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(54) METHOD AND SYSTEM FOR MEASURING AIRBURST MUNITION BURST POINT

VERFAHREN UND SYSTEM ZUR MESSUNG DES DETONATIONSPUNKTES EINER LUFTDETONATIONSMUNITION

PROCÉDÉ ET SYSTÈME DE MESURE D'UN POINT D'ÉCLATEMENT DE MUNITION À EXPLOSION FUSANTE

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Description

Introduction

[0001] The present invention concerns a fire control system for a weapon firing explosive projectiles, and more specifically to a fire control method and system measuring possible deviation from a pre-planned position of a burst point of airburst munitions.

Background and prior art

[0002] For maximum effect on a target, accurate positioning of the airburst detonation point in space is critical. To control the distance to the airburst munition to detonate, most airburst munitions use a technology where the time of flight to a given burst point is programmed into the round. Some systems use an exit velocity (V_0) sensor for better prediction of the time of flight, and the munition can then be programmed in flight. There are however several factors influencing deviations from an expected burst point. Examples of such are head/tail/side winds, air density/pressure and propellant temperature as well as temperature in the barrel of the weapon being used.

[0003] One type of airburst munition comprises a turn count sensor where a given number of turns defines a given distance relatively independent of the exit velocity of the projectile. The number of turns for a projectile will give a specific range, i.e. distance from a weapon to a burst point. A fixed number of turns corresponds to a defined displacement.

[0004] This technology reduces the effect of V_0 variation, but other factors can still contribute to errors in the range. An example of this is that variation of the rifling angle of each individual gun will have an impact on the range to the burst point.

[0005] US 2012/325078 A1 describes a system and method for registration of artillery fire. Outputs from two imaging systems deployed at different locations are monitored to detect potential shell trajectory events. These are then correlated to eliminate potential shell trajectory events not viewed by both optical systems. This system and method require a relatively complex additional set-up deployed at a distance from existing artillery firing shells.

[0006] Most modern weapon stations use a laser range finder to determine the range to the target. For ground targets, it is often desirable to have the burst point of the detonation above or in front of the target. The laser is normally mounted coaxial to the sight of the weapon station for pointing at the target, and not at the predicted burst point of the ammunition. Some fire control systems fire airburst ammunitions in a predefined pattern, while the sight remains stationary at the centre of the target.

[0007] US 9593914 B2 describes a method and fire-control system for acquiring the coordinates of a trigger point of a projectile above a field part on which a target is located. The method is based on emission of at least one laser pulse having a predetermined duration and directed towards the target. Images reflected is received with a receiver equipped for the synchronous visualization of the laser pulses originating from a piece of observation of the field part. Recovery of the coordinates of a desired trigger point when the operator has chosen a location after the piece of observation was moved.

[0008] This solution depends on a receiver with means for synchronous visualization of reflection of laser pulses under the form of a piece of observation of the field part having a width adjustable by selecting a duration for the laser emission or reception, and the distance of the piece of observation with respect to the receiver is adjustable by adjusting a delay between the emission and the reception. A camera is mentioned as the receiver for receiving images of reflections of emitted laser pulses from a target, and where its shutter is synchronised with emission of the laser pulse.

[0009] This method and system require a relatively complex set-up and modification of existing equipment.

[0010] There is a need for a simple method and system for measuring position of airburst munitions burst point thereby automatically enabling correction of the fire control system in case of deviation from pre-planned burst point.

[0011] The present invention describes a solution according to this where one example of implementation is using a laser range finder already comprised in a weapon system.

[0012] A new approach for determining the actual burst point of airburst munitions is suggested. According to the method and system, existing equipment can be used without need for modifications or additional equipment, and where the burst point is measured with high accuracy.

Short description of the invention

[0013] The present invention is defined by a method for measuring a burst point of airburst munition. The method comprises the following steps:

- setting a detonation point distance of the airburst munition;
- firing a weapon with airburst munition at time t_0;
- setting a time of flight, t_1, of the airburst munitions based on its set detonation point distance;
- activating and controlling a laser measurement system comprising a laser transmitter and receiver for sending laser light at a time $to + t_1$ and receiving reflected laser light for measuring distance to cloud of smoke resulting from burst of the airburst munition;
- processing the reflected laser light and defining a

range of distances to the cloud of smoke, and

- setting a range gate around the set detonation point distance prior to processing received reflected laser light within the range gate for limiting the resulting range of distances and cancelling echoes from surrounding terrain.

