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(72) Inventeurs/Inventors:
LI, WEI, CN;
PAN, LU, CN;
ZHANG, BO, CN;
LI, BEIBEI, CN;
LIU, XIUMEI, CN;
ZHU, JINSONG, CN;
LIN, DA, CN;
...

(73) Propriétaire/Owner:

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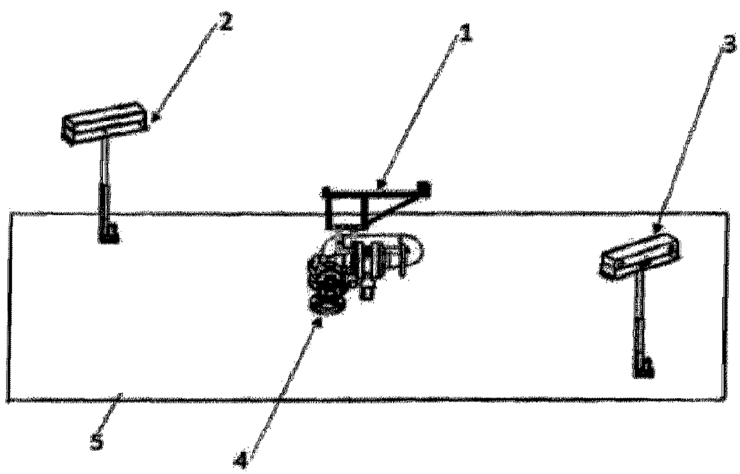

(57) Abrégé/Abstract:
The present invention discloses a multi-mode visual servo control fire-fighting system and a working method thereof. The system includes a fire monitor, an infrared near-field visual device, a binocular visual device and a control system. The infrared near-field

(72) **Inventeurs(suite)/Inventors(continued):** ZHANG, SHUAISHUAI, CN; GAO, HONGZHUANG, CN

(73) **Propriétaires(suite)/Owners(continued):** CHINA UNIVERSITY OF MINING AND TECHNOLOGY, CN

(74) **Agent:** CHEN, JUNYI

(57) **Abrégé(suite)/Abstract(continued):**
visual device includes an infrared camera, a near-field camera, a support frame, a support cross beam and a buckle. The binocular visual device includes an industrial camera, a sensor, a binocular camera box and a rotatable electric telescopic rod. The control system includes a processing unit, a controller and a control cabinet. According to the present invention, visual systems of multiple modes are integrated, the fire extinguishing requirements under multiple environments can be met, the efficiency of fire extinguishing operation is improved, and the intelligent fire extinguishing is achieved.

Abstract

The present invention discloses a multi-mode visual servo control fire-fighting system and a working method thereof. The system includes a fire monitor, an infrared near-field visual device, a binocular visual device and a control system. The infrared near-field visual device includes an infrared camera, a near-field camera, a support frame, a support cross beam and a buckle. The binocular visual device includes an industrial camera, a sensor, a binocular camera box and a rotatable electric telescopic rod. The control system includes a processing unit, a controller and a control cabinet. According to the present invention, visual systems of multiple modes are integrated, the fire extinguishing requirements under multiple environments can be met, the efficiency of fire extinguishing operation is improved, and the intelligent fire extinguishing is achieved.

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MULTI-MODE VISUAL SERVO CONTROL FIRE-FIGHTING SYSTEM AND WORKING METHOD THEREOF

Technical Field

The present invention relates to a multi-mode visual servo control fire-fighting system and a working method thereof, which belong to the field of fire-fighting.

Background

With the rapid development of economy in China, cities are densely built with high-rise buildings. At the same time, there are huge safety hazards in such as chemical plants, and large-scale fires are very likely to occur. Due to the complex fire environment, fires occurring in urban buildings, chemical plants or the like are quite dangerous and very likely to cause huge economic losses and casualties, and cannot be effectively extinguished manually. Therefore, nowadays higher and higher requirements are imposed on fire-fighting technologies.

As far as fire-fighting technologies are concerned, a fire monitor system plays a leading role and is the key to the process of fire-fighting. Conventional fire monitors come in two types: manually controlled type and automatically controlled type. Automatically controlled fire monitors mostly are remotely controlled, and partly are intelligent fire monitors. The remotely-controlled intelligent fire monitor requires a firefighter to determine the position of the fire site and manually control the rotation of the fire monitor to aim at the position of the fire site to extinguish the fire. The conventional intelligent fire-fighting system is mainly composed of fire sensing technologies such as infrared flame sensors, in which the fire sensor technology plays a key role. Such a fire-fighting system mainly employs infrared sensors to determine the fire position, and then controls the rotation of the fire monitor to aim at the fire position to extinguish the fire. However, infrared positioning alone is not accurate, with which only two-dimensional information of the fire site can be obtained,

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and information about the distance to the fire site cannot be obtained. In order to realize accurate positioning, a large number of infrared sensors are required.

With the rapid development of computer technology, technologies such as digital image processing have been widely used in fire monitors. Chinese Patent Application No. 201711364149.8 (published as CN107909615A) proposes a fire monitor positioning method based on binocular vision, which uses the features of the binocular camera to obtain the spatial position of the flame and control the fire monitor to extinguish the fire. This patent mainly focuses on determining the position of the fire site, but does not provide any description on how to control the rotation of the fire monitor after the position of the fire site is determined. In addition, if there is a very serious interference in the fire scene, such as heavy smoke, the accuracy of binocular vision will be seriously affected. In this case, how to determine the position of the fire site? Chinese Patent Application No. 201210277033.1 (published as CN102784451A) discloses an automatic positioning flame detection system in a three-dimensional space, which adopts at least two infrared fire detectors to perform three-dimensional flame positioning in space, but fails to provide a specific description on how the infrared CCD detectors achieve the positioning. Chinese Patent Application No. 201610089595.1 (published as CN105944270A) discloses a method for self-aiming at a fire source and spraying water to extinguish fire. In this method, a thermal imager is used to position the fire site at two different positions to obtain the position information of the fire site, and then extinguish the fire. However, this method requires moving between the two positions in order to realize the positioning, and is not applicable in cases where no movement is allowed, for example, the case where the fire monitor is installed on a fire truck or used as a fixed fire monitor. In addition, most of the conventional technologies first adopt the visual technology to identify the fire site and then control the fire monitor to rotate and spray the fire extinguishing agent. The disadvantages of such methods lie in that if fire-fighting is interfered by, for example, strong wind, fire site transfer, etc., the above methods cannot provide timely adjustment, and the identification and positioning process has to be performed again, which increases the fire-fighting time and affects the fire-fighting progress.

