A High Performance Wall Advertisement Clearing Robot Based on Accuracy Positioning Operation

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Abstract: The small advertisements on the urban street not only damage the beauty of the city, but also often contain bad information such as fraud, which greatly affects the appearance of the city and the social harmony. Small advertisements are scattered all over the city. The advertisements area is large and it's difficult to clean. It is an object of public denunciation in the process of improving the appearance of the city of urban management. The traditional manual removal method is bad effect and low efficiency. In response to the above problems, the wall advertisement clearing robot came into being, using the Arduino open source platform for development, designing a stable robot power transmission system and a powerful positioning operation control system, enabling automatic and efficient removal of small wall advertisements. After trial and comparison, compared with the process of manually removing small wall advertisements, the wall advertisement clearing robot designed in this paper can quickly and efficiently clear small wall advertisements and beautify the urban environment.

1. Introduction

At present, there are many places in the municipal infrastructure sector that can meet the public's aesthetic standards, but it is inevitable that there will be some things that affect the appearance of the city. The first is the small advertisement. Although there are many legal restrictions, it is still difficult to supervise the posting of small wall advertisements, resulting in an endless stream of small advertisements. The small advertisements on the wall give people a feeling of dirty, chaotic and bad, which seriously affects the image of the city. The emergence of small advertisements not only increases the pollution of the environment, but also hurt some juveniles and the elderly who have no ability to distinguish the bad information such as false or fraud information in the advertisements. It is necessary to put an end to this situation. Now in many places people have realized that the harm of small advertisements and prohibits the posting of small advertisements. But the implementation is still not satisfactory.

They generally use two methods to clear small advertisements. One is to scrape little by little with something like a small blade. The second method is to work with water and a brush. The manual method is inefficient, it takes extremely a lot of labor and material insources, and greatly increases labor costs and resources.

At present, some researchers in research institutes are developing automatic clearing equipment. Lin Shaoqun, Wang Liuyi, Fang Mingfeng [5] designed a hand-held small advertisement cleaner. The advantage of this design is that the brush head is small in size and flexible in movement. The disadvantage is that it can not save labor resource and it is not suitable for clearing the larger area. Li Hao et al [4] also designed a portable small advertisement cleaner, mainly using a floating brush head. Dong Haidong [6] designed a portable small advertising cleaner that can be put at the waist. Sun Xiaoxue et al [1] [2] [3] also studied the design of small advertisement cleaner, mainly using

portable water bottles, but One-time clearing area is limited. In addition, some reporters introduced Germany's advanced small advertisement clearing technology, which is mainly for small advertisements of paints using chemical reagents to clean up. An automatic small advertisement clearing robot is designed to solve the problem above. This design can automatically remove small advertisements, giving hands freedom. It can achieve unmanned work, and save human resources. It can remove small wall advertisements in a large area at one time, and can effectively remove small advertisements left on the wall in a timely and effective manner. Use ultrasonic ranging to make the brush and the wall in effective contact. The high-speed rotating brush is used for forceful clearance, which is efficient, and it is simple and easy to use. The brush heads of different specifications and different materials can be changed according to user requirements. Equipped with a large-capacity water storage tank, different water-soluble washing solutions can be pre-injected according to the paper type of different small advertisements during the operation. According to the specific scene of the small advertisement, you can choose from these three working modes: steel brush clearing only, steel brush clearing after liquid solution, synchronized steel brush clearing and liquid supply. The design is beautiful in appearance, reasonable in mechanical structure design, easy to carry, and capable of quickly and efficiently clearing small advertisements on the wall.

A comparison experiment was conducted on the time, effect and scratching degree of manual cleaning small advertisements and robot cleaning small advertisements. A number of comparative tests of robotic effects on different viscose paper removals were also performed, including white glue, double-sided tape, 502 glue, sponge glue and different paper materials. The experiment shows the designed robot can clear the wall small advertisement efficiently and effectively.

2. Hardware Design

2.1 Structural design

The synchronous belt drive is mainly used for the drive of the X-axis direction and the first-stage drive of the motor during the Y-axis movement. During the transmission process, the linear guide device acts as a guide. As shown in the figure, the left picture shows the X-axis synchronous belt transmission structure diagram. The 42-step motor drives the synchronous pulley, the synchronous pulley and the synchronous belt mesh to drive the synchronous belt. The synchronous belt and the moving slider are fixedly connected, and finally drive the moving slider to realize the reciprocating movement, and the linear guide guides the movement during the movement. Right side is the Y-axis synchronous belt transmission structure diagram. It is a first-stage transmission. 42 stepping motor drives the primary synchronous pulley, the primary synchronous belt is meshed with the synchronous belt, and the synchronous belt drives the secondary synchronous belt pulley. The secondary synchronous belt pulley is fixedly connected with the T-type lead screw to finally realize the rotation of the T-type lead screw.

