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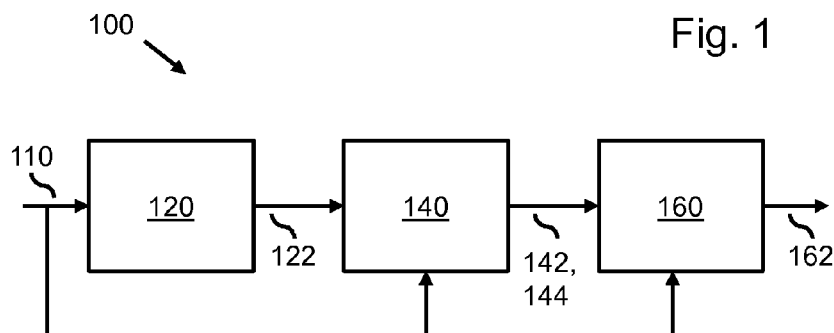
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(54) Title: LABELING A CERVICAL IMAGE



(57) Abstract: System (100) for labeling a cervical image (110) obtained during a colposcopy of a patient, the system comprising: a detector (120) for detecting a cervical region (122) in the cervical image; an analyzer (140) for i) calculating an image characteristic of the cervical region (122), the image characteristic being indicative of a use of a technique for improving a visibility of lesions in the cervical region, and ii) analyzing the image characteristic to determine whether the technique was used in obtaining the cervical image (110), thereby obtaining a determined use (142); and a labeler (160) for labeling the cervical image (110) based on the determined use (142).

Labeling a cervical image

## **FIELD OF THE INVENTION**

The invention relates to a system and a method for labeling a cervical image obtained during a colposcopy of a patient. The invention further relates to a workstation, an imaging system and a colposcope comprising the system. The invention further relates to a computer program product for causing a processor system to perform the method.

Colposcopy is a medical diagnostic technique for examining the cervix and adjoining regions for cervical cancer and other medical conditions. Cervical cancer is a leading cause of cancer for women in India and other developing nations. A colposcopy typically comprises applying staining agents such as acetic acid and Lugol's iodine solution to the cervical region to improve the visibility of lesions. Following this, the cervical region is examined under a microscope while illuminating the cervical region. Precancerous and malignant areas either show as having specific vascular patterns in a cervical image or turning aceto-white and back in a transient manner over a series of cervical images, e.g., in a video. Such characteristics are a cue for an immediate biopsy of such areas.

## **BACKGROUND OF THE INVENTION**

Various systems are known for automatically analyzing cervical images.

For example, US 2009/0046905 A1 describes a Computer-Aided-Diagnosis (CAD) system for cervical cancer screening. The system automatically analyzes data acquired from the uterine cervix and provides tissue and patient diagnosis, as well as adequacy of the examination. It is said that CAD system is designed for multi-data (different moments in time, different contrast agents like acetic acid, Lugol's iodine, etc.). The CAD system employs feature extraction to extract colposcopic features including: anatomic, acetowhite, blood vessel structure, lesion margin, contour, Lugol's iodine staining. Images enhancements can be provided that enhance specific features in the imagery, in particular the colposcopic features. The individual features can also be classified in terms of their significance to the tissue diagnosis: normal, low-grade, high-grade and cancer.

## SUMMARY OF THE INVENTION

A problem of the above system is that it is insufficiently suitable for analyzing and/or processing the aforementioned multi-data type of cervical images.

It would be advantageous to have a system or method which enables better analyzing and/or processing different types of cervical images.

To better address this concern, a first aspect of the invention provides a system for labeling a cervical image obtained during a colposcopy of a patient, the system comprising:

- a detector for detecting a cervical region in the cervical image;
- an analyzer for i) calculating an image characteristic of the cervical region, the image characteristic being indicative of a use of a technique for improving a visibility of lesions in the cervical region, and ii) analyzing the image characteristic to determine whether the technique was used in obtaining the cervical image, thereby obtaining a determined use; and
- a labeler for labeling the cervical image based on the determined use.

In a further aspect of the invention, a workstation, an imaging apparatus and/or a colposcope is provided comprising the system set forth.

In a further aspect of the invention, a method is provided for labeling a cervical image obtained during a colposcopy of a patient, the method comprising:

- detecting a cervical region in the cervical image;
- calculating an image characteristic of the cervical region, the image characteristic being indicative of a use of a technique for improving a visibility of lesions in the cervical region;
- analyzing the image characteristic to determine whether the technique was used in obtaining the cervical image, thereby obtaining a determined use; and
- labeling the cervical image based on the determined use.

In a further aspect of the invention, a computer program product is provided comprising instructions for causing a processor system to perform the method set forth.

