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(54) **REAL-TIME ACQUISITION OF CO-REGISTERED X-RAY AND OPTICAL IMAGES**

ECHTZEIT-AKQUISITION VON GLEICHZEITIG REGISTRIERTEN RÖNTGEN- UND OPTISCHEN BILDERN

ACQUISITION EN TEMPS REEL D'IMAGES OPTIQUES ET RADIOLOGIQUES CO-ENREGISTREES

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Description

BACKGROUND

[0001] The present disclosure is directed towards systems and methods for acquiring co-registered X-ray and optical imagery. Medical image data, for example, is typically desired and/or obtained through various types of imaging modalities.

[0002] U.S. patent application No. 2002 080 999, entitled "System and Method for Highlighting a Scene Under Vision Guidance", which is subject to the same duty of assignment as the present application, discloses a system and method for processing coordinates of a target point in a captured image of a real scene, and converting the image coordinates into the coordinates of a light projector to illuminate the target point. In addition, issued U.S. Patent Nos. 6,227,704; 6,229,873; 6,447,163 and 6,473,489; which are also subject to the same duty of assignment as the present application, disclose systems and methods for acquisition of video and X-ray images.

[0003] What is needed is a new system and method for real-time acquisition of co-registered optical (e.g., fluorescence, coherent, diffused or transmission) and X-ray images. Such a system could provide physicians with new imaging abilities for applications including, for example, Arthritis treatment monitoring. For such an application, an optical image could show the enzyme activities, while a co-registered X-ray image could allow a physician to exactly locate the activity in relation to bone structure. In this way, a physician could take advantage of both imaging systems at the same time, by viewing the superimposed images, and thereby be relieved from having to relate the two types of images in his/her mind. The desired system could allow the physician to visualize each of the optical or X-ray images alone or in combination with a co-registered image. The present disclosure addresses these and other related issues.

[0004] SU 883725 discloses co-registration of multimodal images according to the preamble of the attached independent claims.

SUMMARY

[0005] These and other drawbacks and disadvantages of the prior art are addressed by an apparatus, method and program storage device for co-registration of multimodal images in a three-dimensional environment.

[0006] A first embodiment apparatus for co-registration of multi-modal images in a three-dimensional environment the apparatus comprising; a source of excitation light; a one-way mirror having a transmissive side disposed towards the excitation light for transmitting the excitation light and a reflective side for reflecting light received from a target; an electromagnetic-ray source disposed relative to the source of excitation light; an electromagnetic-ray transparent mirror having a light-reflective surface disposed towards a reflecting side of the one-way mirror and an electromagnetic-ray transmissive surface disposed towards the electromagnetic-ray source; a target location disposed towards the light-reflective surface of the electromagnetic-ray transparent mirror for locating a target and receiving the excitation light and the electromagnetic-rays; an electromagnetic-ray detector disposed on an opposite side of the target location relative to the electromagnetic-ray source for detecting electromagnetic-rays transmitted through the target; and a light detector disposed towards the reflective side of the one-way mirror for detecting light from the target.

[0007] These and other aspects, features and advantages of the present disclosure will become apparent from the following description of exemplary embodiments, which is to be read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present disclosure teaches an apparatus and method for image segmentation in a three-dimensional environment, in accordance with the following exemplary figures, in which:

Figure 1 shows a schematic diagram of an optical imaging system where the source of the excitation light and the optical camera detecting the emitted or reflected light have the same projection geometry;

Figure 2 shows a schematic diagram of an optical imaging system where the source of the excitation light and the optical camera detecting the emitted or reflected light have the same projection geometry, and are each on the same side and attached side-by-side;

Figure 3 shows a schematic diagram of a co-registered imaging system in accordance with an illustrative embodiment of the present disclosure where

Figure 4 shows a schematic diagram of a co-registered imaging system, which does not form part of the present invention, the detector of the transmitted light is positioned such that its images re co-registered with X-ray images;

Figure 5 shows a schematic diagram of a co-registered imaging system, which does not form part of the present invention, where the detector of the transmitted light is positioned such that its images are co-registered with X-ray images and the detector is attached to the side of the X-ray detector; and

Figure 6 shows schematic diagram of a co-registered imaging system, which does not form part of the present invention, where the system is capable of rotating by at least 200 degrees around a patient.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0009] The present disclosure introduces a system and method for real-time acquisition of co-registered X-ray and optical images, including, for example, fluorescence, coherent, diffused or transmission images. System embodiments provide physicians with new imaging capabilities applicable to many applications, including, for example, Arthritis treatment monitoring.

[0010] In an Arthritis treatment monitoring example, the optical image shows the enzyme activities. The co-registered X-ray image allows the physician to precisely locate the enzyme activities in relation to the bone structure of the patient. In this way, the different types of images are superimposed so that the physician may take advantage of both imaging systems at the same time without the need to relate the two images manually. A preferred system embodiment permits the physician to visualize each of the optical or X-ray images alone, or combined into one co-registered image.

[0011] In the description that follows, an X-ray or X-ray fluoroscopy system is illustrated with its two main components: a) X-ray source; and b) X-ray detector. An optical imaging device is also illustrated by its two main components: a) source of excitation light; and b) detector of emitted, reflected, diffused or transmitted light.

[0012] As shown in Figure 1, a first exemplary optical imaging system is indicated generally by the reference numeral 100. The imaging system 100 includes a source of excitation light 110 projecting through a non-reflecting side of a one-way mirror 120 to a target 130. The light emitted or reflected from the target 130 is reflected by a reflecting side of the one-way mirror to a detector of emitted or reflected light 140. Thus, in the optical imaging system 100, the source of the excitation light and the optical camera detecting the emitted or reflected light have the same projection geometry.

