using the brightness histogram of the image, for example with an algorithm for "stretching" the brightness histogram of the image to span over the whole range of the gray scale [http://imageprocessingblog.com/histogram-adjustments-in-matlab-part-i]

1.2. Image binarization, for example the so-called Otsu's binarization, separates connected components (segments) (value 0) and the background (value 1). This step allows to determine a black-and-white binary image the pixels of which have either a high or a low intensity, by comparing with a threshold the intensity of corresponding pixels of the captured image. In the black-and-white binary image it is possible to locate groups of connected pixels either black or white surrounded by either white or black pixels. Further processing procedures are required for selecting connected groups of pixels that correspond to markers

1.3. A first stage of filtering may consist of steps that do not require calculation of the statistical characteristics on a set of connected groups of pixels, such as the sample mean and sample variance. The eventual presence and the number of holes in connected groups of pixels (white/black pixels into connected groups of black/white pixels) may be determined by calculating the so-called Euler number (see R. C. Gonzalez and R. E. Woods (2002), Digital Image Processing, Prentice-Hall, p. 661, herein incorporated by reference, or http://www.mathworks.com/help/images/ref/bweuler.html). Filling holes in connected group of pixels eliminates eventual holes in the binary image in the each of the connected groups of pixels [http://www.mathworks.com/help/images/ref/imfill.html] and allows an easier identification of the markers, especially if made of dark squares printed on a light background.

1.4. Optionally, it may be possible to eliminate single-point noise on the image by means of a median filtering. In order to identify connected groups of pixels that clearly cannot represent the markers because they span over a too large area, it may be appropriate to remove connected groups of pixels of the binary image having area out of a range of tolerance about the value of an expected area for a given image size of the dark squares that constitute the marker, leaving connected groups of pixels whose area is close to the expected area of connected groups of pixels belonging to the markers.

1.5. Removal of elongated connected groups of pixels (see figure 6) may be performed by calculating the second moments for the connected components contours, determining the axes lengths of the ellipse having the same second moments, and calculating the ratio of the semiaxis lengths. The algorithm removes these connected components, wherein the ratio

between the semi-major axis length and the semi-minor axis length exceeds a threshold value [http://www.mathworks.com/help/images/ref/regionprops.html#bqkf8jb].

1.6. Optionally, it may be possible to perform a removal of connected groups of pixels having too low extent with a threshold procedure in order to identify more quickly the dark squares that constitute the markers. A bounding rectangle of connected groups of pixels may be determined and the ratio between the area of the connected groups of pixels and the area of the bounding rectangle may be calculated. It is assumed that this ratio is close to unity for markers because they are made of dark squares.

1.7. The second stage of filtering may use the statistical characteristics of the set of connected components. When filtering connected components by area the set of connected components areas is calculated, which is divided into two clusters by k-means clustering [https://en.wikipedia.org/wiki/K-means_clustering]. It is assumed that all the markers on the original image will be found in the same cluster, because possible perspective distortions do not change their areas significantly. The cluster which mean is greater is selected. The connected groups of pixels belonging to this cluster will be retained on the image.

1.8. Markers on the original image have low average intensity. Filtering may be performed in the following way. Each connected groups of pixels identifies the corresponding region on the initial image. The mean intensity value of the region is calculated during filtering. If this value exceeds the threshold specified then this connected groups of pixels is removed. This filtering leaves those connected groups of pixels for which this value is less than a threshold. Typically, this threshold may be calculated dynamically.

1.9. Filtering of connected components by mean value of component neighborhood intensity on original image may be performed similarly to the previous step. At this step, mean intensity of neighboring pixels that surround connected group of pixels is determined. The mean intensity value of the neighborhood is defined by the connected component contour shape. It is assumed that the marker has a contrasting background, so the mean intensity of the vicinity of each group of pixels must be above a certain threshold, which may be typically calculated dynamically. Thus, the connected groups of pixels having mean intensity smaller than this threshold are removed. At the end of this step, the dark squares that constitute the markers are identified.

1.10. Once the dark squares of the markers are identifies, the main marker may be discriminated from the subordinate markers in order to correct the orientation of the image. In order to determine paired dark squares constituting a main marker, centers of connected groups of pixels are determined. Two connected groups of pixels form a main marker if the distance between them is smaller than the average width and average height of the two connected groups of pixels.

[0040] The output of the method of this disclosure is a corrected image of the captured pages in which perspective distortion has been corrected. This corrected image may be processed

according to well-known image processing techniques for generating a selection image containing only the pixels belonging to the writing or drawings, filtering out the pixels belonging to the markers and to unwritten portions of the page (background).

[0041] The various embodiments of the method of this disclosure may be implemented via a software code run by a computer. According to an embodiment, the software code is an "app" executable by smartphones or tablet computers, that may optionally be configured to allow the smartphone or tablet computer to send the corrected image or the selection image as an image file to a communication hub and/or to a server of a cloud network.