The above measures analyze a cervical image which is obtained from a colposcopic examination of a patient. Such a cervical image is also referred to as colposcopic image since it was obtained from the colposcopic examination. The cervical image typically shows the cervical region of the patient as well as adjoining regions of the cervical region.

The cervical region is detected, e.g., using a cervical region detection algorithm or segmentation algorithm which is known per se from the field of medical image analysis.

An image characteristic is then calculated based on image data of the cervical region. The image characteristic therefore constitutes a characteristic of the cervical region which is derivable from the image data of the cervical region. The image characteristic is indicative of a use of a technique for improving a visibility of lesions in the cervical region. It is noted that several of such techniques are known per se from the field of colposcopy. It is also known by clinicians how such techniques in general terms affect an appearance of the cervical region. The image characteristic thus represents an aspect of the appearance that is derivable from the image data of the cervical region and indicative of a use of the technique.

The image characteristic is analyzed to determine whether said technique was used in obtaining the cervical image. Here, the term “*used in obtaining the cervical image*” refers to a use of the technique before or during the colposcopy which resulted in the technique affecting the appearance of the cervical region in the cervical image. The cervical image is then labeled accordingly, either explicitly, e.g., by modifying a header of the cervical image, or implicitly, e.g., by creating metadata associated with the cervical image.

The above measures have the effect that a cervical image is automatically analyzed to determine whether a technique for improving a visibility of lesions was used in obtaining the cervical image, with the cervical image then being labeled accordingly. As such, further analysis and/or processing of the cervical image can be based on which technique for improving the visibility of lesions was used in obtaining the cervical image.

The inventors have recognized that the further analysis and/or processing of a cervical image benefits from knowing whether said technique was used since this allows the further analysis and/or processing to be optimized for a specific type of cervical image and/or applied selectively to said type of cervical image. Advantageously, an improved cervical cancer screening is obtained. It is noted that known systems such as that of US 2009/0046905 A1 attempt to deal with a wide variety of appearances of the cervical region, e.g., by extracting a wide variety of features from the cervical image. Disadvantageously, the further analysis and/or processing cannot be optimized for a specific type of cervical image. Disadvantageously, manual labeling is needed in order to allow further analysis and/or processing to be applied selectively to said type of cervical image.

Optionally, the analyzer is arranged for:

- calculating a plurality of image characteristics of the cervical region, each of the plurality of image characteristics being indicative of the use of a respective one of

a plurality of different techniques for improving the visibility of lesions in the cervical region; and

- analyzing one or more of the plurality of image characteristics to determine the use of at least one of the plurality of different techniques in obtaining the cervical image.

Different techniques may be used for improving the visibility of lesions in the cervical region. For example, a staining agent may be applied to the cervical region before obtaining the cervical image. Another example is the aforementioned use of a green filter during the acquisition of the cervical image. By calculating multiple image characteristics of the cervical region, with each image characteristic being associated with a different technique for improving the visibility of lesions in the cervical regions, it can be determined whether at least one of the different techniques was used in obtaining the cervical image.

Advantageously, the cervical image is labeled correctly irrespective of which technique of the different technique was used in obtaining the cervical image.

Optionally, the labeler is arranged for labeling the cervical image according to which ones of the plurality of different techniques were used. Certain ones of the plurality of different techniques may be combined. For example, the use of a green filter during image acquisition may be combined with applying acetic acid to the cervical region. By labeling the cervical image according to which ones of the plurality of different techniques were used, the cervical image is labeled correctly even if several different techniques were combined.

Optionally, the plurality of different techniques comprises at least one of: using a green filter during image acquisition, applying a staining agent to the cervical region, and zooming onto the cervical region. Said techniques are well suited for improving the visibility of lesions in the cervical region and thus likely to be used.

Optionally, the staining agent is at least one of: acetic acid and Lugol's iodine.

Optionally, the analyzer is arranged for determining the use of acetic acid by comparing the image characteristic to a reference image characteristic calculated from an earlier cervical image of the patient. The analyzer thus exploits the fact that lesions change a transient manner over a series of cervical images, e.g., by turning aceto-white and back.

Optionally, the analyzer is arranged for determining whether the cervical image is a pre-acetic acid or post-acetic acid cervical image based on said comparing.

Optionally, the analyzer is arranged for determining the use of Lugol's iodine based on determining an absence of at least one of: using the green filter during image acquisition, and applying acetic acid to the cervical region.

Optionally, the analyzer is arranged for determining which of the plurality of different techniques were used by:

- analyzing the one or more image characteristics to determine whether the green filter was applied, Lugol's iodine was applied, or if the cervical region appears normal;
- if the cervical region appears normal, determining whether the cervical image is a satisfactory zoomed or unsatisfactory zoomed cervical image and/or whether the cervical image is a pre-acetic acid or post-acetic acid cervical image.

