



(11) **EP 2 189 117 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication: **26.05.2010 Bulletin 2010/21** (51) Int Cl.: **A61B 8/08 (2006.01) G06T 7/00 (2006.01)**

(21) Application number: **09174826.9**

(22) Date of filing: **03.11.2009**

(84) Designated Contracting States:  
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR**  
Designated Extension States:  
**AL BA RS**

(72) Inventors:  
• **Lee, Jin Yong**  
**135-851, Seoul (KR)**  
• **Shim, Jae Yoon**  
**135-851, Seoul (KR)**

(30) Priority: **19.11.2008 KR 20080115332**

(74) Representative: **Schmid, Wolfgang**  
**Lorenz & Kollegen**  
**Patentanwälte Partnerschaftsgesellschaft**  
**Alte Ulmer Straße 2**  
**89522 Heidenheim (DE)**

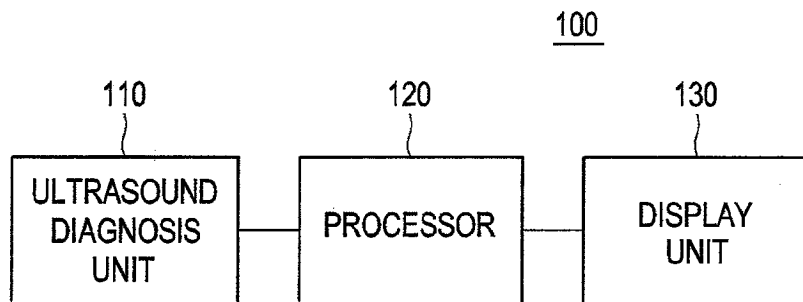
(71) Applicant: **MEDISON CO., LTD.**  
**Kangwon-do 250-870 (KR)**

(54) **Region setting for intima media thickness measurement in an ultrasound system**

(57) The present invention relates to an ultrasound system and a method of setting intima-media thickness (IMT) measuring region. The ultrasound system comprises an ultrasound diagnosis unit configured to transmit ultrasound signals to a target object, receive ultrasound echo signals reflected from the target object and form an ultrasound image including a plurality of pixels based on the ultrasound echo signals, each pixel having an intensity of gray level. The ultrasound system further comprises a processor configured to compute intensities of the

pixels at each row in the ultrasound image to form a first graph, compute first moving averages of the intensities for first subsets of rows in the ultrasound image by dividing the intensities by a thickness of a blood vessel to form a second graph, compute second moving averages of the intensities for second subsets of rows in the ultrasound image by dividing the intensities by a thickness of a vascular wall to form a third graph, and set an intima-media thickness (IMT) measuring region by using inflection points from the second and third graphs.

**FIG. 1**



**EP 2 189 117 A1**

**Description**

[0001] The present application claims priority from Korean Patent Application No. 10-2008-0115332 filed on November 19, 2008, the entire subject matter of which is incorporated herein by reference.

**BACKGROUND OF THE INVENTION**

**[Technical Field]**

[0002] The present invention generally relates to ultrasound systems, and more particularly to an ultrasound system for setting intima-media thickness (IMT) measuring region.

**[Background Art]**

[0003] The ultrasound system has become an important and popular diagnostic tool due to its non-invasive and non-destructive nature. Modern high-performance ultrasound imaging diagnostic systems and techniques are commonly used to produce two or three-dimensional images of internal features of patients.

[0004] Carotid is one of the arteries in a human body, which connects the main artery of the heart with the cerebral artery to supply blood to the brain. Two carotids exist at left and right sides of the neck. About 80% of the blood, which is supplied to the brain, may pass through the carotid. The carotid has been frequently examined using an ultrasound system to accurately evaluate carotid stenosis and arteriosclerosis. Intima-media thickness (IMT) has been used as an index to indicate the degrees of carotid arteriosclerosis. The IMT represents a thickness between lining membrane and media of the carotid.

[0005] Generally, the IMT is repeatedly measured for a small region. However, this requires significant time and effort. Thus, various IMT measurement applications for automatically measuring the IMT have been developed to achieve easy and fast measurement. However, the user is required to directly set a measuring region, which makes it highly difficult to accurately measure the IMT.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0006]**

FIG. 1 is a block diagram showing an illustrative embodiment of an ultrasound system.