[0014] Further features of the method are defined in the claims.

[0015] The invention further comprises a computer program performing said method when executed on a computer, thereby causing a distance to a burst point of airburst munition to be measured.

[0016] The invention is further defined by a fire control system for measuring the distance to a burst point of airburst munition. The system comprises:

- firing means for firing a weapon with airburst munition at time $t_{0;}$
- setting means for setting a time of flight $t_{1,}$ of the airburst munitions based on a set detonation point distance;
- activation and controller means for activating and controlling a laser measurement system comprising a laser transmitter and receiver for sending laser pulses at a time $to + t_{1,}$ and receiving reflected laser light for measuring distance to cloud of smoke resulting from the burst of the airburst munition;
- processor for processing the reflected laser light and defining a range of distances to the cloud of smoke;
- range setting and processing means for setting a range gate around the set detonation point distance prior to processing received reflected laser light within the range gate for limiting the resulting range of distances and cancelling echoes from surrounding terrain.

[0017] The system further comprise means adapted for performing the method defined in the claims as well as a computer program having instructions that when executed in a processor of a computing device or system performs the method.

Detailed description of the invention

[0018] In the following description, different features of the invention will be described with reference to figure 1.

[0019] As mentioned, accurate prediction, estimation and measurement of the position of an airburst point is critical.

[0020] The invention comprises a method, system and computer program for determining the actual distance to the burst point of airburst munition.

[0021] The method is defined by several steps as shown in figure 1. The first step is setting a detonation point distance of airburst munition. This can be done in several ways.

[0022] One way is to manually set the detonation point distance based on a known distance. This is a typical scenario when a weapon in tested and calibrated. A distance of 280 meters is set when a known target is located at this distance.

[0023] If a distance to a target is unknown, the distance can be measured by using integrated distance measuring means being part of a weapon or weapon system. This may for instance be a laser range finder. By using integrated means, a measured distance to a target can be automatically set and programmed into airburst munition ready for being fired.

[0024] Another way of determining a distance from a weapon to a target is to use external means not being part of a weapon or weapon system. An example of this are binoculars with integrated laser range finder. In this case, a measured distance to a target must be manually set on the weapon or airburst munition.

[0025] Detonation of airburst munition can be triggered in different ways. Examples are: time fuse, V_0 fuse and turns count fuse.

[0026] As mentioned, the set detonation point distance can be found by means of a laser range finder. However, other means for determining distance are feasible.

[0027] After setting the distance to the detonation point of the airburst munition, the next step is firing a weapon with the airburst munition at time t_0.

[0028] Another step is setting time of flight, $t_{1,}$ of the airburst munitions based on its set detonation point distance from the weapon. This step and the step of firing a weapon can be performed in any order.

[0029] Determining time of flight for airburst munition and projectiles is well known. This is normally performed by using a range table or an algorithm taking different variables into account and adjusting parameters related to projectile ballistics which is influenced by wind directions, air pressure and humidity, among others.

[0030] The next step of the method is activating and controlling a laser range measurement system comprising a laser transmitter and receiver for sending laser light at a time $t_0 + t_1$ and receiving reflected laser light for measuring distance to a cloud of smoke resulting from burst of the airburst munition.

[0031] Smoke, also called aerosols, can be a colloid of fine solid particles or liquid droplets in air or another gas. In addition to smoke resulting from burst of munition, examples of natural aerosols are fog, dust, forest exudates and geyser steam.

[0032] In one embodiment of the invention, transmitted and received laser light is laser light pulses.

[0033] One type of laser range finder using laser light pulses measures range by transmitting thousands of single pulses per second. More pulses give better accuracy in measurements but will result in longer measurement

times. A laser beam is designed to have a small beam of typically 1mrad. It is thus essential that the beam is pointed into the cloud of smoke when measurements are performed.

[0034] A smoke cloud resulting from burst of ammunition normally appears only for a very short time. It further has low reflectivity. It is therefore essential that the laser sends its light pulses at the right time to get a measurement.

