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(71) Applicant (for all designated States except US):
CELLAVISION AB [SE/SE]; Forskningsbyn Ideon, S-223 70 Lund (SE).
(72) Inventors; and
(74) Agent: AWAPATENT AB; Box 5117, S-200 71 Malmö (SE).
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(54) Title: MICROSCOPE AND METHOD FOR COMPRESSING AND STORING OF DIGITAL IMAGES

(57) Abstract: A microscope comprises an object holder (2), optics (4) which in an image plane forms an image of an object (1) which is placed in the object holder (2), and an image sensor (5) for recording the image. The microscope further comprises a storage means (11), a calculation means (8) which is connected to the image sensor (5) and has an input for input data in the form of a mask, which defines at least one area (16) of the image that is to be stored in a lossless manner. The calculation means (8) is adapted to store in a lossless manner in the storage means (11) those parts of the image that are defined by the mask, to compress at least the remaining parts of the image using a compression algorithm which yields losses, and to store the compressed image and the mask in the storage means (11).
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MICROSCOPE AND METHOD FOR COMPRESSING AND STORING OF DIGITAL IMAGES

Field of the Invention

The present invention relates to a microscope and a method therefor, regarding storing of images of biological preparations taken with the microscope.

Background Art

When studying biological preparations in a microscope, it is desirable to store images of the preparation for subsequent studies and for comparisons with other images taken with a microscope. This is desirable particularly when images of the biological preparation are taken with different focusing to get a conception of the appearance of the preparation in three dimensions.

Especially when leukocytes (white blood corpuscles) are to be studied, it is frequently desirable to record large series of images with up to 1000 images in one series. If images in the size of 182x182 pixels are recorded in three colours at 28 different intensity levels for each colour, a 295 MB storage space is required for 1000 images. This means that extraordinarily large storage spaces are required to be able to store a large number of series of images.

It is well known in image processing to use compression algorithms to reduce the data quantity in storing. However, it is not possible to use compression algorithms which yield losses since important information in the image may then be lost. If lossless compression algorithms are used, the gain in the storage space will not be particularly great.

There is thus a need for a microscope and a method therefor, in which it is possible to store a large number of images without information being lost and without necessitating a large storage space.
Summary of the Invention

An object of the present invention is to provide a microscope which can record a large number of images of biological material without important details in the image being lost and without necessitating large storage spaces.

A further object of the present invention is to provide a method for a microscope, which allows a large number of images of biological material to be stored in a storage means.

These objects are achieved by a microscope and a method according to the appended claims.

A basic idea of the invention was to implement compression algorithms in a microscope, which is provided with an image sensor and a storage means.

By biological material is in the present invention meant cells from plants or animals. In the first place, tissue from human beings and in particular white blood corpuscles are intended.

A microscope according to the invention comprises an object holder, optics which in an image plane forms an image of an object placed in the object holder, and an image sensor for recording the image. The microscope is characterised in that it further comprises a storage means, and a calculation means, which is connected to the image sensor and has an input for input data in the form of a mask, which defines at least one area of the image that is to be stored in a lossless manner. The calculation means is adapted to store in the storage means in a lossless manner those parts of the image which are defined by the mask, to compress at least the remaining parts of the image using a compression algorithm which yields losses, and to store the compressed image and the mask in the storage means.

The form of the areas defined by the mask is arbitrary.
According to a preferred embodiment, the calculation means is adapted to compress the entire recorded image using the compression algorithm which yields losses, to calculate the difference between the compressed image and the recorded image at least in the areas defined by the mask, and to store in a lossless manner the calculated difference in the storage means. As a result, the areas defined by the mask have been stored in a lossless manner and can easily be reproduced from the compressed image and the calculated difference. An advantage of storing the entire recorded image using the compression algorithm is that the compression algorithm can be selected more freely and that it is possible to easily study the recorded image only by unpacking the compressed image.

According to a less preferred embodiment, the calculation means is adapted to store in a lossless manner those parts of the image which are defined by the mask, in the storage means while the remaining parts of the image are compressed using a compression method which yields losses. A drawback of such a microscope is that it is not possible to easily study the entire image without combining two partial images. This also makes the storage somewhat more complicated.

A method for storing a microscope image of a biological preparation comprises according to the invention the step of recording the image by means of an image sensor. The method is characterised in that it also comprises the steps of providing a mask which defines at least one area of the image which is to be stored in a lossless manner, to store in a lossless manner those parts of the image which are defined by the mask, in a storage means, compressing at least the remaining parts of the image using a compression algorithm which yields losses, and storing the compressed image and the mask in a storage means.

By the calculation means being provided with an input for input data in the form of a mask which defines
areas that are to be stored in a lossless manner, a higher compression degree of the remaining areas is permitted. The compression algorithm used to compress the image can be an algorithm in which some information will be lost but which allows a higher compression degree. By calculating the difference between the compressed image and the recorded image, the recorded image can be obtained without losses in the areas that are to be stored in a lossless manner starting from the compressed image. The calculated difference, the mask and the compressed image together take up a considerably smaller space than the recorded image.

