The technology development direction analysis of the small portable unmanned ground platform

X J Liu\textsuperscript{1,2}, B Su\textsuperscript{2}, Y A Yao\textsuperscript{1}, CH Liu\textsuperscript{1}, L Zhou\textsuperscript{1}

1 School of Mechanical, Electronic and Control Engineering, Beijing Jiaotong University, Beijing 100044
2 China North Vehicle Research Institute, Beijing 100072, China
3 Equipment Project Management Center, Beijing 100072, China
Email: yayao@bjtu.edu.cn

Abstract: The small portable unmanned ground platform, with its small size, small quality and diversity of mobile configuration, meets the functional requirements of individual soldiers carrying narrow space reconnaissance and detection tasks. As an effective complement to unmanned aerial vehicle and large unmanned platform, it becomes the end of execution of unmanned combat system, and plays an important role in promoting individual combat capability and improving the construction of unmanned combat system. In this paper, through the application of demand, the unmanned platform mission environment, development trend and key technology analysis to sort out the development platform to build micro unmanned technology framework for the subsequent step by step development of micro unmanned platform technology to provide technical support.

1. Introduction

Small portable ground unmanned platform has small volume, light weight, easy to carry and deploy, It has the ability to perform multiple tasks in complex environments, It can carry out a variety of anti-terrorism tasks, such as interception, surveillance, search, detection, positioning, early warning, attack, strike, electromagnetic interference, communication relay, etc. It has actual combat significance. Research and development of the small portable unmanned ground platform for close reconnaissance and detection equipment to fill the anti-terrorism equipment blank, improve anti-terrorism equipment informaticization and unmanned level, it has important strategic
significance to meet the anti-terrorism forces to complete various tasks in various environmental needs.

2. The Definition of the small portable unmanned ground platform system

The small portable unmanned ground platform is mainly used in urban war, anti-terrorism, law enforcement and search and rescue activities, and is carried by front-line soldiers, or it can be carried and deployed by large and medium-sized unmanned platforms. The unmanned platform can also be deployed by remote control, throwing and other means. The weight of the platform is controlled below 15kg, which can be divided into two grades: 3kg and 10kg. The weight of 3kg small unmanned platform is 0-4.5kg, which belongs to throwing products. Mainly for reconnaissance and detection platform, mainly suitable for indoor, culvert and other narrow space. The weight of 10kg level portable unmanned platform is controlled within 4.5-15kg. With the increase of weight and volume, its adaptability to complex terrain is enhanced. Generally, it needs to have stair climbing function and certain load capacity. It can carry small reconnaissance, biochemical detection, mechanical arm and other task modules to carry out certain tasks, and can also carry firepower equipment to assist combat.

3. The requirement analysis of the small portable unmanned ground platform

The future military operations will be a special operation under the conditions of informatization in many fields and spaces. In this kind of special operations characterized by informatization, the powerful information acquisition ability often determines the course and outcome of the whole operation\(^1\). With the development of the city in the world, the city will become the main battlefield, the face of the narrow roadway, houses, buildings, and some narrow low internal space, Medium and heavy unmanned ground system cannot go deep into the roadway or the interior of buildings for reconnaissance and detection, UAVs can't work effectively. Soldiers are required to conduct close and real-time reconnaissance. Soldiers on duty need to carry reconnaissance equipment with them. With the diversification of tasks, more and more types of equipment carried by individual soldiers and the weight is becoming heavier, Higher requirements are put forward for the weight and volume of personal reconnaissance equipment. Therefore, the small portable unmanned ground platform, can carry out the information collection of the battlefield situation, and instead the soldiers to go deep into dangerous areas to carry out close range reconnaissance, provide reconnaissance guidance for medium and heavy unmanned ground systems, will play an important role in the military mission of detection, decision and destruction, especially in a quick changing battlefield environment\(^2\). And it will become the main form of unmanned combat in the future.

The portable ground unmanned platform can be used as the task load of light and medium manned / unmanned platforms, and can also carry a variety of payloads to implement short-range real-time dynamic reconnaissance, detection and various operation tasks. In the information network operations, it can be used as a communication relay station to carry out reconnaissance and strike at a longer distance, expand the space range of the battlefield, and enhance the ability of situation awareness, which will become a valuable equipment. It can improve mission execution capability, force protection capability and survivability, and reduce logistics support and staffing requirements. The portable ground unmanned platform can be deployed by the light or heavy unmanned platform carrying remote control deployment or throwing. It can enter the building interior, go deep into the roadway, and carry out reconnaissance in narrow space. It has certain
mobile ability and obstacle passing ability, and can carry different combat tasks such as real-time reconnaissance, detection and operation by carrying different task loads.