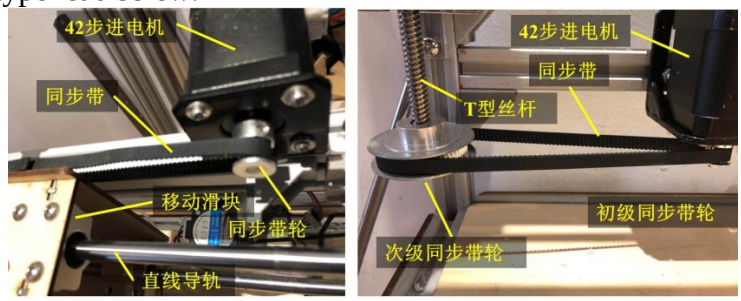


Figure 1. Schematic diagram of the synchronous belt drive

The power of the screw drive comes from the Y-axis one-stage synchronous belt drive as described above. The above-mentioned secondary synchronous pulley drives the T-type lead screw to rotate, and the bearing fixes the T-type screw to ensure the rotation accuracy. The T-type lead screw and the flange nut constitute a spiral motion pair. When the T-type lead screw rotates, the

flange nut moves up and down. The flange nut and the lifting platform are fixedly connected, and finally the up-and-down movement of the lifting platform is realized.

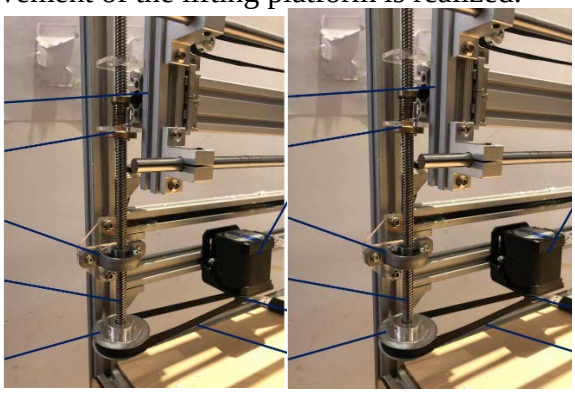


Figure 2.（a）Schematic diagram of the synchronous belt drive (b) Schematic diagram of the rocker slider

The rocker slider mechanism enables the contact between small advertisement the steel brush and the wall. As shown in the Figure.2 (b), the MG996 servo output torque drives the rocker to rotate within a certain angle range. The rocker and the link hinge are connected and drive the connecting rod to make a spatial plane motion. The connecting rod and the slider hinge are connected and make the actuator slider to conduct a linear motion along the linear slide. The high-speed motor is mounted on the actuator slider, and the output shaft end of the high-speed motor is connected to the steel brush using a coupling, and the liquid supply pipe is installed above the steel brush. In the process of clearing the wall advertisement, the rocker slider mechanism can ensure effective contact between the steel brush and the small wall advertisement.

2.2 Controller design

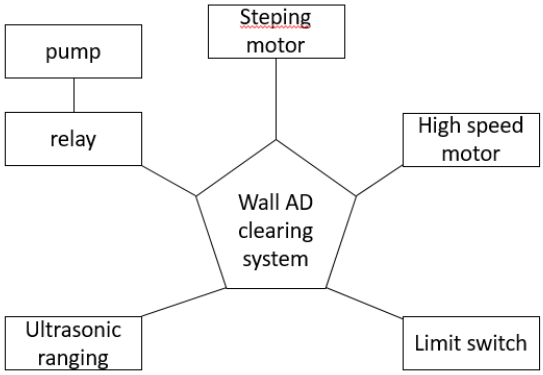


Figure 3. Overall structure of the controller design

The main reason for choosing Arduino UNO is that it is small and efficient, and meets the requirements of small, precise and accurate multi-point monitoring systems. At the same time, the development environment of Arduino is also friendly, which is convenient for the organic combination of many different types of sensors. It is a more suitable selection for the MCU.

The permanent magnet stepping motor 42HB48 is used to drive the X-axis movement and the Y-axis movement. The stepping motor is two-phase, the volume is small, the step angle is 1.8 degrees, and it has a certain torque, which can realize the acute spatial position of the X and Y axes. The stepping motor has a square structure, and the connecting hole is located at the end of the shaft, which is positioned by the outer circle of the boss of the shaft end, and wired by the four-wire DuPont port.

The MG996 steering gear is used to drive the rocker slider mechanism. As shown in Figure 2-6, the MG996 steering gear uses a hollow cup motor, metal gear structure and double ball bearings. Therefore, the MG996 servo has a rotational torque of 13 kg/cm which is durable.

