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(54) **SHAPE INJECTION INTO ULTRASOUND IMAGE TO CALIBRATE BEAM PATTERNS IN REAL-TIME**

FORMINJEKTION IN EIN ULTRASCHALLBILD ZUR KALIBRIERUNG VON STRAHLENMUSTERN IN ECHTZEIT

INJECTION D'UNE FORME DANS UNE IMAGE ULTRASONORE DE FAÇON À ÉTALONNER EN TEMPS RÉEL DES MOTIFS DE FAISCEAU

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**WO-A1-92/16148 WO-A1-2005/055849  
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## Description

### BACKGROUND:

#### Technical Field

[0001] This disclosure relates to medical instruments and more particularly to a system and method for highlighting instruments in images with special shapes using acoustics.

#### Description of the Related Art

[0002] Needles, catheters and other interventional tools are often difficult to visualize under ultrasound due to their specular nature and unfavorable incidence angles. One solution for marking a needle tip under ultrasound guidance is to embed a small ultrasound sensor at the tip of the needle. Such a sensor receives the direct ultrasound signals that impinge upon it as imaging beams from an ultrasound imaging probe sweep the field of view. Different ways of using these signals to highlight the position of the transducer in the ultrasound image have been proposed. These ways rely on time-of-flight of ultrasound from the imaging probe to the sensor for estimating the range coordinate of the sensor, and on the intensity of the received signals as the imaging beams sweep the field of view to recover the lateral coordinate. To estimate time of flight, one must have access to the line trigger events of the scanner, and to estimate the lateral coordinates, one must have access to the frame trigger event and to the coordinates and steering angles of the imaging beams.

[0003] A document WO2005055849A1 discloses a device consisting of a hollow introducer catheter and inside another catheter with a puncture needle. The internal puncture catheter or flexible needle is pushed out to perform a therapeutic or diagnostic puncture. A method for positive ultrasonic localization of a point on an indwelled device, e.g. the said outer or the said inner needle catheter, consists of ultrasonic marking of the catheter and the needle and the use of a transponder to generate a visible mark on the ultrasound scanner screen.

[0004] A document US2013/0041252A1 discloses an ultrasound receive beamformer that is configured for one-way only beamforming of transmissive ultrasound using one-way delays. The receive beamforming in some embodiments is used to track, in real time, a catheter, needle or other surgical tool within an image of a region of interest.

[0005] A document WO92/16148 discloses an ultrasonic imaging system comprising a display which enables the practitioner to visualize a portion of a patient's body. A catheter is inserted into an artery of the patient and its location is viewed on a display. To determine the progress of the catheter, a transducer secured to the catheter provides an electrical signal when the surface

of the transducer is impinged upon by ultrasonic waves.

[0006] A document US4249539 discloses a B-scan pulse echo ultrasound system that produces a real time image of a body area under inquiry, and an aspiration needle. The needle carries an omni-directional ultrasound transducer, electrically connected through the needle to transponder electronics. Incident pulses from the imaging transducer to the omni-directional transducer are sensed at the latter, and the position thereof is inserted into the image either by generation of a return signal from the needle point, or through delay logic and subsequent production of a composite.

[0007] A document by Breyer, B et al, entitled "Ultrasonically marked catheter - A method for positive echographic catheter position identification"; Medical and Biological Engineering and Computing, Springer, Heidelberg, DE, Vol. 22, No. 1, 1st May 1984, pp268 - 271 discloses various methods of catheter tip visualization under ultrasound, including an ultrasonically-marked catheter.

[0008] Document US5921930A describes an arrangement for locating concretions in a patient's body that has an acoustic scanning device, a coupling arrangement and an arrangement for producing a marking. The marking arrangement consists of a sensor which is transparent to emitted sound waves and is designed such that, after the expiration of an adjustable delay time, it generates a signal which can be injected as a marking at a predetermined point into the sonic image.

### SUMMARY

[0009] In accordance with the present principles, a system for highlighting an instrument in an image includes a probe for transmitting and receiving ultrasonic energy to and from a volume and a marker device configured to respond to a received ultrasonic signal and emit an ultrasonic signal after a delay. The ultrasonic signal includes one or more pulses configured to generate a marker, when rendered, of a given size at a position within an image. A medical instrument is disposed in the volume and includes the marker device. A control module is stored in memory and is configured to interpret the ultrasonic energy received from the probe and from the marker device to determine a three dimensional location of the medical instrument and to highlight the three dimensional location of the marker device with the marker in the image.

[0010] Another system for injecting a shape in an image includes a probe for transmitting and receiving ultrasonic energy to and from a volume and a marker device configured to respond to a received ultrasonic signal and emit an ultrasonic signal after a delay. The ultrasonic signal includes one or more pulses configured to generate a marker, when rendered, of a given size at a position within an image. A medical instrument is disposed in the volume and includes the marker device. A workstation includes a processor and memory. The memory stores

a control module configured to interpret the ultrasonic energy received from the probe and from the marker device to determine a three dimensional location of the medical instrument and to highlight the three dimensional location of the marker device with the marker in the image and an image processing module configured to compare a position and shape of the injected signal to an on-screen video output of a position and shape of the marker to determine beamforming parameters.

**[0011]** A method for providing a shaped marker in an image includes estimating a frame rate of an imaging probe; analyzing traces within a detection window to find a temporal maximum which best matches a position of a marker device mounted on an instrument to determine an arrival time; injecting an acoustic feedback signal into the imaging probe by emitting a delayed signal from the marker device to the imaging probe, the delayed signal including one or more timed pulses to simulate a marker shape in an echo back from the marker device; and displaying the marker shape in an image to identify the position of the instrument.

**[0012]** These and other objects, features and advantages of the present disclosure will become apparent from the following detailed description of illustrative embodiments thereof, which is to be read in connection with the accompanying drawings.

**[0013]** The invention is defined in the appended independent claims. Embodiments of the invention are defined in the dependent claims. The use of the word "embodiment" below in this description merely implies the illustration of examples or exemplary embodiments, if not otherwise defined by the appended claims. The scope of the invention is thus defined by the appended claims.

## BRIEF DESCRIPTION OF DRAWINGS

**[0014]** This disclosure will present in detail the following description of preferred embodiments with reference to the following figures wherein:

FIG. 1 is a block/flow diagram showing a system for providing a shaped, acoustically rendered marker in an ultrasound image in accordance with one embodiment;

FIG. 2 is a conceptual diagram showing a system for providing the shaped, acoustically rendered marker in accordance with one embodiment;

FIG. 3 is a diagram showing images having shaped, acoustically rendered markers shown in accordance with other embodiments;

FIG. 4 is a plot of amplitude versus time showing ultrasound pulses for estimating frame rate in accordance with one embodiment;

FIG. 5 is a plot of amplitude versus time showing an ultrasound pulse for determining a detection time in accordance with one embodiment;

FIG. 6 is an event time line showing events occurring between a marker device of an instrument/tool and

a probe in accordance with one embodiment; and FIG. 7 is a flow diagram showing a method for providing a shaped acoustically rendered marker in an ultrasound image in accordance with one illustrative embodiment.

## DETAILED DESCRIPTION OF EMBODIMENTS

**[0015]** In accordance with the present principles, systems and methods permit highlighting of a position of a sensor using special shapes and/or effects. A sensor or sensors are employed on a medical device (e.g., an interventional device) to 'inject' an acoustic signal at a right time inside an ultrasound (US) image. This injected acoustic signal will be perceived by the scanner as a response to its own acoustic field. The signal is processed by a scanner's beamforming pipeline and ultimately, visualized on the US image. Note that even though we may not know the time when the acoustic waves were transmitted by the scanner, the acoustic waves will nevertheless create a signal on the sensor, which is exploited for highlighting the sensor. When the device is inserted inside the US region, a one-time calibration step is run to estimate a frame rate ( $T$ ) of the imaging mode being used. Second, a temporal maximum ( $t_0$ ) of the signals received by the sensor is found, with respect to an arbitrary origin. Third, the sensor is switched to a transmit mode, and an impulse is emitted from it at a time  $t_1 = t_0 + nT + S_i$ ,  $n$  being an integer and  $S_i$  providing pulses (times) to generate a desired shape or shapes. That impulse propagates toward an imaging probe and a subsequent signal is beamformed by the scanner machine. A final visual display shows an echo coming from the sensor location and having the desired shape or shapes.

**[0016]** Piezoelectric sensors are employed to inject special temporal acoustic signals inside the tissue. Since the US scanner will perceive this signal to be part of its own 'reflected' acoustic wave, it will place this signal inside the US image. Note that due to transmission and absorption losses of the original acoustic wave of the scanner, the injected signal will have, e.g., a greater than 30 dB signal advantage over the reflected signal from tissue. More notably, special temporal patterns are provided during signal injection. These patterns will result in planned special shapes in the US image. Injected shapes could include concentric circles, ellipses, arrows, lines, curves, crosses, three dimensional objects, etc. of any shape, size and position in the image, as desired by the automatic injection system. Note that this shape can be injected 'permanently' in the image so that a user can see it all the time, or injected just instantaneously in one single US frame, making it practically invisible to the user. These shapes or markers are provided to mark a tool position or may be employed to be offset to indicate or track other useful positions in real-time. The present embodiments describe 2D images (e.g., right and left beams, and 2D shapes); however the 2D arrays, images and shapes may be extended and include 3D arrays,

images and shapes.

