

Article

Design, Construction, and Testing of an Electric Wheelchair Operated by Arduino Uno R3 Microcontroller

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Abstract

The research aims to design and develop an electric wheelchair based on the Arduino Uno microcontroller as a mobility solution for individuals with disabilities. A conventional wheelchair was modified by integrating an electric drive system controlled by an analog joystick connected to the Arduino Uno and DC motors via a BTS 760 motor driver. The wheelchair design complies with ISO 7176-5 standards and is adapted to the anthropometric dimensions of Indonesian users. Test results indicate that the control system functions effectively, allowing responsive control of wheelchair movements forward, backward, left, and right according to joystick operation. However, several challenges were encountered during the chain adjustment and gear welding processes, requiring further development to achieve optimal performance. This study demonstrates that utilizing the Arduino Uno as the central control unit enables the production of an electric wheelchair at a more affordable cost.

Keywords: Electric wheelchair; microcontroller; Arduino Uno; joystick

INTRODUCTION

In 2020, the number of persons with disabilities in Indonesia reached 22.5 million, accounting for 9% of the total population [1]. A wheelchair is an assistive device designed for individuals with physical limitations or health conditions that hinder their walking ability [2]. Some persons with disabilities experience not only limited leg mobility but also restricted hand movement, which makes the use of conventional wheelchairs challenging in certain situations [3]. Therefore, a control technology is needed to ensure all persons with disabilities can operate a wheelchair effectively. The latest wheelchair technology incorporates an electric drive system, with electrical energy as the primary power source [4]. The trend of using electric wheelchairs has steadily increased in several countries each year [1], [5].

Several factors contribute to the growing adoption of electric wheelchairs, including improvements in ergonomic design, the availability of more advanced control features, and the integration of Internet of Things (IoT) technology for monitoring users' health. Additionally, users benefit from enhanced accessibility and mobility and increased safety awareness during operation [6], [7].

Previous studies have reported that electric wheelchairs are often powered by a microcontroller-based system and controlled using a joystick. Using a joystick allows the wheelchair to move in all directions, making it easier for users to maneuver [8]. Setiawan et al. [9] found that joystick-based control aligns well with wheelchair rotation. However, joystick operation still presents limitations for individuals who cannot use their fingers [9]. In addition to joystick controls, electric wheelchairs are equipped with integrated electronic components such as NodeMCU and voltage sensors, which connect to applications on Android smartphones [4].

High cost remains one of the main factors limiting the widespread adoption of electric wheelchairs. The high cost presents a challenge for developers to provide more affordable solutions. The present study aims to determine whether a conventional wheelchair can be converted into an electric wheelchair with the assistance of an Arduino Uno microcontroller.

Arduino Uno is a microcontroller board fully controlled by an Atmega328 chip. It features 14 digital input/output pins, each with specific functions, six of which can be configured as PWM (Pulse Width Modulation) outputs, and six as analog inputs. Additional components include a USB connection, a 16 MHz crystal oscillator, a power jack, an ICSP (In-Circuit Serial Programming) header, and a reset button. This device was selected because it can be easily connected to a computer via a USB cable or powered using an adapter [10].

Unlike previous studies that mainly emphasized the control aspect of Arduino-based systems or smartphone integration, the present work highlights the local adaptation of an electric wheelchair prototype. The main contributions of this study can be summarized as follows: (1) incorporation of Indonesian user anthropometry into the wheelchair design, ensuring ergonomic suitability and safety; (2) adoption of locally available components that simplify the assembly process and enable replication in small-scale workshops; and (3) demonstration of a lower production cost potential compared to most commercially available electric wheelchairs. Through these contributions, the study addresses the gap between advanced assistive technology and its accessibility in developing countries, promoting affordability and inclusivity.

The significance of this study lies not only in the implementation of an Arduino Uno-based control system but also in the design approach that

incorporates Indonesian anthropometric data and emphasizes simple, low-cost fabrication methods. This localized adaptation demonstrates the potential to produce an electric wheelchair that is both affordable and accessible, especially for communities in resource-constrained settings. Consequently, the research contributes to the broader development of assistive technology by providing a user-centered, cost-effective design model to enhance mobility and independence among people with disabilities.