The inventors have recognized that certain combinations of techniques may occur whereas others are unlikely to occur. The above hierarchical approach takes into account said fact. Advantageously, the use of one or more of the plurality of different techniques can be determined more efficiently, i.e., less computationally complex.

Optionally, the analyzer is arranged for determining the use of zooming onto the cervical region by i) calculating a size of the cervical region, and ii) analyzing the size of the cervical region to determine whether or not the cervical region is satisfactorily zoomed in on in the cervical image.

Optionally, the analyzer is arranged for determining that the cervical image is unsatisfactory for further analysis and/or processing based on said analyzing of the size of the cervical region.

It will be appreciated by those skilled in the art that two or more of the above-mentioned embodiments, implementations, and/or aspects of the invention may be combined in any way deemed useful.

Modifications and variations of the workstation, the imaging apparatus, the colposcope, the method, and/or the computer program product, which correspond to the described modifications and variations of the system, can be carried out by a person skilled in the art on the basis of the present description.

The invention is defined in the independent claims. Advantageous embodiments are defined in the dependent claims.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter. In the drawings,

Fig. 1 shows a system for labeling a cervical image based on whether a technique for improving a visibility of lesions was used in obtaining the cervical image;

Fig. 2 shows a method for labeling the cervical image;

Fig. 3 shows a computer program product for performing the method;

Fig. 4 shows a workflow of a colposcopy procedure; and

Fig. 5 shows a labeling of the cervical image according to which ones of a plurality of different techniques were used.

## **DETAILED DESCRIPTION OF EMBODIMENTS**

Fig. 1 schematically shows a system 100 for labeling a cervical image 110 obtained during a colposcopy of a patient. The system 100 comprises a detector 120 for detecting a cervical region 122 in the cervical image 110. The system 100 further comprises an analyzer 140 for calculating an image characteristic of the cervical region 122 and analyzing the image characteristic to obtain a determined use 142. For that purpose, the analyzer 140 is shown to receive the cervical region 122, or data indicative thereof, from the detector 120. For example, the analyzer 140 may receive the cervical region 122 in the form of coordinates. The analyzer 140 is further shown to receive the cervical image 110, thereby enabling the analyzer 140 to calculate the image characteristics of the cervical region 122. Alternatively or additionally, the analyzer 140 may receive the cervical region 122 in the form of image data of the cervical region 122. Hence, it may not be needed for the analyzer 140 to receive all of the cervical image 122. The system 100 further comprises a labeler 160 for labeling the cervical image 110 based on the determined use 142. For that purpose, the labeler 160 is shown to receive the determined user 142 from the analyzer 140, e.g., in the form of use data. The labeler 160 is further shown to receive the cervical image 110. In this example, the labeler 160 may label the cervical image 110 explicitly, e.g., by including metadata in a header of the cervical image 110 and thereby producing as output 162 a labeled cervical image. Alternatively or additionally, the labeler 160 may produce as output 162 a separate label in the form of label data which is associated with the cervical image 110 but provided separately. Hence, the labeler 160 may not need to receive the cervical image 110.

The operation of the system 100 may be briefly explained as follows. The detector 120 detects a cervical region 122 in the cervical image 110. The analyzer 140 then calculates an image characteristic of the cervical region 122, the image characteristic being indicative of a use of a technique for improving a visibility of lesions in the cervical region. The analyzer 140 further analyzes the image characteristic to determine whether the technique was used in obtaining the cervical image 110, thereby obtaining a determined use 142. Finally, the labeler 160 labels the cervical image 110 based on the determined use 142.

Fig. 2 shows a method 200 for labeling a cervical image obtained during a colposcopy of a patient. It is noted that the method 200 may correspond to the operation of the system 100. However, the method 200 may also be performed in separation of the system 100, e.g., on a different system or device. The method 200 comprises, in a step titled “DETECTING CERVICAL REGION”, detecting 210 a cervical region in the cervical image. The method 200 further comprises, in a step titled “CALCULATING IMAGE CHARACTERISTIC OF CERVICAL REGION”, calculating 220 an image characteristic of the cervical region, the image characteristic being indicative of a use of a technique for improving a visibility of lesions in the cervical region. The method 200 further comprises, in a step titled “ANALYZING IMAGE CHARACTERISTIC”, analyzing 230 the image characteristic to determine whether the technique was used in obtaining the cervical image, thereby obtaining a determined use. The method 200 further comprises, in a step titled “LABELING CERVICAL IMAGE”, labeling 240 the cervical image based on the determined use.

Fig. 3 shows a computer program product 260 comprising instructions for causing a processor system to perform the method according to the present invention. The computer program product 260 may be comprised on a computer readable medium 250, for example as a series of machine readable physical marks and/or as a series of elements having different electrical, e.g., magnetic, or optical properties or values.

