

Method And System Of Locating A Position Within A Human Body

Technical Field

The present invention relates to a method and a system of locating position of an object such
5 as a bone, an organ or an acupuncture point, within a human body.

Background

From a western medicine point of view, a human body is made up of several interdependent
systems such as the skeletal system, the muscular system, the nervous system, the respiratory
system, the cardiovascular system, the digestive system, the integumentary system and etc.
10 Traditional Chinese Medicine (TCM), however, sees the human body quite differently.
According to TCM, the human body is made up of five Zang organs, six Fu organs, five sense
organs, meridians and etc. The Meridian system is a distribution network which enables
fundamental body substances such as qi (or energy), blood and body fluids to flow to the
various organs and throughout the body. Meridians are not blood vessels and have no
15 anatomical structure. Along the meridians are acupuncture points located near to the skin.
Each acupuncture point is associated with certain organ inside the body. There are about 20
meridians and 400 acupuncture points described in TCM. The locations of some acupuncture
points are in relation to specific anatomical landmark, for example, at certain distance away
from head of a bone. Each acupuncture point is usually identified using two letters followed
20 by some numbers. The letters describe the meridian on which the acupuncture point exists
while the numbers indicate its position along the meridian. For example, BL-22 is an
acupuncture point along Bladder meridian at position 22.

Human has for a long time used massage to relieve muscle stiffness, ache and other
symptoms. Pressure is applied to muscle and nerve to achieve the desired result. Acupuncture
25 has also been performed since ancient time by TCM physicians to provide symptomatic relief
or cure to people suffering various kinds of ailment. Depending on the problem, relevant
acupuncture points are stimulated using fine needles to provide the necessary relief or cure.
It is believed that by stimulating the acupuncture points, the imbalances or blockages in the
flow of qi (energy) are corrected.

Massage and acupuncture are traditionally performed manually. As many parts of the body cannot be felt using fingers, the person performing the massage or acupuncture very often has to guess or estimate their locations. The effectiveness of the manual process therefore depends heavily on the experience of the person performing the massage or acupuncture.

5 With advances in various technologies such as computer vision and robotics, it is now possible to mechanize or automate the massage and acupuncture processes involving robotic arms and other equipment. However, no two persons have the same exterior body shape and size. Their bodies also differ internally such as alignment of bone, size of organ and etc. Therefore the mechanized or automated massage and acupuncture processes can only be precise and
10 effective if the automated system has complete and accurate information about the user of the system. More specifically, the automated system needs to know fully and accurately the positions of objects such as bones, internal organs and acupuncture points of the user in order to perform the massage or acupuncture process correctly without hurting the person. Incomplete or inaccurate information given to the system will not only cause the system to
15 perform the processes in a less than ideal way, the operation may even cause harm to the user. Existing automated systems rely on some initial reference points marked manually on user's body to locate positions of other objects such as bones, internal organs and acupuncture points, of the user's body. However, such initial reference points on the surface of the user's body only provide one aspect of the information about the user's body.
20 Therefore, there remains a need to have a more efficient and accurate method and system of knowing the user's body and locating positions of other objects within it.

Summary

It is disclosed in this invention a method of locating a position within a human body comprising selecting a first target object within the human body, capturing an image of the
25 human body, identifying a first internal part within the human body perpendicularly beneath a first location on a surface of the human body, determining a first distance from the first location to the first internal part, mapping the image, the first location and the first distance onto a three dimensional reference human model and deriving position of the first target object. The method further comprises selecting a second target object within the human body,
30 identifying a second internal part within the human body perpendicularly beneath a second location on the surface of the human body, determining a second distance from the second

location to the second internal part, mapping the second location and the second distance onto the three dimensional reference human model and deriving position of the second target object. The first and second internal parts can be a bone or an organ of the human body and the first and second target objects are at least one of acupuncture point, bone, organ, pressure point, blood vessel and meridian of the human body.

The method can further comprise indicating a line on the surface of the human body and determining position of the line relative to the positions of the first and second target objects. Alternatively, the method can further comprise indicating an area on the surface of the human body and determining position of the area relative to the positions of the first and second target objects.