It can be seen that the conventional fire monitors based on the visual technology have the

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following shortcomings:

1. The visual system will stop operating after initially identifying the fire site and then controlling the fire monitor to rotate to a specified angle position. If there is a strong wind or the transfer of the fire site occurs during the fire extinguishing process, the jet cannot accurately reach the position of the fire site, and re-positioning is required.

2. Usually, the binocular technology or the infrared technology alone is used in the prior art. The accuracy of positioning using the binocular technology depends on the complexity of the external environment. The binocular technology can provide accurate positioning in the case of little interference, but has poor positioning accuracy in the case of the presence of a lot of trees or heavy smoke. The infrared technology is mainly used to measure the temperature. If there are multiple fires in the fire extinguishing scene, the fires cannot be accurately extinguished by only relying on the infrared technology. In addition, infrared cameras are often expensive and the use of multiple infrared cameras inevitably will greatly increase the costs. It should be noted that the recognition range of the infrared camera is also limited.

Summary

In view of the above problems, the present invention discloses a multi-mode visual servo control fire-fighting system and a working method thereof, where a variety of visual servo control methods are provided, and different modes can be applied to different fire scenes, thereby solving the problems of conventional intelligent fire monitors such as inaccurate positioning and susceptibility to interference by the fire scene.

To achieve the above technical objectives, the present invention adopts the following technical solutions.

A multi-mode visual servo control fire-fighting system includes

a fire monitor, configured to eject a fire extinguishing agent to a fire site;

a first binocular visual device, disposed on a side and in front of the fire monitor, and configured

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to acquire a fire site image, and acquire spatial positions of the fire monitor and the fire site, where a first angle sensor is installed on the first binocular visual device;

a second binocular visual device, disposed on the other side and in rear of the fire monitor, and configured to acquire a fire site image, and acquire spatial positions of the fire monitor and the fire site, where a second angle sensor is installed on the second binocular visual device;

a third angle sensor, installed on a head of the fire monitor;

an infrared near-field visual device, configured to acquire a fire site temperature image and an initial trajectory image of a jet from the fire monitor; and

a control system, being in a signal connection with the first binocular visual device, the second binocular visual device, the first angle sensor, the second angle sensor, the third angle sensor, the infrared near-field visual device and the fire monitor.

The first binocular visual device and the second binocular visual device have an identical structure and are respectively installed on two sides of the fire monitor to face toward opposite directions.

The first binocular visual device includes a first industrial camera, a second industrial camera, the first angle sensor and a first binocular camera box, where the first industrial camera, the first angle sensor and the second industrial camera are installed in parallel with each other inside the first binocular camera box, and a bottom of the first binocular camera box is connected to a first rotatable electric telescopic rod.

The second binocular visual device includes a third industrial camera, a fourth industrial camera, the second angle sensor and a second binocular camera box, where the third industrial camera, the second angle sensor and the fourth industrial camera are installed in parallel with each other inside the second binocular camera box, and a bottom of the second binocular camera box is connected to a second rotatable electric telescopic rod.

Horizontal rotation axes of the first rotatable electric telescopic rod, the second rotatable electric telescopic rod and the fire monitor are in a straight line.

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The control system includes a processing unit, a controller and a control cabinet.

The infrared near-field visual device includes:

a support frame, where a bottom of the support frame is fixedly installed on the head of the fire monitor by a buckle, an infrared camera is installed on an upper portion of the support frame, the infrared camera is located exactly above the head of the fire monitor, and an optical axis of the infrared camera and an axis of a branch pipe of the fire monitor are in a vertical plane; and

a support cross beam, connected in parallel on a side of the support frame, where a near-field camera is fixedly installed on an end of the support cross beam away from the support frame.

The present invention further discloses a working method based on the multi-mode visual servo control fire-fighting system, including

acquiring fire site images by the binocular visual devices to acquire spatial positions of the fire monitor and the fire site in combination with the angle sensors, then controlling the fire monitor to perform fire extinguishing, and identifying a trajectory of a jet by the binocular visual devices and determining whether the jet reaches the fire site, specifically:

acquiring a spatial position (x, y, z) of the fire site relative to the binocular visual device by the first binocular visual device or the second binocular visual device;

measuring an angle between a central axis of the first binocular visual device and a central axis of the head of the fire monitor by the third angle sensor located on the head of the fire monitor and the first angle sensor located in the first binocular camera box;

measuring an angle between a central axis of the second binocular visual device and the central axis of the head of the fire monitor by the third angle sensor located on the head of the fire monitor and the second angle sensor located in the second binocular camera box;

establishing a first coordinate system by using the first industrial camera located on a left side of the first binocular camera box in the first binocular visual device as an origin, and using an optical axis of the first industrial camera as a z axis, where in the first coordinate system, coordinates of the fire monitor are (x1, y1, z1), and coordinates of the fire site are (x, y, z); moving the first coordinate

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system to the position of the fire monitor to obtain a second coordinate system, where the second coordinate system uses the fire monitor as an origin, coordinates of the fire site in the second coordinate system are (x-x1, y, z-z1), and in the second coordinate system, an angle between a line connecting the fire site to the fire monitor and a z axis of the second coordinate system is β=arctan((x-x1)/(z-z1)); therefore, an angle γ by which the fire monitor needs to rotate horizontally is: γ=β-α;

where α is the angle between the central axis of the first binocular visual device and the central axis of the head of the fire monitor, which is measured by the third angle sensor located on the head of the fire monitor and the first angle sensor located in the first binocular camera box; or the angle between the central axis of the second binocular visual device and the central axis of the head of the fire monitor, which is measured by the third angle sensor located on the head of the fire monitor and the second angle sensor located in the second binocular camera box;

obtaining a distance d between the fire monitor and the fire site based on the following formula:

d=$\sqrt{(H-h)^2+(x-x1)^2+(z-z1)^2}$, where

H is a height of the fire monitor, and h is a degree of elongation of the rotatable electric telescopic rod;

