METHODS AND APPARATUS TO LABEL RADIOLGY IMAGES

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ABSTRACT

Methods and apparatus are disclosed to label radiology images. An example system includes a processor and a database. In response to receiving a first user input via a data input, the processor is to generate first annotations on a spinal image. The processor is to cause the spinal image having the first annotations to be displayed at a user interface. The processor is to prompt a user to provide second user input identifying an error in the first annotations. In response to receiving the second user input, the processor is to generate second annotations on the spinal image. The second annotations is to correct the error in the first annotations.
START

RECEIVE FIRST USER INPUT

GENERATE AND DISPLAY FIRST ANNOTATIONS

RECEIVE USER VALIDATION?

RECEIVE SECOND USER INPUT

GENERATE AND DISPLAY SECOND ANNOTATIONS

FINALIZE ANNOTATIONS

SAVE ANNOTATED IMAGE IN A DATA STORE

END
METHODS AND APPARATUS TO LABEL RADIOLOGY IMAGES

RELATED APPLICATION

[0001] This patent arises from U.S. Provisional Application Ser. No. 61/728,405, which was filed on Nov. 20, 2012, and is hereby incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

[0002] This disclosure relates generally to labeling radiology images, and, more particularly, to methods and apparatus to label radiology images.

BACKGROUND

[0003] Spinal images may be obtained and used to diagnose various spinal diseases. In some examples, these spinal images are manually annotated and/or labeled to identify the different vertebrae and/or disks. In other examples, these spinal images are automatically annotated and/or labeled to identify the different vertebrae and/or disks.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1 is a schematic illustration of an example system to annotate radiology images.

[0005] FIGS. 2-5 are radiology images in accordance with the teachings of this disclosure being annotated by the example system of FIG. 1.

[0006] FIG. 6 is a flowchart representative of machine readable instructions that may be executed to implement the system of FIG. 1.

[0007] FIG. 7 is a processor platform to execute the instructions of FIG. 6 to implement the system of FIG. 1.

[0008] Wherever possible, the same reference numbers will be used throughout the drawings(s) and accompanying written description to refer to the same or like parts.

DETAILED DESCRIPTION

[0009] Spinal images may be annotated and/or labeled to assist in analyzing such images and/or diagnosing various spine diseases, etc. However, correctly annotating and/or labeling these images is sometimes difficult because depending on the image being viewed, the number of visible vertebrae and/or discs vary. While these variations occur, some known automated and/or semi-automated spine labeling algorithms assume that regardless of the image being viewed and the actual number of visible vertebrae and/or discs present, the number of visible vertebrae and/or discs is the same. Thus, some known spine labeling algorithms do not accurately annotate and/or label spine images in instances when not all of the vertebrae are/or discs are visible.

[0010] The examples disclosed herein relate to annotating and/or labeling spine images. To overcome some of the deficiencies encountered with some known annotating and/or labeling methods (e.g., manual or automatic), the examples disclosed herein use an example semi-automated spine annotation algorithm and/or system that annotates and/or re-annotates a spine image based on initial user input and/or subsequent user input received (e.g., feedback on non-validated annotations generated).

[0011] For example, based on initial user input (e.g., identifying a vertebra), the system can automatically provide first annotations to a spine image and present the spine image including the first annotations for user review. To quickly correct any errors included in the first annotations, the system receives user input and/or feedback with respect to the first annotations. In some examples, the user can provide input (e.g., identify new and/or improperly labeled vertebrae and/or candidates) by clicking on a false positive, a false negative, a non-labeled and/or mislabeled vertebra and/or disc, etc. In response to the input and/or feedback received, the system takes into account the user input (e.g., new candidates for labeling based on user input, user identified vertebra and/or disc) and the known spatial organization of the vertebra and automatically provides second annotations and/or labels to the spine image for user review (e.g., the system re-annotates the spine image). The second annotations may correct at least one error present in the first annotations based on the user feedback received. In some examples, the user input and/or feedback is independent of the example annotation algorithm. In some examples, the system iterates and/or alternates between automatically annotating and/or labeling the spine image and receiving user input and/or feedback until the user validates the annotations and/or labels generated.