The identifying of the first and second internal parts inside the human body can be carried out through the sense of touch using a finger. The determining of the first and second distances can comprise depressing the first and second locations until the first and second internal parts are felt through sense of touch using a finger and measuring depth of depression on the first and second locations using a depth sensor.

It is also disclosed in this invention a system for locating a target position within a human body using an image of the human body and a sub-epidermal depth of an internal part of the human body. The system comprises a main module, an image module adapted to communicate the image of the human body to the main module and a depth data module adapted to communicate the sub-epidermal depth to the main module. The main module is configured to map the image and the sub-epidermal depth onto a three dimensional reference human model and predict the target position.

The target position is a position of a bone, an organ, an acupuncture point, a meridian, a pressure point or a blood vessel of the human body. The three dimensional reference human model comprises reference coordinates of at least one of acupuncture points, bones, organs, meridians, pressure points and blood vessels of a standard human body.

Brief Description of the Drawings

Figure 1 depicts the process steps of a first embodiment of the method disclosed in this invention.

5 Figure 4 shows a side view of a prone user's body and an operator depressing the surface of the user's body until a lumbar vertebra is felt.

Figure 6 shows two locations used as initial reference points and are indicated using two fingers on the surface of a prone user's body.

Figure 7 shows three locations used as initial reference points and derivation of some acupuncture points based on three initial reference locations.

Figure 9 shows an automated system employing the invention.

15 In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. The methods and systems described in the detailed description and drawings are for illustrative purpose and are not meant to be limiting. Other embodiments can be utilized, and other changes can be made, without departing from the spirit or scope of the subject matter presented herein. In the present disclosure, depiction of a given element
20 or consideration or use of a particular element number in a particular figure or a reference thereto in corresponding descriptive material can encompass the same, an equivalent, or an analogous element or element number identified in another figure or descriptive material associated therewith.

25 **Table 1** Description of Elements In the Drawings

Element	Description
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100	User's body
110	First location
120	Second location
130	Third location
140	First finger
145	Second finger
150	Surface of user's body
160	Depression on surface of user's body
170	Line from the edge of scapula
180	Line joining first and second locations
190	Acupuncture points derived
200	System modules for deriving positions of target objects
300	Automated system for performing massage or acupuncture

The present invention discloses a method and a system for locating position of a target object such as a bone, an organ, an acupuncture point, a meridian, a pressure point or a blood vessel within a person's body 100. The method and the system disclosed in this invention can be used in improving the mechanization or automation of massage and acupuncture processes. Even though the figures used to illustrate the method of this invention show the method to be performed on the back (or posterior part) of a person's body, the method can be applied equally on other parts of the body such as the front (or anterior part) and the sides of the body.

Figure 1 to 5 illustrate a first embodiment of the method. Figure 1 shows the steps taken by the operator to find the position of a target object within a user's body. The user is the person undergoing the massage or acupuncture process. Figure 2 shows a plan view of the user lying prone or face down horizontally on a platform. The user's body 100 has a surface 150 with an epidermis layer which is the outer layer of the skin. In Figure 2, the first location 110 on the surface 150 of the user's body is indicated by the arm of an operator using a finger 140. Besides using finger 140, the first location 110 can also be indicated using other means such as a pointer.

The steps taken by the operator comprise selecting a first target object within the user's body 100, capturing an image of the user's body 100, identifying a first internal part within the user's body 100 perpendicularly beneath a first location 110 on a surface 150 of the user's body and determining the first distance from the first location 110 on the surface 150 of the user's body to the first internal part. This is followed by mapping the image, the first location 110 and the first distance onto a three dimensional reference human model and deriving position of the first target object. The position of first target object is also known as the first target position.

The image or picture of the user's body is taken, captured or recorded using suitable devices such as an optical device, a camera, an image sensor or a computer vision system. The image or picture of the user's body can be a full body or half body image.

