Abstract: Blood flow in blood vessels is characterised by the movement in 'trains'. The apparatus and method of the present invention is to develop a non-invasive and accurate technique for measuring blood flow, in the form of a train in visible blood vessels, to determine the flow speed and other blood characteristics by performing visual image analytics. The present invention comprises at least one primary (106) and secondary image module (110) to image blood 'trains' connecting to at least one processing device (104). and at least one object of interest that is being studied. The present invention utilizes a camera to image blood 'trains' (group of blood flowing separately). The methodology of the present invention provides for measurement of length and width of the blood stream from the image while the volume of the blood train is determined using width to determine the circumference and multiplying it with the length of the blood train. The width is measured by selecting a cross-section line of a number of pixels (e.g., 5 pixels) thickness for colour variation of the selected area. The pixel values are measured against the similar neighbouring group of pixels to ascertain the colour change between the pixels. If the values are constant, the colour is consistent and if the value is high, the difference will show a change from red hues (the blood vessel) to a lighter colour (the surrounding fat) and vice-versa. From the width (the diameter), circumference is deduced.
Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(H))
- of inventorship (Rule 4.17(iv))

Published:

- with international search report (Art. 21(3))

and by multiplying this with the length, the total volume can be calculated. Measurement of speed is allowed as the initial start and end of a blood train is used to measure the time taken to travel over a length of the blood capillary.
AN APPARATUS AND METHOD FOR VOLUMETRIC AND SPEED MEASUREMENT OF BLOOD 'TRAIN' IN VISIBLE VESSELS

FIELD OF INVENTION

The present invention relates to an apparatus and a non-invasive imaging method for measuring blood flow, in the form of a train in visible blood vessels, in order to determine the flow speed and other blood characteristics by performing visual image analytics. In particular, the invention identifies a blood train in a blood vessel and determines the width and length of the blood train, the volume, and determining the direction and speed of the blood flow using image processing techniques.

BACKGROUND ART

Currently available techniques for measuring blood trains volume and speed is through invasive techniques that requires procedures to be performed on patients. However, present techniques of non-invasive blood volume measurement produces in-accurate results as scientific assumptions are made in deducing the results. Alternatively, an external blood measurement system such as arterial blood pressure (BP) meters provides only the Diastolic and Systolic readings and does not provide the actual characteristics of the blood flow.

One example that relates to a non-invasive blood analysis method, which uses light to obtain data concerning the characteristics of an individual's blood is disclosed in United States Patent Publication No. US 2011/184295 A1 entitled "Blood Analysis" (hereinafter referred to as the US 295 Publication). In the US 295 Publication, an imaging device is used to determine the blood characteristic of an individual's blood. However, the US 295 Publication does not use image correction techniques and only analyzes image from single source. Further, it only identifies the blood flow and uses a method to determine the blood constituents such as glucose, plasma, etc. In contrast, in the present invention, a camera is utilized to image blood 'trains' (group of blood flowing separately) and a method is devised to measure the length and width of the blood train from the image. Further, in the present invention the volume of the blood train is determined using width to determine circumference and multiplying it with the length of the blood train wherein
the initial start and end of a blood train can then be used to measure the time taken to travel over a length of the blood capillary.

Another example that provides an image analysis system for the measurement of blood velocity is disclosed in an IEEE paper entitled "Microvascular red blood cell velocity measurement using the image gradient method" by, Umetani, J. et al., IEEE 1989. In the said paper, a super-high-speed video tape recorder and the image gradient method is described. The measured mean red blood cell velocity of the microvessels (venules having diameters of 15-40 µm) is 0.7-4.0 mm/s and the measured mean flow volume is 0.7-5.0x10⁻³ m³/s. A flow chart of the image processing algorithm and results which show the velocity vectors and temporal change of the red blood cell velocity are given in the said paper. However, the said paper does not provide a method to measure the length and width of the blood train from the image as provided in the present invention. Further, in the present invention the volume of the blood train is determined using width to determine circumference and multiplying it with the length of the blood train wherein the initial start and end of a blood train can then be used to measure the time taken to travel over a length of the blood capillary.