**[0017]** Additionally, since most US scanners also provide a video-out, the video-out signal, together with the injected signal, can be analyzed to quantitatively estimate the internal beam-forming and scan conversion parameters. Since the approximate position and shape of the injected signal is known, a priori, an automated algorithm can pick the exact position and size of the shape from the US image (a function of the internal parameters). This position and shape can then be compared to the estimated injected shape. An optimization routine can then estimate the internal beam-forming and scan conversion parameters. Based on the current parameters, a new shape can now be injected. This process can be performed sequentially in a closed-loop manner, by injecting and detecting an updated shape of varying size/position. For example, the shape could start with an ellipse and end with two concentric circles as the parameters become known. Parameters that can be automatically estimated include beam-angles, absolute beam firing times, left beam number, right beam, depth, etc. This complete self-calibration process could be shown to the user or be kept 'invisible'.

**[0018]** The present principles permit less reliance on the availability of particular scanner data for pinpointing the position of an instrument. For example, a frame, line triggers and beamforming parameters are no longer needed from the scanner. This allows ultrasound-equipped tools to be self-contained (no need for low-level interfacing with the scanner) thus allowing them to be usable with a broad installed base of ultrasound machines from any vendor. In one embodiment, the system is capable of on-the-fly reverse-engineering of crucial parameters from the imaging scanner, e.g., frame rate and line trigger positions, analog acoustic signal injection into the scanner's receive signal path, etc.

**[0019]** It should be understood that the present invention will be described in terms of needles; however, the teachings of the present invention are much broader and are applicable to any medical instruments or other instruments tracked by acoustic energy. In some embodiments, the present principles are employed in tracking or analyzing complex biological or mechanical systems. In particular, the present principles are applicable to internal tracking procedures of biological systems, procedures in all areas of the body such as the lungs, gastrointestinal tract, excretory organs, blood vessels, etc. The elements depicted in the FIGS. may be implemented in various combinations of hardware and software and provide functions which may be combined in a single element or multiple elements. The present embodiments may be employed any time an instrument is inserted into the body under ultrasound guidance, this includes needle procedures (biopsies, ablation, anesthesia, pain management, abscess drainage, etc.), catheter procedures (heart repair, electrophysiology, etc.) or any other procedures.

**[0020]** The functions of the various elements shown in

the FIGS. can be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions can be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which can be shared. Moreover, explicit use of the term "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and can implicitly include, without limitation, digital signal processor ("DSP") hardware, read-only memory ("ROM") for storing software, random access memory ("RAM"), non-volatile storage, etc.

**[0021]** Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future (i.e., any elements developed that perform the same function, regardless of structure). Thus, for example, it will be appreciated by those skilled in the art that the block diagrams presented herein represent conceptual views of illustrative system components and/or circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams and the like represent various processes which may be substantially represented in computer readable storage media and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

**[0022]** Furthermore, embodiments of the present invention can take the form of a computer program product accessible from a computer-usable or computer-readable storage medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer readable storage medium can be any apparatus that may include, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The medium can be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk - read only memory (CD-ROM), compact disk - read/write (CD-R/W), Blu-Ray™ and DVD.

**[0023]** Referring now to the drawings in which like numerals represent the same or similar elements and initially to FIG. 1, a system 100 is illustratively shown in accordance with one embodiment. System 100 may include a workstation or console 112 from which a procedure is supervised and/or managed. Workstation 112

preferably includes one or more processors 114 and memory 116 for storing programs and applications. Memory 116 may store an image processing module 115 configured to process signals from an ultrasonic scanner 125. Module 115 is configured to use the US signals to reconstruct structures deformations, deflections and other changes associated with a medical device, instrument or tool 102 and/or its surrounding region. The medical instrument 102 may include a needle, a catheter, a guidewire, a probe, an endoscope, a robot, an electrode, a filter device, a balloon device, or other medical component, etc.

**[0024]** An acoustic sensor (including a transmitter or transponder) 120 is mounted on the medical instrument 102 to be highlighted. A probe 122, such as a US probe 122 is provided for scanning a patient or subject 160. The probe 122 is capable of reception (to sense signal emission by the probe 122). The received signals at the probe 122 are coupled to a simple data-analysis and control module 124 stored in memory 116 and capable of some amount of signal processing in algorithm/program 123 (e.g., Fast Fourier Transform (FFT), max identification, optional curve fitting, etc.). It should be understood that the control module 124 and the image processing module 115 may be combined in a single component or provided separately, as indicated.

**[0025]** In particularly useful embodiments, the ultrasound sensor 120 is placed at the tip of a needle (for example). That sensor 120 senses ultrasound signals as beams from the imaging probe 122 as it sweeps the field of view. The US signals are analyzed by the workstation 112 and/or in the control module 124 to extract a frame repetition period  $T$ , and a time of arrival  $t_0$  of a maximum signal at the sensor 120. One or more frames later, the sensor 120 is switched into a transmit mode and emits a pulse that includes shape effects  $S_i$  (at, e.g.,  $t_0 + T + S_i$  or  $t_0 + nT + S_i$ , where  $n$  is an integer). The scanner 125 interprets the pulse as being a high echo coming from a position of the sensor 120, thus highlighting the sensor 120 and, in turn, the instrument 102 on an image 150 even under slight out-of-plane alignment.

**[0026]** In particularly useful embodiments, the ultrasound sensor or marker device 120 includes a receive function 130 and a transmit function 132. The ultrasound sensor 120 may include a receiver/transmitter pair, a transponder or a transducer with a transmitter/receiver (T/R) switch on the interventional tool or instrument 102 to be highlighted. A transponder is a device that emits an identifying signal in response to an interrogating received signal. The signal received at the receiver function 130 of the sensor 120, while the imaging probe 122 emits ultrasound into the medium, is coupled to the data-analysis control module 124 capable of signal processing (FFT, max identification, optionally curve fitting) and slow switches. The transmit function 132 is provided for acoustic signal injection back into the medium (to the probe 122 to be processed in the control module 124). In one example, the sensor 120 aboard the tool 102 includes a

transponder (which is also used in a transmit mode). This may call for higher voltage circuits (in the tens of volts) and need to reasonably match the frequencies of the imaging probe 122 and that of the transponder (the signal from the transponder need not be filtered out in the scanner's receive signal path). The transponder may also include a transmit/receive (T/R) switch to switch between a receive mode and transmit mode. In another example, an additional ultrasound emitter for the transmit function 132 may be placed on the device close to the receiver function 130 (or co-located as a transceiver so that received and transmitted signals have a common location). This eliminates the need for a T/R switch and simplifies the detection / injection software.

**[0027]** A display 118 shows a location of the sensor and includes the shapes or visual effects of the injected signal ( $S_i$ ). Display 118 may also permit a user to interact with the workstation 112 and its components and functions, or any other element within the system 100. This is further facilitated by an interface 140 which may include a keyboard, mouse, a joystick, a haptic device, or any other peripheral or control to permit user feedback from and interaction with the workstation 112.

**[0028]** In another embodiment, a video signal-out from the scanner 125 and the instrument 102 with the sensor 120 are employed to compute a 3D location of the instrument 102 at any given time. The video-out signal is easily available on commercial scanners and is streamed into the computational workstation 112.

**[0029]** When the sensor 120 is switched to transmit mode and an impulse is emitted therefrom, the impulse propagates toward the imaging probe 122 and the subsequent signal is beamformed by the scanner 125. A final display provides an echo coming from the sensor location. For example, one or more frames later, when the sensor 120 is switched into transmit mode, a series of pulses may be emitted at times  $(t_0 + T + S_i)$ , where  $S_i$  determines a shape observed/marked on the US image.

**[0030]** Referring to FIG. 2, a conceptual diagram shows interaction between components in accordance with one illustrative embodiment. Signal injection is performed with the sensor 120 with a timed or responsive US emission. The sensor 120 is placed at the tip of the device 102 to be highlighted. Example signals 136 received by that sensor/transponder 120 during one imaging frame from the probe 122 are shown. The sensor 120 senses ultrasound signals 136 as beams from the imaging probe 122 sweep. The signals 136 are analyzed to extract the frame repetition period  $T$ , and the time of arrival  $t_0$  of the maximum signal at the sensor 120. One or two (or more) frames later (138), the sensor 120 is switched into transmit mode and emits a pulse (at, e.g.,  $t_0 + T + S_i$  or  $t_0 + nT + S_i$ ). The scanner 125 interprets the pulse or pulses as being a high echo coming from the position of the sensor 120, thus highlighting it on an image 150.

