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(54) **Simulation system, method and computer program**

(57) Simulation system comprising at least one virtual projectile/missile firing device (1) having movable directing means (3) to direct a virtual projectile/missile towards a target (2) and means to determine the position of said at least one virtual projectile/missile firing device

and the target whereby the simulation system comprises means (4) to capture at least one image of the target scene in front of the directing means (3) and means to process the, or each, image so as to determine the orientation of the directing means (3).

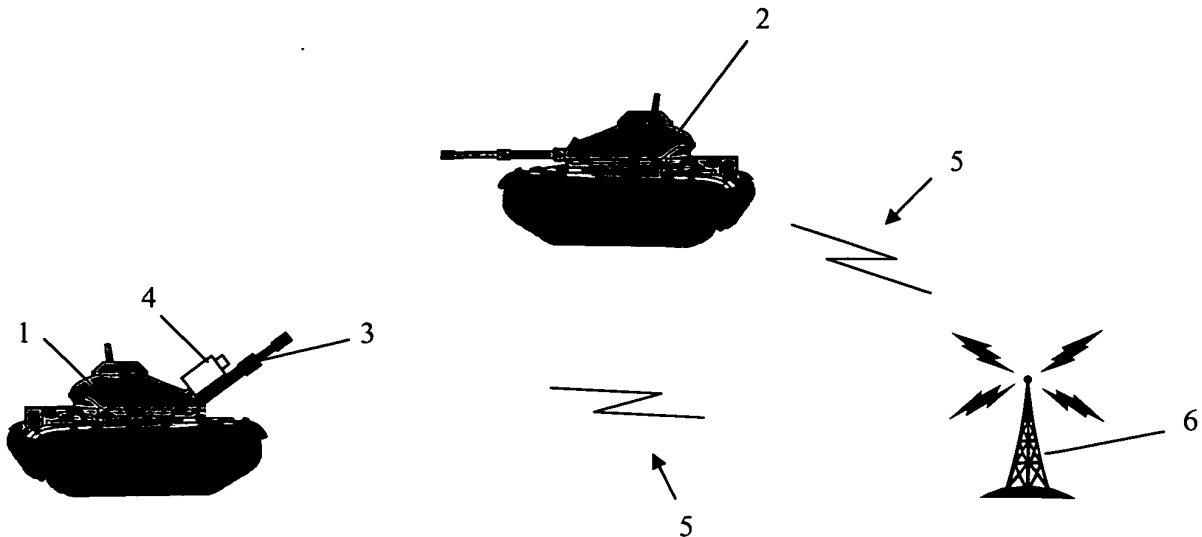


Fig. 1

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Description

TECHNICAL FIELD OF THE INVENTION AND PRIOR ART

[0001] The present invention concerns a simulation system comprising at least one virtual projectile/missile firing device having movable directing means to direct a virtual projectile/missile (i.e. a self-propelling weapon, such as a rocket, or a non-self-propelling weapon that is thrown or projected) towards a target and a method for determining the orientation of the directing means of a virtual projectile/missile firing device.

[0002] Weapon simulators are widely used to take the place of actual weapons during simulation exercises.

[0003] US 6386879 describes a gunnery simulation system in which a turret-mounted gun on a shooter tank with a laser scanner transmitter in its barrel emits a laser beam upon a trigger pull. The laser beam is directed towards a target tank based upon a shooter's ranging and tracking using a standard fire computer. The target tank is scanned with the laser beam to measure target azimuth and target elevation with respect to a bore-sight of the gun of shooter tank.

[0004] Optical receivers mounted on the turret of the target tank detect the laser beam and a system control unit determines the trigger pull time, target azimuth and target super elevation. The laser beam is therefore used both to simulate the ballistic round fired from the gun and to measure the position of the target. A system control unit determines the range to the target tank by comparing a set of GPS coordinates of the two tanks. Based on the target azimuth, the target super elevation, the range to the target and the time of the trigger pull, the system control unit computes an impact point relative to the target tank of a simulated ballistic shell fired from the gun of the first tank at the time of the trigger pull. Casualty assessment is made and the impact point is transmitted back to the shooter for immediate feedback.