[0035] In one embodiment of the invention, timing of sending laser pulses and number of pulses to send is controlled based on said time, t_0, when the weapon is fired and the time of flight, i.e. $t_0 + t_1$. Based on time of flight prior to detonation of burst munition, the timing and number of pulses sent shall be such that a maximum number of pulses will hit the cloud generated by the burst during the life-time of the cloud.

[0036] By setting the trigger signal when firing the weapon at time t_0, and knowing the time of flight, t_1, of the burst munition based on distance to target, the laser can be activated at the best possible time, to ensure that the cloud of smoke is present during the laser measurement.

[0037] In one embodiment of the invention, the fire control system can automatically orient the laser range finder to the predicted burst point. The laser measurement system can then be controlled to send laser pulses in the direction of the burst point and where ballistics of the munition used is accounted for.

[0038] Reflected laser pulses are received and processed for defining a range of distances to the cloud of smoke resulting from burst of the airburst munition. This range of distances may also comprise distances to objects and surrounding terrain not being part of the cloud of smoke.

[0039] For including only relevant range measurements, the next step of the method is to limit the resulting range of distances by setting a range gate around the set detonation point distance prior to processing received reflected laser pulses thereby cancelling measurements due to echoes from other objects than the cloud of smoke.

[0040] A final distance to a burst point can be determined by averaging the distance measurements within the range gate or using different statistical processing methods.

[0041] A range gate also works as a filter automatically filtering out possible disturbances that may occur between the sensors and the burst, thus reducing likelihood of incorrect measurement data. Within the set range gate, an increased sensitivity can be applied such that low signals normally rejected as noise can be used as basis for range measurement.

[0042] In order to further increase likelihood of detecting airburst detonation point, a reference measurement can be performed prior to firing, in order to define a noise floor within the range gate that can be used to correlate with the actual burst measurement.

[0043] The range gate sensitivity can be adjusted pending on the pre-firing (noise floor) measurement.

[0044] Said method is very useful for adjusting subsequent firing of airburst munition according to deviations found in set detonation point distance and the measured distance to cloud of smoke resulting from burst of the airburst munition, as shown in figure 1. By comparing the coordinates of a set detonation point and the coordinates of a cloud point a set detonation point, subsequent firing of airburst munition can be adjusted by setting a new adjusted set detonation point distance. The method can be repeated for each shot when shooting a series of shots. By providing.

[0045] Based on said method, a fire control system can automatically calculate deviations from a pre-planned detonation point to an actual measured burst point. For subsequent firing, the range to detonation of ammunition can be corrected, e.g. by adjusting the number-of-turns-to-detonation in a turn count sensor and the projectile ballistics will be updated accordingly.

[0046] The inventive method can be performed by a fire control system controlling a laser range finder comprised in a weapon, and where same laser range finder is used for both measuring the detonation point distance to target and distances to cloud of smoke.

[0047] The invention is also defined by a fire control system for measuring a distance to a burst point of airburst munition. The system comprises firing means for firing a weapon with airburst munition at time *to* and means for registering the time *to*. It further comprises means for setting a time of flight t_1, of the airburst munitions based on a set detonation point distance.

[0048] The fire control system further comprises activation and controller means for activating and controlling a laser measurement system. The laser measurement system comprises a laser beam device for sending and receiving laser pulses at a time corresponding to $t_0 + t_1$. The system further comprises means for measuring distances to cloud of smoke resulting from the burst of the airburst munition.

[0049] The fire control system further comprises a processor for processing the reflected laser light and defining a range of distances to the cloud of smoke, and range setting and processing means for setting a range gate around the set detonation point distance prior to processing received reflected laser light within the range gate for limiting the resulting range of distances and cancelling echoes from surrounding terrain.

[0050] An example of a system where the inventive method can be implemented is a remote weapon station (RWS). This already comprises all means necessary for implementing the method for controlling the RWS according to the invention, i.e. weapon for shooting airburst munition, laser range finder, control systems for controlling aiming of laser range finder and aiming at a detonation point, and controller for activating a trigger firing the weapon. It is thus not necessary to modify an existing weapon system other than installing a computer program.

[0051] The method according to the invention described above can be implemented in a computer program having instructions that when executed cause a computing device or system to perform the method. The computing device can be the fire control system connected to said RWS system.