Preferably, the entire image is compressed using a first compression algorithm which yields losses while the calculated difference is compressed using a second lossless compression algorithm before it is stored in the storage means, which makes the required storage space still smaller. The lossless compression algorithm can be, for example, Huffman coding.

There are several possibilities of providing the mask which defines those parts of the image which are to be stored in a lossless manner. It is preferred for the microscope to comprise also a recognition means which recognises the structures in the object which are to be stored in a lossless manner, and which is adapted to define the mask. Alternatively, the mask can be defined manually by a user of the microscope when studying the recorded image.

It is desirable that the first compression algorithm used to compress the entire image be such that a viewer of the image conceives it as corresponding with the recorded image. An example of a suitable compression algorithm that satisfies this desideratum is the one defined by JPEG (Joint Photographic Expert Group). By selecting the JPEG algorithm in the compression, an image which still has all details in the relevant areas and which is recognisable in the remaining areas will be
obtained by means of the compressed image, the mask and
the calculated difference. It is possible to select the
desired compression degree in JPEG images. A person
skilled in the art easily realises in the light of the
invention which compression degree is suitable for use of
a small space in the storage means while at the same time
the image will be recognisable. In the JPEG format, there
is also space for inserting the calculated differences
between the compressed image and the recorded image. This
gives the advantage that it will be possible to easily
study the image without making corrections with regard to
the differences that exist between the recorded image and
the compressed image.

It is frequently desirable to record two or more
images of the same area of an object taken with different
focusing to obtain images which give a conception of the
appearance of the object in three dimensions. According
to one aspect, one of the images, corresponding to one
focusing, is selected to be the reference image. Then the
remaining images are translated in relation to the refer-
ence image so as to minimise the difference between the
reference image and the remaining images. The difference
between the reference image and another image can be
defined as the sum of the squares of the difference in
intensity value between each one of the pixels in the
reference image and the corresponding pixel in the other
image. After translation, each image is processed in the
manner described above.

It goes without saying that the above features can
be combined in the same embodiment.

With a view to further elucidating the invention,
detailed embodiments of the invention will be described
below without, however, the invention being considered to
be restricted thereto.

**Brief Description of the Drawings**

Fig. 1 is a schematic view of a microscope according
to a preferred embodiment of the present invention.
Fig. 2 schematically illustrates images recorded by means of a microscope set with three different focuses. Fig. 3 is a flow chart which describes the function of a microscope according to a preferred embodiment of the invention.

**Detailed Description of the Invention**

Fig. 1 shows a microscope according to a preferred embodiment of the present invention. An object 1 is placed on an object holder 2 and illuminated from below by a source of light 3 which in this case is a bulb. An objective 4 produces an image of the object 1 on the surface of a CCD 5. The CCD has a number of sensor elements 6 which are distributed over the surface of the CCD at a mutual centre distance d. The CCD is connected to a calculation means 7 which in this case is a computer 8 having a display 9 and an input means in the form of a keyboard and a mouse 10.

A user of the microscope initiates that an image of the object 1 is recorded. The image is recorded after the user has set the focus at the desired depth in the object 1 either manually or with the aid of the input means 10. The object 1 is, for example, a specimen of leukocytes which is to be studied in the microscope. The recorded image is input into the computer 8 and processed therein before it is stored in a storage means 11, which in this case is a hard disk. The processing of the image results in the image taking up a smaller space in the storage means 11 while at the same time no essential information is lost.

Fig. 2 shows images 12, 13, 14 which have been recorded by the CCD 5. The images 12, 13, 14 have been recorded with the objective 4 in different vertical positions for focusing at different depths in the object 1. A preferred embodiment of the invention will be described in detail starting from the image 12. The image 12 contains images of five leukocytes 15 which are encompassed by frames 16.
With reference to Fig. 1 as well as Fig. 2, the image 12 is recorded by the CCD 5 and transferred to the computer 8. In the recorded image 12, there are images of leukocytes 15 which are to be examined later. When storing the image 12, it is essential that no information about the leukocytes be lost. According to the preferred embodiment, the computer 8 is equipped with a recognition means 21 which is adapted to recognise the leukocytes 15 and define areas 16 which encompass the entire leukocyte 15. The areas 16 form a mask which defines the areas that are to be stored in a lossless manner in the storage means 11.

Fig. 3 shows a flow chart of how recording and storage of the microscope image occur. An image is recorded by the CCD 5 and is transferred to the computer 8. In step 17, the computer defines a mask by defining rectangular areas 16 by which the leukocytes are completely encompassed. In step 18, a JPEG compressed image of the image 12 is calculated. In step 19, the difference between the recorded image and the compressed image within areas that are defined by the mask is calculated. The difference calculated in step 19 is compressed in step 20 using a lossless compression algorithm, such as Huffman coding. Subsequently the compressed image, the compressed calculated difference and the mask are stored in the storage means 11. The compressed image, the compressed calculated difference and the mask take up a considerably smaller space in the storage means 11 compared with the non-compressed image. JPEG is a compression algorithm where some information is lost, but owing to the fact that the difference between the compressed and the actual image has been stored, the original information can be reproduced from the compressed image within the areas defined by the mask 16.

