

Design and implementation of wild plant grabbing system and car in Tibet based on Raspberry Pi 4B

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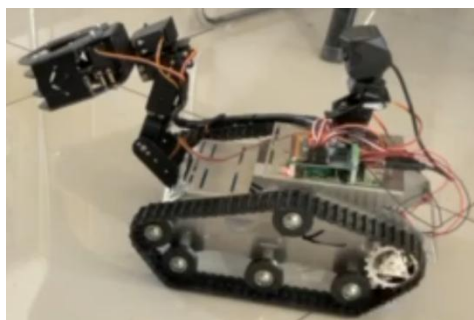
Abstract. This article introduces a plant collection system applied in Tibet to solve the challenges of traditional manual collection in the plateau environment. The system uses a remotely controlled Raspberry Pi trolley^[1] to collect plants, which improves the collection efficiency and the safety of collectors. Hardware modules include basic functional systems and artificial intelligence subsystems for control, navigation and plant recognition. The AI^[2] subsystem uses the YOLOv5s^[3] model for plant recognition and cooperates with sensors to implement environmental monitoring. The software interface provides slider and button controls, allowing the operator to precisely control the robot's movement and camera angles. Experimental results show that the system performs well in heavy object grabbing, muddy driving, sloping driving, and plant grabbing, etc., and provides an effective tool for field plant research and protection work.

Keywords: plant collection; plateau; remote control; YOLOv5s.

1. Introduction

As the world's climate continues to change, species diversity has been greatly affected. As a unique and special area in the world, Tibet has rich plant resources, some of which are of great significance to the study of climate change at various historical stages. In order to improve the China Plateau germplasm bank and conduct in-depth research on the relationship between climate and biodiversity at various historical stages, it is crucial to collect these plateau plants. However, the traditional manual collection process faces problems such as hypoxia, muddy remote roads, and complex collection scenarios in plateau areas.

In order to meet these challenges, we proposed an innovative solution, which is to use a remotely controlled Raspberry Pi car to collect plants in extreme environments. This technology can not only improve collection efficiency, but also ensure the safety of collection personnel. Through remote control, operators can easily cope with complex terrain and climate conditions, collect required plant samples, and make important contributions to scientific research and species protection. This innovative approach will help promote greater progress in biodiversity research and conservation in Tibet.



2. Functional design

2.1 Functional requirements analysis

In Tibet, road conditions are often affected by complex terrain such as muddy slopes, frost freezes, wet and soft soil, and these conditions often pose challenges to plant collection work.

Collectors are vulnerable to injury and their productivity is limited under these conditions. In order to solve this problem, this article proposes an innovative method, using the Raspberry Pi 4G4B board as the main control board, connected to a mobile phone or PC, to achieve remote control operation to complete plant collection tasks under various complex conditions. This technology can effectively improve the safety and efficiency of collection, and provides a feasible solution for plant collection under unique terrain and climate conditions.

2.2 Hardware module design

The hardware system is divided into basic function system and hardware artificial intelligence subsystem. The basic function system includes basic platform control module, road inspection module, wireless transmission module, and motor drive module. The artificial intelligence subsystem includes AI system control module, plant identification module^[4], data Collect module diagram and car model diagram

