Integration System of Voice Recognition and DC Motor Control Using Fuzzy Logic on Smart Wheel Chair

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Abstract. The main problem experienced by persons with disabilities and disabilities is the limitation of doing all activities, in general they need the help of others to perform activities in everyday life. It causes dependence on others which impact on the lack of productivity and hamper their potential in their lives. Based on these problems it is necessary to contribute technological innovation as a solution to help facilitate the activity of disabled and disability patient. The use of fuzzy logic method on DC motor control system integrated with Bluetooth communication media system to Android Smartphone using Rasberry phi microcomputer system integrated with arduino microcontroller can be used on the result of technology research of automatic wheelchair control system that can be driven using, voice recognition based control Android smartphone. The test results are performed on several parameters such as DC motor movement, DC motor load capacity, integration of voice recognition communication to DC motor control system and sound intensity to Android Smartphone. The results of this research are expected to help facilitate the activities of the disabled or disability so as to increase their productivity.

1. Introduction

The main problem experienced by people with disabilities is the limitation in doing all activities, generally they need the help of others to perform activities in everyday life. It causes dependence on others who have an impact on the lack of productivity and hampering their potential in their lives, whereas many should have the potential to be developed. The number of persons with disabilities in Indonesia is categorized as high and may increase annually. Based on WHO data in 2014 there are 285 million people suffering disability and disability around the world and based on data from the Indonesian Ministry of Social Affairs there are 2.1 million Indonesians with leg defects and can not walk.

According to the Ministry of Education and Culture in "Reference Data of Special Education Unit Data (School) Per Province" there are 2,186 Special Schools (SLB) scattered throughout Indonesia
In addition there are also several campuses in Indonesia that began to implement the system of "campus inclusions" where students with disabilities including visually impaired can follow regular lectures, following the inclusive campus data in Indonesia:

Table 1. List of universities that apply the concept of inclusion

| No | Nama Perguruan Tinggi | Alamat                          |
|----|-----------------------|--------------------------------|
| 1  | UNNES (Universitas Negeri Semarang) | Semarang, Jawa Tengah          |
| 2  | UNS (Universitas Seska Maret) | Surakarta, Jawa Tengah         |
| 3  | UNIBRA (Universitas Brawijaya) | Malang, Jawa Timur             |
| 4  | UIN Sunan Kalijaga (Universitas Islam Negeri) | Sleman, Yogyakarta |
| 5  | UAD (Universitas Ahmad Dahlan) | Bantul, Yogyakarta             |
| 6  | UNIGA (Universitas Garut) | Garut, Jawa Barat              |
| 7  | UNAIR (Universitas Airlangga) | Surabaya, Jawa Timur           |
| 8  | UM Surabaya (Universitas Muhadyiah Surabaya) | Surabaya, Jawa Timur |
| 9  | UI (Universitas Indonesia) | Depok, Jawa Barat              |
| 10 | UNI (Universitas Negeri Jakarta) | Jakarta Timur, Jakarta         |
| 11 | UIN Syarif Hidayatullah (Universitas Islam Negeri) | Tangerang Selatan, Banten |
| 12 | UPI (Universitas Pendidikan Indonesia) | Bandung, Jawa Barat |
| 13 | UNM (Universitas Negeri Makassar) | Makasar, Sulawesi Selatan      |
| 14 | UGM (Universitas Gajah Mada) | Yogyakarta, Yogyakarta        |
| 15 | UNPAD (Universitas Padjadjaran) | Bandung, Jawa Barat            |
| 16 | UNSU (Universitas Negeri Surabaya) | Surabaya, Jawa Timur           |
| 17 | UDINUS (Universitas Dian Nuswantoro) | Semarang, Jawa Tengah         |

Figure 1. Special Education Force (School) For Top 5 Province Data
As a solution of these conditions it is necessary a breakthrough technology research that can bridge to meet the needs of people with disabilities and disabilities in living their daily activities. In its development there are researchers who discuss about medical. One of them is Pramujo Day which discuss about "Implementation of Fuzzy Logic Controller in DC Motor For Electric Wheelchair Movers Equipped With Safety Distance System" Surabaya State Electronic Polytechnic, 2007. Pramujo Day discusses about automatic wheelchair using joystick as the tool of the wheel drive.