[0012] FIG. 1 depicts an example system 100 for annotating images such as spinal images. In some examples, the system 100 includes a computer 102 and an annotator 104 communicatively coupled to the computer 102. In this example, the computer 102 includes a user interface 106 and a data input (e.g., a keyboard, mouse, microphone, etc.) 108 and the annotator 104 includes a processor 110 and a database 112.

[0013] In some examples, the user interface 106 displays data such as images (e.g., spinal images, radiology images, etc.) and/or annotated images received from the annotator 104. In some examples, the user interface 106 receives commands and/or input from a user 114 via the data input 108. For example, in examples in which the system 100 is used to annotate spinal images, the user interface 106 displays a spinal image(s) and/or an annotated spinal image(s) and the user 114 provides(s) an initial input identifying, for example, a location of a vertebra on the spinal image(s) and/or provides subsequent input identifying, for example, an error in the annotations generated on the spinal image.

[0014] In some examples, after the user interface 106 displays a spinal image (e.g., a T1-weighted MRI image, a non-annotated spinal image), the user 114 may select and/or identify a vertebra (FIG. 2, 202) using the data input 108 and, in response to receiving this user input, the annotator 104 uses the first user input to generate first annotations (FIG. 3, 302) on the spinal image (FIG. 3, 302). While the annotator 104 can generate annotations using any suitable labeling algorithm, in some examples, the annotator 104 generates the first annotations 302 from an initial set of spatially ordered points, x^{(1)}, \ldots , x^{(N)}\text{,} \text{where N = 6 and x^{(6)}}\text{corresponds to the L1 vertebra, x^{(2)}}\text{corresponds to the L2 vertebra, etc.}

[0015] Additionally or alternatively, in some examples, the annotator 104 generates the first annotations 302 by automatically detecting connected regions of the spinal image that are consistent with an image context of the vertebrae and selecting N-points on the spinal image that follow and/or benefit the shape of the spine. In some examples, the annotator 104 automatically detects the connected regions by using data stored in the database 112 such as contextual information about spines, vertebrae and/or neighboring structures and/or
other optimization and/or statistical modeling techniques (e.g., by interpolating based on statistical data and/or models), etc.).

[0016] In some examples, the connected regions may be detected by generating and/or building contextual-information features, statistical modeling the contextual information within the vertebral and/or finding the centroids of all connected-component regions whose contextual features are consistent with the statistical model. In some examples, the contextual-information features are generated and/or built by generating a feature vector, F(p), for each point, p, in the image domain. For example, for each point, p, a 5-dimensional feature vector, F(p) = [F₁, F₂, F₃], may be built, where F₁ is the mean intensity within a 3x10 rectangularly-shaped, vertically-oriented patch centered at point, p, F₂ is the mean intensity within a 10x3 rectangularly-shaped, horizontally-oriented patch centered at point, p, and F₃ corresponds to the intensity of a pixel, p.

[0017] In some examples, the feature vector contains image statistics within several box-shaped image patches of different orientations and/or scales. Such patch-based features may encode contextual information about the vertebral and/or neighboring structures (e.g., size, shape, orientation, relationships to neighboring structures, etc.).

[0018] In some examples, the contextual information within the vertebral may be statistically modeled by building a multi-dimensional model distribution using all the feature vectors, F(p), within a circular space centered at and/or around the first user input (e.g., the one-click user input).

[0019] In some examples, the centroids of all connected-component regions whose contextual features are consistent with the statistical model are determined by optimizing a cost function containing two constraints. In this example, the first constraint is based on a Bhattacharyya measure of similarity between feature distributions. In some examples, the first constraint substantially ensures the obtained and/or identified spinal regions are consistent with the statistical model. In this example, the second constraint is a smoothness constraint that removes small and isolated regions caused by imaging noise. In some examples, the second constraint substantially ensures that the surfaces are smooth. In some examples, K-regions of the spinal image are obtained and [z₁, . . . , zₖ] are the centroids of these regions.