FIG. 2 is a block diagram showing an ultrasound diagnosis unit.

FIG. 3 is a schematic diagram showing an ultrasound image including a plurality of pixels.

FIG. 4 is a block diagram showing a processor.

FIG. 5 is a schematic diagram showing a first graph.

FIG. 6 is a schematic diagram showing a second graph and an inflection point.

FIG. 7 is a schematic diagram showing a third graph and an inflection point.

**DETAILED DESCRIPTION OF THE INVENTION**

[0007] FIG. 1 is a block diagram showing an illustrative embodiment of an ultrasound system. The ultrasound system 100 may include an ultrasound diagnosis unit 110, a processor 120 and a display unit 130.

[0008] The ultrasound diagnosis unit 110 may be configured to transmit ultrasound signals to a target object and receive ultrasound echo signals reflected from the target object. The ultrasound diagnosis unit 110 may be further configured to form ultrasound images of the target object based on the received ultrasound echo signals.

[0009] FIG. 2 is a block diagram showing the ultrasound diagnosis unit 110. The ultrasound diagnosis unit 110 may include a transmit (Tx) signal generating section 111, an ultrasound probe 112 including a plurality of transducer elements (not shown), a beam former 113, a signal processing section 114 and an ultrasound image forming section 115.

[0010] The Tx signal generating section 111 may generate Tx signals according to an image mode set in the ultrasound system 100. The image mode may include a brightness (B) mode, a Doppler (D) mode, a color flow mode, etc. In one embodiment, the B mode is set in the ultrasound system 100 to obtain a B mode image.

[0011] The ultrasound probe 112 may generate ultrasound signals, which may travel into the target object, in response to the Tx signals received from the Tx signal generating section 111. The ultrasound probe 112 may further receive ultrasound echo signals reflected from the target object and convert them into electrical receive signals. In such a case, the electrical receive signals may be analog signals. The electrical receive signals may correspond to a plurality of ultrasound image frames, which are obtained by repeatedly performing the transmission and reception of the ultrasound

signals. The ultrasound probe 112 may be one of a three-dimensional probe, a two-dimensional probe, a one-dimensional probe and the like.

[0012] The beam former 113 may convert the electrical receive signals outputted from the ultrasound probe 112 into digital signals. The beam former 113 may further apply delays to the digital signals in consideration of distances between the transducer elements and focal points to thereby output receive-focused beams.

[0013] The signal processing section 114 may form a plurality of ultrasound data corresponding to the ultrasound image frames by using the receive-focused beams. The plurality of ultrasound data may be radio frequency (RF) data or IQ data.

[0014] The ultrasound image forming section 115 may form an ultrasound image of the target object based on the plurality of ultrasound data. Referring to FIG. 3, the ultrasound image may be formed with a plurality of pixels, each having an intensity of a gray level denoted by  $h_{11}$ - $h_{mn}$ .

[0015] The processor 120, which is shown in FIG. 1, may analyze the ultrasound image to set an intima-media thickness (IMT) measuring region on the ultrasound image. The analysis of the ultrasound image for setting the IMT measuring region will be described in detail with reference to FIG. 4.

[0016] FIG. 4 is a schematic diagram showing the configuration of the processor 120. In one embodiment, the processor 120 may include a first graph forming section 121, a second graph forming section 122, a third graph forming section 123 and an IMT measuring region setting section 124.

[0017] In one embodiment, the first graph forming section 121 may compute average intensities of the pixels at each row in the ultrasound image to thereby form a first graph. The average intensities  $f_k$  may be computed by using the following equation (1).

$$f_k = \frac{h_{k1} + h_{k2} + \dots + h_{(k-1)(n-1)} + h_{kn}}{n} \quad (1)$$

wherein "k" indicates a row of pixels in the ultrasound image, wherein "k" ranges from 1 to m, and wherein "n" indicates a number of pixels in the same row.

[0018] In another embodiment, the first graph forming section 121 may compute sum intensities of the pixels at each row and form the first graph of the sum intensities with respect to the row of pixels in the ultrasound image.

[0019] As shown in FIG. 5, the first graph forming section 121 may form the first graph of the average intensities with respect to the row of pixels in the ultrasound image.

