

APPARATUS FOR GUIDING PLACEMENT OF AUXILIARY EQUIPMENT IN USE WITH ULTRASOUND PROBE

Field

[0001] The present invention relates to an apparatus, system and method for medical imaging.

Background

[0002] The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

[0003] Ultrasonography is a type of medical imaging technique which can be adopted in a variety of medical diagnosis and examination applications. Such diagnosis and examination applications include detection of tumors, providing images of fetuses for assessment of their development, and monitoring blood flow within various vital organs.

[0004] Ultrasonography has also been deployed to identify anatomy features of an individual such as a lumbar interspace of a vertebrate, such as, but not limited to, a human being. A known apparatus for use in ultrasonography is the wave guide, also known as an ultrasound probe. In the context of identifying a lumbar interspace, such waveguide apparatus typically operates on the principle of reflection of ultrasonic waves to identify the lumbar interspace before a mark is made on the outer skin of the person. A suitable equipment may then be inserted to the interspace using the mark for guidance. Such equipment may include, for example, a needle or catheter to administer local or general anesthetic.

[0005] In utilizing the waveguide and marker, it may be appreciated that both of the user's hands are utilized, i.e. one hand for holding and moving the wave guide to identify the lumbar interspace, the other hand for using a marker/identifier to mark the interspace area/spot on the skin. This may compromise the overall accuracy of the identification process as it depends on the user to ensure that the waveguide is not inadvertently shifted or moved when the user is marking the interspace area/spot on the skin.

[0006] An object of the invention is to ameliorate one or more of the above-mentioned difficulties.

Summary

[0007] According to one aspect of the disclosure, there is provided an apparatus for facilitating medical imaging of a subject comprising: a medical imaging device receiver configured to receive a medical imaging device, at least one auxiliary equipment receiver configured to receive an auxiliary equipment for placement at a target portion of the subject, and a sound wave manipulation module arranged to direct transmission of sound waves between the medical imaging device and the subject, wherein an image of the target portion is formed by the medical imaging device for guiding placement of the auxiliary equipment.

[0008] In some embodiments, the soundwave manipulation module comprises a soundwave deflection surface arranged to alter a direction of transmission of at least part of the sound waves.

[0009] In some embodiments, the soundwave deflection surface is configured to facilitate at least one of the following: - reflection, refraction, diffraction of sound waves.

[0010] In some embodiments, the soundwave deflecting surface is formed from a material having a sound transmission velocity at a ratio ranging from 3.0 to 11.0 relative to water.

[0011] In some embodiments, the soundwave manipulation module comprises a soundwave transmission portion arranged to facilitate transmission of the sound waves between at least the medical imaging device and the soundwave deflection surface.

[0012] In some embodiments, the soundwave transmission portion is formed from a material having a sound transmission velocity at a ratio ranging from 0.8 to 5.0 relative to water.

[0013] In some embodiments, the soundwave transmission interface comprises a gel-based material.

[0014] In some embodiments, the gel-based material is disposed at a hollow portion the sound wave manipulation module.

[0015] In some embodiments, the soundwave manipulation module is formed from a homogenous material having a sound transmission velocity at a ratio ranging from 2.0 to 3.0 relative to water.

[0016] In some embodiments, the sound wave manipulation module, the medical imaging device receiver and the auxiliary equipment receiver are integrally formed as a one-piece element.

[0017] In some embodiments, the at least one auxiliary equipment receiver is configured to facilitate placement of the auxiliary equipment at more than one desired positions with respect to a base plane of the apparatus.

[0018] In some embodiments, the medical imaging device is mounted at a first angle between 0 to 90 degrees with respect to a base plane of the apparatus, and the sound wave deflection surface may be mounted at a second angle between 0 to 90 degrees with respect to a base plane of the apparatus.

[0019] In some embodiments, the apparatus comprises a handle for controlling movement of the apparatus on a body surface of the subject.

[0020] In some embodiments, the apparatus comprises a locking mechanism for maintaining the medical device at a desired position relative to a part of the apparatus.

[0021] In some embodiments, the apparatus comprises a fiducial marker to indicate a position of the auxiliary equipment.

[0022] In some embodiments, the medical imaging device receiver and the at least one auxiliary equipment receiver are rotatable with respect to each other.

[0023] In some embodiments, the apparatus further comprises a frame mountable onto a body portion of the subject, wherein the frame is arranged to facilitate movement of the medical image device receiver and the at least one auxiliary equipment receiver along at least two axis.

[0024] In some embodiments, the apparatus further comprises a plurality of quick release mechanisms to facilitate mounting of the frame onto the body portion.

[0025] In some embodiments, the quick release mechanisms include at least one the

following: suction device, strap and buckle, removable adhesive.

[0026] In accordance to another aspect of the disclosure, there is provided a method for deploying an apparatus for facilitating medical imaging. The method comprises the steps of:- attaching a medical imaging device to the medical imaging device receiver of the apparatus; placing the apparatus on a body surface of a subject; moving the apparatus on the body surface for obtaining an image of a target portion of the subject; attaching an auxiliary equipment to the at least one auxiliary equipment receiver of the apparatus; adjusting position of the auxiliary equipment based on the image of the target portion, and inserting the auxiliary equipment towards the target portion.