[0013] Turning to Figure 2, a second exemplary optical imaging system is indicated generally by the reference numeral 200. The imaging system 200 includes a source of excitation light 210 projecting through a non-reflecting side of a one-way mirror 220 to a target 230. The light emitted or reflected from the target 230 is reflected by a reflecting side of the one-way mirror to a mirror 222, which reflects the light to a detector of emitted or reflected light 240. Thus, in the optical imaging system 200, the source of the excitation light and the optical camera detecting the emitted or reflected light have the same projection geometry. In addition, the source and the detector are on the same side and can be attached side-by-side.

[0014] Turning now to Figure 3, a first exemplary co-registered imaging system is indicated generally by the reference numeral 300. The imaging system 300 includes a source of excitation light 310 projecting through a non-reflecting side of a one-way mirror 320 to a mirror 360. The mirror 360 is an X-ray transparent mirror that reflects the light to a target 330. The light emitted or reflected from the target 330 is reflected by the mirror 360 to a reflecting side of the one-way mirror 320, which reflects the light to a detector of emitted or reflected light 340. The imaging system 300 further includes an X-ray source 350 projecting through the X-ray transparent mirror 360 to the target 330. An X-ray detector plate 370 receives the X-rays transmitted through the target 330.

[0015] Thus, the resulting system 300 provides co-registered X-ray and emitted or reflected images. In a case where the excitation is done with a source of coherent light, the detector detects the reflected light. In a case of fluorescence imaging, the detector will detect the emitted light from the object. Note that different detectors and special filters may be used for each of the imaging systems described herein.

[0016] As shown in Figure 4, a co-registered imaging system is indicated generally by the reference numeral 400. The imaging system 400 includes a source of excitation light 410 reflecting from a mirror 422. The light reflected from the mirror 422 to a mirror 460. The mirror 460 is an X-ray transparent mirror that reflects the light to a target 430. The light transmitted through the target 430 is reflected by another X-ray transparent mirror 462, which reflects the light to a detector of transmitted light 442. The imaging system 400 further includes an X-ray source 450 projecting through the X-ray transparent mirror 460 to the target 430. The light transmitted through the target 430 is further transmitted through the other X-ray transparent mirror 462. An X-ray detector plate 470 receives the X-rays transmitted through the target 430 and the other X-ray transparent mirror 462. Thus, in the system 400, the detector of the transmitted light is positioned in a way that the images it provides are co-registered with X-ray images.

[0017] Turning to Figure 5, a co-registered imaging system is indicated generally by the reference numeral 500. The imaging system 500 includes a source of excitation light 510 reflecting from a mirror 522. The light reflected from the mirror 522 to a mirror 560. The mirror 560 is an X-ray transparent mirror that reflects the light to a target 530. The light transmitted through the target 530 is reflected by another X-ray transparent mirror 562, which reflects the light to a detector of transmitted light 542. The imaging system 500 further includes an X-ray source 550 projecting through the X-ray transparent mirror 560 to the target 530. The light transmitted through the target 530 is further transmitted through the other X-ray transparent mirror 562 to another mirror 524. An X-ray detector plate 570 receives the X-rays transmitted through the target 530, the other X-ray transparent mirror 562 and the other mirror 524. Thus, in the system 500, the detector of the transmitted light is positioned in a way that the images it provides are co-registered with X-ray images, and this detector can be conveniently attached to the side of the X-ray detector.

[0018] Turning now to Figure 6, a co-registered imaging system is indicated generally by the reference numeral 600. The imaging system 600 includes a source

of excitation light 610 reflecting from a mirror 622. The light reflected from the mirror 622 to a mirror 660. The mirror 660 is an X-ray transparent mirror that reflects the light to a target 630. The light transmitted through the target 630 is reflected by another X-ray transparent mirror 662, which reflects the light to a detector of transmitted light 642. The imaging system 600 further includes an X-ray source 650 projecting through the X-ray transparent mirror 660 to the target 630. The light transmitted through the target 630 is further transmitted through the other X-ray transparent mirror 662 to another mirror 624. An X-ray detector plate 670 receives the X-rays transmitted through the target 630, the other X-ray transparent mirror 662 and the other mirror 624. The entire system 600, excluding the target 530, is mounted to gimbals, tracks or like devices for rotating about the centrally disposed target 530.

[0019] Thus, in a particularly preferred embodiment, the co-registered X-ray and Transmitted Optical Imaging system 600 rotates around the target or patient by at least 200 degrees, while acquiring X-ray and transmitted optical images. These images are then used for tomographic reconstruction. The two sets of resulting reconstructed 3D data are thus fully co-registered by design. This allows the physician to visualize the data as two separate data sets or one composite data set.

[0020] According to one aspect of the present disclosure, the image capture device and the illumination device comprise common optical properties. This may be realized by means of one one-way mirror. Figure 1 provides an exemplary construction of such a system. Figure 2 provides a second exemplary construction where the source and the detector can be attached side-by-side using an additional mirror.

[0021] In another aspect of this present disclosure, the system allows the acquisition of real-time X-ray and fluorescence or coherent optical imaging. Figure 3, illustrates an exemplary construction of such a system. The system allows the user to choose a target to be illuminated in a real scene using X-ray image data of the same scene.

[0022] In one aspect, a method for illuminating a target point in a real scene comprises the steps of capturing X-ray image data of a scene, identifying X-ray image data associated with a target point, and projecting a light beam at the target point in the rear scene. The step of projecting comprises the steps of converting image coordinates of the target point to light coordinates for directing the light beam, and processing the light coordinates to direct the light beam to the target point in the real scene.