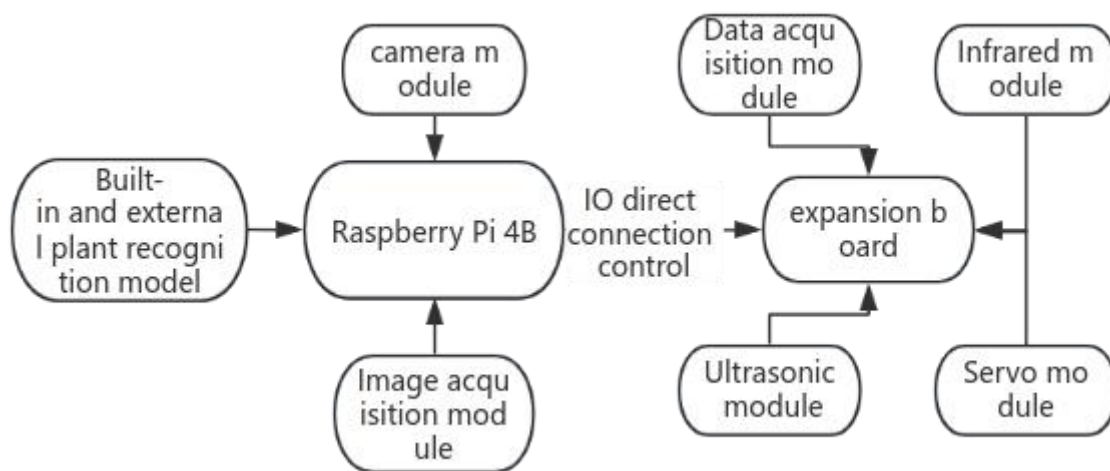


Figure 1 Car model diagram

2.3 Basic functional platform hardware design

2.3.1 Basic platform control module

The core of the basic platform control module is Raspberry Pi 4B, which uses the ARM A72 core and has powerful performance and comprehensive resources. It realizes multiple functions such as dynamic trajectory control of the robot, road inspection path planning, steering gear angle rotation, and data transmission.

2.3.2 Road inspection module

The road inspection module includes 5-channel infrared sensor interface XR-IR infrared sensor and 1-channel ultrasonic interface ultrasonic obstacle avoidance module HC-SR04. The infrared sensor consists of an infrared transmitter and an infrared receiving device and is used to detect the reflected infrared rays. The infrared sensor controls the movement trajectory of the inspection robot by detecting infrared rays to realize the route tracking inspection function^[5].

2.3.3 Wireless transmission module

The inspection robot main control module transmits inspection data to the central control system^[6] in real time through the Bluetooth HC05 module, and transmits the instructions issued by the central control system to the inspection robot main control module through Bluetooth. This enables real-time data exchange between fixed devices, mobile devices and smart building LANs.

2.3.4 Motor drive module

The motor drive module adopts the TB drive scheme, the drive current is not less than 2A, and the drive power is not less than 24W. It uses the XR Servo_K1500 PWM generator and generates a PWM square wave^[7] with an accuracy error of not more than 1% through the XR_API call. This module has strong anti-interference capabilities, high stability and driving capabilities, providing strong support for inspections, ultrasonic navigation and other tasks.

2.3.5 Robotic arm grabbing module

The robotic arm grabbing module uses DS-R001 and DS-S015M servos to form a 4-degree-of-freedom steering gear system, and uses a variety of homemade grippers to perform different grabbing tasks.

This design is divided into two parts: the robot basic function platform and the artificial intelligence expansion subsystem. The basic function platform includes a crawler vehicle, Raspberry Pi expansion board, WiFi and Bluetooth modules, infrared obstacle avoidance module and ultrasonic obstacle avoidance module, which are used to implement functions such as operation control, trajectory tracking, motor control and data transmission with the central server. The artificial intelligence expansion subsystem is mainly composed of Raspberry Pi 4B, temperature and humidity sensor, ultrasonic sensor, camera, USB module, power supply, lighting, audio and other modules. The YOLOV5s model is deployed on Raspberry Pi 4B, which monitors the distribution of plants in various complex environments by comparing pre-built plant models with camera images, and detects data information^[8] about the surrounding environment through temperature and humidity sensors and ultrasonic sensors. It comprehensively realizes multiple functions such as plant identification, environmental temperature measurement, environmental perception and data collection, and is suitable for comprehensive operations in complex scenes in the wild. The structural module diagram of the overall design scheme is shown in Figure 2 below.

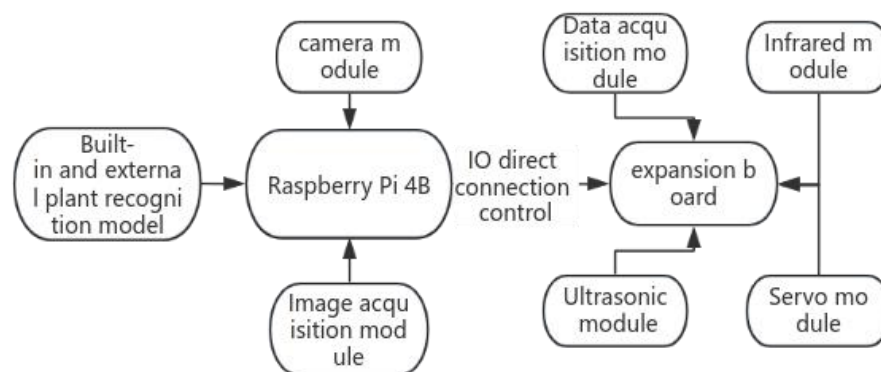


Figure 2 Module structure diagram

2.4 Hardware design of artificial intelligence subsystem

2.4.1 AI system control module

The core of the AI system control module is Raspberry Pi 4B, and its processor is ARM Cortex-A72. It is responsible for many functions such as plant species identification, temperature detection, and environmental data collection.