obtaining a pitch angle of the fire monitor according to the distance d;

according to the spatial position of the fire site relative to the head of the fire monitor, issuing an instruction by the control system to control the fire monitor to yaw and pitch, so that the fire monitor aims at the fire site and ejects a jet of a fire extinguishing agent;

identifying a trajectory of the jet of the fire extinguishing agent by the binocular visual devices, and by the control system, calculating a spatial position of the trajectory of the jet of the fire extinguishing agent, and determining whether a drop point of the jet of the fire extinguishing agent reaches the fire site; if the drop point does not reach the fire site, issuing an instruction by the control system to control the fire monitor to yaw and pitch, until the drop point of the jet of the fire extinguishing agent reaches the fire site;

recognizing a temperature distribution in a field of view by the infrared camera in the infrared near-field visual device, and when a highest temperature is not significantly higher than an ambient temperature, issuing an instruction by the controller to control the fire monitor to yaw, until the highest temperature is significantly higher than the ambient temperature;

determining, by the control system, whether a point with the highest temperature appears in a middle region of the field of view of the infrared camera, and if the point with the highest temperature does not appear in the middle region of the field of view of the infrared camera, issuing an instruction by the control system to control the fire monitor to yaw, until the point with the highest temperature appears in the middle region of the field of view of the infrared camera;

capturing, by the near-field camera in the infrared near-field visual device, an initial image of the trajectory of the jet of the fire extinguishing agent from the fire monitor; and

by the control system, predicting a straight-line distance between the drop point of the jet of the fire extinguishing agent from the fire monitor and the head of the fire monitor, based on the initial image of the trajectory of the jet of the fire extinguishing agent from the fire monitor that is captured by the infrared near-field visual device, and issuing, according to the predicted straight-line distance between the drop point of the jet of the fire extinguishing agent and the head of the fire monitor, an instruction to control the fire monitor to pitch, until the predicted straight-line distance between the drop point of the jet of the fire extinguishing agent and the fire site is zero.

When starting to work, the first binocular visual device and the second binocular visual device respectively raise the first rotatable electric telescopic rod and the second rotatable electric telescopic rod at the same time, and capture images and rotate to aim at the fire site, so that the fire site is in a middle of the images; at this moment, if the fire monitor is not in an image of a binocular visual device of the first binocular visual device and the second binocular visual device, the binocular visual device lowers a respective one of the first rotatable electric telescopic rod and the second rotatable electric telescopic rod, and stops working.

Beneficial effects of the present invention:

A multi-mode visual servo control fire-fighting system provided by the present invention

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includes an infrared near-field visual system, binocular visual systems, a fire monitor and a control system. The binocular visual systems acquire a fire site image to acquire spatial positions of the fire monitor and the fire site in combination with the angle sensors, and then, the fire monitor is controlled to perform fire extinguishing, and at the same time, a trajectory of a jet is identified and it is determined whether the jet reaches the fire site. In this way, the fire extinguishing accuracy of the fire monitor is improved. Two binocular visual systems are provided, which can photograph the surrounding fire site at all angles, and can also be applied to fire scenes where the infrared visual system is not applicable, such as those where the position of the fire site is beyond the range of the infrared camera or the fire in one of a plurality of the fire sites needs to be extinguished. The infrared visual system acquires the fire site temperature image and the initial trajectory image of the jet in order to control the fire monitor to extinguish the fire, which can be applied to complex fire site environments as well as fire scenes where the binocular visual system is not applicable, such as those where there are a lot of trees or heavy smoke on the fire site. The infrared near-field visual system and the binocular visual system can work separately or synergistically so as to be applicable to various fire scenes. Compared with the system using a single vision mode, the system of the present invention can meet the fire extinguishing requirements in different scenes, which greatly increases the applicability of the fire monitor, solves the problem that a single visual system is only applicable to a limited number of application scenes, improves the efficiency of fire extinguishing operation, and significantly improves the robustness of the system. In addition, during the fire extinguishing process, the visual system is in an on state all the time, and therefore can monitor in real time the trajectory of the jet of the fire extinguishing agent, thereby realizing the closed loop control of the rotation angle of the fire monitor to ensure that the fire extinguishing agent accurately reaches the position of the fire site.

Brief Description of the Drawings

FIG. 1 shows an overall layout of the present invention.

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FIG. 2 is a structural front view of an infrared near-field visual device according to the present invention.

FIG. 3 is a structural top view of an infrared near-field visual device according to the present invention.

FIG. 4 is a schematic structural view of a binocular visual device according to the present invention.

FIG. 5 is a schematic layout view of angle sensors in the binocular visual device according to the present invention.

FIG. 6 is a schematic structural view of a control system according to the invention.

FIG. 7 is a control flowchart of a fire extinguishing process according to the present invention.

FIG. 8 is a view showing the principle of acquiring the position of the fire site by a processing unit.

In the figures,

1. infrared near-field visual device; 2. first binocular visual device; 3. second binocular visual device; 4. fire monitor; 5. infrared camera; 6. near-field camera; 7. support frame; 8. support cross beam; 9. buckle; 10. first industrial camera; 11. first angle sensor; 12. second industrial camera; 13. first binocular camera box; 14. first rotatable electric telescopic rod; 15. third angle sensor; 16. head of the fire monitor; 17. processing unit; 18. controller; 19. control cabinet.

Detailed Description of the Embodiments

The technical solutions of the present invention will be further described in detail below with reference to the accompanying drawings of the specification.

As shown in FIG. 1 to FIG. 5, the present invention provides a multi-mode visual servo control fire-fighting system and a control method thereof. The system includes an infrared near-field visual device 1, a first binocular visual device 2, a second binocular visual device 03, a fire monitor 4, and a control system.

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The infrared near-field visual device 1 includes an infrared camera 5, a near-field camera 6, a support frame 7, a support cross beam 8 and a buckle 9. The infrared camera 5 and the near-field camera 6 are installed above the fire monitor 4 through the support frame 7, the support cross beam 8 and the buckle 9.

