

Geometric image transformation based on text line searching

The present invention is related to Optical Character Recognition (OCR) systems, and especially to a method, system or digital camera comprising said method for geometric
5 image transformation of deformed images of text based on text line searching.

In prior art the flat bed scanner has become a standard equipment in almost every office providing scanned input of typed text, book pages and different types of documents such as for example handwritten applications or partially handwritten schemes etc. to
10 computers for further word-processing, electronic storage, electronic distribution etc. However, whenever a document or page is not properly aligned on the flatbed scanner, or the thickness of a book renders the page adjacent to the back of the book curved above the flatbed scanner, the scanned images transferred to the computer provides a deformed image of the text that is difficult to recognize in an OCR program as known in
15 prior art.

In recent years, digital cameras have become an alternative to flatbed scanners due to the flexibility when using the camera. However, the problem with deformed text images for OCR processing in digital cameras is further enhanced since the misalignment of a
20 camera image may occur in three dimensions (perspective distortion), even for pictures of flat pages. Lens faults like lens aberration and distortion may also influence the OCR efficiency.

A geometrical transformation of the deformed document image providing corrected
25 images suitable for the OCR processing may solve the problem. The US patent 6.304.313 disclose a digital camera with an OCR function based on dividing a document page into blocks, where each block is photographed before each block is processed by the OCR function. When all the blocks has been processed by the OCR function, the recognized blocks with text corresponding to the plurality of images are
30 combined together to form one text data set corresponding to the whole document. However, the geometrical transformation according to this disclosure is merely to divide the page in such small blocks that the deformation in each small block is negligible. Therefore, this solution may require extensive processing to accomplish the task when the deformation exceeds a specific level. Further, the division of text may
35 render the text in each block unrecognizable because the blocks are becoming too small to contain recognizable text.

The US patent application US 2003/0026482 from February 6, 2003 disclose a method for correcting perspective distortion in a digital document image, for example from a digital camera, wherein a mathematical model of how parallel lines passes a single point when viewed under some perspective view is used to identify the perspective of the
5 image. According to a preferred embodiment of this invention, horizontal and vertical border lines of an image comprising text is used to identify the perspective of the image. Based on this mathematical model of the distortion due to the perspective, text lines are corrected. As easily understood, this perspective based method do not cope with the other types of distortion readily encountered when for example a page in a book is
10 photographed, and then passed through an OCR function. Besides perspective distortions, structural distortions due for example to bending or curving of book pages adds significantly to the problem of correcting such images from cameras. It is also clear from practical experience when using a camera for capturing images of text, the camera usually is oriented straight ahead above the page to be photographed. Therefore,
15 the perspective distortion will usually contribute less to the total distortions encountered in the image compared to for example structural distortions of the object (text page, bending of book pages, curving pages etc.) itself.

The paper "Correcting Document Warping based on regression of curved text lines" by
20 Zhang and Tan, International Conference on Document Analysis and Recognition, ICADR-2003, disclose a method based on models of the text line deformations as quadratic polynomial curves instead of using a more common cylinder model for the book deformation near the back of the book as described above. The lines are tracked using a connected element clustering algorithm within bounding boxes defined by the
25 orientation of an already identified segment of the text lines.

The paper "Document image de-warping for text/graphics recognition" by Wu and Agam, International Symposium on Statistical Pattern Recognition, SSPR-2002, disclose a method based on lines that are tracked using a local adaptive cumulative
30 projection at different angles. The tracked lines may cross each other due to the local nature of the algorithm when two starting points result in two different search directions. A second step of removing lines that are crossing based on the average orientation of the lines is included, limiting the method to images with fairly regular lines and a small perspective distortion. A rectangular mesh is fitted to the remaining
35 lines for dewarping.

The paper "Rectifying the bound document image captured by a camera: A model based approach" by Cao et. al., International Conference on Document Analysis and Recognition, ICADR-2003, disclose a method based on applying a cylinder model to the book deformation near the back of the book and a perspective model to compensate for the depth difference. A best match between the cylinder model and a set of threshold skeletons of the lines are used to rectify the images.

All of these above referenced papers disclose methods having clear limitations with respect to the type of geometric deformations that can be dewarped by these methods. The cylinder model and the quadratic polynomials will only fit the type of geometric deformations that is found in books with stiff book cover. The average orientation filtering requires that the text lines are fairly regular, which is found in the case with open books, and which also limits the methods to only small perspective deformations.

