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Design and Implementation of Medical Service Robot with Single Arm and Tracking Function*

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***Abstract* - Service robots are emerging from the laboratory as commercial products. This paper focuses on one such service robot for Medical service purposes; it introduces the tracing type single-arm medical service robot production process. All parts of the design have been simulated and implemented using Altera tools. The robot can accomplish a number of provisions of action such as tracing, localization, grasping, lifting, and flat. The production of the robot to complete the above action and some research process are discussed in detail.**

Index Terms* - *Service Robot; Tracking; Mechanical arm; Grasping; Localization

I. INTRODUCTION

The robot to perform different tasks with available computer and special system programmable device growing rapid recently, This new technology has many useful applications in various fields from military, civilian to industrial use..Chinese Academy of Engineering Song Jian pointed out: "the robot study progress and the application of automatic control in twentieth Century is the most convincing achievements, is the highest sense of automation ". Robot technology is a comprehensive technology of multidisciplinary development achievement, representing the high technology development forward, causing the recognized the role of robotics and influence. Medical robot is one of the important research directions [1-3]. This paper is a college student innovation training program outcomes, in participating in the national robot contest based on the completion of a medical robot design. The robot can accomplish tracing, localization, grasping, lifting, flat and the location of a number of provisions of actions. The practical test shows that the robot has good stability and accuracy. And it provides a helpful way of robot design.

II.ARCHITECTURE OF THE ROBOT

There are various design options for the locomotion mechanism, such as external/internal dual wheeled drives, external/internal four wheeled drives, and six wheeled drives [4-8]. In this robot design we use the external four wheeled drive which is experimentally found to be suitable for the service robot. The robot we made adopts a layer type construction method, the bottom layer is a motor driving module; the drive wheels are placed on each side of the robot platform. Above is the battery module; and above is the core board; the top is a mechanical arm. The whole Robot architecture is shown in Figure 1.

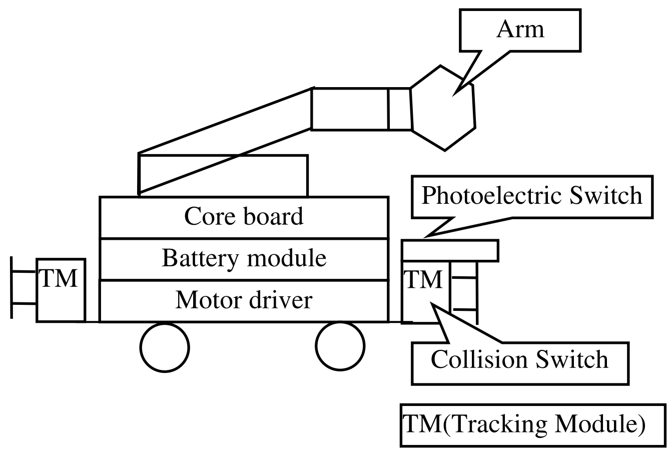

Fig. 1 Robot profile.

III. THE HARDWARE COMPONENT

A. *Driver module BTS7960*

Motor drive module is consisted with BTS7960 module. BTS7960 is a half-bridge driver chip; we used two piece of BTS7960 to drive a motor. Current is up to 43A, the resistance is very small, so small quantity of heat is emitted.

As shown in Figure 2, for the two block of BTS7960 synthetic full bridge driver module. Intelligent power chip BTS7960 is applied to the motor drive current half-bridge high integrated chip, our robot with four wheel drive, four BTS7960 respectively drive two motors, front and rear wheels through the transmission of the gear box. The benefits of doing so are the steering system, when one side of the wheel turn, the other side of the backwards wheel can turn quickly.

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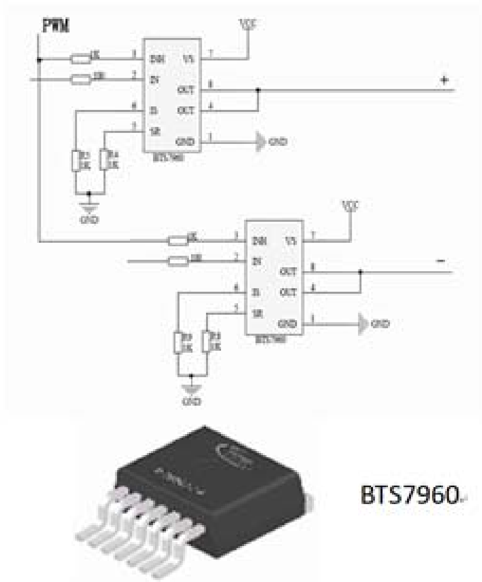

Fig. 2 Driver module

C. Mechanical arm

Our own production Mechanical arm is shown in Figure 3, a total of four servo machines. The three servo machines are used as the arm joints, 1# servo machine used as grip angle control.