[0020] The second graph forming section 122, which is shown in FIG. 4, may compute first moving averages of the average intensities for first subsets of the rows by dividing the intensities by a thickness of a blood vessel. As shown in FIG. 6, the second graph forming section 122 may form a second graph of the first moving averages with respect to the row of pixels in the ultrasound image. The blood vessel may be a carotid, although it is certainly not limited thereto. The first moving averages  $MA_{11}$ - $MA_{1m}$  may be computed by using the following equation (2).

$$MA_{11} = \frac{f_1 + f_2 + \dots + f_{i-1} + f_i}{i}$$

$$MA_{12} = \frac{f_2 + f_3 + \dots + f_i + f_{i+1}}{i}$$

$$MA_{1m} = \frac{f_{m-i+1} + f_{m-i+2} + \dots + f_{m-1} + f_m}{i} \quad (2)$$

wherein "i" indicates the number of pixels included within the thickness of blood vessel and "m" indicates the number of

first moving averages. Generally, the thickness of the blood vessel may range from 2 to 5 mm. For example, assuming that the thickness of the carotid is about 3 mm and the height of the pixel is 0.5 mm, "i" becomes 6.

**[0021]** FIG. 6 shows the second graph of the first moving averages with respect to the rows of pixels in the ultrasound image. Referring back to FIG. 4, the IMT measuring region setting section 124 may detect a plurality of inflection points at which an inclination of curvatures on the second graph changes and selects the inflection point ("I<sub>1</sub>" in FIG. 6) having a smallest moving average on the second graph.

**[0022]** The third graph forming section 123 may compute second moving averages of the average intensities for second subsets of the rows by dividing the intensities by a thickness of a vascular wall. As shown in FIG. 7, the third graph forming section 123 may form a third graph of the first moving averages with respect to the row of pixels in the ultrasound image. The second moving averages MA<sub>21</sub>-MA<sub>2m</sub> may be computed by using the following equation (3).

$$MA_{21} = \frac{f_1 + f_2 + \dots + f_{j-1} + f_j}{j}$$

$$MA_{22} = \frac{f_2 + f_3 + \dots + f_j + f_{j+1}}{j}$$

$$MA_{2m} = \frac{f_{m-j+1} + f_{m-j+2} + \dots + f_{m-1} + f_m}{j} \quad (3)$$

wherein "j" indicates the number of pixels included within the thickness of the vascular wall and "m" indicates the number of second moving averages. Generally, the thickness of the carotid wall ranges from 0.5 to 1.5 mm. For example, assuming that the thickness of the carotid wall is 1mm and the height of the pixel is 0.5mm, "j" becomes 2. FIG. 7 shows the third graph of the second moving averages with respect to the row of pixels in the ultrasound image. In FIG. 7, "I<sub>m</sub>" represents an inflection point having the largest second moving average on the third graph.

**[0023]** The IMT measuring region setting section 124 may detect the inflection points I<sub>1</sub> and I<sub>m</sub> on the second and third graphs. The IMT measuring region setting section 124 may detect a plurality of inflection points at which an inclination of curvatures on the second graph changes and selects the inflection point I<sub>1</sub> having the smallest first moving average value. The IMT measuring region setting section 124 may detect a plurality of inflection points at which an inclination of curvatures on the third graph changes and selects the inflection point I<sub>m</sub> having the largest second moving average value. The IMT measuring region setting section 124 may set the inflection points I<sub>1</sub> and I<sub>m</sub> on the ultrasound image. In one embodiment, the IMT measuring region setting section 124 may set the region between I<sub>1</sub> and I<sub>m</sub> as the IMT measuring region.

**[0024]** Referring back to FIG. 1, the display unit 130 may display the ultrasound image on which the IMT measuring region is set. The display unit 130 may include liquid crystal display (LCD), cathode ray tube (CRT) and the like.

**[0025]** Any reference in this specification to "one embodiment," "an embodiment," "example embodiment," "illustrative embodiment," etc. means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to affect such feature, structure or characteristic in connection with other ones of the embodiments.

**[0026]** Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, numerous variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

**Claims**

1. An ultrasound system, comprising:

5 an ultrasound diagnosis unit configured to transmit ultrasound signals to a target object, receive ultrasound echo signals reflected from the target object and form an ultrasound image including a plurality of pixels based on the ultrasound echo signals, each pixel having an intensity of gray level; and  
 a processor configured to compute intensities of the pixels at each row in the ultrasound image to form a first graph, compute first moving averages of the intensities for first subsets of rows in the ultrasound image by  
 10 dividing the intensities by a thickness of a blood vessel to form a second graph, compute second moving averages of the intensities for second subsets of rows in the ultrasound image by dividing the intensities by a thickness of a vascular wall to form a third graph, and set an intima-media thickness (IMT) measuring region by using inflection points from the second and third graphs.

