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(54) **ULTRASOUND IMAGING WITH ZOOM HAVING INDEPENDENT PROCESSING CHANNELS**

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(22) Filed: **Feb. 7, 2000**

Related U.S. Application Data

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(51) **Int. Cl.**[7] **A61B 8/00**
(52) **U.S. Cl.** **600/440**
(58) **Field of Search** 600/437, 440, 600/441, 443, 447; 382/128, 131–132, 298–300, 276, 284

(56) **References Cited**

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5,483,963 1/1996 Butler et al. .
6,063,032 * 5/2000 Grunwald 600/440

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2 089 537 6/1982 (GB) .
2 304 251 3/1997 (GB) .

OTHER PUBLICATIONS

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EPO Publication No. EP 0 859 242 A1, R.E. Daigle, et al., "High Resolution Ultrasonic Imaging Through Interpolation of Received Scanline Date", Feb. 13, 1997.

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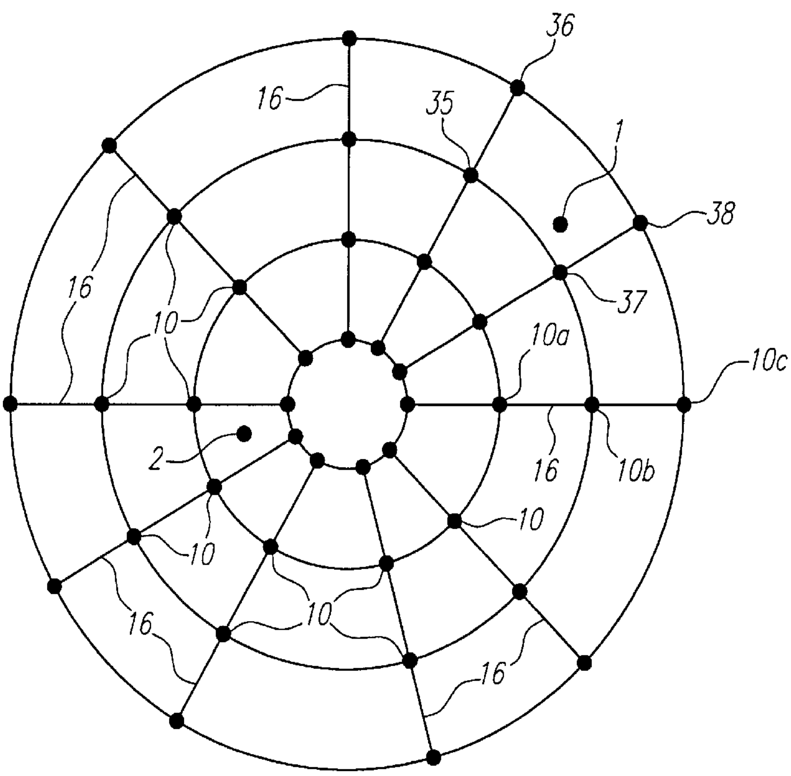
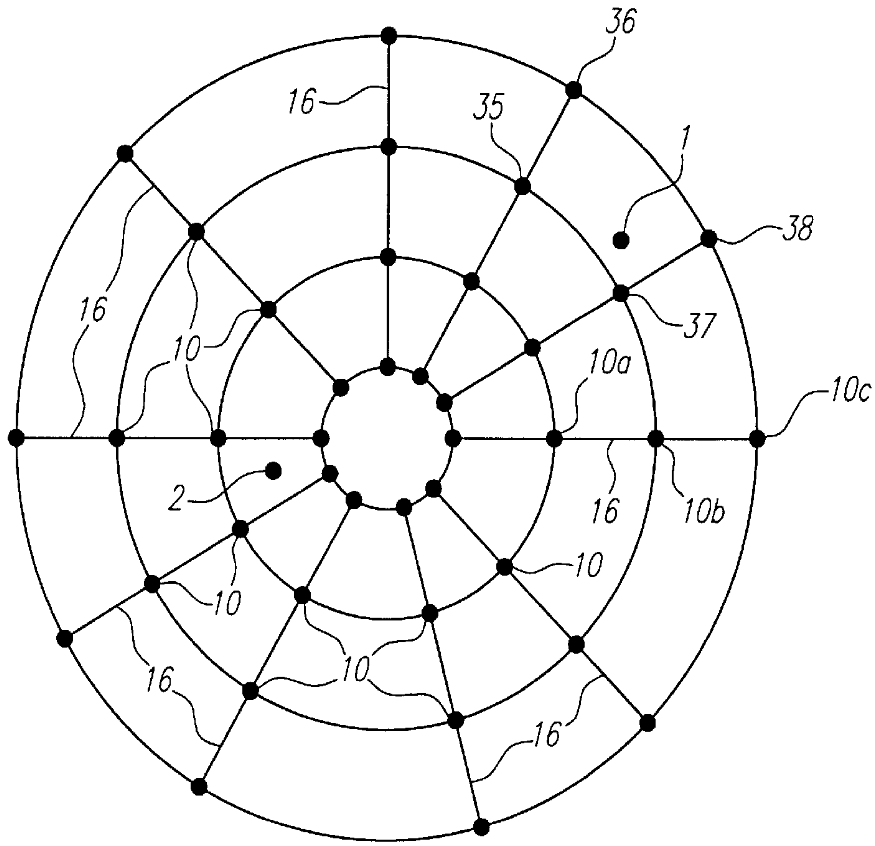
(57) **ABSTRACT**