The first binocular visual device 2 and the second binocular visual device 3 have the same configuration and each include two industrial cameras disposed in left-right symmetry, an angle sensor disposed between the two industrial cameras, a binocular camera box and a rotatable electric telescopic rod. The two industrial cameras and the angle sensor are installed in parallel with each other inside the binocular camera box. The first binocular visual device 2 is installed on a side and in front of the fire monitor 4 through the rotatable electric telescopic rod, and the second binocular visual device 3 is installed on the other side and in rear of the fire monitor 4 through the rotatable electric telescopic rod. The two binocular visual devices face toward opposite directions.

A third angle sensor 15 is installed on a head of the fire monitor.

The control system includes a processing unit 17, a controller 18 and a control cabinet 19.

Horizontal rotation axes of the respective rotatable electric telescopic rods of the binocular visual devices and the fire monitor 4 are in a straight line. When starting to work, the two binocular visual devices respectively raise the rotatable electric telescopic rods, capture images and rotate to aim at the fire site, so that the fire site is in the middle of the images. At this moment, if the fire monitor 4 is not in the image of a binocular visual device of the two binocular visual devices, the binocular visual device lowers a respective one of the rotatable electric telescopic rods, and stops working. The two binocular visual devices independently obtain spatial positions (x, y, z) of the fire site relative to the binocular visual devices, respectively.

The third angle sensor 15 located on the head 16 of the fire monitor and the angle sensor located in the binocular camera box measure an angle α between a central axis of the binocular visual device and a central axis of the head 16 of the fire monitor.

A height of the binocular visual device relative to the head 16 of the fire monitor is calculated

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according to a degree of elongation h of the rotatable electric telescopic rod 14. The height H of the fire monitor 4 is known. The processing unit 17 calculates a spatial position of the fire site relative to the head 16 of the fire monitor and a rotation angle of the fire monitor 4 according to the above information. The processing procedure is as follows. As shown in FIG. 8, a first coordinate system is established by using the first industrial camera 10 in the first binocular camera box 13 of the first binocular visual device as an origin and using an optical axis of the first industrial camera 10 as a z axis, and in the first coordinate system, coordinates of the fire monitor are (x1, y1, z1), and coordinates of the fire site are (x, y, z). The first coordinate system is moved to the position of the fire monitor to obtain a second coordinate system that uses the fire monitor as an origin, and coordinates of the fire site in the second coordinate system are (x-x1, y-y1, z-z1). In the second coordinate system, an angle between a line connecting the fire site to the fire monitor and a z axis of the second coordinate system in the xoz plane of the second coordinate system is $\beta=\arctan((x-x1)/(z-z1))$, and therefore, an angle γ by which the fire monitor needs to rotate horizontally is: $\gamma=\beta-\alpha$.

A distance d between the fire monitor 4 and the fire site is: $d=\sqrt{(H-h)^2+(x-x1)^2+(z-z1)^2}$. A pitch angle of the fire monitor 4 can be obtained according to the distance d. According to the spatial position of the fire site relative to the head 16 of the fire monitor and the pitch angle, the controller 18 issues an instruction to control the fire monitor to yaw and pitch, so that the fire monitor 4 aims at the fire site and ejects a jet of a fire extinguishing agent. The binocular visual device 2 or 3 identifies a trajectory of the jet of the fire extinguishing agent, and the processing unit 17 calculates a spatial position of the trajectory of the jet of the fire extinguishing agent, and determines whether a drop point of the jet of the fire extinguishing agent reaches the fire site. If the drop point does not reach the fire site, the controller 18 issues an instruction to control the fire monitor to yaw and pitch, until the drop point of the jet of the fire extinguishing agent reaches the fire site.

When two binocular visual devices are provided, comprising a first binocular visual device and a second binocular visual device.

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The first binocular visual device is configured to acquire an image of the fire site and acquire the spatial positions of the fire monitor and the fire site, where a first angle sensor is installed on the first binocular visual device.

The second binocular visual device is configured to acquire an image of the fire site and acquire the spatial positions of the fire monitor and the fire site, where a second angle sensor is installed on the second binocular visual device.

The first binocular visual device or the second binocular visual device obtains a spatial position (x, y, z) of the fire site relative to the binocular visual device.

The third angle sensor located on the head of the fire monitor and the first angle sensor located in the first binocular camera box measure an angle α_1 between a central axis of the first binocular visual device and the central axis of the head of the fire monitor, and an angle γ by which the fire monitor needs to rotate horizontally is: $\gamma=\beta-\alpha_1$.

The third angle sensor located on the head of the fire monitor and the second angle sensor located in the second binocular camera box measure an angle α_2 between a central axis of the second binocular visual device and the central axis of the head of the fire monitor, and an angle γ by which the fire monitor needs to rotate horizontally is: $\gamma=\beta-\alpha_2$.

The infrared camera 5 in the infrared near-field visual device 1 recognizes a temperature distribution in a field of view. When the highest temperature is not significantly higher than the ambient temperature, the controller 18 issues an instruction to control the fire monitor to yaw, until the highest temperature is significantly higher than the ambient temperature. The processing unit 17 determines whether a point with the highest temperature appears in a middle region of the field of view of the infrared camera 5, and if the point with the highest temperature does not appear in the middle region of the field of view of the infrared camera 5, the controller 18 issues an instruction to control the fire monitor to yaw, until the point with the highest temperature appears in the middle

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region of the field of view of the infrared camera 5. The near-field camera 6 in the infrared near-field visual device 1 captures an initial image of the trajectory of the jet of the fire extinguishing agent from the fire monitor 4. The processing unit 17 predicts a straight-line distance between the drop point of the jet of the fire extinguishing agent from the fire monitor 4 and the head 16 of the fire monitor based on the initial image. The controller 18 issues, according to the predicted straight-line distance between the drop point of the jet of the fire extinguishing agent and the head 16 of the fire monitor, an instruction to control the fire monitor to pitch, until the predicted straight-line distance between the drop point of the jet of the fire extinguishing agent and the fire site is zero.

While exemplary embodiments of the present invention have been described above, the present invention is not limited thereto. It should be appreciated that some improvements can be made by those skilled in the art without departing from the principles of the present invention, which are also contemplated to be within the scope of the present invention.

