SUGISAKA MASANORI

Journal of Advances in Artificial Life Robotics
Vol. 4(2); September (2023), pp. 94–97
ON LINE ISSN 2435-8061; ISSN-L 2435-8061
https://alife-robotics.org/jallr.html

Research Article

Design of Intelligent Ground Air Multi Robot Collaborative Transportation System

Hucheng Wang, Huahao Li
College of Electronic Information and Automation, Tianjin University of Science and Technology, 300222, China.

ARTICLE INFO

Article History

Received 15 December 2022
Accepted 26 October 2023

Keywords

Transportation
UGV
UAV
Air ground coordination

ABSTRACT

With the rapid development of the logistics industry, the traditional logistics transportation mode has been difficult to meet the needs of modern logistics. Intelligent ground and air multi-robot cooperative transportation system can use robot technology to achieve automated and intelligent logistics transportation, improve logistics efficiency and quality, reduce logistics costs, and meet customer needs. This paper introduces a new type of intelligent ground to air multi-robot cooperative transportation system, which is designed and integrated with a variety of technologies, such as robot technology, artificial intelligence technology, Internet of Things technology, etc., to promote technological innovation and development. This paper introduces the research status and background of intelligent ground to air multi-robot cooperative transportation system, and introduces the working principle and equipment selection of the system in detail.

1. Introduction

The logistics industry faces challenges such as traffic congestion, high logistics costs, and insufficient labor. The intelligent ground and air multi-robot cooperative transportation system can solve these problems through automated and intelligent transportation methods, and improve the competitiveness of the logistics industry. China's logistics market is huge, but the logistics transport mode is still dominated by traditional transport mode, and the "last kilometer" in logistics distribution has also become a transportation problem in the logistics industry [1]. Data show that China's end distribution costs have accounted for more than 30% of the total cost of the logistics industry, and some even account for 50%. With the continuous development and maturity of UAV technology, UAV has been widely used in energy, agriculture, disaster relief and other industries. The deepening and diversification of UAV applications provides more possibilities for the development of the logistics industry [2], [3].

Under the research background of ground-to-air cooperative mobile group intelligent sensing technology, the intelligent robot ground-to-air cooperative unmanned transportation system is developed by using existing mobile sensing resources such as drones and ground mobile vehicles to obtain the required perceptual data, and carrying out communication and cooperation under the technical support of the Internet of Things to complete the transmission of information and the transmission of instructions.

This design has the following advantages:

In terms of hardware technology, the load capacity of UAV is relatively small, but the sensing capacity and sensing range are relatively strong, and the intelligent vehicle is just the opposite, so this design combines the advantages of a large sensing range of UAV and a strong carrying capacity of intelligent vehicle.

In terms of production benefits, the intelligent robot ground-air cooperative unmanned transportation system reduces the participation of personnel in the logistics and distribution process, reduces the expenditure on personnel, and avoids the safety problems of personnel in the distribution process, greatly improving economic benefits.

In the context of unmanned distribution, unmanned distribution can change the previous face-to-face logistics

Corresponding author's E-mail: 1983618432@qq.com URL: www.tust.edu.cn

terminal distribution scenarios, to a certain extent, improve the degree of intelligence and enhance productivity.

At the public level, the intelligent multi-robot air-ground cooperative transportation system can improve the efficiency of logistics distribution, reduce transportation costs, improve logistics transportation services, and enable the service population to obtain better logistics distribution service experience.

2. Overall design scheme

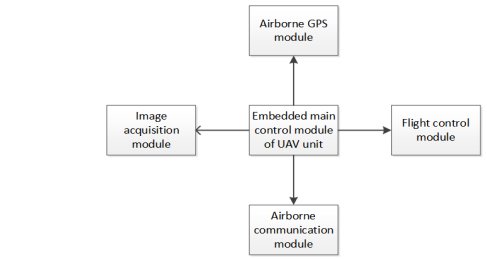
The intelligent multi-robot air-ground cooperative transportation system is mainly divided into three units, which are UAV unit, ground monitoring station unit and intelligent vehicle group unit.

First of all, the drone unit and the intelligent vehicle unit are connected to the ground station unit through the communication module for information transmission. The drone units can communicate with each other, and the drone can transmit information to the leading intelligent vehicle unit.

