New Design of All-terrain Smart Car Based on Arduino

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Abstract. Due to bad working environment, the flexibility and steering stability of all-terrain vehicles have become the main factors affecting the performance. Designing a new all-terrain electric vehicle is aimed at improving the stability of driving on low-attach roads and maneuverability at low speeds. Compared with traditional internal combustion engines, four-wheel-drive all-terrain vehicles have obvious advantages in vehicle motion control and optimal allocation of driving force, thus making it play an important role in all-terrain vehicle technology in the future. Within the scope of the requirements of the “Explorer” modular component equipment, by means of prototype design, assembly, commissioning, operation, the smart vehicles that can automatically and smoothly pass through the obstacles of ten different characteristics and different difficulty without any intervention are designed and completed.

1. Introduction
Smart cars have great advantages over manned driving. They can go to places where people can't survive, small places and places with high risk factors. Off-road is a necessary feature for most smart cars. The purpose of this car is to consider the environment faced by the car as much as possible, and constantly innovate and improve the off-road and obstacle avoidance methods, while increasing the function of the car.

2. Smart car structure design

2.1. Chassis structure design
The all-terrain smart chassis body is composed of “Explorer” modular smart components. Because the smart car needs a variety of terrains, it must ensure that the overall quality is light, and the components are all made of aluminum-magnesium alloy material, which is light in weight and high in strength. The stability is effective to ensure that the smart has good off-road performance. The chassis of the smart car is higher enough to ensure that the phenomenon on the chassis of grounding doesn’t happen when climbing the ladder and passing the pit.

2.2. actuating device
The drives adopt four A171:10 model tires with four M06 dual-axis DC motors for forwarding, reversing, turning left and right upon the all-terrain smart car. The four-wheel drive car is the most stable form of driving, which greatly avoids the "pushing head" of the front wheel drive and the "fishtailing" of the rear wheel drive, thus reducing the impact of hardware problems on the obstacle crossing system.
3. Mechanical structure innovation
The smart car as shown in figure 1 uses a simple structure to complete complex work. According to the functional requirements, in order to smoothly cross various terrains including steps, potholes, slopes, etc., the smart car adopts the front wheel as the rear wheel of the big wheel as the structure of the centre of gravity of the small wheel, which is more conducive to the function of driving wheel and the increase to the power of smart cars[1].

![Figure 1. The overall structure of the smart car](image1)

The tire as shown in figure 2 is equipped with a track to make the smart car more gripped to prevent slipping; screwing the bolt on the track makes it easier for the smart car to climb the ladder through the reaction force of the step on the bolt when the smart car is going uphill.

![Figure 2. The overall structure of the tire](image2)

![Figure 3. The Installation location of four guide wheels](image3)

Four guide wheels as shown in figure 3 are installed in front of and behind the smart car to avoid obstacles. The auxiliary steering module is formed by the upper guide wheel of the leading phoenix tail, which not only reduces the forward resistance, but also helps to increase the speed of the vehicle, and also protects the front end. The guide wheel allows the car to quickly pass through the tunnel without slowing down.

4. Each part hardware circuit design
4.1. Main control board module
The software design and entry of the car design use the software “Arduino”, which greatly reduces the difficulty of software development and is suitable for beginners. Arduino is a convenient, flexible and
easy-to-use open source hardware product with rich interfaces, digital I/O ports, analogue I/O ports, and support for SPI, IIC, and UART serial communication. It senses the environment through a variety of sensors by controlling the wheels to turn over obstacles and reach the end. It has no complicated underlying code of the microcontroller, no incomprehensible assembly, just a simple and practical function [2-3]. And Arduino has a simple programming environment IDE, great freedom, and high scalability. The standardized interface model provides a solid foundation for its sustainability. The pin definition for Arduino is shown in Figure 4.

4.2. Path detection module
The grayscale sensor is an analogue sensor. The gradation sensor uses different colours to detect the difference in the degree of reflection of light, and the photoresistor performs colour depth detection on the principle that the resistance of the light which is returned from different detection surfaces is different. The grayscale sensor is used to distinguish black from the others when ambient light interference is not severe. It also has a wide operating voltage range and can still work normally when the power supply voltage fluctuates greatly. It outputs a continuous analogue signal, so it can be easily judged by the A/D converter or a simple comparator to determine the degree of deviation of the car. It is a practical intelligent line sensor. At the same time, we can add different path detection modules in accordance to different needs [4].

The ultrasonic ranging module (HC-SR04) provides 2cm-400cm non-contact distance sensing function with a range accuracy of up to 3mm. The module includes an ultrasonic transmitter, receiver and control circuit. Car avoids obstacle through distance measurement. The Schematic diagram of ultrasonic transmission module is shown in figure 5.
4.3. **PSCM**

The steering module of the all-terrain smart car uses the differential wheel of the rear wheel of the car, so that the distance from the braking point to the path detecting module is far enough, and the car has sufficient response time to achieve precise control of the car. Compared with the direction of steering engine control, the differential steering will not cause the deviation of the steering gear of the car in the stepped and pit section.