The operation of the system 100 and the method 200 may be further explained in reference to Figs. 4 and 5. Fig. 4 shows a workflow 300 of a colposcopy procedure as may be performed by a clinician. A first stage 310 of the colposcopy may comprise douching and cleaning any secretions occurring in the cervical region as well as adjoining regions of the cervical region. For this purpose, a normal saline solution may be used. Hence, at this stage 310 of the colposcopy, it may be that no special technique for improving a visibility of lesions in the cervical region was used. Therefore, if a cervical image 110 is acquired using a colposcope at this stage 310 of the colposcopy, the cervical image may be considered a ‘normal’ cervical image and it may be desirable to label it accordingly. At this stage 310 of the colposcopy, the colposcope may also be zoomed onto the cervical region. Zooming constitutes a technique 144 for improving the visibility of lesions in the cervical region since it allows a clinician to obtain a better view of the cervical region and thus of the lesions therein. A cervical image 110 acquired at this stage 310 may be therefore also be a satisfactory zoomed cervical image. Alternatively, in certain situations, the cervical image may also be considered an unsatisfactory zoomed cervical image.

A second stage 320 of the colposcopy may comprise using a green filter to highlight certain blood pattern vessel patterns which may be indicative of lesions in the cervical region. A cervical image 110 acquired at this stage 320 of the colposcopy may therefore be a green filter cervical image. A strength of the green filter, i.e., a width of the passed and/or blocked spectrum, may vary. In case a 'strong' green filter was used, the cervical image 110 may be a green+ filter cervical image. In case a 'weak' green filter was used, the cervical image 110 may be a green- filter cervical image. A third stage 330 of the colposcopy may comprise applying acetic acid to the cervical region, e.g., a 3-5% acetic acid solution. A cervical image 110 acquired at this stage 330 of the colposcopy may therefore be a post-acetic cervical image. A fourth stage 340 of the colposcopy may comprise applying Lugo's Iodine to the cervical region. A cervical image 110 acquired at this stage 340 of the colposcopy therefore may be a post-acetic cervical image. Finally, a fifth stage 350 of the colposcopy may comprise performing a biopsy from an abnormal area of the cervix.

It is noted that the above workflow of a colposcopy procedure is an example which typically varies across countries and regions. In particular, the stage of applying Lugo's Iodine to the cervical region may be omitted in many countries and regions.

It may not be known whether, and if so which technique for improving a visibility of lesions in the cervical region was used in obtaining the cervical image. A reason for that may be that it is not known during which stage of the colposcopy the cervical image was acquired, which techniques were actually applied during a stage, and which stages the colposcopy comprised. The present invention involves determine whether a technique was used in obtaining the cervical image, and labeling the cervical image accordingly.

For that purpose, the detector 120 may detect the cervical region 122 in the cervical image as follows. Initially, a Gaussian low-pass filter may be applied to the RGB values of the cervical image to remove impulse noise. This may be followed by a two-step method to identify the presence of pink pixels in the cervical image based on the cervix being pink in color. In a first step, a feature space may be identified for cervical region detection. The feature space may be defined as the red color component of the RGB color space, where the red color values exceed a threshold  $T_h$ . The threshold  $T_h$  may be defined experimentally, e.g., having a value of 225 in case of 8-bit color values. Having identified the feature space, an unsupervised two class clustering technique based on K-Means may be applied. A central cluster in cervical image may then be identified as the cervical region. The above detection of the cervical region 122 is based on detecting a convex hull of the cervical

region obtained after color filtering. Alternatively, other cervical region detection algorithms or segmentation algorithms from the field of medical image analysis may be used as well.

Fig. 5 shows a labeling of the cervical image 110 according to which ones of a plurality of different techniques were used in obtaining the cervical image. The plurality of different techniques 144 may comprise one or more of, e.g., using a green filter during image acquisition, applying a staining agent to the cervical region, and zooming onto the cervical region. Here, the staining agent may be, e.g., acetic acid or Lugol's iodine. For labeling the cervical image accordingly, the analyzer 140 may be arranged for calculating a plurality of image characteristics of the cervical region 122, each of the plurality of image characteristics being indicative of the use of a respective one of the plurality of different techniques 144. The analyzer 140 may be further arranged for analyzing one or more of the plurality of image characteristics to determine the use of at least one of the plurality of different techniques in obtaining the cervical image. Moreover, the labeler 160 may be arranged for labeling the cervical image 110 according to which ones of the plurality of different techniques were used. Consequently, the cervical image 110 may be labeled with one or more labels.