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Claims

What is claimed is:

1. A method for operating a multi-mode visual servo control fire-fighting system, wherein the system comprises:

a fire monitor configured to eject a jet of fire extinguishing agent to a fire site, the fire monitor comprising a first side, a second site opposite the first side and a head;

a first binocular visual device disposed on the first side and in front of the fire monitor and configured to acquire a first fire site image and a first spatial position of the fire monitor and the fire site, wherein a first angle sensor is installed on the first binocular visual device and the first binocular visual device comprises a first binocular camera box;

a second binocular visual device disposed on the second side and in rear of the fire monitor and configured to acquire a second fire site image and a second spatial position of the fire monitor and the fire site, wherein a second angle sensor is installed on the second binocular visual device and the second binocular visual device comprises a second binocular camera box;

a third angle sensor installed on the head of the fire monitor;

an infrared near-field visual device configured to acquire a fire site temperature image and an initial trajectory image of the jet from the fire monitor, the infrared near-field visual device comprising an infrared camera and a near-field camera; and

a control system in a signal connection with the first binocular visual device, the second binocular visual device, the first angle sensor, the second angle sensor, the third angle sensor, the infrared near-field visual device and the fire monitor, the control system comprising a controller;

the method comprising:

acquiring the first fire site image by the first binocular visual device or the second fire site image by the second binocular visual device;

acquiring the first spatial position of the fire site relative to the first binocular visual device by the first binocular visual device or the second spatial position of the fire site

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relative to the second binocular visual device by the second binocular visual device;

measuring an angle α between a central axis of the first binocular visual device and a central axis of the head of the fire monitor by the third angle sensor and the first angle sensor located in the first binocular camera box of the first binocular visual device or between a central axis of the second binocular visual device and the central axis of the head of the fire monitor by the third angle sensor and the second angle sensor located in the second binocular camera box of the second binocular visual device;

establishing a first coordinate system by using a first industrial camera in the first binocular camera box as an origin, and using an optical axis of the first industrial camera as a z axis, wherein in the first coordinate system, a coordinate of the fire monitor is (x1, y1, z1), and a coordinate of the fire site is (x, y, z); moving the first coordinate system to a position of the fire monitor to obtain a second coordinate system, wherein the second coordinate system uses the fire monitor as an origin, the coordinate of the fire site in the second coordinate system is (x-x1, y-y1, z-z1), and in the second coordinate system, an angle between a line connecting the fire site to the fire monitor and a z axis of the second coordinate system on an xoz plane of the second coordinate system is $\beta=\arctan((x-x1)/(z-z1))$; therefore, an angle γ by which the fire monitor is rotated horizontally is: $\gamma=\beta-\alpha$;

obtaining a distance d between the fire monitor and the fire site based on the following formula:

$$d=\sqrt{(H-h)^2+(x-x1)^2+(z-z1)^2}$$

wherein H is a height of the fire monitor, and h is a degree of elongation of a first rotatable electric telescopic rod connected to a bottom of the first binocular camera box;

obtaining a pitch angle of the fire monitor according to the distance d;

according to the coordinate of the fire site in the second coordinate system, issuing an instruction by the control system to control the fire monitor to yaw and pitch, so that the fire monitor aims at the fire site and ejects the jet of the fire extinguishing agent; and

identifying a trajectory of the jet of the fire extinguishing agent by the first binocular

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visual device or the second binocular visual device, and by the control system, calculating a spatial position of the trajectory, and determining whether a drop point of the jet reaches the fire site; and if the drop point does not reach the fire site, issuing an instruction by the control system to control the fire monitor to yaw and pitch, until the drop point of the jet reaches the fire site,

wherein said identifying the trajectory and said controlling the fire monitor to yaw and pitch comprise

recognizing a temperature distribution in a field of view by the infrared camera in the infrared near-field visual device, wherein when a highest temperature is not higher than an ambient temperature, the control system instructs the controller to control the fire monitor to yaw, until the highest temperature is higher than the ambient temperature;

determining, by the control system, whether a point with the highest temperature appears in a middle region of the field of view of the infrared camera, wherein if the point with the highest temperature does not appear in the middle region, control system instructs the controller to control the fire monitor to yaw, until the point with the highest temperature appears in the middle region;

capturing, by the near-field camera of the infrared near-field visual device, the initial trajectory image; and

by the control system, predicting a linear distance between the drop point of the jet and the head of the fire monitor based on the initial trajectory image, and instructing, according to the predicted linear distance, the fire monitor to pitch, until the predicted linear distance is zero.

2. The method of claim 1, wherein in an operating status, the first binocular visual device raises the first rotatable electric telescopic rod and the second binocular visual device raises a second rotatable electric telescopic rod connected to a bottom of the second binocular visual device at the same time, and the first binocular visual device and the second binocular visual device capture

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images and rotate to aim at the fire site, so that the fire site is in a middle of the images.

3. The multi-mode visual servo control fire-fighting system carrying out the method of claim 1 or claim 2, wherein:

the first binocular visual device further comprises a second industrial camera, wherein the first industrial camera, the first angle sensor and the second industrial camera are installed in parallel with each other inside the first binocular camera box; and

a horizontal rotation axis of the fire monitor, the first rotatable electric telescopic rod and the second rotatable electric telescopic rod are on a linear line.

4. The multi-mode visual servo control fire-fighting system of claim 3, wherein the control system further comprises a processing unit and a control cabinet.

5. The multi-mode visual servo control fire-fighting system of claim 3, wherein the infrared near-field visual device further comprises:

a support frame, wherein a bottom of the support frame is fixedly installed on the head of the fire monitor by a buckle, the infrared camera is installed on an upper portion of the support frame and located above the head of the fire monitor, and an optical axis of the infrared camera and an axis of a branch pipe of the fire monitor are on a vertical plane; and

a support cross beam connected in parallel with a side of the support frame, wherein the near-field camera is fixedly installed on an end of the support cross beam away from the support frame.

6. The multi-mode visual servo control fire-fighting system of claim 3, wherein the first binocular visual device and the second binocular visual device have identical structures and are respectively installed on the first and the second sides of the fire monitor to face toward opposite directions.

