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# INTELLIGENT CONTROLLER OF ELECTRIC WHEELCHAIR FROM MANUAL WHEELCHAIR FOR DISABLED PERSON USING 3-AXIS JOYSTICK

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Abstract. *Patients who are unable to walk and accident victims need a wheelchair. However, the use of a wheelchair also needs to be considered about privacy and ease of use. In this paper, we propose an intelligent electric wheelchair using the joystick for general purpose and for the paraplegic patient who is paralyzed from the waist down due to a spinal cord injury or other circumstances. Our wheelchair is based on a manual wheelchair so it can be used in manual or electric mode. DC motor with a gearbox with a coupling system to the main wheel and 10 A driver can move this wheelchair with a 10-degree slope. The ultrasonic sensor is used for safety so that the user does not hit the barrier in front of him/her. Based on our development and experiment, this intelligent wheelchair is easy to be used. The maximum weight of the wheelchair capacity is 80 kg and max usage of duration is 30 minutes.*
**Keywords:** Electric wheelchair, Artificial intelligence, DC motor, Joystick

1. **Introduction.** Smart wheelchairs have been the subject of research since the early 1980s. Manual wheelchairs provide a relatively low-cost solution to the mobility needs of such individuals. An intelligent electric wheelchair is one of the assistive robotics technologies that solve the problem of privacy and simplicity for the patients. While the needs of many individuals with disabilities can be satisfied with traditional manual wheelchairs, a segment of the disabled community finds that it is difficult or impossible to use wheelchairs independently. To avoid obstacles, electric wheelchairs need sensors to perceive their surroundings. By far, the sensor most frequently used by smart wheelchairs is the ultrasonic acoustic range finder (i.e., sonar). Sonar sensors are very accurate when the sound wave emitted by the sensor strikes an object at a right angle or head on [1].

Some people with disabilities cannot use a manual wheelchair to navigate the wheelchair and they should use alternative control systems such as joystick [2,3]. Many types of research focus on how to navigate the wheelchair with various advantages and disadvantages, such as using EEG [4] and voice recognition [5]. Walter et al. proposed a framework for electric wheelchair using a voice-commandable wheelchair that enables robots to efficiently learn human-centric models of their environment from natural language descriptions. They are fusing high-level knowledge that people can uniquely provide through speech with metric information from the robot's low-level sensor streams. The robotic wheelchair learns the layout of the environment (hospital, rehabilitation center, home, etc.) through a narrated, guided tour given by the user or the user's caregivers [6]. Rabhi et al. [7] designed a device "hand gesture-controlled wheelchair" which is performed at low cost and has been tested on real patients and exhibits good results. Before testing the proposed

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control device, we have created a three-dimensional environment simulator to test performances with extreme security.

Coelho [8] made an intelligent wheelchair with the multimodal interface, and the user can control the wheelchair by using some input, like keyboard input, joystick input, gamepad, voice recognition, or combination of them. From the survey and evaluation, they found that joystick is the second highest result, to easily control the wheelchair. The highest result is by using a combination of them. Ruzaij et al. [9] made intelligent wheelchair dedicated for patients with disabilities like quadriplegia, paralyzed, amputee, and elderly that cannot use the joystick to control the electric wheelchair. They use voice control and head tilt controller, with an auto-calibrated algorithm, to make disabled people can control the wheelchair easily. Auto-calibrated algorithm simplifies the wheelchair movement while passing a hill and makes it similar to driving the wheelchair on a straight road with normal head tilt angles. Mounir et al. [10] used brain-computer interface with ultrasonic sensors to detect obstacles. So the wheelchair user can control the wheelchair using the EEG signal, and the wheelchair could automatically avoid obstacles near them. Elderly supportive intelligent wheelchair was proposed by [15], and the system is employed with joystick control interface and human interactive facilities to achieve the daily tasks of the user easily. In addition to that, human interactive facilities such as emotion detection, voice recognition, taking calls, checking the availability of meals and washroom from the point where the user stayed are deployed into the system.

