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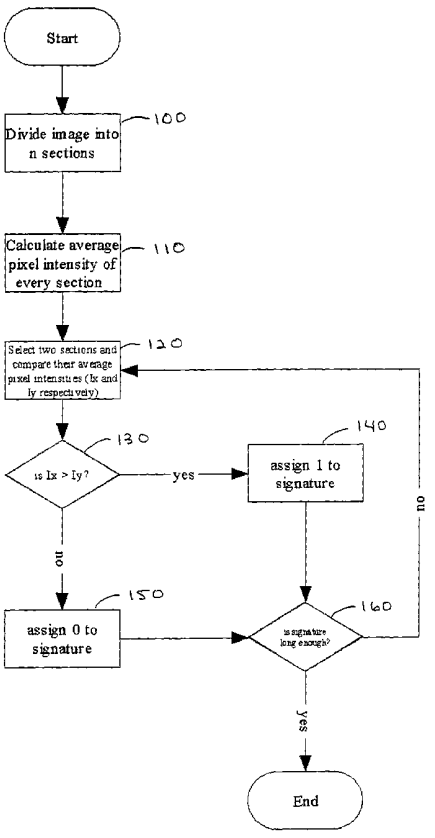
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(54) Title: METHOD FOR INDEXING, SEARCHING FOR, AND RETRIEVING IMAGES ON A COMPUTER



(57) Abstract: A method for indexing a digital image is disclosed. The image is divided into sections, the average pixel intensity of each section is determined, the average pixel intensity of each section is compared to the average pixel intensity of at least one other section, and a numerical identifier or signature is established. Also disclosed is a method of searching for an image on a computer. The signature for the image to be searched for is established, which includes allowing for a specified tolerance as sections of the image are compared. The signature of the image to be searched for is then compared to signatures of other images. An image is a match if the signatures are identical, within a specified tolerance.

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METHOD FOR INDEXING, SEARCHING FOR, AND RETRIEVING IMAGES ON A COMPUTER

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CROSS-REFERENCE TO RELATED APPLICATION

The present application claims the benefit of U. S. provisional patent application no. 60/227,870, filed on August 25, 2000, and entitled "Method and System for Searching for and Retrieving Images on a Computer," which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to methods for indexing, searching for, and retrieving digital images on a computer, including images contained on the Internet.

2. Description of Related Art

Most currently available methods for indexing and searching for images on a computer, including on the Internet, rely on text and are not image-based; they require a text-based query. The methods for conducting image-based searches that are available rely upon attributes of an image such as color and contour and are not narrowly tailored. Thus, the existing methods are cumbersome, time-consuming, and space-intensive, and they often turn up images that are not relevant and may miss images that are being sought. As such, existing methods are not

comprehensive or thorough. Accordingly, there is a need for a method of indexing and searching for digital images which is image-based and is quicker and more accurate than the existing methods.

SUMMARY OF THE INVENTION

The present invention includes a method for indexing a digital image by establishing a numerical identifier for the image.

An image is divided into a number of sections. The average pixel intensity of each section is determined. The average pixel intensities of two sections are compared, and it is determined whether the first section is greater than the second section. Depending on the outcome, the bit is assigned to a "1" or a "0." The comparisons are repeated until the average pixel intensity of each section has been sequentially and separately compared to the average pixel intensity of at least one other section, assigning the bit consistently. An identifier or signature consisting of a series of all of the bits is established. The bits are stored as a long.

The invention also includes a method for searching for an image on a computer. In this method, a target signature is established for an image to be searched, where an indicator, instead of a "1" or a "0," is assigned if the intensities are within a specified tolerance. Then the target signature is compared to a database of signatures for other images and locations of the images. The indicators are treated as both a "1" and a "0" for the comparison. A match is determined if a signature is identical to the target signature, where each indicator is treated as

both a "1" and a "0." The method for searching can also be performed without utilizing an existing database.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flowchart of the steps of the method for establishing a signature for an image.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention includes a method for indexing a digital image, i.e., establishing a "signature" or numerical identifier for the image. Using the method, a database or index may be created that contains at least one signature for an image. The invention also includes a method for searching for an image on a computer where the image to be searched for has been given a signature. The invention can declare two images to be identical if they appear to be the same to the human eye.