15 2. The ultrasound system of Claim 1, wherein the first graph is formed by averaging the intensities of the pixels per each row in the ultrasound image.

3. The ultrasound system of Claim 1, wherein the first graph is formed by summing the intensities of the pixels per each row.

20 4. The ultrasound system of Claim 1, wherein the processor is further configured to detect a plurality of inflection points at which an inclination of curvatures on the second graph changes, select a smallest value of the inflection points in the second graph as a first inflection point, detect a plurality of inflection points at which an inclination of curvatures on the third graph changes, select a largest value of the inflection points in the third graph as a second inflection  
 25 point, and set the first and second inflection points on the ultrasound image as the IMT measuring region.

5. The ultrasound system of Claim 1, wherein the first subsets of rows are determined by dividing the thickness of the blood vessel by a size of the pixel.

30 6. The ultrasound system of Claim 1, wherein the second subsets of rows are determined by dividing the thickness of the vascular wall by a size of the pixel.

7. A method of setting intima-media thickness (IMT) measuring region in an ultrasound system, comprising:

35 a) obtaining an ultrasound image including a plurality of pixels by an ultrasound diagnosis unit within the ultrasound system;  
 b) computing intensities of the pixels at each row in the ultrasound image to form a first graph by a processor within the ultrasound system;  
 c) computing first moving averages of the intensities for first subsets of rows in the ultrasound image by dividing  
 40 the intensities by a thickness of a blood vessel to form a second graph by the processor within the ultrasound system;  
 d) computing second moving averages of the intensities for second subsets of rows in the ultrasound image by dividing the intensities by a thickness of a vascular wall to form a third graph by the processor within the ultrasound system;  
 45 e) detecting inflection points from the second and third graphs by the processor within the ultrasound system; and  
 f) setting an intima-media thickness (IMT) measuring region by using the inflection points by the processor within the ultrasound system.

50 8. The method of claim 7, wherein the step b) comprises averaging the intensities of the pixels per each row in the ultrasound image by the processor.

9. The method of claim 7, wherein the step b) comprises summing the intensities of the pixels per each row by the processor.

55 10. The method of claim 7, wherein the step e) comprising:

e1) detecting a plurality of inflection points at which an inclination of curvatures on the second graph changes;  
 e2) selecting a smallest value of the plurality of inflection points in the second graph as a first inflection point;

e3) detecting a plurality of inflection points at which an inclination of curvatures on the third graph changes; and  
e4) selecting a largest value of the plurality of inflection points in the third graph as a second inflection point.

5 11. The method of claim 10, wherein the step f) comprises setting the first and second inflection points on the ultrasound image as the IMT measuring region.

12. The method of claim 7, wherein the first subsets of rows are determined by dividing the thickness of the blood vessel by a size of the pixel.

10 13. The method of claim 7, wherein the second subsets of rows are determined by dividing the thickness of the vascular wall by a size of the pixel.

14. A computer readable medium comprising instructions that, when executed by a processor performs a method of setting intima-media thickness (IMT) measuring region, cause the processor to perform steps comprising:

- 15
- a) obtaining an ultrasound image, which includes a plurality of pixels;
  - b) computing intensities of the pixels at each row in the ultrasound image to form a first graph;
  - c) computing first moving averages of the intensities for first subsets of rows in the ultrasound image by dividing the intensities by a thickness of a blood vessel to form a second graph;
  - 20 d) computing second moving averages of the intensities for second subsets of rows in the ultrasound image by dividing the intensities by a thickness of a vascular wall to form a third graph;
  - e) detecting inflection points from the second graph and the third graph; and
  - f) setting an intima-media thickness (IMT) measuring region by using the inflection points.

25 15. The computer readable medium of claim 14, wherein the step e) comprising:

- e1) detecting a plurality of inflection points at which an inclination of curvatures on the second graph changes;
- e2) selecting a smallest value of the plurality of inflection points in the second graph as a first inflection point;
- e3) detecting a plurality of inflection points at which an inclination of curvatures on the third graph changes; and
- 30 e4) selecting a largest value of the plurality of inflection points in the third graph as a second inflection point.