The contribution of this research is the development of a low-cost intelligent wheelchair with simple algorithm based on joystick. If the user wants to use the wheelchair manually, they could use it without any change in hardware. The significance of this research is using coupling and without chain, and the advantage of the proposed method is easy to use the joystick and minimum voltage of power supply.

A clinical survey has shown that 10% of the patients cannot use the electric wheelchair in daily life activities and 40% of regular powered wheelchair users have difficulties with steering tasks such as passing through open doors, and nearly 9% of them find it impossible without assistance [11]. To accommodate those conditions, we present our research that successfully builds an electric wheelchair based on the manual wheelchair, and the manual wheelchair also still functioned. Figure 1 shows our prototype of intelligent electric wheelchair named as Ratanggalih V8.

We propose an intelligent wheelchair. Part 1 is an introduction about the problem in wheelchair and its demand, Part 2 is recent wheelchair technology, we proposed a method in Part 3, main result in Part 4 and the conclusion in Part 5.

Figure 1. Intelligent wheelchair named Ratanggalih. Demo video can be accessed at [12].

## 2. Wheelchair Technology.

2.1. **Joystick mechanism.** The issue of a manual wheelchair is about the privacy of the patient, if the patient is able to control the wheelchair itself, then he/she has more privacy of life. The trend of increasing intelligence has been encouraged by microcontrollers and sensors. For these reasons, many researchers have been working to find new, sophisticated control algorithms for easy handling of the wheelchair during the last 20 years. Our systems are designed with a low-cost microcontroller and driver modules and a 3-axis joystick with resistance value 5 K as shown in Figure 2. The specification of the joystick is Output Smoothness: 0.5% Maximum, X/Y Axis Electricity Corner: $+/-25°$, and Z-Axis Electricity Corner: $+/-45°$.

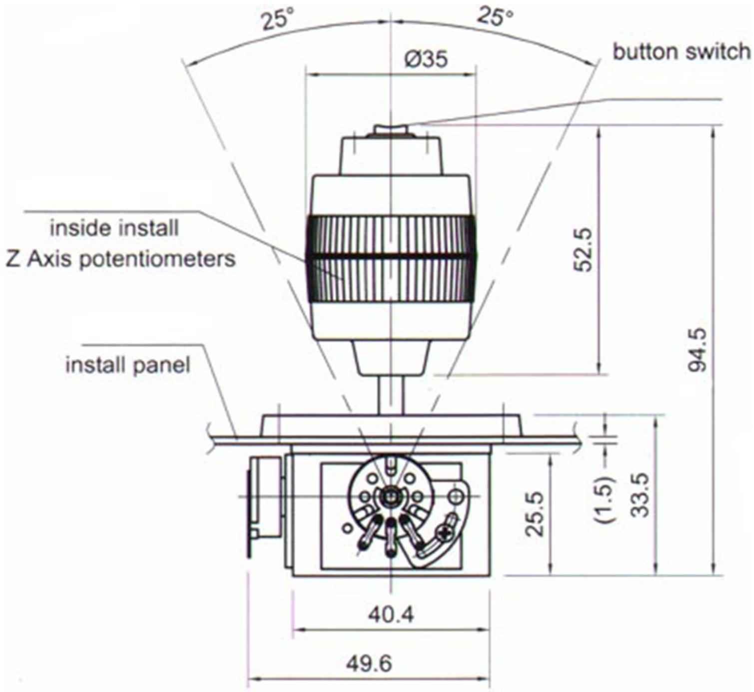


FIGURE 2. Three-axis joystick in the wheelchair [13]

2.2. **PID controller.** PID control is a mature and widely used engineering control method. On condition that the structure and parameters of the linear time-invariant system are known, it has good control performance, and the algorithm is simple and easy to realize. The adjustment object of the PID controller is the system error, a kind of scale, integral, differential adjustment rules, and the equation is

$$u(t) = K_P e(t) + K_I \int_0^t e(t)dt + K_D \frac{de(t)}{dt} \tag{1}$$

In the equation, $K_P$, $K_I$, and $K_D$ are the parameters of the PID controller, $e(t)$ the deviation input signal of the controller, $u(t)$ the control signal [14].