METHODS

Components

This study employs an applied research approach in designing and developing an electric wheelchair assistive device for persons with disabilities, based on an Arduino Uno microcontroller. In this research, testing was conducted on the joystick's function as a motion controller. This test evaluates whether the joystick operates as intended.

The components used in the development of the Arduino Uno controller are listed in Table 1.

Table 1. Main components of the Arduino Uno controller

No.	Component	Type / Specification
1.	Wheelchair	Conventional
2.	Motor Driver BTS 760	H-bridge, 43 A
3.	Arduino Uno	R3
4.	Joystick	Analog
5.	DC Motor	24 V, 17 A
6.	Battery (Accu)	24 V

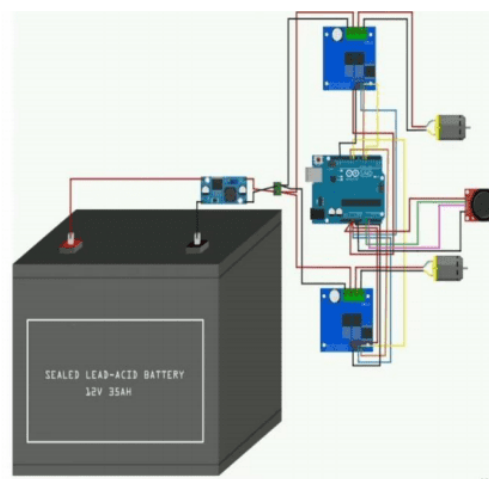


Figure 1. Control circuit diagram of the wheelchair

Design

Several factors must be considered in the design of a wheelchair. These include the shape of the wheelchair, the turning diameter required, the minimum maneuvering space, and the space needed for reverse movement. Based on ISO 7176-5 standards (Table 2) and the anthropometric measurements of the Indonesian population, the wheelchair dimensions can be determined as follows.

Table 2. Dimensional specifications according to ISO 7176-5

No.	Component	Type / Specification
1.	Wheelchair	Conventional
2.	Motor Driver BTS 760	H-bridge, 43 A
3.	Arduino Uno	R3
4.	Joystick	Analog
5.	DC Motor	24 V, 17 A
6.	Battery (Accu)	24 V

The wheelchair frame was constructed using $20 \times 20 \times 2$ mm hollow steel, with overall dimensions of 500×850 mm (width $\times$ length). The battery stand was fabricated with a $370 \times 160 \times 3$ mm base dimension. The wheelchair design was created using Autodesk Inventor software, as shown in Figure 2.



Figure 2. Design of the electric wheelchair

RESULT AND DISCUSSION

Production Results

The initial stage involved the fabrication of the drive mount, using a 5 mm thick steel plate cut into a rectangular shape measuring 10×8 cm. The battery holder was made from a 2 mm-thick angle plate with 37×16 cm dimensions. The joystick was then mounted on the wheelchair handle. The fabrication results for this control system are consistent with those reported by Mawardi & Lianda, with the main difference being the type of components used [11].

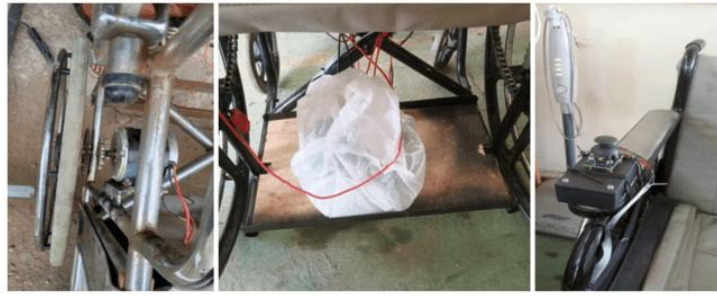


Figure 3. Fabrication of electric wheelchair components

The wheels were equipped with a connecting axle, with the fabrication process carried out using a lathe, and a chain of size 428 was employed. The assembly process utilized a DC dynamo, as only a limited number of wheelchairs currently incorporate this type of motor. The essential components supporting the electric wheelchair include the DC dynamo, Arduino Uno, BTS motor driver, battery, and joystick.