Therefore there is a need for a method and system providing better geometrical transformation of distorted images comprising text before processing images with an OCR function to achieve more reliable and more complete text recognition of documents in a computer system or digital camera system.

According to an aspect of the present invention, text like information in an image may be identified and evaluated on basis of connected pixels that probably comprise text, and on basis of direction of connected pixels constituting text, a text line direction may be identified without any introduction of an a priori assumption or model of present document deformations. Based on the property that most text-lines are parallel and are relatively homogenous in size in actual documents, text-lines may be geometrically transformed providing aligned and parallel text lines that much more easily are handled by OCR programs, thereby providing more reliable and more complete recognition of images comprising text by said OCR program.

According to an example of embodiment of the present invention an image is reviewed to identify text like structures, and to make an assessment if the total text like structure comprised in the image is enough to extract text lines as basis for a geometrical transformation of the whole document, wherein potentially connected pixels that may form characters are identified and traced to form text lines providing points for a definition of transformation points on said text lines, wherein said transformation points are used for a geometrical transformation of said text lines or parts of said text lines,

providing images comprising parallel and homogenous text lines as input for an OCR program.

Figure 1 depicts an example of connected pixels forming a probable word.

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Figure 2 depicts examples of connected pixels forming probable characters that are forming words.

Figure 3 illustrates an image of a document page comprising slight deformation.

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Figure 4 illustrates text line tracking according to an example of embodiment of present invention.

Figure 5 illustrates an example of meshes for forward and inverse geometric morphing transformation according to an example of embodiment of present invention.

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Figure 6 depicts a flow diagram of an example of embodiment of present invention.

According to an aspect of the present invention, in stead of establishing an a priori mathematical model of distortions in an image comprising text, the main issue is that pixels representing characters, character fragments (which may be natural due to typographical aspects of the text or artificial due to deformations), words or parts of words constitute connected pixels, wherein connected pixels related to characters are spaced apart by a distance defined by the typeface used (Times New Roman etc.), and wherein groups of connected pixels forming words are spaced by another distance defining distance between words on a text line, wherein it is possible to search an image to identify even deformed text lines based on said searching using for example said distances.

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According to an aspect of the present invention, the objective of the present invention may be solved in a process comprising three basic steps:

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a) performing an initial check to evaluate if there is enough text like structures in the images to perform a transformation according to the present invention,

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b) identify connected pixels probably forming characters, words and searching said probable characters, words to identify transformation points,

- c) based on said transformation points, transforming the image or a part of an image comprising text to an image where the text lines are straight and parallel, and homogenous in size.

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According to an aspect of the present invention, a reference system providing a coordinate system for locating graphical elements, objects, characters etc. in an image may be defined by the plane provided by the flatbed scanner platen or the surface of the image capturing device, such as a digital camera, for example. However, any definition
10 of a coordinate system may be used according to the present invention.

Any pixel in an image is therefore referable by an ordered set of coordinate values. Pixels related to an image of characters constituting text provides several attributes that may be used in OCR functions as known to a person skilled in the art. For example, the
15 shape of characters may be identified providing means for recognizing characters, and then whole words, for example. Whenever there is a deformation of the image, the recognition is difficult as described above.

According to an example of embodiment of the present invention, the geometrical
20 image transformation may be executed whenever there is enough information in the image to provide a transformation grid. According to the present example, an initial text check is performed analysing connected pixels to verify that they are consistent in size, shape and relative position consistent with text. For example, if images has insufficient resolution (character height below five to ten pixels, for example), insufficient text line
25 structure (a single line or sparse words cannot be used to define a transformation grid), the image is rejected. In some instances, the text lines may extend outside the edges of the image.

Whenever such situations occur, they may be signalled back to users providing a
30 possibility to correct the reason why the image does not provide sufficient information for the geometrical transformation according to the present invention. The signalling may be displaying a message to the user on a computer display. According to an example of embodiment of the present invention comprising a digital camera, the initial check provides a feedback signal as a green light whenever the initial analysis
35 concludes with sufficient information. When the green light is not present the user may perform adjustments, for example changing camera position relative to the document the user at present is investigating, zooming into the image or moving the camera closer

to the paper, book etc., or just by turning the viewing angle of the camera. When the green light comes on, the image may be captured to be processed by an OCR program running in the camera itself, or in an attached computer receiving the image from the camera.