[0023] The illumination system and its control for embodiments of the present disclosure may be realized as described in the co-pending U.S. Patent Application (Atty. Docket Nos. 2000P09022US01 & 8706-538), entitled "System and Method for Highlighting a Scene Under Vision Guidance". A difference here is that the system can also be guided by X-ray vision in cases where the target for illumination can be better defined in respect to the anatomical targets visible under X-rays. Once the target is illuminated, the reflected or the emitted light, in the case of fluorescence imaging, is captured by an optical sensor with the same imaging geometry as the X-ray imaging system. This allows the user, such as a physician, to see a composite image, which includes both information from X-ray and optical imaging. Such system embodiments can provide new imaging possibilities, which can play an important role in improving the diagnosis and treatment monitoring procedures for many diseases.

[0024] In the cases of Figures 4 and 5, the system co-registers the X-ray and transmitted optical imaging. The Transmitted Optical imaging here is defined as a system composed of a light source, which emits the light rays towards an object of interest and a detector on the other side of the target, which measures the intensity of the transmitted light. This intensity is a function of the absorption of the tissues and/or material forming the object (for example see "Imaging through Random Media Using Low Coherence Optical Heterodyning" by A. Schmidt, R. Cotey, and P. Saulnier, Optics Letters, Volume 20, Number 4, February 15, 1995). System embodiments of the present disclosure can use two, three or four mirrors, for example, depending on the choice of having the light source and transmitted light optical detector on the side, or orthogonal to, the X-ray source and detector, respectively.

[0025] According to another aspect of this present disclosure, the co-registered X-ray and Transmitted Optical Imaging system rotates around the patient or animal target by at least 200 degrees, while acquiring both X-ray and optical images. These images can then be used for tomographic reconstruction. The two sets of resulting reconstructed 3D data are thus fully co-registered. This allows the physician to visualize the data as two separate or one composite data set. The calibration and reconstruction from rotating C-arms have been extensively discussed in the literature. For example, the following U.S. Patents propose different methods for calibration and tomographic reconstruction using such system: US-6,049,582; US-6,038,282; US-5,963,613; US-5,963,612; US-5,923,727; US-5,835,563 and US-5,822,396. In preferred embodiments of the present disclosure, a particularly advantageous feature is in the co-registration of the X-ray and Transmitted Optical Imaging systems by the particular construction and calibration of this system. This allows obtaining co-registered 3D reconstruction data from these two modalities.

[0026] The relative placement of the elements of embodiments of the present disclosure are important. The X-ray imaging system, the optical imaging system, and the mirrors need to be placed correctly, as will be understood by those of ordinary skill in the pertinent art. There is also a feature for computing a transformation, taking into account the differences in the intrinsic imaging parameters of the X-ray and Optical images. These geometrical and imaging calibrations can be considered as

modifications and improvements of those described in U.S. Patent Nos. 6,473,489; 6,447,163; 6,229,873 and 6,227,704, for example.

[0027] These and other features and advantages of the present disclosure may be readily ascertained by one of ordinary skill in the pertinent art based on the teachings herein. It is to be understood that the teachings of the present disclosure may be implemented in various forms of hardware, software, firmware, special purpose processors, or combinations thereof.

[0028] Most preferably, the teachings of the present disclosure are implemented as a combination of hardware and software. Moreover, the software is preferably implemented as an application program tangibly embodied on a program storage unit. The application program may be uploaded to, and executed by, a machine comprising any suitable architecture. Preferably, the machine is implemented on a computer platform having hardware such as one or more central processing units ("CPU"), a random access memory ("RAM"), and input/output ("I/O") interfaces. The computer platform may also include an operating system and microinstruction code. The various processes and functions described herein may be either part of the microinstruction code or part of the application program, or any combination thereof, which may be executed by a CPU. In addition, various other peripheral units may be connected to the computer platform such as an additional data storage unit and a printing unit.

[0029] It is to be further understood that, because some of the constituent system components and methods depicted in the accompanying drawings are preferably implemented in software, the actual connections between the system components or the process function blocks may differ depending upon the manner in which embodiments of the present disclosure are programmed. Given the teachings herein, one of ordinary skill in the pertinent art will be able to contemplate these and similar implementations or configurations of the present disclosure.

[0030] Although the illustrative embodiments have been described herein with reference to the accompanying drawings, it is to be understood that the present disclosure is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one of ordinary skill in the pertinent art. All such changes and modifications are intended to be included within the scope of the invention as set forth in the appended claims.

Claims

1. An apparatus for co-registration of multi-modal images in a three-dimensional environment, the apparatus comprising:

   a source (310, 410, 510, 610) of excitation light;
   a one-way mirror having a transmissive side disposed towards the excitation light for transmitting the excitation light and a reflective side for reflecting light received from a target;
   an electromagnetic-ray source (350, 450, 550, 650) disposed relative to the source (310, 410, 510, 610) of excitation light;
   an electromagnetic-ray transparent mirror (360, 460, 560, 660) having a light-reflective surface disposed towards a reflecting side of the one-way mirror (320, 422, 522, 622) and an electromagnetic-ray transmissive surface disposed towards the electromagnetic-ray source (350, 450, 550, 650);
   a target location disposed towards the light-reflective surface of the electromagnetic-ray transparent mirror (360, 460, 560, 660) for locating a target (330, 430, 530, 630) and receiving the excitation light and the electromagnetic-rays;
   an electromagnetic-ray detector (370, 470, 570, 670) disposed on an opposite side of the target location relative to the electromagnetic-ray source for detecting electromagnetic-rays transmitted through the target (330, 430, 530, 630); and
   a light detector (442, 542, 642) disposed towards the reflective side of the one-way mirror (320, 422, 522, 622) for detecting light from the target (130, 430, 530, 630).