The first internal part within the user's body 100 is perpendicularly beneath the first location 110 on the surface 150 of the user's body. The first internal part can be an organ, a bone or other constituent of the user's body. It is preferable that the first internal part selected for use is one which can be felt or detected using fingers. The first internal part is also selected based on how relevant it is in deriving position of the first target object.

Having selected the first internal part to use, the operator uses his fingers to feel or detect the first internal part of the user's body 100. A detectable position on the first internal part such as the end of a bone or edge of an organ is identified through sense of touch using a finger 140. The operator then indicates on the surface 150 of the user's body a first location 110 where depressing the surface 150 perpendicularly at the first location 110 using finger will lead the operator to feel the detectable position on the first internal part beneath the surface 150. In other words, the first location 110 on the surface 150 of the user's body is a location on the surface 150 in its natural state or level before the location is depressed. By depressing the first location 110 in a direction perpendicular to the surface 150 and towards the inside of the user's body the will allow the operator to feel the detectable position on the first internal part beneath the surface 150. The meaning of "perpendicular" and "perpendicularly" also includes "approximately perpendicular" and "almost perpendicularly" respectively.

Figure 3 shows a side view of a prone user's body and an operator indicating a first location 110 on the surface 150 of the user's body using a finger 140. The first location 110 on the surface 150 of the user's body thus indicated is captured or recorded using a suitable device such as an optical device, a camera or a computer vision system. The coordinates of the first location 110 are calculated.

Having obtained the first location 110 on the surface 150 of the user's body, the first distance from the first location 110 on the surface 150 of the user's body to the first internal part is determined and recorded. The first distance from the first location 110 on the surface 150 of the user's body to the first internal part can be determined by depressing the first location 110 until the first internal part is felt through sense of touch using a finger 140 and then measuring depth of depression 160 on the first location 110 using a depth sensor which can comprise an optical device, a camera or a computer vision system.

Figure 4 shows a side view of a prone user's body and an operator depressing the first location 110 on the surface 150 of the user's body until the first internal part, which in this case is a lumbar vertebra, is detected or felt. Other first location which corresponds to another first internal part can be used. Figure 5 shows the depression 160 made by the operator on the surface of a prone user's body.

The image or picture of the user's body, the first location 110 and the first distance are initial references for use in subsequent steps. Having obtained the image of the user's body 100, the location 110 on the surface 150 of the user's body and the distance from the location 110 on the surface 150 to the internal part, position of a target object within the user's body 100 can be derived, calculated or predicted. Target object can be a bone, an organ, an acupuncture point, a meridian, a pressure point or a blood vessel of the user's body 100 which is not used as initial reference. The derivation, calculation or prediction of the position of target object is through mapping the image, the location 110 and the first distance onto a three dimensional reference human model. In the mapping process, scaling and transformation, including rigid and non-rigid transformation, are performed on the image of the user's body 100, the first location 110 on the surface 150 of the user's body and the first distance from the location 110 on the surface 150 to the first internal part. Alternatively, the

scaling and transformation can be performed on the three dimensional reference human model.

Using one location 110 on the surface 150 of the user's body as an initial reference will allow a limited number of target positions in the user's body 100 to be derived, calculated or predicted. Therefore, a second location 120 can be added as another reference in a second embodiment of the method. The steps in the second embodiment of the method therefore further comprise selecting a second target object within a user's body 100, identifying a second internal part within the user's body 100 perpendicularly beneath a second location 120 on the surface 150 of the user's body, determining a second distance from the second location 120 to the second internal part, mapping the second location 120 and the second distance onto the three dimensional reference human model and deriving position of the second target object.

Figure 6 illustrates the second embodiment of the method as used on a user's body 100 where two locations (110 and 120) on the surface 150 of the user's body are used as reference points and are indicated concurrently using two fingers (140, 145). The first 110 and second 120 locations can be captured and recorded consecutively one after another or concurrently at the same time using a suitable device such as an optical device, a camera or a computer vision system.

The coordinates of the first and second locations (110, 120) are calculated. Having obtained the first and second locations (110, 120) on the surface 150 of the user's body, the respective distances from the first and second locations (110, 120) on the surface 150 of the user's body to the first and second detectable positions on the first and second internal parts are determined or recorded. The distances can be determined in the same way as in the case of the first embodiment described above.