Another mechanism which provides a method for visualizing and measuring blood flow parameters are disclosed in an IEEE paper entitled Optimization of real-time high frequency ultrasound for blood flow imaging in the microcirculation", by Kruse, D. et al, IEEE 2000. In the said paper, real-time high frequency ultrasound system is utilized wherein the system uses a swept-scan or swept-Doppler, to rapidly acquire 2-D frames for color flow frame rates approaching 10 fps. RF data from the phantom was processed to optimize wall filter order, cutoff and attenuation for a 25 MHz, f/2 transducer for both M-mode and swept-mode. These parameters were then used in processing measurements of flow velocity and volume flow rate from within the phantom at a typical operating PRF of 500 Hz (scan speed of 1 mm/sec). The measured flow rates were consistent with the known flow rates, after considering the finite size of the resolution cell. Optimized color flow settings were then applied to in vivo imaging of the microcirculatory flow within the nail bed region of a human finger. However, the said system as described in the said IEEE paper does not provide a method which determines the volume of the blood train as compared to in the present invention. In the present invention, the volume of the blood train is determined using width to determine
the circumference and multiplying it with the length of the blood train wherein the initial start and end of a blood train can then be used to measure the time taken to travel over a length of the blood capillary.
SUMMARY OF INVENTION

The present invention relates to an apparatus and a non-invasive imaging method for measuring blood flow, in the form of a train in visible blood vessels, in order to determine the flow speed and other blood characteristics by performing visual image analytics. In particular, the invention identifies a blood train in a blood vessel and determines the width and length of the blood train, the volume, and determining the direction and speed of the blood flow using image processing techniques.

One aspect of the present invention provides an apparatus (100) for volumetric and speed measurement of blood flow in visible vessels. The apparatus comprising at least one primary (106) and secondary image module (110) to image blood 'trains' connecting to at least one processing device (104); and at least one object of interest that is being studied. The said processing device (104) having means for determining blood flow characteristics further comprises at least one Primary Image Capture Module (114) and Secondary Image Capture Module (112) having means for capturing images; at least one Width Determination Module (124) having means for determining width of a blood train; at least one Height Determination Module (126) having means for determining height of a blood train; at least one Direction Analysis Module (120) having means for determining direction of a blood train; at least one Speed Determination Module (122) having means for determining speed of a blood train; at least one Image Colour Intensity Module (118) having means for correcting image for processing; at least one Image Angle Correction Module (116) having means for correcting image for processing; at least one AOI (Artery of Interest) and OOI (Object of Interest) Module (108) having means for selecting artery of interest and object of interest.

Another aspect of the invention provides a method (200) for volumetric and speed measurement of blood flow in visible vessels. The method comprises steps of receiving a request from a user by the Primary Image Capture Module to move and focus on artery of interest within the object of interest (202); allowing user to identify the artery of interest by the Artery of Interest (AOI) and Object of Interest (OOI) Selection Module (204); capturing an instance of the artery of instance by the Primary Capture Module (206); determining movement of Primary Image Module by Image Angle Correction Module (208); triggering Secondary Imaging Module by the Image Angle Correction
Module to move same amount in a direction of Primary Imaging Module (210); receiving a request by the Secondary Imaging Module to focus on artery of interest within object of interest from the Image Angle Correction Module (212); capturing an instance of the artery of interest from different angle by the Secondary Image Capture Module (214); interlacing images from the Primary and Secondary Capture Modules by the Image Angle Correction Module (216); adjusting colour intensity to highlight object of interest by the Colour Intensity Measurement module (218); identifying location of similarities and mapping the image for further analysis by the Image Angle Correction Module (220); determining width of blood train by the Width Determination Module (222); determining length of blood train by the Length Determination Module (224); and determining speed of blood train by the Speed Determination Module (226).

Yet another aspect of the invention relates to the step for identifying location of similarities and mapping the image for further analysis by the Image Angle Correction Module (220). The said step further comprises steps of feeding output data of imaging module movement into the Image Angle Correction Module (302); selecting a vertical and horizontal axis sets of pixels for comparison between the primary and secondary imaging module by the Image Angle Correction Module (304); comparing selected pixels between primary and secondary image by the Image Angle Correction Module (306); generating composite image of co-related pixels by the Image Angle Correction Module (308); and forwarding said composite image to a display device by the Image Angle Correction Module (310).