Use RS775 to drive steel brush to achieve wall advertisement clearance work. As shown in Figure 2-8, the permanent magnet brushless DC motor has a large air gap, high efficiency, simple rotor structure, which is suitable for ultra-high speed operation. It is a hot research topic in the field of special motors and one of the ideal driving components for ultra-high-speed precision electric spindles. The rotor adopts a monolithic magnetic ring structure. In order to prevent the permanent magnet from being damaged by the large tensile stress generated during high-speed rotation, the permanent magnet is protected by the non-magnetic alloy steel sheath, and the interference fit is used between the protective sleeve and the permanent magnet.

The brushless DC micro submersible pump is used, and the pump power is 25W, the voltage is 12V. The pump body is made of environmentally friendly materials, with low noise, small size and stable performance. The shaft of the pump is made of high-performance ceramic shaft with high precision and good shock resistance.

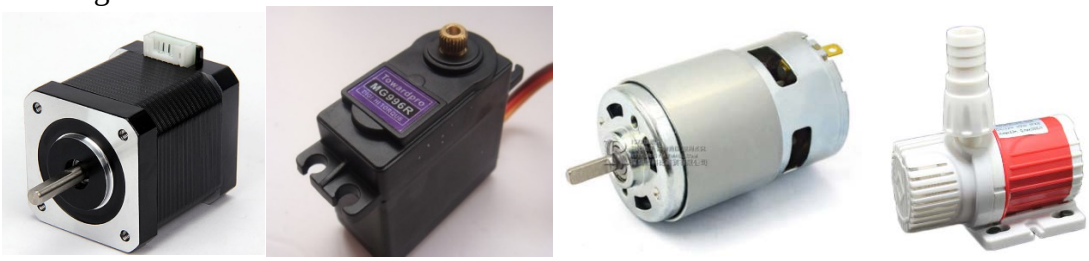


Figure 4. Picture of the main controller component

3. Software Design

3.1 Transmission dynamics analysis

During the work of the wall advertisement clearing robot, the transmission dynamics analysis mainly exists in the above three transmission mechanisms, in which the force in the screw transmission process is the largest. As shown in the picture, the screw drive member flange nut supports the entire lifting platform, and the lifting platform includes the entire X-axis moving device. As shown, the lifting platform structural components include the lifting platform aluminum alloy frame, the X-axis moving seat, the linear guide member, the clearing device components, and the mounting standard. The overall measure weight of the lifting platform is $Mg = 1.081\text{kg}$. The overall weight friction is negligible relative to the lifting platform. Therefore, the maximum pressure of the entire lifting platform is $F_{load} = Mg = 1.081 \times 9.8 = 10.594N$, where the gravity constant is $g = 9.8\text{N/kg}$.

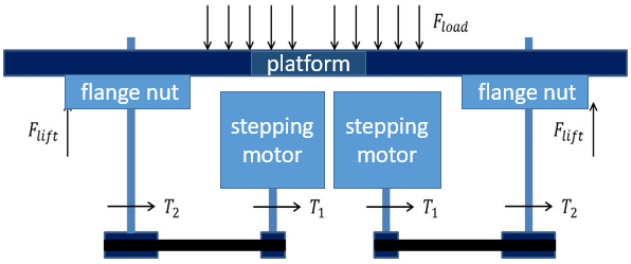


Figure 5. Schematic diagram of the force analysis of the screw

As shown in the figure, the static torque of the stepping motor is $T_1 = 0.6\text{N}\cdot\text{M}$, the number of teeth of the primary timing belt is $z_1 = 16$, the number of teeth of the secondary timing belt is $z_2 = 30$, the transmission torque of the screw is $T_2 = T_1 \times \frac{z_2}{z_1} = 0.6 \times \frac{30}{16} = 1.125\text{N}\cdot\text{M}$. Since the lead of the screw is L=8mm and the efficiency of the transmission is $\eta = 0.9$, the lifting force of the single

set of screw nut is $F_{lift} = \frac{20\pi\eta T_2}{L} = \frac{20\times\pi\times0.9\times1.125}{8} = 7.952\text{N}$. Since the device has two sets of devices which are arranged symmetrically left and right, the total lifting force is $F_{Output} = 2\times F_{lift} = 15.904\text{N}$. Comparing the total output liftng force with the total workload, because $F_{Output} > F_{load}$, the transmission force parameters meet the working requirements.

3.2 Processing Design

After building the hardware, we need to program the SCM to properly position and clean the wall advertisement clearing device. The software design of the system includes: software design of stepping motor drive module, servo module, position detection module and relay module. The overall structure of the software design is shown in the figure.