[0052] There are several benefits of the invention. An operator can receive information of exact position of a burst point of airburst munition and can adjust a set detonation point for a subsequent shot. The method can be implemented in existing equipment without need for modifications or additional equipment.

Claims

1. A method for measuring the distance to a burst point of airburst munition, comprising the following steps:

   - setting a detonation point distance (10) of the airburst munition;
   - firing a weapon with airburst munition at time t_0 *(20);*
   - setting a time of flight, t_1 (30) of the airburst munition based on its set detonation point distance,
   - activating and controlling a laser measurement system (40) comprising a laser transmitter and receiver for sending laser light at a time *to* + t_1 (50) and receiving reflected laser light (60) for measuring distance to a cloud of smoke resulting from burst of the airburst munition,

   charactherized in:

   - processing the reflected laser light and defining a range of distances to the cloud of smoke (70),
   - setting a range gate around the set detonation point distance (65) prior to processing received reflected laser light within the range gate for limiting the resulting range of distances and cancelling echoes from surrounding terrain.

2. The method according to claim 1, **characterised in that** the set detonation point distance (10) is found by means of a laser range finder.

3. The method according to claim 1 or 2, **characterised in that** the controlling of the laser measurement system comprises orienting and directing the laser beam at the cloud of smoke.

4. The method according to any of the previous claims, **characterised in** accounting for ballistics of the munition used when sending the laser light in the direction of the burst point.

5. The method according to any of the previous claims, **characterised in** comparing (75) the set detonation point distance (10) and the measured distance to the cloud of smoke (70), and adjusting the set detonation point (80) for subsequent firing of airburst munition according to deviations.

6. The method according to any of the previous claims, **characterised in** using same laser range finder for both measuring the detonation point distance to target and distances to the cloud of smoke.

7. The method according to any of the previous claims, **characterised in** transmitting and receiving the laser light as laser pulses.

8. The method according to claim 7, **characterised in** controlling number of laser pulses to send, as well as when to send the pulses based on the time $t_0 + t_1$.

9. The method according to any of the previous claims, **characterised in** performing a pre-firing reference measurement prior to firing, in order to define a noise floor within the range gate used for correlating with the actual burst measurement.

10. The method according to claim 9, **characterised in** adjusting the range gate sensitivity pending on the pre-firing measurement.

11. A fire control system for measuring the distance to a burst point of airburst munition, comprising:

    - firing means for firing a weapon with airburst munition at time t_0,
    - setting means for setting a time of flight t_1, of the airburst munitions based on a set detonation point distance,
    - activation and controller means for activating and controlling a laser measurement system comprising a laser transmitter and receiver for sending laser pulses at a time $t_0 + t_1$, and receiving reflected laser light for measuring distance to cloud of smoke resulting from the burst of the airburst munition, **charactherized in** further comprising
    - processor for processing the reflected laser light and defining a range of distances to the cloud of smoke,
    - range setting and processing means for setting a range gate around the set detonation point distance prior to processing received reflected laser light within the range gate for limiting the resulting range of distances and cancelling echoes from surrounding terrain.

12. The fire control system according to claim 11, further adapted to perform the method according to claims 2 to 10.

13. Computer program having instructions that when executed in a processor of a computing device or system performs the method according to claims 1 to 10.

Patentansprüche

1. Verfahren zum Messen der Distanz zu einem Detonationspunkt von Luftdetonationsmunition, das die folgenden Schritte umfasst:

    - Einstellen der Detonationspunktdistanz (10) der Luftdetonationsmunition;
    - Abfeuern einer Waffe mit Luftdetonationsmunition zur Zeit *to* (20);
    - Einstellen einer Flugzeit *t1* (30) der Luftdetonationsmunition auf der Grundlage der eingestellten Detonationspunktdistanz,
    - Aktivieren und Steuern eines Lasermesssystems (40), das einen Lasersender und -empfänger umfasst, zum Aussenden von Laserlicht zu einem Zeitpunkt $t_0 + t_1$ (50) und Empfangen von reflektiertem Laserlicht (60) zum Messen der Distanz zu einer Rauchwolke, die aus der Explosion der Luftdetonationsmunition resultiert,

    gekennzeichnet durch:

    - Verarbeiten des reflektierten Laserlichts und Definieren eines Distanzbereiches zu der Rauchwolke (70),
    - Einstellen eines Bereichsgatters um die eingestellte Detonationspunktdistanz (65) vor dem Verarbeiten des empfangenen reflektierten Laserlichts innerhalb des Bereichsgatters zur Begrenzung des resultierenden Distanzbereiches und zur Auslöschung von Echos aus dem umgebenden Gelände.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die eingestellte Detonationspunktdistanz (10) mittels eines Laserentfernungsmessers ermittelt wird.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Steuerung des Lasermesssystems das Ausrichten und Richten des Laserstrahls auf die Rauchwolke umfasst.

4. Verfahren nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass die Ballistik der verwendeten Munition berücksichtigt wird, wenn das Laserlicht in Richtung des Detonationspunkts gesendet wird.

5. Verfahren nach einem der vorhergehenden Ansprüche,
gekennzeichnet durch das Vergleichen (75) der eingestellten Detonationspunktdistanz (10) und der gemessenen Distanz zur Rauchwolke (70) und Anpassen des eingestellten Detonationspunkts (80) für das nachfolgende Abfeuern der Luftdetonationsmunition entsprechend den Abweichungen.

6. Verfahren nach einem der vorhergehenden Ansprüche,
gekennzeichnet durch das Verwenden desselben Laserentfernungsmessers sowohl für die Messung der Detonationspunktdistanz zum Ziel als auch für die Messung der Distanzen zur Rauchwolke.

7. Verfahren nach einem der vorhergehenden Ansprüche,
gekennzeichnet durch das Senden und Empfangen des Laserlichtes als Laserimpulse.

8. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, dass** die Anzahl der zu sendenden Laserimpulse sowie der Zeitpunkt des Sendens der Impulse in Abhängigkeit von der Zeit $to + t_1$ gesteuert wird.

9. Verfahren nach einem der vorhergehenden Ansprüche,
gekennzeichnet durch das Durchführen einer Referenzmessung vor dem Abschuss, um eine Rauschuntergrenze innerhalb des Bereichsgatters zu definieren, das für die Korrelation mit der tatsächlichen Detonationsmessung verwendet wird.

10. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** die Empfindlichkeit des Bereichsgatters in Abhängigkeit von der Messung vor dem Abschuss eingestellt wird.

11. Feuerleitsystem zum Messen der Distanz zu einem Detonationspunkt von Luftdetonationsmunition, umfassend:

    - Abfeuerungsmittel zum Abfeuern einer Waffe mit Luftdetonationsmunition zur Zeit t_0,
    - Einstellmittel zum Einstellen einer Flugzeit t_1 der Luftdetonationsmunitionen auf der Grundlage einer eingestellten Detonationspunktdistanz,
    - Aktivierungs- und Steuermittel zum Aktivieren und Steuern eines Lasermesssystems, das einen Lasersender und -empfänger umfasst, zum Aussenden von Laserlicht zu einem Zeitpunkt $to + t_1$ und Empfangen von reflektiertem Laserlicht zum Messen der Distanz zu einer Rauchwolke, die aus der Explosion der Luftdetonationsmunition resultiert, **dadurch gekennzeichnet, dass** es des Weiteren umfasst:

    - einen Prozessor zum Verarbeiten des re-

flektierten Laserlichts und Definieren eines Distanzbereiches zu der Rauchwolke,
- Bereichseinstellungs- und Verarbeitungsmittel zum Einstellen eines Bereichsgatters um die eingestellte Detonationspunktdistanz vor dem Verarbeiten des empfangenen reflektierten Laserlichts innerhalb des Bereichsgatters zur Begrenzung des resultierenden Distanzbereiches und zur Auslöschung von Echos aus dem umgebenden Gelände.

12. Feuerleitsystem nach Anspruch 11, das ferner zur Durchführung des Verfahrens nach den Ansprüchen 2 bis 10 geeignet ist.

13. Computerprogramm mit Befehlen, das, wenn es in einem Prozessor einer Computervorrichtung oder eines Systems ausgeführt wird, das Verfahren nach den Ansprüchen 1 bis 10 durchführt.