REFERENCES CITED IN THE DESCRIPTION

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- US2005053304A [0007]
- US2012320427A [0008]
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Patentkrav

1. Fremgangsmåde til generering af et korrigeret billede fra et forvrænget billede, som gengiver mindst to hosliggende plane sider af en notesbog eller planlægningskalender, som hver især har en hovedmarkør og en flerhed af underordnede markører, hvor alle markører af siderne, som er anbragt ved sidegrænser, definerer toppunkter af en første rektangel, som har et første nominelt aspektforhold, hvor fremgangsmåden omfatter de følgende operationer:

a) anbringelse i det forvrængede billede af positioner af optagede underordnede markører og af en optaget hovedmarkør,

b) bestemmelse af en geometrisk transformation for at kortlægge lokationer af korrigerede pixels af det korrigerede billede svarende til optagede pixels af det forvrængede billede,

c) generering af det korrigerede billede, som indeholder de korrigerede pixels ved lokationer, der er bestemt i trin b),

kendetegnet ved, at markørerne af to hosliggende plane sider af de plane sider definerer en anden rektangel med et andet aspektforhold, **ved, at** det forvrængede billede gengiver to hosliggende plane sider af en notesbog eller planlægningskalender, og **ved, at** operationen b) udføres med de følgende trin, når to hovedmarkører er i det samme forvrængede billede:

b3) generering af et mellembillede af de to hosliggende sider af notesbogen eller planlægningskalenderen gennem de følgende trin:

- for hver optagede side af de to hosliggende sider, bestemmelse af relative positioner, i forhold til hovedmarkøren, af underordnede markører, som tilhører den optagede side, og bestemmelse af en øvre kantlinje (AB; FB), som forbinder to øvre markøer af markørerne af den optagede side, en nedre kantlinje (CD; ED), som forbinder to nedre markører af markørerne af den optagede side, en udvendig kantlinje (AC; FE), som forbinder to udvendige markører af markørerne af den optagede side, en øvre sidelinje (AF), som forbinder to øvre og udvendige markører af markørerne af de to hosliggende sider, en nedre sidelinje (CE), som forbinder to nedre og udvendige markører af markørerne

af de to hosliggende sider, et øvre tværpunkt (B) mellem de øvre kantlinjer (AB, FB) af de to hosliggende sider, et nedre tværpunkt (D) mellem de nedre kantlinjer (CD, ED) af de to hosliggende sider, en ledlinje (BD) af de to hosliggende sider, som passerer gennem det øvre tværpunkt (B) og det nedre tværpunkt (D), et øvre målpunkt (G) som skæringspunkt mellem ledlinjen (BD) og den øvre sidelinje (AF), et nedre målpunkt (H) som skæringspunkt mellem ledlinjen (BD) og den nedre sidelinje (CE), hvor den udvendige kantlinje (AC; FE) skærer den nedre kantlinje (CD; ED) og den øvre kantlinje (AB; FB) i overensstemmelse med henholdsvis en nedre og udvendig markør (C; E) og en øvre og udvendig markør (A; F),

- bestemmelse af et centralt transformationspunkt (O), som tilhører ledlinjen (BD), som det punkt, ved hvilket forholdet mellem afstanden (OD) fra det nedre tværpunkt (D) af afstanden (OH) fra det nedre målpunkt (H) er lig med forholdet mellem afstanden (OB) fra det øvre tværpunkt (B) og afstanden (OG) fra det øvre målpunkt (G),

- for hver optagede side af de to hosliggende sider, bestemmelse af et respektive udvendigt fast transformationspunkt (X1; X2), som tilhører den respektive udvendige kantlinje (AC; FE), som det punkt, ved hvilket forholdet mellem afstanden (X1C; X2E) fra den nedre og udvendige markør (C; E) og afstanden (X1A; X2F) fra den øvre og udvendige markør (A; F) er lig med forholdet mellem afstanden (OD) af det centrale faste transformationspunkt (O) fra det nedre tværpunkt (D), og afstanden (OB) af det centrale faste transformationspunkt (O) fra det øvre tværpunkt (B), og bestemmelse af et respektive fast transformationssegment (OX1; OX2), som forbinder det centrale faste transformationspunkt (O) med det respektive udvendige faste transformationspunkt (X1; X2), derefter for hver optagede pixel (P), som ligger i et sideområde, der ligger mellem det respektive faste transformationssegment (OX1; OX2) og den respektive øvre/nedre kantlinje (AB/CD; FB/ED), bestemmelse af tilsvarende mellempixel (P1) i overensstemmelse med en billedstrækningsalgoritme, som bevarer alle punkter af den udvendige kantlinje (AC; FE) og alle punkter af det faste transformationssegment (OX1; OX2) uforandret, og som kortlægger punkter, der ligger i sideområdet, for at forlænge ledlinjen for at bringe det

øvre/nedre tværpunkt (B; D) ind i det øvre/nedre målpunkt (G; H) og for at transformere den øvre/nedre kantlinje (AB; BF / CD; DE) til den øvre/nedre sidelinje (AF / CE),

- bestemmelse af mellembilledet, som indeholder nævnte mellempixels af de to hosliggende sider og en føringsfirkant, bestående af den øvre sidelinje (AF), den nedre sidelinje (CE) og de udvendige kantlinjer (AC, FE);

b4) bestemmelse af lokationer af korrigerede pixels af det korrigerede billede ved at behandle pixels af mellembilledet med en perspektivisk korrekturalgoritme, der er indrettet til at transformere føringsfirkanten til en rektangel med det nominelle andet aspektforhold ved som referenceside at tage den udvendige kantlinje eller den indvendige kantlinje og ved tilsvarende justering af længden af de øvrige linjer af firkanten.