[0005] A disadvantage of such a simulation system is that a lot of equipment has to be mounted on the vehicles that participate in a simulation exercise, which makes installation of the system complex and time consuming. The amount of hardware that is necessary also increases the cost of such a system. Another disadvantage is that optical equipment on the shooter tank may be damaged by optical radiation reflected from optical equipment, such as prisms, mounted on the target tank, especially if the target tank comes too close to the shooter tank. The laser scanner transmitter can consequently not be used tactically without limitation. Furthermore, the gunning of targets outside the field of view of the laser scanner transmitter is not possible.

[0006] Several conventional simulation systems use a compass to determine the orientation of a gun barrel however the accuracy of compasses is very low and metal objects and electrical sources, such as power lines, guns, trucks, tanks, telephone wires, barbed wire or steel hel-

metals can affect their performance and consequently their reliability. If the orientation of the gun barrel is inaccurate, the calculation of the ballistic trajectory of the virtual projectile/missile fired from the gun barrel will be inaccurate. An inaccurate and therefore unrealistic simulation system will prevent participants in a simulation exercise from developing their aiming and shooting ability.

SUMMARY OF THE INVENTION

[0007] The object of the present invention is to provide a simulation system that allows the orientation of the directing means of a virtual projectile/missile firing device to be accurately determined so as to enable more accurate calculation of the ballistic trajectory of a virtual projectile/missile.

[0008] This object is fulfilled by a simulation system having the features disclosed in claim 1 namely a system comprising at least one virtual projectile/missile firing device, such as a tank, having movable directing means, such as a gun barrel, to direct a virtual projectile/missile, such as a virtual anti-tank missile, towards a target and means to determine the position of said at least one virtual projectile/missile firing device and the target at the time of firing the virtual projectile/missile and means to capture at least one image of the target scene in front of the directing means as well as means to process the, or each, image so as to determine the orientation of the directing means.

[0009] When a virtual projectile/missile is fired, the simulation system is provided with information concerning how the directing means is oriented from the captured target scene image and with information concerning the geographical position of potential targets in the line of fire of the virtual projectile/missile at the time of firing said virtual projectile/missile. The accurate orientation of the directing means of the virtual projectile/missile firing device can therefore be accurately determined using this information. Accurate determination of the orientation of the directing means allows a more accurate ballistic trajectory of the virtual projectile/missile to be determined and this consequently enhances the realism and improves the effectiveness of the simulation exercise.

[0010] The inventive simulation system requires relatively little equipment to be mounted on the participants taking part in a simulation exercise. Participants may be moving or stationary vehicles, aircraft or sea-going vessels, movable or stationary weapons, buildings, fixed or movable structures and/or people. This allows the system to be assembled more quickly than a conventional system thus making the inventive system more cost effective. Furthermore if a laser-based distance sensor is used by any of the participants in a simulation exercise, its use does not have to be limited. It is also possible to extend the inventive concept to enable the gunning of objects outside the field of view of the virtual projectile/missile firing device.

[0011] According to an embodiment of the invention

the simulation system also comprises compass means to provide a preliminary indication of the orientation of the directing means. The rough compass bearing together with its estimated inaccuracy may be used to limit the scope of the target scene image.

[0012] According to another embodiment of the invention the image capturing means comprises at least one optic or infrared camera. The image capturing means are optionally arranged to take wide-angle photographs and transform them into digital panoramic images. A software program may optionally used to generate a three-dimensional image of at least part of the target scene. According to a further embodiment of the invention the image capturing means is mounted on the directing means whereby the orientation of the image capturing means with respect to the directing means is known. Alternatively the image capturing means is incorporated into the bore sight of the directing means.