[0020] In some examples, N-points that follow and/or benefit the shape of the spine may be selected using Equation 1 and/or by choosing N-points out of all possible combinations of N-points in the set of determined centroids, [z₁, . . . , zₖ]. Referring to Equation 1, V₁ is the vector pointing from z₀ to xₙₐ, l=1, . . . , N-1, where Vₙ = xₙₐ - x₀.

\[
\text{Equation 1}
\]

[0021] As shown in FIG. 3, some of the first annotations 302 generated may contain errors. For example, the first annotations 302 failed to label the L₃ vertebra 304 (false negative), the first annotations 302 labeled the L₅ vertebra 306 as both L₄ and L₅ (false positive) and the first annotations 302 incorrectly labeled the L₄ vertebra 308 as the L₃ vertebra (incorrect label).

[0022] In response to reviewing the first annotations 302, the user 114 may use the input device 108 to identify one of the errors present within the first annotations 302 (e.g., a single-click correction, second user input, subsequent user input). For example, as shown in FIG. 4, the user 114 identifies and/or selects the L₃ vertebra 304, which the first annotations 302 failed to label. In some examples, the annotator 104 may receive the second user input and generate second annotations 402 based on a new set of spatially ordered points, as shown in Equation 2, where xₘₜₐ corresponds to the coordinate vector of the new point entered by the user 114 (second user input, new candidate). In some examples, Equation 2 is solved for by choosing N points [x₁ₙ, . . . , xₖₙ] out of the N+l points in P, by enforcing Equations 2, 3, 4.

\[
P_{t} = x₁ₙ, . . . , xₖₙ\quad \text{Equation 2}
\]

[0023] Referring to Equation 3, [x₁ₙ, . . . , xₖₙ] maximizes the shape-based criterion over all possible combinations of N points [x₁ₙ, . . . , xₖₙ] in P, where xₘₜₐ = [x₁ₙ, . . . , xₖₙ] ensures that the solution of Equation 3 contains the second user input. Thus, in response to receiving the second user input, the annotator 104 reassigns the labels and/or annotations 302, 306, 308 by taking into account the second user input (e.g., new candidates and/or identified vertebra) and/or the known spatial organization of the vertebrae. As shown in Equation 3, Σₜ₌₁,N₋₁ (cos Vₖ₈₉ₚₚ₉₄) is an angle constraint and

\[
\sum_{i=1}^{N-1} \text{min} (\|Vᵢ\|, \|Vᵢ₊₁\|, \|Vᵢ₋₁\|, \|Vᵢ₋₁⁺\|)
\]

is a distance constraint. In some examples, the angle constraint substantially ensures that each neighboring vertebra [xₖ₈, xₖ₉₊₁, xₖ₉₊₂] is almost and/or substantially aligned and the distance constraint substantially ensures that the distances between neighboring vertebrae are approximately the same.

\[
[x₁ₙ, . . . , xₖₙ] = \text{Equation 3}
\]

[0024] Equation 4 describes vector pointing for xₖₙ to Xₖₙ₊₁, Vₖₙ₊₁, where k=1, . . . , N-1.

\[
Vₙ = xₙₐ - xₙ \quad \text{Equation 4}
\]

[0025] As shown in FIG. 4, the second annotations 402 may be displayed via the user interface 106 for user review. In response to reviewing the second annotations 402, the user 114 may validate the second annotations 402 as being accurate or identify an additional error present within the second annotations 402 (e.g., a single-click correction, third user input, subsequent user input). If the user 114 identifies another error, the loop identified by Equation 5 is repeated until the user 114 validates the annotations.

\[
i = i+1; \quad \text{and} \quad [x₁ₙ, . . . , xₖₙ] = \beta₁ₙ, . . . , \betaₖₙ \quad \text{Equation 5}
\]

