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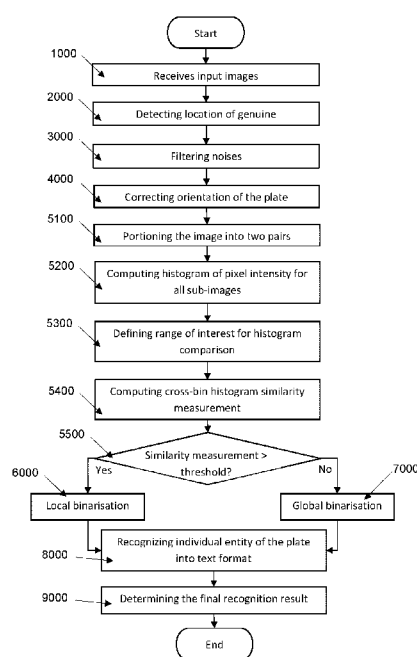


FIG. 2

(57) Abstract: The present invention relates to a method for binarising license plate. The method includes the steps of filtering noises in an image of the license plate, correcting the orientation of the image of the license plate, portioning the image of the plate into two pairs of sub-images, computing histograms of pixel intensity for all the sub-images, defining range of interest for each histogram, computing cross-bin histogram similarity measurement, determines whether the similarity measurement is higher than a certain threshold, adapting a local binarisation if the similarity score is higher than the threshold, recognising individual entity of the plate and transforming individual entity of the license plate into the text format of alphabet and number, and analysing all the recognised entity in order to determine the final context of the plate.

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A METHOD FOR BINARISING LICENSE PLATE**FIELD OF INVENTION**

The present invention relates to a method for binarising license plate. More particularly, the present invention relates to a method for binarising license plate using histogram analysis.

BACKGROUND OF THE INVENTION

Binarisation is a procedure which converts grayscale image into binary image. In an automated licence plate recognition, binarisation is a common procedure which turns grayscale plate image into binary license plate image. The purpose of the binarisation is to separate characters on the license plate image from background. The separated characters are sent to a classifier for recognition purposes.

An example of an automated license plate recognition system which performs binarisation is disclosed in a United States Patent Publication No. 2013/0294654 A1 that relates to a method and system for achieving accurate segmentation of characters. The system computes a vertical projection histogram to produce an initial character boundary. The system also employs local statistical information to split a large initial character boundary and insert a missing character. The initial character boundaries can be classified as a valid character or a suspect character, wherein the suspect character is normalised and passed to an optical character recognition sub-system for decoding and generating a confidence quote. The system eliminates non-character images by enforcing a confidence threshold.

Although there are many methods for automated license plate recognition systems which perform binarisation, most of the methods can only adapt local binarisation or global binarisation. Implementing local binarisation may increase the risk of over binarisation, whereby a single character might be separated into two or more parts. On the other hand, implementing global binarisation on uneven illuminated grayscale plate image leads to loss of information and linkages of characters. Therefore, there is a need for a method which can implement both local binarisation and global binarisation.

SUMMARY OF INVENTION

The present invention relates to a method for binarising license plate. The method includes the steps of filtering noises in an image of the license plate, correcting the orientation of the image of the license plate, portioning the image of the plate into two pairs of sub-images, computing histograms of pixel intensity for all the sub-images, defining range of interest for each histogram, computing cross-bin histogram similarity measurement, determines whether the similarity measurement is higher than a certain threshold, adapting a local binarisation if the similarity score is higher than the threshold, recognising individual entity of the plate and transforming individual entity of the license plate into the text format of alphabet and number, and analysing all the recognised entity in order to determine the final context of the plate.

Preferably if the cross-bin histogram similarity measurement is lower than the threshold the steps include adapting a global binarisation, recognising individual entity of the plate into the text format of alphabet and number, and analysing all the recognised entity in order to determine the final context of the plate.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. 1 illustrates a block diagram of a system (**100**) for binarising license plate according to an embodiment of the present invention.

FIG. 2 illustrates a flowchart of a method for binarising a license plate according to an embodiment of the present invention.

FIG. 3 illustrates a flowchart of sub-steps for computing cross-bin histogram similarity measurement of the method of **FIG. 2**.

FIG. 4 illustrates a flowchart of sub-steps for performing the local binarisation of the method of **FIG. 2**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well known functions or constructions are not described in detail since they would obscure the description with unnecessary detail.