2. An apparatus as defined in claim 1, wherein the electromagnetic-ray source (350, 450, 550, 650) emits X-rays.

3. An apparatus as defined in claim 1, wherein the source (310, 410, 510, 610) of excitation light emits at least one of optical, fluorescent, coherent, diffusive and transmissive light.

4. An apparatus as defined in claim 1, wherein the light detector (442, 542, 642) detects at least one of emitted and reflected light from the target (330, 430, 530, 630).

5. A method for co-registration of multi-modal images in a three-dimensional environment, the method comprising:

   defining a frame of reference;
   providing excitation light to a target (330, 430, 530, 630) relative to the frame of reference;
   providing electromagnetic-rays to the target (330, 430, 530, 630) relative to the frame of reference;
   redirecting the excitation light relative to the target (330, 430, 530, 630) without redirecting the provided electromagnetic-rays;
   detecting electromagnetic-rays transmitted by the target (330, 430, 530, 630) relative to the

frame of reference;
detecting light from the target (330, 430, 530, 630) relative to the frame of reference; and
providing co-registered electromagnetic-ray and light images of the target to a user, **characterised in that** the method further comprises redirecting reflecting light received from a target (330, 430, 530, 630) without redirecting the excitation light transmitted to the target (330, 430, 530, 630) by using a one-way mirror having a transmissive side disposed towards the excitation light and a reflective side to reflect light received from a target;

6. A method as defined in claim 5, further comprising:

capturing X-ray image data; and
identifying X-ray image data associated with the target (330, 430, 530, 630).

7. A method as defined in claim 5, wherein providing excitation light comprises:

converting image coordinates of the target (330, 430, 530, 630) into light coordinates for directing the excitation light; and
processing the light coordinates to direct the excitation light to the target (330, 430, 530, 630) in a real scene.

8. A method as defined in claim 7, further comprising redirecting the light to be detected from the target (330, 430, 530, 630) without redirecting the electromagnetic-rays to be detected from the target (330, 430, 530, 630).

9. A program storage device readable by machine, tangibly embodying a program of instructions to cause the apparatus according to claim 1 to carry out the method according to anyone of claims 5 to 8.

Patentansprüche

1. Vorrichtung, die multimodale Bilder in einer dreidimensionalen Umgebung miteinander ausrichtet, wobei die Vorrichtung umfasst:

eine Quelle (310, 410, 510, 610) für Erregerlicht;
einen Einwegspiegel, der eine durchlässige Seite aufweist, die zum Erregerlicht ausgerichtet ist, damit das Erregerlicht durchgelassen wird, und eine reflektierende Seite, damit Licht reflektiert wird, das von einem Ziel empfangen wird;
eine Quelle (350, 450, 550, 650) für elektromagnetische Strahlen, die in einer bestimmten Lage bezüglich der Quelle (310, 410, 510, 610) des Erregerlichts angeordnet ist;
einen für elektromagnetische Strahlen durchlässigen Spiegel (360, 460, 560, 660), der eine Licht reflektierende Seite aufweist, die hin zu einer reflektierenden Seite des Einwegspiegels (320, 422, 522, 622) ausgerichtet ist, und eine für elektromagnetische Strahlen durchlässige Seite, die hin zur Quelle (350, 450, 550, 650) für elektromagnetische Strahlen ausgerichtet ist;
einen Zielort, der hin zur Licht reflektierenden Seite des für elektromagnetische Strahlen durchlässigen Spiegels (360, 460, 560, 660) angeordnet ist, damit ein Ziel (330, 430, 530, 630) platziert wird und das Erregerlicht und die elektromagnetischen Strahlen empfangen werden;
einen Detektor (370, 470, 570, 670) für elektromagnetische Strahlen, der bezogen auf die Quelle für elektromagnetische Strahlen an einer gegenüberliegenden Seite des Zielorts angeordnet ist, damit elektromagnetische Strahlen erfasst werden, die durch das Ziel (330, 430, 530, 630) hindurchgelassen werden; und
einen Lichtdetektor (442, 542, 642), der hin zur reflektierenden Seite des Einwegspiegels (320, 422, 522, 622) angeordnet ist, damit er Licht vom Ziel (130, 430, 530, 630) empfängt.

2. Vorrichtung nach Anspruch 1, worin die Quelle (350, 450, 550, 650) für elektromagnetische Strahlen Röntgenstrahlen aussendet.

3. Vorrichtung nach Anspruch 1, worin die Quelle (310, 410, 510, 610) für Erregerlicht mindestens eine der folgenden Lichtarten aussendet, nämlich optisches Licht, Fluoreszenzlicht, kohärentes Licht, zu streuendes Licht und durchdringendes Licht.

4. Vorrichtung nach Anspruch 1, worin der Lichtdetektor (442, 542, 642) zumindest entweder das ausgesendete oder das vom Ziel (330, 430, 530, 630) reflektierte Licht erfasst.