A system and method for simultaneously displaying an ultrasound image of an area of interest and a magnified portion of the image are disclosed. Pixel locations on the display device are translated to locations within the area of interest. Signals corresponding to locations adjacent to the translated location are acquired and multiplied with coefficients. The coefficients may be varied in real time to address, for example, context dependence. The multiplied signals are summed to form an interpolated signal corresponding to a given pixel.

15 Claims, 3 Drawing Sheets




36
16
35
1
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10a
10c
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10b
2
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10
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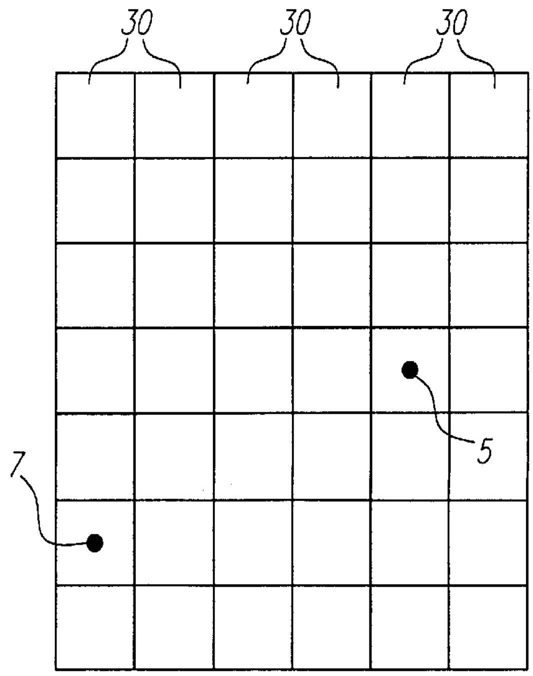
10
16