2. Fremgangsmåde ifølge krav 1, hvor føringsfirkanten i det væsentlige er en trapez, hvis base er en af de udvendige kantlinjer, og billedstrækningsalgoritmen omfatter følgende trin:

- bestemmelse af en parallel linje (K1; O1) til ledlinjen, som passerer gennem den optagede pixel (P), skærer det respektive faste transformationssegment (OX1; OX2) ved et relativt fast punkt (O1), skærer den respektive øvre/nedre kantlinje (AB/CD; FB/ED) ved et relativt øvre/nedre punkt (K1; L1) og skærer den respektive øvre/nedre sidelinje (AF; CE) ved et relativt øvre/nedre målpunkt (K; L), og
- bestemmelse af den tilsvarende mellempixel (P1), således at forholdet mellem afstanden (P1O1) fra det relative faste punkt (O1) og afstanden (PO1) af den optagede pixel (P) fra det relative faste punkt (O1) er lig med forholdet mellem afstanden (KO1) af det relative øvre/nedre målpunkt (K; L) fra det relative faste punkt (O1) og afstanden (K1O1) af det relative øvre/nedre punkt (K1; L1) fra det relative faste punkt (O1).

3. Fremgangsmåde ifølge et af kravene 1 til 2, yderligere omfattende et trin med rotation af det forvrængede billede for at orientere enten den indvendige

kantlinje eller ledlinjen vertikalt.

4. Fremgangsmåde ifølge et af kravene 1 til 3, hvor hovedmarkøren består af to parrede mørke firkanter ved en fælles afstand, der er mindre end bredden og højden af firkanterne, og enhver af de underordnede markører er en enkelt mørk firkant, hvor markørerne er placeret over en lys baggrund, og hvor operation a) udføres gennem de følgende trin:

a1) forbehandling af det forvrængede billede med en algoritme af adaptiv belysningskorrektur, der udføres med punktvis beregning af lokal gennemsnitlig intensitetsværdi af pixels i et område af en pixel af det forvrængede billede og udførelse af en billedintensitetstilpasning i forhold til den lokale gennemsnitlige intensitetsværdi for at bestemme en tilsvarende forbehandlet pixel;

a2) bestemmelse af et binært sort-hvidt billede, hvis pixels har enten en høj eller en lav intensitet, ved at sammenligne intensiteten af tilsvarende forbehandlede pixels af det forvrængede billede med en tærskelværdi;

a3) lokalisering af grupper af forbundne pixels af det binære sort-hvide billede, derefter i grupperne af forbundne pixels af det binære sort-hvide billede, lokalisering af eventuelle omgivne pixels, som derved har en intensitet af modsat værdi i forhold til intensiteten af de forbundne pixels og korrigering af den modsatte værdi med en fyldalgoritme, således at grupperne af forbundne pixels fremstår som et ensartet udfyldt område uden huller;

a4) bestemmelse for hver forbundne gruppe pixels af statistiske momenter af anden ordning langs to koordinatsakser, og bestemmelse af halvakselængder af en tilsvarende ellipse med de samme statistiske momenter af anden ordning, derpå for enhver af ellipserne, sammenligning af forholdet mellem længderne af den store halvakse og den lille halvakse med en anden tærskelværdi, derpå udfiltrering af de tilsvarende grupper, for hvilke den anden tærskelværdi er overskredet, eller den lille halvakse er mindre end en tredje tærskelværdi, og fastholde de resterende grupper;

a5) behandling, med en k-means-clustering-algoritme, af de pixels af det forvrængede billede svarende til de fastholdte grupper i trin a4) for at lokalisere

to klynger pixels, og fastholde de pixels, som tilhører klyngen med den største middelværdi;

a6) lokalisering af grupper af forbundne pixels, som tilhører den i trin a5) fastholdte klynge, sammenligning af den gennemsnitlige intensitet af hver gruppe med en fjerde tærskelværdi, derpå udfiltrering af grupper af pixels, for hvilke den fjerde tærskelværdi er overskredet, og fastholde grupper af pixels, for hvilke den fjerde tærskelværdi ikke er overskredet;

a7) lokalisering af konturpixels, som omgiver de i trin a6) fastholdte grupper af forbundne pixels, sammenligning af den gennemsnitlige intensitet af nævnte konturpixels af hver gruppe med en femte tærskelværdi, derpå udfiltrering af grupper af pixels, for hvilke den femte tærskelværdi ikke er overskredet og fastholde grupper af pixels, for hvilket den femte tærskelværdi er overskredet, hvor de fastholdte grupper af pixels svarer til de mørke firkanter af markørerne af den optagede side;

a8) sondring af hovedmarkøren fra de underordnede markører ved behandling af de i trin a7) fastholdte grupper af pixels ved at lokalisere centrum af enhver af grupperne af pixels og ved at bestemme to grupper af pixels ved en indbyrdes afstand, som er mindre end den gennemsnitlige bredde og den gennemsnitlige højde af de to grupper af pixels.

5. Fremgangsmåde ifølge krav 4, omfattende et trin med forstærkning af kontrasten af det forvrængede billede med en histogramstrækningsalgoritme forud for bestemmelse af det binære sort-hvide billede.