5. Verfahren, mit dem multimodale Bilder in einer dreidimensionalen Umgebung miteinander ausgerichtet werden, umfassend:

das Definieren eines Bezugsrahmens;
das Bereitstellen von Erregerlicht für ein Ziel (330, 430, 530, 630) bezogen auf den Bezugsrahmen;
das Bereitstellen von elektromagnetischen Strahlen für das Ziel (330, 430, 530, 630) bezogen auf den Bezugsrahmen;
das Umleiten des Erregerlichts bezogen auf das Ziel (330, 430, 530, 630) ohne das Umleiten der bereitgestellten elektromagnetischen Strahlen;
das Erfassen der elektromagnetischen Strahlen, die das Ziel (330, 430, 530, 630) durchlässt, bezogen auf den Bezugsrahmen;

das Erfassen von Licht vom Ziel (330, 430, 530, 630) bezogen auf den Bezugsrahmen; und
das Bereitstellen von miteinander ausgerichteten Bildern des Ziels, die durch elektromagnetische Strahlen und Licht entstehen, für einen Benutzer, **dadurch gekennzeichnet, dass** das Verfahren zudem das Umleiten von reflektiertem Licht umfasst, das von einem Ziel (330, 430, 530, 630) empfangen wird, ohne das Erregerlicht umzuleiten, das zum Ziel (330, 430, 530, 630) übertragen wird, und zwar mit Hilfe eines Einwegspiegels, der eine durchlässige Seite aufweist, die hin zum Erregerlicht ausgerichtet ist, und eine reflektierende Seite, die Licht reflektiert, das von einem Ziel empfangen wird.

6. Verfahren nach Anspruch 5, ferner umfassend:

das Aufnehmen von Röntgenstrahl-Bilddaten; und
das Kennzeichnen von Röntgenstrahl-Bilddaten, die dem Ziel (330, 430, 530, 630) zugeordnet sind.

7. Verfahren nach Anspruch 5, worin das Bereitstellen von Erregerlicht umfasst:

das Konvertieren von Bildkoordinaten des Ziels (330, 430, 530, 630) in Lichtkoordinaten zum Leiten des Erregerlichts; und
das Verarbeiten der Lichtkoordinaten, damit das Erregerlicht auf das Ziel (330, 430, 530, 630) in einem realen Szenario gelenkt wird.

8. Verfahren nach Anspruch 7, zudem umfassend das Umleiten des zu erfassenden Lichts von dem Ziel (330, 430, 530, 630), ohne die elektromagnetischen Strahlen umzuleiten, die von dem Ziel (330, 430, 530, 630) zu erfassen sind.

9. Programmspeichervorrichtung, die maschinenlesbar ist und greifbar ein Programm aus Befehlen verkörpert, das die Vorrichtung nach Anspruch 1 veranlasst, das Verfahren nach irgendeinem der Ansprüche 5 bis 8 auszuführen.

Revendications

1. Appareil de co-enregistrement d'images multi-modales dans un environnement tridimensionnel, l'appareil comprenant :

une source (310, 410, 510, 610) de lumière d'excitation ;
un miroir à une voie ayant un côté de transmission disposé vers la lumière d'excitation pour transmettre la lumière d'excitation et un côté de réflexion pour réfléchir la lumière reçue d'une cible ;
une source de rayons électromagnétiques (350, 450, 550, 650) disposée relativement à la source (310, 410, 510, 610) de lumière d'excitation ;
un miroir (360, 460, 560, 660) transparent aux rayons électromagnétiques ayant une surface de réflexion de lumière disposée vers un côté de réflexion de miroir à une voie (320, 422, 522, 622) et une surface de transmission de rayons électromagnétiques disposée vers la source de rayons électromagnétiques (350, 450, 550, 650) ;
un emplacement de cible disposé vers la surface de réflexion de lumière du miroir (360, 460, 560, 660) transparent aux rayons électromagnétiques pour localiser une cible (330, 430, 530, 630) et pour recevoir la lumière d'excitation et les rayons électromagnétiques ;
un détecteur de rayons électromagnétiques (370, 470, 570, 670) disposé sur un côté opposé de l'emplacement cible relativement à la source de rayons électromagnétiques pour détecter des rayons électromagnétiques transmis à travers la cible (330, 430, 530, 630) ; et
un détecteur de lumière (440, 542, 642) disposé vers le côté de réflexion du miroir à une voie (320, 420, 522,622) pour détecter la lumière de la cible (130, 430, 530, 630).

2. Appareil selon la revendication 1, où la source de rayons électromagnétiques (350, 450, 550, 650) émet des rayons X.

3. Appareil selon la revendication 1, où la source (310, 410, 510, 610) de la lumière d'excitation émet au moins une d'une lumière optique, fluorescente, cohérente, de diffusion et de transmission.

4. Appareil selon la revendication 1, où le détecteur de lumière (442, 542, 642) détecte au moins une parmi une lumière émise et réfléchie de la cible (330, 430, 530, 630).

5. Procédé de co-enregistrement d'images multi-modales dans un environnement tridimensionnel, le procédé comprenant
définir un cadre de référence ;
fournir de la lumière d'excitation à une cible (330, 430, 530, 630) relativement au cadre de référence ;
fournir des rayons électromagnétiques à la cible (330, 430, 530, 630) relativement au cadre de référence ;
rediriger la lumière d'excitation relativement à la cible (330, 430, 530, 630) sans rediriger les rayons électromagnétiques fournis ;
détecter les rayons électromagnétiques transmis par la cible (330, 430, 530, 630) relativement au cadre

de référence ;
détecter la lumière de la cible (330, 430, 530, 630) relativement au cadre de référence ; et
fournir des rayons électromagnétiques et images de lumière co-enregistrés d'une cible à un utilisateur, **caractérisé en ce que** le procédé comprend en outre la redirection de la lumière réfléchie reçue d'une cible (330, 430, 530, 630) sans rediriger la lumière d'excitation transmise à la cible (330, 430, 530, 630) en utilisant un miroir à une voie ayant un côté de transmission disposé vers la lumière d'excitation et un côté de réflexion pour réfléchir la lumière reçue d'une cible.

6. Procédé selon la revendication 5, comprenant en outre :

capturer des données d'images de rayons X ; et
identifier les données d'images de rayons X associés à la cible (330, 430, 530, 630).