**[0031]** The system 100 identifies the position of the maximum and its timing relative to the line trigger infor-

mation from plots 144 and 146. One (or more) frame period(s) 138 later, a signal 141 is injected by the sensor/transponder 120 back to the probe 122 with the appropriate timing to generate a bright marker or markers 142, 143, 145, 147 where the sensor 120 is located and is visible on the display 118. Illustrative markers 142, 143, 145, 147 are depicted with unique shapes. Marker 142 includes concentric circles about a pinpointed position of the sensor 120. Marker 143 includes a star-like shape centered on the pinpointed position of the sensor 120. Marker 145 includes an arrow shape pointing to the pinpointed position of the sensor 120. Marker 147 includes an "X" shape pointing to the pinpointed position of the sensor 120.

**[0032]** In particularly useful embodiments, if  $S_i$  is fixed to just a single fire or pulse firing and set to 0, then the marker seen on the image will just be a dot. In other examples, if  $S_i$  is set to  $-2t_0$ ,  $-t_0$ , 0,  $t_0$ ,  $2t_0$ , then the response will be a small line segment roughly parallel to the horizontal axis. In sector and curved probe geometries, the curvature of this line segment will allow on-the-fly identification of the beamforming and scan conversion parameters. Note that for a linear scanner, increasing the number of fires at periodic time slots will create a long horizontal line. If  $S_i$  is set to  $-k(t_0 + x)$  where  $k$  goes from  $-K$  to  $+K$ , a slanted straight line is created on a linear probe where the slope depends on  $x$  and the length of the segment depends on  $K$ . By controlling  $x$  and observing the response on the image, the beam-forming and scan conversion parameters can be estimated.  $S_i$  can similarly be set to a variety of functions to get a variety of shapes such as circles, ellipses, stars, etc.

**[0033]** Note that this shape or marker can be injected 'permanently' in the image 150 so that a user can see it all the time, or injected just instantaneously in one single US frame, making it practically invisible to the user. Additionally, since most US scanners also provide a video-out 152, the video-out signal can be analyzed, together with the injected signal, to quantitatively estimate the internal beam-forming and scan conversion parameters in the image processor or processing module 115.

**[0034]** In one embodiment, the image processing module 115 compares the approximate position and shape of the injected signal 141, which is known, a priori, to the video out image 152 using an automated algorithm or program 154, configured to determine an exact position and size of the shape (e.g., marker 142, 143, 145, 147) from the US image 150. This can be as a function of the internal display parameters or pixel assignments, etc. The position and shape is compared to the estimated injected shape. An optimization routine 156 can then estimate the internal beam-forming and scan conversion parameters. This comparison may be employed as a check on position or may be employed for other functions. For example, based on the current estimate of the internal parameters, a new shape can now be injected at a same or different position. Note that this process can be done sequentially in a closed-loop manner, by injecting and

detecting an updated shape of varying size/position. This can be employed to impose blinking effects, alternating size increased/decreases, spinning or translating shapes, etc.

**[0035]** In one example, the shape (e.g., marker 142, 143, 145, 147) could start with an ellipse and end with two concentric circles as the parameters become known. Parameters that can be automatically estimated may include beam-angles, absolute beam firing times, left beam number, right beam number, depth, etc. This complete self-calibration process may be shown to the user or be kept 'invisible'.

**[0036]** Referring to FIG. 3, four images (150) are shown with different linear shapes generated therein. One image 170 shows a tilted straight line shape. Another image 172 shows a horizontal line shape. Another image 174 shows a short line segment shape, and another image 176 shows a split line shape. A straight line can be used as a calibration shape since straight lines are simple and accurate for automatic segmentation. Different lines could be drawn and picked up in the image. As an example, to identify the 'beginning' beam, a split line (176) can be very useful. In addition, the system could 'flash' one shape, do some analysis, and then flash a second frame, and so on until all the needed parameters are identified. Within a few frames (e.g.,  $<1$  sec.), all parameters should be available. Given that the beamforming parameters are dynamic, but not changing in real-time, this routine could be run in the background using the image processing module 115 every few seconds to check if the parameters have changed. Alternately, the calibration routine could be triggered every time a significant change is observed in a frame-grabbed video out from the scanner 125.

**[0037]** Referring to FIG. 4, a frame rate  $T$  of the imaging probe needs to be estimated. This is done by listening to a received signal for a relatively long time  $T_{est}$  (e.g., a quarter of a second, to record, e.g., 10 frames at 40Hz) and analyzing the signal for its dominant period, i.e., by Fourier analysis. A received trace 202 is depicted in FIG. 4. On the trace 202, individual impulses 204 correspond to different beams hitting the sensor (120 on the device 102) (the amplitude varies as beams get closer and then further from the sensor 120). The pattern is then repeated several times as several identical frames are acquired in continuous sequence. The trace 202 received by the sensor (120) during a time  $T_{est}$  can be used to estimate the frame rate  $T$  of the system. Once this is done, the receiver system analyzes traces of a length  $T_{detect}$  ( $T < T_{detect} < 2T$ , ideally).

**[0038]** Referring to FIG. 5, one of these impulses 204 of a length  $T_{detect}$  is depicted. Note that acquisition of these impulses 204 is not synchronized with the frames. The system searches for the temporal maximum  $t_0$  of this trace. That maximum corresponds to the instant when the pulse from the transmit event that is best aligned with the sensor 120 reaches the sensor 120. The trace received by the sensor 120 during a time  $T_{detect}$  (e.g.,  $T_{detect}$

= 1.2T here) is used to find the time  $t_0$  when the most on-axis transmit reaches the sensor 120.  $t_0$  is simply the temporal maximum of the impulse or trace 204.

**[0039]** Instead of a simple peak detection for identifying the beam closest to the sensor 120 and the arrival time, it may be advantageous to fit the curve or trace 204 (e.g., signals received by the sensor 120 during  $T_{est}$ ) to the local maxima of the individual pulses or to a simple signal model, e.g., a polynomial or a Gaussian.

**[0040]** Next, an acoustic signal is injected back into the imaging probe 122 to create an echo that comes from the sensor position. It may also be desirable for the injected acoustic signal to blink (short periods of "injection on" alternating with periods of "injection off"). The human eye is more sensitive to a blinking signal. In other embodiments, visual effects may be imparted to the acoustic echo to change its size, change its shape or change its visual attributes as described. These visual effects may be introduced through the signal generated or sent back from the sensor 120. If the videostream is captured and synchronized to the signal acquisition and injection set-up, differential images can be generated to highlight the injected signal (the "blink off" image is subtracted from the "blink on" image). The differential images can be enhanced and superimposed on the original image in an entirely image-processing chain that only requires access to video data from the scanner 125.

**[0041]** For FIG. 6, two embodiments may illustratively be described: the sensor 120 is a transponder (can be switched into a transmit mode with a T/R switch), or two transducers in close proximity are used, one being a receiver for signal detection and the other one being a transmitter for signal injection. Either way, the sequence of events outlined in FIG. 6 applies.

**[0042]** Referring to FIG. 6, a sequence of events for frame rate estimation, peak pulse detection, and pulse injection in the transponder embodiment are illustratively shown. Note that the external system's clock may be totally independent from the US scanner's clock. A relatively long period 225 ( $T_{est}$ ) (long enough to comfortably span tens of frames) is used to estimate the imaging system's frame rate. Then, peak detection periods 221 (receive mode, darker shade) alternate with signal injection periods 223 (transmit mode, lighter shade). If a signal peak is detected at a time  $t_0$ , a signal is injected at  $t_0+2T$ ; this creates an artificial echo at the position of the transponder two frames after its detection. Detection events 224 are depicted as rounded ends, and injection events 226 are arrows.

**[0043]** After detection, an impulse is sent from the transponder or transmitter at a time  $t_0+nT+S_i$ , where  $S_i$  determines the shape observed/marked on the US image and  $n$  being an integer, preferably  $n = 1$  (transmitter embodiment) or 2 (transponder embodiment). Shape pulses 228 are depicted in circles at injection events 226. This has the effect of creating an artificial echo or echos that seems to come from the sensor position or other position,  $n$  frames after the detection frame. The trace analysis

and injection of a feedback signal may be repeated to actualize the position of the sensor 120. Frame rate estimation may also be repeated periodically to account for possible parameter changes as the user changes the imaging settings (imaging mode, settings, and depth may all affect frame rate).

**[0044]** Next, in one embodiment, the injected video is frame-grabbed and an automated segmentation algorithm is employed to determine a location and shape of the shape inside the US image. This provides a real-time estimate of the beamforming and scan conversion parameters as described above. Note that the parameters may need adjustment if estimated by using a single image. Hence, an embodiment may iterate through the process steps using minor (or major) changes in the injected shape to maximize the accuracy of the parameter estimation. Note that these shapes could be flashed in split-second times so that a pattern will be practically invisible to a user. Post-calibration, the patterns could be entirely stopped, or replaced by patterns that only highlight the shape of the entire/partial device, or replaced by periodic flashes to recheck the calibration. The calibration can be done periodically in the background, or when a significant change is perceived in the frame-grabbed image from the video out.