Initial reference is made to **FIG. 1** which illustrates a block diagram of a system (**100**) for binarising license plate according to an embodiment of the present invention. The system (**100**) comprises a plate detection module (**10**), a plate segmentation module (**20**), a plate recognition module (**30**) and a plate post analyser module (**40**). The system (**100**) generates a binary license plate image from a gray scale image of license plate to isolate characters of the license plate. The isolated characters of the license plate are then recognised.

The plate detection module (**10**) is configured to detect the location of the license plate from an image of a vehicle passing by. The plate detection module (**10**) receives the image of the vehicle from an image capturing device such as a camera. The plate detection module (**10**) extracts the license plate from the image captured by the camera and sends the image of the license plate to the plate segmentation module (**20**) for segmentation stage.

The plate segmentation module (**20**) is configured to segment characters in the license plate by applying background estimation based binarisation in order to obtain isolated characters. The isolated characters include alphabet and numeric. The plate segmentation module (**20**), which is connected to the plate detection module (**10**) and plate recognition module (**30**), receives the image of the license plate from the plate detection module (**10**), obtains the isolated characters and sends the isolated characters to the plate recognition module (**30**) for recognition stage.

The plate recognition module (**30**) is configured to recognise individual entity of the plate and transform individual entity of the license plate into a text format of alphabet and numeric.

The plate post analyser module (40) is configured to analyse all the recognised characters of the license plate to determine final text content of the license plate.

5 Reference is now made to **FIG. 2** which illustrates a flowchart of a method for binarising a license plate according to an embodiment of the present invention. Initially, the plate detection module (10) receives an input image of a vehicle passing from the image capturing device as in step **1000**. The plate detection module (10) then detects the location of the license plate as in step **2000** and sends the image of
10 the license plate to the plate segmentation module (20).

 The plate segmentation module (20) receives the image of the license plate and filters noises in the image of license the plate as in step **3000**, wherein noises are non-character objects that appear in the image of the license plate. Thereon, the
15 plate segmentation module (20) corrects the orientation of the image of the plate by tilting the image of the plate to a desired orientation as in step **400**. Preferably, the desired orientation is when the characters of the license plate are written horizontally.

 The plate segmentation module (20) then portions the image of the license
20 plate into two pairs of sub-images as in step **5100**. One of the two pairs of the sub-images is a pair of equal sized sub-images from horizontal portioning, whereas another pair of the sub-images is a pair of equal sized sub-images from vertical portioning. The pair of sub-images from horizontal portioning is used to capture uneven illumination across vertical direction. On the other hand, the pair of sub-
25 images from vertical portioning is used to capture uneven illumination across horizontal direction. Each sub-image of each pair will be compared via histograms to quantify the discrepancies of the pixel intensity distribution.

 The plate segmentation module (20) computes histograms of pixel intensity
30 for all the sub-images as in step **5200**. Thereafter, the plate segmentation module (20) defines range of interest for each histogram by using mean and standard deviation as in step **5300**. The range of interest is between two lines, wherein one line is sum of the mean and standard deviation, while another line is subtraction of the standard deviation from the mean. If both sub-images from the same portioning

have even illumination, the range of interest for both sub-images should be almost similar.

5 The plate segmentation module (20) computes cross-bin histogram similarity measurement by using Earth mover's distance for each pair of the sub-images as in step 5400. Earth mover's distance quantifies dissimilarity between two distributions in multi-dimensional feature space. The sub-steps for computing cross-bin histogram similarity measurement are further explained in relation to FIG. 3.

10 The plate segmentation module (20) determines whether the cross-bin histogram similarity measurement is higher than a certain threshold as in decision 5500. If the cross-bin histogram similarity measurement is higher than the threshold, a local binarisation is adapted as in step 6000. The local binarisation is a type of binarisation where each pixel in the image is treated differently according to the
15 pixels' neighbouring pixels by comparing to an adaptive threshold computed from the neighbouring pixels. The sub-steps for performing the local binarisation will be further explained in relation to FIG. 4.

20 On the other hand, if the cross-bin histogram similarity measurement is lower than the threshold, the global binarisation is adapted as in step 7000. The global binarisation is a type of binarisation where each pixel in the image is treated equally by comparing to a global threshold. Preferably, the global threshold is a pre-determined threshold set by a user.

25 After the plate segmentation module (20) performs either the local binarisation or global binarisation, the plate recognition module (30) recognises individual entity of the license plate and transforms individual entity of the license plate into the text format of alphabet and number as in step 8000. Finally, the plate post-analyser module (40) analyses all the recognised entity in order to determine
30 the final context of the plate as in step 9000.