Fig. 5 schematically illustrates a labeling of the cervical image 110 by arrows leading from the cervical image 110 to a plurality of labels which are indicated as follows: NRML for normal cervical images, ZM for satisfactory zoomed cervical images, PR-AC for pre-acetic acid cervical images, PO-AC for post-acetic acid cervical images, UN-ZM for unsatisfactory zoomed cervical images, GRN for green filter cervical images, LU-IO for Lugol's Iodine cervical images. Fig. 5 also schematically indicates during which of the stages of the colposcopy procedure 300, as was shown in Fig. 4, the cervical image 110 was most likely acquired by means of dashed bounding boxes. For labeling the cervical image 110 in accordance with Fig. 5, the analyzer 140 may be arranged for determining which of the plurality of different techniques 144 were used by analyzing the one or more image characteristics to determine whether the green filter was applied GRN, Lugol's iodine was applied LU-IO, or if the cervical region appears normal NRML, and if the cervical region appears normal, determining whether the cervical image is a satisfactory zoomed ZM or unsatisfactory zoomed UN-ZM cervical image and/or whether the cervical image is a pre-acetic acid PR-AC or post-acetic acid PO-AC cervical image.

It is noted that in the above, some labels are mutually exclusive whereas others are not. Whether this is the case depends on the particular technique and the colposcopy procedure. For example, in this particular example, it is unlikely that the labels GRN indicating use of a green filter and the label LU-IO indicating application of Lugol's

iodine are both applied since typically a green filter is not used during or after applying Lugol's iodine. However, the label PO-AC indicating a post-acetic acid application and the label ZM indicating zooming onto the cervical region may both be applied at a same time.

In the following, a more detailed example is provided of how the labeling of the cervical image 110 in accordance with Fig.5 may be achieved.

In a first step, the cervical region 122 as detected by the detector 120 is converted into a binary mask. Then, a so-termed perceivable magnification level is calculated based on a ratio of the area of the binary mask and the total area of the cervical image 110.

In a second step, if the area of the cervical region 122 exceeds a predetermined threshold, it is determined whether the cervical image is a first image from a series of images. In this case, the cervical image is labeled as normal, i.e., NRML and a R/G color channel ratio is pre-computed for use in labeling subsequent images from the series of images:

- a. Randomly sample  $N$  (e.g., 100-200) pixels from the cervical region;
- b. Sort the pixels based on the intensity;
- c. Compute the mean intensity  $M_1$  of each color channel of the first ( $N/2$ ) pixels, with  $M_1$  being a 3-channel vector, i.e., (R, G, B);
- d. Compute the R/G ratio  $R_1 = M_1(1)/M_1(2)$ , i.e., the mean intensity of the red color channel divided by the mean intensity of the green color channel.

In a third step, if the cervical image is not a first image from a series of images, it is determined whether the cervical image is a post-acetic acid cervical image by:

- a. Randomly sample  $N$  pixels from the cervical region, the value  $N$  may be chosen to be approximately 200 considering computational complexity and performance;
- b. Sort the pixels based on the intensity;
- c. Compute the mean intensity  $M_2$  of, e.g., the first 100 pixels;
- d. Compute the R/G ratio  $R_2 = M_2(1)/M_2(2)$  and compare  $R_1$  and  $R_2$  using the relation ' $R_1 > R_2 + \Delta$ ';
- e. If the relation is satisfied, apply the label post-acetic acid, i.e., PO-AC, otherwise normal, i.e., NRML.

In a fourth step, if the area of the cervical region 122 exceeds a predetermined upper threshold  $T_h$  and if it satisfies certain positional requirements, the cervical image 110 is considered a sufficiently zoomed image, i.e., a satisfactory zoomed image. An example of a positional requirement is that the cervical region is in the center of the cervix image. The positional requirements may also take into account that the cervical region is significantly

and thus a part of the cervical region is located outside of said center. Hence, the label ZM is applied. Otherwise, the above process is continued in the following fifth step.

In the fifth step, if the area of the cervical region 122 is below a predetermined lower threshold  $T_L$ , it is determined whether the cervical image is a green filter image by comparing the average intensity of the red and green color components. Here, if the average intensity of the green color component is higher than that of the red color component, the cervical image is considered a green filter cervical image and the label GRN is applied. Optionally, the label GRN+ may be applied if the average intensity of the green color component is significantly higher than that of the red color component and the label GRN- may be applied if the average intensity of the green color component is somewhat higher than that of the red color component. If neither of said labels is applied, the above process is continued in the following sixth step.

In the sixth step, a number of pixels are sampled from the image randomly which are validated with color heuristics. Such color heuristics may be derived experimentally after analyzing several labeled images. For Lugol's iodine stained images, the cervical region generally has a brownish/blackish/yellowish kind of appearance. Hence, color heuristics may be checked for presence of these color/hues, and if the number of pixels  $N$  satisfying the heuristics is more than a threshold  $N_T$ , the cervical image is considered a Lugol's iodine stained cervical image and the label LU-IO is applied. Optionally, the label LU-IO+ may be applied if the number of pixels  $N$  is more than an upper threshold  $N_H$ . Alternatively, the label LU-IO- may be applied if the number of pixels  $N$  is more than a lower threshold  $N_L$ . If the number of pixels  $N$  is lower than  $N_L$ , the above process is continued in the following seventh step.