[0027] In accordance to another aspect of the disclosure, there is provided a method for deploying an apparatus for facilitating medical imaging. The method comprises the steps of:- mounting the frame of the apparatus on a body portion of a target subject; attaching a medical imaging device to the medical imaging device receiver of the apparatus; attaching an auxiliary equipment to the at least one auxiliary equipment receiver of the apparatus; moving the medical imaging device along a first axis and moving the auxiliary equipment along a second axis for obtaining an image of a target portion of the subject; adjusting position of the auxiliary equipment based on the image of the target portion, and inserting the auxiliary equipment towards the target portion.

[0028] In some embodiments, the method further comprises the following steps of: a) securing a catch mechanism of the frame upon quick release, and/or (b) releasing the catch mechanism for the medical imaging device or auxiliary equipment to move along an opposite direction.

[0029] Other aspects and features of the present invention will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

Brief Description of the Drawings

[0030] In the figures, which illustrate, by way of example only, embodiments of the present invention, wherein

[0031] Figure 1 and 2 show an apparatus for facilitating medical imaging in use with a medical imaging device and an auxiliary equipment mounted thereon in accordance to one embodiment;

[0032] Figure 3 and 4 show an apparatus for facilitating medical imaging in accordance to another embodiment;

[0033] Figure 5A and 5B show an apparatus for facilitating medical imaging in accordance to another embodiment;

[0034] Figure 6A and 6B show an apparatus with a frame for facilitating movement of the auxiliary equipment and/or of the medical imaging device mounted thereon in accordance to one embodiment;

[0035] Figure 7A to Figure 7D illustrate adjustment of the medical imaging device and the auxiliary equipment mounted on the apparatus;

[0036] Figure 8 shows another embodiment of the apparatus in use with a medical imaging device;

[0037] Figure 9 shows another embodiment of the apparatus in use with and integrated with a medical imaging device;

[0038] Figure 10A depicts a method of using the apparatus according to some embodiments; and

[0039] Figure 10B depicts a method of using the apparatus according to further embodiments.

Detailed Description

[0040] Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, “having” and the like, are to be construed as non-exhaustive, or in other words, as meaning “including, but not limited to”.

[0041] Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including” will be understood to imply

the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0042] Throughout the specification, the term ‘medical image’ or ‘medical imaging’ may include images or imaging methods based on a variety of techniques and include the process of creating visual representations of an interior of a body for clinical analysis and medical intervention, as well as visual representation of the function of some organs or tissues.

[0043] According to one aspect of the invention and with reference to Figure 1 to 6 there is an apparatus 10 for facilitating medical imaging of a subject, for example a body portion of a patient. The apparatus 10 comprises a medical imaging device receiver 140 configured to receive a medical imaging device 20, a sound wave manipulation module 110 arranged to direct transmission of sound waves between the medical imaging device 20 and the subject along a designated path, and at least one auxiliary equipment receiver 130 configured to receive an auxiliary equipment 22 for placement at a target portion of the subject, wherein an image of the target portion is formed by the medical imaging device 20 for guiding placement of the auxiliary equipment 22.

[0044] In various embodiments, the medical imaging device 20 may be in the form of an ultrasound probe 20. An exemplary ultrasound probe may include a transducer for producing sound waves of a specific frequency range, which are focused either by the shape of the transducer, a lens in front of the transducer, or a complex set of control pulses from a transmit beam-former coupled to the transducer. An arc-shaped sound wave is transmitted from the face of the ultrasound probe 20 into a target subject (for example, a patient). The waveform and frequency of the sound waves may be adapted such that the sound waves may travel along one or more ultrasound scan lines and may travel into the target subject at a desired depth. The transducer of the ultrasound probe is operable to receive echoes of the sound waves from the target subject. The ultrasound probe may further comprise or may be connected to image processing modules/circuits which are operable to interpret the received echoes data to generate an image of the target subject.

[0045] It is to be appreciated that that alternative techniques of generating and controlling ultrasound waves as well as receiving and interpreting echoes received therefrom for the purpose of diagnostic medical imaging may also be used with the various embodiments of the present disclosure. For example, other types of transmitters and/or receivers may be used

in addition to or in substitution of the transducer, which may eliminate the need for a transmit beamformer, and may permit beam forming to be performed by post processing the received echoes. It is also appreciated that various signal processing techniques may be performed on the received echoes. For example, a receive beamformer and/or various digital/analog signal processing techniques may be used to acquire image information from the received sound wave echoes and to perform three-dimensional image reconstruction from a plurality of two-dimensional image planes of the target subject.

[0046] In various embodiments, the auxiliary equipment 22 may be a tool for assisting a medical diagnostic procedure. In some embodiments, the auxiliary equipment may be an invasive medical device including, but not limited to, an aspiration or biopsy needle, a catheter, and an endoscope. In use, a clinical practitioner needs to place or insert the auxiliary equipment 22 towards specific targets at/inside a body portion of the subject. It is appreciated that accuracy and speed of placement/insertion of the auxiliary equipment can be critical in such procedures.

[0047] In various embodiments, the apparatus 10 comprises a medical imaging device receiver 140 for receiving and/or holding the medical imaging device 20.

[0048] In some embodiments as shown in Figure 1, Figure 2 and Figure 4 to 5B, the apparatus 10 may comprise a casing for containing components of the apparatus including the sound wave manipulation module 110. The casing of the apparatus may be provided with a structure (e.g. a moulded plastic part) shaped and dimensioned as a medical imaging device receiver 140 for receiving the medical imaging device 20. In use, the medical imaging device 20 (e.g. an ultrasound probe) may be plugged or fitted into the medical imaging device receiver 140. The medical imaging device receiver 140 may be adaptable or comprise adaptable structures (e.g. adjustable sides, slidable portions) to receive most, if not all commercially available ultrasound probes.