**[0045]** In accordance with the present principles, the embodiments described herein may be employed any time an instrument is inserted into a body under ultrasound guidance. This includes needle procedures (biopsies, ablation, anesthesia, pain management, abscess drainage, etc.) and catheter procedures (heart repair, electrophysiology, etc.), and others.

**[0046]** Referring to FIG. 7, a method for providing a shaped marker in an image is shown in accordance with one embodiment. In block 402, a frame rate of an imaging probe is estimated. In block 404, estimating the frame rate may include listening to a received signal for a period of time, and analyzing the received signal to determine its dominant period.

**[0047]** In block 406, traces are analyzed to determine if they are within a detection window to find a temporal maximum which best matches a position of a sensor or marker device mounted on an instrument to determine an arrival time. The detection window includes a detection time  $T_{detect}$  between  $T$  and  $2T$ , where  $T$  is the frame rate.

**[0048]** In block 408, an acoustic feedback signal is injected into the imaging probe by emitting a delayed signal from the marker device to the imaging probe. The delayed signal includes one or more timed pulses to simulate a marker shape in an echo back from the marker device. The injected signal is generated by a transponder or transceiver (transmitter) on the instrument to the imaging probe to simulate an echo back from the sensor mounted on the instrument. In block 410, the acoustic feedback signal may be injected in frames at  $t_0+nT+S_i$ , where  $t_0$  is a temporal maximum of signals received by the sensor,  $T$  is frame rate,  $n$  is an integer and  $S_i$  includes shape

pulses.

**[0049]** In block 412, the marker shape is displayed in an image to identify the position of the instrument. In block 414, displaying the marker shape may include changing one of shape, size and visual attributes of the marker over time. In block 416, displaying the marker shape may include selecting a shape, size and position of the marker to provide a reference. The reference may be employed for indicating a position of the instrument in use (e.g., during tracking), aligning other instruments, making measurements, delineating organs or any other use.

**[0050]** In block 418, a position and shape of the delayed signal may be compared to an on-screen video output of a position and shape of the marker to determine beamforming parameters of a scanner. Once the beamforming parameters of the scanner are determined, the marker and other images or overlays may be placed or rendered in the images.

**[0051]** In interpreting the appended claims, it should be understood that:

- a) the word "comprising" does not exclude the presence of other elements or acts than those listed in a given claim;
- b) the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements;
- c) any reference signs in the claims do not limit their scope;
- d) several "means" may be represented by the same item or hardware or software implemented structure or function; and
- e) no specific sequence of acts is intended to be required unless specifically indicated.

**[0052]** Having described preferred embodiments for acoustic highlighting of interventional instruments (which are intended to be illustrative and not limiting), it is noted that modifications and variations can be made by persons skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiments of the disclosure disclosed which are within the scope of the embodiments disclosed herein as outlined by the appended claims. The invention is defined in the appended independent claims. Embodiments of the invention are defined in the dependent claims.

## Claims

1. A system for injecting a shaped marker in an image of an ultrasound scanner (150), the system comprising:

an ultrasound scanner (150) configured to generate an image and a video-out signal;  
a probe (122) connected to the ultrasound scanner (150) for transmitting and receiving ultrasonic energy to and from a volume;

ic energy to and from a volume;

a marker device (120) configured to respond to a received ultrasonic signal transmitted by the probe (122) and to emit an ultrasonic signal after a delay, the ultrasonic signal including one or more pulses which when rendered in the image generate a marker of a given size at a position within the image;

a medical instrument (102) configured to be disposed in the volume, wherein the medical instrument (102) includes the marker device (120); and

a memory (116) comprising a control module (124), wherein the control module (124) is configured to interpret the ultrasonic energy received from the probe (122) and from the marker device (120), to determine a three dimensional location of the medical instrument, to highlight the three dimensional location of the marker device (120) with the marker in the image, and to extract a frame repetition period T of the imaging mode used by the ultrasound scanner, and a time of arrival  $t_0$  of a maximum signal from the probe to the marker device (120);

**characterized in that** the ultrasonic signal emitted from the marker device (120) is configured to be injected at times  $t_0 + nT + S_i$ , where n is an integer and  $S_i$  is a time delay corresponding to the emission of the one or more pulses which when rendered in the image correspond to a predetermined shape of the marker, such that the video-out signal of the ultrasound scanner (150), together with the injected signal, can be analysed to quantitatively estimate the internal beamforming and scan conversion parameters of the ultrasound scanner (150).

2. The system as recited in claim 1, wherein the marker device (120) includes a transponder and the transponder includes a switch, the switch being configured to change the marker device (120) from a receive mode to a transmit mode.
3. The system as recited in claim 1, wherein the marker device (120) includes a transceiver having a receiver and a transmitter.
4. The system as recited in claim 1, further comprising an image processing module (115) configured to compare a position and shape of the injected signal to an on-screen video output of a position and shape of the marker to determine the beamforming and scan conversion parameters.
5. The system as recited in claim 1, wherein the control module (124) is configured to change one of shape, size and visual attributes of the marker over time.

6. The system as recited in claim 1, wherein the marker is configured to indicate a position of the marker device.
7. The system as recited in claim 1, wherein the marker is configured to indicate a reference position.
8. The system according to claim 1 further comprising a workstation (112) including a processor; and an image processing module (115) configured to compare a position and shape of the injected signal to an on-screen video output of a position and shape of the marker to determine beamforming parameters.
9. A method for providing a shaped marker in an image of an imaging probe of an ultrasound scanner configured to generate a video-out signal, the method comprising:

receiving, with a marker device mounted on an instrument, an ultrasonic signal transmitted by the imaging probe;  
 estimating (402), from the received ultrasonic signal, a frame repetition period  $T$  of an imaging mode used by the imaging probe;  
 analyzing (406) the received ultrasonic signal within a detection window to find a time of arrival  $t_0$  of a maximum signal from the probe to the marker device (120) which best matches a position of the marker device;  
 injecting (408) an acoustic feedback signal into the imaging probe by emitting a delayed signal from the marker device to the imaging probe, the delayed signal including one or more timed pulses to simulate a marker shape in an echo back from the marker device; and  
 displaying (412) the marker shape in the image to identify the position of the instrument;  
 wherein injecting (408) the acoustic feedback signal includes injecting the acoustic feedback signal in frames at  $t_0 + nT + S_i$ , where  $n$  is an integer and  $S_i$  is a time delay corresponding to the emission of the one or more pulses which when rendered in the image correspond to the marker shape, such that the video-out signal of the ultrasound scanner (150), together with the injected signal, can be analysed to quantitatively estimate the internal beamforming and scan conversion parameters of the ultrasound scanner (150).

10. The method as recited in claim 9, wherein the step of displaying the marker shape includes changing one of shape, size and visual attributes over time of the marker.
11. The method as recited in claim 9, wherein the step

of displaying the marker shape includes selecting a shape, size and position of the marker to provide a reference.

12. The method as recited in claim 9, further comprising the step of: comparing (418) a position and shape of the delayed signal to an on-screen video output of a position and shape of the marker to determine the beamforming and scan conversion parameters of the ultrasound scanner.
13. Computer readable storage medium comprising program code which when executed by a processor of the system of claim 1 causes the system of claim 1 to carry out the method of any one of claims 9 - 12.

### Patentansprüche

1. System zum Injizieren eines geformten Markers in ein Bild eines Ultraschallscanners (150), wobei das System umfasst:
- einen Ultraschallscanner (150), der ausgestaltet ist, ein Bild und ein Videoausgangssignal zu erzeugen;  
 einen Sensor (122), der mit dem Ultraschallscanner (150) verbunden ist, um Ultraschallenergie an ein Volumen zu senden und von diesem zu empfangen;  
 eine Markervorrichtung (120), die ausgestaltet ist, auf ein empfangenes Ultraschallsignal, das von dem Sensor (122) gesendet wurde, zu antworten und ein Ultraschallsignal nach einer Verzögerung auszusenden, wobei das Ultraschallsignal einen oder mehrere Impulse beinhaltet, die, wenn sie im Bild wiedergegeben werden, einen Marker einer gegebenen Größe an einer Position innerhalb des Bildes erzeugen;  
 ein medizinisches Instrument (102), das ausgestaltet ist, in dem Volumen angeordnet zu werden, wobei das medizinische Instrument (102) die Markervorrichtung (120) beinhaltet; und  
 einen Speicher (116), umfassend ein Steuermodul (124), wobei das Steuermodul (124) ausgestaltet ist, die von dem Sensor (122) und von der Markervorrichtung (120) empfangene Ultraschallenergie zu interpretieren, einen dreidimensionalen Ort des medizinischen Instruments zu bestimmen, den dreidimensionalen Ort der Markervorrichtung (120) mit dem Marker im Bild zu kennzeichnen und eine Bildwiederholddauer  $T$  des Bildgebungsmodus, der von dem Ultraschallscanner verwendet wird, und eine Ankunftszeit  $t_0$  eines Maximalsignals von dem Sensor an die Markervorrichtung (120) zu extrahieren;  
**dadurch gekennzeichnet, dass** das von der