6. Fremgangsmåde ifølge krav 4, yderligere omfattende mindst en af følgende operationer:

- efter trin a3) og inden trin a4), også udfiltrering af enkeltpunktlyd ved hjælp af en medianfiltrering af det sort-hvide billede;
- efter trin a3) og inden trin a4), også bestemmelse af området af enhver af grupperne af forbundne pixels og udfiltrering af grupper af forbundne pixels, hvis område oversiger en sjette tærskelværdi;

- efter trin a4) og inden udførelse af trin a5), bestemmelse for enhver af grupperne af forbundne pixels af en omsluttende rektangel, området af den omsluttende rektangel og området af den pågældende gruppe af forbundne pixels, derpå udfiltrering af grupperne af forbundne pixels, for hvilke forholdet mellem området af den omsluttende rektangel og området af den pågældende gruppe af forbundne pixels ikke er omfattet i et forud etableret omfang omkring 1.

7. Fremgangsmåde til generering af et udvælgelsesbilledet af en tekst eller tegning, der er skitseret på en side eller på to hosliggende sider af en notesbog eller planlægningskalender, omfattende mindst ét plant foromslag og ét plant bagomslag for at dække modstående sider af notesbogen eller planlægningskalenderen og et deformerbart rygomslag, og rektangulære sider, der er bundet til omslagene med en binding, således at når notesbogen eller planlægningskalenderen er åben, ligger hvilke som helst to plane hosliggende sider, ved hvilke notesbogen eller planlægningskalenderen er åben, fladt over omslagene af notesbogen eller planlægningskalenderen uden i det væsentlige at være krum, hvor hver side af de hosliggende sider har en hovedmarkør ved et udvendigt hjørne af siden og en flerhed af underordnede markør, der er placeret ved de andre hjørner af den samme side, hvor hovedmarkørerne af de to plane hosliggende sider er anbragt ved diametralt modsatte hjørne i forhold til et midtpunkt af en ledlinje af siderne af notesbogen eller planlægningskalenderen, hvor alle markørerne af hver side er anbragt ved grænser af siden som toppunkter af en første rektangel med et første nominelt aspektforhold, hvor markørerne af to hosliggende plane sider af de plane sider definerer en anden rektangel med et andet aspektforhold, hvor fremgangsmåden omfatter de følgende trin:

optagelse af et billede med en billedoptagelsesindretning af enten en plan side eller af to hosliggende plane sider af en notesbog eller planlægningskalender, optagelse af et forvrænget billede;

behandling af det forvrængede billede med fremgangsmåden ifølge et af kravene 1 til 6, generering af et korrigeret billede;

sondring i nævnte korrigerede billedpixels tilhørende markørerne, af pixels tilhørende den skitserede tekst eller tegning og pixels tilhørende en uskrevet del af siderne af notesbogen eller planlægningskalenderen;
generering af udvælgelsesbilledet ved fra det korrigerede billede at udvælge pixels tilhørende den skitserede tekst eller tegning.

8. Fremgangsmåde ifølge krav 7, yderligere omfattende behandling af det korrigerede billede med en algoritme, der er udvalgt i sættet bestående af uskarphedskorrektur, fokuseringskorrektur, lysheds- og/eller kontrastkorrektur og støjfjernelse, inden generering af udvælgelsesbilledet.

9. Computerprogram til PC eller en mobil applikation til smarttelefoner eller tablet-computere, omfattende en programkode til udførelse af fremgangsmådetrinnene ifølge et af kravene 1 til 8, når det udføres på en PC eller en smarttelefon eller en tablet-computer.

10. Indbundet notesbog eller indbundet planlægningskalender til at udføre fremgangsmåden ifølge krav 1, omfattende:
et plant foromslag og et plant bagomslag til at dække modstående sider af notesbogen eller planlægningskalenderen, og
i det væsentlige rektangulære sider, der er bundet til omslagene, hvor:
- hver side af de i det væsentlige rektangulære sider har en hovedmarkør ved et udvendigt hjørne af siden og en flerhed af underordnede markører, placeret ved de andre hjørner af den samme side,
- alle markører af hver side er anbragt ved grænser af siden som toppunkter af en første rektangel med et første nominelt aspektforhold,
kendetegnet ved, at
den indbundne notesbog eller indbundne planlægningskalender har et deformerbart rygomslag, og de i det væsentlige rektangulære sider er bundet til omslagene med en binding, der er konfigureret således, at når notesbogen eller planlægningskalenderen er åben, er det muligt for hvilke som helst to plane hosliggende sider, ved hvilke notesbogen eller planlægningskalenderen

er åben, at ligge fladt over omslagene af notesbogen eller planlægningskalenderen uden i det væsentlige at være krum;
hovedmarkørerne af de to plane hosliggende sider er anbragt ved diametralt modsatte hjørner i forhold til et midtpunkt af en ledlinje af siderne af notesbogen eller planlægningskalenderen;
markørerne af to hosliggende plane sider af de plane sider definerer en anden rektangel med et andet aspektforhold.

11. Indbundet notesbog eller planlægningskalender ifølge krav 10, hvor:
hovedmarkøren består af to parrede mørke firkanter ved en indbyrdes afstand, der er mindre end bredden og højden af firkanterne, og
enhver af de underordnede markører er en enkelt mørk firkant, hvor markørerne er anbragt over en lys baggrund.

