Intelligent high-altitude power inspection vision module based on KendryteK210 microcontroller

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Abstract: Now our country has a huge electric power system, it needs a complex electric power transmission network to support its normal operation. With the development of unmanned aerial vehicle platform and microprocessor technology in recent years, the unmanned aerial vehicle inspection platform based on microprocessor is an important development direction of power transmission network maintenance. Based on this background, this paper designs an intelligent high-altitude line inspection vision module based on KendryteK210 microcontroller. The module can be used as a UAV load to carry out efficient power line patrol work, and wireless communication is carried out by ESP8285Wi-Fi. First of all, the inspection vision module uses OV2640 visible light camera to complete the target image data acquisition. Then, in the process of data processing, the least square method and Theil-Sen regression algorithm are combined to get the target line object, so as to get the slope and length of the line object and other parameters. Finally, the target in the image was identified based on the yolov2 neural network model, and then the flight path instruction was provided for the UAV platform.

Key words: single-chip microcomputer; KendryteK210; OV2640; Drone vision module; ESP8285; yolov2;

I. Introduction

In the 21st century with the rapid development of science and technology, the application of unmanned aerial vehicle (UAV) has covered various fields such as military patrol missile, UAV photography, terrain survey and power inspection. At present, the grid line patrol mode mainly includes three types: manual line patrol, drone line patrol and robot line patrol, and each of the three ways has its advantages and disadvantages. Manual line inspection has low efficiency and high cost, but manual line inspection can deal with special problems more flexibly. The robot line patrol structure is complex and limited by the structural design is usually not high efficiency, and the direct contact with the power grid, its mechanical structure failure may damage the power grid, but the detection accuracy is generally higher than that of the drone line patrol; Uav line inspection efficiency is high, and the use and design scheme of UAV head is more mature than that of the robot line inspection, but to achieve high-precision line inspection has high requirements on algorithm, hardware and design. Therefore, in order to reduce the probability of accidents and improve the efficiency of inspection, each power grid company has formulated the goal of realizing the cooperative inspection work in the short term with the robot patrol as the main task and the human patrol as the auxiliary task. Hunan Electric Power plans to electrify the mature equipment, carry out intelligent transformation of the high-altitude operation equipment, further strengthen the transformation of innovation achievements, and adhere to the integration of production, university and research. To promote the construction of power grid in a safe, high-quality and efficient manner.

In the field of technology to realize automatic inspection, people have proposed a variety of schemes. Wang Bin et al. designed a lightweight power inspection system based on LiDAR technology. The system can effectively establish the three-dimensional coordinates of the ground light spot, so as to realize the precise control of its own heading Angle. Ke Ao et al. put forward the scheme of combining deep learning with image processing in the literature. In terms of image recognition technology, R-CNN, SSD, YOLO and other algorithms have attracted the attention of many scholars. However, this kind of algorithm has the disadvantages of high computing power and slow computing speed, and it often needs to install on-board computer when applied to the UAV platform, such as DJI MANIFOLD and other equipment. In this paper, a high-altitude power inspection vision module based on KendryteK210 MCU is proposed. The module communicates directly with the terminal through the module onboard Wi-Fi unit. The drone rotates horizontally after reaching the target area, and the module guides the drone close to the power transmission pole post. The drone then identifies the transmission wires. Finally, the module will guide the drone to make attitude adjustments and begin the line patrol. In the process of line patrol, if the module encounters the situation of too thin wire, foreign body attached to the wire and so on, which causes the target to be lost, the system will enter the interrupt procedure and automatically deal with abnormal information.

II. Hardware design of intelligent high-altitude power inspection vision module

Under the idea of modularity, the hardware design has made a certain choice of compatibility and system operability. In order to ensure the reliability of the module at the same time, reduce the maintenance cost and difficulty. On the one hand, software design is to make full use of computing power to improve the performance of the module; On the other hand, optimize the operation process, improve the level of automation to reduce the burden of labor. The block diagram of the overall system is shown in Figure 1.

This design uses Kendryte K210 MCU, which is a system-on-chip (SoC) integrating machine vision and machine hearing ability. It uses the ultra-low power 28nm advanced manufacturing process of Taiwan Semiconductor Manufacturing Company (TSMC), and has a dual-core 64-bit processor, which has good power consumption performance, stability and reliability. The SE5218ALG-LF voltage regulator module is used to power the MCU, the input/output voltage of the UAV platform is 5V and 3.3V, and the 500mA power ripple rejection ratio (PSRR) is 75dB. The voltage regulator circuit can reduce the requirement of MCU to the UAV platform power supply. CH340 is used to convert UART2 into USB interface, and TTL protocol level is used to communicate with UAV platform. Since the target operating environment is high-voltage transmission network, serial communication can avoid the risk of electromagnetic interference to ensure the safety of transmission network and UAV equipment. The extended circuit will use the k210's UART3 interface. The Wi-Fi communication uses the ESP8285 module and uses UART1 to communicate with the MCU. As a communication module, users can also replace other suitable modules by themselves. If the UAV platform has suitable communication modules, they can also directly cancel the Wi-Fi module. OV2640 is adopted as the visible light camera module. Users can also replace the appropriate camera module with the OV2640 in 1/4 inch optical format and supports a maximum resolution of 1600x1200. It uses CMOS image sensing technology and can capture grayscale, RGB and other formats. It has low power consumption, high quality image output and high image processing performance.