- Markervorrichtung (120) ausgesendete Ultraschallsignal ausgestaltet ist, zu Zeiten  $t_0 + nT + S_i$  injiziert zu werden, wobei  $n$  eine ganze Zahl ist und  $S_i$  eine Zeitverzögerung ist entsprechend der Aussendung des einen oder der mehreren Impulse ist, die, wenn sie im Bild wiedergegeben werden, einer vorbestimmten Form des Markers entsprechen, sodass das Videoausgangssignal des Ultraschallscanners (150), zusammen mit dem injizierten Signal, analysiert werden kann, um die internen Strahlenbildungs- und Scanumwandlungsparameter des Ultraschallscanners (150) quantitativ zu schätzen.
2. System nach Anspruch 1, wobei die Markervorrichtung (120) einen Transponder beinhaltet und der Transponder einen Schalter beinhaltet, wobei der Schalter ausgestaltet ist, die Markervorrichtung (120) von einem Empfangsmodus in einen Sendemodus zu ändern.
  3. System nach Anspruch 1, wobei die Markervorrichtung (120) einen Transceiver beinhaltet, der einen Empfänger und einen Sender aufweist.
  4. System nach Anspruch 1, weiter umfassend ein Bildverarbeitungsmodul (115), das ausgestaltet ist, eine Position und Form des injizierten Signals mit einer Bildschirmvideoausgabe einer Position und Form des Markers zu vergleichen, um die Strahlenbildungs- und Scanumwandlungsparameter zu bestimmen.
  5. System nach Anspruch 1, wobei das Steuermodul (124) ausgestaltet ist, eines von Form-, Größen- und Sichtattributen des Markers mit der Zeit zu ändern.
  6. System nach Anspruch 1, wobei der Marker ausgestaltet ist, eine Position der Markervorrichtung anzugeben.
  7. System nach Anspruch 1, wobei der Marker ausgestaltet ist, eine Referenzposition anzugeben.
  8. System nach Anspruch 1, weiter umfassend einen Arbeitsplatz (112), der einen Prozessor beinhaltet; und ein Bildverarbeitungsmodul (115), das ausgestaltet ist, eine Position und Form des injizierten Signals mit einer Bildschirmvideoausgabe einer Position und Form des Markers zu vergleichen, um Strahlenbildungsparameter zu bestimmen.
  9. Verfahren zur Bereitstellung eines geformten Markers in einem Bild eines Bildgebungssensors eines Ultraschallscanners, der ausgestaltet ist, ein Videoausgangssignal zu erzeugen, wobei das Verfahren umfasst:
    - Empfangen, mit einer auf einem Instrument angebrachten Markervorrichtung, eines Ultraschallsignals, das von dem Bildgebungssensor gesendet wird;
    - Schätzen (402), aus dem empfangenen Ultraschallsignal, einer Bildwiederholdauer  $T$  eines Bildgebungsmodus, der von dem Bildgebungssensor verwendet wird;
    - Analysieren (406) des empfangenen Ultraschallsignals innerhalb eines Erfassungsfensters, um eine Ankunftszeit  $t_0$  eines Maximalsignals von dem Sensor an die Markervorrichtung (120) zu finden, die am besten zu einer Position der Markervorrichtung passt;
    - Injizieren (408) eines akustischen Rückkopplungssignals in den Bildgebungssensor durch Aussenden eines verzögerten Signals von der Markervorrichtung an den Bildgebungssensor, wobei das verzögerte Signal einen oder mehrere zeitgesteuerte Impulse beinhaltet, um eine Markerform in einem Echo zurück von der Markervorrichtung zu simulieren; und
    - Anzeigen (412) der Markerform in dem Bild, um die Position des Instruments zu identifizieren; wobei das Injizieren (408) des akustischen Rückkopplungssignals das Injizieren des akustischen Rückkopplungssignals in Bildern bei  $t_0 + nT + S_i$  beinhaltet, wobei  $n$  eine ganze Zahl ist und  $S_i$  eine Zeitverzögerung ist entsprechend der Aussendung des einen oder der mehreren Impulse ist, die, wenn sie im Bild wiedergegeben werden, der Markerform entsprechen, sodass das Videoausgangssignal des Ultraschallscanners (150), zusammen mit dem injizierten Signal, analysiert werden kann, um die internen Strahlenbildungs- und Scanumwandlungsparameter des Ultraschallscanners (150) quantitativ zu schätzen.
  10. Verfahren nach Anspruch 9, wobei der Schritt des Anzeigens der Markerform das Ändern von einem von Form-, Größen- und Sichtattributen des Markers mit der Zeit beinhaltet.
  11. Verfahren nach Anspruch 9, wobei der Schritt des Anzeigens der Markerform das Auswählen einer Form, Größe und Position des Markers beinhaltet, um eine Referenz bereitzustellen.
  12. Verfahren nach Anspruch 9, weiter umfassend den Schritt des: Vergleichens (418) einer Position und Form des verzögerten Signals mit einer Bildschirmvideoausgabe einer Position und Form des Markers, um die Strahlenbildungs- und Scanumwandlungsparameter des Ultraschallscanners zu bestimmen.
  13. Computerlesbares Speichermedium, umfassend einen Programmcode, der, wenn er von einem Pro-

zessor des Systems nach Anspruch 1 ausgeführt wird, das System nach Anspruch 1 veranlasst, das Verfahren nach einem der Ansprüche 9-12 durchzuführen.

## Revendications

1. Système d'injection d'un marqueur formé dans une image d'un scanner ultrasonore (150), le système comprenant :

un scanner ultrasonore (150) configuré pour générer une image et un signal de sortie vidéo ;  
une sonde (122) connectée au scanner ultrasonore (150) pour transmettre de l'énergie ultrasonore à un volume et en recevoir de celui-ci ;  
un dispositif de marquage (120) configuré pour répondre à un signal ultrasonore reçu transmis par la sonde (122) et émettre un signal ultrasonore après un certain délai, le signal ultrasonore incluant une ou plusieurs impulsions qui, lorsqu'elles sont rendues dans l'image, génère un marqueur d'une taille donnée dans une position au sein de l'image ;

un instrument médical (102) configuré pour être disposé dans le volume, dans lequel l'instrument médical (102) inclut le dispositif de marquage (120) ; et

une mémoire (116) comprenant un module de commande (124), dans lequel le module de commande (124) est configuré pour interpréter l'énergie ultrasonore reçue de la sonde (122) et du dispositif de marquage (120), déterminer un emplacement tridimensionnel de l'instrument médical, accentuer l'emplacement tridimensionnel du dispositif de marquage (120) avec le marqueur dans l'image et extraire une période de répétition de trame T du mode d'imagerie utilisé par le scanner ultrasonore et un temps d'arrivée  $t_0$  d'un signal maximal de la sonde au dispositif de marquage (120) ;

**caractérisé en ce que** le signal ultrasonore émis par le dispositif de marquage (120) est configuré pour être injecté aux instants  $t_0 + nT + S_i$ , où  $n$  est un entier et  $S_i$  est un retard correspondant à l'émission des une ou plusieurs impulsions qui, lorsqu'elles sont rendues dans l'image, correspondent à une forme prédéterminée du marqueur de sorte que le signal de sortie vidéo du scanner ultrasonore (150), conjointement avec le signal injecté, puisse être analysé pour estimer quantitativement les paramètres internes de formation de faisceaux et de conversion de balayage du scanner ultrasonore (150).

2. Système selon la revendication 1, dans lequel le dis-

positif de marquage (120) inclut un transpondeur et le transpondeur comprend un commutateur, le commutateur étant configuré pour faire passer le dispositif de marquage (120) d'un mode de réception à un mode de transmission.

3. Système selon la revendication 1, dans lequel le dispositif de marquage (120) inclut un émetteur récepteur ayant un récepteur et un émetteur.

4. Système selon la revendication 1, comprenant en outre un module de traitement d'image (115) configuré pour comparer une position et une forme du signal injecté à une sortie vidéo sur écran d'une position et d'une forme du marqueur afin de déterminer les paramètres de formation de faisceaux et de conversion de balayage.

5. Système selon la revendication 1, dans lequel le module de commande (124) est configuré pour changer l'un(e) ou l'autre de la forme, de la dimension et des attributs visuels du marqueur au fil du temps.

6. Système selon la revendication 1, dans lequel le marqueur est configuré pour indiquer une position du dispositif de marquage.

7. Système selon la revendication 1, dans lequel le marqueur est configuré pour indiquer une position de référence.

8. Système selon la revendication 1, comprenant en outre un poste de travail (112) incluant un processeur ; et un module de traitement d'image (115) configuré pour comparer une position et une forme du signal injecté à une sortie vidéo sur écran d'une position et d'une forme du marqueur afin de déterminer des paramètres de formation de faisceaux.