[0049] In some embodiments, the medical device receiver 140 may comprise a disposable interface (not shown). The disposable interface can include an interface attachment and may be an area/feature where sterility is to be maintained.

[0050] In some embodiments, the disposable interface contains or comprises of various materials such as polymers. Such materials are single-use and disposable because of the

nature of the material, and its limited shelf life. In addition, when used with any ultrasound gel and the ultrasound probe, some wear and tear would render this part unusable or not economical or not easy to clean, prepare and re-use.

[0051] In some embodiments, the medical device receiver 140 may be further provided with a locking mechanism 120 for securing/maintaining the medical imaging device 20 at a desired position with respect to the apparatus 10. One non-limiting example of the locking mechanism 120 may be a snap fastener for locking a corresponding protruding edge on the medical imaging device 20. It is to be appreciated that various types of snap fastener including annular, torsional, cantilever snap fit designs may be implemented as the locking mechanism 120 for securing the medical imaging device 20. Loose movement of the medical imaging device 20 with respect to the apparatus 10, which may introduce noises/interferences to the imaging system, may be reduced by using the locking mechanism 120.

[0052] In various embodiments, the apparatus 10 comprises a soundwave manipulation module 110 arranged to direct transmission of sound waves between the medical imaging device 20 and the subject (more specifically, a body portion of the subject where the apparatus 10 is placed on). In particular, the soundwave manipulation module 120 includes one or more acoustic components that are capable of changing at least the transmission direction of the sound waves.

[0053] In various embodiments, the soundwave manipulation module 110 may include a soundwave deflecting surface 113 and a soundwave transmission portion 116. A deflector material may be provided to achieve function of deflecting or re-directing the soundwaves at the soundwave deflecting interface 113. A sound transmission material may be used for forming the soundwave transmission portion 116 so as to facilitate transmission of the sound waves therein.

[0054] In various embodiments, the soundwave deflection surface 113 may be arranged to alter a direction of transmission of at least part of the sound waves. In use, the medical imaging device 20 (e.g. the ultrasound probe) is placed next to or immediately adjacent the soundwave manipulation module 110 so that ultrasound waves produced from the medical imaging device 20 are directed to travel towards the soundwave deflection surface 113.

[0055] In various embodiments, the medical imaging device may be mounted at a first angle between 0 to 90 degrees with respect to the base plane 15 of the apparatus 10, and the soundwave deflection surface 113 may be arranged at a second angle between 0 to 90 degrees with respect to the base plane 15 of the apparatus 10. In use, the base plane 15 of the apparatus may be rested on the surface 43 of the body portion of the subject (i.e. the body surface 43), or may be substantially parallel with and close to the body surface 43. The medical imaging device 20 is not firing acoustic energy or transmitting the sound waves directly towards the body surface 43, when the apparatus 10 (with the medical imaging device 20 attached thereon) are placed on the body surface 43.

[0056] The soundwave deflection surface 113 functions as a soundwave re-director that allows the sound waves to travel towards the body portion of the subject, and allows the echoes from the body portion to travel back to the ultrasound probe for image construction. The transmission of the sound waves follows a designated path or a designated propagation trajectory. More specifically, as can be seen in Figure 2, the sound waves propagate from the ultrasound probe 20 to the soundwave deflection surface 113 in a first direction substantially along a base plane 15 of the apparatus 10. The soundwave deflection surface 113 may be positioned at an angle with respect to the base plane 15. As the sound waves (e.g. in the form of longitudinal acoustic arrays) strikes the soundwave deflection surface, at least part of the sound waves are deflected to propagate along a second direction and towards a body portion of the subject where the base plane 15 of the apparatus 10 is rested on. Soundwave echoes from the body portion of the subject are transmitted towards the soundwave deflection surface 113 and are redirected to propagate to towards the ultrasound probe receptor along a similar or the same propagation trajectory.

[0057] In various embodiments, the soundwave deflection surface 113 may be configured to work based on principles of wave reflection, wave refraction, or wave diffraction. In particular, there are several ways to redirect the ultrasound waves. These include:- a. diffraction as the ultrasound waves pass through one or more openings (grating) if present or around a barrier; b. refraction as the ultrasound waves pass through material of different properties, i.e. through layers of dissimilar or inhomogeneous media. Examples of such properties may be density of the material, a sound wave impedance or a sound wave transmission velocity of the material.

[0058] In some embodiments, the soundwave deflection surface 113 is formed from a deflector material having a sound transmission velocity substantially different from the sound transmission material of the soundwave transmission portion 116. Alternatively, the sound transmission velocity of the deflector material may be in a substantially different range as compared to that of the soundwave transmission material. In some embodiments, suitable deflector material may have a sound transmission velocity at a ratio ranging from 3.0 to 11.0 relative to water.

[0059] Deflection of the sound waves occurs at an interface of two dissimilar medium, i.e. the deflector material and the sound transmission material. Due to the differences in the sound wave transmission velocity of the deflector material and of the sound transmission material, the sound waves are deflected at the soundwave deflection surface. In this manner, the propagation path/trajectory of the sound waves may be altered. It is to be appreciated that a desired degree of change in the propagation direction (i.e. the degree of deflection of the sound waves) may be achieved by selecting a suitable deflector material, and/or by positioning and shaping the soundwave deflection surface 113 in a suitable manner.