Fig. 1 is a flowchart of the steps of the method for establishing a signature for an image. The method can be used for many types of images, including graphics, photographs, and streaming media. The images may be in color or black and white, and need not be of the highest quality. (In a preliminary step, if the image is in color, it is converted to black and white). In step 100, the image is divided into a number of sections, where the number of sections is "n." This may be satisfactorily done using a grid, such as an 8 by 8 grid having 64 squares. Other

ways of sectioning and other sizes of grids will work as well, including using sections that are not formed by a grid or that are overlapping.

In step 110, for each section, the average pixel intensity ("I") of the portion of the image falling within that section is determined.

In step 120, two sections, "x" and "y," are selected, and the average pixel intensity of the portion of the image contained in section "x" is compared to the average pixel intensity of the portion of the image contained in section "y." If, in step 130, the average pixel intensity of "x" is greater than the average pixel intensity of "y," then, in step 140, the bit is assigned to a "1." If, in step 130, the average pixel intensity of "x" is not greater than the average pixel intensity of "y," then, in step 150, the bit is assigned to a "0." The method can work just as well if the assignment of bits is reversed; i.e., if the average pixel intensity of "x" is greater than the average pixel intensity of "y," the bit is assigned to "0," and if the average pixel intensity of "x" is not greater than the average pixel intensity of "y," the bit is assigned to "1." The bits must be assigned in a consistent manner, however, such that all comparisons for all images are done in the same way.

If, in step 160, it is determined that the signature, or number of bits, is long enough, then the process is complete. If, in step 160, it is determined that the signature is not long enough, then the process is repeated from step 120, until the average pixel intensity of each section has been sequentially and separately compared to the average pixel intensity of at least one other section. The length

of the signature is selected in advance and must be at least as long as one-half of the number of sections n. For example, if the grid consists of 64 squares, and each square is compared to two other squares, then the signature will consist of 64 bits, a series of 64 ones and zeroes. If the grid consists of 16 sections and each section is compared to one other section, then the signature will consist of eight bits. The bits are stored as a long.

The selection, in step 120, of the two sections to be compared is preferably conducted in a random (but consistent for all images) fashion. For example, "x" would be section 1 and "y" would be section 47, then "x" would be section 47 and "y" would be section 12, and so forth until the average pixel intensity of each section has been separately compared to the average pixel intensities of two other sections. Thus, section 47 has been compared to section 1 and to section 12. Alternatively, the selection of the sections to be compared can be conducted in a numerical fashion such that adjacent sections are compared. For example, "x" would be section 1 and "y" would be section 2, then "x" would be section 2 and "y" would be section 3, and so on. Thus, section 2 has been compared to section 1 and to section 3.

It is preferable to compare each section to two other sections as shown in the above two examples; however, a comparison to one other section, three other sections, or any other number of sections will also work. For example, if each section is compared to one other section, and adjacent sections are selected, the

comparisons would be: section 1 to section 2, section 3 to section 4, section 5 to section 6, and so forth. If the selection of the sections to be compared is done randomly, the comparisons would be, for example: section 1 to section 47, section 12 to section 50, section 24 to section 7, and so forth.

The method of the invention can be used to create a database containing the signatures of multiple images. Such a database can also include the locations where each image can be found. The database could be organized by the signature, but may be organized in other fashions as well.

The invention also includes a method for a user to conduct a search for an image on a computer. The image to be searched for may be obtained from a number of different sources, including the Internet or any other computer on a network, scanned into a computer, taken from a CD, diskette, or digital camera, or any other means by which an image can be imported into a computer. In addition, if the image to be searched for is on a network, such as the Internet, it need not be saved, but can be searched for by using its location information (e.g., URL). A search can be done using an existing database containing signatures of images and the locations of the images or without using an existing database.