[0013] According to an embodiment of the invention the means to determine the position of said at least one virtual projectile/missile firing device and the target comprises a global positioning system (GPS) or differential global positioning system (DGPS).

[0014] According to another embodiment of the invention the simulation system comprises means to log the time at which the, or each, image of a target scene is captured.

[0015] According to a further embodiment of the invention the simulation system comprises a central network that is arranged to receive/send/store and/or communicate information concerning the position of said at least one virtual projectile/missile firing device and/or the orientation of its directing means and the position and/or orientation of the, or each target to any, or all of the participants in a simulation exercise and optionally to a third party. All of the participants in a simulation exercise therefore transmit time-logged information concerning the position and orientation to the central network.

[0016] According to a yet further embodiment of the invention the simulation system comprises assessment means to provide an assessment of injury/damage that would have been caused by the impact of such a projectile/missile in a real situation. Said assessment means may be arranged to activate visible or audible signals to communicate the simulated damage/injury to participants in the simulation exercise or a third party.

[0017] According to an embodiment of the invention the assessment means contain range of action data for a certain type, or each type of virtual projectile/missile fired by said at least one virtual projectile/missile firing device versus distance of participants in a simulation exercise from such a device in order to assess the degree of injury/damage that would have been caused by impact of such a projectile/missile in a real situation. According to another embodiment of the invention the means to evaluate an injury/damage assessment are arranged to be carried any, or all of the participants in a simulation exercise.

[0018] The present invention also concerns a method for determining the orientation of the directing means of a virtual projectile/missile firing device. The method comprises the steps of determining the position of the virtual projectile/missile firing device and the target, capturing at least one image of the target scene in front of the directing means and processing the, or each, image in order to determine the orientation of the directing means using information concerning the position of the target in the, or each, image.

[0019] According to an embodiment of the invention the method also comprises the step of obtaining a preliminary indication of the orientation of the directing means so as to enable the scope of the target scene to be limited.

[0020] According to another embodiment of the invention a camera takes at least one photograph of the target scene.

[0021] According to a further embodiment of the invention the method comprises the step of using a global positioning system (GPS) or differential global positioning system (DGPS) to determine the position of said at least one virtual projectile/missile firing device and the target.

[0022] According to a yet further embodiment of the invention the method comprises the step of logging the time at which the, or each, image of a target scene is captured.

[0023] The present invention furthermore concerns a computer program containing computer program code means for making a computer or processor execute image processing of at least one target scene provided by a simulation system according to any of the embodiments described above or obtained using a method according to any of the embodiments disclosed herein in order to determine the orientation of the directing means of a virtual projectile/missile firing device. Optionally the computer program is arranged to provide an assessment of injury/damage that would have been caused by the impact of such a projectile/missile in a real situation.

[0024] According to an embodiment of the invention the computer program is stored by means of a computer-readable medium.

[0025] The system, the method and the computer program according to the present invention claim is intended for simulating the effect any projectile/missile, such as an anti-tank missile, anti-aircraft missile, anti-sea-craft missile, a chemical, biological or nuclear device, fired from any stationary or moving virtual projectile/missile firing device.

[0026] Further advantages as well as advantageous features of the invention appear from the following description and the other dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

Fig. 1 shows a simulation system according to the

present invention adapted for simulating tank fire in a training exercise, and

Fig. 2 is a flow chart describing the inventive method according to an embodiment of the invention.

[0028] The following description and drawings are not intended to limit the present invention to the embodiment disclosed. The embodiments disclosed merely exemplify the principles of the present invention.

[0029] It should be noted that the drawing is not drawn to scale and that the size of certain features has been exaggerated for the sake of clarity.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

[0030] Figure 1 shows a simulation system used to simulate the firing of virtual anti-tank projectiles/missiles from tank 1 at tank 2 during a simulation exercise. Tank 1 comprises a gun barrel 3 that is movable by means of the revolvable turret on which it is mounted and which is arranged to direct a virtual anti-tank projectile/missile towards the target tank 2.