Still another aspect of the invention provides for the step for determining width of blood train by the Width Determination Module. The said step further comprises steps of feeding a multi coloured image with visible blood train in red scale into a Width Determination Module (402); measuring image colour intensity by the Image Colour Intensity Measurement Module (404); selecting the artery of interest within the object of interest by the user (406); selecting a cross-section line of configurable pixel thickness for colour variation along the width of artery of interest by the Width Determination Module (408); measuring width of the artery of interest by comparing immediate neighbouring configured pixels (410); determining if the measured values are constant (412); repeating step 408 above if the measured values are constant. If measured values are not constant; detecting beginning of blood train (414) by measuring the width
of the blood train by comparing immediate neighbouring configured pixels by the by Width Determination Module (416); determining if said measured values of the width of blood train are constant (418); repeating step 416 above if the said measured values are constant; else detecting end of blood train (420).

A further aspect of the invention provides for the step for determining length of blood train by the Length Determination Module (224). The said step further comprises steps of feeding a multi-coloured image with visible blood train in red scale into a Width Determination Module (502); measuring image colour intensity by the Image Colour Intensity Measurement Module (504); selecting artery of interest within the object of interest by the user (506); selecting a cross-section line of configurable pixel thickness for colour variation along the length of artery of interest by the Width Determination Module (508); measuring length of blood train by comparing immediate neighbouring configure pixels by the Width Determination Module (510); determining if said measured values are constant (512); repeating step 508 above if the said measured values are constant. If measured values are not constant, detecting beginning of blood train (514) by measuring the width of blood train by comparing the immediate neighbouring configured pixel cells (516); determining if said measured values are constant (518); and repeating step 516 above if the said measured values are constant; else detecting end of blood train (520).

Still another aspect of the invention provides for the step for determining speed of blood train by the Speed Determination Module (226). The said step further comprises steps of feeding a multi-coloured image with visible blood train in red scale into a Width Determination Module (602); selecting artery of interest within the object of interest by the user (604); determining direction of the flow by the Direction Analysis Module (606); marking end of blood train by identifying values by Speed Determination Module (608); selecting a fixed point over a distance where the blood train will arrive in time by the Speed Determination Module (610); measuring blood train by comparing immediate neighbouring configured pixel cells by the Speed Determination Module (612); determining if the values are constant (614); repeating step 612 above if the said values are constant. If measured values are not constant, determining distance of the end point to arrival at the fixed point (616); and determining time taken from start-point to end-point (618).
The present invention consists of features and a combination of parts hereinafter fully described and illustrated in the accompanying drawings, it being understood that various changes in the details may be made without departing from the scope of the invention or sacrificing any of the advantages of the present invention.
BRIEF DESCRIPTION OF ACCOMPANYING DRAWINGS

To further clarify various aspects of some embodiments of the present invention, a more particular description of the invention will be rendered by references to specific embodiments thereof, which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the accompanying drawings in which:

FIG. 1 illustrates the general architecture of the apparatus of the present invention.

FIG. 2 is a flowchart illustrating the general methodology of an embodiment of the present invention.

FIG. 3 is a flowchart illustrating the steps for identifying location of similarities and mapping the image for further analysis by the Image Angle Correction Module.

FIG. 4 is a flowchart illustrating the steps for determining width of blood train by the Width Determination Module.

FIG. 5 is a flowchart illustrating the steps for determining length of blood train by the Length Determination Module.

FIG. 6 is a flowchart illustrating the steps for determining speed of blood train by the Speed Determination Module (226).
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to an apparatus and a non-invasive imaging method for measuring blood flow, in the form of a train in visible blood vessels, in order to determine the flow speed and other blood characteristics by performing visual image analytics. In particular, the invention identifies a blood train in a blood vessel and determines the width and length of the blood train, the volume, and determining the direction and speed of the blood flow using image processing techniques.

Hereinafter, this specification will describe the present invention according to the preferred embodiments. It is to be understood that limiting the description to the preferred embodiments of the invention is merely to facilitate discussion of the present invention and it is envisioned without departing from the scope of the appended claims.

