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CERTIFICATE

Federal Institute of Industrial Property hereby certifies that the enclosed materials are an exact reproduction of the specification, claims, abstract and drawings (if any) of the first (priority) patent application for an invention № 2015121582, filed on June 5, 2015 (05.06.2015).

On the subsequent filing of the application in the patent offices of participating states of the Paris Convention for the Protection of Industrial Property your first (priority) application number should be submitted with the two-letter code of the priority country in accordance with WIPO Standard ST.3 (for the Russian Federation - **RU**), disposable with no space before application number: **RU2015121582**.

Title of the invention: The system for the coordination of terrestrial mobile automated devices

Applicant: Limited Liability Company "TRANSIST VIDEO"

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The Head of the International Patent Cooperation Division

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Coordination System for Ground Movable Automated Devices

Art

The system relates to the control systems of automated devices and may be used for the coordination of the ground movable automated devices (automated transport, automated agricultural machines, municipal and aerodrome vehicles, garden lawnmowers and so on), hereinafter referred to as the robots.

Background

One of the major challenges of video navigation, coordination and control of robots is the absence of cheap and reliable system of navigation and situational action coordination. For instance, in order that the robot-lawnmower does not leave the mowing area it must be marked by the wire (see the Internet publication dated June 15, 2012 <http://www.therobotreport.com/news/robot-lawnmowers-still-a-work-in-progress>).

Recently the systems of IR fences or markings are offered. Also it is possible to use the ground radio beacons. But this approach complicates the system substantially.

Using of GPS and even more precise DGPS systems implies a number of shortcomings:

1) GPS signal near houses may be shielded, re-reflected or just damped by interferences or purposely resulting in the robot loss of coordination;

2) it is required to measure the coordinates of the operation area limits (for instance, the operation area for the robot-lawnmower) and to point them out to the robot that is a labour-intensive process;

3) these systems give coordinates but not the robot orientation;

4) the robots orientate by abstract coordinates not by the real world (so if there is a stationary or moving obstacle (a dog or a child) then the system will not detect it/him);

5) these systems may not detect where on the area there is grass not mowed;

6) only with DGPS or GPS it is hard to organize the intercoordination of the robots that are not aware of the interposition and must have the complex system of mutual detection and signal exchange;

7) the satellite systems have high working cost.

Many of these problems may be solved by a video navigator set on the robot. But such solution has a limited visibility area that may be expanded only by using a large number of cameras with a wide visibility area that considerably complicates the system. Besides a number of well detectable ground markings must be used. Natural landmarks do not always have these properties so the mowing area must be marked by ground markings. The intercoordination of the robots keeps to be a sophisticated way including using of a complex system of the artificial vision and decentralized object detection system. The decentralized control system of joint activity is multiply more complex and more expensive than one centralized system.

The prior art discloses the useful model patent No 131276 “Apparatus for Coordinating Automated Devices” published on 20.08.2013, the patent application No 2012147923 “A Method for Navigation and Joint Coordination of Automated Devices” published on 20.02.2014. Unlike the systems used GPS the tracing devices (one or more cameras) are located over the controlled area before the robot operation and the place and the height depend on the visibility conditions of the controlled area. That is compared to the GPS systems located whatever the robot coordination purposes the tracing devices are located exactly for convenient coordination of the robots solving the GPS problems, for instance, shielding and re-reflection of the signal. It is to be noted that the GPS satellites are not the environment or the robot tracing devices which coordinates must be detected. Vice versa the robots themselves are the GPS satellite tracing systems and the robot coordinates may be detected by GPS only on the robot itself and provided that there are three or more GPS system satellites in its available space environment. In the mentioned documents the efficiency of detecting the coordinates (space or angular) and the intercoordination of the robots is reached due to the devices for coordinating the robots including aerial apparatus or those located on the tower tracing the robots on the controlled area and supervising their environment including natural and artificial markings where the module for detecting the aerial apparatus coordinates designed with the possibility of the information exchange with

another module located on the same devices with the possibility to detect the coordinates of the controlled robot. And the mentioned module is designed with the possibility to receive and transfer the control commands and signals to the controlled robot. The aerial device located above or the device located on the tower may be:

1. UAV,
2. tower-antenna,
3. high-altitude tethered platform of continuous supervision (tethered aerostatic airships or constant-level balloons),
4. tethered aerodynamic rotor-driven due to the electric energy supplied to the rotors (similar to tethered helicopter platforms of Hovermast-100 by Skysapience),
5. Tethered rotor-driven aerial apparatuses with aerodynamic unloading due to the energy of the high altitude wind (autorotation) always existing at high altitude (approx. 4 m/s at 100 m, Fig. 1), for instance, tethered autogyros and gyroplanes (similar to tethered autogyros Fa330 used by the Germans during the World War II).