35

40

45

50

55

FIG. 1

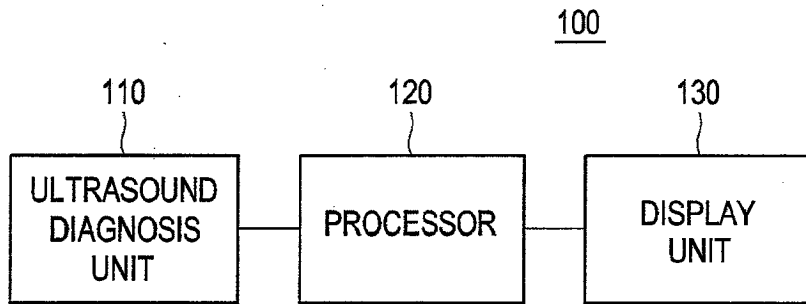


FIG. 2

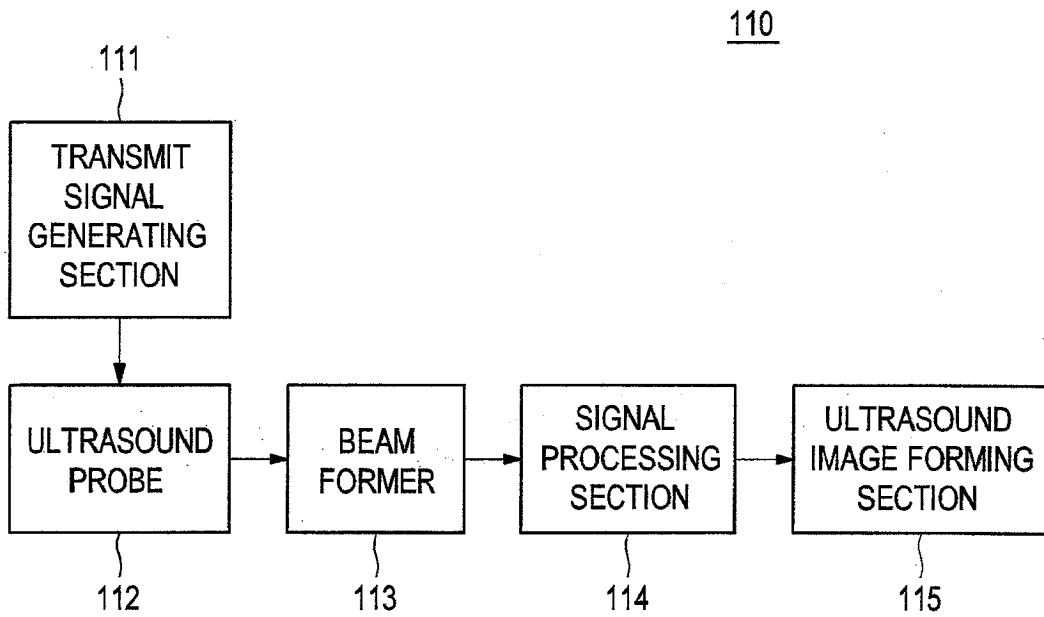


FIG. 3

$h_{11}$	$h_{12}$	$h_{13}$	...	$h_{1(n-1)}$	$h_{1n}$
$h_{21}$	$h_{22}$	$h_{23}$	...	$h_{2(n-1)}$	$h_{2n}$
$h_{31}$	$h_{32}$	$h_{33}$	...	$h_{3(n-1)}$	$h_{3n}$
$h_{41}$	$h_{42}$	$h_{43}$	...	$h_{4(n-1)}$	$h_{4n}$
$\vdots$	$\vdots$	$\vdots$	...	$\vdots$	$\vdots$
$h_{(m-1)1}$	$h_{(m-1)2}$	$h_{(m-1)3}$	...	...	$h_{(m-1)(n-1)}$
$h_{m1}$	$h_{m2}$	$h_{m3}$	...	$h_{m(n-1)}$	$h_{mn}$