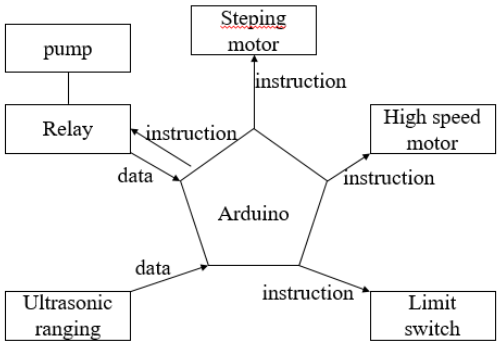


Figure 6. Overall structure of the software design

The specific operation flow chart of the software configuration in this design is shown in Figure 5-2. It mainly includes the initialization of the Arduino firmware; X and Y axis positions are cleared to protect the entire device; The job coordinates are determined according to the size of the small advertisement on the wall; According to the distance between the robot and the wall advertisement, the steering gear is ensured the effective contact between the steel brush and the wall, and the liquid supply and the clearing work are performed after the steel brush and the wall are in effective contact.

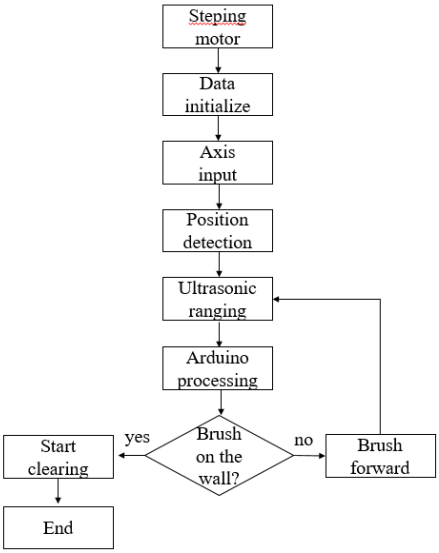
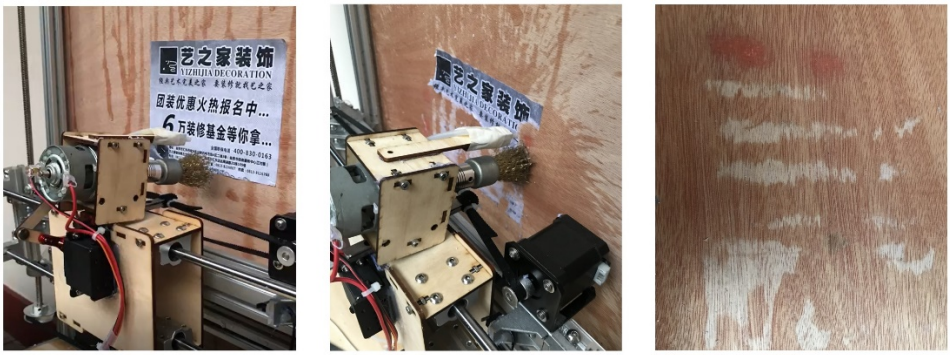


Figure 7. Overall structure of the software design

4. System Text

4.1 Robot clearance test

To verify the effect of the designed robot, a clearing experiment is carried out. And the test result is shown in figure.7



(a) (b) (c)

Figure 8. Effect of robot clearing wall advertisements

It can be seen that the wall advertisement clearing robot works well. As shown in Figure 6-1, Figure (a) shows the situation before the wall advertisement is cleared, Figure (b) shows the robot in the cleaning operation, and Figure (c) shows the effect of clearing the wall advertisement. The robot completed the removal of a 20cm x 15cm printing adhesive advertising paper in 3 minutes and 20 seconds. According to the experimental test results, the wall advertising removal robot is very effective.

4.2 Comparison test of manual and robotic job

A Comparison test of manual and robotic job is designed to verify the high performance of the robot. The test conditions are printing adhesive advertising paper 20cmx15cm, and test time is 3 minutes and 30 seconds.

(a)

(b)

Figure 9. (a) Picture at the beginning of the contrast test (b) Effect comparison of robot clearance and manual removal

It can be seen from the figure hat after the manual removal, there is still residual glue paper on the wall surface, the wall surface damage is serious, and there will be heavy scratches. The effect of robot clearing is better, there is basically no residue, and there is only slight wear on the wall.

5. Conclusion

There is still much space for improvement in the development of wall advertisement clearing robots. This design provides a simple and easy way to remove wall advertisements for small wall advertisements. And we did some tests and research work, summarized as follows:

(1) Solve the current problem that small advertisements are scattered all over the city, large in size and difficult to clean. In particular, it solves the problem of the inefficiency of manual clearing of small advertisements.

(2) Use ultrasonic ranging to make the brush and the wall effectively contact, the application effect is very good.

(3) Conduct research and implementation of the Arduino UNO as the terminal of the actual application;

(4) Use the control circuit to design and test the clearance of small advertisements.

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This project attempts to solve the problem of low efficiency of manual clearing small advertisements. At the same time, due to the good price of the Arduino, the cost is reduced when implementing this solution. Meanwhile, due to the expandability of the Arduino module, modules can be added and upgraded according to the actual effect.

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