2.4.2 Plant species identification module

On the ARM processor, we adopted the YOLOV5s development environment, used Paddle Lite for model preview, and used the YOLOV5s environment under the autodl platform to train small

data sets to generate CNN and VGG 16 recognition technology models. The system captures images through a camera and uses OpenCV for plant identification and detection. It extracts features of mature plants and compares them with the naive Bayes model to achieve the effect of plant identification. The specific process is as shown in Figure 3.

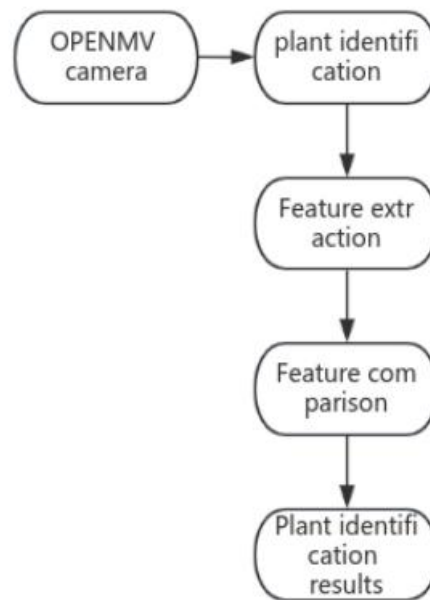


Figure 3 Software workflow chart

2.5 Software UI interface design

The video transmission on the mobile APP uses Raspberry Pi for target detection, control of the servo selector button, and control of the application user interface (APPUI), which is mainly used to remotely control the movement of the robot and adjust the viewing angle of the camera gimbal. The slider function in the interface is used to control the servos, which may be responsible for different moving parts of the robot, such as the precise angle adjustment of the camera gimbal. Users can adjust the pitch and roll of the camera gimbal by sliding these sliders up and down, ensuring images or videos are captured from the best angle.

The buttons are used to control the basic movement of the robot, including forward, backward, left turn, and right turn. These control options allow operators to precisely position and navigate the robot in a variety of environments. In addition, there is a dedicated camera button that allows users to quickly capture still images when needed and transfer the images to other devices or store them through the app. As shown in Figure 4 and Figure 5.

2.5.1 Rotation angle button mode

Basic movement controls allow the robot to easily move forward, backward, and turn over uneven terrain, which is especially important for avoiding obstacles and approaching target plants.



Figure 4 Button mode

2.5.2 Slider mode

The fine angle adjustment controlled by the slider can help the operator aim the camera pan and tilt at specific plants to obtain a clear perspective even in complex natural environments. This means plants can be viewed from different heights and angles for better identification and documentation.



Figure 5 Slider mode

2.5.3 Photo transfer

Rapid photography and image transmission capabilities allow field data to be instantly transmitted back to researchers for further analysis and confirmation. These integrated functions greatly improve the efficiency of field operations, allowing researchers to conduct observations and data collection without direct contact with the environment, which is an important technological advancement for botanical research and ecological monitoring.

3. Experiment

The field experimental tests are shown in Table 1 below.

Table 1 Test experiment table

serial number	Experiment name	Number of experiments	Number of successes	Success rate
1	Heavy object grabbing	50	45	90%
2	Driving through mud in the wild	50	48	96%
3	Driving through wild slopes	50	47	94%
4	Driving through muddy slopes in the wild	50	46	92%
5	Micro plant grabbing	50	50	100%

Conclusion

This study proposes an innovative solution to address the challenges of plant collection in the Tibetan Plateau, combining hardware and software technologies to implement a remotely controlled Raspberry Pi car for plant collection. The system hardware includes multiple modules, from basic control to artificial intelligence plant recognition, providing a feasible solution for collection under complex terrain and climate conditions. The AI subsystem uses the YOLOV5s model for plant recognition while monitoring environmental data. Experimental results show that the system performs well in various field tasks, provides a powerful tool for biodiversity research and plant protection, and is expected to promote greater progress in scientific research and conservation work in plateau areas.

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