[0060] In some embodiments, for the purpose of effective soundwave deflection, one or more reflective surface(s) may be provided to substitute or supplement the deflector material. The reflective surface(s) can be fabricated out of suitable materials for reflecting ultrasound waves coherently and efficiently. The shape or texture of the reflective surface(s) may also be designed to reshape or focus the wave pattern so as to improve clarity or efficiency of wave reception through soundwave manipulation.

[0061] In some embodiments, the reflective surface(s) may comprise one or more rigid materials such as polypropylene (PP), polycarbonate (PC), glass, metal or suitable polymers. The following modifications may be made to one or more of the aforementioned material(s):- Suitable coating materials may be chemically deposited or electroplated with various metals such as gold, nickel, copper, chrome, etc. The reflective surface(s) may comprise or predominantly consist of microstructures or patterned textures to manipulate the ultrasound waves so as to achieve proper focusing or beam forming. The reflective surface may be constructed of porous or non-porous internal structure of the materials mentioned.

[0062] In some embodiments, the reflective surface(s) may be supplemented by one or more diffraction mechanisms such as ultrasonic acoustic grating. In some embodiments,

multiple reflective surfaces may be arranged at various angles with respect to each other for the optimal reflection.

[0063] In some embodiments, the soundwave deflection surface 113 may be a replaceable part. Different configuration or different wave forming feature may be mounted onto the apparatus 10 and be deployed as the soundwave re-director. For example, a replaceable part, which will influence the pattern of the sound wave differently, may be used to generate the image in a more efficient manner for different thickness of the skin or body structure.

[0064] In various embodiments, the soundwave manipulation module 110 may further comprise a soundwave transmission portion 116 arranged to facilitate efficient transmission of the sound waves within the soundwave manipulation module 110. More specifically, the soundwave transmission portion 116 is arranged as a medium for the soundwaves to travel between the medical imaging device 20 (e.g. the ultrasound probe transmitter/receptor end) and the soundwave deflection surface 113, as well as between the soundwave deflection surface 113 and the target portion of the subject, in accordance to the designated transmission or propagation trajectory controlled by the soundwave deflection surface 113.

[0065] Suitable sound transmission material(s) having a desired acoustic characteristic (e.g. a desired sound transmission velocity) may be used for forming the soundwave transmission portion 116. In some embodiments, the sound transmission material(s) may have a sound transmission velocity at a ratio ranging from 0.8 to 5.0 relative to water. In some embodiments, the sound transmission materials may have a sound transmission velocity at a ratio ranging from 2.0 to 3.0 relative to water.

[0066] In various embodiments, the soundwave transmission module may be formed with a clear and homogeneous structure. The structure may be transparent or translucent. Artifacts within the soundwave transmission portion 116 are minimized or eliminated so as to facilitate efficient transmission of the sound waves therein.

[0067] In various embodiments, suitable sound transmission materials for forming the soundwave transmission portion 116 includes, but are not limited to Poly(methyl methacrylate) or PMMA, Polycarbonate or PC, Polyamide (e.g. Nylon), Polyvinyl chloride or PVC, Polystyrene or PS, Polypropylene or PP, silicone or polysiloxanes, natural or synthetic rubber. .

[0068] In some embodiments, the soundwave transmission portion 116 may be formed from a water-based material or a gel-based sound transmission material which results in the travel speed of ultrasound resembling that of water or a soft tissue. Such water-based or gel-based sound transmission materials may include, but are not limited to water, gelatine, polyvinyl alcohol, agarose, and polyacrylamide. The water-based or gel-based soundwave transmission material may be provided in the form of a gel pad. The gel pad may be disposed at a hollow portion or a cavity of the soundwave manipulation module 110. The form and shape of the gel pad soundwave transmission material are adaptable according to the inner profile of the hollow portion/the cavity of the soundwave manipulation module 110. Advantageously, any gaps, air pockets, or other irregularities which may interfere the sound wave propagation within the soundwave transmission portion 116 (in the form of a gel pad disposed in the hollow portion) can be minimized.

[0069] In various embodiments, the soundwave manipulation module 110 may be supplemented by one or more interface materials. In use, the one or more interface materials may be disposed at an interface between the medical imaging device 20 and the sound wave transmission portion 116 (i.e. the probe-apparatus interface 141) and/or at an interface between the sound wave transmission portion 116 and the body portion of the subject.

[0070] Similar to the sound transmission material used for forming the gel-pad form soundwave transmission portion 116, the primary (core) component of the interface material(s) may be water-based (e.g., gelatine, polyvinyl alcohol, agarose, polyacrylamide) which results in the travel speed of ultrasound resembling that of water or soft tissue. In addition, a scattering agent may be suspended in the buffer/gel medium to produce the backscatter that enhances ultrasound imaging. Scattering agents generally comprise particulate matter and may include graphite particles, silica particles, and polystyrene spheres.