FIG. 3 illustrates a flowchart of sub-steps for computing cross-bin histogram similarity measurement of step 5400 of the method of FIG. 2. Initially, the plate segmentation module (20) computes probability density function of each discrete

6

pixel intensity bin for each sub-image as in step **5410**. The probability density function is computed based on the equation below:

$$P(k) = \frac{n_k^L}{T^1}, 0 \leq k \leq L - 1,$$

wherein L represents the total number of discrete bin, k represents pixel intensity, T represents the total number of pixels in the sub-image, and n_k^L represents the total number of pixels with gray intensity equals to k . Preferably, the pixel intensity ranges from 0 to 255, wherein 0 represents black and 255 represents white.

10

The plate segmentation module (20) then computes cumulative probability function for each sub-image as in step **5420** based on the equation below:

$$C(k) = \sum_{k=0}^{k=L-1} P(k).$$

15

Thereon, the plate segmentation module (20) computes histogram equalised output for each sub-image as in step **5430**. The plate segmentation module (20) computes the histogram equalised output by transforming each discrete gray pixel intensity in original sub-image, I_E to a new discrete gray pixel according to the cumulative probability function based on the equation below:

20

$$I_E(x, y) = \lfloor (L - 1)C(k = I(x, y)) \rfloor,$$

wherein x represents coordinate on X-axis, y represents coordinate on Y-axis, and $I(x, y)$ represents pixel intensity of digital image I at coordinate (x, y) .

25

The plate segmentation module (20) then computes chi-histogram distance measurement as in step **5440**. The chi-histogram distance is a bin-to-bin measurement that compares both sub-images after portioning to assess the level of discrepancy in terms of gray level pixel intensity distribution. The Chi-histogram distance between first sub-image, I_{E1} and second sub-image, I_{E2} denoted as $Chi_D(I_{E1}, I_{E2})$, is defined as follows:

30

$$Chi_D(I_{E1}, I_{E2}) = \sum_{k=1}^{k=L-1} \frac{[P_{E1}(k) - P_{E2}(k)]^2}{P_{E1}(k) + P_{E2}(k)}.$$

Earth mover's distance for each pair of the sub-images is computed by the plate segmentation module (20) as in step 5450. Earth mover's distance quantifies dissimilarity between two distributions in multi-dimensional feature space. Earth
5 movers distance for the pair of the sub-images is computed based on the equation below:

$$EMD(P_{E1}, P_{E2}) = \frac{\sum_{i=1}^{i=L-1} \sum_{j=1}^{j=L-1} d_{ij} M_{i,j}}{\sum_{i=1}^{i=L-1} \sum_{j=1}^{j=L-1} M_{i,j}},$$

10 wherein i represents gray intensity level in a histogram of the first sub-image, j represents gray intensity level in a histogram of the second sub-image, $d_{i,j}$ represents distance between the histogram of the first sub-image and histogram of the second sub-image and $M_{i,j}$ represents the weight of the histogram of the first sub-image and histogram of the second sub-image.

15

The value of Earth mover's distance between the pair of sub-images is viewed as the cross-bin similarity measurement between two pixel intensity distributions. Therefore, the cross-bin similarity measurement is computed as in step 5460 based on the equation below:

20

$$Similarity\ Measurement = \frac{Chi_D(I_1)Chi_D(I_2) + EMD(P_{I1}, P_{I2})EMD(P_{I3}, P_{I4})}{2},$$

wherein $Chi_D(I_1)$ represents chi-histogram distance measurement between a pair of the sub-images, $Chi_D(I_2)$ represents chi-histogram distance measurement between
25 another pair of the sub-images, $EMD(P_{E1}, P_{E2})$ represents Earth mover's distance for a pair of the sub-images, and $EMD(P_{E3}, P_{E4})$ represents Earth mover's distance for another pair of the sub-images.

FIG. 4 illustrates a flowchart of sub-steps for performing the local binarisation of the step **6000** of the method of **FIG. 2**. If the cross bin similarity measurement is higher than the threshold, and the local binarisation is adopted, the plate segmentation module (**20**) initialises a window size as in step **6100**. The window size is then expanded by a finite step size as in step **6200**.

Thereon, the plate segmentation module (**20**) computes coefficient of variations as in step **6300** based on the equation below:

$$COV = \sqrt{\frac{\sum_{i=1}^{max\ i} \sum_{j=1}^{max\ j} (W(i,j) - \bar{W})^2}{(max\ i)(max\ j)}},$$

wherein W represents a resultant image after processing image I , and $\bar{W}$ represents average intensity of the image W .