FIG. 1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7

FIG. 2

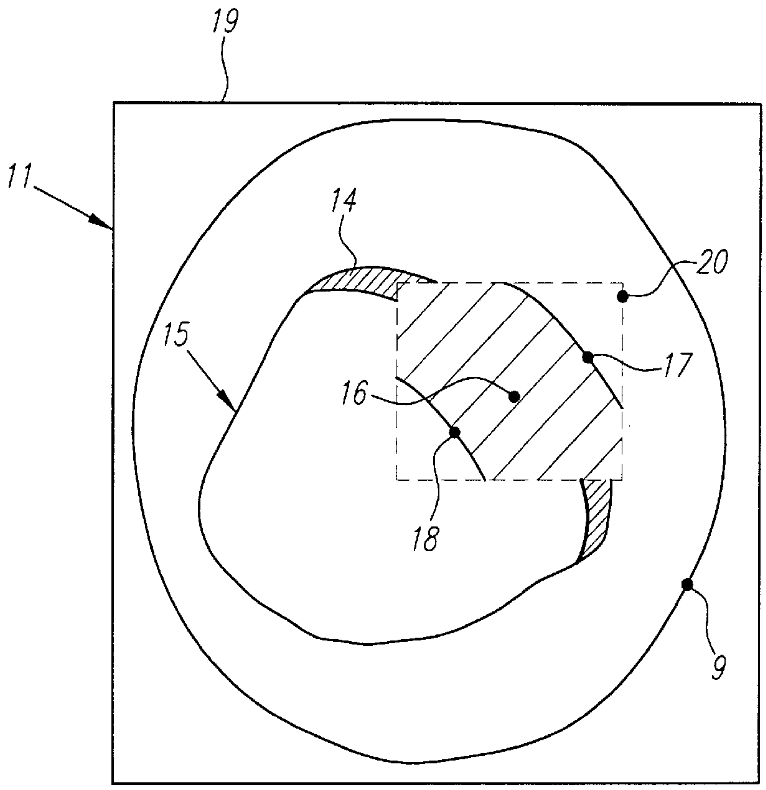

FIG. 3

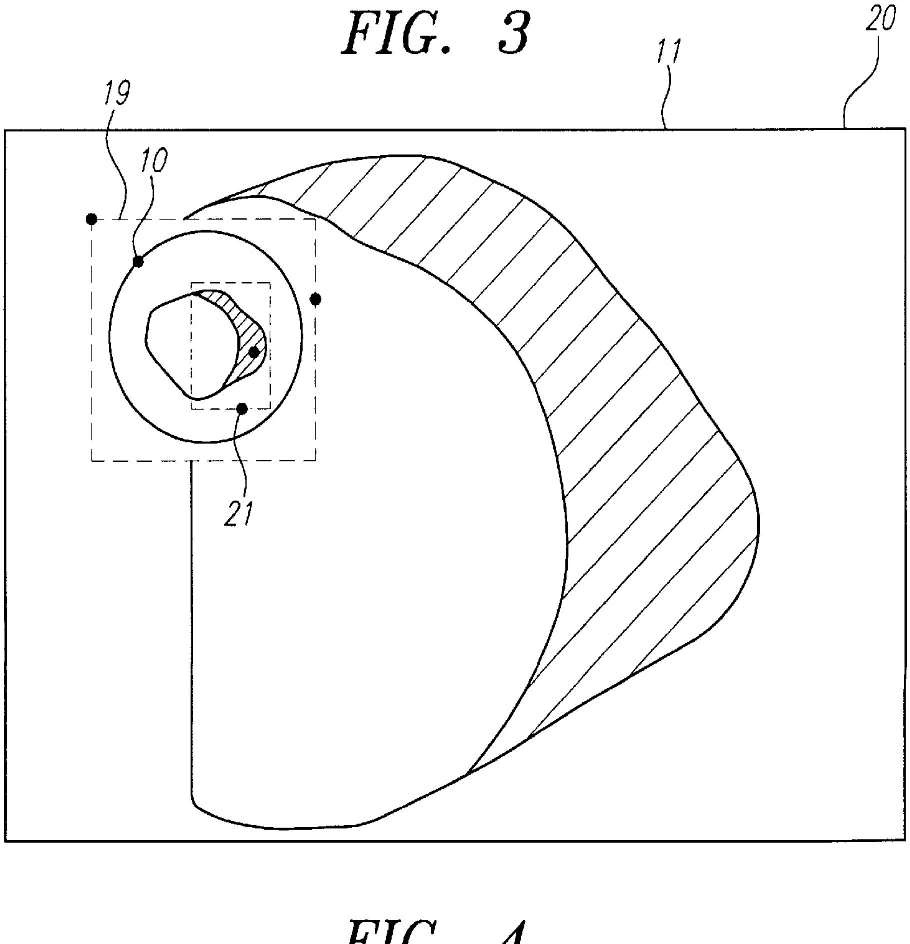

FIG. 4

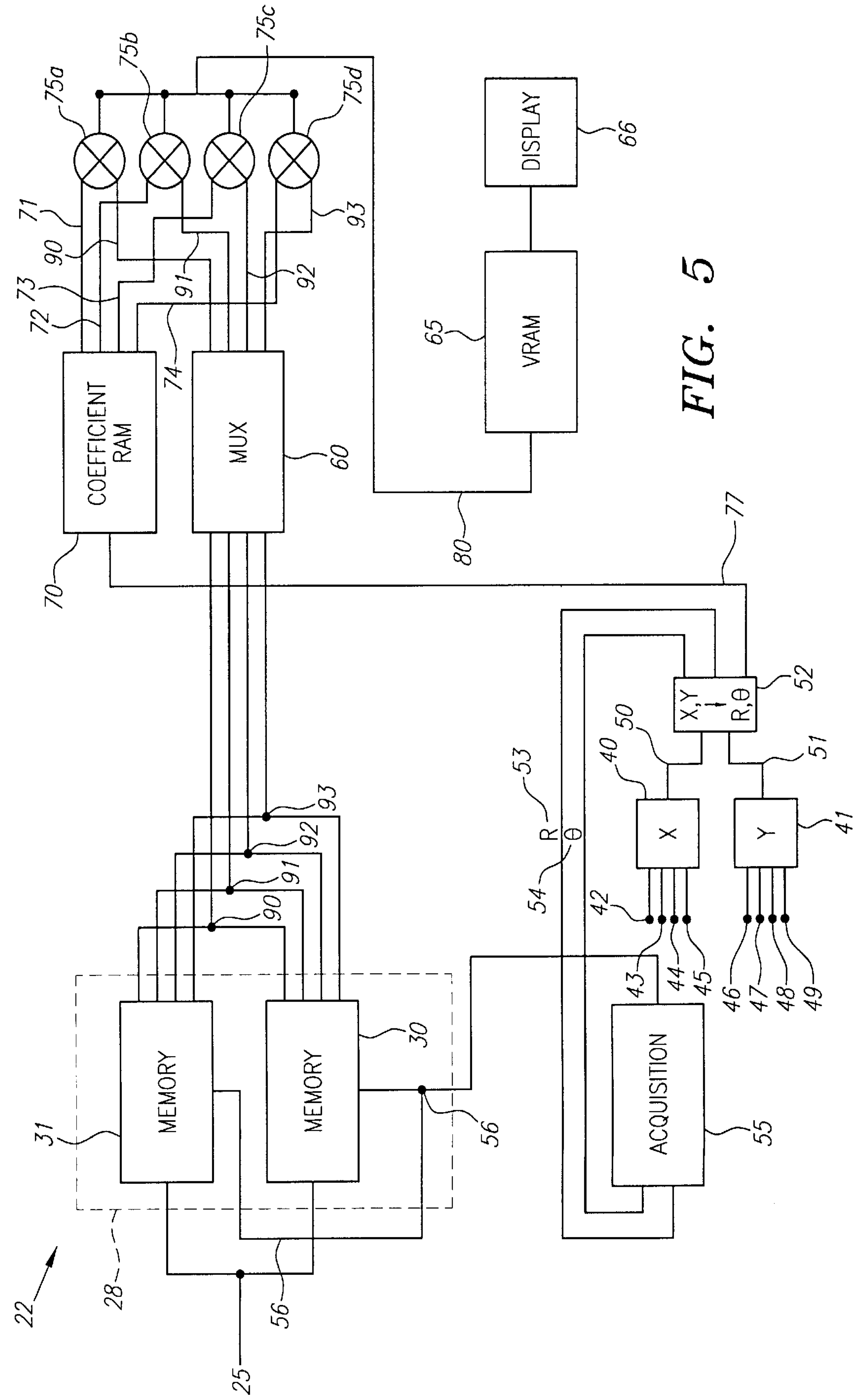
COEFFICIENT RAM
MUX
DISPLAY
VRAM
MEMORY
MEMORY
ACQUISITION
X
Y
X,Y → R,θ
R
θ

FIG. 5

ULTRASOUND IMAGING WITH ZOOM HAVING INDEPENDENT PROCESSING CHANNELS

This application is a continuation of Ser. No. 09/162,057, filed Sep. 28, 1996, now U.S. Pat. No. 6,063,032.

INTRODUCTION

This invention relates to diagnostic imaging, and more particularly relates to scan conversion systems and methods used to display enlarged portions of a diagnostic image such as an ultrasonic image.

BACKGROUND OF THE INVENTION

Diagnostic imaging systems are conventionally used in numerous medical procedures. These systems often require scan conversion techniques. For example, intravascular ultrasound systems scan within an area of interest in a vessel using a rapidly rotating catheter-mounted transducer transmitting ultrasound pulses and receiving returned echo signals. The detected ultrasound echo signals correspond to a particular R, θ location in the area of interest. For example, at a particular θ, echo signals are received corresponding to a radial distance **R1**, **R2**, etc., forming what is conventionally known as a vector of data signals. Other vectors at varying values of θ are collected to complete a scan of the area of interest. Although the data is collected according to R, θ locations, CRT displays using conventional raster scans display pixels according to Cartesian or X, Y locations. Each screen pixel display element has an X, Y coordinate position within a raster scan. This X, Y coordinate position must be mapped back to a correlated location in the area of interest in order to assign a screen pixel display