[0071] The interface material(s) may be provided to improve efficiency and compatibility with existing ultrasound probe (i.e. for ultrasound buffer). Such interface material(s) can include acoustic materials including gelatine-based material (i.e. gel) with various additives to provide realistic acoustic properties to enhance or control ultrasonic (US) waves. The additives may be micron-sized silica particles or similar to induce acoustic scattering and a percentage (range) of fat emulsion to change ultrasonic attenuation. It is to be appreciated that in general the interface material can be modified to achieve an optimum or optimum range of

speed of ultrasound travelling through a medium, acoustic attenuation and acoustic backscatter.

[0072] In some embodiments, the soundwave transmission portion 116 may further comprise a buffer material that enhances the soundwave transmission efficiency through the various mediums to the ultrasound probe receptor by providing an interface with the feature. This buffer material may be a disposable part which is connectable to and compatible with various probe shapes.

[0073] In various embodiments, the apparatus 10 comprises at least one auxiliary equipment receiver 130 for receiving the at least one auxiliary equipment 22. The auxiliary equipment 22 may be disposed on or otherwise connected to the soundwave deflection surface 113 of the soundwave manipulation module 110.

[0074] In various embodiments, the auxiliary equipment receiver 130 is shaped and dimensioned to receive an auxiliary equipment for insertion towards and/or into the body portion of the subject. The auxiliary equipment receiver 130 provides a means for holding and/or guiding the auxiliary equipment. For example, as shown in Figure 1 to 4, the auxiliary equipment receiver 130 may be in the form of an aperture/channel shaped and dimensioned for the auxiliary equipment 22 (such as a needle or a catheter) to be inserted. The auxiliary equipment receiver 130 may be configured to receive most, if not all commercially available aspiration/biopsy needles and catheters.

[0075] In some embodiments, the at least one auxiliary equipment receiver 130 may be configured to facilitate placement of the auxiliary equipment at more than one positions with respect to the base plane 15 of the apparatus 10. For example, the apparatus 10 may be provided with more than one apertures/channels of different shapes and dimensions for receiving auxiliary equipment 22 of different types. Further, as illustrated in Figure 4, the apertures/channels for receiving the auxiliary equipment 22 may be arranged at different angles with respect to the base plane 15 of the apparatus 10. This allows placement/insertion of the auxiliary equipment 22 from different directions, with reference to the base plane of the apparatus 15 or the body surface 43.

[0076] The shape and dimension of the aperture/channel may correspond substantially to the shape and dimension of the needle or the catheter, which allows insertion of the needle or

the catheter along a longitudinal axis of the aperture/channel, and at the same time may allow lateral or rotational movement of the needle/catheter within the aperture/channel to a certain degree. In other words, the aperture/channel and the auxiliary equipment are not in a tight-fit arrangement. When the needle/catheter is inserted into the aperture/channel, a gap is left between the needle/catheter and the inner wall of the aperture/channel so that is the needle/catheter is not completely confined by the aperture/channel and the position of the needle/catheter is adjustable to a certain degree. In some embodiments, the inserted needle or catheter is capable of an angular movement and/or a lateral movement within the aperture/channel. For example, the needle/catheter held by the aperture/channel may be capable of an angular movement of -20° to 20° about the central axis of the aperture or about the longitudinal axis of the channel.

[0077] In some embodiments, the apparatus 10 further comprises a handle for controlling movement of the apparatus on the body surface 43 of the subject. For example, the handle 121 may be a protruding part provided on an upper surface of the apparatus 10, as shown in Figure 2. Particularly, the handle 121 provides convenience to the user (e.g. a medical practitioner) to move the apparatus 10 across the body surface 43 to identify the target portion.

[0078] In some embodiments, the medical imaging device receiver 140 and the at least one auxiliary equipment receiver 130 are rotatable with respect to each other to achieve an optimal view of an auxiliary equipment 22 (when present) and a clear pathway to the target subject. More specifically, the ultrasound probe 20 and/or the auxiliary equipment receiver 140 may be rotatable about a portion (point) on the base plane 15 of the apparatus 10 to provide for angular adjustment. A practitioner may adjust the position of the ultrasound probe 20 and the auxiliary equipment receiver 40 to obtain an optimal ultrasound image.

[0079] Advantageously, the afore-described apparatus 10 provides for an arrangement to redirect ultrasound waves effectively by reflection or diffraction techniques to provide a clear view of the auxiliary equipment such as needle (when present) for insertion into an identified location on a subject. The arrangement also provides for a clear pathway and an optimal view of the auxiliary equipment 22 to the identified location of the subject.

[0080] Further, by referring to a real-time image of the target portion formed by the medical image device, a practitioner may accurately place the auxiliary equipment at or insert the auxiliary equipment into the target portion of the subject. The step of marking a location

for placement/insertion of the auxiliary equipment, and removing the ultrasound probe to prepare for placing/inserting the auxiliary equipment into the target portion may be eliminated.

[0081] It is to be appreciated that the arrangement of the various components of the apparatus 10 as described may implemented in various suitable manners.

[0082] In some embodiments as illustrated in Figure 1 and Figure 2, one both of the auxiliary equipment receiver 130 and the medical imaging device receiver 140 may be formed as part of the casing of the apparatus 10. For example, these features may be may be integrally formed with the casing of the apparatus using a plastic molding technique. The casing may comprise adaptable structures for placement and/or attachment of other components of the apparatus 10 including the soundwave deflection surface 113 and the soundwave transmission portion 116.