The electric wheelchair's operating principle begins with the electrical current supplied from the battery to the BTS motor driver, which then distributes power to the Arduino and the dynamo. The dynamo transmits rotational force from the small gear to the rear wheel gear, with movement controlled via the joystick. The study by Ferdiansyah & Susanto employed a similar working system for an electric wheelchair, in which the research focused on the design and development of a prototype wheelchair using the Arduino R3 with Android-based control. The difference lies in the motion controller, which, in their case, was integrated with a smartphone [12].

Research by Rieza Anara examined a robotic wheelchair with flex sensor-based motion control. To operate the wheelchair, commands were given through finger bending gestures. System testing of the robotic wheelchair achieved a movement success rate of 83.3% when using flex sensor commands [13].



Figure 4. Gear and prototype of the electric wheelchair

Microcontroller Programming

The movement system of the wheelchair involves a combination of wheel rotations to achieve the desired motion. The electric wheelchair can move forward, to the left, right, and reverse.

The user pushes the joystick forward to move forward, causing both electric motors to rotate and drive the small gears forward. To turn left, the user pushes the joystick to the left, causing the right-side motor to rotate while the left-side motor remains stationary. To turn right, the user pushes the joystick to the right, activating the left-side motor while the right-side motor remains stationary. Pulling the joystick backward commands reverse motion, causing both motors to rotate in the opposite direction. This operating principle is consistent with the findings of Setiawan et al [14].

Motion Testing

Table 3. Motion test results of the electric wheelchair

No.	Result	Analysis
1.	<pre> int dataX = map(averageX, 0, 1023, -255, 255); int dataY = map(averageY, 0, 1023, -255, 255); if(dataX > 0){ // Maju // Motor Kanan digitalWrite(R_ENA, HIGH); digitalWrite(L_ENA, HIGH); analogWrite(RPWMA, dataX); analogWrite(LPWMA, 0); // Motor Kiri digitalWrite(R_ENB, HIGH); digitalWrite(L_ENB, HIGH); analogWrite(RPWMB, dataX); analogWrite(LPWMB, 0); delay(100); } </pre>	When the joystick was moved forward, the Y-axis data exhibited the following variation: initially, the Y-axis value was -17. The Y-axis value increased from -17 to 255 after pushing the joystick forward.
2.	<pre> }else if(dataX < -9){ // Mundur // Motor Kanan digitalWrite(R_ENA, HIGH); digitalWrite(L_ENA, HIGH); analogWrite(RPWMA, 0); analogWrite(LPWMA, -dataX); // Motor Kiri digitalWrite(R_ENB, HIGH); digitalWrite(L_ENB, HIGH); analogWrite(RPWMB, 0); analogWrite(LPWMB, -dataX); delay(100); } </pre>	When the joystick was moved backward, the initial Y-axis value was -17. After the joystick was fully pulled backward, the Y-axis value changed to -255.
3.	<pre> }else if(dataY > 6){ // Belok Kanan // Motor Kanan digitalWrite(R_ENA, LOW); digitalWrite(L_ENA, LOW); analogWrite(RPWMA, 0); analogWrite(LPWMA, 0); // Motor Kiri digitalWrite(R_ENB, HIGH); digitalWrite(L_ENB, HIGH); analogWrite(RPWMB, dataY); analogWrite(LPWMB, 0); delay(100); } </pre>	In this program, only the left motor is set to move forward. With the left motor moving forward, the electric wheelchair will turn to the right. When the joystick was moved to the right, the initial X-axis value was -18. After the joystick was fully pushed to the right, the X-axis value changed to 255.

4.

```
}else if(dataY < -8){ // Belok Kiri
// Motor Kiri
digitalWrite(R_ENB, LOW);
digitalWrite(L_ENB, LOW);
analogWrite(RPWM, 0);
analogWrite(LPWM, 0);

// Motor Kanan
digitalWrite(R_ENA, HIGH);
digitalWrite(L_ENA, HIGH);
analogWrite(RPWMA, -dataY);
analogWrite(LPWMA, 0);
delay(100);
```

In this program, only the right motor is activated. When the joystick is moved to the left, the X-axis data initially registers a value of -19. After the joystick is fully shifted to the left, the X-axis data changes to -255.