7. Procédé selon la revendication 5, où la fourniture de la lumière d'excitation comprend :

convertir les coordonnées d'images de la cible (330, 430, 530, 630) en coordonnées de lumière pour diriger la lumière d'excitation ; et
traiter les coordonnées de lumière pour diriger la lumière d'excitation à la cible (330, 430, 530, 630) dans une scène réelle.

8. Procédé selon la revendication 7, comprenant en outre la redirection de la lumière à détecter par la cible (330, 430, 530, 630) sans rediriger les rayons électromagnétiques à détecter de la cible (330, 430, 530, 630).

9. Dispositif de stockage de programme lisible par machine, incorporant de manière perceptible un programme d'instructions pour amener l'appareil selon la revendication 1 à exécuter le procédé selon l'une quelconque des revendications 5 à 8.

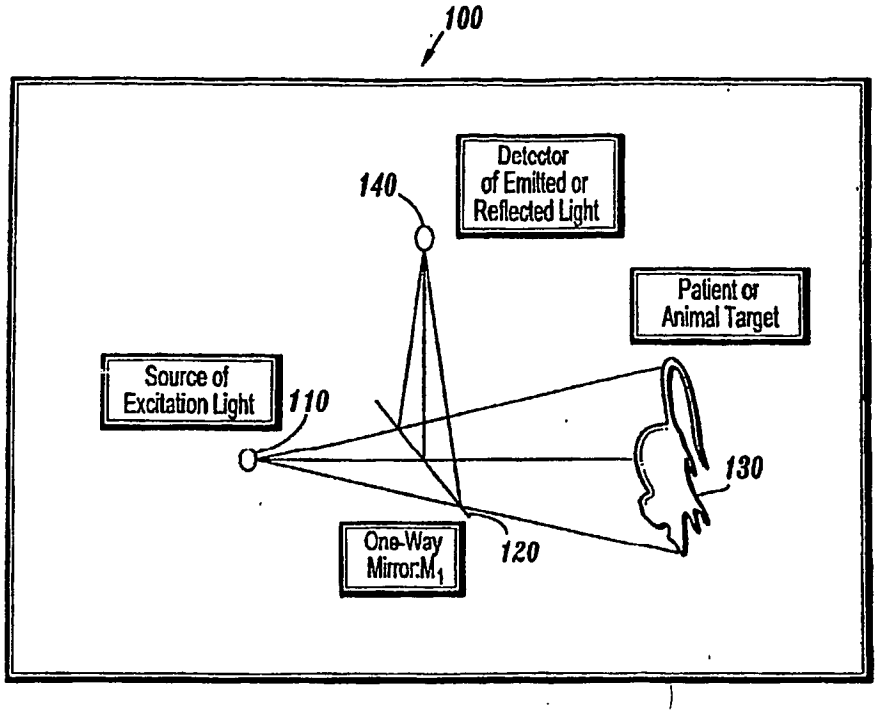
100
Detector of Emitted or Reflected Light
140
Patient or Animal Target
Source of Excitation Light
110
130
One-Way Mirror:M1
120

FIG. 1

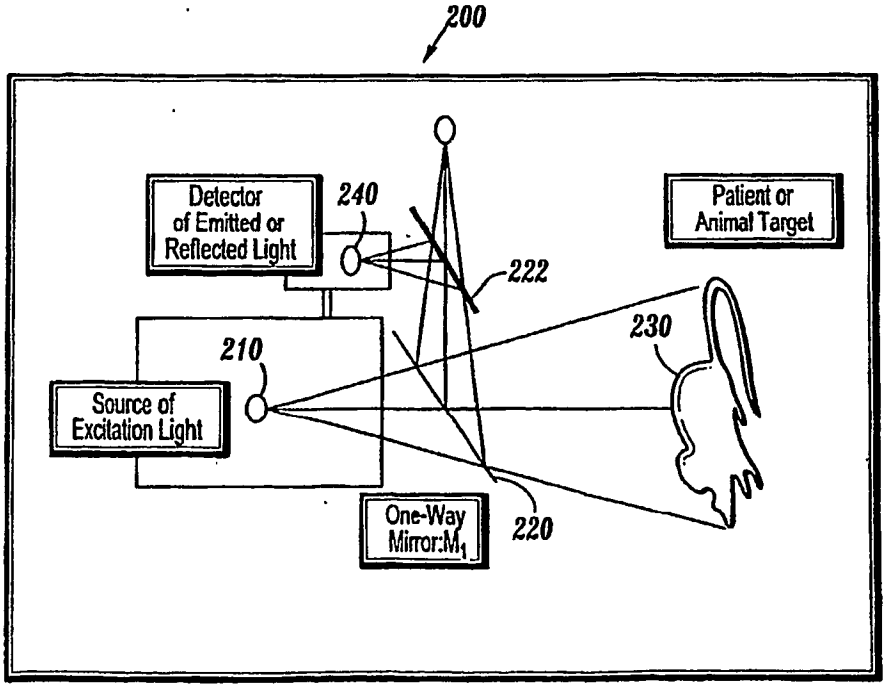
200
Detector of Emitted or Reflected Light
240
Patient or Animal Target
222
230
210
Source of Excitation Light
One-Way Mirror:M1
220