9. Procédé de fourniture d'un marqueur formé dans une image d'une sonde d'imagerie d'un scanner ultrasonore configuré pour générer un signal de sortie vidéo, le procédé comprenant :

la réception par un dispositif de marquage monté sur un instrument d'un signal ultrasonore transmis par la sonde d'imagerie ;

l'estimation (402) à partir du signal ultrasonore reçu d'une période de répétition de trame T d'un mode d'imagerie utilisé par la sonde d'imagerie ;  
l'analyse (406) du signal ultrasonore reçu dans une fenêtre de détection pour trouver un temps d'arrivée  $t_0$  d'un signal maximal de la sonde au dispositif de marquage (120) qui s'adapte le mieux à une position du dispositif de marquage ;  
l'injection (408) d'un signal de rétroaction acoustique dans la sonde d'imagerie en émettant un

- signal retardé du dispositif de marquage à la sonde d'imagerie, le signal retardé incluant une ou plusieurs impulsions synchronisées pour simuler une forme de marqueur dans un écho revenant du dispositif de marquage ; et 5
- l'affichage (412) de la forme du marqueur dans l'image afin d'identifier la position de l'instrument ;
- dans lequel l'injection (408) du signal de rétroaction acoustique comprend l'injection du signal de rétroaction acoustique dans des trames à  $t_0 + nT + S_i$ , où  $n$  est un entier et  $S_i$  est un retard correspondant à l'émission des une ou plusieurs impulsions qui, lorsqu'elles sont rendues dans l'image, correspondent à la forme du marqueur de sorte que le signal de sortie vidéo du scanneur ultrasonore (150), conjointement avec le signal injecté, puisse être analysé afin d'estimer quantitativement les paramètres internes de formation de faisceaux et de conversion de balayage du scanneur ultrasonore (150). 10 15 20
10. Procédé selon la revendication 9, dans lequel l'étape d'affichage de la forme du marqueur inclut le changement de l'un(e) de la forme, de la taille et des attributs visuels au fil du temps du marqueur. 25
11. Procédé selon la revendication 9, dans lequel l'étape d'affichage de la forme du marqueur comprend la sélection d'une forme, d'une taille et d'une position du marqueur pour fournir une référence. 30
12. Procédé selon la revendication 9, comprenant en outre l'étape de comparaison (418) d'une position et d'une forme du signal retardé à une sortie vidéo sur écran d'une position et d'une forme du marqueur afin de déterminer les paramètres de formation de faisceaux et de conversion de balayage du scanneur ultrasonore. 35 40
13. Support de stockage lisible par ordinateur comprenant un code de programme qui, lorsqu'il est exécuté par un processeur du système de la revendication 1, amène le système de la revendication 1 à effectuer le procédé selon l'une quelconque des revendications 9 à 12. 45

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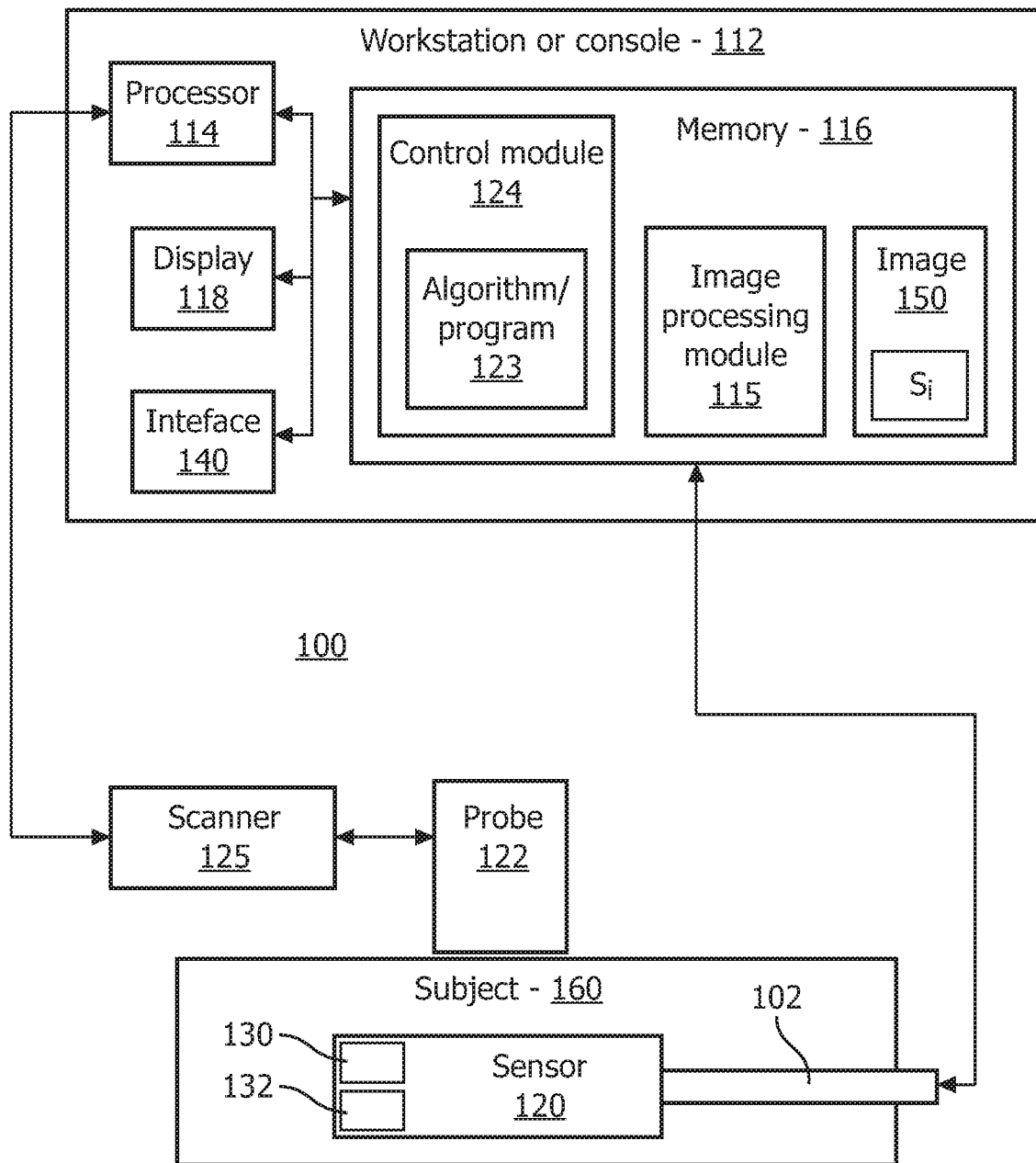