The results of the Arduino-based motion test indicate that the program executes the motion commands as intended.

Joystick Testing

The joystick control system was tested to evaluate the correspondence between the given command and the movement of the joystick module lever in the desired direction. The results of the joystick control system testing are presented in Table 3.

Table 4. Joystick controller test results

No.	Joystick Command	Right Motor	Left Motor	Motor Rotation Pattern	Wheelchair Response
1.	Forward	Active (CW)	Active (CW)	Symmetrical	Moves forward straight
2.	Backward	Active (CCW)	Active (CCW)	Symmetrical	Moves backward straight
3.	Turn Right	Inactive	Active (CW)	Asymmetrical	Turns to the right
4.	Turn Left	Active (CW)	Inactive	Asymmetrical	Turns to the left

Based on the joystick control system testing results, where the check mark indicates motor rotation, the experiment was successful as the motors operated according to the joystick control inputs. When the joystick was set to move forward, both the right and left motors rotated clockwise (CW). Conversely, when the joystick was set to move backward, the motors rotated in a counterclockwise (CCW) direction. When the joystick was moved to the right, only the left motor rotated while the right motor remained stationary; likewise, when moved to the left, only the right motor rotated while the left motor remained stationary. Similar findings were reported by Rieza Anara [13] and Abdillah et al [15].

Despite these results, several shortcomings were identified in this study. One of the main limitations encountered in the prototype was the misalignment between the small gear and the rear sprocket during the chain adjustment process. This problem primarily resulted from inaccuracies in welding between the small gear and the motor shaft. Consequently, the gear position was not

perfectly aligned, leading to uneven force distribution on the chain. Such a condition generated excessive vibration during operation, reduced power transmission efficiency, and increased the risk of premature wear on both the chain and the sprocket. In terms of performance, the gear misalignment negatively affected the stability of wheelchair movement, especially during directional changes and low-speed maneuvers. The gear misalignment could compromise user comfort and, over the long term, pose a risk of mechanical failure.

To overcome these issues, several technical solutions are proposed. First, the use of a dedicated jig or fixture during welding can improve the accuracy of gear-to-shaft alignment. Second, replacing direct welding with a flexible coupling or standard hub sprocket may minimize positional deviations. Finally, applying precision machining to the gear mount could ensure better alignment tolerances. These improvements are expected to enhance system stability and extend the service life of the mechanical components in the electric wheelchair.

CONCLUSION

Based on the design, fabrication, and testing processes, this study successfully demonstrated the development of an electric wheelchair controlled by an Arduino Uno microcontroller and an analog joystick. With good responsiveness, the system effectively translated joystick inputs into accurate directional movements, including forward, backward, right, and left. The integration of Arduino Uno, BTS 760 motor driver, DC motor, and a 24 V battery provided a reliable electronic framework to convert a conventional wheelchair into an affordable electric-powered assistive device. This research also emphasizes the importance of local adaptation by incorporating Indonesian anthropometric data to ensure ergonomic suitability and user safety, while relying on locally available and easily assembled components that make replication feasible in small-scale workshops. In addition, the prototype demonstrates the potential for cost reduction compared to most commercial electric wheelchairs, which is particularly relevant for improving accessibility in resource-limited settings.

Nevertheless, the study observed some limitations, particularly gear misalignment and chain tension issues caused by welding inaccuracies, which affected operational stability. Moreover, the current testing primarily focused on motion response, whereas other performance parameters such as maximum speed, battery endurance, and load capacity were not comprehensively evaluated. These shortcomings indicate the need for further refinement in both the mechanical system and the scope of testing. Future work should improve fabrication precision, optimize power transmission, and integrate more adaptive control methods such as voice, EMG, or smartphone-based interfaces to

accommodate users with severe motor impairments. With such enhancements, the design has the potential to evolve into a more robust, safe, and inclusive mobility solution that contributes significantly to the independence and quality of life of persons with disabilities.

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