The following are the steps to conduct a search for an image utilizing a database with signatures of images and the locations of the images. In the first step, the user inputs the image to be searched, called the target image. In the second step, the target image is given a signature as described above, except that,

for all comparisons of the average pixel intensities of two sections, if the intensities are within a specified tolerance, an indicator, for example, an "*," is assigned, instead of a "1" or "0." Thus, the signature for the target image, called the target signature, may include indicators, as well as ones and zeros. In the third step, the target signature is compared to the database of signatures and locations. The comparison is preferably performed using a brute force search through the database. Any indicators in the target signature are treated as both a "1" and a "0," allowing for more matching. A signature is determined to be a "match" to the target signature if it is identical to the target signature, where each indicator is treated as both a "1" and a "0."

A search may also be conducted without using an existing database, instead utilizing a crawler or "bot" that searches a computer or computers for images. The computer may be a local computer not connected to a network or a computer connected to a network, such as the Internet, an intranet, or other type of network. In that case, the bot compares the target signature to the signature of each image it encounters as it crawls through the network.

The method also includes providing a specified tolerance for the search which can be preset or selected by the user. In other words, the search may be limited to images having signatures within a certain tolerance (degree of difference) of the target signature. For example, if the search is set for ten percent tolerance, it will return only images having signatures that are ten percent or less different

from the target signature, and the results of the search will only include those images. The search can also be limited to a minimum number of results (either preset or set by the user). In that case, if the minimum number of results is not obtained at a certain tolerance, the tolerance will increase until the minimum number of results is obtained.

The results of the search may be presented, as a list, by location, of the signatures in the database that match the target signature. Thus, these signatures identify the images that match the target image. The list of matching images is preferably shown in decreasing order of similarity, such that the closest match is listed first. The user may then locate any of the matched images by its location information (e.g., for an image on the Internet, by its URL).

The invention has been described above with reference to the preferred embodiments. Those skilled in the art may envision other embodiments and variations of the invention that fall within the scope of the claims.

CLAIMS

What is claimed is:

1. A method for indexing a digital image, comprising:

dividing a digital image into a plurality of sections;

determining, for each of said sections, the average pixel intensity of the portion of the image contained within said section;

selecting a first of said plurality of sections and a second of said plurality of sections, wherein said second section is different from said first section;

comparing the average pixel intensity of said first section to the average pixel intensity of said second section,

and further, if the average pixel intensity of said first section is greater than the average pixel intensity of said second section, assigning the bit to a "1," and if the average pixel intensity of said first section is not greater than the average pixel intensity of said second section, assigning the bit to a "0";

repeating said selecting, comparing, and assigning until each of said plurality of sections has been compared separately to at least one other of said plurality of sections, wherein, for all comparisons, the bit is assigned to a "1" if the average pixel intensity of said

first section is greater than the average pixel intensity of said second section, and the bit is assigned to a "0" if the average pixel intensity of said first section is not greater than the average pixel intensity of said second section; and

establishing an identifier for the image consisting of a series of all of said assigned bits.

2. The method of Claim 1, wherein said selecting of said first and said second sections is conducted randomly from said plurality of sections.

3. The method of Claim 1, wherein said selecting, comparing and, assigning is repeated until each of said plurality of sections has been compared separately to two other of said sections.

4. The method of Claim 1, further comprising storing the bits as a long.

5. A method for indexing a digital image, comprising:

dividing a digital image into a plurality of sections;

determining, for each of said sections, the average pixel intensity of the portion of the image contained within said section;

selecting a first of said plurality of sections and a second of said plurality of sections, wherein said second section is different from said first section;

comparing the average pixel intensity of said first section to the average pixel intensity of said second section,

and further, if the average pixel intensity of said first section is greater than the average pixel intensity of said second section, assigning the bit to a "0," and if the average pixel intensity of said first section is not greater than the average pixel intensity of said second section, assigning the bit to a "1";

repeating said selecting, comparing, and assigning until each of said plurality of sections has been compared separately to at least one other of said plurality of sections, wherein, for all comparisons, the bit is assigned to a "0" if the average pixel intensity of said first section is greater than the average pixel intensity of said second section, and the bit is assigned to a "1" if the average pixel intensity of said first section is not greater than the average pixel intensity of said second section; and,

establishing an identifier for the image consisting of a series of all of said assigned bits.