The first and second internal parts can be a bone or an organ of the user's body 100. The first and second target objects are at least one of bone, organ, acupuncture point, meridian, pressure point and blood vessel of the user's body 100. The reason for using a bone or an organ as the first or second internal part as initial reference is because they can be easily detected, felt and identified using finger.

Besides using sense of touch of a finger to detect or identify the first internal part or the second internal part, the operator can also use a suitable device or instrument to detect and identify them. Besides using depth of depression to determine the first distance or the second distance, the operator can also use a suitable device or instrument to determine the distance.

- 5 Besides the coordinates of the first and second locations (110 and 120) on the surface 150 of the user's body, coordinates of the first and second detectable positions are calculated based on respective distances from the first and second locations (110 and 120) to the detectable positions on the first and second internal parts beneath the surface.

10 With two locations (110 and 120) on the surface 150 of the user's body and two distances from each of the two locations to the two detectable positions on two internal parts, positions of more target objects can be derived, calculated or predicted accurately. The accuracy increases with the number of initial reference locations.

Figure 7 illustrates a third embodiment of the method as applied on a user's body 100 where three locations (110 , 120 and 130) on the surface 150 of the user's body are used as initial reference points. The first location 110 is above the L5 lumbar vertebra while the second location 120 is above the L1 lumbar vertebra. The third location 130 is on the edge of scapula or the shoulder blade. The line 180 joins first location 110 and second location 120 while the line 170 is a line from the third location 130 on the edge of scapula. After determining the respective distances from the three locations to their respective internal parts beneath and performing the necessary mapping onto a three dimensional reference human model, some acupuncture points 190 along Bladder meridian (BL) are derived. The names of the acupuncture points 190 derived are shown in table below:

Acupuncture Points Derived	Name
BL-22	San Jiao Shu
BL-23	Shen Shu
BL-24	Qi Hai Shu
BL-25	Da Chang Shu
BL-26	Guan Yuan Shu

25 In a fourth embodiment of the method, the steps can comprise indicating a line on the surface 150 of the user's body and determining position of the line relative to the positions of the

target objects. In a fifth embodiment of the method, the steps can comprise indicating a point or an area on the surface 150 of the user's body and determining position of the point or the area relative to the positions of the target objects. The line on the surface 150 of the user's body can correspond, for example, to that of a cut or an abrasion on the surface 150 of the user's body. The point or the area on the surface 150 of the user's body can correspond, for example, to a place of broken skin or a wound. The places represented by the line, the point or the area are sensitive and delicate areas, especially when the cut or the wound is not fully healed. Such places should be avoided by either the massage or the acupuncture process. Without correlating these places with the target objects and providing information of these places to the system, the massage or the acupuncture process can potentially hurt the patient when such sensitive and delicate part of the user's body 100 is touched or manipulated. Therefore the line, the point or the area representing places to be avoided is captured or recorded using a suitable device such as a camera, an optical device or a computer vision system. The position of the line, the point or the area in relation to all target objects is calculated.

One person's body differs from another person's body not only in shape and size in the X and Y dimensions, they also differ in the Z dimension. Without accounting for the Z dimension, the information provided to the automated massage or acupuncture system is incomplete. When an automated system performs massage or acupuncture without information of the internal organs in the Z dimension, its accuracy is compromised. For example, the force applied by a robotic arm controlled by the automated massage system may be too strong, hurting the person undergoing the massage. In another example, the depth of the acupuncture needle inserted by a robotic arm controlled by the automated acupuncture system may be too deep.

The information obtained as a result of using the various embodiments of the method can be provided to the automated system used in performing massage and acupuncture so that the automated system has spatial knowledge of the exterior part of the user's body and the internal parts such as organs and bones inside the user's body. The sub-epidermal depth or distance from the location on the surface of user's body to the internal part enables accurate derivation of position of target object. When the automated system has accurate positions of the bones, organs, acupuncture points, meridians, pressure points and blood vessels, the

respective massage or acupuncture process can be carried out safely and with precision to achieve the desired results.