level, thus forming an image on the display. The correlated location in the area of interest will not ordinarily correspond to the R, θ location of collected data. Accordingly, the screen pixel display level is generated by interpolating the signals corresponding to echoes from R, θ locations adjacent to the correlated location. The mapping and interpolation of data from R, θ to X, Y coordinates prior to CRT display is known as scan conversion.

Scan conversion and display of diagnostic images is complicated by the desires of clinicians who, in real time, want to: a) image as much of the area of interest as possible, but also b) display as much detail as possible in the resulting image. Numerous conventional "Zoom" techniques may be used to magnify portions of a main or orientation image while still displaying the full depth of the area of interest in the main image. However, prior art solutions implementing "zoom" techniques did not perform simultaneous and independent scan conversion of the main image and the magnified image.

For example, Roundhill et al., U.S. Pat. No. 5,471,989, disclose a system for processing zoom ultrasonic images. The user outlines a portion of a displayed image. The outlined portion of the image is then enlarged to occupy the larger area of the original image. Although Roundhill et al. disclose a varying filter bandwidth optimized to maximize information content of the displayed image, their system does not independently scan convert the main and magnified image windows for simultaneous display. Thus, there is a need in the art for an imaging system which can independently process a main and a magnified image simultaneously. The present invention provides a system which allows the display of both small and high magnification at the same time but in different regions of the image.