6. A method for establishing an identifier for a digital image, comprising:

dividing a digital image into a plurality of sections;

determining, for each of said sections, the average pixel intensity of the portion of the image contained within said section;

selecting a first of said plurality of sections and a second of said plurality of sections, wherein said second section is different from said first section;

comparing the average pixel intensity of said first section to the average pixel intensity of said second section,

and further, if the average pixel intensity of said first section is greater than the average pixel intensity of said second section, assigning the bit to a "1," and if the average pixel intensity of said first section is not greater than the average pixel intensity of said second section, assigning the bit to a "0";

repeating said selecting, comparing, and assigning until each of said plurality of sections has been compared separately to at least one other of said plurality of sections, wherein, for all comparisons, the bit is assigned to a "1" if the average pixel intensity of said first section is greater than the average pixel intensity of said second section, and the bit is assigned to a "0" if the average pixel intensity of said first section is not greater than the average pixel intensity of said second section; and,

creating an identifier for the image consisting of a series of all of said assigned bits.

7. A method for establishing an identifier for a digital image, comprising:

dividing a digital image into a plurality of sections;

determining, for each of said sections, the average pixel intensity of the portion of the image contained within said section;

selecting a first of said plurality of sections and a second of said plurality of sections, wherein said second section is different from said first section;

comparing the average pixel intensity of said first section to the average pixel intensity of said second section,

and further, if the average pixel intensity of said first section is greater than the average pixel intensity of said second section, assigning the bit to a "0," and if the average pixel intensity of said first section is not greater than the average pixel intensity of said second section, assigning the bit to a "1";

repeating said selecting, comparing, and assigning until each of said plurality of sections has been compared separately to at least one other of said plurality of sections, wherein, for all comparisons, the bit is assigned to a "0" if the average pixel intensity of said first section is greater than the average pixel intensity of said second section, and the bit is assigned to a "1" if the average pixel

intensity of said first section is not greater than the average pixel intensity of said second section; and,

creating an identifier for the image consisting of a series of all of said assigned bits.

8. A computerized method for identifying matches between a target image to be searched for and other images, comprising:

establishing a target identifier for a target image to be searched, using the method of Claim 1, wherein said comparing and assigning further includes assigning an indicator, instead of a bit, if the average pixel intensity of said first section is within a specified tolerance of the average pixel intensity of said second section, and further, wherein said target identifier consists of a series of all of said assigned bits and said indicators;

comparing said target identifier to a database containing the identifiers of images and the locations of said images, wherein said identifiers were established using the method of Claim 1; and,

determining whether any of said identifiers in said database are identical to said target identifier, wherein said indicator is treated as both a "1" and a "0."

9. A method for searching for an image on a computer, comprising:

establishing a target identifier for a target image to be searched, using the method of Claim 1, wherein said comparing and assigning further includes assigning an indicator, instead of a bit, if the average pixel intensity of said first section is within a specified tolerance of the average pixel intensity of said second section, and further, wherein said target identifier consists of a series of all of said assigned bits and said indicators;

comparing said target identifier to a database containing the identifiers of images and the locations of said images, wherein said identifiers were established using the method of Claim 1; and,

determining whether any of said identifiers in said database are identical to said target identifier, wherein said indicator is treated as both a "1" and a "0."