In the seventh step, if the cervical image 110 is not labeled in the last four steps, it is declared as unsatisfactory colposcopy image and not fit for analysis. If applicable, also a label UN-ZO for unsatisfactory zoom is applied to the cervical image.

In general, the analyzer 140 may be arranged for determining the use of acetic acid PR-AC, PO-AC by comparing the image characteristic to a reference image characteristic calculated from an earlier cervical image of the patient, which was, if the cervical image was obtained after the use of the acetic acid, most likely obtained without said use. The earlier cervical image may be identified based on a time stamp, in particular a comparison of the time step of the cervical image and the presumed earlier cervical image. In case the system involves acquiring the cervical image, the system may automatically activate the time stamp mode such that such time information is available for the acquired images.

Moreover, the analyzer 140 may be arranged for determining whether the cervical image 110 is a pre-acetic acid PR-AC or post-acetic acid PO-AC cervical image based on said comparing. The analyzer 140 may be arranged for determining the use of Lugol's iodine LU-IO based on determining an absence of at least one of: using the green filter during image acquisition GRN, and applying acetic acid to the cervical region PR-AC, PO-AC. The analyzer 140 may be arranged for determining the use of zooming ZM onto the cervical region 122 by i) calculating a size of the cervical region, and ii) analyzing the size of the cervical region to determine whether or not the cervical region is satisfactorily zoomed in on the cervical image 110.

It will be appreciated that the invention also applies to computer programs, particularly computer programs on or in a carrier, adapted to put the invention into practice. The program may be in the form of a source code, an object code, a code intermediate source and an object code such as in a partially compiled form, or in any other form suitable for use in the implementation of the method according to the invention. It will also be appreciated that such a program may have many different architectural designs. For example, a program code implementing the functionality of the method or system according to the invention may be sub-divided into one or more sub-routines. Many different ways of distributing the functionality among these sub-routines will be apparent to the skilled person. The sub-routines may be stored together in one executable file to form a self-contained program. Such an executable file may comprise computer-executable instructions, for example, processor instructions and/or interpreter instructions (e.g. Java interpreter instructions). Alternatively, one or more or all of the sub-routines may be stored in at least one external library file and linked with a main program either statically or dynamically, e.g. at run-time. The main program contains at least one call to at least one of the sub-routines. The sub-routines may also comprise function calls to each other. An embodiment relating to a computer program product comprises computer-executable instructions corresponding to each processing step of at least one of the methods set forth herein. These instructions may be sub-divided into sub-routines and/or stored in one or more files that may be linked statically or dynamically. Another embodiment relating to a computer program product comprises computer-executable instructions corresponding to each means of at least one of the systems and/or products set forth herein. These instructions may be sub-divided into sub-routines and/or stored in one or more files that may be linked statically or dynamically.

The carrier of a computer program may be any entity or device capable of carrying the program. For example, the carrier may include a storage medium, such as a

ROM, for example, a CD ROM or a semiconductor ROM, or a magnetic recording medium, for example, a hard disk. Furthermore, the carrier may be a transmissible carrier such as an electric or optical signal, which may be conveyed via electric or optical cable or by radio or other means. When the program is embodied in such a signal, the carrier may be constituted by such a cable or other device or means. Alternatively, the carrier may be an integrated circuit in which the program is embedded, the integrated circuit being adapted to perform, or used in the performance of, the relevant method.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

## CLAIMS:

1. System (100) for labeling a cervical image (110) obtained during a colposcopy of a patient, the system comprising:
  - a detector (120) for detecting a cervical region (122) in the cervical image;
  - an analyzer (140) for i) calculating an image characteristic of the cervical region (122), the image characteristic being indicative of a use of a technique for improving a visibility of lesions in the cervical region, and ii) analyzing the image characteristic to determine whether the technique was used in obtaining the cervical image (110), thereby obtaining a determined use (142); and
  - a labeler (160) for labeling the cervical image (110) based on the determined use (142).
2. System (100) according to claim 1, wherein the analyzer (140) is arranged for:
  - calculating a plurality of image characteristics of the cervical region (122), each of the plurality of image characteristics being indicative of the use of a respective one of a plurality of different techniques (144) for improving the visibility of lesions in the cervical region; and
  - analyzing one or more of the plurality of image characteristics to determine the use of at least one of the plurality of different techniques in obtaining the cervical image.
3. System (100) according to claim 2, wherein the labeler (160) is arranged for labeling the cervical image according to which ones of the plurality of different techniques were used (144).
4. System (100) according to claim 2, wherein the plurality of different techniques (144) comprises at least one of: using a green filter during image acquisition (GRN), applying a staining agent to the cervical region (LU-IO, PR-AC, PO-AC), and zooming onto the cervical region (ZM, UN-ZM).

