Design and Implementation of Survey Vehicle Based on VR

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Abstract. This project is aiming to design a kind of survey robot that has the combined functions of the large-scale disaster search and rescue equipment and industrial surveillance camera, use virtual reality (VR) technology to improve human-robot interface, to provide more simpler way to present the true images of the survey environment. The whole design solution consists of three parts: survey vehicle, VR (virtual reality) display system, Hand grip remote control. Remote control can control survey vehicle mode conversion, robot movement, and high beam brightness adjustment. Data collected by survey vehicle are used to construct the image by VR imaging method, coupled with the VR on the camera point of the somatosensory remote control. This can enhance the sense of environmental immersion.

Keywords: VR · Manipulator · Multi-machine communication
Survey robot

1 Introduction

The development of archaeology nowadays has played an important role in the process of peoples' learning of ancient culture. However, there may be several conditions when the archaeologists are not so familiar with the surroundings that they could not take on archaeological investigation immediately. Thus, it will be beneficial for the members to be able to use the survey robot with the aim at reducing the destruction of the surroundings when they know little about it. In addition, some high risk industrial plants are still using corner camera to monitor, which is not good enough to satisfy the needs of data collection when some emergency like nuclear leakage occurs. With the growth of robot technology, many research are being carried out with the aim at applying various robots to related specific environment, trying to improve peoples' operation ways and efficiency in different environments [1]. In our research, a kind of survey robot that not only has the combined functions of large survey facility and traditional industrial surveillance camera. But also provides the real images of the environment in a simpler user friendly way, with the help of manipulator it can also satisfy the need of investigation and material transfer.

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2 Scheme of the Design

2.1 The Design of Overall System

The works designed in this project consists three subsystems, respectively, using different data transmission means to communicate with (shown in Fig. 1). The data transmission between the survey vehicle and the grip remote control is required to be achieved through very long distance and with better wall penetration, so enhanced WIFI transmission circuit is used. This circuit use the MSP430 as the core, with enhanced nRF24l01 as a data receiver and transmitter. The data transmission distance of the open area can reach up to 2 km; VR display system and grip remote control is used by an operator, so the requirement is not very strict, in the aspect of transmission distance. But the packet loss rate and bit error rate are strictly required to maintain in a very low range, therefore these two systems can use Bluetooth for data transmission, and set the algorithm filter at the receiving end to achieve the purpose of data stability.

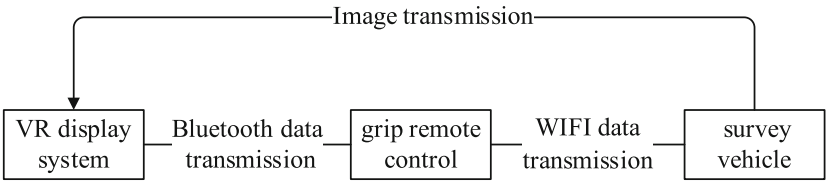

Fig. 1. Subsystem data transfer chart

2.2 The Design of Hardware Structure

All of the three sub-systems: the survey vehicle, VR display system, and hand grip remote control are based on microprocessor MSP430 made by TI, which is an ultra low power consumption with 16-bites mixed signal processing, it has several characteristics including lower voltage range, several operation modes with low power consumption, high-speed operational capability, and abundant functional models. It is playing an increasingly important role in embedded system, low-end areas especially in instrument, supervision, medical equipment, and automobile [2].

Survey vehicle's hardware structure is complicated, it consists of several parts (Fig. 2), including: caterpillar-belt body frame, manipulator of three degrees of freedom, 10 W high beam adjustment circuit, camera rotation positioning circuit, WIFI wireless data receiving circuit, image transmission circuit, and power supply circuit.

VR display system uses original left-right display modes, with two convex lens, it creates the sense of environmental immersion for the operator [3]. The hardware structure of this system includes blue-tooth data transmission circuit, image receiving circuit, and somatosensory measurement circuit.

Hand grip remote control has four function keys and a rocking bar, with those working together it can realize modes transfer of survey vehicles and other functions. Circuits of this part is as follows (Fig. 3): blue-tooth data receiving circuit, WIFI wireless data transmitting circuit, AD collection circuit, and power-supply circuit. Besides, the remote control also has somatosensory measurement circuit to make manual change of camera angle in mode 1.