FIG. 4

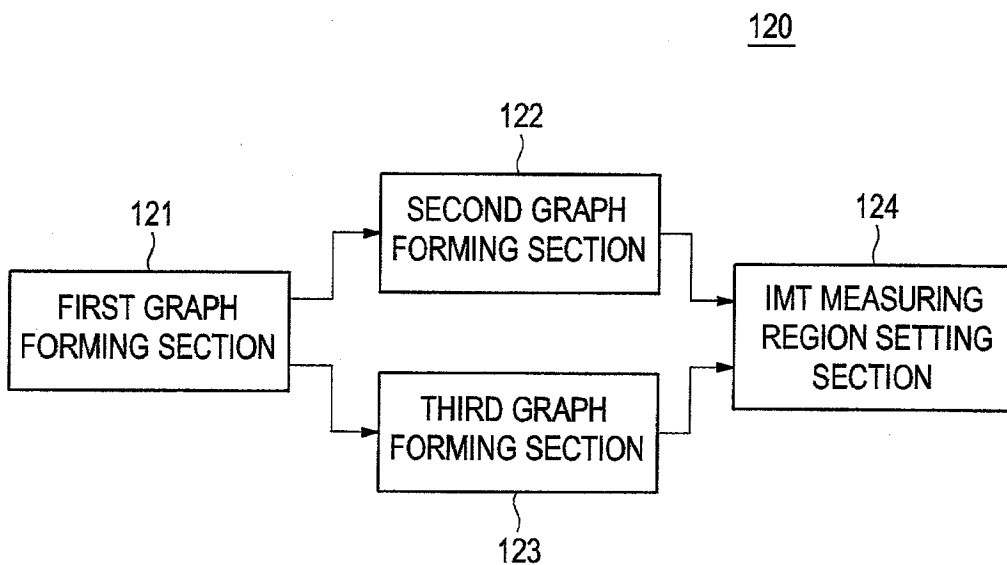


FIG. 5

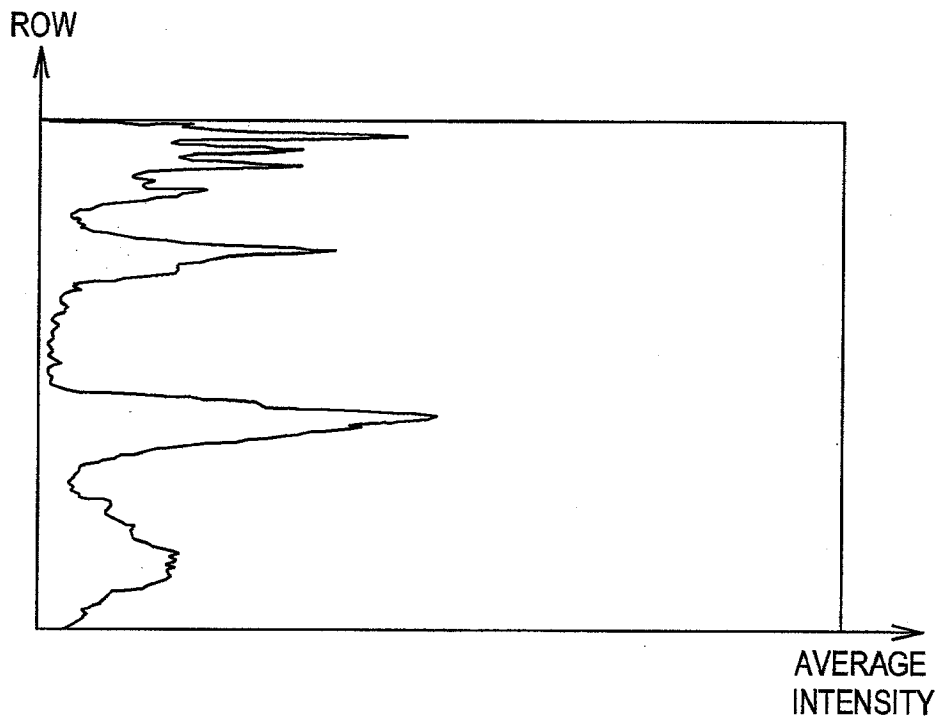