Revendications

1. Procédé pour mesurer la distance jusqu'à un point d'éclatement d'une munition à explosion fusante, comprenant les étapes suivantes consistant à :

- établir une distance de point de détonation (10) de la munition à explosion fusante ;
- mettre à feu une arme avec une munition à explosion fusante à un instant t_0 (20) ;
- établir un temps de vol, t_1 (30) de la munition à explosion fusante sur la base de sa distance de point de détonation établie,
- activer et commander un système de mesure laser (40) comprenant un émetteur et récepteur laser pour envoyer une lumière laser à un instant $t_0 + t_1$ (50) et recevoir une lumière laser réfléchie (60) pour mesurer la distance jusqu'à un nuage de fumée résultant de l'éclatement de la munition à explosion fusante,

caractérisé par :

- le traitement de la lumière laser réfléchie et la définition d'une plage de distances jusqu'au nuage de fumée (70),
- l'établissement d'une entrée de plage autour de la distance de point de détonation établie (65) avant de traiter la lumière laser réfléchie reçue à l'intérieur de l'entrée de plage pour limiter la plage de distances résultante et annuler des échos provenant du terrain avoisinant.

2. Procédé selon la revendication 1, **caractérisé en ce que** la distance de point de détonation établie(10) est trouvée au moyen d'un télémètre laser.

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** la commande du système de mesure laser comprend l'orientation et la direction du faisceau laser au niveau du nuage de fumée.

4. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il tient compte de la balistique de la munition utilisée lors de l'envoi de la lumière laser dans la direction du point d'éclatement.

5. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par** la comparaison (75) de la distance de point de détonation établie (10) et de la distance mesurée jusqu'au nuage de fumée (70), et l'ajustement du point de détonation établi (80) pour une mise à feu ultérieure de la munition à explosion fusante en fonction d'écarts.

6. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par** l'utilisation d'un même télémètre laser pour mesurer à la fois la distance de point de détonation jusqu'à la cible et des distances jusqu'au nuage de fumée.

7. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par** la transmission et la réception de la lumière laser sous forme d'impulsions laser.

8. Procédé selon la revendication 7, **caractérisé par** la commande du nombre d'impulsions laser à envoyer, ainsi que du moment où envoyer les impulsions sur la base de l'instant $t_0 + t_1$.

9. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par** la mise en œuvre d'une mesure de référence de pré-mise à feu avant la mise à feu, afin de définir un bruit de fond dans l'entrée de plage utilisée pour une corrélation avec la mesure d'éclatement réel.

10. Procédé selon la revendication 9, **caractérisé par** l'ajustement de la sensibilité de l'entrée de plage en attente de la mesure de pré-mise à feu.

11. Système de commande de mise à feu pour mesurer la distance jusqu'à un point d'éclatement d'une munition à explosion fusante, comprenant :

- des moyens de mise à feu pour mettre à feu une arme avec une munition à explosion fusante à l'instant t_0,
- des moyens d'établissement pour établir un temps de vol t_1, des munitions à explosion fusante sur la base d'une distance de point de détonation établie,
- des moyens d'activation et de commande pour

activer et commander un système de mesure laser comprenant un émetteur et récepteur laser pour envoyer des impulsions laser à un instant to + t_1, et recevoir une lumière laser réfléchie pour mesurer une distance jusqu'à un nuage de fumée résultant de l'éclatement de la munition à explosion fusante, **caractérisé en ce qu'**il comprend en outre

- un processeur pour traiter la lumière laser réfléchie et définir une plage de distances jusqu'au nuage de fumée,
- des moyens d'établissement et de traitement de plage pour établir une entrée de plage autour de la distance de point de détonation établie avant le traitement de la lumière laser réfléchie reçue dans l'entrée de plage pour limiter la plage de distances résultante et annuler des échos provenant du terrain avoisinant.

12. Système de commande de mise à feu selon la revendication 11, adapté en outre à effectuer le procédé selon les revendications 2 à 10.

13. Programme informatique comportant des instructions qui, lorsqu'elles sont exécutées dans un processeur d'un dispositif ou système informatique, effectuent le procédé selon les revendications 1 à 10.