Referring to FIG. 1.0, an apparatus (100) for volumetric and speed measurement of blood flow in visible vessels is illustrated. As illustrated in FIG. 1.0, the apparatus for volumetric and speed measurement of blood flow in visible vessels comprising a primary (106) and secondary image module (110) to image blood ‘trains’ connecting to a processing device (104); and an object of interest that is being studied. The processing device (104) having means for determining blood flow characteristics further comprises a Primary Image Capture Module (114) and Secondary Image Capture Module (112) with means for capturing images; a Width Determination Module (124) having means for determining width of a blood train; a Height Determination Module (126) having means for determining height of a blood train; a Direction Analysis Module (120) having means for determining direction of a blood train; a Speed Determination Module (122) having means for determining speed of a blood train; an Image Colour Intensity Module (118) having means for correcting image for processing; an Image Angle Correction Module (116) having means for correcting image for processing; an AOI (Artery of Interest) and OO1 (Object of Interest) Module (108) having means for selecting artery of interest and object of interest.

The general methodology (200) of an embodiment of the present invention is as illustrated in FIG. 2.0. As illustrated in FIG. 2.0, volumetric and speed measurement of
blood flow in visible vessels is initiated when the Primary Image Capture Module receives a request from a user. Thereafter, the Primary Image Capture Module moves and focuses on the artery of interest (AOI) within the object of interest (OOI) (202). The Artery of Interest (AOI) and Object of Interest (OOI) Selection Modules allows user to identify the artery of interest (204). The Primary Capture Module captures an instance of the artery of instance (206) and the Image Angle Correction Module determines the movement of the Primary Image Module (208). The Secondary Imaging Module is triggered by the Image Angle Correction Module to move the same amount in a direction of Primary Imaging Module (210). Secondary Imaging Module receives a request to focus on the artery of interest within the object of interest from the Image Angle Correction Module (212) and an instance of the artery of interest is captured from different angle by the Secondary Image Capture Module (214). Images from the Primary and Secondary Capture Modules are interlaced by the Image Angle Correction Module (216) while colour intensity is adjusted to highlight the object of interest by the Colour Intensity Measurement module (218). Subsequently, the location of similarities is identified and the image is mapped for further analysis by the Image Angle Correction Module (220) while the width of blood train is determined by the Width Determination Module (222); the length of blood train is determined by the Length Determination Module (224); and the speed of blood train is determined by the Speed Determination Module (226).

Referring to FIG. 3.0, a detailed description of the steps for identifying location of similarities and mapping the image for further analysis by the Image Angle Correction Module (220) is illustrated. As illustrated in FIG. 3.0, the steps for identifying location of similarities and mapping the image for further analysis by the Image Angle Correction Module (220) begins by feeding output data of imaging module movement into the Image Angle Correction Module (302). Thereafter, the Image Angle Correction Module selects vertical and horizontal axis sets of pixels for comparison between the primary and secondary imaging module (304) and the selected pixels are compared between the primary and secondary image by the Image Angle Correction Module (306). A composite image of co-related pixels is generated by the Image Angle Correction Module (308); and said composite image is forwarded to a display device by the Image Angle Correction Module (310).
Reference is now made to FIGs. 4.0, 5.0 and 6.0 respectively. Referring to FIG. 4.0, a detailed description of the steps for determining the width of blood train by the Width Determination Module is illustrated. As illustrated in FIG. 4.0, a multi coloured image with visible blood train in red scale is first fed into a Width Determination Module (402) and the image colour intensity is measured by the Image Colour Intensity Measurement Module (404). Accordingly, the artery of interest within the object of interest is selected by the user (406) while a cross-section line of configurable pixel thickness for colour variation along the width of artery of interest is selected by the Width Determination Module (408). The width of the artery of interest is measured by comparing the immediate neighbouring configured pixels (410) and it is further determined if the measured values are constant (412). Step 408 is repeated if the measured values are constant. Else, if the measured values are not constant the beginning of the blood train (414) is detected by measuring the width of the blood train by comparing the immediate neighbouring configured pixels by the by Width Determination Module (416). It is determined if said measured values of the width of blood train are constant (418) and step 416 is repeated if the said measured values are constant; else the end of blood train is detected (420).