It is also disclosed in this invention a system for locating a target position within a user's body 100 using an image of the user's body 100 and a sub-epidermal depth of an internal part of the user's body 100. The system comprises a main module, an image module adapted to communicate the image of the user's body 100 to the main module and a depth data module adapted to communicate the sub-epidermal depth to the main module. The main module is configured to map the image of the user's body and the sub-epidermal depth onto a three dimensional reference human model and predict the target position.

Figure 8 illustrates an embodiment of the system for deriving, calculating or predicting positions of target objects or target positions within a user's body 100. The image module receives an image of the user's body 100, processes the image and transmits the relevant information about the image to the main module. The graphical format of the image can be that of bitmap, TIFF, JPEG, GIF, PNG or raw unprocessed data. The depth data module receives the sub-epidermal depth, processes the depth information and transmits the relevant information to the main module. The main module uses the image of the user's body 100, the sub-epidermal depth of the internal part and a three dimensional reference human model to derive, calculate or predict the target position.

The target position is a position of a target object such as a bone, an organ, an acupuncture point, a meridian, a pressure point or a blood vessel of the user's body 100. The three dimensional reference human model comprises reference coordinates of at least one of bones, organs, acupuncture points, meridians, pressure points and blood vessels of a standard or typical human body.

In order for position of target object such as bone, organ, acupuncture point, meridian, pressure point and blood vessel of the user's body 100 to be derived, calculated or predicted, the three dimensional reference human model is required to contain information of the desired target objects. The information includes identity of the target objects and positional information including coordinates specifying positions of one object in relation to another object in a standard or typical human body. The coordinates specifying positions of one object in relation to another object in a standard or typical human body are known as the reference

coordinates. The reference coordinates can be three dimensional. As an example, if the internal part used as initial reference is a bone and the target object is an acupuncture point, the three dimensional reference human model is required to have information about the bones and acupuncture points including three dimensional reference coordinates of bones relative to acupuncture points. The shape and size of a target object can be derived using three dimensional reference coordinates of multiple locations on the target object.

The organ, pressure point, blood vessel or other part of the body described here can be that of the western medicine or TCM point of view. The camera referred to in the description here can be a stereoscopic camera.

Figure 9 illustrates an embodiment of an automated system employing the invention. The automated system comprises a computing system, a database, a robotic system and human computer interfaces. The system modules illustrated in Figure 8 can be in the computing system. In the automated system, an operator can provide command, instruction or information to the system through various forms of input such as gesture, voice, switch, touchscreen or keyboard input. For example, after indicating a first location 110 on the surface 150 of the user's body, the operator can give a voice command to the system to activate the capturing of the first location 110 by a suitable device such as an optical device, a camera or a computer vision system. The voice is picked up or received by microphone and interpreted by a voice recognition module in the computing system. Besides activating the capturing of the first location 110, other information related to the first location 110 such as name of the internal part beneath the first location 110 can also be given to the system by the operator using voice as the input means. For example, if the first location 110 is above lumbar vertebra L5 of the user, the operator can say "lumbar vertebra L5" and the words spoken will be recognized and recorded by the voice recognition module.

Alternatively, after indicating the first location 110 on the surface 150 of user's body 100 using a finger of one hand, the operator can use the other hand to gesture to the system to activate the capturing of the first location 110 by a suitable device such as an optical device, a camera or a computer vision system. The gesture can be, for example, an "ok" sign. The gesture is interpreted by a gesture recognition module in the computing system.

In situation where the operator is using two hands to indicate two locations, for example first and second locations (110 and 120), on the surface 150 of the user's body, the operator can activate the capturing of the two locations by stepping on a foot switch. Other channels of providing command, instruction or information to the system include touchscreen or
5 keyboard and the inputs are handled by respective I/O modules in the computing system.