4. Environment / task requirements and function enumeration of the small portable unmanned ground platform

Based on the analysis of task requirements, technical development status and development trend of existing products, the functions of portable ground unmanned platform are listed as follows:

**Table 1 3kg level small portable unmanned ground platform function list**

| Task requirement | Street corridor | Culvert | Under the car | Hand hold | Throwable |
|------------------|-----------------|---------|---------------|-----------|-----------|
| Function enumeration | Fast driving on flat road, fast real-time reconnaissance; | Have the ability to cross obstacles and climb, and have the ability to pass through low, narrow and blocked areas | The body is flat, easy to move in narrow spaces; | The overall configuration makes it easier for soldiers to be placed in backpacks, and for soldiers to handle with one hand; | With throwing function, with at least 3or5 meters vertical drop ability, with self - positive ability. |

**Table 2. 10kg level small portable unmanned ground platform function list**

| Task requirement | Stairs | Culvert | Complex terrain | Load capacity | Easy to carry |
|------------------|-------|---------|-----------------|---------------|--------------|
| Function enumeration | Having the ability of climbing stairs and scouting inside buildings; | Carrying capacity in low, narrow and blocked areas; | Have the ability to climb over obstacles and slopes; | With a certain load capacity, easy to function expansion of the robot; | Light weight and portability; |

**Table 3. Reconnaissance function and man-machine interactive function of small portable unmanned ground platform**

| Task requirement | Short range rapid real-time reconnaissance | Reconnaissance under dark environment (car / table / bed / culvert bottom) | Reconnaissance of persons / objects within a certain room / corridor / street; Enlarged or accurately monitored for key targets; | Soldiers are outside the building, reconnaissance vehicles are located on the 2 floor or inside the building | A variety of interaction and ease of operation needs |
|------------------|--------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Function | Panoramic | With low light or The camera has a | There is a certain | A variety of modes | |
| Enumeration                        | Re却nnaissance Function Requirements, Camera Focus and Pitch Angle Adjustment Function; | Dark Environment Reconnaissance Function, with Active Lighting Function; | Wide Angle, Which Can Be Viewed from Ground to One Meter Away from the Ground; A Camera with Adjustable Pitch Angle Is Used to Focus and Focus Angle Reconnaissance; | Distance Between the Receiver and the Robot in the Physical Position, and There Is a Barrier to the Wall, So It Needs a Strong Communication System; | Of Operation to Meet the Needs of Individual Soldiers Simple Control; Operation with Real-time Audio and Video Reception and Display Function; Light Quality, Small, Convenient for Soldiers Handheld Operation; Each Function Keys Set Reasonable, Convenient for Soldiers to Operate; |

Through the function requirement analysis and function listing, forming the functional requirements of small portable unmanned ground platform, has important guiding significance to the type of product development.

5. Development status of the small portable unmanned ground platform

In the development of small portable unmanned ground platform technology, generally used in serialization and modularization development methods, which is more representative are Nerva series robots developed by NEXTER company in France, two kinds of portable unmanned platforms of Roboteam company in the United States, and Firstlook and Packbot series of iRobot company in the United States.

Nexter company developed NERVA series robot [3], mainly including 2 wheels, 4 wheels, 6 wheeled robots, respectively NERVA-S, NERVA-LG, NERVA-HD. The robot is developed in series and family, with a weight range of 2kg-12kg. It is a portable individual soldier equipment. Both of the 3 platforms have rugged features, in which both 4 and 6 wheeled robots have semi autonomous capabilities for path navigation, automatic return, leader and follower functions. By adding task components, automatic search and map description can be realized. The serial platform can be controlled by a variety of control platforms, such as PC, tablet PCs and smart phones. More than 20 task components can be installed in the 4 and 6 versions, and a set of control systems can be used for multitasking applications.
The United States Roboteam company produces two kinds of portable unmanned platform, IRIS\(^{4}\) robot, 1.85kg, is very small, can be carried by soldiers with one hand, the robot is equipped with a camera and microphone, can be manipulated by tablet computer. Mainly used for collecting regional intelligence. It is mainly used in special reconnaissance, city conflict, public security, underground and pipeline reconnaissance and mobile relay. MTGR\(^{5}\) robot, 9.4kg, used for patrols and intelligence gathering, have the ability to overcome obstacles on complex terrain, with a single portable function, with 4 degrees of freedom manipulator, the reconnaissance camera 360 degrees, all terrain mobility, can climb the stairs, with self correction ability, have high mobility in the room and outdoor, suitable for military, law enforcement, public security and other tasks, can carry out explosive demolition tasks.