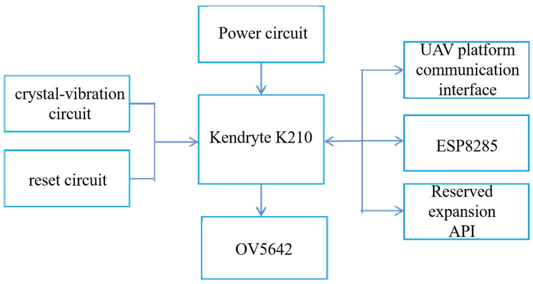

Figure 1. Block diagram of intelligent high-altitude power inspection system

III. Intelligent high-altitude power inspection vision module software design

When the software is designed, functions are used to encapsulate multiple functions, and the corresponding functions can be realized as long as the module is called in response when it is used. The main program flow chart of the intelligent high-altitude power inspection system is shown in Figure 2. The design uses the least square method combined with Theil-Sen regression to complete the patrol line estimation process. Firstly, for the sample points (xi,yi) and (xj,yj), the slope ki=(Y-yji)/(xi-xj) is calculated. Then, sort all the slopes ki to get the sorted list of slopes. Choose the median as your final slope estimate.

The design uses Yolov2 algorithm to recognize and process the image target. YOLOv2 adopts Darknet-19 feature extractor, including 19 convolution layers and 5 maxpooling layers. After adopting the 2×2 maxpooling layer in Darknet-19, the feature map dimension is reduced by two times, while the channles of the feature map are increased by two times. By using a smaller convolution kernel and stride length, the size of the feature map is reduced while the number of channels is increased. Such a design reduces the amount of computation while maintaining feature richness. With Darknet-19, the mAP value of YOLOv2 is not significantly improved, but the computation is reduced by approximately 33%.

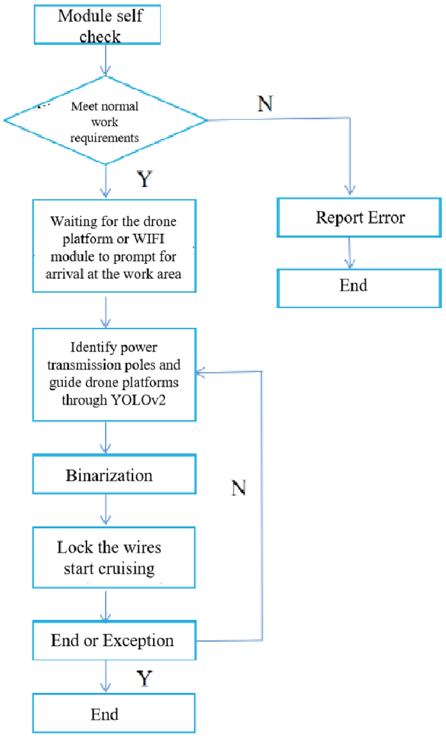

Figure 2. Flowchart of the main program of the intelligent high-altitude power inspection system

IV. System function test

Table 1 shows the yaw distance of module tracking at different speeds and the average yaw rate within 2m. When the speed is in the speed range of 0.5m/s to 1.5m/s, the yaw error of the high-altitude power inspection vision module is not more than 2cm, and the average yaw rate within 2m is not more than 1%. FIG. 3 shows the monitoring effect diagram of the actual operation of the module.

Table 1: yaw distance of module tracking at different speeds and average yaw rate within 2m

Velocity m/s	Yaw distance cm	Average yaw rate within 2m
	Left yaw right yaw	
0.5	1.3 1.1	0.6%
1	1.7 1.6	0.8%
1.5	2.0 2.0	1%

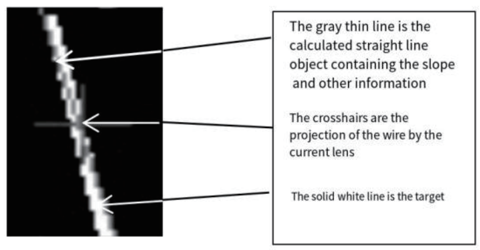

Figure 3. Actual operation of the module effect

Compared with R-CNN algorithm, SSD algorithm, etc., the yolov2 algorithm used in this design runs faster. FIG. 4 is the effect diagram of yolov2's digital recognition under the condition of 400 samples and 100 iterations. The running speed is maintained at 7fps to 9fps in KendryteK210 environment.

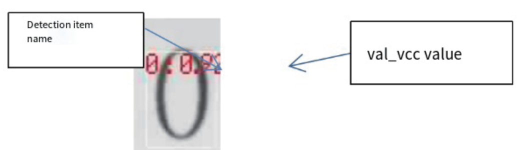

Figure 4.yolov2 digital target recognition rendering

Summary

This design is based on KendryteK210 chip and OV2640 visible light camera and other devices to patrol the line for the purpose of the design of an intelligent high-altitude power inspection vision module. The traverse slope is calculated by Theil-Sen regression and least square method, and corrected by yolov2 and other algorithms. Finally, the direction of the UAV platform is guided. The results show that when the UAV speed is in the range of 0.5 m/s to 1.5 m/s, the yaw error of the vision module of the high-altitude power inspection is less than 2 cm, and the average yaw rate within 2 m is less than 1%.

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