[0031] The tanks 1 and 2 are equipped with sensors, such as GPS-sensors, turret traversing sensors, a compass to give a rough indication of the compass bearing of the gun barrel, a gyroscope and gun barrel orientation sensors that provide information concerning the elevation and rotation of the gun barrel towards the vertical plane. Additional sensors, such as a wind sensor may also be utilized if such information is to be considered in calculating the ballistic trajectory of the virtual anti-tank projectile/missile.

[0032] Time-logged information 5 concerning the position and orientation of the tanks 1,2 and parts thereof is transmitted to a central network 6. This information 5 is saved so as to be available for searches when information concerning the position of a tank 1,2, at a certain time is requested.

[0033] A camera 4 is mounted at the bottom of the gun barrel 3 of tank 1 in a fixed and known position with respect to the gun barrel 3. Alternatively, use can be made of the tank's existing equipment such as a video camera and/or an infrared camera. The camera 4 is used to capture at least one image of the target scene in front of the gun barrel 3 and the image is then processed to accurately determine the orientation of the gun barrel 3.

[0034] Figure 2 is a flow chart showing a method for determining the orientation of the directing means 3 of a virtual projectile/missile firing device 1 according to a preferred embodiment of the invention. A virtual projectile/missile is fired at the target 2. This event is time-logged and an image from the camera 4 is saved together with information 5 concerning the position and orientation of the virtual projectile/missile firing device 1 and/or parts thereof including the rough compass bearing together with the estimated inaccuracy of the compass bearing.

This information 5 is transmitted to the central network 6. A target scene search field is then created on the basis of that information. The position, orientation and type of potential targets that were located within the search field at the time the virtual projectile/missile was fired are identified by their GPS-position, type and orientation.

[0035] The orientation of the gun barrel 3 is accurately determined by locating the target 2 in the image by means of an image analysis algorithm. The target's position relative to the directing means 3 is then calculated from the results of the image processing. An equation is complied taking the following into consideration; the virtual projectile/missile firing device's (1) position and orientation, the target's (2) position and orientation, the directing means' (3) direction and orientation and the target scene image and the compass bearing of the directing means 3 where said compass bearing is the unknown variable.

[0036] By solving the equation the orientation of the directing means can be accurately determined. The accuracy of the determination is dependent on the accuracy of the sensors and this gives a more accurate determination of the orientation of the directing means than that given by the compass means.

[0037] Once the orientation of the directing means is known, the virtual projectile/missile's ballistic trajectory is calculated which allows the simulation system to determine which, if any, participants in the exercise have been hit. All of the participants taking part in the simulation exercise are informed as to whether they have been hit via the central network 6, for example, and, if so, they are provided with the extent of the injury/damage caused by the hit i.e. the damage that would have been caused had that target been hit in such a way by a real projectile/missile. Such information is for example provided on a visual display unit carried by the participants 1,2 in the simulation exercise.

[0038] The invention is of course not in any way restricted to the embodiments thereof described above, but many possibilities to modifications thereof would be apparent to a man with ordinary skill in the art without departing from the basic idea of the invention as defined in the appended claims.

Claims

1. Simulation system comprising at least one virtual projectile/missile firing device (1) having movable directing means (3) to direct a virtual projectile/missile towards a target (2) and means to determine the position of said at least one virtual projectile/missile firing device and the target, **characterized in that** it comprises means (4) to capture at least one image of the target scene in front of the directing means (3) and means to process the, or each, image so as to determine the orientation of the directing means (3).
2. Simulation system according to claim 1, **character-**

ized in that it also comprises compass means to provide a preliminary indication of the orientation of the directing means (3).