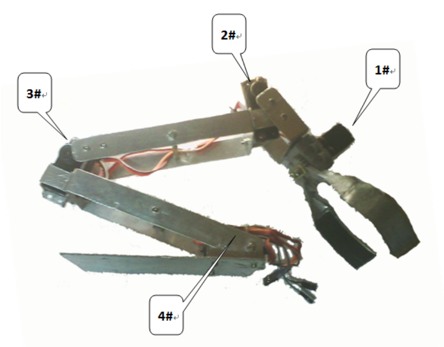

Fig. 3 Mechanical arm

Mechanical arm is aluminum alloy; it has light weight and high strength, not easy deformation and low cost. We used the MG945 servo machine. Mechanical arm adopted this practice; it can finish all the required action. The 1# actuator for gripping action, the other three actuators are responsible for lifting, stretching, contraction and other action. So, the mechanical arm can do flexible operation and can be easily controlled.

The Robot crawling process is described as follows: 2#, 3#, 4# servo machine to complete the function of lifting, uplift, to maintain the mechanical hand level, 2# and 4# parameters must always be a fixed value. Placement process and grasping process is similar, it will be discussed later.

D. Ultrasonic module

US-100 ultrasonic ranging module can realize 2cm~4.5m non-contact measuring function, It has 2.4~5.5V wide range of input voltage, static power consumption is lower than 2mA, with the temperature sensor on the measuring result is corrected, but with GPIO, serial and other means of communication, with a watchdog, stable and can work reliable. The front and back of US-100 ultrasonic ranging module is shown in Fig.4:


Fig. 4 Front and back of Ultrasonic module

Localization system is a component of a navigation system. It continuously supplies current positional data to the robot's computer, which makes course corrections based on this positional data. It scans its surroundings two-dimensionally through 360° by means of its rotational movement and detects fixed, defined, reflector marks. The system has a serial interface for connecting to the computer of the service robot. According to the body away from the wall distance to locate the robot, in this way it reach the target point. Our paper achieved the localization with wireless sensor network based on ultrasonic Ranging and RFID technology. The fixed nodes are arranged in the interior at the top arranged in a shape of triangle. The robot on the ground is arranged as unfixed nodes. Every node has a independent address. The fixed nodes and mobile nodes all have ultrasonic emit and receive equipment. So it constructs a WSN. Suppose the vertical distance is *h*, the distance to mark nodes is *R*,the maximum ranging of ultrasonic must exceed $\sqrt{h^2+r^2}$,the point angle $\phi \ge arctg(R/h)$ .according the arrangement in the roof. The robots can in the range of at least three nodes .so in this way the robots can get precise localization. The localization approach can be seen in Fig.5.