As illustrated in FIG. 5.0, the length of blood train is determined by the Length Determination Module (224). To determine the length of blood train, a multi-coloured image with visible blood train in red scale is first fed into a Width Determination Module (502). Thereafter, the image colour intensity is measured by the Image Colour Intensity Measurement Module (504). The artery of interest within the object of interest is selected by the user (506) while a cross-section line of configurable pixel thickness for colour variation along the length of artery of interest is selected by the Width Determination Module (508). Subsequently, the length of blood train is measured by comparing the immediate neighbouring configure pixels by the Width Determination Module (510) and it is determined if said measured values are constant (512). Step 508 is repeated if the said measured values are constant. Else, if measured values are not constant, the beginning of the blood train (514) is detected by measuring the width of blood train by comparing the immediate neighbouring configured pixel cells (516) and it is determined if said measured values are constant (518). Step 516 is repeated if the said measured values are constant; else the end of the blood train is detected (520).
As illustrated in FIG. 6.0, the speed of blood train is determined by the Speed Determination Module (226) by first feeding a multi-coloured image with visible blood train in red scale into a Width Determination Module (602). The artery of interest within the object of interest is selected by the user (604) and the direction of the flow is determined by the Direction Analysis Module (606). Subsequently, the end of the blood train is marked by identifying values by Speed Determination Module (608) and a fixed point is selected over a distance where the blood train will arrive in time by the Speed Determination Module (610). Blood train is measured by comparing the immediate neighbouring configured pixel cells by the Speed Determination Module (612). Thereafter, it is determined if the values are constant (614). Step 612 is repeated if the said values are constant. Else, if measured values are not constant, the distance of the end point to arrival at the fixed point is determined (616); and the time taken from start-point to end-point is determined (618).

In the present invention, a luminescence based digital camera with zoom is used to image blood vessels under the skin. As erythrocytes (red blood cells) cause each blood 'train' to have a reddish hue, the width is measured by selecting a cross-section line of a number of pixels (e.g. 5 pixels) thickness for colour variation of the selected of the area. The pixel values are measured against the similar neighbouring group of pixels to ascertain the colour change between the pixels. If the values are constant, the colour is consistent and if the value is high, the difference will show a change from red hues (the blood vessel) to a lighter colour (the surrounding fat) and vice-versa. From the width (the diameter), circumference is deduced and by multiplying this with the length, the total volume can be calculated.

The present invention may be embodied in other specific forms without departing from its essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore indicated by the appended claims rather than by the foregoing description. All changes, which come within the meaning and range of equivalency of the claims, are to be embraced within their scope.
CLAIMS

1. An apparatus (100) for volumetric and speed measurement of blood flow in visible vessels comprising:

   at least one primary (106) and secondary image module (110) to image blood 'trains' connecting to at least one processing device (104); and

   at least one object of interest that is being studied

   characterized in that

   said processing device (104) having means for determining blood flow

   characteristics further comprises

   at least one Primary Image Capture Module (114) and Secondary Image Capture Module (112) having means for capturing images;

   at least one Width Determination Module (124) having means for determining width of a blood train;

   at least one Height Determination Module (126) having means for determining height of a blood train;

   at least one Direction Analysis Module (120) having means for determining direction of a blood train;

   at least one Speed Determination Module (122) having means for determining speed of a blood train;

   at least one Image Colour Intensity Module (118) having means for correcting image for processing;

   at least one Image Angle Correction Module (116) having means for correcting image for processing;

   at least one AOI (Artery of Interest) and OOI (Object of Interest) Module (108) having means for selecting artery of interest and object of interest.

2. A method (200) for volumetric and speed measurement of blood flow in visible vessels comprises steps of:

   receiving a request from a user by the Primary Image Capture Module to move and focus on artery of interest within the object of interest (202);

   allowing user to identify the artery of interest by the Artery of Interest (AOI) and Object of Interest (OOI) Selection Module (204);
capturing an instance of the artery of instance by the Primary Capture Module (206);
determining movement of Primary Image Module by Image Angle Correction Module (208);
triggering Secondary Imaging Module by the Image Angle Correction Module to move same amount in a direction of Primary Imaging Module (210);
receiving a request by the Secondary Imaging Module to focus on artery of interest within object of interest from the Image Angle Correction Module (212);
capturing an instance of the artery of interest from different angle by the Secondary Image Capture Module (214);
interlacing images from the Primary and Secondary Capture Modules by the Image Angle Correction Module (216);
adjusting colour intensity to highlight object of interest by the Colour Intensity Measurement module (218);
identifying location of similarities and mapping the image for further analysis by the Image Angle Correction Module (220);
determining width of blood train by the Width Determination Module (222);
determining length of blood train by the Length Determination Module (224); and
determining speed of blood train by the Speed Determination Module (226).