The result of our technology research is an automated wheelchair control system that can be driven using voice recognition based on Android smartphones is expected to help facilitate the activities of the disabled or disability so as to increase their productivity. The use of fuzzy logic method on DC motor control system can make the efficiency of Torque in DC motor. The communication media system between the inputs of the DC motor integrated with the Android Smartphone uses serial Bluetooth communication. The integration system uses Rasberry phi microcomputer system integrated with arduino microcontroller. This research is expected to be developed into a ready-to-use commercial healthcare product and can reach a wide range of user backgrounds, ranging from people with disabilities and stroke.

2. Methodology

In this technology research system integration using the concept of fuzzy logic method on DC motor control system. The use of fuzzy logic can be tailored to the needs of DC motor controls on smart wheelchair control systems.

2.1 Basic Concept of Fuzzy Logic

Fuzzy logic was first introduced by prof. Lotfy A. Zadeh from the University of California at Barkeley (1965). Unlike Boolean logic which only divides a state into two conditions ie 0 and 1, fuzzy logic gives the possibility of a state in the interval between 0 and 1. Here is an illustration of the difference:

![Figure 2. Difference Between Boolean Logic and Fuzzy Logic](image)

In boolean logic, the temperature of 69.9 °C is categorized as Warm, and 70.1 °C is categorized as Heat. This small difference will cause a significant reaction to the system. While the fuzzy logic temperature of 69.9 °C and 70.1 °C fall into the same category as Warm as well as Heat and is considered in the same temperature, so it will not cause a meaningful reaction for the system.
1. **Crips Input**: Firm and specific inputs (such as 90 degrees)
2. **Membership Function**: The definition of a fuzzy set by mapping out crisp input from its domain to its membership degree.
3. **Label**: The name of a membership function.
4. **Scope/Domain**: Wide membership function.
5. **Degree of Membership**: 
6. **Function**: The degree of membership where the crisp value is compatible with the membership function (from 0 -> 1).
7. **Universe of Discourse**: The universe of conversation is the range of inputs that may enter into the system.

### 2.2 Design Fuzzy System

To design a fuzzy system, there are three steps that must be done is fuzzification, rule evaluation and defuzzification. The following figure shows the three stages along with the parameters required in each stage.

**Figure 3.** Steps of Fuzzy Logic

1. **Fuzzification**: Processing crisp input into fuzzy input in the form of membership function
2. **Rule Evaluation**: Stages of use of rules to determine what control actions to perform in response to inputs.
3. **Defuzzification**: The last stage after rule evaluation is defuzzification. In defuzzification, all significant fuzzy outputs will be combined into specific output variables. One commonly used defuzzyfication technique is the Center of Gravity (COG) method.
2.3 Research Methods

Methods and concepts of research used in voice recognition integration system and motor control dc using fuzzy logic that is as follows:

3. Result and Discussion

In the results and discussion of this research we will explain some of the experiments we have done on some hardware and software parameters.
3.1 Ultrasonic Sensor Testing Trial
To know the automatic braking system using ultrasonic module HC-SR04 whether it works or not, is doing the test by comparing the actual distance with the measurement results using LCD display readings.