FIG. 2

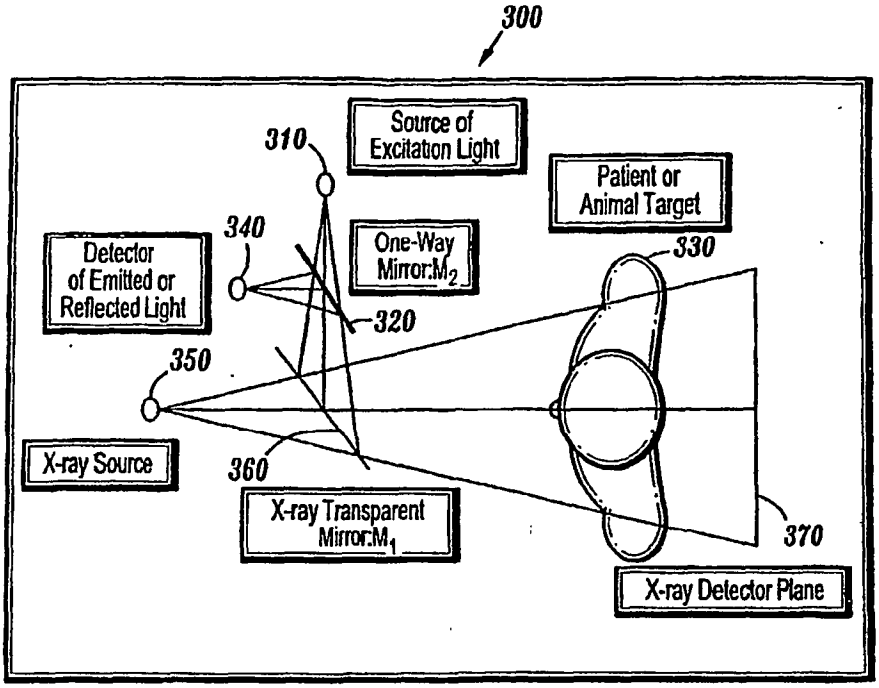
300
Source of Excitation Light
310
Patient or Animal Target
340
Detector of Emitted or Reflected Light
One-Way Mirror:M2
330
320
350
X-ray Source
360
X-ray Transparent Mirror:M1
370
X-ray Detector Plane

FIG. 3

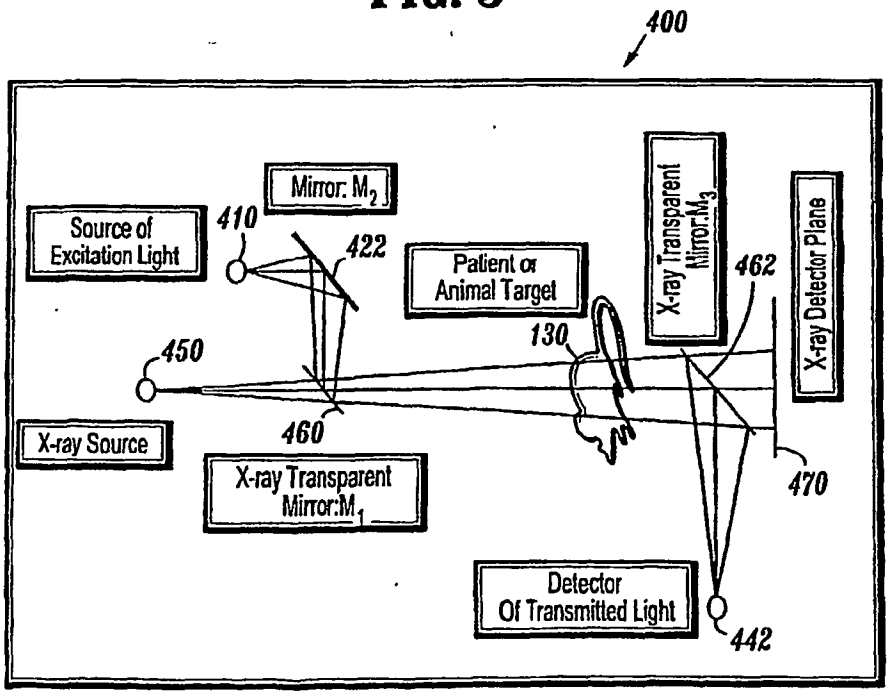
400
Mirror: M2
Source of Excitation Light
410
422
Patient or Animal Target
X-ray Transparent Mirror:M3
462
X-ray Detector Plane
130
450
X-ray Source
460
X-ray Transparent Mirror:M1
470
Detector Of Transmitted Light
442

FIG. 4

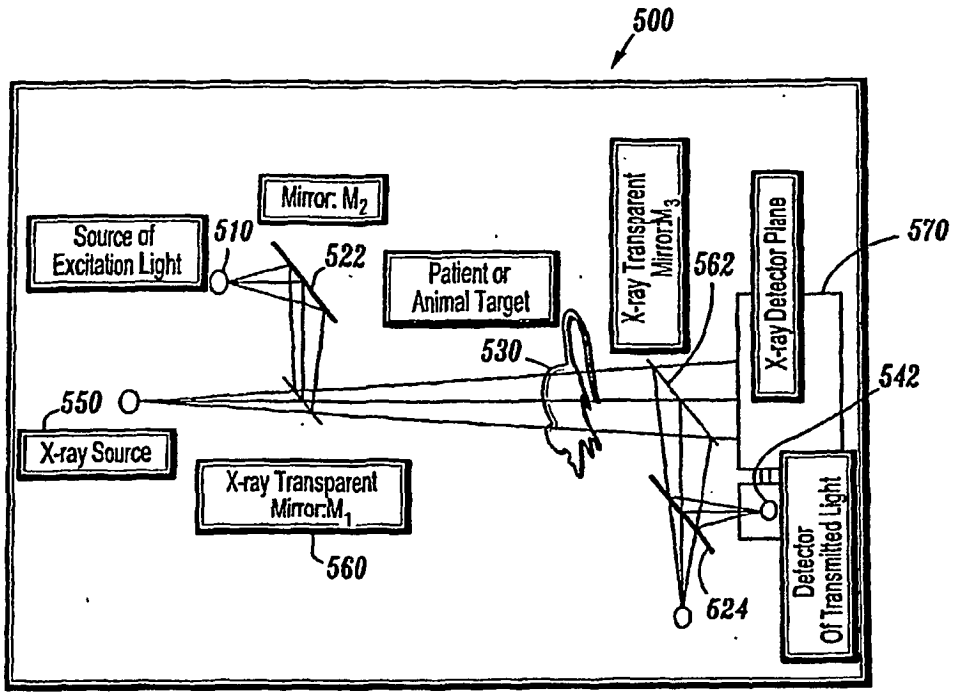
500
Source of Excitation Light
510
Mirror: M_2
522
Patient or Animal Target
X-ray Transparent Mirror:M_3
562
X-ray Detector Plane
570
530
542
550
X-ray Source
X-ray Transparent Mirror:M_1
560
624
Detector Of Transmitted Light