3. A method (200) according to Claim 2, wherein identifying location of similarities and mapping the image for further analysis by the Image Angle Correction Module (220) further comprises steps of:
   feeding output data of imaging module movement into the Image Angle Correction Module (302);
   selecting a vertical and horizontal axis sets of pixels for comparison between the primary and secondary imaging module by the Image Angle Correction Module (304);
   comparing selected pixels between primary and secondary image by the Image Angle Correction Module (306);
generating composite image of co-related pixels by the Image Angle Correction Module (308); and
forwarding said composite image to a display device by the Image Angle Correction Module (310).

4. A method (200) according to Claim 2, wherein determining width of blood train by the Width Determination Module further comprises steps of:

feeding a multi-coloured image with visible blood train in red scale into a Width Determination Module (402);

measuring image colour intensity by the Image Colour Intensity Measurement Module (404);

selecting the artery of interest within the object of interest by the user (406);

selecting a cross-section line of configurable pixel thickness for colour variation along the width of artery of interest by the Width Determination Module (408);

measuring width of the artery of interest by comparing immediate neighbouring configured pixels (410);

determining if the measured values are constant (412);

repeating step 408 above if the measured values are constant; else if measured values are not constant

detecting beginning of blood train (414) by measuring the width of the blood train by comparing immediate neighbouring configured pixels by the by Width Determination Module (416);

determining if said measured values of the width of blood train are constant (418);

repeating step 416 above if the said measured values are constant; else

detecting end of blood train (420).

5. A method (200) according to Claim 2, wherein determining length of blood train by the Length Determination Module (224) further comprises steps of:

feeding a multi-coloured image with visible blood train in red scale into a Width Determination Module (502);
measuring image colour intensity by the Image Colour Intensity Measurement Module (504);
selecting artery of interest within the object of interest by the user (506);
selecting a cross-section line of configurable pixel thickness for colour variation along the length of artery of interest by the Width Determination Module (508);
measuring length of blood train by comparing immediate neighbouring configure pixels by the Width Determination Module (510);
determining if said measured values are constant (512);
repeating step 508 above if the said measured values are constant; else
if measured values are not constant
detecting beginning of blood train (514) by measuring the width of blood train by comparing the immediate neighbouring configured pixel cells (516);
determining if said measured values are constant (518); and
repeating step 516 above if the said measured values are constant; else
detecting end of blood train (520).

6. A method (200) according to Claim 2, wherein determining speed of blood train by the Speed Determination Module (226) further comprises steps of:
feeding a multi-coloured image with visible blood train in red scale into a Width Determination Module (602);
selecting artery of interest within the object of interest by the user (604);
determining direction of the flow by the Direction Analysis Module (606);
marking end of blood train by identifying values by Speed Determination Module (608);
selecting a fixed point over a distance where the blood train will arrive in time by the Speed Determination Module (610);
measuring blood train by comparing immediate neighbouring configured pixel cells by the Speed Determination Module (612);
determining if the values are constant (614);
repeating step 612 above if the said values are constant; else
if measured values are not constant
determining distance of the end point to arrival at the fixed point (616); and
determining time taken from start-point to end-point (618).
FIG. 1.0
200

Start

202
Primary Imaging Module receives request to move and focus on the AOI within the OOI

204
AOI and OOI Selection module allows the user to identify the AOI

206
Primary Capture Module Captures an instance of the AOI

208
Image Angle Correction module calculates the movement of the Primary Imagine Module

210
Image Angle Correction module triggers the Secondary Imaging module to move the same amount in the direction of the Primary Imaging module

220
Image Angle Correction module matches the location of similarities and maps the image for analysis

218
Color Intensity Measurement module adjusts the color intensity to highlight the OOI

216
Image Angle Correction module interfaces the images from the Secondary and Primary Capture Modules

214
Secondary Capture Module Captures an instance of the AOI from different angle

212
Secondary Imaging Module receives request to focus on the AOI within the OOI from the Image Angle Correction module

222
Width Determination module determines the width of the blood train

224
Length Determination module determines the length of the blood train

226
Speed Determination module determines the speed of the blood train

End

FIG. 2.0
Imaging module movement output data is fed into the Image Angle Correction module.