[0083] In some other embodiments, as illustrated in Figure 3 and Figure 4, the apparatus 10, in particular, the sound wave manipulation module 110, the medical device receiver 140 and the auxiliary equipment receiver 130 may be integrally formed as a one-piece element, for example, by using a plastic moulding process. Where necessary, one or more other shaping processes may be used to form structures for mounting/receiving the medical imaging device 20 and the auxiliary equipment 22. Such an apparatus 10 may be referred to as a “mono-block” design or a “mono-block” apparatus 10.

[0084] In various embodiments, mono-block apparatus 10 is shaped and dimensioned such that the soundwaves propagating within the mono-block apparatus along a designated path. In particular, the soundwave deflecting surface 113 may be disposed at a suitable angle for re-directing the soundwaves towards the target body portion or re-directing the soundwave echoes towards the medical imaging device 20 (or ultrasound probe). Further, the mono-block apparatus 10 may be formed to extend along a suitable length from the probe-apparatus interface 141 to the soundwave deflecting surface 113, for example, in a range of 5mm to 60mm.

[0085] As can be seen from Figure 3 and Figure 4, in the mono-block design, an interface 113 between the mono-block material and the air forms and functions as the soundwave deflection surface 113.

[0086] Materials with a suitable sound transmission velocity, which allows the trajectory of sound waves to be deflected at a desired angle at the sound deflection surface 113, may be used for forming the mono-block apparatus 10. Such materials may include the afore-described sound transmission materials, such as Poly(methyl methacrylate) or PMMA, Polycarbonate or PC, Polyamide (e.g. Nylon), Polyvinyl chloride or PVC, Polystyrene or PS, Polypropylene or PP, silicone or polysiloxanes, natural or synthetic rubber.

[0087] In some embodiments, the material used for forming the mono-block apparatus 10 may have a sound transmission velocity at a ratio ranging from 2.0 to 3.0 relative to water. Accordingly, sound waves that are transmitted from the medical imaging device 20 and echoes that come from the body surface may be deflected towards the mono-block material at a desired angle when striking on the soundwave deflection surface 113. In various embodiments, the mono-block apparatus 10 may be formed with a clear and homogeneous structure, where artifacts (such as air pockets, impurities) are minimized or eliminated with the apparatus so as to minimize interference to the sound waves travelling therein. The soundwave deflecting surface 113 and the probe-apparatus interface 141 are smooth and homogenous surfaces formed with minimal surface roughness/irregularities. Advantageously, efficient soundwave transmission within the mono-block apparatus 10, and efficient soundwave diffraction at the soundwave deflecting interface 113 may be achieved.

[0088] In some embodiments as illustrated in Figure 5A and 5B, the auxiliary equipment receiver 130, the casing, and other components of the apparatus including the soundwave deflection surface 113, the medical imaging device receiver 140, and the soundwave transmission module 116, may be formed as separate parts which are assembled/connected together. As can be seen, a hollow portion 212 may be formed by a top block 214, a bottom block 216 and a catch 217 when assembled together. The hollow portion 212 may be used for containing a soundwave transmission material, e.g. a gel pad containing a gel-based material. Multiple attachment means (e.g. by using screws, rivets, adhesive material(s), mechanical interlocking structures) may be used for connecting/assembling the aforementioned parts to form the apparatus 10.

[0089] In this configuration, the soundwave deflection surface 113 and other components of the apparatus may be replaceable. A suitable soundwave deflection surface 113 may be selected based on the specific application of the apparatus, for example, based on the required image resolution and focus. Also, broken or worn parts may be replaced.

[0090] In some embodiments as shown in Figure 6A and 6B, and Figure 7A to 7D, the apparatus 10 may further comprise a frame 412 mountable onto the body portion of the subject, wherein the frame is arranged to facilitate movement of the medical image device receiver 140 and the at least one auxiliary equipment receiver 130 along at least two axis.

[0091] The frame 412 is mountable onto a body portion of the subject, such as a back of a human being. The frame 412 comprises a first portion 414 operable to receive a medical imaging device 20, and a second portion 416 for receiving an auxiliary equipment 22. The medical imaging device 20 may be an ultrasound probe and the auxiliary equipment 22 may be a needle or catheter for insertion into the body portion at a specified location of the body portion. Fastening/adjustment means may be used to hold the ultrasound probe 20 at an angle.

[0092] Figure 7A and 7B show a medical imaging device 20 in the form of an ultrasound probe and an auxiliary equipment receiver 130 in the form of a needle holder 134. A soundwave deflection surface 113 (e.g. in the form of one or more soundwave reflective surfaces) may be positioned on the needle holder 134. The soundwave deflection surface 113 may be replaceable for purpose of different configurations or for wave manipulation methods as afore-described. The needle holder 134 comprises at least one aperture/channel shaped and dimensioned to receive a needle or a catheter.

[0093] In various embodiments, the frame 412 can be a rectangular-shaped frame having two opposite ends 412a, 412b functioning as guides to slidably receive the medical image device 20. The opposite ends 412a, 412b include rails 432 or other suitable mechanism such as gear teeth arranged to allow first portion 414 to be moved along the rails 432 along an axis such as the Y axis. The first portion 414 may comprise a plate for the ultrasound probe 20 to rest thereon.