5. System (100) according to claim 4, wherein the staining agent is at least one of: acetic acid and Lugol's iodine.
6. System (100) according to claim 5, wherein the analyzer (140) is arranged for determining the use of acetic acid (PR-AC, PO-AC) by comparing the image characteristic to a reference image characteristic calculated from an earlier cervical image of the patient.
7. System (100) according to claim 6, wherein the analyzer (140) is arranged for determining whether the cervical image (110) is a pre-acetic acid (PR-AC) or post-acetic acid (PO-AC) cervical image based on said comparing.
8. System (100) according to claim 5, wherein the analyzer (140) is arranged for determining the use of Lugol's iodine (LU-IO) based on determining an absence of at least one of: using the green filter during image acquisition (GRN), and applying acetic acid to the cervical region (PR-AC, PO-AC).
9. System (100) according to claim 4, wherein the analyzer (140) is arranged for determining which of the plurality of different techniques (144) were used by:
  - analyzing the one or more image characteristics to determine whether the green filter was applied (GRN), Lugol's iodine was applied (LU-IO), or if the cervical region appears normal (NRML);
  - if the cervical region appears normal, determining whether the cervical image is a satisfactory zoomed (ZM) or unsatisfactory zoomed (UN-ZM) cervical image and/or whether the cervical image is a pre-acetic acid (PR-AC) or post-acetic acid (PO-AC) cervical image.
10. System (100) according to claim 4, wherein the analyzer (140) is arranged for determining the use of zooming (ZM) onto the cervical region (122) by i) calculating a size of the cervical region, and ii) analyzing the size of the cervical region to determine whether or not the cervical region is satisfactorily zoomed in on the cervical image (110).
11. System (100) according to claim 10, wherein the analyzer (140) is arranged for determining that the cervical image (110) is unsatisfactory for further analysis and/or processing based on said analyzing of the size of the cervical region (122).

12. Workstation or imaging apparatus comprising the system according to claim 1.
13. Colposcope comprising the system according to claim 1.
14. Method (200) for labeling a cervical image obtained during a colposcopy of a patient, the method comprising:
  - detecting (210) a cervical region in the cervical image;
  - calculating (220) an image characteristic of the cervical region, the image characteristic being indicative of a use of a technique for improving a visibility of lesions in the cervical region;
  - analyzing (230) the image characteristic to determine whether the technique was used in obtaining the cervical image, thereby obtaining a determined use; and
  - labeling (240) the cervical image based on the determined use.
15. A computer program product (260) comprising instructions for causing a processor system to perform the method according to claim 14.

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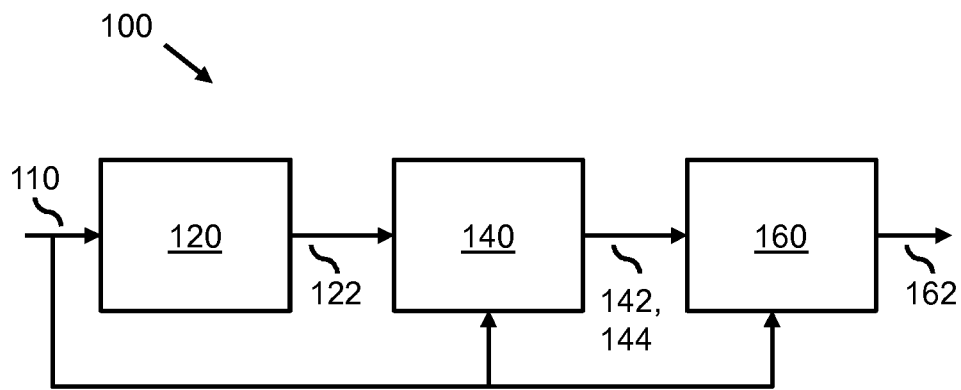