Image Angle Correction module selects a vertical and horizontal axis sets of pixels for comparison between the primary and secondary Imaging module.

Image Angle Correction module compares the selected pixels between primary and secondary image.

Image Angle Correction generates a composite image of the co-related pixels.

Image Angle Correction forwards the composite image to a display device.

End

FIG. 3.0
Multi-coloured image with visible blood train in red scale is fed into the Width Determination module

Image colour intensity is measured by the Image Colour Intensity Measurement module

User selects the AOI within the OOI

A cross section line of configurable pixel thickness for color variation is selected across the width of the AOI

Width of blood vessel is measured by comparing immediate neighbouring configured pixel cells using standard deviation

Are the standard deviation values constant?

End of a blood train is detected

Are the standard deviation values constant?

Width of blood train is measured by comparing immediate neighbouring configured pixel cells using standard deviation

Beginning of a blood train is detected

FIG. 4.0
Multi-coloured image with visible blood train in red scale is fed into the Width Determination module (502).

Image colour intensity is measured by the Image Colour Intensity Measurement module (504).

User selects the AOI within the OOI (506).

A line of configurable pixel thickness for color variation is selected along the length of the AOI (508).

Length of blood train is measured by comparing immediate neighbouring configured pixel cells using standard deviation (510).

Are the standard deviation values constant? (512)

End of a blood train is detected (520).

Are the standard deviation values constant? (518)

Width of blood train is measured by comparing immediate neighbouring configured pixel cells using standard deviation (516).

Beginning of a blood train is detected (514).

FIG. 5.0
Multi-coloured image with visible blood train in red scale is fed into the Width Determination module.

User selects the AOI within the OOI.

Direction of the flow is determined by the Direction Analysis Module.

Speed Determination Module marks the end of the blood train (start-point) by finding the deviation in standard deviation values.

A fixed point (end-point) is selected over a distance where the blood train will arrive in (d) time.

Blood train is measured by comparing immediate neighbouring configured pixel cells using standard deviation.

Calculation is done to measure the time taken from (start-point) to (end-point).

Distance of the end point to arrival at the fixed point is measured.

Are the standard deviation values constant?

Yes

No
A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B19/00
ADD.

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
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<td>X</td>
<td>US 2005/182434 A1 (DOHERTY JOHN C [CA] ET AL) 18 August 2005 (2005-08-18) paragraphs [0051], [0056], [0059] - [0061]; figure 1</td>
<td>1</td>
</tr>
</tbody>
</table>

See patent family annex.

Date of the actual completion of the international search
7 January 2015

Date of mailing of the international search report
15/01/2015

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Authorized officer
Schindler, Martin
This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. X Claims Nos.: 2-6 because they relate to subject matter not required to be searched by this Authority, namely:

   see FURTHER INFORMATION sheet PCT/ISA/210

2. O Claims Nos. because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. O Claims Nos. because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

This International Searching Authority found multiple inventions in this international application, as follows:

1. O As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. O As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. O As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. X No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.
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Claims 2-6 define a method for measuring blood flow in a visible artery comprising the method steps of "allowing user to identify the artery of interest" and "capturing an instance (image) of the artery of interest from two different angles". These method steps require the exposure of the internal artery (see figure 2 "heart" and page 12, 1. 15-16) by a surgical intervention on the human or animal body. The claimed method steps are inextricably linked to the step of exposing the internal artery and therefore the claimed method qualifies as surgery according to Rule 39.1 (iv) PCT. No written opinion will be drafted in respect to these claims (see Art. 17(2) (a) PCT, Rule 66.1(e) PCT).