[0094] In some embodiments, the first portion 414 may comprise a catch mechanism (not shown) to interact with the rails 432 such that when the first portion 414 is moved to a first position along the rails 432 via a first direction) along the rail, it can be held in the first position via the catch mechanism (e.g. via friction and/or other quick-release catch). In order to move to a second position along the rails 432, the first portion 414 can continue moving in the first direction (Y1), which can be a forward direction. However, if the second position 416 is not along the first direction, but in, for example, an opposite direction from the first

direction (i.e. Y2), the catch mechanism needs to be released before the first portion 414 can be moved to the second position 416.

[0095] In various embodiments, the frame 412 can include a plurality of fasteners 18 for attachment to the body portion. Such fasteners 418 can be in the form of for example, suction cups, releasable straps (such as the velcroTM type), strap and buckle arrangements, removable adhesives, and one or more combinations of the aforementioned.

[0096] In various embodiments, the first portion 414 may be a plate mounted on the rails 432 of the frame 412. The first portion 414 is shaped and dimensioned to support an ultrasound probe 20 which can be mounted thereon. The first portion 414 may comprise grooves, flanges and/or fasteners arranged to be corresponding to the shape(s) of one or more types of ultrasound probe.

[0097] In various embodiments, the second portion 416 can be mounted on the first portion 414. In some embodiments, the second portion 416 can be slidably moveable along the first portion 414. The second portion 416 comprises a holder operably configured to receive an auxiliary equipment such as a needle, catheter for insertion at a specific location on the body portion. The second portion 16 is configured to move in an approximately perpendicular direction relative to the first portion 414. For example, if the first portion 414 is configured to move along a y-axis, the second portion 416 is configured be moveable along the x-axis.

[0098] In some embodiments, the second portion 416 can move along the first portion 414. The second portion 416 can be moved by a user to a direction (X1), which can be a forward direction, to a desired position. However, if the user wishes to move in an opposite direction (X2), then the catch mechanism (not shown) needs to be released before the second portion 416 can move in the direction of X2.

[0099] Position of the auxiliary equipment receiver 130 may be adjusted in order to achieve the best ultrasound image quality. In some embodiments, the auxiliary equipment receiver 130 and the soundwave deflection surface 113 mounted thereon may be further configured to rotate with respect to the ultrasound probe 20.

[00100] In some embodiments and with reference to Figure 7A to 7D, the apparatus 10 may comprises a rotatable sub-assembly 134 to rotation of the ultrasound probe 20 and the

auxiliary equipment receiver 130 with respect to each other. This feature provides at least the following advantages: (a) The angle of the soundwave deflection surface 113 is adjustable to get the best ultrasound image quality, and/or to adjust focus of the image. The image quality may be further improved by adjusting a distance of the ultrasound deflection surface 113, i.e. by moving the ultrasound probe 20 towards or away from the soundwave deflection surface. b) When mounted on the frame 412, the rotatable sub-assembly 134 provides for a rotational movement of the needle (when present), so as to facilitate accurate aiming of the auxiliary equipment 22, and/or accounting for body contour(s) before insertion.

[00101] In some embodiments, the first portion 414 may include one or more fiducial marker(s) 415 to indicate a position of the auxiliary equipment 22 relative to the ultrasound probe 20 (when both are present). The fiducial marks 415 may be opaque to sound waves, so that the waveform and/or the propagation trajectory of the soundwaves are not affected by the fiducial marks 415.

[00102] It is to be appreciated that the afore-described arrangements of the various components of the apparatus 10 are non-limiting examples, and other suitable arrangements may be contemplated to achieve the same effect of re-directing the sound waves using a sound manipulation module, allowing a real-time image of the subject to be formed for guiding the insertion/placement of an auxiliary equipment. Two other non-limiting examples of the apparatus 10 are illustrated below and in Figure 8 and Figure 9.

[00103] As shown in Figure 8, the ultrasound probe may be mounted at a sticker plate 460 via a probe holder 462 (one specific form of the medical imaging device receiver 130). The sticker plate 460 is attached on a user during use, and the ultrasound probe 20 is held at an angle by the probe holder 130. A soundwave deflection surface 113 is arranged opposite the direction of movement of the ultrasound probe 20 so as to provide a guide for a user to identify a precise location for needle insertion. The soundwave deflection surface 113 may be in the form of a reflective surface (e.g. a mirror) and comprise an aperture shaped and dimensioned for the auxiliary equipment to be inserted.

[00104] After insertion, an ultrasound gel may be used in this specific embodiment to serve as the soundwave transmission portion 116 as well as the auxiliary equipment receiver 116. A needle, or other auxiliary equipment may be held in place by the ultrasound gel, which also facilitates transmission of ultrasound waves between the ultrasound probe 20 and the

target subject. The probe may be mounted at a first angle between 0 to 90 degrees with respect to the plane of the sticker plate, and the reflective surface 113 may be mounted at a second angle between 0 to 90 degrees with respect to the plane of the sticker plate. The reflective surface 113 can be integral to the sticky plate.

[00105] Another possible configuration of the apparatus 10 is illustrated in Figure 9 wherein the medical image device 20 is in the form of an ultrasound probe. A soundwave manipulation module 110 (in the form of a buffer material) and an auxiliary equipment receiver 130 (in the form of an aperture, a channel, or a needle holder attached to the buffer material) are integrated with the ultrasound probe 20 to provide convenient experience to a user. In general, the engineering of the ultrasound buffer (as well as the angle to refract the ultrasound rays) should be such that the needle does not need to pass through the buffer or does not interfere with the sound waves, while having real time ultrasound imaging as the needle is inserted. The needle track would be either through a hole in the buffer or not passing through the buffer.