The plate segmentation module (**20**) computes histogram skewness as in step **6400** based on the equation below:

$$Skewness = \frac{\sum_{i=1}^{max\ i} \sum_{j=1}^{max\ j} (W(i,j) - \bar{W})^3}{(max\ i)(max\ j) s^3},$$

wherein s represents standard deviation of all pixels in image W .

A histogram kurtosis is then computed by the plate segmentation module (**20**) as in step **6500** based on the equation below:

$$Kurtosis = \frac{\sum_{i=1}^{max\ i} \sum_{j=1}^{max\ j} (W(i,j) - \bar{W})^4}{(max\ i)(max\ j) s^4} - 3.$$

Thereon, the plate detection module (**20**) determines whether the coefficient of variation, histogram skewness and histogram kurtosis are within range as in decision **6600**, wherein the range may be predetermined by the user. If either coefficient of variation, histogram skewness or histogram kurtosis is not within range, the plate segmentation module (**20**) repeats from the step **6200** which is expanding window size by the finite step size. On the other hand, if the coefficient of variation,

histogram skewness and histogram kurtosis are within range, the plate segmentation module (20) sends binarised image of the license plate to the plate recognition module (30) for recognition stage.

- 5 While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specifications are words of description rather than limitation and various changes may be made without departing from the scope of the invention.

CLAIMS

1. A method for binarising a license plate is characterised by the steps of:
 - a) filtering noises in an image of the license plate by a plate segmentation module (20);
 - 5 b) correcting orientation of the image of the license plate by tilting the image of the plate to a desired orientation by the plate segmentation module (20);
 - 10 c) portioning the image of the plate into two pairs of sub-images, wherein one pair of the sub images is a pair of equal sized sub-images from horizontal portioning and another pair of the sub-images is a pair of equal sized sub-images from vertical portioning by the plate segmentation module (20);
 - 15 d) computing histograms of pixel intensity for all the sub-images by the plate segmentation module (20);
 - e) defining range of interest for each histogram by using mean and standard deviation by the plate segmentation module (20);
 - f) computing cross-bin histogram similarity measurement by using Earth mover's distance for each pair of the sub-images by the plate segmentation module (20);
 - 20 g) determining whether the cross-bin histogram similarity measurement is higher than a threshold by the plate segmentation module (20);
 - h) adapting a local binarisation if the similarity score is higher than a certain threshold by the plate segmentation module (20);
 - 25 i) recognising individual entity of the license plate and transforming individual entity of the license plate into the text format of alphabet and number by a plate recognition module (30); and
 - j) analysing all the recognised entity in order to determine final context of the plate by a plate post-analyser module (40).
- 30 2. The method as claimed in claim 1, wherein computing cross-bin histogram similarity measurement by using Earth mover's distance for each pair of the sub-images by the plate segmentation module (20) includes the steps of:
 - a) computing probability density function of each discrete pixel intensity bin for each sub-image;
 - 35 b) computing cumulative probability function for each sub-image;

- c) computing histogram equalised output for each sub-image by transforming each discrete gray pixel intensity in original sub-image to a new discrete gray pixel according to the cumulative probability function;
 - 5 d) computing chi-histogram distance measurement between a pair of sub-images;
 - e) computing Earth mover's distance for each pair of the sub-images; and
 - f) computing cross-bin similarity measurement.
- 10
3. The method as claimed in claim 1, wherein adapting a local binarisation if the similarity score is higher than the threshold by the plate segmentation module (20) includes the steps of:
- a) initialising a window size;
 - 15 b) expanding the window size by a finite step size;
 - c) computing coefficient of variations;
 - d) computing histogram skewness; and
 - e) computing histogram kurtosis.
- 20
4. The method as claimed in claim 1, wherein if the cross-bin histogram similarity measurement is lower than the threshold the steps include:
- a) adapting a global binarisation;
 - b) recognising individual entity of the plate into the text format of alphabet and number by the plate recognition module (30); and
 - 25 c) analysing all the recognised entity in order to determine the final context of the plate by the plate post-analyser module (40).