Experiment reading LCD display using program code below.

digitalWrite(TRIGPIN, LOW);
delayMicroseconds(2);
digitalWrite(TRIGPIN, HIGH);
delayMicroseconds(10);
digitalWrite(TRIGPIN, LOW);
int distance = pulseIn(ECHOPIN, HIGH);
lcd.setCursor(0,0);
lcd.print(distance / 58, DEC);
lcd.print("cm");
distance= distance/58;
H2=250-distance;

The results of the experiment by comparing the reading on the LCD display with the actual distance from the measured data recorded in Table 3.1 below

| No. | Measurement | LCD Display | Error % |
|-----|-------------|-------------|---------|
| 1.  | 10 cm       | 11 cm       | 10%     |
| 2.  | 50 cm       | 49 cm       | 2%      |
| 3.  | 100 cm      | 103 cm      | 3%      |
| 4.  | 150 cm      | 155 cm      | 3,33%   |
| 5.  | 300 cm      | 310 cm      | 3,33%   |

From the table above, the biggest error rate is 10%. With the following formula:

\[
\text{Error \%} = \left( \frac{\text{Measurement}}{\text{LCD Display}} \right) \times 100\% \quad (3-1)
\]

3.2 DC Motor Testing Trial
To drive a wheelchair requires 2 DC motors. In order for the DC motor to work properly and correctly, it must be tested motor movement in several directions rotate. Based on the tests performed get the results according to the data table 4.

| No. | Navigation | motor 1     | motor 2     | Result   |
|-----|------------|-------------|-------------|----------|
| 1.  | Forward    | Left Rotate | Right Rotate| success  |
| 2.  | Back       | Right Rotate| Left Rotate | success  |
| 3.  | Right Rotate| Right Rotate| Right Rotate| success  |
| 4.  | Left Rotate| Left Rotate | Left Rotate | success  |
| 5.  | Stop       | Stop        | Stop        | success  |
DC Motor Testing can be said to succeed if the DC motor can move in accordance with the directions navigation command. Based on the tests that have been done DC motor testing can work according to the instruction command with 100% success rate.

3.3 DC Motor Load Test
In order for the wheelchair to run properly when uplift the patient's burden, we need to test the load resistance on the DC Motor. Giving a load on the DC Motor aims to get the data weight of the maximum weight of patients who can use a wheelchair. Based on the test conducted on the DC Motor load get the results according to the data in table 4

| NO | Load (kg) | Success | Not Success | Time (second) |
|----|-----------|---------|-------------|---------------|
| 1  | 45 kg     | √       | -           | 6.38 (second) |
| 2  | 50 kg     | √       | -           | 7.29 (second) |
| 3  | 55 kg     | √       | -           | 8.81 (second) |
| 4  | 60 kg     | √       | -           | 9.25 (second) |
| 5  | 65 kg     | √       | -           | 11.39 (second) |
| 6  | 70 kg     | √       | -           | 14.15 (second) |
| 7  | 75 kg     | -       | √           | ∞*            |

The result of load test on DC motor according to table 3.3. with the initial load of 45 kg and 3 meters distance generated travel time about 6.38 seconds. At the time of 75 kg load, the motor does not move so it can be concluded that the maximum load on the DC motor is 70 kg.

3.4 Voice Recognition Algorithm Testing using Android Smartphone
Testing of voice recognition function To know whether patient voice can be detected using android smartphone, there are several steps that must be done in this testing process, among others:

1. Opening the voice recognition app on Android Smartphone.
2. Google Talk settings.
3. Turn on bluetooth configuration.
4. Setting Bluetooth Module Configuration.
5. Test voice commands by bringing the sound on the android smartphone by giving voice commands forward, backward, right and left.
   a. If the right voice command will display right on the smartphone.
   b. If the left voice command will display the left text on the smartphone.
   c. If the voice command is advanced then it will appear forward writing on the smartphone.
   d. If the voice command is backed down it will appear retrograde on the smartphone.
   e. The program code used in the test is:
      
      ```python
      x = cv.GetSpatialMoment(moments, 1, 0)
      y = cv.GetSpatialMoment(moments, 0, 1)
      if 130 <= x <= 170
         if y >= 105
            print "maju"
         else
            print "mundur"
      elif x < 130
       ```
if y >= 105
    print "kiri"
elif x > 170
    if y >= 105
        print "kanan"
Detection of voice command testing is very influential on the accuracy in the process of scanning the sound on the smartphone. If the sound detection parameters are as expected then the voice command will be readable.