[00106] The apparatus 10 is described in the context of a method for facilitating medical imaging. The method may suitably be deployed to identify a lumbar interspace of an individual but it is to be appreciated that the method may be deployed for other types of medical imaging as known to a skilled person.

[00107] In accordance to one embodiment, the method for deploying the apparatus 10 may comprise the following steps:-

[00108] The medical imaging device 20 is first attached to the apparatus 10 via a medical imaging device receiver 140 (step s101). The sound wave manipulation module 110 is then placed on a body portion of a subject, e.g. on a back of the individual, preferably by a qualified medical practitioner (step s102). The base plane 15 of the apparatus 10 may be rested on the body surface 43.

[00109] Position of the apparatus 10 can be adjusted for obtaining an image of the target subject (step s104) by the medical imaging device 20 (step s103). The medical imaging device 20, i.e. the ultrasound probe is switched on and the apparatus 10 may be moved on and across the body surface 43, whereby a target portion may be identified for further procedures to be performed by the auxiliary equipment 22. For example, a user may move the apparatus

10 and the ultrasound probe 20 to locate the lumbar interspace of the subject, which can be, but not limited to, an L2-L3 interspace, L3-L4 interspace, L4-L5 interspace.

[00110] An auxiliary equipment 22 (e.g. a needle, a catheter or an endoscope) can be attached to the apparatus 10 via the at least one auxiliary equipment receiver 130 (step s104). The apparatus 10 may comprise more than one auxiliary equipment receiver 130, and a suitable auxiliary equipment receiver 130 may be selected primarily based on the size and shape of the auxiliary equipment 22.

[00111] Once the target portion is identified, the auxiliary equipment 22 may be inserted towards the target portion. The real-time image formed by the medical imaging device 20 may be used to guide the placement/insertion of the auxiliary equipment 22 (step s105). In this process, the position of the auxiliary equipment 22 may be adjusted based on the real-time image of the target portion. In this manner, accurate and fast placement of the auxiliary equipment 22 is achieved.

[00112] In accordance to another embodiment, a method for deploying the apparatus 10 may comprise the following steps:-

[00113] The frame 412 is first mounted on a body portion of a subject, preferably by a qualified medical practitioner (step s302). Next the medical imaging device 20, i.e. the ultrasound probe 20 is switched on and a user moves the ultrasound probe 20 (which has been mounted on the first portion 414) to locate the lumbar interspace, which can be, but not limited to, an L2-L3 interspace, L3-L4 interspace, L4-L5 interspace (step s304).

[00114] Upon identification of the desired lumbar interspace, the medical practitioner will then position the needle/catheter on the second portion 416 (step s306). The second portion 416 is next adjusted to the desired position on the lumbar interspace. The adjustment may include angular adjustment via the rotational sub-assembly (step s308).

[00115] Once the first portion 414 and second portion 416 are in position, the process may continue either via the insertion of the catheter, or if other types of auxiliary equipment 22 is used, the process may continue via the use of the auxiliary equipment 22 (step s310).

[00116] In some embodiments, a part of the apparatus 10 may be disposable to maintain a standard of hygiene.

[00117] For example, the disposable parts of the frame 12 may be made of moulded polypropylene or polycarbonate or similar plastic. Some parts such as the attachment features may be made out of silicone or rubber for suction cups, or nylon fabric for straps and buckles.

[00118] Essentially, the rectangle frame needs to be ergonomic – when lumbar puncture is done the patient is curled up when lying to the side or hunched forward when sitting – so that may pose a problem when we want to secure the 4 ends to the patient. One other alternative is a stand with a flexible mechanical arm holding the probe. Both solutions need to ensure that the contact between the probe and the skin of the patient is good at all times.

[00119] An apparatus for use with a medical imaging device, such as an ultrasound waveguide device has been contemplated as described in the present disclosure. The medical imaging device and one or more auxiliary equipment holder are arranged at various positions with respect to one another to achieve an optimal view of an auxiliary equipment (when present) and pathway to a target portion of a subject (e.g. a patient).

[00120] The various embodiments are advantageous to provide a quick-release, body mountable, multi-axes tracking device for guiding ultrasound probes and puncture needles to improve the accuracy of such a medical procedure as well as freeing up the user's hands by holding the aforementioned instruments at the guided position and orientation. The guide is adjustable and compliant for user-triggered movements with active friction locking for hands-free approach.

[00121] It should be appreciated by the person skilled in the art that the above invention is not limited to the embodiments described. In particular, modifications and improvements may be made without departing from the scope of the present invention.

It should be further appreciated by the person skilled in the art that one or more of the above modifications or improvements, not being mutually exclusive, may be further combined to form yet further embodiments of the present invention.

REFERENCE

10	apparatus
15	base plane
20	medical imaging device
22	auxiliary equipment
40	target subject
43	body surface
110	sound wave manipulation module
113	sound wave deflection surface
116	sound wave transmission portion
120	locking mechanism
121	handle
130	auxiliary equipment receiver
134	needle holder
140	medical imaging device receiver
141	probe-apparatus interface
212	hollow portion
214	top block
215	bottom block
216	sound wave transmission portion
217	catch
412	frame
412a, 412b	opposite ends of the frame
413	sound wave deflection surface
414	first portion
415	fiducial mark(s)
416	second portion
418	fastener
432	rail
460	sticker plate
462	probe holder