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According to the present example of embodiment, connected pixels are also measured to provide a ratio between area/height/width which must be higher than a lower threshold value, and below a higher threshold value. If said ratio is below said lower threshold, the pixels are regarded as noise or artefacts. If said ratio is above said higher
10 threshold value, the pixels are regarded as being non-text elements or artefacts. Any set of connected pixels not falling between said lower and higher threshold values are rejected from being part of the geometric transformation. According to an example of embodiment of the present invention, a table is created identifying locations of such rejected sets of connected pixels.

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Figure 1 illustrates an example of an image comprising an inclined word "city". Pixels constituting a character is a connected set of pixels as outlined above, wherein the connectivity is provided for example in a four-way direction as a north-south-west-east connected set of pixels (or up, down, left, right), or in an eight-way manner that in
20 addition to the north-south-west-east directions also comprise the diagonals. The denominations of directions are merely a convenient way of assigning different directions rather than being actual directions. However, directions related to a reference system based on the flat bed scanner platen for example, provide an orientation as north, south etc. or up, down etc. that is easily comprehended and easy to implement as
25 computer program routine. Based on these rules for connectivity, an analysing routine may be programmed, as known to a person skilled in the art, to provide an identification of connected pixels. In figure 1, the letter 'c' is a connected set of pixels using any rule of connectivity. The letter 'i' comprises two sets of connected pixels, the stem and the dot using any of the connectivity rules. The letters 't' and 'y' comprises two sets of
30 connected pixels when using the four-way rule, while they are one set of connected pixels when applying the eight-way rule. In figure 2 another example of connected pixels forming words are illustrated. Figure 2 also illustrates the problem sometimes encountered in OCR when deformations change the size of characters. According to an aspect of the present invention such changed character heights may be rejected by said
35 test of said ratio of area/height/width as described above. Figure 3 depicts an example of an image of text with a back ground making it difficult to distinguish pixels from the background. Whenever such situations arise, it may be signalled back to users,

providing adjustments for example of scanner parameters etc. that may improve the quality of the images to be processed.

When the initial analysis concludes that an image provides sufficient information to be
5 used in a geometrical transformation, according to the present invention, the image
under investigation is searched to identify possible text lines. According to an example
of embodiment the image is first searched to measure distances between connected
pixels. The distance is measured as a count of pixels or space between the connected
pixels. The search is performed in a plurality of directions. In the present example of
10 embodiment, the measured distances are assembled in a histogram where the x-axis
represent distance measured in pixels and the y-axis is the count of each measured
distance. Since any document comprising text provides a first distinct distance between
characters, and another second distinct distance between words, the histogram provides
to distinct columns representing the count of each of said distinct distances. In this
15 manner identified connected pixels may be interlinked or clustered in any direction
searched in the image to identify any identifiable collection or clustering of connected
pixels as being probable words based on said distinct distances. In an example of
embodiment of the present invention, locations of connected pixels being probable
words are listed in a table, one entry for each probable word. The locations listed in said
20 table may be compared with the list of rejected pixels identified in the initial analysis as
described above. Any pixels being listed as rejected is removed from said table. In this
manner the relationship between locations of characters listed in an entry in said table
representing a probable word provides a direction of the text line on the location on the
text line the present probable word is located, wherein said direction is relative to the
25 coordinate system used. As known to a person skilled in the art, the locations listed in
said table may be relative coordinates.

In yet another example of embodiment of the present invention, other parameters in
addition to distance characterising characters and words are used. For example, size of
30 connected pixels should also reflect that same characters in the same font set actually
have similar size. In this manner size and/or directions (i.e. height-width relationship of
characters) may be used to form homogeneity criteria providing a tool to further
increase the probable detection of words. In an example of embodiment of the present
invention, any known method of geometric sorting may be used to cluster connected
35 pixels, for example range searching algorithms. In yet another example of embodiment,
the relationship between height-width of clustered connected pixels is used to identify
the local text line direction for the probable word.

According to an aspect of the present invention, a word on a text line is probably followed by a next probable word spaced with said second distinct distance. By searching the image in a plurality of directions, following words apart from a selected
5 word with said second distinct distance, an example of embodiment of the present invention provides a listing of candidates that may be linked together to identify a text line.