American Irobot's Firstlook\(^{6}\) and Packbot\(^{7}\) unmanned platforms. Firstlook is only 2.3 kilograms and can be placed in the soldier's backpack. Able to withstand a 4.6 meter drop, overcome a 0.17 meter hurdles, and has a self turning capability that can be used extensively in infantry and special combat missions, including building cleaning, attacks, and other short-range missions. Firstlook installs four built-in cameras that provide multi-faceted situational awareness that allows operators to stay away from damage. The upgrade function including two-way audio communication and digital network, which will allow multiple robots in the far distance relay radio communication, but also increased the thermal imaging sensors and chemical sensors can collect more information at the same time increase the operating room, the robot arm, help the bomb team to check or direct contact with explosive ordnance. Packbot reconnaissance robot by crawler structure and equipped with flippers, can go through the field across the rocks, sand, mud, after simple preparation can be wading driving. You can climb over obstacles in flipper help, climb stairs. Packbot has been designed as an all-weather and all terrain mobile carrier with high reliability. Its platform can be loaded with laser range finder, stereo camera and GPS system to carry out reconnaissance work.
Through the research on the development status of micro and small portable unmanned ground platform in the world, it can be found that all the ground unmanned platform companies have carried out series development of micro and small unmanned platform products, realizing technology borrowing and function complementation. Taking Nerva series products as an example, this series uses Nerva LG products as the base products to generate the radiation of series products. The serial robots cover the equipment requirements of individual portable reconnaissance system, and the functions involve the tasks of reconnaissance, defense, detection and rescue. It meets the needs of individual soldiers. The development of serialization is conducive to the application of product system. The standardized modular design of control module, power module, communication module, control module, reconnaissance module and other basic functional modules can shorten the product development cycle, improve the maintainability of the product and reduce the maintenance cost. The development of serialization is also conducive to the systematic application of products. For example, through networking and collaboration, robots can perform tasks cooperatively, which is conducive to data transmission and collaborative control.

Its seriation product development mainly displays in:

1) Taking one of the products as the basic key product, the radiation development of series products is carried out to form a product network. The use scenarios and task functions of products are complementary. Platforms can carry and relay each other. The unified standard mechanical interface and electrical interface are adopted. With the same operating system, users can use the products according to the task and environmental requirements.

2) Generally, a variety of control modes are adopted to meet the interactive requirements of manned vehicles, unmanned vehicles, soldiers, commanders and other multi sites; it can be controlled by one to many points, or many to one, which can be controlled by the command vehicle, or controlled by mobile phones, iPads or computers, etc., so as to meet various site requirements.

3) Has a variety of task load carrying capacity to meet the diversity requirements of executing tasks;

6.2 Mobile systems and mission operations integration design technology development

Boston Dynamics company in the new release of electric dog (SpotMini)\(^1\) says it is also a mobile manipulator (Mobile Manipulator) company, The robot arm of SpotMini can deal with such scenes as cleaning the dishwasher (such as navigation and moving some objects). Especially after Spotmini falls down, the manipulator can help it stand up. The control of the manipulator arm is also the control of the quadruped mobile body. Robosimian\(^2\) robot, a newly developed robot developed by NASA's Jet Propulsion Laboratory (JPL), mainly moves in the foot mode, but according to the modular design method, it can be installed on the crawler mobile chassis as a mission operating system. A wheel is also installed at the joint to make it have the compound walking mode of wheel foot. At the foot end of Robosimian robot, there are dexterous operating fingers, which make it have the fine actions of climbing, screwing the valve, opening the door and so on. And it can grasp the drill bit and other tools, further expanding its multi task operation ability.
The above research on Spotmini robot and JPL Robosimian robot fully demonstrates the new trend of research and development of micro and small portable mobile ground unmanned platform, and the integrated design of mobile ontology and task load. The ground mobile system can also be called mobile mission operating system. Its mission execution terminal is also a part of the ground mobile system. Therefore, the portable mobile operating robot is mainly oriented to the instrumental mobile operating system. The portable mobile system can not only be used as the task load of large-scale mobile system, but also can be used as an independent mobile operation tool to realize reconnaissance, detection and task operation. The mobile system is modularized and the operating system is instrumented. As shown in Figure 4, the development of miniaturized portable unmanned ground platform is bound to expand its application scope, not only to replace human beings to reconnaissance, but also to replace human beings to carry out various tasks, making the micro portable unmanned ground platform become a mobile toolbox.