DRAWINGS

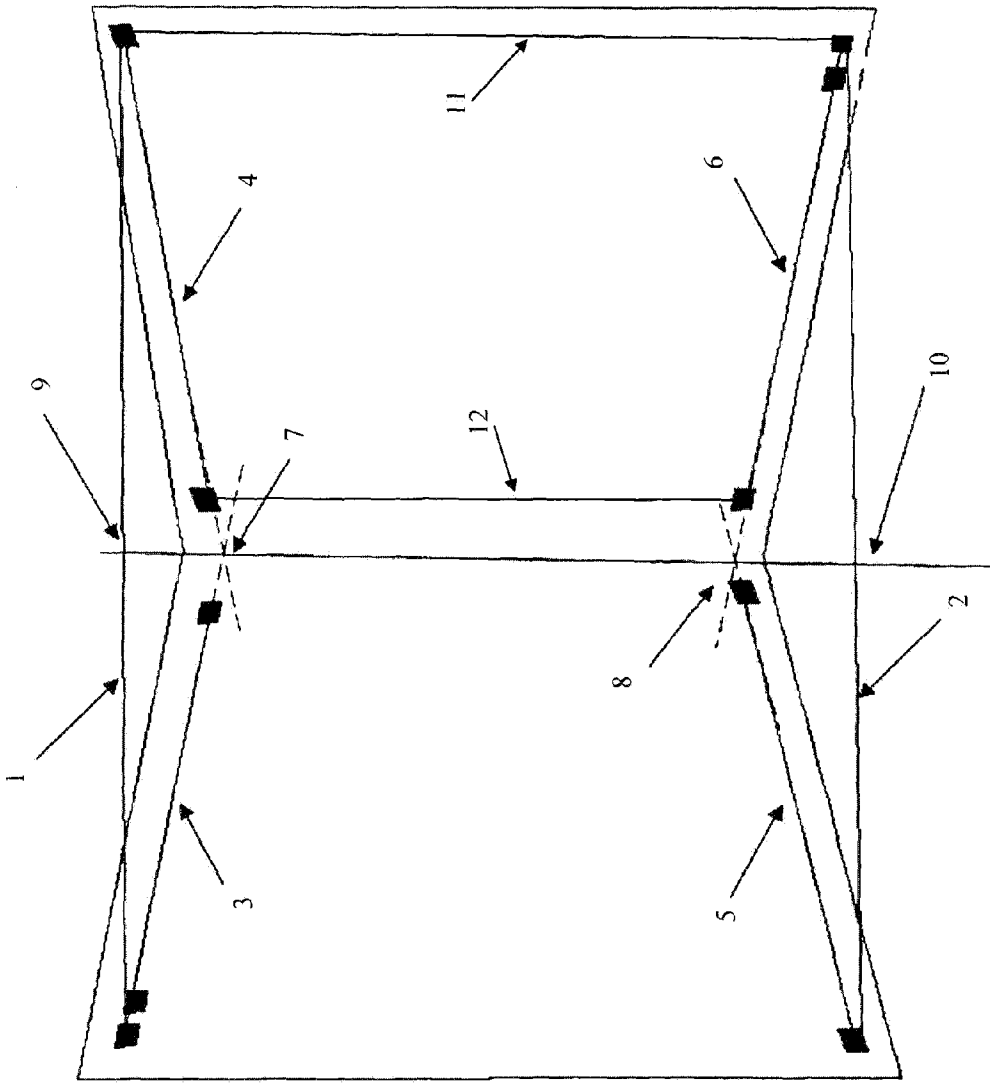

FIG. 1

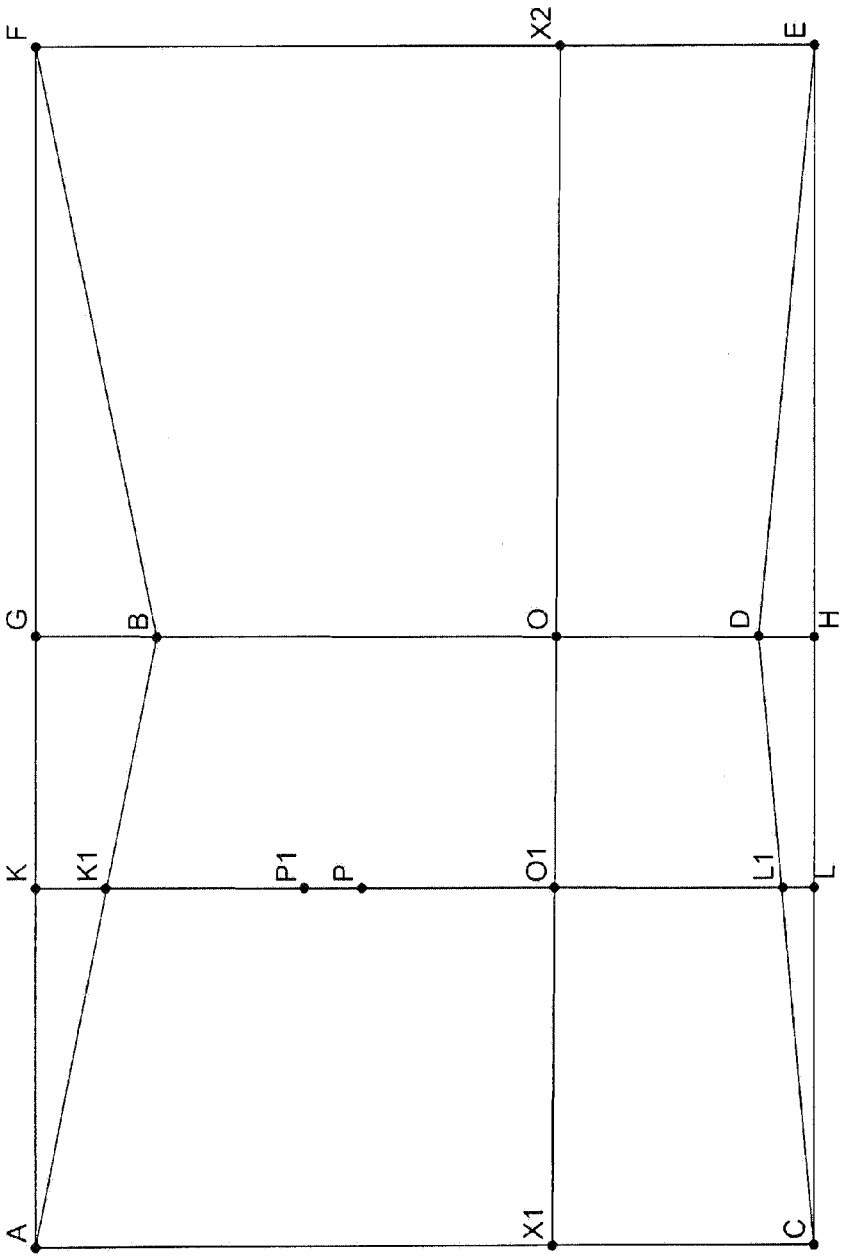

FIG. 2

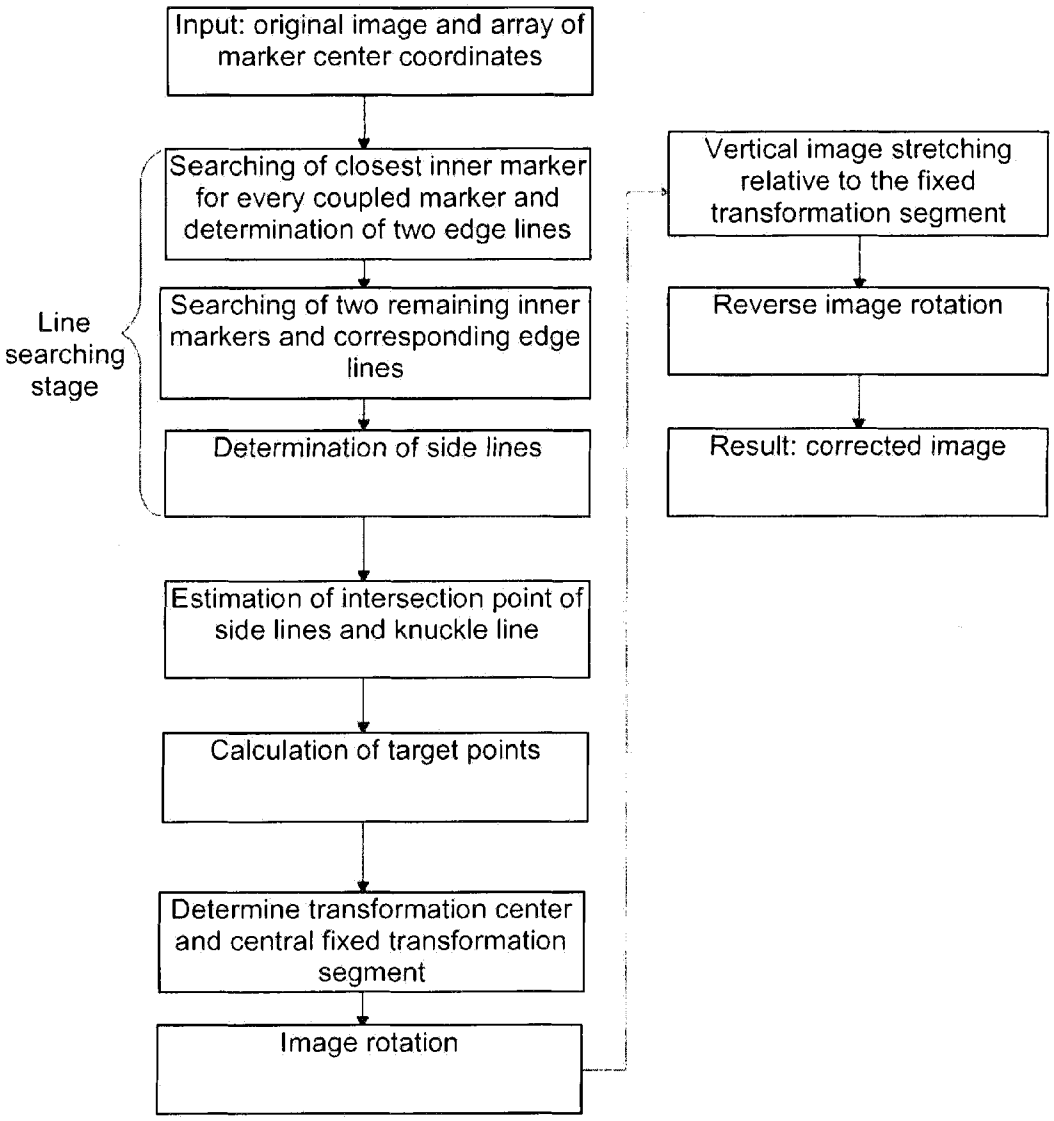
Input: original image and array of marker center coordinates
Searching of closest inner marker for every coupled marker and determination of two edge lines
Searching of two remaining inner markers and corresponding edge lines
Determination of side lines
Line searching stage
Estimation of intersection point of side lines and knuckle line
Calculation of target points
Determine transformation center and central fixed transformation segment
Image rotation
Vertical image stretching relative to the fixed transformation segment
Reverse image rotation
Result: corrected image