FIG. 1

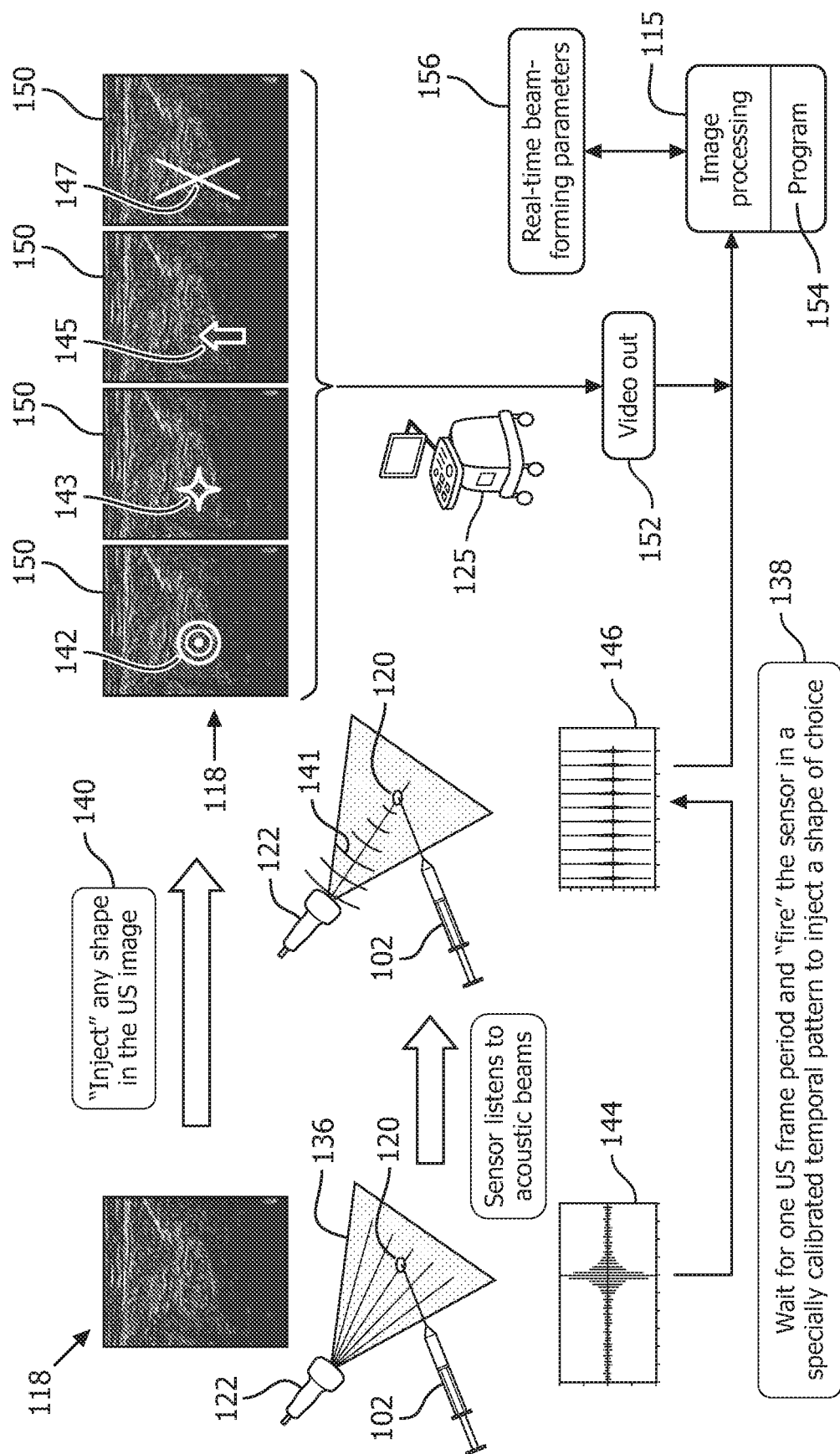


FIG. 2

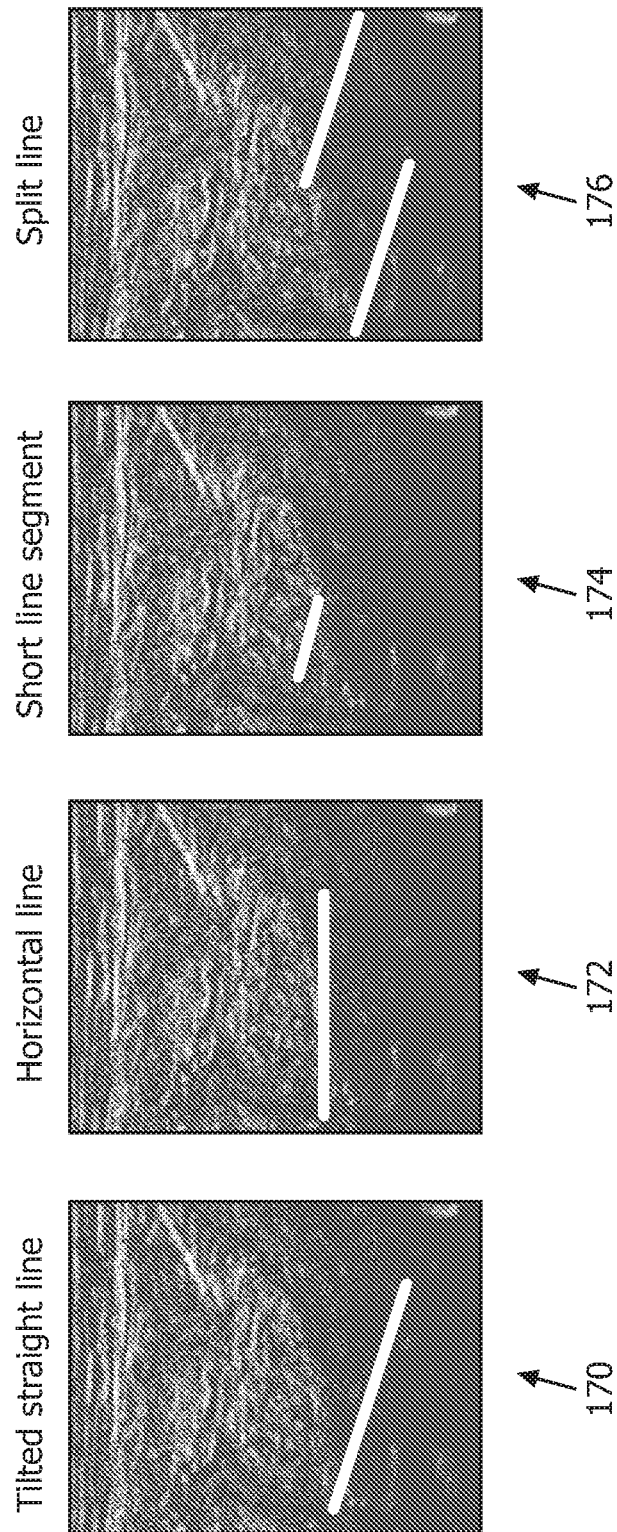


FIG. 3

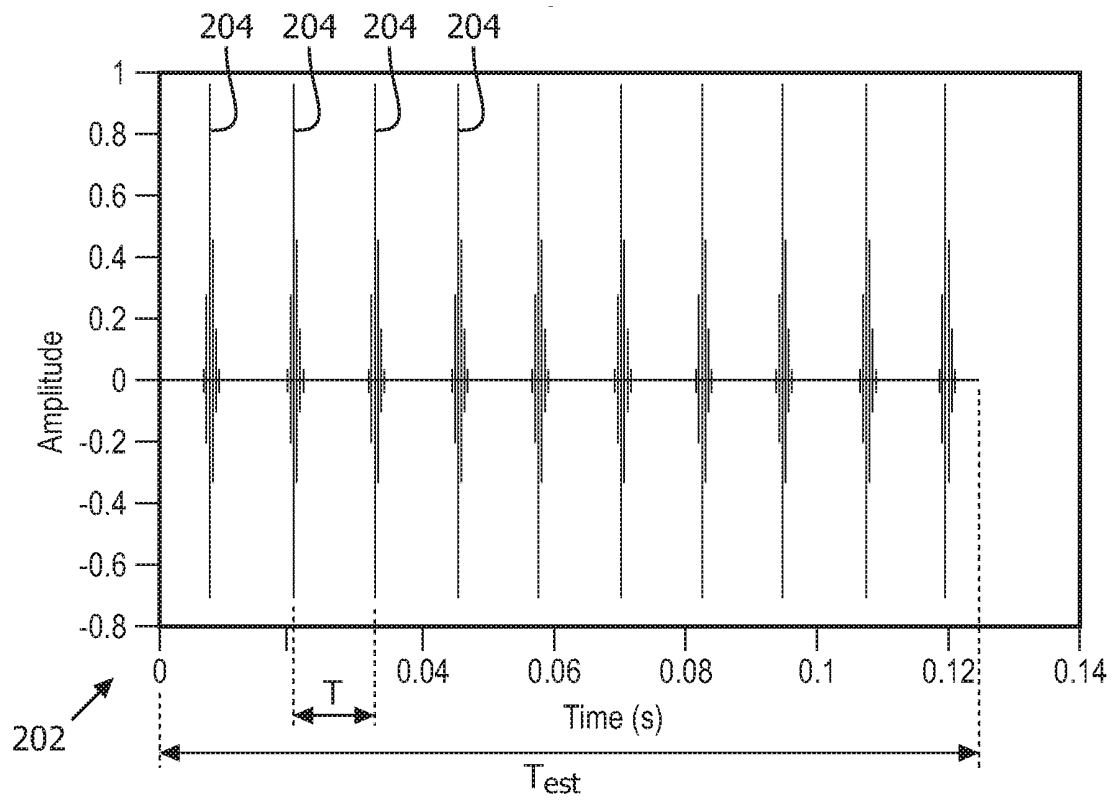


FIG. 4

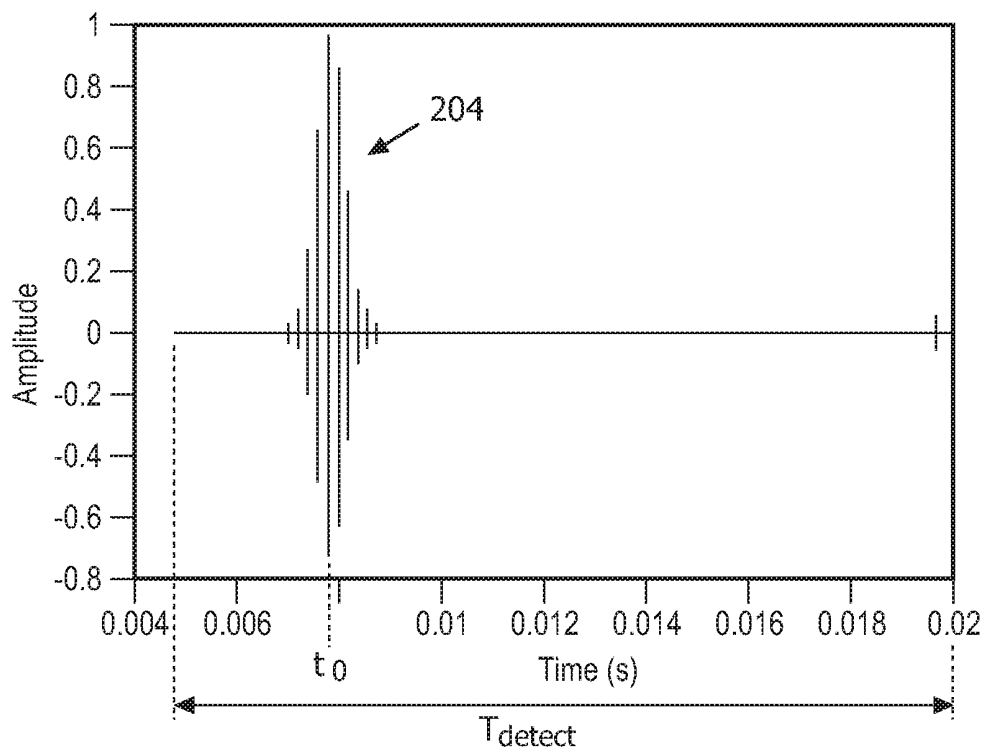
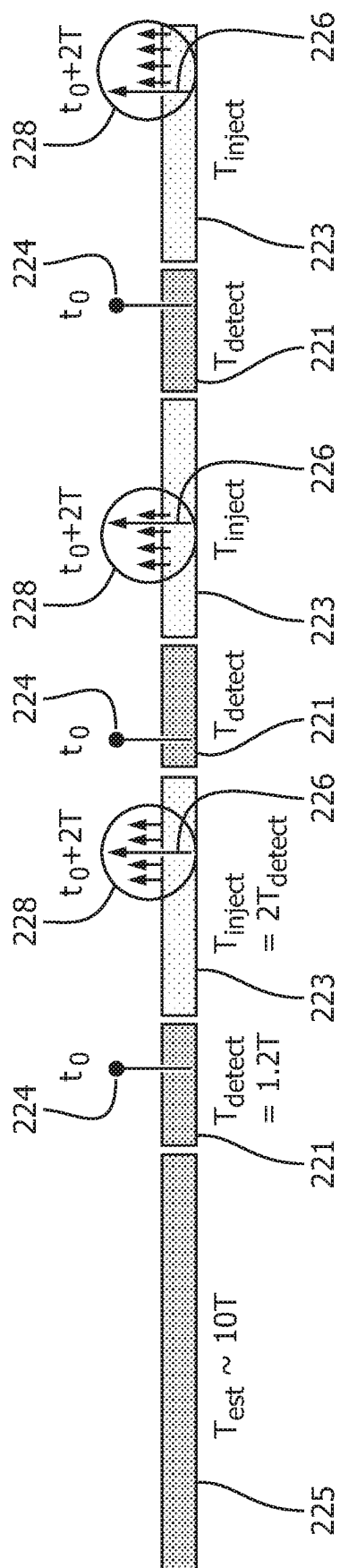


FIG. 5

6  
G  
H

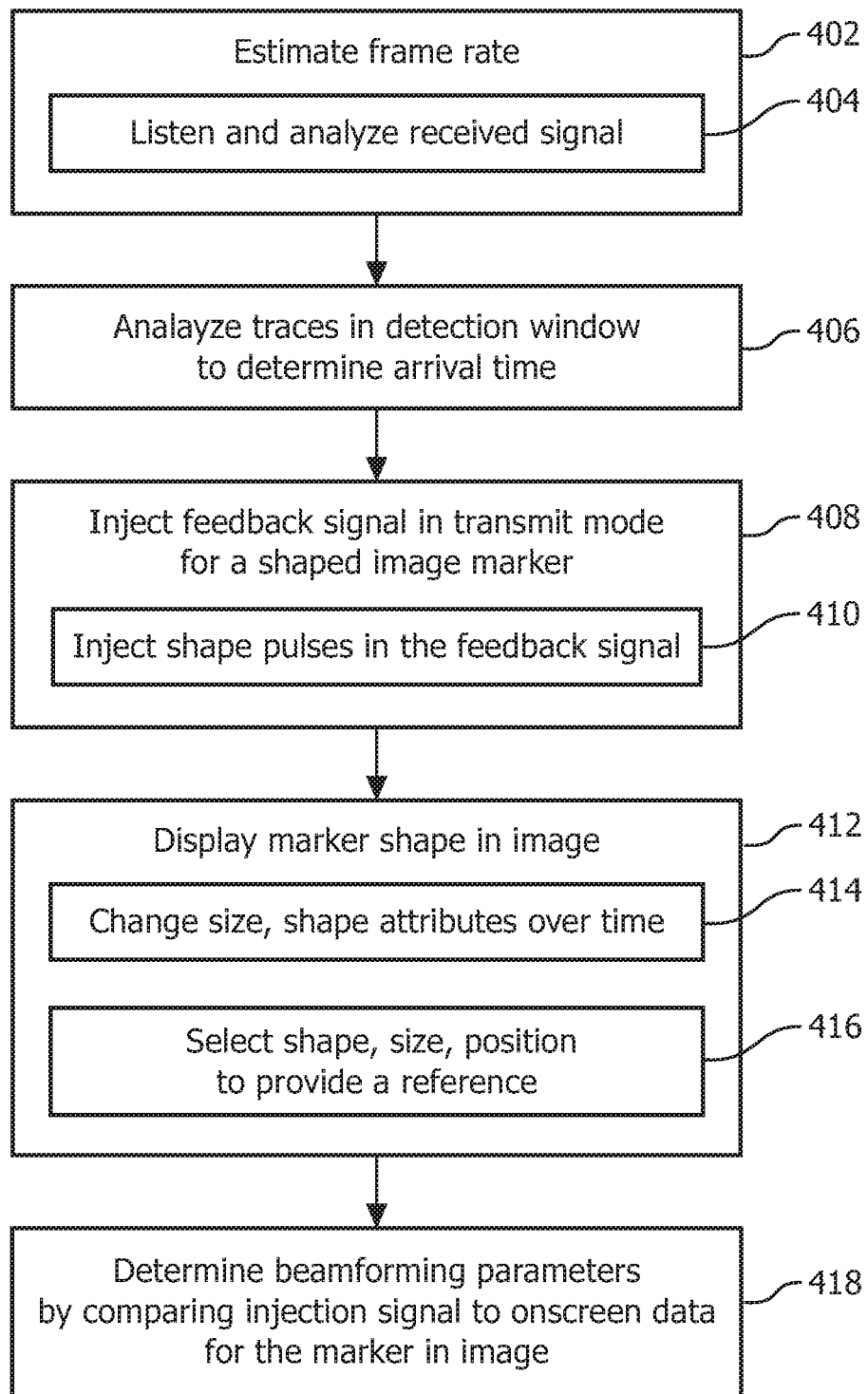


FIG. 7

## REFERENCES CITED IN THE DESCRIPTION

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|                |                                                                                                                    |         |            |
|----------------|--------------------------------------------------------------------------------------------------------------------|---------|------------|
| 专利名称(译)        | 将形状注入到超声图像中以实时校准光束图案                                                                                               |         |            |
| 公开(公告)号        | <a href="#">EP3013245A1</a>                                                                                        | 公开(公告)日 | 2016-05-04 |
| 申请号            | EP2014752398                                                                                                       | 申请日     | 2014-06-30 |
| [标]申请(专利权)人(译) | 皇家飞利浦电子股份有限公司                                                                                                      |         |            |
| 申请(专利权)人(译)    | 皇家飞利浦N.V.                                                                                                          |         |            |