However each of these methods has drawbacks:

- 1) UAV are expensive and complicated for controlling and calculation, have limited continuous observation time,
- 2) the towers are hard to install and locate or re-install,
- 3) the tethered aerostatic airships or constant-level balloons require a compound pumping mechanism and are inconvenient for stabilisation,
- 4) tethered aerodynamic rotor-driven vehicles required much energy,

the tethered autogyros and gyroplanes do not fly if no wind.

Engineering Challenge

The engineering challenge to be solved by this invention is the development of the robot efficient coordination using the devices located on the towers or the aerial apparatuses

tracing the robots on the controlled area and supervising their environment including natural and artificial markings. The technical result coincides with the engineering challenge.

Summary of Invention

To support the challenge it is supposed the system of navigation and intercoordination of one or more robots located on the controlled area including one or more robot tracing devices on the suspended platforms, natural or artificial markings, central module for robot coordination and orientation detection to which the information is transferred from all the tracing devices characterized in that at least one suspended platform is a rotor device able to operate in the following modes: a) autogyro due to the relative airflow, b) wind-driven motor receiving the energy from the ram wind, c) helicopter receiving the energy from the ground charger and the system is equipped with the central calculation module located on the suspended platform, on the ground, on the charger or on the robot designed with the possibility to detect the coordinates, to orient the system and to form the control commands based on the information received from all the above described devices.

And the rotor-driven aerial apparatus may be connected to the charger or the robot with the possibility to receive/ transfer the energy. The system may be additionally equipped with one or more upper hemisphere tracing devices located on the surface of the controlled area or on the robots designed with the possibility to receive/ transfer the information with the central calculation module and one or more device for sunlight-to-electricity conversion located on the rotor aerial apparatus and/ or robot and/ or on the surface of the controlled area. The sunlight-to-electricity conversion device may be designed with the possibility to transfer the energy to one or more chargers for battery charging of at least one robot and/ or at least one rotor-driven aerial apparatus in the helicopter mode. One or more rotor-driven aerial apparatus may be designed with the possibility to transfer the energy output in the wind-driven motor mode to the energy storage device located on the rotor-driven aerial apparatus and/ or one or more charger to be used in the helicopter mode.

The rotor device may be used as the drone-guard for a house or an area

Brief Description of Drawings

The Fig. 1 shows the wind force-height dependency diagram for different types of area: urban, village and settlement.

The Fig. 2 shows the variants of the project realization. And the following designations are used: tethered unmanned aerial apparatus (tethered UAV) 1, charging and control unit 2, with the camera (cameras) 3, markings on the ground 4 and on the robot 5, natural markings - bush 6.

Embodiment of Invention

During the embodiment of the invention the centralized robot control system is created and the accuracy of their coordinate (space or angular) detection is increased.

Using of tethered platforms with the supervision units that may operate in three different modes: autogyro, wind-driven motor and helicopter provides the efficient robot coordination using the devices located on the towers or the aerial apparatuses tracing the robots on the controlled area and supervising their environment including natural and artificial markings.

The joint use of different modes enables to add each and to compensate the drawbacks of each separate.

The solution is explained on the fig 2 where three possible variants (a, b and c) of the supposed system realization are shown. The fixed cameras covering the whole lower hemisphere are on the suspended platform. It is cheaper than the one controlled camera and the wire communication channel (optic fibre or twisted pair) is reliable and intensive. Several cameras may be located on the tethered platform and on its gimball - at the required small height. The tethered platforms are fixed to the ground by the rope (fig. 2a) or to the energy accumulation and output unit by the cable (fig. 2b) or directly to one of the robots on the controlled area (fig. 2c).

Also the energy may be output due to the solar batteries mounted on the tethered platform, ground or the robots.

The supposed solution may use the relative (differential) robot video positioning both regarding the area and aerial apparatus (tower). The robot coordination from the aerial

apparatus (tower) may not always require the coordinates of the UAV supervision itself. Precise relative robot positioning regarding 3 and more special markings, fixed ground objects and other ground robots is possible.

Precise UAV coordinates do not ensure precise ground robot coordinates. However these UAV coordinates (position and orientation) may be needed for correcting the project distortions of the received images.

Passive video supervision in broad and artificial daylight is possible. The all-weather capability is provided by the IR and radio locating vision, passive reflectors and active IR markings, IR LEDs and so on.

Using of several supervision cameras over the controlled area (different combination of on fixed and high-altitude tethered platforms) improves the reliability, stereoscope positioning accuracy, eliminates the dead areas (for instance, behind and under the trees).

The markings easy to be seen from above may be installed on the robot and on its charger.