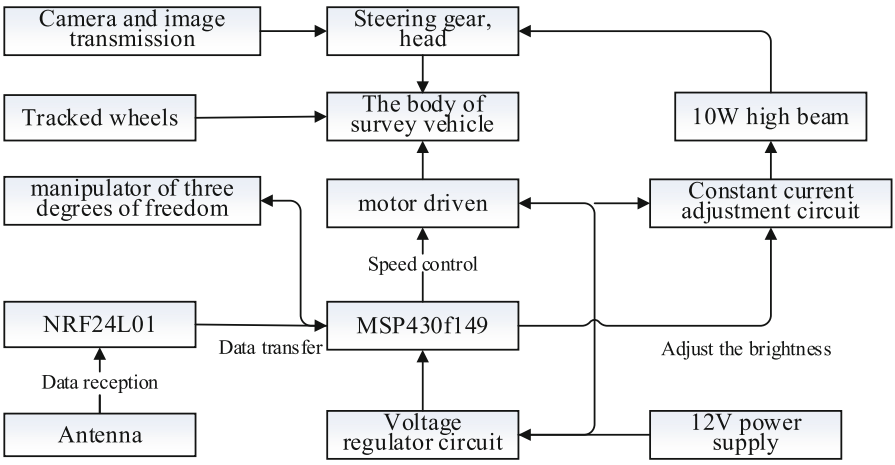

Fig. 2. Block diagram of the survey vehicle structure

2.3 Data Processing and Improvements in Algorithm

2.3.1 Improvements in Continuously Variable Algorithm

Continuously variable is in general realized by pulse width modulation technique (PWM), if the duty ratio can be continuously adjusted, then continuously variable of direct current machine can be developed [4]. Because there are only 8 comparable timers of MCU, if four timers are used to regulate the speed, the regulation of degrees of freedom in manipulator must be realized by externally connecting PWM output model, so the improvement in algorithm is needed [5]. The function of speed regulation is achieved by the electrical level changing of two PWMs and two TLLs. When the electrical level of two TLLs is low, the bigger of the duty ratio of PWM, the higher its speed, then the vehicle body would have a tendency of advance; when the electrical level of two TLLs is high, the smaller of the duty ratio of PWM, the higher its speed, then the vehicle body would have a tendency of retreat; the value of two PWMs is depended on the value of two ADs of the rocking bar, Omni direction of the vehicle body can be approximately obtained by the Omni direction of the rocking bar.

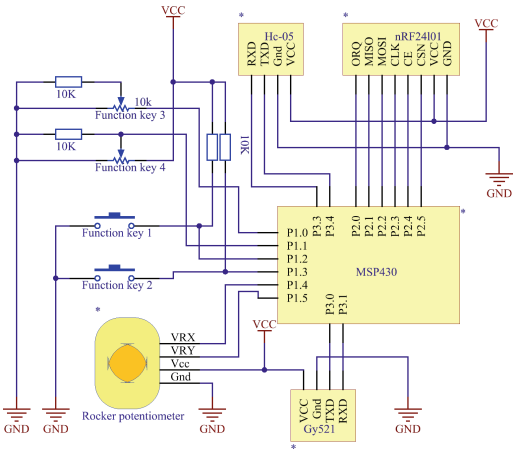

Fig. 3. Handle remote control circuit diagram

2.3.2 Improvements in Mean Filtering Algorithm

Filtering calculation using traditional method is to select a certain amount of continuous array elements and calculate the average value as the final numerical value, then eliminate the first value and the left will shift left as a whole to meet the next one, and so on [6, 7]. Whole left shift algorithm costs too much time, if it is still used to filter waves, vision delay of VR will excess the range of persistence of vision, reaction ability of the vehicle body will be decreased dramatically. Therefore, the improvement in algorithm is needed. Improved algorithm eliminates the part of whole left shift, and uses received value and data replacement: recording the average value of the last group of data as "result", then the average value of the next group of data is the sum of the last one minus the contribution value (data value "fl"/total data "atn") of the original data and the contribution value of the last data (fn/atn): result = result + (f1 − fn)/atn, after that, replacing the first one with the last, the second with the next, and so on. Key process is listed as below:

```
void init_filter()
{
  for(int i=0;i<40;i++)   filter[i]=2000;
}
int filter_LV(int fn,int num)
{
result=result+(fn-filter[num])/40;
 filter[num]=fn;
 return result;
}
```

2.3.3 Data Receiving and Examination

According to the difference between transmit media and transmit protocol, data receiving of this work consists two parts: data receiving of grip remote control with blue-tooth and data receiving of survey vehicle body with WIFI. In fact, the package loss rate and bit error rate of blue-tooth transmission are of seriousness. When there is a bit error or data disorder, the receiver with no ability to identify would face data chaos, as a result, it will cause the collapse of the whole system. Especially when the somatosensory information is transmitted disorderly in the head, the camera would shake dramatically, even make the wearer of VR feel dizzy [8]. Because of the uncertainty of the loss of data and the change, it is only possible to filter data in the receiving end [9].