In yet another embodiment of the present invention, other parameters in addition to
10 distance characterising words are used to identify said candidates. For example, the height-width relationship between clustered connected pixels may be sorted to identify probable long words providing a more probable identification of direction of said text lines.

15 According to an example of embodiment of the present invention, candidates linked to probable text lines are sorted and grouped to form text blocks based on their mutual distance and position in the image. According to the present example of embodiment, the consistency of the identified text lines are then investigated, for example by investigating if any text lines are crossing each other, or if that they are discontinuous.

20 Figure 4 illustrates text line tracking according to an example of embodiment of present invention. Based on the requirement that a font set provides similar height for connected pixels constituting characters, staff-lines interconnecting characters on a text line may be introduced. Intersections between staff-lines and connected pixels may provide
25 points in the image that may be used for the geometrical transformation. Such selected points are marked with crosses in figure 4.

Figure 5 illustrates an example of meshes for forward and inverse geometric morphing transformation according to an example of embodiment of present invention. The
30 morphing may be performed as known to a person skilled in the art. According to an aspect of the present invention, any type of transformation may be used.

Figure 6 depicts a flow diagram illustrating a preferred example of embodiment of the present invention in a computer program running in a computer system or in a processor
35 element comprised in a digital camera. An image 10 is communicated to a quality measuring module 14. The purpose of the quality measuring module is to provide an initial analysis of the image to assess if there is sufficient information in the image 10 to

perform the geometrical transformation according to the present invention, as described above. Parameters are stored in a storage location 15 providing a possibility to adjust parameters to improve the quality of the image 10, if necessary. The threshold module 11 receives parameters from the storage location 15 providing a bitmap 12 of the image 10 with reduced noise, as known to a person skilled in the art. The bitmap 12 is communicated to the module 13 providing an identification of connected pixels, as described above. Identified connected pixels are analysed and sorted in module 17. Module 19 identifies single connected pixels as words while module 16 is clustering connected pixels to probable words as described above. Output from module 16 and 19 are communicated to the module 18 providing a consistency check of words. Results from the consistency check is communicated back to the quality measuring module 14 resulting in a possible adjustment of parameters stored in the storage location 15. Words are communicated from module 18 to module 21 providing linking of words to candidate text-lines as described above. A consistency check may be performed in module 20 which communicates text-line candidates to document analysis module 23. On basis of the image 10, document analysis module 23 is providing for example staff-lines as described above in the image 10. An example of alternative embodiment provides a module 24 comprising a model description of text, for example based on knowledge about fonts that are used in the present image. The document analysis 23 provides text blocks 26 that is combined with document layout 22, where module 25 extracts the geometry in the image 10 that is used to identify transformation points 27, as described above. The actual transformation is performed in module 28 outputting the transformed image 29, which is communicated to an OCR program as known to a person skilled in the art.

According to the present invention, deformed text lines may be corrected to provide straight and parallel text lines providing more reliable recognition of text in OCR programs with no a priori knowledge of images, or by a priori geometrical modelling of deformations. A computer program executing the steps of a method according to the present invention may be incorporated in a standard OCR program running in a computer system or programmable device receiving images of documents from an attached scanner, or from a digital camera transferring said images to said computer system, for example via wire transfer, or via wireless communication such as Bluetooth, for example. According to another embodiment of the present invention, said method may be executed in a program or programmable device running in such a processor element comprised in said camera. According to yet another embodiment of the present invention, said method may be implemented as an ASIC (Application Specific

Integrated Circuit), as known to a person skilled in the art, in a digital camera or in any another type of equipment. Said digital camera may be implemented in a mobile telephone, or any other type of mobile wireless user equipment.

C l a i m s :

1.

Method for geometrical transformation of deformed image comprising text by searching
5 text-lines in said image, comprising the steps of:

- a) performing an initial analysis to evaluate if there is enough text-like structures in
said image to perform said transformation,
- 10 b) identify connected pixels probably forming characters, words and searching said
probable characters, words to identify transformation points related to text-lines,
staff-lines or similar elements constituting a direction of said text-lines,
- c) based on said transformation points, transforming the image or a part of an
15 image comprising text to an image where the text lines are straight and parallel.