[0026] If the user 114 validates the second annotations 402, the annotator 104 automatically completes the labeling of the
remaining vertebrae, if any, using information from the N-vertebra labeling from Equation 3. In some examples, \([x_1, \ldots, x_N]\) is set to the corrected N-vertebra labeling (e.g., the vertebrae identified including the initial and subsequent user input) and the annotator 104 solves for and/or iterates Equation 6 for \(j = 1, 2, \ldots\) if points \(2x_{Nj+1}\) and \(X_{Nj+2}\) exist.

\[
x_{Nj+2} = 2x_{Nj+1} - x_{Nj+2}
\]  
Equation 6

[0027] In some examples, if \(x_{Nj}\) falls within a spatial image domain, the annotator 104 assigns a label to \(x_{Nj+2}\). For example, if \(N = 6, x_{Nj+1} = T/11\) for \(j = 1, x_{Nj+2} = T/10\) for \(j = 2, x_{Nj+3} = T/9\) for \(j = 3\), etc. However, if \(x_{Nj}\) does not fall within the spatial image domain, the annotator 104 exits the loop of Equation 6.

[0028] In some examples, once the vertebrae are annotated and/or labeled, the annotator 104 annotates the discs 502 of the spinal image using the second annotations 402 and/or the annotations determined using Equation 6 above. In some examples, \([x_1, \ldots, x_N]\) corresponds to the completed M-vertebra labeling determined using Equation 5, where \(M \rightarrow N\). In some examples, Equations 7 and 8 may be used to determine the coordinates of the M-discs, where disc labels are assigned to \([y_0, y_1, \ldots, y_{M-1}]\) to account for the spatial ordering of the spine discs.

\[
y_0 = \frac{x_1 + x_{M-1}}{2}, \quad y_1 = \frac{x_2 + x_{M-1}}{2}, \quad \ldots, \quad y_{M-1} = \frac{x_{M-1} + x_M}{2}.
\]  
Equation 7

\[
y_j = \frac{x_j + x_{j+1}}{2} \quad \forall j \in [1, \ldots, M-1], \text{ and}
\]  
Equation 8

[0029] FIG. 6 depicts a manner of implementing the system 100 of FIG. 1. While an example manner of implementing the system of FIG. 1 has been illustrated in FIG. 6, one or more of the elements, processes and/or devices illustrated in FIG. 6 may be combined, divided, re-arranged, omitted, eliminated and/or implemented in any other way. Further, the example annotator 104, the example processor 110, the example computer 102 and/or, more generally, the example flowchart of FIG. 6 may be implemented by hardware, software, firmware and/or any combination of hardware, software and/or firmware. Thus, for example, any of the example annotator 104, the example processor 110, the example computer 102 and/or, more generally, the example flowchart of FIG. 6 could be implemented by one or more circuit(s), programmable processor(s), application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)) and/or field programmable logic device(s) (FPLD(s)), etc. When any of the apparatus or system claims of this patent are read to cover a purely software and/or firmware implementation, at least one of the example annotator 104, the example processor 110 and/or the example computer 102 are hereby expressly defined to include a tangible computer readable medium such as a memory, DVD, CD, Blu-ray, etc. storing the software and/or firmware. Further still, the example flowchart of FIG. 6 may include one or more elements, processes and/or devices in addition to, or instead of, those illustrated in FIG. 6, and/or may include more than one of any or all of the illustrated elements, processes and devices.

[0030] A flowchart representative of example machine readable instructions for implementing the system 100 of FIG. 1 is shown in FIG. 6. In this example, the machine readable instructions comprise a program for execution by a processor such as the processor 712 shown in the example computer 700 discussed below in connection with FIG. 7. The program may be embodied in software stored on a tangible computer readable medium such as a CD-ROM, a floppy disk, a hard drive, a digital versatile disk (DVD), a Blu-ray disk, or a memory associated with the processor 712, but the entire program and/or parts thereof could alternatively be executed by a device other than the processor 712 and/or embodied in firmware or dedicated hardware. Further, although the example program is described with reference to the flowchart illustrated in FIG. 6, many other methods of implementing the example system 100 may alternatively be used. For example, the order of execution of the blocks may be changed, and/or some of the blocks described may be changed, eliminated, or combined.

