Claims

1. An ultrasound imaging method for identifying an anatomical feature of a spine, the method comprising:

receiving, by a processor, a transverse ultrasound image of a portion of the spine;

extracting, by the processor, features of the portion of the spine from the transverse ultrasound image based on a distinct pattern associated with the anatomical feature of the spine;

identifying, by the processor, a midline of the portion of the spine in the transverse ultrasound image;

extracting, by the processor, midline features using pixel intensity values of the transverse ultrasound image; and

identifying, by the processor based on a combination of the extracted features of the portion of the spine and the extracted midline features, the anatomical feature in the transverse ultrasound image,

wherein the anatomical feature of the spine includes a neuraxial space, and

wherein the extracted features of the portion of the spine include a horizontal position of a posterior complex and a horizontal position of an anterior complex.

2. The method of claim 1, wherein the extracted features of the portion of the spine further include one or more of: a depth of the posterior complex, a depth of the anterior complex, a normalized cross-correlation strength of the posterior complex, a normalized cross-correlation strength of the anterior complex, a location of a left articular process, a location of a right articular process, a normalized cross-correlation value of a left articular process, and a normalized cross-correlation value of a right articular process.

3. The method of claim 1 or claim 2, wherein the extracted midline features include a ratio of black pixels in a predefined window and a ratio of white pixels below the posterior complex.

4. The method of claim 3, wherein identifying the midline of the spine comprises using, by the processor, a cost function associated with a presence of white pixels within the

predefined window of the ultrasound image, wherein the cost function includes a first term associated with a depth of the pixels and a second term associated with a position of the midline in relation to a centre of the transverse ultrasound image.

5. The method of any preceding claim, further comprising:

receiving, by the processor, a paramedian sagittal ultrasound image of another portion of the spine;

identifying, by the processor, morphological features of the paramedian sagittal ultrasound image for classifying the another portion of the spine, the morphological features comprise one or more of: a contour linearity, a size, a centre location and an area of the paramedian sagittal ultrasound image; and

determining, by the processor based on the identified morphological features, if the another portion of the spine includes a sacrum.

6. The method of claim 5, wherein identifying the morphological features of the paramedian sagittal ultrasound image comprises identifying, by the processor, the morphological features using template matching, and the method further comprises identifying, by the processor, an interspinous space based on the identified morphological features of the paramedian sagittal ultrasound image.

7. The method of claim 5 or claim 6, wherein the another portion of the spine is determined to include the sacrum, the method further comprising:

receiving, by the processor, a further paramedian sagittal ultrasound image of the spine;

determining, by the processor based on template matching of (i) laminas of the spine in the paramedian sagittal ultrasound image and the further paramedian sagittal ultrasound image and (ii) a cross relation strength between the paramedian sagittal ultrasound image and the further paramedian sagittal ultrasound image, if the further paramedian sagittal ultrasound image is suitable to be stitched to the paramedian sagittal ultrasound image; and

stitching, by the processor, the further paramedian sagittal ultrasound image to the paramedian sagittal ultrasound image to form a portion of a panorama image of the spine if it is determined that the further paramedian sagittal ultrasound image is suitable to be stitched to the paramedian sagittal ultrasound image.

8. The method of claim 7, further comprising:

identifying, by the processor, locations of interspinous spaces of the portion of the panorama image; and

identifying, by the processor, spinal levels using the locations of the interspinous spaces.

9. The method of claim 8, wherein identifying locations of interspinous spaces of the portion of the panorama image further comprises:

calculating, by the processor, a motion between the further paramedian sagittal ultrasound image and a leading edge of the paramedian sagittal ultrasound image using phase correlation; and

transforming, by the processor, coordinates of a centre of a ultrasound probe in respect of the portion of the panorama image.

10. The method of claim 9, further comprising:

determining, by the processor, if the ultrasound probe is at an optimal level of the spine based on the identified spinal levels; and

transmitting, by the processor, a request for obtaining the transverse ultrasound image of the portion of the spine if the ultrasound probe is at the optimal level.

11. The method of claim 10, wherein the optimal level includes a location of the L3-L4 interspinous space of the spine.

12. The method of any preceding claim, further comprising pre-processing, by the processor, the transverse ultrasound image prior to extracting features of the portion of the spine and the midline.

13. The method of claim 12, wherein pre-processing the transverse ultrasound image comprises performing, by the processor, a contrast enhancement on the transverse ultrasound image using a Difference of Gaussians (DoG) local normalization filter.

14. The method of claim 12 or claim 13, wherein pre-processing the transverse ultrasound image comprises eliminating, by the processor, candidate contour points in the transverse ultrasound image using intensity thresholding.

15. The method of any one of claims 5 to 11, further comprising pre-processing, by the processor, the paramedian sagittal ultrasound image prior to identifying the morphological features.

16. The method of claim 15, wherein pre-processing the paramedian sagittal ultrasound image comprises performing, by the processor, a contrast enhancement on the paramedian sagittal ultrasound image using a Difference of Gaussians (DoG) local normalization filter.