The central module where all the information from all the tracing devices is transferred detects the coordinates and the orientation of the one or more controlled robots (relative (differential) robot video positioning both regarding the area and the tracing devices (cameras) and if necessary detects the coordinates and the orientation of the tracing devices. And the mentioned module is designed with the possibility to transfer the control commands and signals (including RF) to the robots, tracing devices, chargers and the exchange of control and information signal between them is possible.

If there are several robots, then their centralized coordination is simple - the cameras shows them all simultaneously and the unified computer system coordinates their joint movement. The boundaries of the operation area (for instance, mowing for the robot lawnmower) may be set by setting the boundaries on the screen of the computer system by the area image (for instance, using the mouse arrows or drawing by the sensor pen or the finger on the screen).

The developed system functions as follows: firstly one or more robots are located on the controlled area (for instance, a lawn). Before the robot operation the tracing devices (one

or more cameras) are located on the aerial apparatus or the towers over the controlled area and the places and the height of the gimball depend on the visibility conditions of the controlled area.

It is also possible that starting the operation the tracing device is located on the ground or on one or more robots and the while operating it may fly up, fly or land on the robot tracing towers on the controlled area.

The tethered platform tracing devices may be located on the ground and on the robots enabling to detect the interposition and orientation of the tracing devices and the robots and to detect the robot rotation angle more accurately and to find the robot position in the camera dead areas (under the shelters or under the trees) by orientation by the shelter ceilings or the tree leaves above the robot.

Besides instead of the visible signal other spectre sections may be used. And the signal may be not only natural but generated by the robot or the device on the camera or in other space point. Sound, ultrasound signals, radio detection, sensors and markings, for instance, odour or chemosignals or radioactivity a little bit above the background level (for instance, silicon slices) may be used.

The supervision system is capable to detect the obstacles or the moving objects, determines the level and the quality of grass mowing. It is easy to realize and has low cost price.

This system may be used for a wide class of robots: automated lawnmowers, robots for cleaning the rooms, tractors, snow-removal, garbage disposal and flushing vehicles, vehicles for people and goods transportation, agricultural and municipal vehicles, transport and so on. This system may be used for extra-terrestrial robots on other planets, for instance, for Mars rovers.

The system easily stays within the frames of the “smart home” or even “smart city” enabling to coordinate simultaneously a lot of actions, robots and other control objects and to solve many tasks - for instance, not only navigation but detection.

The invention is disclosed above with reference to the concrete variant of its implementation. The experts may know other variants of the invention embodiment not

altering its essence as it is disclosed herein. Thus the invention description is deemed to be limited by volume only by the invention formula below.

Formula of Invention

1. The system of navigation and intercoordination of one or more roots located on the controlled area including one or more robot tracing devices on the suspended platforms, natural or artificial markings, central module for robot coordination and orientation detection to which the information is transferred from all the tracing devices characterized in that at least one suspended platform is a rotor device able to operate in the following modes: a) autogyro due to the relative airflow, b) wind-driven motor receiving the energy from the ram wind, c) helicopter receiving the energy from the ground charger and the system is equipped with the central calculation module located on the suspended platform, on the ground, on the charger or on the robot designed with the possibility to detect the coordinates, to orient the system and to form the control commands based on the information received from all the above described devices.
2. The system by the cl. 1 characterized in that the rotor-driven aerial apparatus is connected to the charger or the robot with the possibility to receive/ transfer the energy.
3. The system by the cl. 1 characterized in that it is additionally equipped with one or more upper hemisphere tracing devices located on the surface of the controlled area or on the robots designed with the possibility to receive/ transfer the information with the central calculation module.
4. The system by the cl. 1 characterized in that it is additionally equipped with one or more device for sunlight-to-electricity conversion located on the rotor aerial apparatus and/ or robot and/ or on the surface of the controlled area.
5. The system by the cl. 4 characterized in that the sunlight-to-electricity conversion device may be designed with the possibility to transfer the energy to one or more chargers for battery charging of one robot and/ or one rotor-driven aerial apparatus in the helicopter mode.
6. The system by the cl. 1 characterized in that one or more rotor-driven aerial apparatus may be designed with the possibility to transfer the energy output in the wind-driven motor mode to the energy storage device located on the rotor-driven aerial apparatus and/ or one or mode charger to be used in the helicopter mode.

7. The navigation method by the cl. 1 characterized in that the rotor device may be used as the drone-guard for a house or an area.

Abstract

The system relates to the control systems of automated devices and may be used for the coordination of the ground movable automated devices (automated transport, automated agricultural machines, municipal and aerodrome vehicles, garden lawnmowers and so on), hereinafter referred to as the robots.