FIG. 6

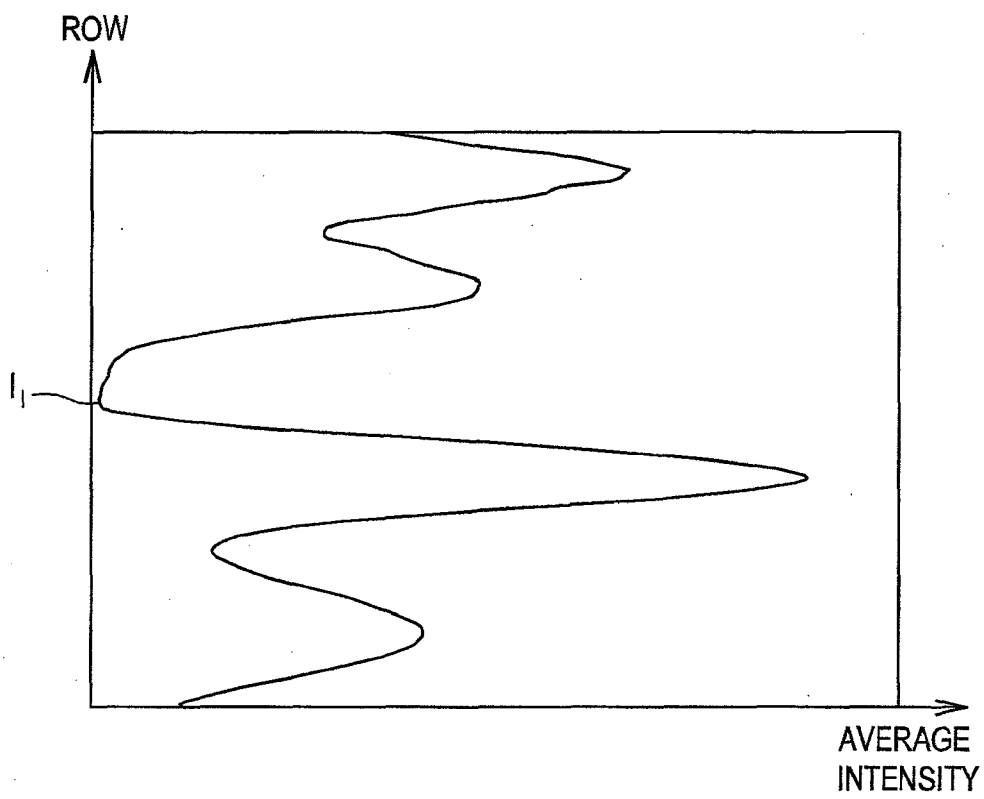
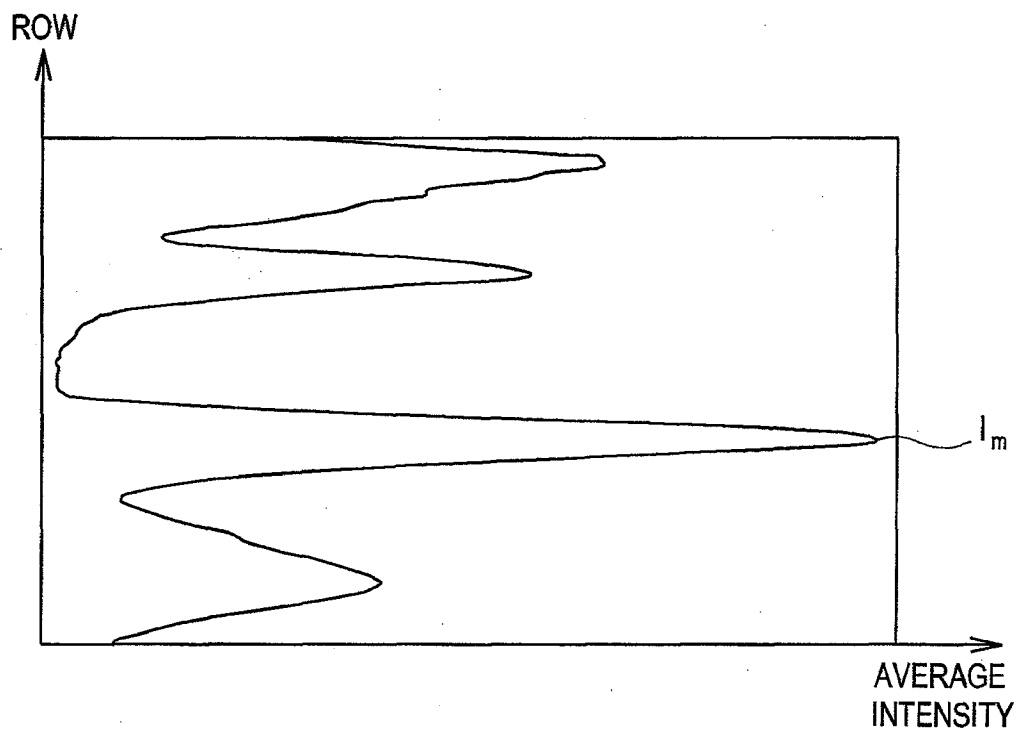