5. **Host programming language**

![Figure 6. The logic schematic of smart car working.](image)

**Figure 6.** The logic schematic of smart car working.
This all-terrain trolley uses BASRA as the main control chip, the power is provided by four DC machines, and the tracking sensor is 3 gray scales. The installation method is that the middle gray level is horizontally placed, and the gray scales are placed vertically on both sides, and the middle gray level is used to judge the state of the vehicle body by the gray level of the two sides of the track black line, and whether the black line is guided away from the centre. When the sensor detects that the vehicle body is off centre black line, the DC motor is controlled by the program to form a differential speed while slowly adjusting the car to restore the vehicle body to the straight state. When entering the tunnel, the track is a 180° curve, and the car also makes a turn through the differential. The degree of modification of the steering can be increased according to the number of added gradations. The main program flow chart is: The program is initialized, the gray level sensor receives the signal, and the car goes straight or turns and stops. The gray level sensor continues to sense. If the black line is not sensed, the car repeats the last operation, and at the same time avoids the possibility that the car moves too fast and does not sense the black line to rush out of the specified route. The car continuously executes the program in a cyclical manner to achieve the purpose of automatic tracking [5]. The logic schematic of smart car working is shown in Figure 6.

Part of the car driving control code: The moving path of the smart car is to adjust the forward and reverse rotation of the four DC motors through the main control board connection sensor and motor drive to complete the forward and reverse, and different degrees of steering and direction.

5.1. DC motor control
void Forwards ()
{
    digital Write (5, HIGH);
    digital Write (6, LOW);
    digital Write (9, HIGH);
    digital Write (10, LOW);
    analogue Write (9,200);
    analogue Write (10,0);
    analogue Write (5,200);
    analogue Write (6,0);
}

5.2. Smart car steering control code
The smart car decomposes complex control logic into a finite number of stable states and determines events in each state by applying a finite state machine. Since the finite state machine has a limited number of states, it can be implemented in practice. The finite state machine can be widely applied to the judgment of the combined state of multiple sensors of the all-terrain car, which greatly improves the detection efficiency. The following are some of the control procedures:
{
    value = 0;
    for(int i=0; i<3; i++)
    {
        value |= (digital Read(pin[i]) << i);
    }
    if(value == 0x07){ //Default to last value when no sensors are triggered
        value = value his://Record the last sensor value
    }
}

5.3. Smart car obstacle avoidance controlling code
The smart car uses the ultrasonic ranging module to judge the distance of the obstacle and then avoids the obstacle through the steering module. Some codes are as follows:
{  
digital Write(TRIGPIN, LOW);  
delay Microseconds(2);  
digital Write(TRIGPIN, HIGH);  
delay Microseconds(10);  
digital Write(TRIGPIN, LOW);  
float distance = pulse In(ECHOPIN, HIGH);  
distance = distance/58;  
Serial.println(distance);  
delay(500);  
}

6. System debugging
In order to solve the bug, the functions of the car should be inspected: It can smoothly pass the terrain uphill, downhill, steps, grille, etc. identify the ditch that cannot pass; The Smart car test site schematic is shown in figure 7. The test procedure is:
(1) Testing the car to cross three obstacles by arranging the site and placing the grille, steps and slope in order.
(2) Using a square to form a platform and leaving a gap in the middle of the platform. For the first time, the gap distance should be controlled less than 10cm to see if the car can pass smoothly.
(3) Placing the car on the open space and making it drive automatically without black line, seeing if the car can stop immediately or execute the last instruction.
(4) Simulating grassland and snow slide test.

Figure 7. The smart car test site schematic.

(5) Multiple obstacle avoidance tests.
1) For the problem that the car front is not against downhill when the car is going downhill, the solution is to accurately direction of uphill, and the steering module is quickly debugged.
2) When the car is slipping in a curve, the reaction speed is slow and does not meet the expectation. The solution is to reduce the speed of turning at an acute angle.
3) For the problem that the car encounters multiple obstacles without optimal route, the solution is to measure the distance of the car and determine whether the distance meets the obstacle avoidance condition (the obstacle avoidance distance can be determined according to the actual situation), When it is necessary to turn to avoid obstacles, the car stops. The ultrasonic wave swings left and right with the rotation of the steering gear while detecting car to the obstacle distance, thereby judging the optimal route.

7. Summary
The smart car has a simple hardware structure, a high degree of modularity, convenient debugging, and a smooth system response. The car uses the BASRA control board as the control core, the sensor feedbacks the signal of the environment in which the car is located, and the BASRA controls the car to perform the corresponding action. The operator only needs to open the switch to allow the all-terrain smart car to drive on the pre-prepared all-terrain track. From the final test results, the design proposal of the all-terrain smart car is correct, and the indicators are stable and achieve the intended purpose.
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References
[1] Zhao Wang, Eng Gee Lim, “Design of An Arduino-based Smart Car”, 2014 International SoC Design Conference (ISOCC), November 2014, DOI: 10.1109/ISOCC.2014.7087683
[2] BOLUN ZENG 1, JIANBO ZHANG (Corresponding Author) 2, LANG CHEN 1 ,YAO WANG,”Self-balancing car based on ARDUINO UNO R3”, 2018 IEEE 3rd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC 2018).
[3] Ruslan T. a, Yerden K. a, and Md. Hazrat Ali a, “Development of Arduino Glove-Based autonomous Car”, 2017 21st International Conference on System Theory, Control and Computing (ICSTCC).
[4] Mohammad O. Khan and Gary Parker, “Learning Live Autonomous Navigation: A Model Car with Hardware Arduino Neurons”, 2016 IEEE International Conference on Systems, Man, and Cybernetics • SMC 2016 | October 9-12, 2016 • Budapest, Hungary.
[5] Hemant Chaudhary, Prateek Bansal, Dr. B. Valarmathi, “Advanced CAR Parking System using Arduino”, 2017 International Conference on Advanced Computing and Communication Systems (ICACCS-2017), Jan. 06 – 07, 2017, Coimbatore, INDIA.