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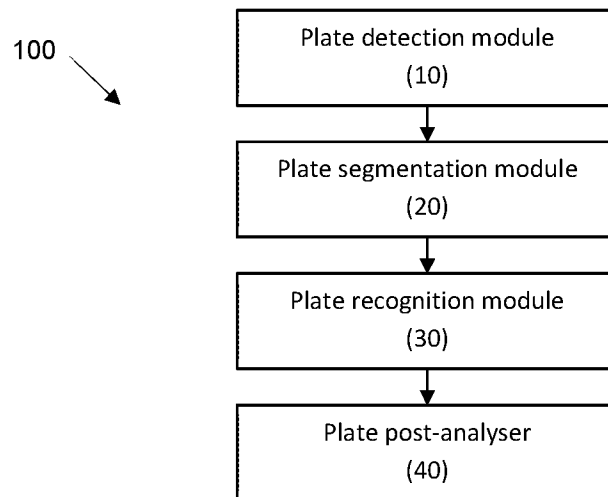
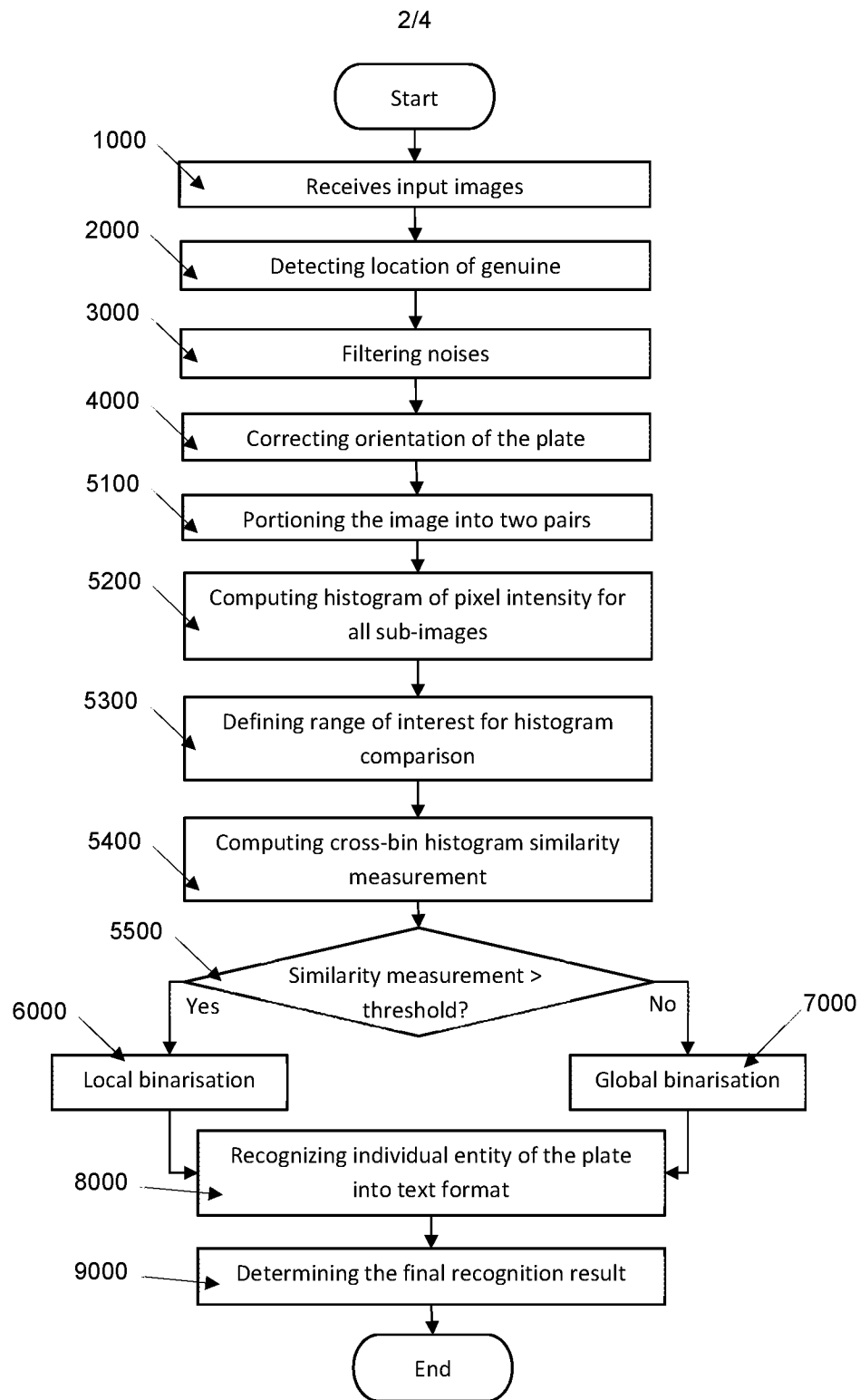