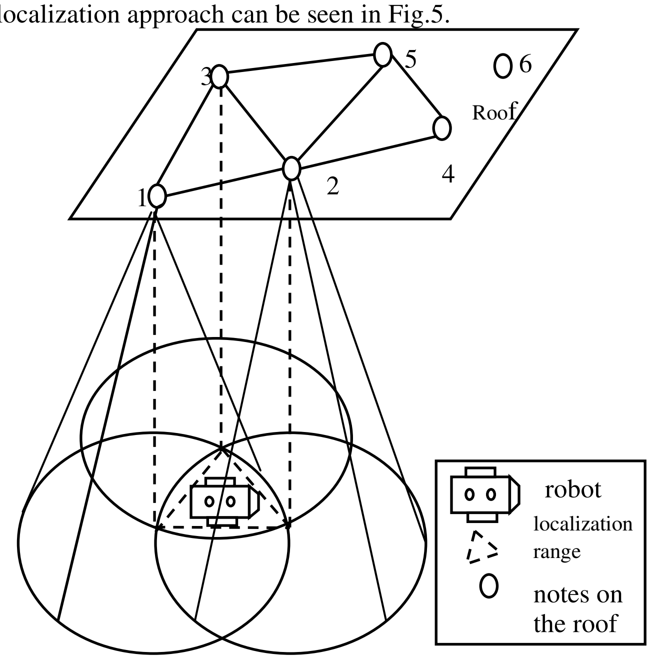

Fig.5 the Localization system

The robot mobile nodes transmit ultrasonic to the roof. Then the fixed nodes in the ultrasonic range are waked. The waked nodes transmit information (address and locating) to the robots. Then the robots know the location and address of these nodes. Robots control the waked nodes transmit ultrasonic and RFID Synchronous signal. Receive start timing when receive the Synchronous signal. Stop timing when receive the ultrasonic signal. Then according to the ultrasonic transmit time to count the distance of the nodes to the robot. Then, robots can compute its location (x, y) with the Trilateral measured approach. (x_1, y_1) , (x_2, y_2) , (x_3, y_3) is the fixed nodes of our known. The distance to the robot is d1, d2 and d3, and then we can get the equation as follows:

$$\begin{cases} (x_1 - x)^2 + (y_1 - y)^2 + h^2 = d_1^{\,2} \\ (x_2 - x)^2 + (y_2 - y)^2 + h^2 = d_2^{\,2} \\ (x_3 - x)^2 + (y_3 - y)^2 + h^2 = d_3^{\,2} \end{cases}$$

According to the theoretical analysis and experiments to validate, this approach is more accurate localization, so we chose it as our localization scheme.

E. The core board

Our core board is made using Freescale MC9S12X128MAL MCU, Freescale Series MCU using Harvard structure and instruction pipeline structure. It has shown a low cost high performance characteristic in many areas, its architecture for product development saves a large amount of time. In addition, Freescale offers a variety of integrated module and the bus interface can be in a different system more flexible role. It has following features: clock module (three modules, seven kinds of work modes), a variety of communication module's interface, with more optional modules, high reliability, and anti-interference, low power consumption. Below is our minimum system board:

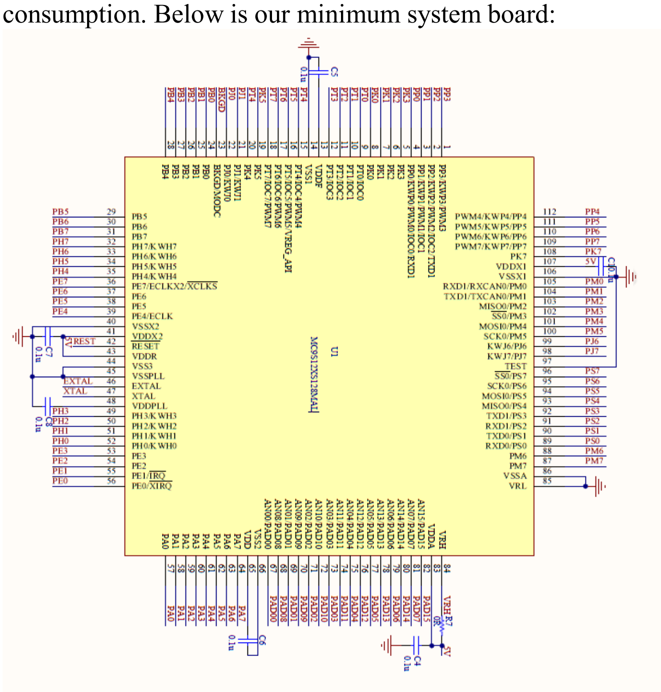

Fig. 6 minimum system board

F. Collision and photoelectric switch module

Collision switch is a robotic discipline with the objective of moving vehicles on the basis of the sensorial information. Three reflective infrared sensors are placed around the robot for obstacle avoidance. Three infrared sensors are numbered from 1 to 3 in a counterclockwise direction. If the obstacle is in front of the robot or on the left hand side, it will turn right. If the obstacle is on the right hand side, it will turn left.

The photoelectric switch is to improve the accuracy. The following is the overlooking schematic diagram:

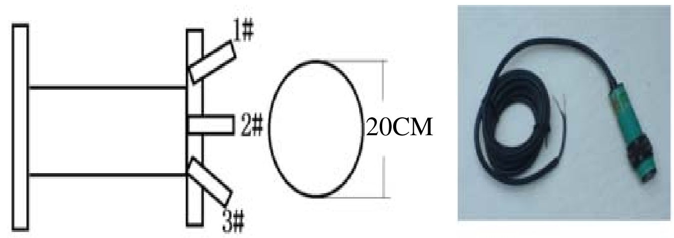

Fig.7 photoelectric switch

The body is arranged in front of the three photoelectric switches, the aim is to realize a certain precision, so that the mechanical arm gripping and placed the bottle can be accurate and proper.