In the automated system, the three-dimensional reference human model is stored in the Reference Model part of the database. Information related to the image of the user's body 100, the locations on the surface 150 of the user's body and the sub-epidermal depths of the internal parts or distances from the locations on the surface 150 of the user's body to the
10 internal parts is stored in the User Model part of the database. Positions of target objects or target positions which are derived, calculated or predicted are stored in the Mapped Model part of the database. The Mapped Model portion of the database also contains information resulting from mapping the three dimensional reference human model onto the image of the user's body 100, the locations on the surface 150 of the user's body and the sub-epidermal
15 depths of the internal parts or distances from the locations on the surface 150 of the user's body to the internal parts.

The information in the Mapped Model part of the database is fed into the automated system which performs the massage or acupuncture process. The automated system adjusts its actions, for example the actions of a robotic arm in the robotic system, based on the
20 information in the Mapped Model so that the respective massage or acupuncture process is carried out safely and with precision to achieve the desired results.

While various aspects and embodiments have been disclosed herein, it will be appreciated by a person skilled in the art that several of the above-disclosed structures, materials, parameters or processes thereof, can be desirably modified, adapted and combined into
25 alternative structures, processes and/or applications. It is intended that all such modifications, alterations, adaptations, and/or improvements made to the various embodiments that are disclosed to come within the scope of the present disclosure. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit of the invention being indicated by the following claims.

Claims

1. A method of locating a position within a human body comprising

selecting a first target object within the human body;

capturing an image of the human body;

5 identifying a first internal part within the human body perpendicularly beneath a first location on a surface of the human body, the first internal part being an edge of a first internal structural component;

depressing the first location perpendicularly relative to the surface of the human body till contact with the first internal part is made to obtain a first depression;

10 determining a first distance from the first location to the first internal part using a depth sensor to measure the depth of the first depression;

mapping the image, the first location and the first distance onto a three dimensional reference human model, the reference human model comprising spatial relationship data between the first internal part and the first target object; and

15 deriving position of the first target object from the spatial relationship data.

2. The method of claim 1 further comprising

selecting a second target object within the human body;

20 identifying a second internal part within the human body perpendicularly beneath a second location on the surface of the human body the second internal part being an edge of a second internal structural component;

depressing the second location perpendicularly relative to the surface of the human body till contact with the second internal part is made to obtain a second depression;

determining a second distance from the second location to the second internal part using the depth sensor to measure the depth of the second depression;

mapping the second location and the second distance onto the three dimensional reference human model, the reference human model further comprising spatial relationship data between the second internal part and the second target object; and deriving position of the second target object from the spatial relationship data.

- 5 3. The method of claim 2 wherein the first and second internal structural components are a bone or an organ of the human body.
4. The method of claim 2 wherein the first and second target objects are at least one of bone, organ, acupuncture point, meridian, pressure point and blood vessel of the human body.
5. The method of claim 2 further comprising indicating a line on the surface of the human
10 body and determining position of the line relative to the positions of the first and second target objects.
6. The method of claim 2 further comprising indicating an area on the surface of the human body and determining position of the area relative to the positions of the first and second target objects.
- 15 7. The method of claim 2 wherein the identifying of the first and second internal parts inside the human body is through sense of touch using a finger.
8. The method of claim 2 wherein the first and second internal parts are felt through sense of touch using a finger.
9. A system for locating a target position within a human body using an image of the human
20 body and a sub-epidermal depth of an internal part of the human body, comprising
 - a main module;
 - an image module adapted to communicate the image to the main module; and
 - a depth data module adapted to communicate the sub-epidermal depth to the main module, the sub-epidermal depth obtained using a depth sensor.
- 25 wherein the main module is configured to map the image and the sub-epidermal depth onto a three dimensional reference human model, the reference human model

comprising spatial relationship data between the internal part and the target position and predict the target position based on the spatial relationship data.

10. The system of claim 9 wherein the target position is a position of a bone, an organ, an acupuncture point, a meridian, a pressure point and a blood vessel of the human body.

- 5 11. The system of claim 9 wherein the three dimensional reference human model comprises reference coordinates of at least one of bones, organs, acupuncture points, meridians, pressure points and blood vessels of a standard human body.