Fig. 2 shows three images taken with the focus set at three different depths in the object 1. When displacing in depth, the image will be somewhat displaced on the
CCD, which means that the images 12, 13, 14 need be displaced somewhat in relation to each other to reflect a correct three-dimensional image. When recording images with three different focusings, two of the images are therefore displaced in relation to the third which is called the reference image. Image 12 is selected as reference image and images 13 and 14 are displaced in relation thereto in order to minimise differences between the images. First, image 13 is displaced relative to image 12 so that the sum of the squares of the difference in intensity value between each of the pixels in image 12 and the corresponding pixel in image 13 will be minimised. Image 14 is correspondingly displaced so that the differences between image 12 and image 14 will be minimised. Thus, the entire image 13 and the entire image 14 will be displaced in relation to image 12. After adjustment of the images relative to each other, each of the images is processed according to the flow chart in Fig. 3. It is of course possible to use the described method also in the case where only two images have been recorded with different focusing.

If the images recorded by the CCD are colour images, the images will suitably be divided into their colour components before being processed according to the flow chart as from step 17 in Fig. 3.

A person skilled in the art realises that the invention is not restricted to the embodiment here shown and that many modifications are feasible within the scope of the invention. For example, the compression algorithm that is used to compress the entire image can be some other compression algorithm that produces a recognisable compressed image. The image sensor can be of an optional type, for example, a vidicon.
CLAIMS

1. A microscope comprising
   an object holder (2),
   optics (4) which in an image plane forms an image
   of an object (1) placed in the object holder (2),
   an image sensor (5) for recording the image,
   characterised in that the microscope further
   comprises
   a storage means (11), and
   a calculation means (8), which is connected to the
   image sensor (5) and has an input for input data in the
   form of a mask, which defines at least one area (16) of
   the image which is to be stored in a lossless manner, the
   calculation means (8) being adapted
   to store in the storage means (11) in a lossless
   manner those parts of the image which are defined by the
   mask,
   to compress at least the remaining parts of the
   image using a compression algorithm which yields losses,
   and
   to store the compressed image and the mask in the
   storage means (11).

2. A microscope as claimed in claim 1, characterised in that the calculation means is adapted
   to compress the entire recorded image using the compression algorithm which yields losses,
   to calculate the difference between the compressed
   image and the recorded image (12, 13, 14) at least in the
   areas (16) defined by the mask, and
   to store in a lossless manner the calculated difference in the storage means (11).

3. A microscope as claimed in claim 2, characterised in that the calculation means (8) is
   adapted
to compress the entire recorded image using a first compression algorithm which yields losses, and
to compress, using a lossless second compression algorithm, the calculated difference between the recorded image and the compressed image and subsequently store the compressed, calculated difference in the storage means (11).

4. A microscope as claimed in claim 3, characterised in that the second compression algorithm is Huffman coding.

5. A microscope as claimed in any one of the preceding claims, characterised in that it also comprises a recognition means, which recognises the structures in the object which are to be stored in a lossless manner, and which is adapted to define the mask.

6. A microscope as claimed in any one of the preceding claims, characterised in that the compression algorithm which yields losses satisfies the requirements in respect of the compression algorithm JPEG defined by Joint Photographic Expert Group.

7. A microscope as claimed in any one of the preceding claims, characterised in that it is adapted to record a plurality of images (12, 13, 14) with different focusing, to select one of the images as reference image, and then translate the remaining images in relation to the reference image, thereby minimising the difference between the reference image and the remaining images.

8. A method for storing a microscope image of a biological preparation, comprising the step of recording an image using an image sensor (5), characterised in that it comprises the further steps of supplying a mask which defines at least one area (16) of the image which is to be stored in a lossless manner,
storing in a lossless manner those parts of the image that are defined by the mask, in a storage means (11),

compressing at least the remaining parts of the image using a compression algorithm which yields losses, and

storing the compressed image and the mask in a storage means (11).

9. A method as claimed in claim 8, characterized in that it comprises the further steps of

compressing the entire recorded image using the compression algorithm,

calculating the difference between the compressed image and the recorded image within the areas that are defined by the mask, and

storing in a lossless manner the calculated difference in the storage means (11).

10. A method as claimed in claim 9, characterized in that it comprises the further steps of

comparing the image with a known pattern,

defining at least one area which covers those parts of the image that correspond with the pattern, and

defining the mask in correspondence with said at least one area.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G02B 21/00, H04N 7/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04N, G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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Further documents are listed in the continuation of Box C. See patent family annex.

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Authorized officer: Patrik Blidefalk/AE

Telephone No.: +46 8 782 25 00

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