FIG. 7





EUROPEAN SEARCH REPORT

Application Number  
EP 09 17 4826

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 0 958 784 A1 (ITO MASAO [JP]; YAMASAKI YOSHIMITSU [JP]) 24 November 1999 (1999-11-24) * paragraphs [0038] - [0065] * -----	1-15	INV. A61B8/08 G06T7/00
A	US 2008/051658 A1 (DEMI MARCELLO [IT] ET AL) 28 February 2008 (2008-02-28) * abstract * -----	1-15	
A	EP 1 728 471 A1 (HITACHI MEDICAL CORP [JP]) 6 December 2006 (2006-12-06) * paragraphs [0026] - [0047] * -----	1-15	
A	WENDELHAG I ET AL: "A new automated computerized analyzing system simplifies readings and reduces the variability in ultrasound measurement of intima-media thickness" STROKE, LIPPINCOTT WILLIAMS & WILKINS, US, vol. 28, no. 11, 1 November 1997 (1997-11-01), pages 2195-2200, XP009126865 ISSN: 0039-2499 * the whole document * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) A61B
A	US 2007/038084 A1 (BURLA ELINA [IL] ET AL) 15 February 2007 (2007-02-15) * figures 3-5 * -----	1-15	
A	US 5 469 850 A (IIZUKA MIYUKI [JP] ET AL) 28 November 1995 (1995-11-28) * abstract * -----	1-15	
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>9 December 2009</b>	Examiner <b>Willig, Hendrik</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	

2  
EPO FORM 1508 03 82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.

EP 09 17 4826

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-12-2009

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0958784	A1	24-11-1999	JP 2889568 B2	10-05-1999
			JP 11318896 A	24-11-1999
			US 6132373 A	17-10-2000
-----				
US 2008051658	A1	28-02-2008	NONE	
-----				
EP 1728471	A1	06-12-2006	WO 2005087111 A1	22-09-2005
			US 2007149877 A1	28-06-2007
-----				
US 2007038084	A1	15-02-2007	JP 2007050246 A	01-03-2007
-----				
US 5469850	A	28-11-1995	JP 8206117 A	13-08-1996
-----				

**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- KR 1020080115332 [0001]

专利名称(译)	超声系统中内膜中层厚度测量的区域设置		
公开(公告)号	<a href="#">EP2189117A1</a>	公开(公告)日	2010-05-26
申请号	EP2009174826	申请日	2009-11-03
申请(专利权)人(译)	MEDISON CO. , LTD.		
当前申请(专利权)人(译)	三星MEDISON CO. , LTD.		
[标]发明人	LEE JIN YONG SHIM JAE YOON		
发明人	LEE, JIN YONG SHIM, JAE YOON		
IPC分类号	A61B8/08 G06T7/00		
CPC分类号	A61B8/0858 A61B5/02007 G06T7/0012 G06T7/62 G06T2207/10132 G06T2207/30101		
代理机构(译)	SCHMID , WOLFGANG		
优先权	1020080115332 2008-11-19 KR		
其他公开文献	EP2189117B1		
外部链接	<a href="#">Espacenet</a>		

摘要(译)

超声系统和设置内膜中层厚度 ( IMT ) 测量区域的方法技术领域超声系统包括：超声诊断单元，被配置为将超声信号发送到目标对象，接收从目标对象反射的超声回波信号，并基于超声回波信号形成包括多个像素的超声图像，每个像素的强度为灰度。超声系统还包括处理器，该处理器被配置为计算超声图像中的每行处的像素的强度以形成第一图形，通过将强度除以厚度来计算超声图像中的第一行的子集的强度的第一移动平均值通过将血管壁的厚度除以血管壁的厚度以形成第三图，计算超声图像中第二行子集的强度的第二移动平均值，并设定内膜中层厚度 ( IMT ) 通过使用来自第二和第三图的拐点来测量区域。

FIG. 1