17. The method of claim 15 or claim 16, wherein pre-processing the paramedian sagittal ultrasound image comprises eliminating, by the processor, candidate contour points in the paramedian sagittal ultrasound image using intensity thresholding.

18. The method of any one of claims 1 to 17, further comprising calculating, by the processor, a depth of the neuraxial space.

19. The method of one of claims 1 to 18, further comprising identifying, by the processor, the neuraxial space using a Support Vector Machine (SVM) classifier.

20. The method of claim 19, further comprising training, by the processor, the SVM classifier using historical data associated with the features of the portion of the spine and the midline features.

21. A computer readable medium storing processor executable instructions which when executed on a processor cause the processor to carry out a method according to any one of claims 1 to 20.

22. An ultrasound imaging system for identifying an anatomical feature of a spine, the system comprising:

an ultrasound probe arranged to scan the spine for a transverse ultrasound image of a portion of the spine; and

a computer comprising a processor and a data storage storing computer program instructions operable to cause the processor to:

receive the transverse ultrasound image of the portion of the spine;

extract features of the portion of the spine from the transverse ultrasound image based on a distinct pattern associated with the anatomical feature of the spine;

identify a midline of the portion of the spine in the transverse ultrasound image;

extract midline features using pixel intensity values of the transverse ultrasound image; and

identify, based on a combination of the extracted features of the portion of the spine and the extracted midline features, the anatomical feature in the transverse ultrasound image,

wherein the anatomical feature of the spine includes a neuraxial space, and

wherein the extracted features of the portion of the spine include a horizontal position of a posterior complex and a horizontal position of an anterior complex.

23. The system of claim 22, wherein the extracted features of the portion of the spine further include one or more of: a depth of the posterior complex, a depth of the anterior complex, a normalized cross-correlation strength of the posterior complex, a normalized cross-correlation strength of the anterior complex, a location of a left articular process, a location of a right articular process, a normalized cross-correlation value of a left articular process, and a normalized cross-correlation value of a right articular process.

24. The system of claim 22 or claim 23, wherein the extracted midline features include a ratio of black pixels in a predefined window and a ratio of white pixels below the posterior complex.

25. The system of any one of claims 22 to 24, wherein the data storage further stores computer program instructions operable to cause the processor to:

receive a paramedian sagittal ultrasound image of another portion of the spine;

identify morphological features of the paramedian sagittal ultrasound image for classifying the another portion of the spine, the morphological features comprise one or more of: a contour linearity, a size, a centre location and an area of the paramedian sagittal ultrasound image; and

determine, based on the identified morphological features, if the another portion of the spine includes a sacrum.

26. The system of claim 25, wherein the data storage further stores computer program instructions operable to cause the processor to: identify the morphological features using template matching; and identify an interspinous space based on the identified morphological features of the paramedian sagittal ultrasound image.

27. The system of claim 25 or claim 26, wherein the another portion of the spine is determined to include the sacrum, the data storage further stores computer program instructions operable to cause the processor to:

receive a further paramedian sagittal ultrasound image of the spine;

determine, based on template matching of (i) laminas of the spine in the paramedian sagittal ultrasound image and the further paramedian sagittal ultrasound image and (ii) a cross relation strength between the paramedian sagittal ultrasound image and the further paramedian sagittal ultrasound image, if the further paramedian sagittal ultrasound image is suitable to be stitched to the paramedian sagittal ultrasound image; and

stitch the further paramedian sagittal ultrasound image to the paramedian sagittal ultrasound image to form a portion of a panorama image of the spine if it is determined that the further paramedian sagittal ultrasound image is suitable to be stitched to the paramedian sagittal ultrasound image.

28. The system of claim 27, wherein the data storage further stores computer program instructions operable to cause the processor to:

identify locations of interspinous spaces of the portion of the panorama image; and

identify spinal levels using the locations of the interspinous spaces.

29. The system of claim 28, wherein the data storage further stores computer program instructions operable to cause the processor to:

calculate a motion between the further paramedian sagittal ultrasound image and a leading edge of the paramedian sagittal ultrasound image using phase correlation; and

transform coordinates of a centre of the ultrasound probe in respect of the portion of the panorama image.

30. The system of claim 28 or claim 29, wherein the data storage further stores computer program instructions operable to cause the processor to:

determine if the ultrasound probe is at an optimal level of the spine based on the identified spinal levels; and

transmit a request for obtaining the transverse ultrasound image of the portion of the spine if the ultrasound probe is at the optimal level.

31. The system of any one of claims 22 to 30, wherein the ultrasound probe comprises a clamping system arranged to attach a needle to the ultrasound probe for performing a neuraxial procedure.

32. The system of claim 31, wherein the clamping system comprises a clip for attaching the needle using a spring loading mechanism.

33. The system of claim 32, wherein the clamping system further comprises a locking mechanism for locking a position of the clip to fix a position and an angle of the needle.

34. The system of any one of claims 31 to 33, wherein the clamping system is in a form of a cover for the ultrasound probe.