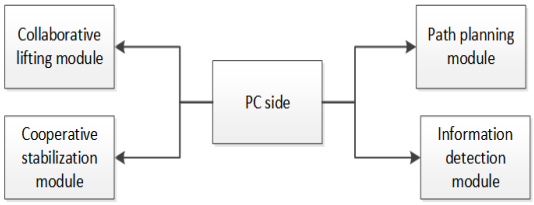
The UAV unit has two main functions. On the one hand, it detects the position information between the target object to be transported and the UAV itself, and assists the intelligent vehicle unit to carry out the transportation of the target object.

Second, in the process of transporting the target object, the ground environment information around the intelligent vehicle group unit is transmitted to the intelligent vehicle responsible for receiving the information, to assist the intelligent vehicle group unit to perceive the surrounding environmental information, and to ensure the safety of the surrounding environment during the transportation of the target object.

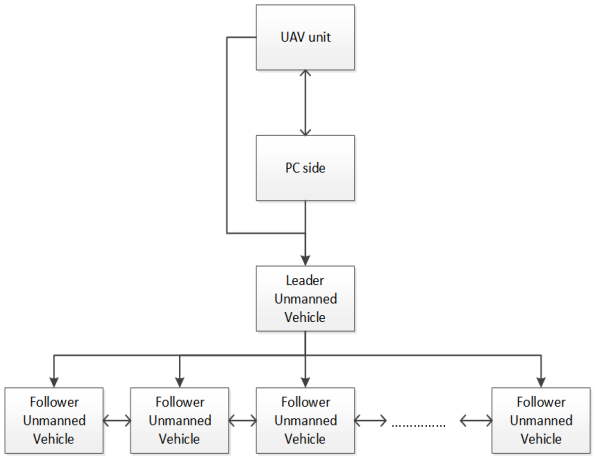
The ground monitoring station unit is mainly responsible for monitoring the working status of the UAV unit and the intelligent vehicle group unit, and selecting the optimal route for the transportation of the target object. The intelligent vehicle unit transports the cargo after receiving the optimal route selected by the ground station. The leader of the smart car is responsible for receiving the transmission information from the ground station unit and the drone unit to ensure that the optimal route is followed and obstacles are avoided. Among them, the intelligent vehicle unit will adjust the overall intelligent vehicle unit according to the multi-agent robot consistency algorithm to ensure that the entire intelligent vehicle unit can stably and quickly transport the target object to the specified location.(overall structure Fig 1 (a), (b), (c), (d).



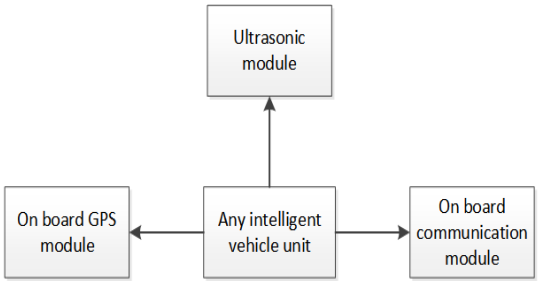
(a)



(b)



(c)



(d)

Fig.1. Overall structure

3. Device selection

Device selection is shown in Table 1 and Table 2.

Table 1. Device Selection of UAV

UGV	Pixhawk four rotor aircraft
Battery	5200mah 3S lithium battery
Flight control module	Pixhawk 2.4.8 Flight control module
Camera lens	SJ5000
GPS module	NEO-M8N GPS module
Image processing module	STM32(1)+Opencv3.4.1
The wireless data transmission module is connected with the main control module.	

Table 2. Device Selection of UAV

Control module	STM32F103ZET6 microcontroller
On board communication module	STM32 (2) sets up LAN through router for communication between smart cars; The wireless data transmission module is connected with the ground communication module.
GPS module	NEO-M8N GPS module

4. Technical realization principle

4.1. *Target cargo handling*

We send the transport object and the transport destination to the system. The ground workstation unit sends path information to the drone unit and the smart car unit according to the location of the transported object, so that the drone and the smart car can fly and transport near the transported object.

The UAV can collect and identify the transport target object through the image acquisition and processing function, so that the UAV can transmit the position information of the target object, and keep the flight over the target object.

After receiving the location information of the target object sent by the drone unit, the ground workstation unit performs unified scheduling for the drone unit, so that the drone is located directly above the target object, and provides accurate location information for the subsequent intelligent vehicle transportation of the target object.

The ground station unit issues a transport command, and the unmanned vehicle unit lifts the transport target object after receiving the command.

Fig. 2 is the schematic diagram of lifting scheme and Fig. 3 is the lifting scheme flow chart.