FIG. 3

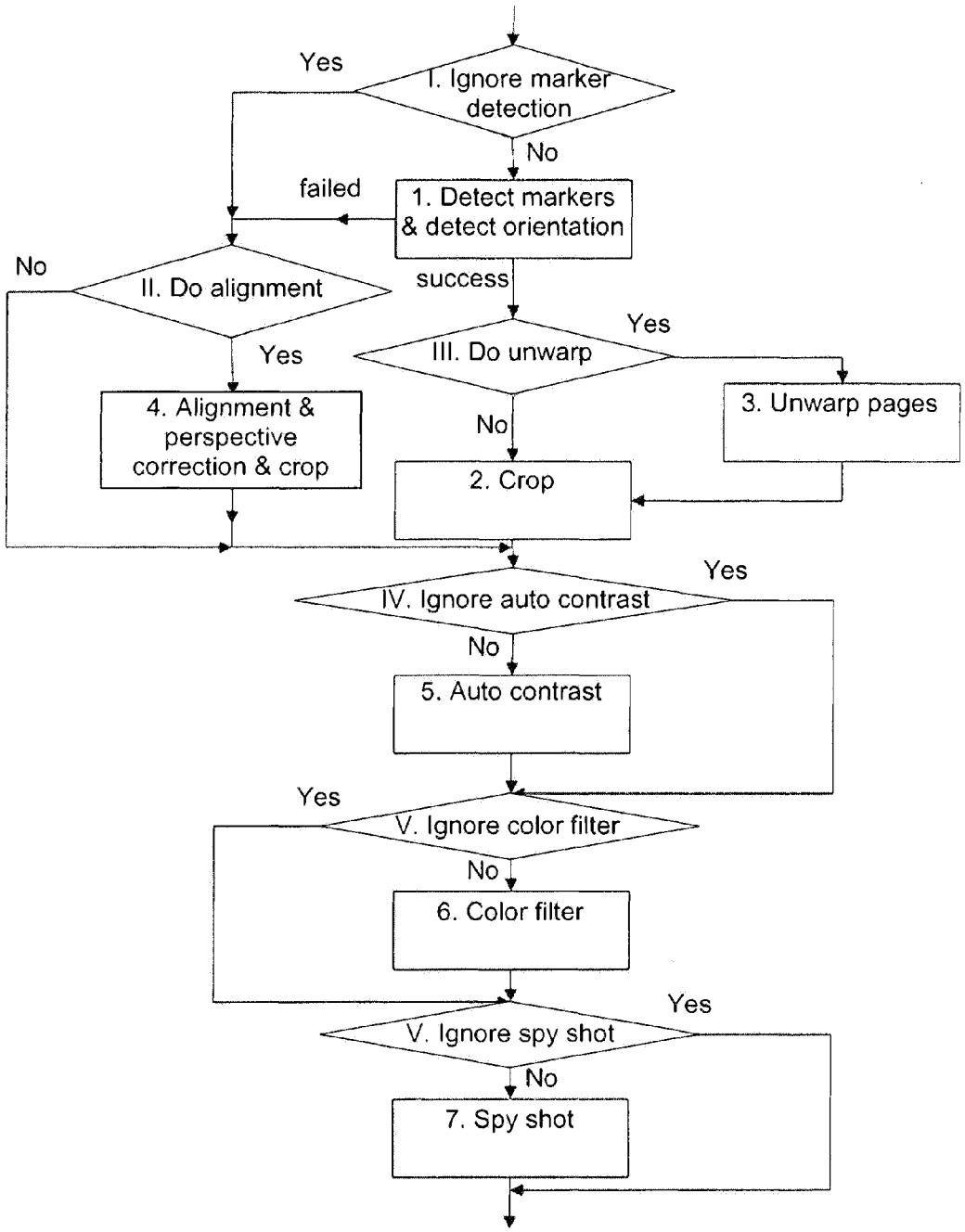
I. Ignore marker detection
Yes
No
1. Detect markers & detect orientation
failed
II. Do alignment
No
Yes
success
III. Do unwarp
Yes
No
4. Alignment & perspective correction & crop
3. Unwarp pages
2. Crop
IV. Ignore auto contrast
Yes
No
5. Auto contrast
V. Ignore color filter
Yes
No
6. Color filter
V. Ignore spy shot
Yes
No
7. Spy shot