IV. THE ROBOT CONTROL ALGORITHM

Control algorithm should take into account all limits mentioned above. Only feasible commands should be used. Simultaneously the control algorithm should be simple enough to allow fast reactions of the robots due to rapidly changing situation in the field.

Our algorithm flow chart is as follows:

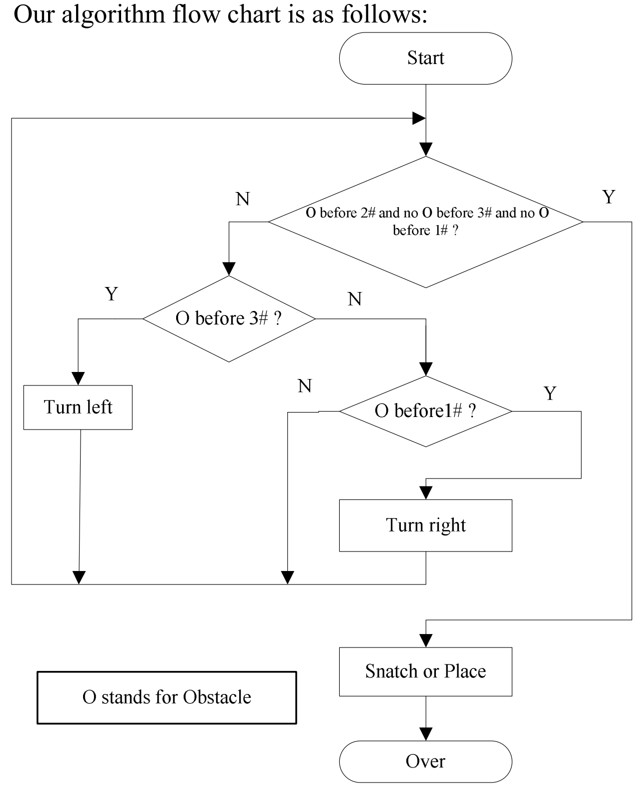

Fig.8 Control Algorithm

V. EXPERIMENTAL RESULTS

The prototype of Medical service robot was fabricated and experiments were conducted to evaluate the design concepts. The robot was programmed to run along a planned path. The robot is show in Fig.9.

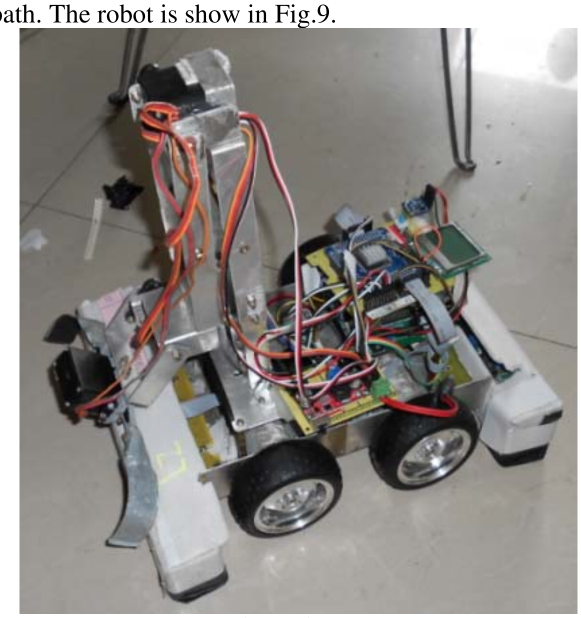

Fig.9 Robot prototype

The robot can travels in an average speed of 0.15m/s. then it can perform a number of actions. The navigation system of the robot is being tested in an indoor environment. The robot stops when there is an object in front of it at the distance of 40cm. It is able to perform 90°-turns when an obstacle is blocking the path. Pick and place task is being carried out to test the accuracy and efficiently of the robot. The precision of the robot to locate the object is dependent on the accuracy of the vision sensor system and proximity sensor system in identifying the position of the object.

Conclusion

The robot introduced in this article is based on Chinese medical service robot competition robot contest with the 2012 game rules[9] and the production of medical service robot. Works won the first prize in the competition of the good results. This paper introduces in detail the robot in the finish requirements tracing, localization, crawl, contraction, raising the compulsory technical details, which chuck ward and grab the bottle. Medical high-end robot R&D can draw lessons from the design of our Robot.

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