2.

Method according to claim 1, wherein said step a) further comprising an analysis of
connected pixels to verify that said connected pixels are consistent in size, shape and
20 relative position with text.

3.

Method according to claim 1, wherein said step a) further comprising comparing heights
of connected pixels with a predefined threshold level identifying a minimum pixel
25 resolution of said image.

4.

Method according to claim 1, wherein said step a) further comprising measuring
connected pixels providing a ratio between area/height/width of each of said connected
30 pixels, and providing a comparison of said measured ratio with a predefined lower
threshold level and a higher threshold level, rejecting connected pixels having said ratio
outside the range defined by said lower and higher threshold levels.

5.

35 Method according to claim 1, wherein said step b) further comprising measuring
distances between connected pixels providing a first distinct distance related to spacing
between characters, and a second distinct distance related to spacing between words.

6.

Method according to claim 5, further comprising clustering connected pixels forming probable words based on said first and second distinct distances.

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7.

Method according to claim 6, further comprising clustering said connected pixels by geometric sorting.

10 8.

Method according to claim 5, further comprising identifying a direction of said text-lines based on said clustering of connected pixels reflecting the direction of a local text-line on a location on the text-line wherein said clustering of said connected pixels are located.

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9.

Method according to claim 8, further comprising sorting said local text line directions into text lines based on said second distinct distance spacing said words.

20 10.

Method according to claim 9, further comprising identifying long words by sorting height-width relationship between clustered connected pixels, and using said long words as basis for sorting said local text line directions.

25 11.

System implemented in a programmable computer system or device for geometrical transformation of deformed image comprising text, by searching text-lines in said image, comprising:

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d) a program module performing an initial analysis to evaluate if there is enough text-like structures in said image to perform said transformation,

e) a program module identify connected pixels probably forming characters, words and searching said probable characters, words to identify transformation points,

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- f) based on said transformation points, a program module is transforming the image or a part of an image comprising text to an image where the text lines are straight and parallel.

5 12.

System according to claim 11, wherein said module d) further comprises an analysis of connected pixels to verify that said connected pixels are consistent in size, shape and relative position with text.

10 13.

System according to claim 11, wherein said module d) further comprises comparing heights of connected pixels with a predefined threshold level identifying a minimum pixel resolution of said image.

15 14.

System according to claim 11, wherein said module d) further comprises measuring connected pixels providing a ratio between area/height/width of each of said connected pixels, and providing a comparison of said measured ratio with a predefined lower threshold level and a higher threshold level, rejecting connected pixels having said ratio
20 outside the range defined by said lower and higher threshold levels.

15.

System according to claim 11, wherein said module e) further comprises measuring distances between connected pixels providing a first distinct distance related to spacing
25 between characters, and a second distinct distance related to spacing between words.

16.

System according to claim 15, wherein said module further comprises clustering connected pixels forming probable words based on said first and second distinct
30 distances.

17.

System according to claim 16, wherein said module further comprises clustering said connected pixels by geometric sorting.

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18.

System according to claim 15, further comprising identifying a local text line direction based on said clustering of connected pixels reflecting the direction of said text line on a location on said text line wherein said clustering of said connected pixels are located.

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19.

System according to claim 18, wherein said module further comprises sorting said local text line directions into text lines based on said second distinct distance spacing said words.

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20.

System according to claim 19, wherein said module further comprises identifying long words by sorting height-width relationships between clustered connected pixels, and using said long words as basis for sorting said local text line directions.

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21.

System according to claim 11, wherein said module d) further comprises signaling users if said initial analysis concludes that said image comprise insufficient information.

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22.

Digital Camera comprising programmable device executing program for geometrical transformation of deformed image comprising text, by searching text-lines in said image, comprising:

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g) a program module performing an initial analysis to evaluate if there is enough text-like structures in said image to perform said transformation,

h) a program module identify connected pixels probably forming characters, words and searching said probable characters, words to identify transformation points,

30

i) based on said transformation points, a program module is transforming the image or a part of an image comprising text to an image where the text lines are straight and parallel.

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23.

Digital Camera according to claim 22, wherein said module g) further comprises an analysis of connected pixels to verify that said connected pixels are consistent in size, shape and relative position with text.

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24.