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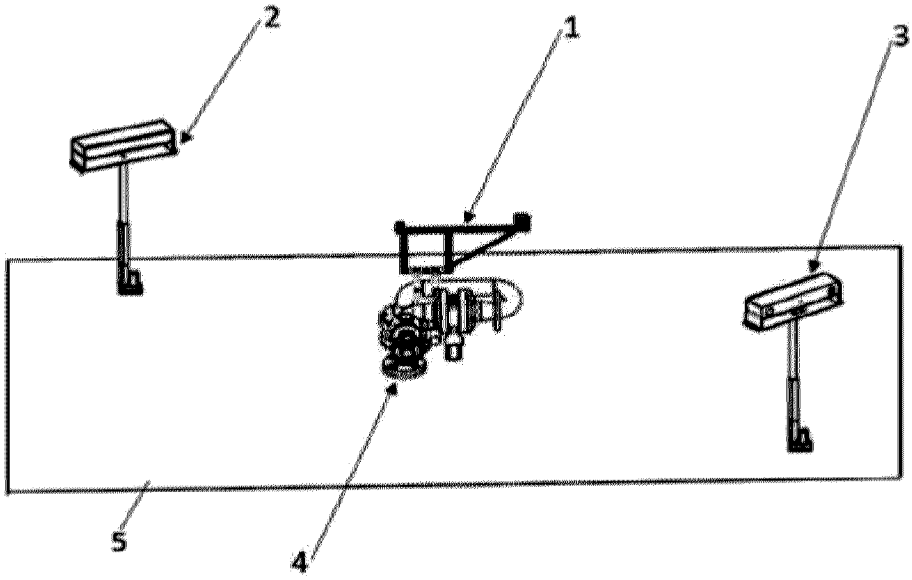