3.5 Overall System Testing
Testing the system as a whole is testing in accordance with the system workflow that is testing system integration between hardware and software system. To know the level of accuracy and success of integration system based on voice recognation need to be experimental system as a whole, that is by combining between hardware and software.

Integration testing between software and hardware using integrated Bluetooth serial communication media using Arduino microcontroller system and Rasberry Phi microcomputer system.

![System Input](Voice Recognition) ➔ Control System (MikroComputer & MicroController) ➔ Output System (Movement DC Motors)

**Figure 5. Schematics of Work Principle System**

The first step of testing this system integration is to test the sound intensity around to know the level of reading voice commands on Android smartphone. Based on experiments that have been done to get data in accordance with table 5 below:

**Table 5. System Testing Tests Against Changes in Sound Intensity**

| No. | Sound Intensity | Result Detection |
|-----|-----------------|------------------|
| 1.  | < 10 Wm-2       | Failed           |
| 2.  | 11 Wm-2         | Detected         |
| 3.  | 12 Wm-2         | Detected         |
| 4.  | 14 Wm-2         | Detected         |
| 5.  | > 15 Wm-2       | Failed           |

Description: on frequency 1000 Hz

Failed = the process of reading voice command not detected.
Detected = process of reading voice command detected.

From the above experimental table it is known that the system can work with the sound intensity of 11-15 Wm-2. At low sound intensity the success rate of voice command detection did not work because the voice command detection algorithm did not work properly so no sound type was detected.

The next test is a hardware system test to determine the results of reading voice commands that are integrated with DC motors. The test will be done 10 times using the following formula:
Success Rate = \left| \frac{\text{Amount Data} - \text{Amount failed Data}}{\text{Amount Data}} \right| \times 100\% \quad (3-2)

The system can be said to succeed if the change of movement of voice command followed by wheelchair movement according to voice command given. Results From 10 times the test, get the results as in the following table:

**Table 6. Integration Voice Recognition and DC Motor Data Trial**

| No. | Change of Movement Based Voice Recognition System | Motor DC Action | Data Result | Success |
|-----|-----------------------------------------------|-----------------|-------------|---------|
| 1.  | Forward                                      | Forward         | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ | 100%    |
| 2.  | Back                                         | Back            | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ | 100%    |
| 3.  | Right                                        | Right           | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ | 100%    |
| 4.  | Left                                         | Left            | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ | 100%    |

Description :  
✓ = Success  
X = Failed

Calculation : 
Success Rate = \left| \frac{10-0}{10} \right| \times 100\%  
= 100\%

From table 6 data, it can be seen that the test result is done by moving forward, backward, right and left. All of these can work with a variety of conditions including the sound intensity conditions at 11-15 Wm-2 and the specified patient load according to the load test data in Table 4.

4. Conclusion

1. Test results on DC motor control using fuzzy logic for forward control system control, reverse, turn right and turn left running in accordance with the program logic.
2. Ultrasonic sensor testing results as automatic brake control can detect the maximum distance as far as 300 cm with a margin error of 6%
3. From the tests performed on each voice command that has a different intensity, the system can work with a success rate of between 80% to 100% at the sound intensity of about 11-15 Wm-2.
4. Overall testing results include testing that integrates hardware and software that is testing the input system in the form of voice commands using android smartphone and Bluetooth serial communication with test output system that is the motion of DC motor according to the input command and from the test results obtained error percent between 0 to 5%.
5. Based all test results obtained conclusion that voice recognition integration system with DC Motor control using fuzzy logic suitable for use in smart wheelchair system which will be used by disabled people.
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