FIG. 1



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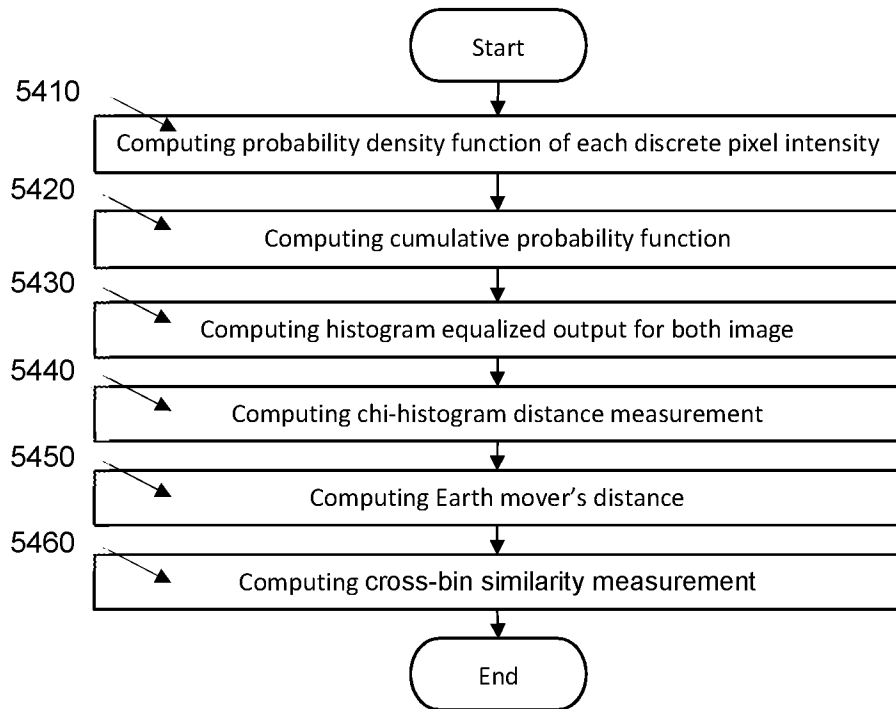


FIG. 3

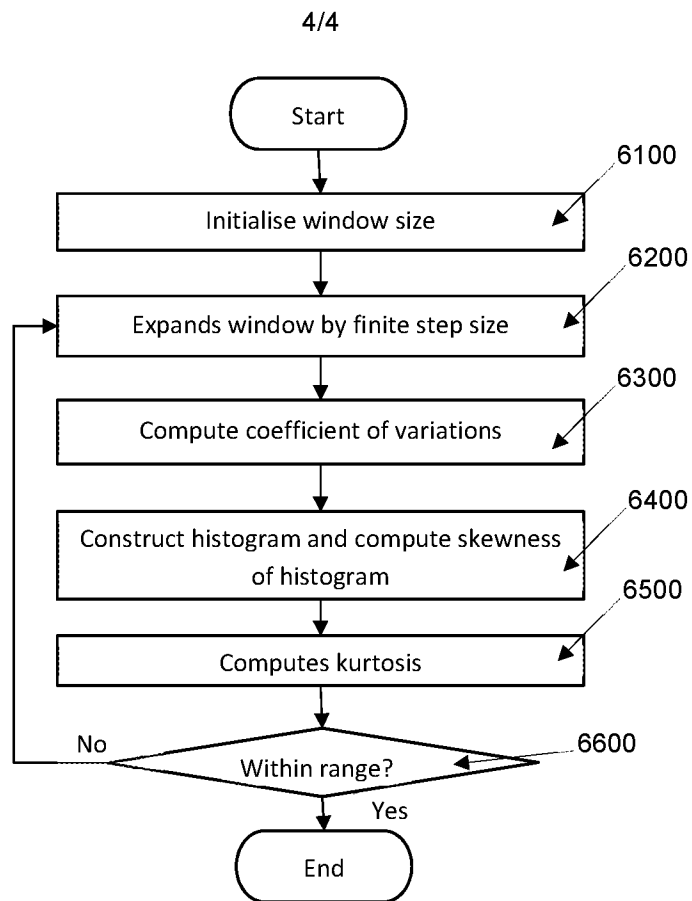


FIG. 4