3. Simulation system according to claim 1 or 2, **characterized in that** the image capturing means (4) comprises at least one optic or infrared camera. 5
4. Simulation system according to any of the preceding claims, **characterized in that** the image capturing means (4) is mounted on the directing means (3). 10
5. Simulation system according to any of the preceding claims, **characterized in that** the means to determine the position of said at least one virtual projectile/missile firing device (1) and the target (2) comprises a global positioning system (GPS) or differential global positioning system (DGPS). 15
6. Simulation system according to any of the preceding claims, **characterized in that** it comprises means to log the time at which the, or each, image of a target scene is captured. 20
7. Simulation system according to any of the preceding claims, **characterized in that** it comprises a central network (6) that is arranged to receive/send/store and/or communicate information (5) concerning the position of said at least one virtual projectile/missile firing device (1) and/or the orientation of its directing means (3) and the position and/or orientation of the, or each, target (2) to any, or all, of the participants in a simulation exercise and optionally to a third party. 25 30
8. Simulation system according to any of the preceding claims, **characterized in that** it comprises assessment means to provide an assessment of injury/damage that would have been caused by the impact of such a projectile/missile in a real situation. 35 40
9. Simulation system according to claim 8, **characterized in that** the assessment means contain range of action data for a certain type, or each type, of virtual projectile/missile fired by said at least one virtual projectile/missile firing device (1) versus distance of participants in a simulation exercise from such a virtual projectile/missile firing device (1) in order to assess the degree of injury/damage that would have been caused by impact of such a projectile/missile in a real situation. 45 50
10. Simulation system according to claim 8 or 9, **characterized in that** the means to evaluate an injury/damage assessment are arranged to be carried any, or all of the participants in a simulation exercise. 55
11. Method for determining the orientation of the directing means (3) of a virtual projectile/missile firing de-

vice (1) comprising the steps of determining the position of the virtual projectile/missile firing device (1) and the target (2), **characterized in that** it also comprises the step of capturing at least one image of the target scene in front of the directing means (3) and processing the, or each, image in order to determine the orientation of the directing means (3) using information concerning the position of the target (2) in the, or each, image.

12. Method according to claim 11, **characterized in that** it also comprises the step of obtaining a preliminary indication of the orientation of the directing means (3) so as to enable the scope of the target scene to be limited.
13. Method according to claim 11 or 12, **characterized in that** a camera takes at least one photograph of the target scene.
14. Method to any of claims 11-13, **characterized in that** it comprises the step of using a global positioning system (GPS) or differential global positioning system (DGPS) to determine the position of said at least one virtual projectile/missile firing device and the target.
15. Method to any of claims 11-14, **characterized in that** it comprises the step of logging the time at which the, or each, image of a target scene is captured.
16. A computer program containing computer program code means for making a computer or processor execute image processing of at least one target scene provided by a simulation system according to any of claims 1-10 or obtained using a method according to any of claims 11-15 in order to determine the orientation of the directing means (3) of a virtual projectile/missile firing device (1).
17. A computer program according to claim 16 stored by means of a computer-readable medium.
18. Use of a system according to any of claims 1-10, a method according to any of claims 11-15, or a computer program according to claim 16 or 17 for simulating the effect any projectile/missile, such as an anti-tank missile, anti-aircraft missile, anti-sea-craft missile, a chemical, biological or nuclear device, fired from a fixed or moving virtual projectile/missile firing device (1).

Amended claims in accordance with Rule 86(2) EPC.

1. Simulation system comprising at least one virtual projectile/missile firing device (1) having movable directing means (3) to direct a virtual projectile/missile

towards a target (2), means to determine the position of said at least one virtual projectile/missile firing device and the target, means (4) to capture at least one image of the target scene in front of the directing means (3), **characterized in that** it comprises means to process the, or each, image so as to determine the compass bearing of the directing means (3).

2. Simulation system according to claim 1, **characterized in that** it also comprises compass means to provide a preliminary indication of the orientation of the directing means (3).

3. Simulation system according to claim 1 or 2, **characterized in that** the image capturing means (4) comprises at least one optic or infrared camera.