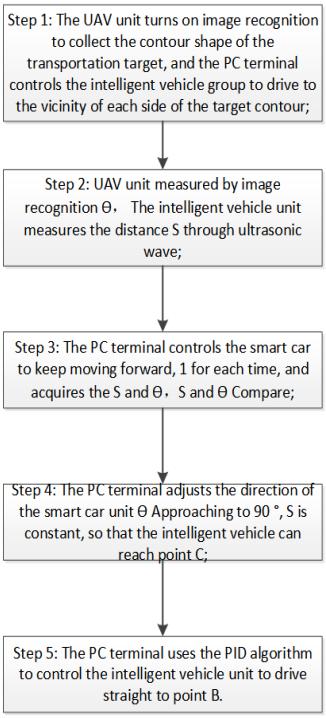


Fig.2. The schematic diagram of lifting scheme

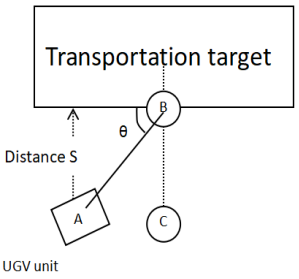


Fig.3. The lifting scheme flow chart

4.2. *Target cargo transportation*

After the system gets the transport instruction of the target object, the ground workstation unit will calculate the optimal transport path of the target object, and at the same time, receive the position information of the target object and the location information of the destination where the object moves, and calculate and plan the best transport path for them. The ground workstation unit will transmit the location information of the target object and the destination location information to the UAV working unit and the intelligent vehicle group unit through wireless data transmission, and transport the target object according to the best planned path after receiving the transport instruction. Note：

(1) During the transportation of the target object, the scattered unmanned aircraft will transmit the location information such as the ground road condition to the information collection UAV through wireless transmission. Information collection The unmanned vehicle will conduct reasonable obstacle avoidance and path guidance according to the collected ground road condition information, and the intelligent vehicle unit will complete the transportation of the target object under the path guidance provided by the unmanned vehicle unit.

(2) The ground station unit monitors and observes the operating status of the UAV unit and the intelligent vehicle unit in real time, including the operating speed, position information, path deviation, etc. It can also control the drone unit and intelligent car unit at any time to prevent failure and loss. This is also one of the fundamental iot technologies. Fig. 4 is the schematic diagram of the system.

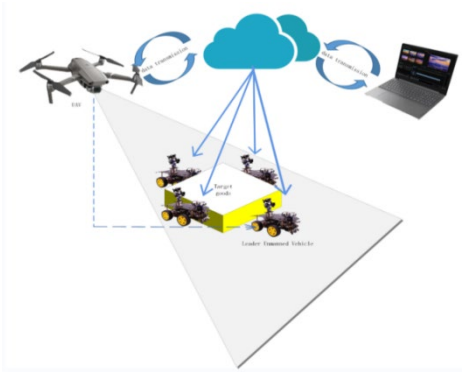


Fig.4. the overall schematic diagram of the system

4.3. *Target goods release*

When the target object reaches the target position, the target object is unloaded, and the UAV unit and the intelligent car unit enter the standby state, which is convenient to return after the subsequent unloading and complete the transportation.

5. Conclusion

In this paper, an intelligent robot unmanned air transportation system is designed, and its working principle and system architecture are described. The development of artificial intelligence technology provides technical support for ground-air cooperative mobile group intelligent perception, and the development of Internet of Things technology provides more convenient communication and data transmission methods for ground-air cooperative mobile group intelligent perception, which can make robots work together more efficiently. The system designed in this paper combines the advantages of both to provide more possibilities for the logistics and transportation industry.

References

1. DORLING K, HEINRICHS J, MESSIER G G, et al. Vehicle routing problems for drone delivery, IEEE Transactions on System, Man and Cybernetics: Systems, 2016, 47(1):70-85.
2. WANG X H, DUAN L J. Dynamic pricing and capacity allocation of UAV-provided mobile services, Proceedings of IEEE Conference on Computer Communications. IEEE, 2019: 1855-1863.
3. LIU C H, PIAO C Z, TANG J. Energy-efficient UAV crowdsensing with multiple charging stations by deep learning, Proceedings of IEEE Conference on Computer Communications. IEEE, 2020: 199-208.

Authors Introduction

Mr. Hucheng Wang

He is a master candidate in Tianjin University of Science and Technology, majoring in machine learning.

Mr. Huahao Li

He is a master candidate in Tianjin University of Science and Technology, majoring in Intelligent multibody robot.