Fig. 1

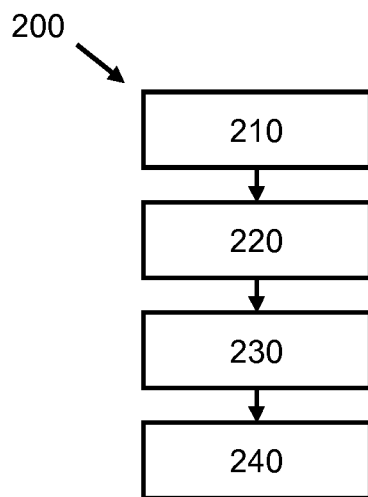


Fig. 2

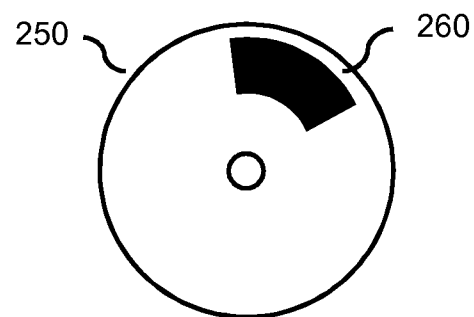


Fig. 3

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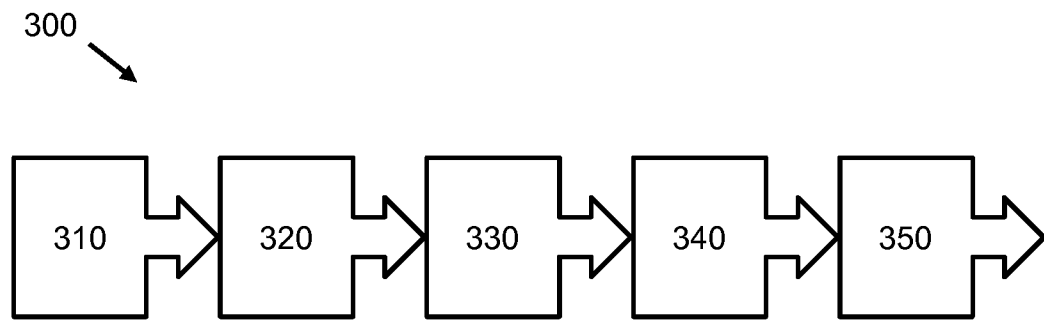


Fig. 4

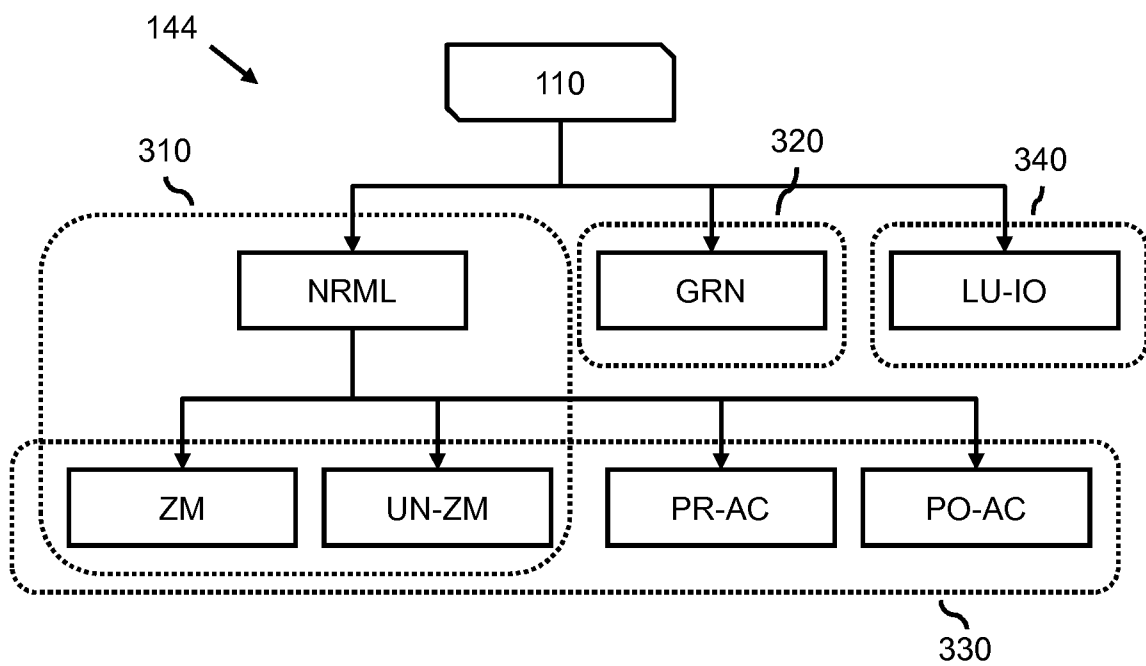


Fig. 5

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2013/058523

## A. CLASSIFICATION OF SUBJECT MATTER

INV. A61B5/00  
ADD. G06T7/00

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)

A61B G06T G06K G06F

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

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

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                            | Relevant to claim No. |
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| A         | pages 22,28-30<br>pages 32,40-53<br>page 56; claims; figures<br>-----                                                         | 8,9                   |
| X         | WO 02/25588 A2 (LEVENTON M)<br>28 March 2002 (2002-03-28)                                                                     | 1-7,<br>12-15         |
| A         | page 2, lines 28-30<br>page 3, line 29 - page 4, line 24<br>page 24 - page 33; claims; figures<br>-----                       | 8,9                   |
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☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

6 February 2014

Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No  
PCT/IB2013/058523

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