| 当前申请(专利权)人(译)  | 皇家飞利浦N.V.                                                                                                          |         |            |
| [标]发明人         | JAIN AMEET KUMAR<br>VIGNON FRANCOIS GUY GERARD MARIE                                                               |         |            |
| 发明人            | JAIN, AMEET KUMAR<br>VIGNON, FRANCOIS GUY GERARD MARIE                                                             |         |            |
| IPC分类号         | A61B8/08                                                                                                           |         |            |
| CPC分类号         | A61B8/08 A61B8/0841 A61B8/463 A61B8/585 A61B2034/2063 A61B2090/3929 G01S7/52073 G01S15/74 G01S15/899 A61B2090/3925 |         |            |
| 优先权            | 61/840503 2013-06-28 US                                                                                            |         |            |
| 其他公开文献         | EP3013245B1                                                                                                        |         |            |
| 外部链接           | <a href="#">Espacenet</a>                                                                                          |         |            |

#### 摘要(译)

探针 ( 122 ) 向体积发送超声波能量并从该体积接收超声波能量，并且标记设备 ( 120 ) 被配置为响应于接收到的超声波信号并在延迟之后发射超声波信号。 超声信号包括一个或多个脉冲，该一个或多个脉冲被配置为在被渲染时在图像内的位置处生成给定大小的标记。 医疗仪器 ( 102 ) 被布置在该体积中并且包括标记装置。 控制模块 ( 124 ) 被存储在存储器中，并且被配置为解释从探针和从标记设备接收的超声能量以确定医疗仪器的三维位置，并以高亮显示标记设备的三维位置。 图片中的标记。