SUMMARY OF THE INVENTION

In one innovative aspect, the present invention provides a system and method for independently and simultaneously scan converting a main ultrasonic image and a magnified portion of the main image. A conventional transducer scans an area of interest and processes received ultrasound echo signals. A memory stores the plurality of received signals. These received signals correspond to the ultrasound echo from various locations throughout the area of interest. Pixel locations in a display device for both the main and the magnified window are mapped into the corresponding correlated location within the area of interest. Signals corresponding to echoes from positions adjacent to the correlated location are acquired from the memory, forming a set of acquired signals. Should the desired location correspond to an area within the main image, a display signal is interpolated from the acquired signals using a first subset of coefficients. If the desired location corresponds to an area within the magnified image, a display signal is interpolated from the acquired signals using a second subset of coefficients. The subsets may be varied according to the spatial relationship between the correlated location and the adjacent signal locations. In addition, depending on the image characteristics to be emphasized, the value of the first and second set of coefficients may be varied according to the context of the correlated location. Thus, the present invention allows independent and simultaneous scan conversion of both a main and a magnified portion of an ultrasound image. Both the main and the magnified portion may be displayed at the same time on either a conventional CRT display or another suitable display device.

DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a representation of R, θ locations corresponding to collected echo signals in an ultrasound scan.

FIG. **2** illustrates the Cartesian arrangement of pixels in a typical CRT display.

FIG. **3** illustrates an intravascular ultrasound image having a window illustrating a magnified portion according to one embodiment of the invention.

FIG. **4** illustrates an intravascular ultrasound image wherein the magnified portion occupies the display and the main image is compressed into a window on the magnified portion.

FIG. **5** is a block diagram of a scan conversion process according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Turning now to the figures, a representation of the various locations to which ultrasound echoes correspond in an intravascular ultrasound scan is illustrated in FIG. **1**. Because a rotating transducer transmits the ultrasound pulses and receives the ultrasound echoes, each particular echo signal corresponds to a particular radial distance and angle (R and θ) with respect to the transducer. For example, consider echo signal locations **10***a*, **10***b*, and **10***c*. Each is positioned at the same angle θ whereas location **10***a* corresponds to a radius **R1**, location **10***b* corresponds to a larger radius **R2**, and location **10***c* corresponds to an even larger radius **R3** and so on for other locations not illustrated. The echo signals corresponding to locations at the same angle but with varying radii are conventionally referred to as a vector **16**. An intravascular ultrasound transducer may collect many such vectors **16** consisting of echoes from signal locations **10** at the same angle θ but at varying radii as illustrated.

A problem arises in displaying the data collected according to the locations **10** in FIG. **1** using a typical CRT display. As shown in FIG. **2**, in such a display, pixels **30** are illuminated in a raster scan pattern. Thus, the pixels **30** are arranged in a Cartesian (or X, Y) pattern. Each pixel **30** must be mapped back to a correlated location within the scanned area of interest in order to form an image on the display. A given raster scan location **5** or location **7**, when mapped into its correlated location within the area of interest, will not usually align with any echo signal location **10** as shown in FIG. **1**. As shown, raster scan location **5** is mapped to correlated location **1** whereas raster scan location **7** is mapped to correlated location **2**. Neither location corresponds with any of the locations **10** from which data has been collected. Therefore, the signal level in correlated location **1** or correlated location **2** is calculated by an interpolation of the nearest R, θ locations **10**. For example, the signal level in correlated location **1** would be interpolated from signals corresponding to R, θ locations **35**, **36**, **37**, and **38**. The interpolation and mapping of the signals from the collected R, θ signal locations **10** to the Cartesian locations corresponding to pixels in the CRT display is known conventionally as scan conversion.

The present invention allows an independent and simultaneous scan conversion of both the main image and a magnified portion of the main image (conventionally known as a "zoom" image). A typical display generated by one embodiment of the present invention is illustrated in FIG. **3**. An intravascular ultrasound image **9** is displayed on a display device **11** such as a CRT display. Within the image **9** is a blood vessel **15** with plaque **16**. Orientation window **19**, which may occupy the entire display **11**, contains image **9**. A magnification window **20** shows a magnified image of the plaque **16** within the outer vessel wall **17** and the inner vessel wall **18**. The size, position, and magnification factor in magnification window **20** may be varied in real time. In addition, different interpolation factors may be used in the two windows as the context of the windows varies. The user may change these factors or the system may automatically vary the factors according to predetermined image requirements.