[0031] As mentioned above, the example processes of FIG. 6 may be implemented using coded instructions (e.g., computer readable instructions) stored on a tangible computer readable medium such as a hard disk drive, a flash memory, a read-only memory (ROM), a compact disk (CD), a digital versatile disk (DVD), a cache, a random-access memory (RAM) and/or any other storage media in which information is stored for any duration (e.g., for extended time periods, permanently, brief instances, for temporarily buffering, and/or for caching the information). As used herein, the term tangible computer readable medium is expressly defined to include any type of computer readable storage and to exclude propagating signals. Additionally or alternatively, the example processes of FIG. 6 may be implemented using coded instructions (e.g., computer readable instructions) stored on a non-transitory computer readable medium such as a hard disk drive, a flash memory, a read-only memory, a compact disk, a digital versatile disk, a cache, a random-access memory and/or any other storage media in which information is stored for any duration (e.g., for extended time periods, permanently, brief instances, for temporarily buffering, and/or for caching the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable medium and to exclude propagating signals. As used herein, when the phrase “at least” is used as the transition term in a preamble of a claim, it is open-ended in the same manner as the term “comprising” is open ended. Thus, a claim using “at least” as the transition term in its preamble may include elements in addition to those expressly recited in the claim.

[0032] The program of FIG. 6 begins at block 602 where the computer 102 receives, via the data input 108, initial input on a spine image displayed at the user interface 106 and/or stored in the database 112 (block 602). In some examples, the initial input is associated with the user 114 clicking on a vertebra of the displayed spinal image and/or labeling it manually. For example, if the L5 vertebra may be clicked (e.g., one-click, single click), identified and/or labeled by the user. In some examples, the initial user input identifying a feature and/or vertebra on the spinal image assists and/or enables the example and/or selected automated and/or semi-automated annotating algorithm to annotate and/or label the remaining vertebrae and/or discs. In some examples, the
examples disclosed herein can be employed with various annotating algorithms and/or software.

[0033] At block 604, the annotator 104 generates initial spinal labeling results and/or annotations using the example and/or selected automated and/or semi-automated annotating algorithm (block 404). For example, based on the initial user input of identifying the L5 vertebra, the annotator 104 labels the L5 vertebra, the L2 vertebra, the L3 vertebra, etc. and these first annotations may be displayed at the user interface 106 for user review.

[0034] At block 606, the user 114 reviews the first annotations and the computer 102 prompts the user regarding the validity of the first annotations and/or receives a decision of whether the first annotations are valid (block 606). If the first annotation are not validated (e.g., there is at least one error present in the first annotations), the computer 102 may receive second user input relating to the error in the generated annotations (608). In some examples, the second user input identifies a false positive in the first annotations, a false negative in the first annotations and/or an incorrect label in the first annotations. In some examples, a false positive occurs when the annotator 104 detects a vertebra where none exists. In some examples, a false negative occurs when the annotator 104 fails to detect a vertebra. In some examples, an incorrect labeling occurs when a target vertebra is detected but assigned an incorrect label. In some examples, the user 114 identifies an error in the first annotations via a single-click correction using the data input 108. For example, if the first annotations fail to and/or incorrectly label the L3 vertebra, the user 114 can click on the L3 vertebra and/or enter a correct label for the L3 vertebra.