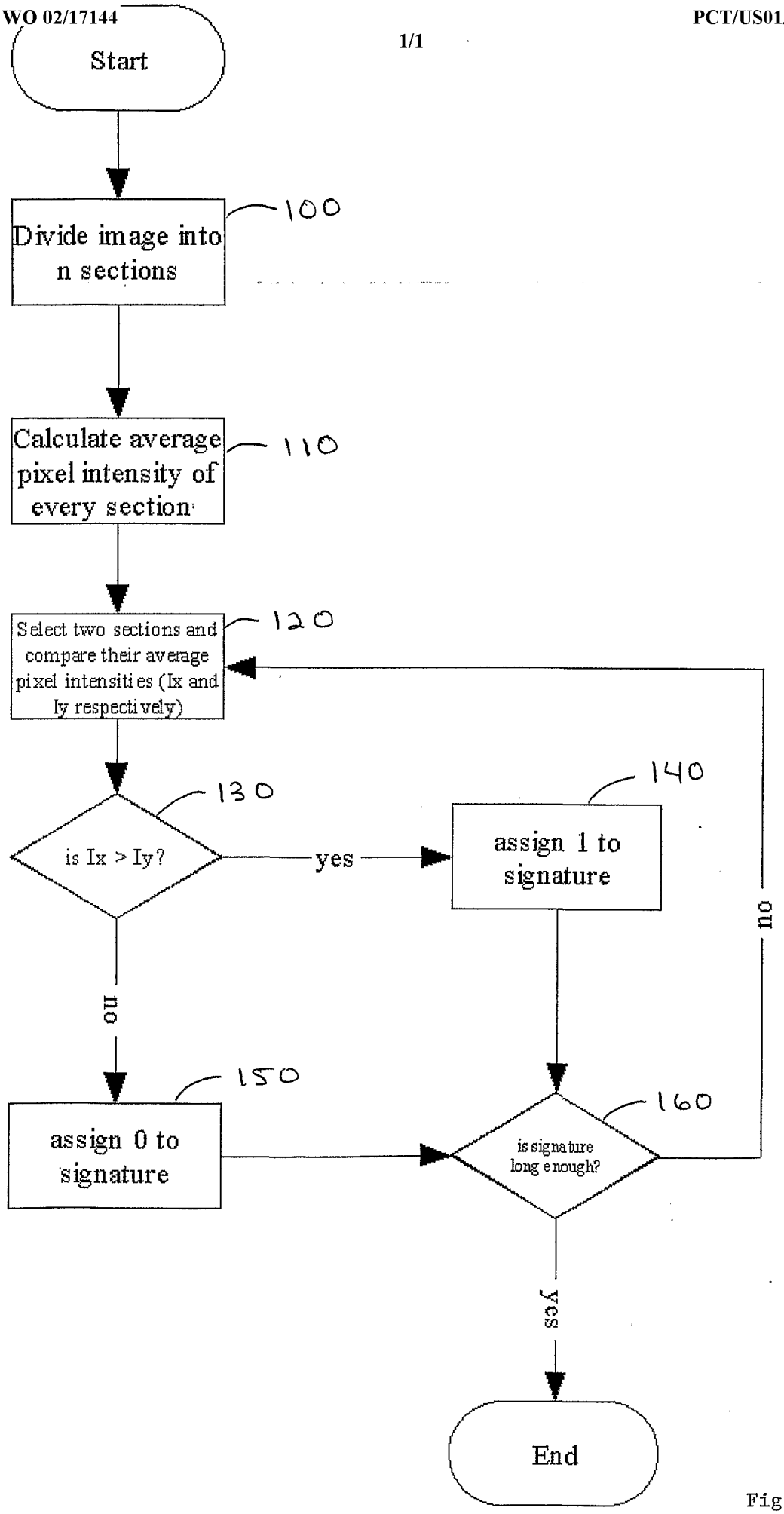

Start
Divide image into n sections
100
Calculate average pixel intensity of every section
110
Select two sections and compare their average pixel intensities (Ix and Iy respectively)
120
is Ix > Iy?
130
yes
assign 1 to signature
140
no
assign 0 to signature
150
is signature long enough?
160
no
yes
End

Fig. 1