Filtering process is composed of the following two steps: examination of data identity and examination of rationality (Fig. 4). Examination of data identity aims to identify data transmitted belongs to which category, like information of head pitching movement and information of head horizontal movement. Flags can be set in this part, every category of information has its own flag, only when all flags are matched can data be used. Although the problem of package loss and bit error can't be solved completely by this method, it improves the anastomosis rate of data processed to a reasonable range. Examination of data rationality aims at eliminating few error points. For example, when the numerical value is possible within the range of 0–180, but the data received is 2000, this can be eliminated with if statement.

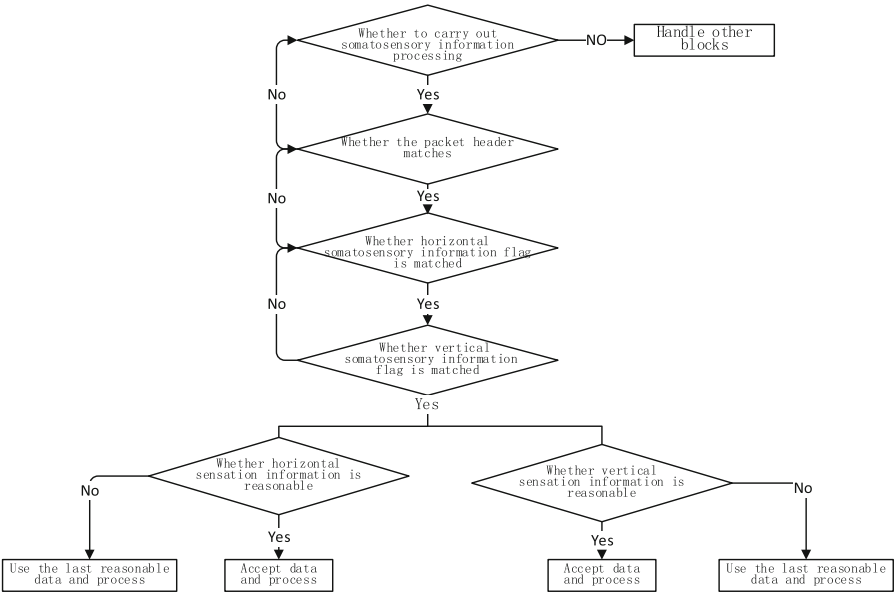

Fig. 4. Data reception and verification

3 Functional Analysis and Product Samples

3.1 Main Specifications

(1) The data packet loss rate after filtering is $\leq$ 0.001 and the bit error rate is $\approx$ 0.
(2) VR visual effects delay is $\approx$ 0.1 s within the scope of persistence of vision.
(3) Control distance and VR video transmission distance $\leq$ 2 km.
(4) Camera monitoring horizontal angle has adjustable range from 0 to 360°, and vertical angle is range from 0 to 180°.
(5) The controllable angles of the three-degree-of-freedom manipulator are 90°, 180°, 180°, respectively, and the torque force is 13 kg/cm.
(6) The power of high beam has adjustable range from 0 to 10 W.
(7) Length, width and height of the vehicle:35 cm $\times$ 15 cm $\times$ 20 cm.

3.2 Sample Pictures

See Figs. 5 and 6.

Fig. 5. The sample of vehicle

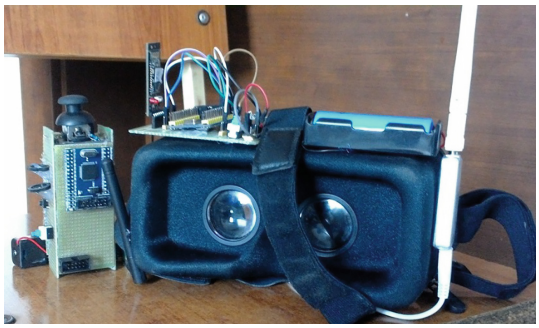

Fig. 6. The sample of VR display system and grip remote

4 Conclusion

There are several survey vehicles in the current market, but all of them have problems of monotonous function and complicated operation. The PackBot robots designed by a US company called iRoBot have three types: situational awareness robot, reconnaissance robot, and explosive ordnance disposal robot, they are suitable for different situations [10]. In this report, the work is a combination of situational awareness robot and explosive ordnance disposal robot, which can be switched between these two models randomly and conveniently, and it can be applied in areas like engineering construction, medical rescue, and accident handling. What is more, operational steps and processes can be simplified greatly and the ability to control can be improved greatly by using VR technique, which can effectively reduce labor cost and increase working efficiency. Therefore, compared to most products in the current market, this design is of great superiority and great prospect.

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