4. Simulation system according to any of the preceding claims, **characterized in that** the image capturing means (4) is mounted on the directing means (3).

5. Simulation system according to any of the preceding claims, **characterized in that** the means to determine the position of said at least one virtual projectile/missile firing device (1) and the target (2) comprises a global positioning system (GPS) or differential global positioning system (DGPS).

6. Simulation system according to any of the preceding claims, **characterized in that** it comprises means to log the time at which the, or each, image of a target scene is captured.

7. Simulation system according to any of the preceding claims, **characterized in that** it comprises a central network (6) that is arranged to receive/send/store and/or communicate information (5) concerning the position of said at least one virtual projectile/missile firing device (1) and/or the orientation of its directing means (3) and the position and/or orientation of the, or each, target (2) to any, or all, of the participants in a simulation exercise and optionally to a third party.

8. Simulation system according to any of the preceding claims, **characterized in that** it comprises assessment means to provide an assessment of injury/damage that would have been caused by the impact of such a projectile/missile in a real situation.

9. Simulation system according to claim 8, **characterized in that** the assessment means contain range of action data for a certain type, or each type, of virtual projectile/missile fired by said at least one virtual projectile/missile firing device (1) versus distance of participants in a simulation exercise from such a virtual projectile/missile firing device (1) in order to assess the degree of injury/damage that

would have been caused by impact of such a projectile/missile in a real situation.

10. Simulation system according to claim 8 or 9, **characterized in that** the means to evaluate an injury/damage assessment are arranged to be carried any, or all of the participants in a simulation exercise.

11. Method for determining the orientation of the directing means (3) of a virtual projectile/missile firing device (1) comprising the steps of determining the position of the virtual projectile/missile firing device (1) and the target (2), and capturing at least one image of the target scene in front of the directing means (3), **characterized in that** it also comprises the step of processing the, or each, image in order to determine the compass bearing of the directing means (3) using information concerning the position of the target (2) in the, or each, image.

12. Method according to claim 11, **characterized in that** it also comprises the step of obtaining a preliminary indication of the orientation of the directing means (3) so as to enable the scope of the target scene to be limited.

13. Method according to claim 11 or 12, **characterized in that** a camera takes at least one photograph of the target scene.

14. Method to any of claims 11-13, **characterized in that** it comprises the step of using a global positioning system (GPS) or differential global positioning system (DGPS) to determine the position of said at least one virtual projectile/missile firing device and the target.

15. Method to any of claims 11-14, **characterized in that** it comprises the step of logging the time at which the, or each, image of a target scene is captured.

16. A computer program containing computer program code means for making a computer or processor execute image processing of at least one target scene provided by a simulation system according to any of claims 1-10 or obtained by using any of the methods as claimed in claim 11 to 15 in order to determine the compass bearing of the directing means (3) of a virtual projectile/missile firing device (1).

17. A computer program according to claim 16 stored by means of a computer-readable medium.

18. Use of a system according to any of claims 1-10, a method according to any of claims 11-15, or a computer program according to claim 16 or 17 for simu-

lating the effect any projectile/missile, such as an anti-tank missile, anti-aircraft missile, anti-sea-craft missile, a chemical, biological or nuclear device, fired from a fixed or moving virtual projectile/missile firing device (1).