An alternative display generated by one embodiment of the present invention is illustrated in FIG. **4**. In this embodiment the magnification window **20** occupies the display **11**. Whereas the intravascular image **9** occupied the display in FIG. **3**, it is placed in a smaller orientation window **19** in FIG. **4**. A region of interest window **21** on image **9** within orientation window **19** demarcates the portion to be magnified. As with FIG. **3**, the magnification factor, the size and location of the region of interest window **21** may be varied in real time. In addition, different interpolation factors may be used in the orientation window **19** illustrating the image **9** and in the magnification window **20**.

A system **22** for generating the multiple display windows having varying magnification factors according to one embodiment of the invention is illustrated in FIG. **5**. A transducer (not illustrated) transmits pulses of ultrasound and receives the returned echo signals. A receiver (not illustrated) detects the returned echo signals and digitizes these signals. As the transducer completes an entire scan, a frame of echo signals **25** is collected and the digitized echo signals **25** are stored in a memory **28**. Memory **28** preferably consists of dual RAM blocks **31** and **30**. This allows more efficient operation because the blocks are alternatively written to and read from. For example, while system **22** reads a current frame of data from block **31**, the frame still being formed would be written into block **30** and so on.

The data **25** residing in memory **28** must be scan converted before display. Blocks **40** and **41** represent the X and Y raster scan translation units. Those skilled in the art will appreciate that these blocks may be implemented in software or hardware. Their function may be understood through the following discussion. As illustrated in FIG. **2**, a typical CRT display consists of pixels **30** arranged in Cartesian X and Y positions. The X, Y address of the pixels in the displayed image will correspond to an X, Y position in image **9** or in the magnification window **20**. Indeed, image **9** is simply a representation of the signal strengths received at the R, θ locations **10** shown in FIG. **1**. These locations may also be described in an X, Y Cartesian coordinate system. Translation units **40** and **41** translate the X, Y location of pixels on the CRT display to X, Y locations within the image **9** or the magnification window **20**.

X raster scan translation unit **40** may have four inputs **42**, **43**, **44** and **45**. Input **42** is the starting X address for the main or orientation window **19**. Input **43** is the magnification factor in the X direction for orientation window **19**. Input **44** supplies the starting address for the magnification window **20** with input **44** providing the corresponding magnification factor in the X direction for magnification window **20**.

Similarly, Y raster scan translation unit **41** which generates the Y raster scan address location may have four inputs **46**, **47**, **48** and **49**. Input **42** is the starting Y address for the main or orientation window **19**. Input **47** is the magnification factor in the Y direction for orientation window **19**. Input **48** supplies the starting Y address for the magnification window **20** with input **49** providing the corresponding magnification factor in the Y direction for magnification window **20**.

Translation units **40** and **41** output an X location **50** and a Y location **51** signal, respectively. Because signals **25** are stored in a plurality of R, θ vectors in memory **28**, these signals **50** and **51** must be translated into the corresponding cylindrical coordinates R location **53** and θ location **54** in coordinate transformation unit **52**. Those skilled in the art will appreciate that such a unit may be implemented in either software or hardware. As discussed previously with respect to raster scan locations **5** or **7** in FIG. **1**, R location **53** and θ location **54** will not ordinarily correspond to a the R, θ location **10** of a collected echo signal. Thus, interpolation of signals from memory **28** corresponding to R, θ locations adjacent to R location **53** and θ location **54** is normally required to calculate the signal strength at R location **53** and θ location **54**.

Acquisition unit **55** acquires the signals corresponding to adjacent locations from the memory **28**. As described previously, memory **28** stores the received signals in dual RAM blocks **30** and **31**. After a dual RAM block has had a current frame of data written into it, memory **28** writes to the other dual RAM block. Acquisition unit **55** then acquires data from the dual RAM block which stores the current frame of data. In this way, acquisition unit **55** can acquire data from a current frame without the data being corrupted by new data being written over a current data value. Acquisition unit **55** selects signals corresponding to positions adjacent to the R location **53** and θ location **54** from the dual RAM block which stores the current frame of data. As illustrated in FIG. **1**, in one embodiment of the current invention, four adjacent locations **35**, **36**, **37**, and **38** may be selected to interpolate a value for location **5** corresponding to the R location **53** and θ location **54** as determined by X and Y raster scan translation units **40** and **41**. Those of ordinary skill in the art will appreciate that a number greater or less than four adjacent signal locations could be selected by acquisition unit **55** without departing from the spirit of the invention. Those of ordinary skill will also appreciate that acquisition unit **55** may be implemented in either hardware, software, or a combination of both.

Acquisition unit **55** acquires signals **90**, **91**, **92**, and **93** corresponding to locations **35**, **36**, **37**, and **38**, respectively. Adjacent signals **90**, **91**, **92**, and **93** are input to MUX **60** which multiplexes signals **90** through **93** in that these signals will, in one embodiment of the invention, originate in one of dual RAM blocks **30** or **31** for a given frame of data and in the next frame of data originate in the other of dual RAM blocks **30** or **31**. Signals **90** through **93** are each inputted to separate multipliers **75***a* through **75***d* respectively.