[0035] At block 610, second annotations are generated in response to receiving the second user input (block 610). In some examples, in response to receiving the user input, the annotator 104 automatically selects a new set of candidates (e.g., possible vertebrae) and/or points on the spinal image that better fit the shape of the spine. The new set of candidates and/or points includes the initial user input, the subsequent user input, point input and/or identified by the user 114. For example, based on subsequent user input received identifying a false positive, the annotator 104 removes the point associated with the falsely identified point from the set of points. In some examples, when selecting a new set of candidates, points and/or possible vertebrae, the annotator 104 uses shape-based criterion having angel and distance constraints. In some examples, the angle constraint substantially ensures that each three neighboring vertebrae is almost and/or substantially aligned. In some examples, the distance constraint substantially ensures that the distance between neighboring vertebrae is substantially and/or approximately the same. In some examples, the annotator 104 uses the constraints, the subsequent user input (e.g., the newly identified point and/or candidate) and/or known spatial organization of the vertebrae (e.g., L1 is below T12, L2 is L1, etc.) to generate the second annotations that are more accurate than and/or/and at least one error present in the first annotations. In some examples, blocks 606, 608 and 610 are repeated and/or iterated until the user 114 validates the annotations generated and/or displayed.

[0036] At block 620, the annotator 104 finalizes the annotations (block 620). For example, the annotator 104 annotates any non-labeled vertebrae using information obtained and/or associated with generating the second annotations. In some examples, any remaining vertebrae are annotated using point coordinates for labeled vertebrae and, if the coordinates fall within a spatial image domain, the annotator 104 assigns annotations and/or labels based on the coordinates. Additionally or alternatively, the annotator 104 finalizes the annotations by annotating the discs between the vertebrae. In some examples, the discs are annotated by determining the coordinates of the discs based on the coordinates and/or annotated vertebrae and assigning labels to the discs based on the spatial ordering of the spine discs. In some examples, the annotated spine including vertebrae and disc labels is displayed to the user 114 using the user interface 106 and/or saved in the database 112 (block 614).

[0037] FIG. 7 is a block diagram of an example computer 700 capable of executing the instructions of FIG. 6 to implement the system of FIG. 1. The computer 700 can be, for example, a server, a personal computer, a mobile phone (e.g., a cell phone), a personal digital assistant (PDA), an internet appliance or any other type of computing device.

[0038] The system 700 of the instant example includes a processor 712. For example, the processor 712 can be implemented by one or more microprocessors or controllers from any desired family or manufacturer.

[0039] The processor 712 includes a local memory 713 (e.g., a cache) and is in communication with a main memory including a volatile memory 714 and a non-volatile memory 716 via a bus 718. The volatile memory 714 may be implemented by synchronous dynamic random access memory (SDRAM), dynamic random access memory (DRAM), Rambus Dynamic Random Access Memory (RDRAM) and/or any other type of random access memory device. The non-volatile memory 716 may be implemented by flash memory and/or any other desired type of memory device. Access to the main memory 714, 716 is controlled by a memory controller.

[0040] The computer 700 also includes an interface circuit 720. The interface circuit 720 may be implemented by any type of interface standard, such as an Ethernet interface, a universal serial bus (USB), and/or a PCI express interface.

[0041] One or more input devices 722 are connected to the interface circuit 720. The input device(s) 722 permit a user to enter data and commands into the processor 712. The input device(s) can be implemented by, for example, a keyboard, a mouse, a touchscreen, a track-pad, a trackball, isopoint and/or a voice recognition system.

[0042] One or more output devices 724 are also connected to the interface circuit 720. The output devices 724 can be implemented, for example, by display devices (e.g., a liquid crystal display and/or a cathode ray tube display (CRT)). The interface circuit 720, thus, typically includes a graphics driver card.

[0043] The interface circuit 720 also includes a communication device (e.g., communication device 56) such as a modem or network interface card to facilitate exchange of data with external computers via a network 726 (e.g., an Ethernet connection, a digital subscriber line (DSL), a telephone line, coaxial cable, a cellular telephone system, etc.).

[0044] The computer 700 also includes one or more mass storage devices 728 for storing software and data. Examples of such mass storage devices 728 include floppy disk drives, hard drive disks, compact disk drives and digital versatile disk (DVD) drives. The mass storage device 728 may implement the local storage device 762.