FIG. 4

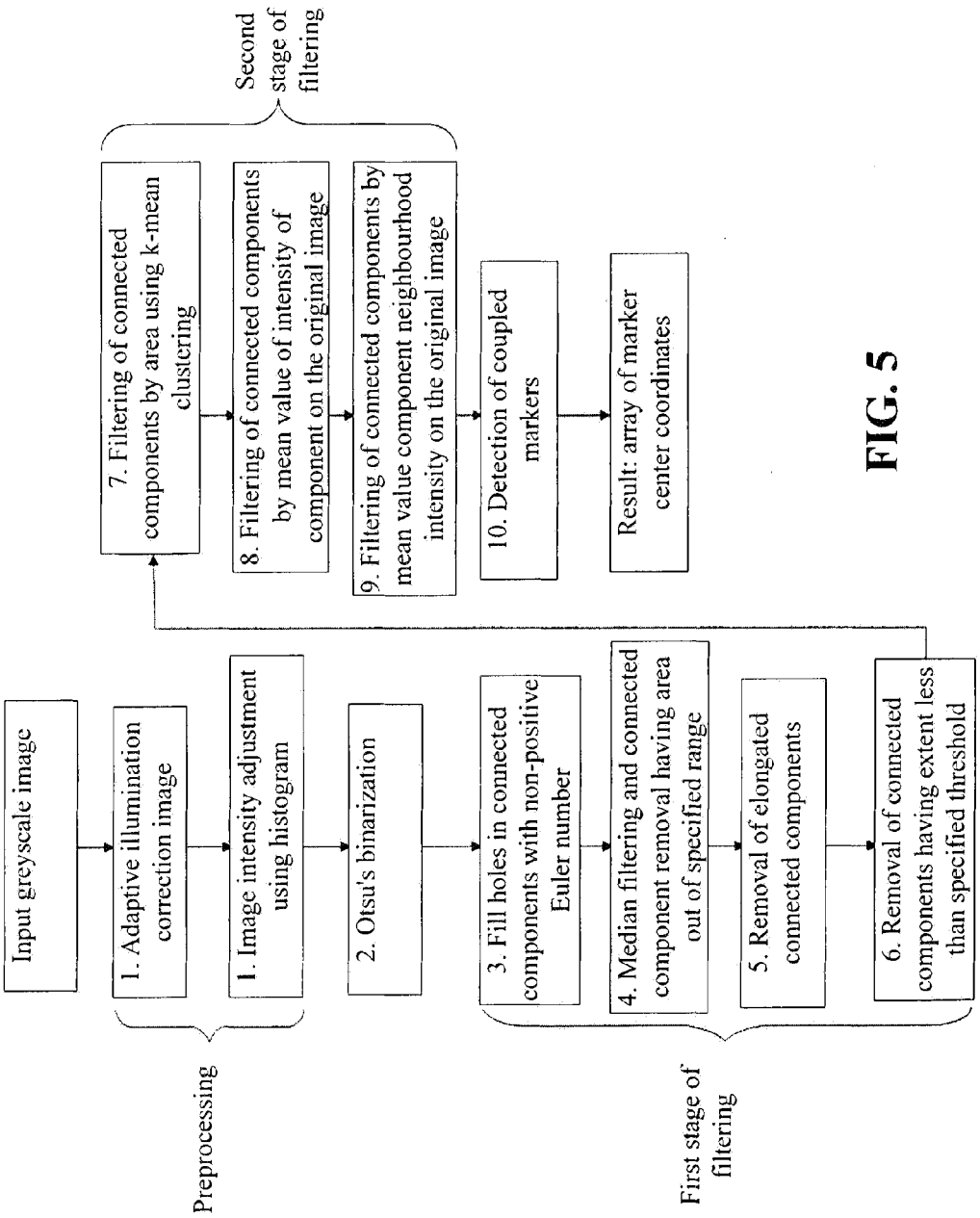
Input greyscale image
1. Adaptive illumination correction image
1. Image intensity adjustment using histogram
2. Otsu's binarization
3. Fill holes in connected components with non-positive Euler number
4. Median filtering and connected component removal having area out of specified range
5. Removal of elongated connected components
6. Removal of connected components having extent less than specified threshold
7. Filtering of connected components by area using k-mean clustering
8. Filtering of connected components by mean value of intensity of component on the original image
9. Filtering of connected components by mean value component neighbourhood intensity on the original image
10. Detection of coupled markers
Result: array of marker center coordinates
Preprocessing
First stage of filtering
Second stage of filtering

FIG. 5

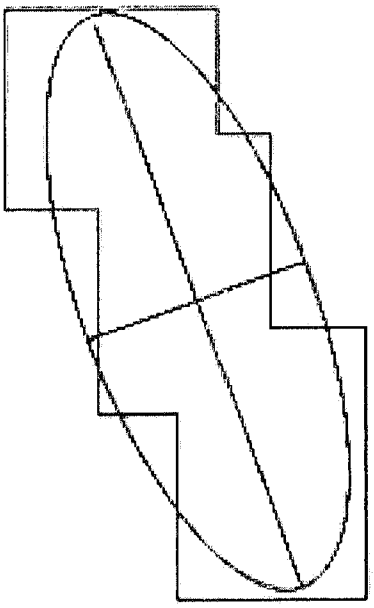

FIG. 6