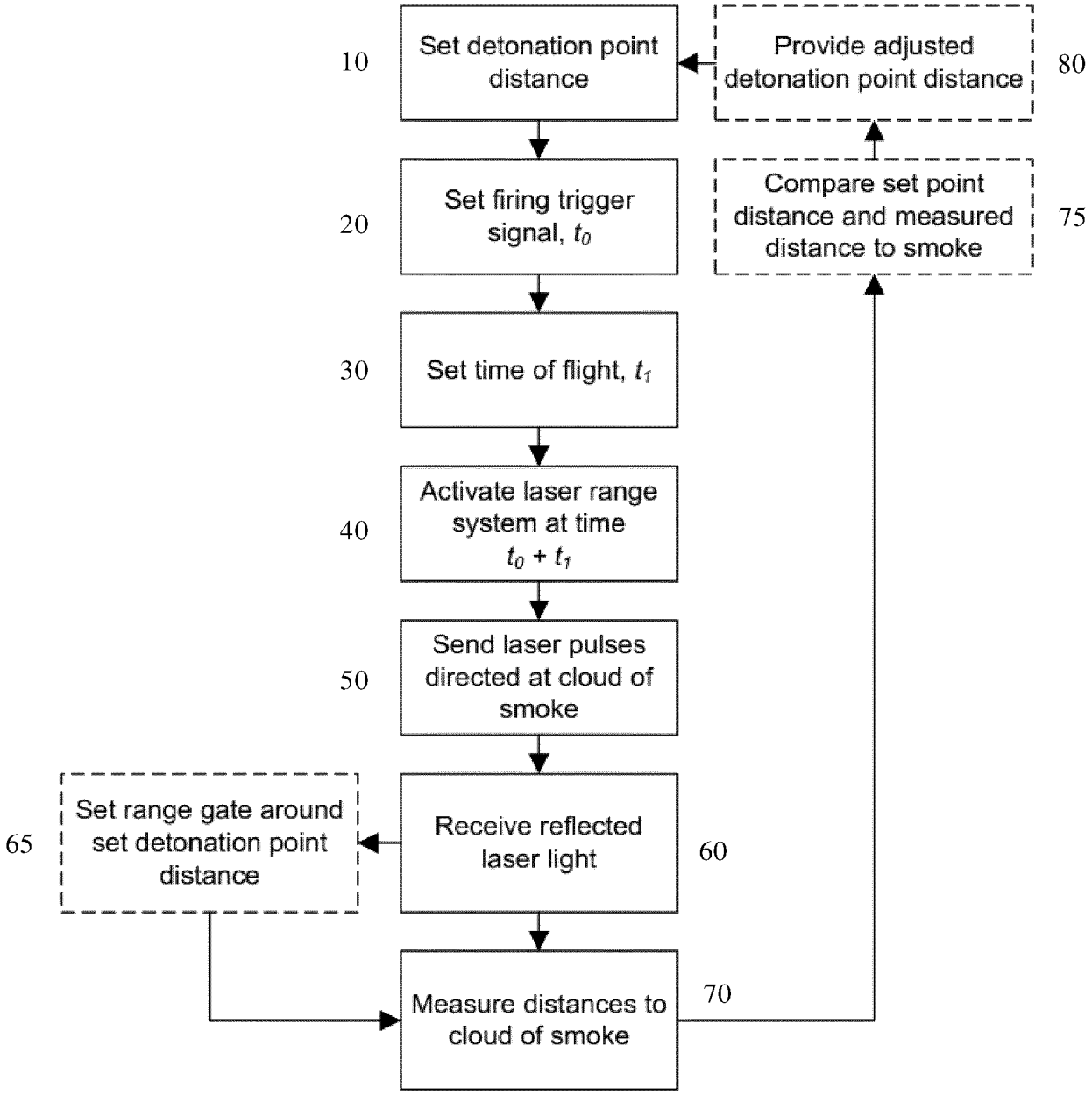
10
Set detonation point distance
Provide adjusted detonation point distance
80
20
Set firing trigger signal, t_0
Compare set point distance and measured distance to smoke
75
30
Set time of flight, t_1
40
Activate laser range system at time $t_0 + t_1$
50
Send laser pulses directed at cloud of smoke
65
Set range gate around set detonation point distance
Receive reflected laser light
60
Measure distances to cloud of smoke
70

FIG. 1

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2012325078 A1 **[0005]**
- US 9593914 B2 **[0007]**