Multipliers **75***a* through **75***d* also receive coefficients **71** through **74** respectively, such that multiplier **75***a* receives coefficient **71**, multiplier **75***b* receives coefficient **72**, and so on. Multipliers **75***a* through **75***d* multiply signals **90** through **93** with coefficients **71** through **74** to produce output signals which are then summed to produce interpolated signal **80**. Coefficients **71** through **74** are supplied by coefficient RAM **70** as selected by an appropriate combination of hardware and software. Coefficients **71** through **74** are varied as follows. Consider the example correlated locations **1** and **2** in FIG. **1**. Location **2** is much closer to the transducer location (the intersection of vectors **16**) than is location **1**. Therefore, correlated location **2** is much closer to the locations **10** of the adjacent echo signals than is correlated location **1** to its locations **35**, **36**, **37** and **38** of the adjacent echo signals. Accordingly, the signals **90** through **93** should be interpolated differently to assign a value to correlated location **1** than the manner in which correlated location **7** would be interpolated from signals corresponding to adjacent locations **10**. This difference is accounted for by spatial signal **77**. Spatial signal may be generated by transformation unit **77**. Spatial signal **77** relates to where the correlated location corresponding to the R location **53** and the θ location **54** is with respect to its adjacent signal locations **35**, **36**, **37** and **38**. Coefficients **71** through **74** stored in coefficient RAM **70** are selected as a function of spatial signal **77**.

In one embodiment of the invention, coefficients **71** and **74** are inversely proportional to the distance between the correlated location (mapped from the raster scan location corresponding to pixels in either image **9** or magnification window **20**) and their corresponding adjacent signal locations **35**, **36**, **37**, and **38**. For example, consider correlated location **1** in FIG. **1**. It is closest to adjacent signal location **37**. Thus, the signal from location **37** (signal **92**) should influence interpolated signal **80** corresponding to correlated location **1** more greatly than the other signals **90**, **91** and **93** corresponding to locations **35**, **36**, and **38**. Making the coefficients inversely proportional to the distance between its adjacent signal location and the correlated location would ensure that the signal **92** corresponding to location **37** would most greatly influence interpolated signal **80** because coefficient **73** (which is multiplied with signal **92**) is greater in magnitude than the other coefficients **71**, **72**, and **73**. Preferably, in this embodiment, the sum of coefficients **71** through **73** equals one.

Moreover, in addition to using a spatial dependence, coefficients **71** and **74** may also be varied as a function of whether the current display pixel (with its corresponding R location **53** and θ location **54**) is within the main image **9** or within magnification window **20**. For example, magnification window **20** may be concentrating on an area of plaque **16** which is calcified and thus requires a different form of interpolation than would a given pixel within the main image **9**. This allows the imaging to be context-dependent. Spatial signal **77** would have to be adjusted accordingly to carry this information to coefficient RAM **70**. The present invention also allows a user to adjust selection of coefficients in coefficient RAM **70** according to user preference using an input (not illustrated) into coefficient RAM **70**. Thus, the user could adjust the interpolation within the main image **9** and the magnification window **20** independently of one another.

Regardless of the type of interpolation used, an interpolated signal **80** is formed by summing the outputs of multipliers **75***a* through **75***d*. Interpolated signal **80** may then be stored in VRAM **65** before being output at display **66**. In this fashion, system **22** generates an interpolated signal **80** for each pixel in the display. Consider the advantages afforded by the present invention embodied in system **22**. R, θ signals are scan converted and mapped simultaneously and independently into the main image **9** and magnification window **20**. This happens in real time regardless of whether the display is in the embodiment illustrated in FIG. **3** or the embodiment illustrated in FIG. **4**. Moreover, those of ordinary skill in the art will appreciate that the present invention, while discussed with respect to a main image **9** and a magnification window **20**, is easily adapted to display multiple magnification windows **20** corresponding to different magnified portions of the main image **9**.

While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

1. An ultrasound imaging system for scanning an area of interest and displaying a main image of the area of interest and a magnified portion of the image, comprising:

a raster scan translation unit, said raster scan translation unit translating a pixel location on a display device to an X, Y location within the area of interest, said X, Y location being a function of whether said pixel location is within the main image or the magnified portion of the image;

a coordinate transformation unit, said coordinate transformation unit transforming said X,Y location to an R, θ location;

an acquisition unit, said acquisition unit selecting a plurality of signals from a given frame of ultrasound echo signals, the plurality of signals corresponding to locations adjacent to said R, θ location within the area of interest;

a multiplier, said multiplier multiplying each of said plurality of signals with a coefficient to produce a plurality of multiplied signals; and

a summer; said summer adding said multiplied signals to produce an interpolated signal corresponding to said pixel location, wherein the coefficient is varied according to whether the pixel location is within the main image or the magnified portion of the image for the given frame of ultrasound echo signals.