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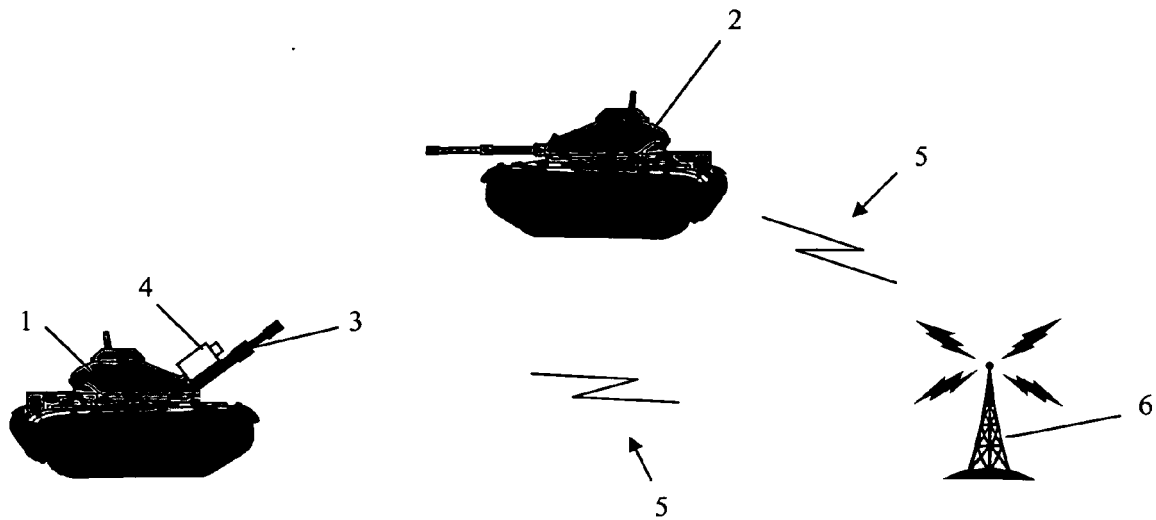


Fig. 1

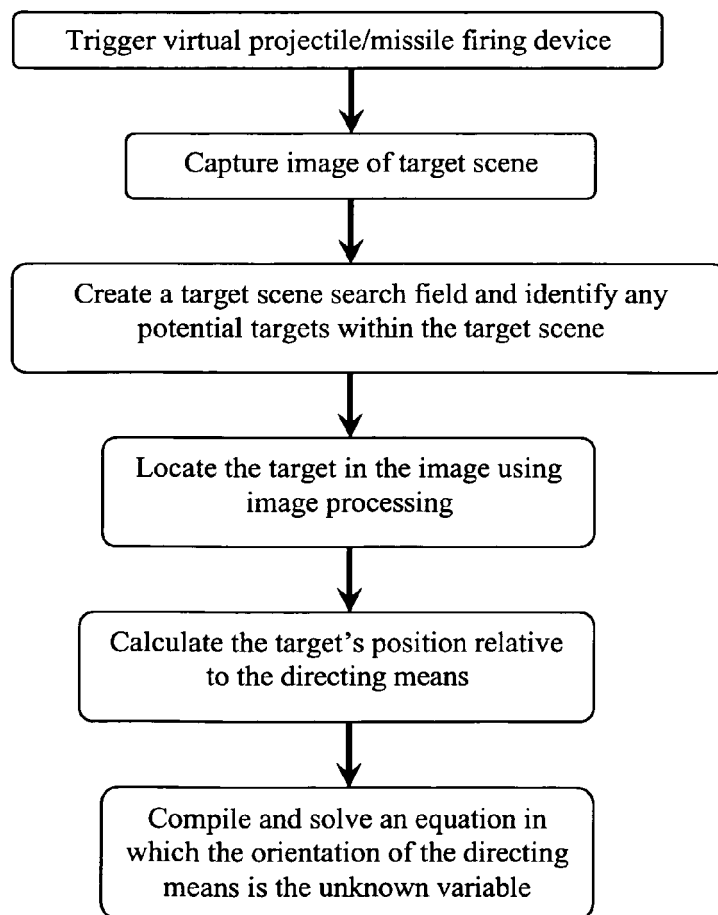


Fig. 2



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 04 02 3534

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 February 2005	Examiner Blondel, F
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03/82 (P04C01)



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 02 3534

DOCUMENTS CONSIDERED TO BE RELEVANT			
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Place of search The Hague		Date of completion of the search 7 February 2005	Examiner Blondel, F
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 02 3534

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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