FIG. 1

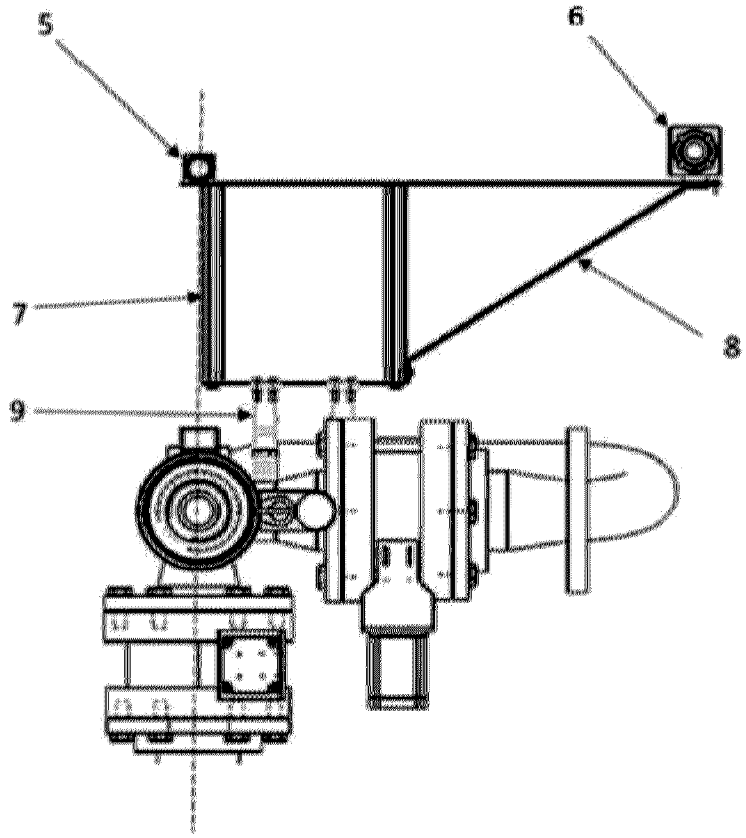


FIG. 2

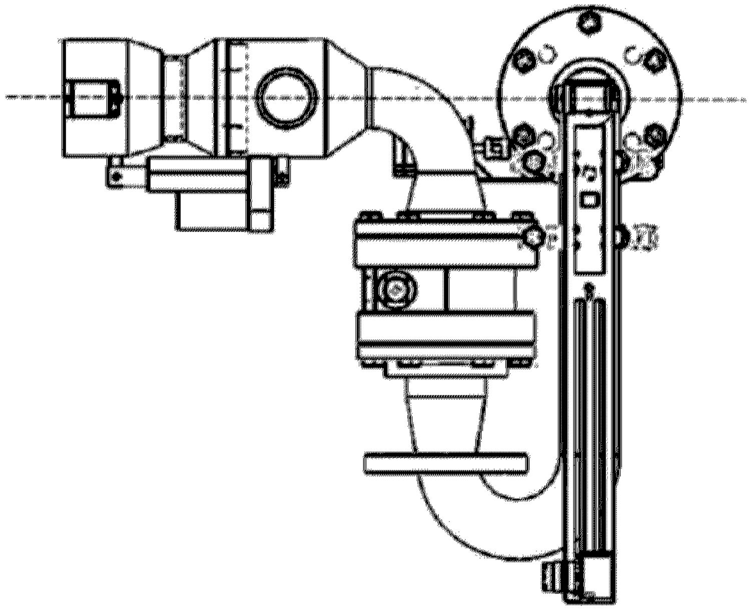


FIG. 3

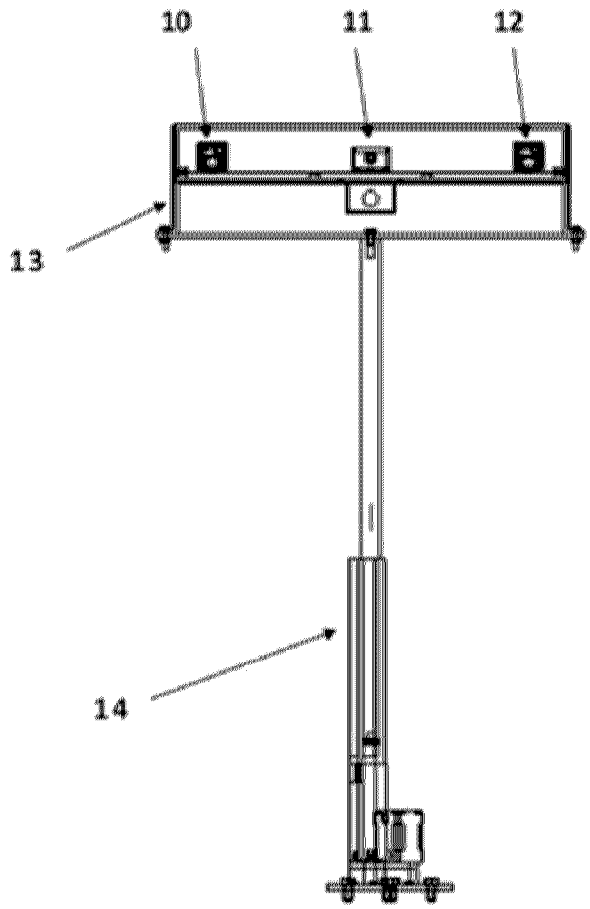


FIG. 4

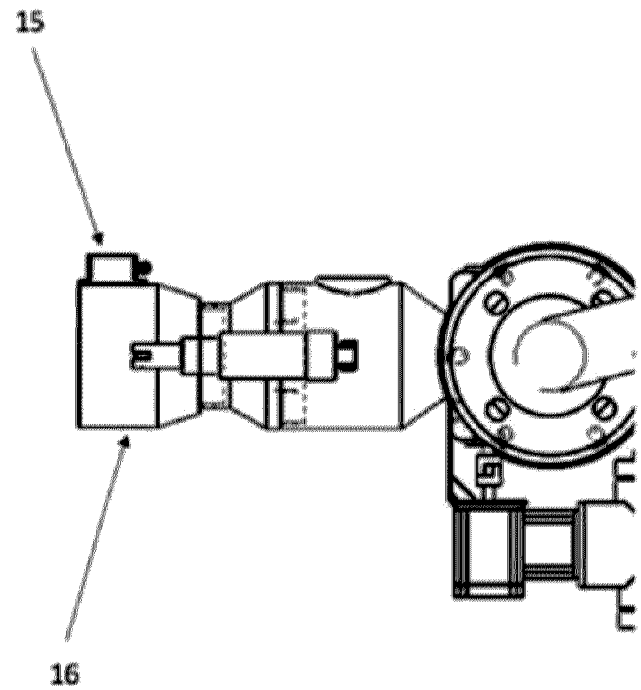


FIG. 5

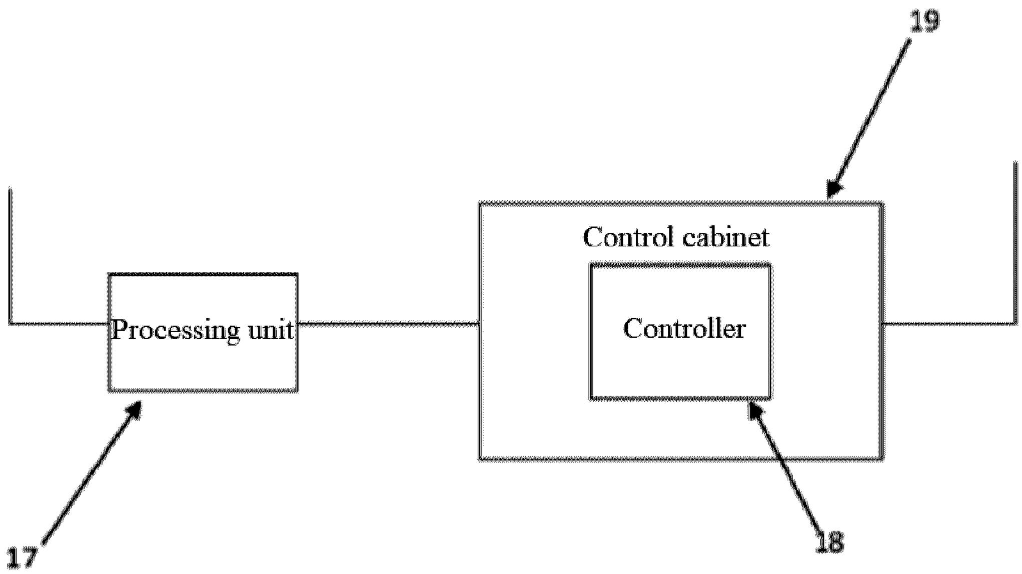


FIG. 6

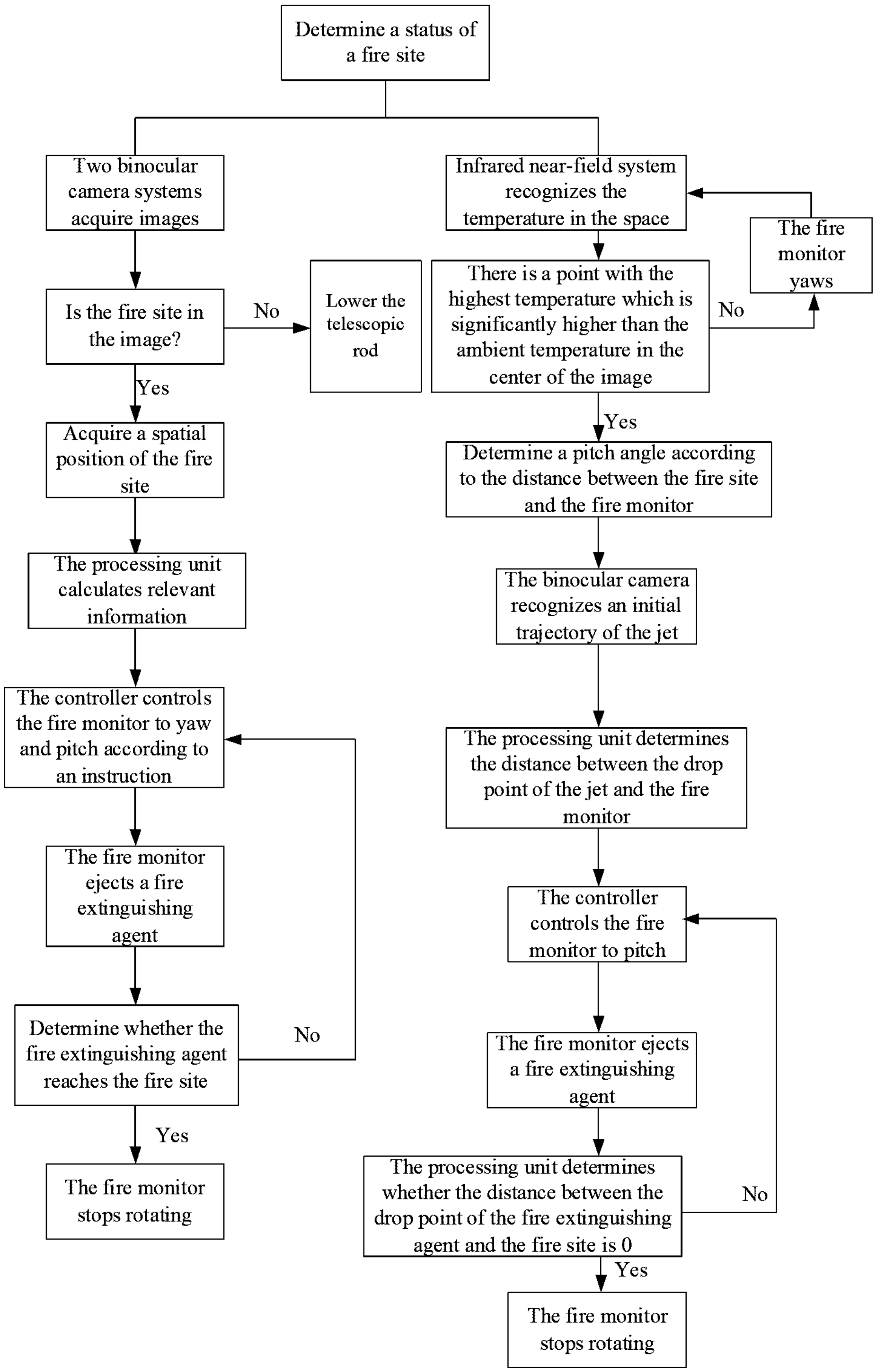

Determine a status of a fire site
Two binocular camera systems acquire images
Is the fire site in the image?
No
Lower the telescopic rod
Yes
Acquire a spatial position of the fire site
The processing unit calculates relevant information
The controller controls the fire monitor to yaw and pitch according to an instruction
The fire monitor ejects a fire extinguishing agent
Determine whether the fire extinguishing agent reaches the fire site
No
Yes
The fire monitor stops rotating
Infrared near-field system recognizes the temperature in the space
The fire monitor yaws