Digital Camera according to claim 22, wherein said module g) further comprises comparing heights of connected pixels with a predefined threshold level identifying a minimum pixel resolution of said image.

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25.

Digital Camera according to claim 22, wherein said module g) further comprises measuring connected pixels providing a ratio between area/height/width of each of said connected pixels, and providing a comparison of said measured ratio with a predefined lower threshold level and a higher threshold level, rejecting connected pixels having said ratio outside the range defined by said lower and higher threshold levels.

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26.

Digital Camera according to claim 22, wherein said module h) further comprises measuring distances between connected pixels providing a first distinct distance related to spacing between characters, and a second distinct distance related to spacing between words.

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27.

Digital Camera according to claim 26, wherein said module further comprises clustering connected pixels forming probable words based on said first and second distinct distances.

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28.

Digital Camera according to claim 27, wherein said module further comprises clustering said connected pixels by geometric sorting.

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29.

Digital Camera according to claim 26, further comprising identifying a local text line direction based on said clustering of connected pixels reflecting the direction of said text line on a location on said text line wherein said clustering of said connected pixels
5 are located.

30.

Digital Camera according to claim 29, wherein said module further comprises sorting said local text line directions into text lines based on said second distinct distance
10 spacing said words.

31.

Digital Camera according to claim 30, wherein said module further comprises identifying long words by sorting height-width relationships between clustered
15 connected pixels, and using said long words as basis for sorting said local text line directions.

32.

Digital Camera according to claim 11, wherein said module g) further comprises
20 signaling users if said initial analysis concludes that said image comprise insufficient information.

33.

ASIC (Application Specific Integrated Circuit) comprising electronic circuit means for
25 geometrical transformation of deformed image comprising text, by searching text-lines in said image, comprising:

- j) electronic circuit means performing an initial analysis to evaluate if there is enough text-like structures in said image to perform said transformation,
30
- k) electronic circuit means identifying connected pixels probably forming characters, words and searching said probable characters, words to identify transformation points,
- 35 l) based on said transformation points, electronic circuit means is transforming the image or a part of an image comprising text to an image where the text lines are straight and parallel.

34.

ASIC according to claim 33, wherein said electronic circuit means j) further comprises an analysis of connected pixels to verify that said connected pixels are consistent in
5 size, shape and relative position with text.

35.

ASIC according to claim 33, wherein said electronic circuit means j) further comprises comparing heights of connected pixels with a predefined threshold level identifying a
10 minimum pixel resolution of said image.

36.

ASIC according to claim 33, wherein said electronic circuit means j) further comprises measuring connected pixels providing a ratio between area/height/width of each of said
15 connected pixels, and providing a comparison of said measured ratio with a predefined lower threshold level and a higher threshold level, rejecting connected pixels having said ratio outside the range defined by said lower and higher threshold levels.

37.

20 ASIC according to claim 33, wherein said electronic circuit means k) further comprises measuring distances between connected pixels providing a first distinct distance related to spacing between characters, and a second distinct distance related to spacing between words.

25 38.

ASIC according to claim 37, wherein said electronic circuit means further comprises clustering connected pixels forming probable words based on said first and second distinct distances.

30 39.

ASIC according to claim 38, wherein said electronic circuit means further comprises clustering said connected pixels by geometric sorting.

40.

35 ASIC according to claim 37, wherein said electronic circuit means further comprises identifying a local text line direction based on said clustering of connected pixels

reflecting the direction of said text line on a location on said text line wherein said clustering of said connected pixels are located.

41.

- 5 ASIC according to claim 40, wherein said electronic circuit means further comprises sorting said local text line directions into text lines based on said second distinct distance spacing said words.

42.

- 10 ASIC according to claim 41, wherein said electronic circuit means further comprises identifying long words by sorting height-width relationships between clustered connected pixels, and using said long words as basis for sorting said local text line directions.

15 43.

ASIC according to claim 33, wherein said electronic circuit means j) further comprises signaling users if said initial analysis concludes that said image comprise insufficient information.

20 44.

Mobile wireless user equipment comprising said Digital Camera according to claim 22 to 32.

45.

- 25 Optical Character Recognition System comprising said method according to claim 1 to 10.

46.

- Optical Character Recognition System comprising said system according to claim 11 to 30 21.

47.

Optical Character Recognition System comprising said ASIC according to claim 33 to 43.