FIG. 5

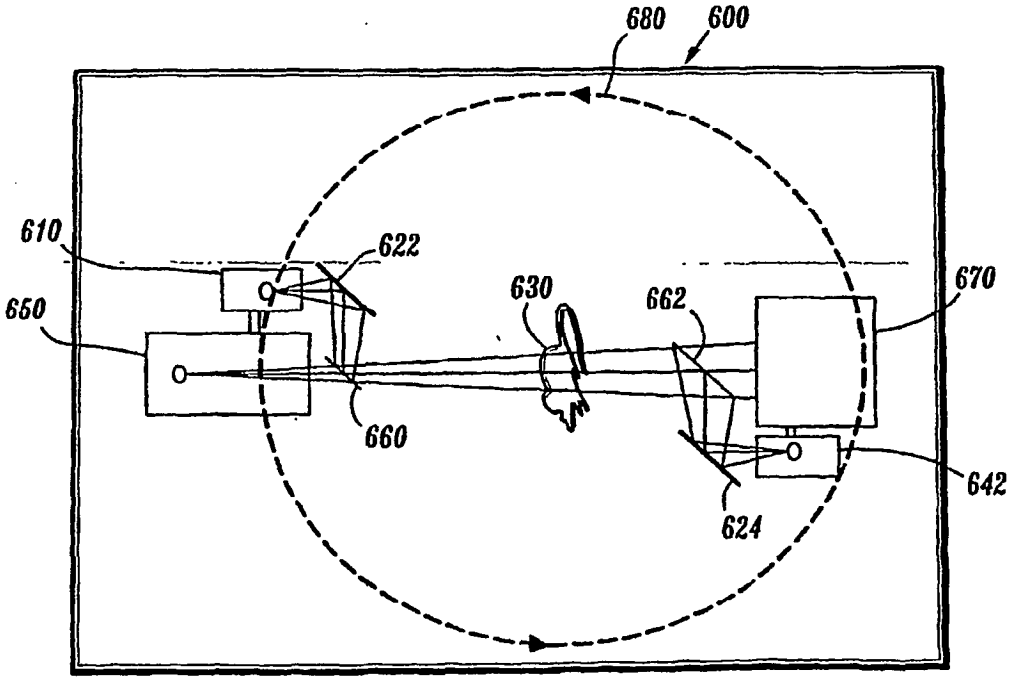
680
600
610
622
630
662
670
650
660
642
624

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	实时采集共同注册的X射线和光学图像		
公开(公告)号	EP1610672B1	公开(公告)日	2009-03-11
申请号	EP2004758871	申请日	2004-04-02
[标]申请(专利权)人(译)	西门子公司		
申请(专利权)人(译)	西门子公司研究，INC.		
当前申请(专利权)人(译)	西门子医疗解决方案USA，INC.		
[标]发明人	NAVAB NASSIR WILLIAMS JAMES P		
发明人	NAVAB, NASSIR WILLIAMS, JAMES, P.		
IPC分类号	A61B5/00 A61B6/00 A61B6/03		
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优先权	60/460086 2003-04-03 US 10/812631 2004-03-30 US		
其他公开文献	EP1610672A1		
外部链接	Espacenet		

摘要(译)

提供一种装置（300,400,500,600），方法和程序存储装置，用于在三维环境中共同配准多模态图像，其中该装置包括激发光源（510），电磁射线源（550）相对于激发光源设置，电磁射线透明镜（560）具有朝向激发光设置的第一表面和朝向电磁射线源设置的第二表面，目标位置（530）朝向电磁射线透明镜的第一表面设置，用于定位目标并接收激发光和电磁射线，电磁射线检测器（570）设置在目标位置相对于电磁射线的相对侧用于检测透过目标的电磁射线的透明镜，具有朝向光学反射表面设置的光反射表面的第二电磁射线透明镜（562） s是目标位置，并且朝向第二电磁射线透明镜的光反射表面设置的光检测器（542）用于检测来自目标的光

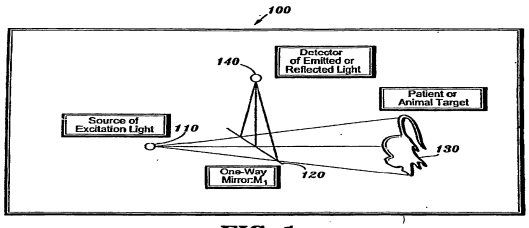

FIG. 1

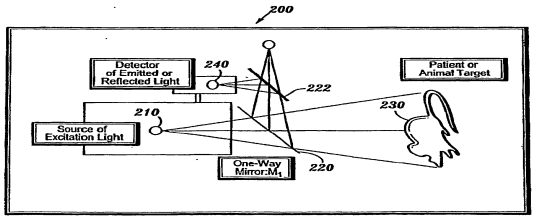

FIG. 2