There is a point with the highest temperature which is significantly higher than the ambient temperature in the center of the image
No
Yes
Determine a pitch angle according to the distance between the fire site and the fire monitor
The binocular camera recognizes an initial trajectory of the jet
The processing unit determines the distance between the drop point of the jet and the fire monitor
The controller controls the fire monitor to pitch
The fire monitor ejects a fire extinguishing agent
The processing unit determines whether the distance between the drop point of the fire extinguishing agent and the fire site is 0
No
Yes
The fire monitor stops rotating

FIG. 7

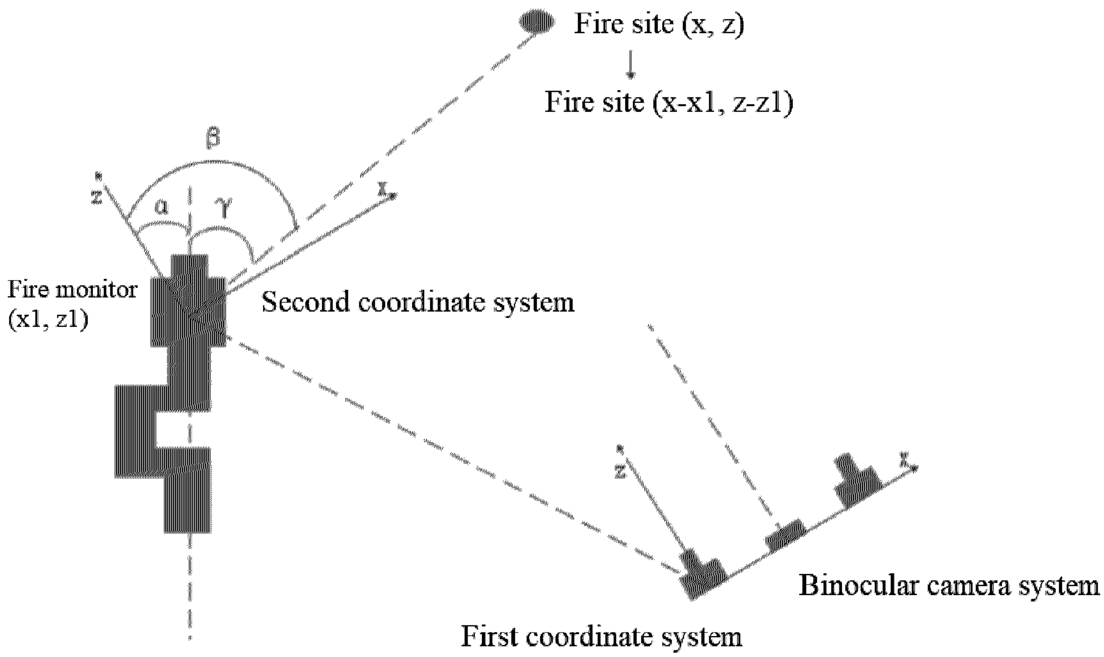
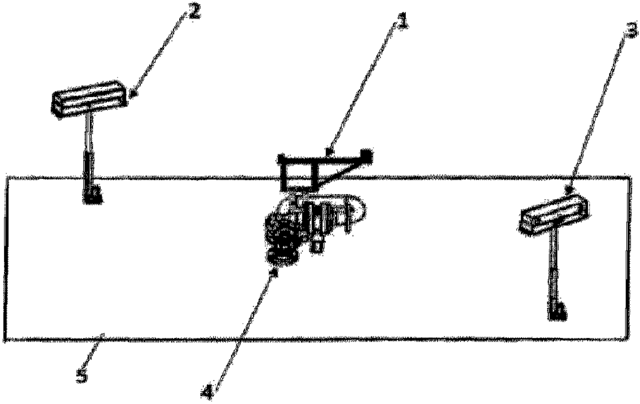

Fire site (x, z)
Fire site (x-x1, z-z1)
β
z
α
γ
x
Fire monitor
(x1, z1)
Second coordinate system
z
x
Binocular camera system
First coordinate system

FIG. 8


2
1
3
5
4