## 3. Proposed Method.

3.1. **Architecture.** In order of smooth movement, we control the speed of the wheelchair using Pulse Width Modulation (PWM). A Pulse Width Modulation (PWM) signal is a method for generating an analog signal using a digital source. We use minimum components, additional motor, and efficient power supply system's 12 V/10 A so that the weight of the wheelchair is light enough. The architecture of the intelligent wheelchair is shown in Figure 3.

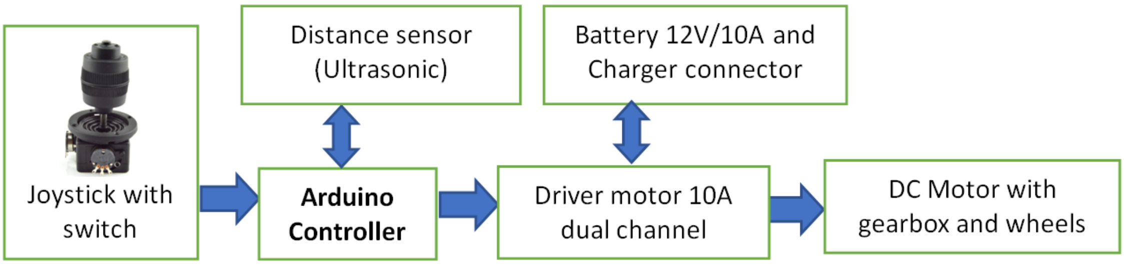


FIGURE 3. The architecture of the low-cost intelligent wheelchair using the joystick, PWM used as the controller of the motors

When the Joystick moves, the Joystick will trigger the Arduino Controller. Arduino will forward the command to the Driver motor, and the Driver motor will send the command to DC Motor to move according to the joystick. If the Distance Sensor (Ultrasonic) detects obstacle near the wheelchair, the Arduino will send the command to Driver motor to move, and Driver motor will send the command to DC Motor to avoid the obstacle. The driver motor gets the power supply from the battery and charger connector and will send the energy to the DC Motor.

The invention in this research is a model of the coupling between the manual wheel and the electric wheel and controlled only using 10 A dual channel as shown in Figure 4.

FIGURE 4. Power window motor with wheels coupled to the main wheels

3.2. **Algorithm.** First, the program will measure the obstacle in front of the wheelchair and detect the status of the joystick. The distance sensor can measure the distance between 3 cm – 3 meters. If no obstacle, then the wheelchair may move forward or move based on the patients' commands. Using the joystick, we can navigate the robot as shown in Algorithm 1.

**Algorithm 1. Intelligent electric wheelchair using 3-axis joystick**

Declare variables
configure input and output variables
status==on
configure PWM
begin
while status != stop
//measure the distance of the obstacle
call distanceSensor

```
begin
if joystick status = standby then
   call standBy
if joystick status = forward and distance > 30 cm then
   call forward
if joystick status = turn left then
   call turnLeft
if joystick status = turn right then
   call turnRight
if joystick status = back then
   call backward
end if
if buttonREset = true then
   status==stop
   call motorStop
endif
end
end while
end
```

4. **Main Results.** We conduct the experiment using a 12 V battery that charged fully and the wheelchair can be operated for about 1 hour. PWM signal used in our research is 20 kHz. DC motor with a gearbox with a coupling system to the main wheel and 10 A driver can move this wheelchair with a 10-degree slope. Based on our experiment, we successfully navigate the wheelchair using 3-axis joystick without error to control the direction (forward, left, right, stop, and backward).

This research successfully develops a low cost and multifunction wheelchair in dual mode (manual and electric). The main problem when developing an electric wheelchair is about the power of the motor and power consumption. So, choosing the right DC motor and coupling system in this model is very useful. From the experiment, the maximum weight capacity is 80 kg and max usage duration is 30 minutes.

5. **Conclusions.** DC motor with a gearbox with a coupling system to the main wheel and 10 A driver can move this wheelchair with a 10-degree slope. The ultrasonic sensor is used for safety so that the user does not hit the barrier in front of him/her. Based on our development and experiment, prototype of intelligent wheelchair is easy to be used. For future work, we will improve the mechanism to be able to lift a patient.

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