The invention essence is the system of navigation and intercoordination of one or more robots located on the controlled area including one or more robot tracing devices on the suspended platforms, natural or artificial markings, central module for robot coordination and orientation detection to which the information is transferred from all the tracing devices characterized in that at least one suspended platform is a rotor device able to operate in the following modes: a) autogyro due to the relative airflow, b) wind-driven motor receiving the energy from the ram wind, c) helicopter receiving the energy from the ground charger and the system is equipped with the central calculation module located on the suspended platform, on the ground, on the charger or on the robot designed with the possibility to detect the coordinates, to orient the system and to form the control commands based on the information received from all the above described devices.

The technical result is the development of the robot efficient coordination using the devices located on the towers or the aerial apparatuses tracing the robots on the controlled area and supervising their environment including natural and artificial markings. The technical result coincides with the engineering challenge

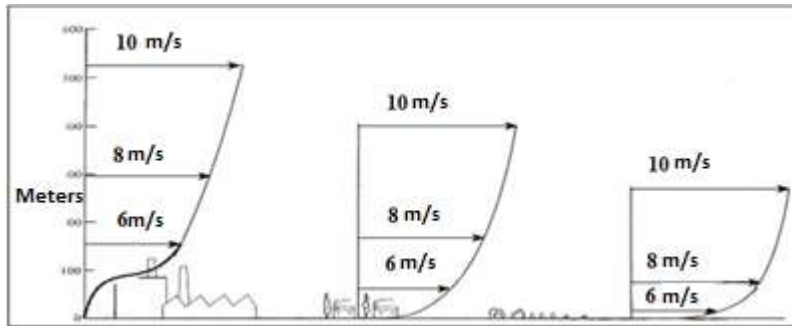


Fig. 1

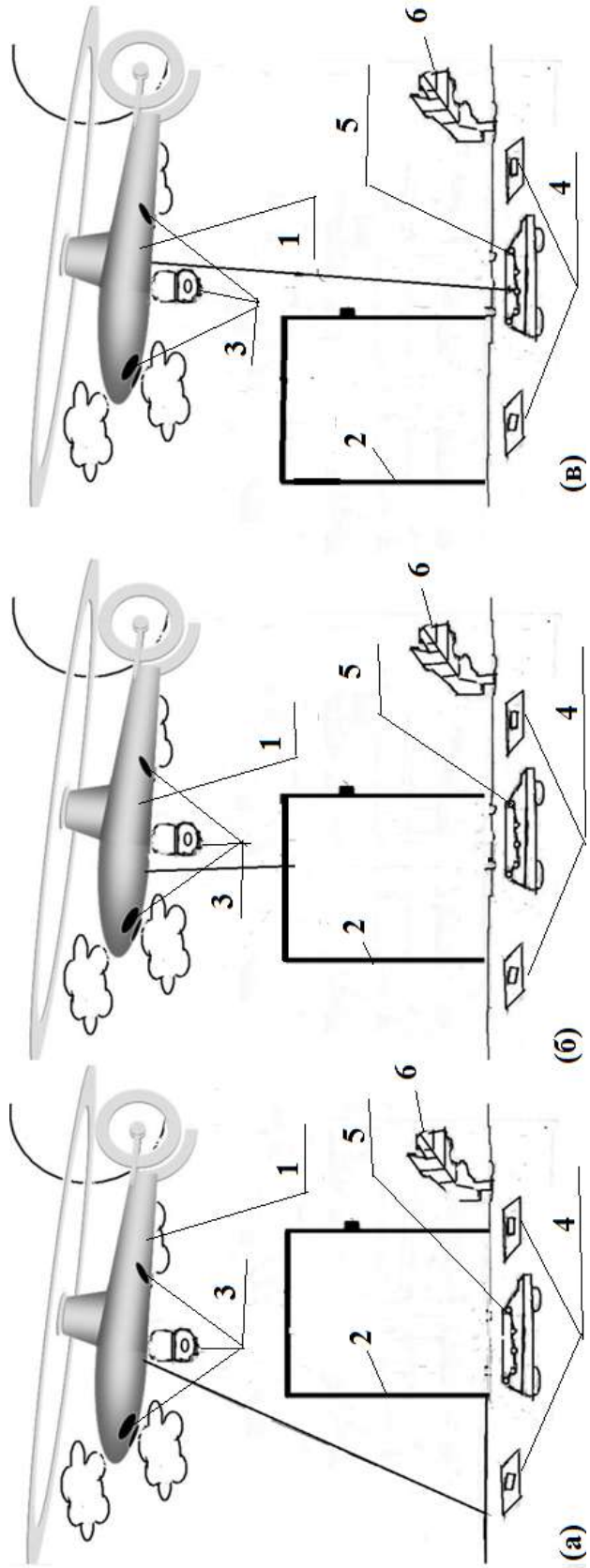


Fig. 2