6.3 Development of mobile configuration modular Library

According to the operational environment for the diverse needs of small, block, culvert, such as wall complex detection and task demand for mobile environment, configuration of various types of modular design, the formation of a portable mobile platform tool library. Running, jumping, playing, covering, climbing, flying, such as remote control tools or break into unmanned operation tools unmanned platform is bound to expand its application scope, not only to replace human beings to reconnaissance, but also to replace human beings to carry out various tasks, making the micro portable unmanned ground platform become a mobile toolbox.

6.4 Panoramic dynamic display and image based control technology development

At present, most of the small portable unmanned ground platform are remote control platforms based on the images, and the single camera or front and rear camera schemes are adopted. Because the field of view is very limited, it is difficult for remote control personnel to identify and understand the environment around the platform according to the video images transmitted. It is difficult to drive the unmanned platform remotely and enter the reconnaissance state quickly. Therefore, it can not meet the requirements of diversified armies Mission and complex and changeable combat environment. The distributed panoramic image system can meet the perception requirements of large field of view, and realize 360 degree panoramic battlefield target detection. The technology of panoramic dynamic display and target guidance realizes the detection and recognition of special targets in 360 ° panoramic images. It realizes the research of target guidance technology based on video image, realizes the mobile control of mobile robot body and the call of each camera through the touch screen target guidance technology, realizes the integration of reconnaissance, detection and remote control, reduces the difficulty of soldiers’ remote control of vehicles, and increases the sense of presence.
7. Analysis on Key Technologies of the small portable unmanned ground platform

7.1 Lightweight design technology

The lightweight design technology of the microminiature portable ground unmanned platform is mainly reflected in the lightweight design of the mechanism structure and the integrated custom design of the drive control and communication system and the reconnaissance detection and acquisition system. Under the design constraints of power consumption, weight and space, both integrated design and custom design are required. In integrated design, lightweight design technology is the key technology for the first breakthrough in the design of portable ground unmanned platforms. In order to obtain a technical solution with reasonable structure, balanced performance, ruggedness and strong reliability, carry out an integrated design of lightweight functional structure. Based on the finite element simulation analysis of materials and structures, the goal is to obtain the overall optimal solution of the design, and finally achieve the design goals.

The lightweight design technology for micro-portable groundless unmanned platforms is mainly from the development of an integrated design method of overall functional structure as a breakthrough, to achieve the minimum quality under the guarantee of functional structural strength.

7.2 Impact resistant design technology

Micro portable unmanned ground platform is faced with drop and impact conditions when deploying and executing tasks, and it needs to resist the impact vibration of 3m vertical drop at least. At present, the relevant throwing products in the world can resist the impact of 4.6m vertical drop at most. The difficulty of its design is to carry out the design of anti impact and vibration components under the constraints of light weight and small volume. The internal electronic components are mostly installed in the way of vibration reduction to improve their reliability. At present, most of the shock resistant design components are spiral elastic wheels with buffering function, honeycomb elastic wheels, and many plastics or foam materials with impact resistance. Because the impact force is the result of the interaction between the damping parts, the wheel and the overall frame, and is related to many factors such as the weight of the body, the height of the drop, the type of the ground and the landing posture of the mobile platform, there is no accurate theoretical formula, so the relevant design parameters need to be obtained by simulation and test methods.

7.3 Miniaturized reconnaissance, perception, and communication technology

Under the design constraints of small size and light weight, the overall structural layout of small portable unmanned ground platform needs to meet both the volume and weight constraints and its functional constraints, so as to realize the reconnaissance functions of "seeing clearly" and "leaning up" under the conditions of small size and small weight. At the same time, the real-time communication in the space with more obstacles is needed. The real-time design of image data transmission is one of the key technologies for the practicability of unmanned ground platform. It not only needs to have fast image processing speed, more image paths, simultaneous transmission of image and data, but also needs to meet the technical requirements of small size, light weight and low power consumption.

8. Conclusion
In the future, the small portable unmanned ground platform will undertake more tasks. Through modular design, it will be able to carry a variety of payloads and realize multi-functional loading. In the information network operation, it can be used as the relay station needed by the information decision support network to realize the reconnaissance and attack in a longer distance, expand the battlefield space range, and enhance the situation awareness ability. It will become a valuable equipment to improve the mission execution ability, force protection ability and survival ability, and reduce the logistics support and personnel allocation requirements. The future development direction is to develop its intelligent and autonomous capabilities, enhance its operational reliability, improve its energy and durability, and improve its reliability in the combat space, improve its anti-jamming capability, and its robustness and durability by increasing its mobility. Strengthen the design of human-computer interaction of control terminal, so that soldiers can operate more easily.

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