[0045] The coded instructions 732 of FIG. 6 may be stored in the mass storage device 728, in the volatile memory 714, in
the non-volatile memory 716, and/or on a removable storage medium such as a CD or DVD.

[0046] From the foregoing, it will appreciate that the above disclosed methods and apparatus provide an interactive protocol that enables fast and user-friendly corrections and/or visualizations of spine annotations and/or substantially guarantees correct results in substantially all clinical scenarios. The above disclosed methods and apparatus enable annotations to be rapidly corrected independent of the choice of a labeling algorithm and/or any associated software.

[0047] It is noted that this patent claims priority from U.S. Provisional Application Ser. No. 61/728,405, which was filed on Nov. 20, 2012, and is hereby incorporated herein by reference in its entirety.

[0048] Although certain example methods, apparatus and articles of manufacture have been described herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus and articles of manufacture fairly falling within the scope of the claims of this patent.

What is claimed is:

1. A computer-implemented method, comprising: generating first annotations on a spinal image; receiving first user input from a user on the first annotations to identifying an error within the first annotations; and in response to receiving the first user input, generating second annotations on the spinal image, the second annotations to correct the error present within the first annotations.

2. The computer-implemented method of claim 1, wherein generating the first and second annotations is independent of the first input received.

3. The computer-implemented method of claim 1, further comprising receiving second user input from the user validating the second annotations.

4. The computer-implemented method of claim 3, wherein, in response to the user validating the second annotations, generating third annotations.

5. The computer-implemented method of claim 4, wherein the third annotations comprise vertebra labels and disc labels.

6. The computer-implemented method of claim 1, wherein the annotations comprise vertebrae labels.

7. The computer-implemented method of claim 1, wherein the first annotations are generated in response to receiving initial user input from the user identifying a vertebra on the spinal image.

8. The computer-implemented method of claim 1, wherein the first annotations are generated based on first spatially ordered points and the second annotations are generated based on second spatially ordered points, wherein the second spatially ordered points account for the first user input.

9. The computer-implemented method of claim 1, wherein the first annotations are generated based on an optimization model, a statistical model, or contextual information associated with a spine or vertebrae.

10. The computer-implemented method of claim 1, wherein generating the second annotations comprises reassigning a label of a vertebra labeled by the first annotations.

11. A computer readable storage medium including computer program code to be executed by a processor, the computer program code, when executed, to implement a method to annotate a spinal image, the method comprising: generating first annotations on a spinal image; receiving first user input from a user on the first annotations to identifying an error within the first annotations; and in response to receiving the first user input, generating second annotations on the spinal image, the second annotations to correct the error present within the first annotations.

12. The computer readable storage medium of claim 11, wherein generating the first and second annotations is independent of the first input received.

13. The computer readable storage medium of claim 11, further comprising receiving second user input from the user validating the second annotations.

14. The computer readable storage medium of claim 13, wherein, in response to the user validating the second annotations, generating third annotations.

15. The computer readable storage medium of claim 14, wherein the third annotations comprise vertebra labels and disc labels.

16. The computer readable storage medium of claim 11, wherein the annotations comprise vertebrae labels.

17. The computer readable storage medium of claim 13, wherein the first annotations are generated based on first spatially ordered points and the second annotations are generated based on second spatially ordered points, wherein the second spatially ordered points account for the first user input.

18. A system, comprising: a processor, wherein in response to receiving a first user input via a data input, the processor is to generate first annotations on a spinal image, the processor is to cause the spinal image having the first annotations to be displayed at a user interface, the processor is to prompt a user to provide second user input identifying an error in the first annotations, wherein in response to receiving the second user input, the processor is to generate second annotations on the spinal image, the second annotations to correct the error in the first annotations.

19. The system of claim 18, wherein the processor is to cause the spinal image having the second annotations to be displayed at the user interface and to prompt the user to provide third user input.

20. The system of claim 20, wherein the third user input validates the second annotations or identifies an error in the second annotations.

* * * * *