2. The ultrasound imaging system of claim **1** further comprising:

a VRAM, said VRAM storing said interpolated signal; and a display device for displaying said interpolated signal in said pixel location.

3. The ultrasound imaging system of claim **2** further comprising:

a coefficient RAM, said coefficient RAM selecting the coefficients for multiplication with said plurality of signals adjacent to said R, θ location.

4. The ultrasound imaging system of claim **3** wherein said coefficient RAM selects from a plurality of sets of coefficients, said coefficient RAM selecting from a particular one of said sets depending of the spatial relationship of said R, θ location to the corresponding locations of said plurality of signals.

5. The ultrasound imaging system of claim **4** wherein said coefficient RAM further selects from a plurality of sets of coefficients depending on the context of the R, θ location.

6. The ultrasound imaging system of claim **3** wherein said acquisition unit selects at least four signals corresponding to locations adjacent to said R, θ location within the area of interest.

7. The ultrasound imaging system of claim **6** wherein said set of coefficients selected by said coefficient RAM has a sum, said sum substantially equaling one.

8. A method for displaying a main ultrasound image of an area of interest and a magnified portion of the main image, said method comprising:

collecting a frame of signals corresponding to echo locations within the area of interest;

generating a set of pixel locations corresponding to a raster scan;

correlating a given pixel location to a correlated location within the area of interest according to whether the pixel location is within the main image or the magnified portion of the main image;

acquiring a subset of signals from the set of signals corresponding to echo locations adjacent to the correlated location;

multiplying the subset of signals with a set of coefficients to generate a display signal level for the given pixel, wherein the set of coefficients is varied according to whether the given pixel is within the main image or the magnified portion of the main image;

repeating said correlating, acquiring and multiplying steps to generate display signal levels for all the pixels within the main image and the magnified portion of the image in real time.

9. The method of claim **8** wherein said set of coefficients in said multiplying step is selected according to a spatial relationship between the correlated location and the echo locations adjacent to the correlated location.

10. The method of claim **8** further comprising the step of storing said generated display signal levels in a VRAM.

11. The method of claim **8** wherein said subset of signals in said acquiring step and said multiplying step comprises at least four signals.

12. The method of claim **11** wherein said set of coefficients in said multiplying step has a sum, said sum substantially equaling one.

13. The method of claim **11** wherein said set of coefficients in said multiplying step is varied according to the context of the correlated location.

14. The method of claim **8** wherein said echo locations within the area of interest correspond to R, θ locations.

15. A method of displaying a main ultrasound image of an area of interest in a patient and a magnified portion of the main image, said method comprising:

collecting signals from a ultrasound transducer scanning the area of interest, said collecting step forming a frame of signals, said frame of signals corresponding to echo locations within the area of interest;

generating a raster scan for a display device, said raster scan corresponding to pixels in the display device;

assigning a signal level for each pixel corresponding to said raster scan by sequentially mapping the location of a given pixel into a correlated location within the area of interest, said mapping depending on whether the given pixel is within said main image or said magnified portion of the image, said signal level being formed by an interpolation of signals corresponding to echo locations adjacent to the correlated location, the interpolation being varied according to whether the given pixel is within the main image or the magnified portion of the image, whereby said main image and said magnified image are formed independently in real time from said frame of signals.

* * * * *

专利名称(译)	具有独立处理通道的变焦的超声成像		
公开(公告)号	US6217517	公开(公告)日	2001-04-17
申请号	US09/499270	申请日	2000-02-07
[标]申请(专利权)人(译)	波士顿科学有限公司		
申请(专利权)人(译)	SCIMED LIFE SYSTEMS INC. BOSTON SCIENTIFIC LIMITED		
当前申请(专利权)人(译)	SCIMED LIFE SYSTEMS INC. BOSTON SCIENTIFIC LIMITED		
[标]发明人	GRUNWALD SORIN		
发明人	GRUNWALD, SORIN		
IPC分类号	G01S7/52 A61B8/00 G01S15/89		
CPC分类号	G01S7/52034 G01S7/52044 G01S7/52074 G01S7/52025 G01S7/52073		
外部链接	Espacenet USPTO		

摘要(译)

公开了一种用于同时显示感兴趣区域的超声图像和图像的放大部分的系统和方法。显示设备上的像素位置被转换为感兴趣区域内的位置。获取对应于与翻译位置相邻的位置的信号并将其与系数相乘。系数可以实时变化以解决例如上下文依赖性。对相乘的信号求和以形成对应于给定像素的内插信号。