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Implementation of Exponential Moving Average Filter in DC Motor Speed Reading for Smart Wheelchair Movement

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Abstract—In controlling the speed of the wheelchair, a speed sensor is needed to read the speed of the wheelchair. The speed sensor used in this research is the encoder sensor. In the speed reading using the encoder sensor directly there is noise generated so that the speed reading is less accurate. Various methods are used to overcome noise so that the system can provide better output quality. Good output quality has a significant impact on the measurement or reading of the data carried out, especially in sensor readings using a microcontroller to take measurements or reading signals mixed with noise. Therefore, the purpose of this research is to reduce the noise that occurs in every reading of the encoder sensor value on the microcontroller so that the motor speed reading on the wheelchair can be better. The method used to reduce noise on speed readings with an encoder sensor using the Arduino Mega2560 microcontroller is the exponential moving average (EMA) method or the exponential smoothing method (Exponential Smoothing). The results of motor speed readings can be refined using an EMA filter with α value of 0.1 with a sampling frequency of 0.05 seconds.

Keywords—encoder; speed; noise; Smoothing; EMA filter.

1. INTRODUCTION

In the current era, there have been many developments regarding wheelchairs such as electric wheelchairs with joystick-controlled commands [1], wheelchairs with voice instructions [2], wheelchairs with head gestures as the driving command [3], and so on. In Arum Patmadani research [4] adjusted the speed of the wheelchair with the aim of user comfort using Sugeno fuzzy logic. Mochamad Ilman Arzak [5] in his research designed a wheelchair that can be controlled using brain waves using the fuzzy method while controlling the DC motor using the PD (Proportional Derivative) control method. In A.M.N Imron research, [6] conducted an electric wheelchair movement speed regulation based on subject intention variable speed using a bioelectrical impedance signal. M. Chen, T. Jiang, and W. Zou [7] proposed a system capable of generating a secret key based on the exponential moving average (EMA) on a wireless network. Where the results of this study indicate that the EMA method applied can provide a stronger secret key offer. Aufa Nizar Faiz, Rizal Maulana and Fitri Utaminingrum [8] The signals received by EMG have noise that can interfere with detection, so signal smoothing is needed in the form of an exponential moving average (EMA) method. Joko Sulistyo [9] in his research used SMA and EMA filters to reduce random noise that occurs in the reading of the electrode sensor resistance value. In the research of Belyaev Alexander [10] analyzed the quality of noise signal recovery with an exponential moving average filter.

Smart wheelchairs include a speed control feature where the wheelchair speed reading is needed for feedback in the speed control system. In the speed reading required a speed sensor. The speed sensor used is the encoder sensor and Arduino Mega as the microcontroller. In this research, using an EMA filter to smooth the encoder sensor readings on the Arduino Mega2560 microcontroller so that the speed of the motor used in the wheelchair can be read more accurately.

2. MATERIALS & METHODS

2.1 Hardware Description

In the mechanical design that is done, namely modifying a standard wheelchair by installing a DC motor on the wheels. The DC motor is coupled to the wheel by means of a gear connected to a chain. the gear ratio of a DC motor to a wheel is 16 to 40, so the rotation ratio between a DC motor and a wheel is 1:2.5. In Figure 1 it can be seen that a DC motor is connected to the wheels using a chain.

Figure 1. Wheelchair modification

2.2 Electrical Design

The design of the smart wheelchair electrical system is based on the system design block diagram as shown in Figure 2. The electronic components used in the smart wheelchair design include an internal Encoder Sensor, Arduino Mega 2560, motor driver module, DC motor, 24 Volt and 5 Volt power supply. The encoder sensor is used to read the speed of the DC motor to be used as feedback for speed control. The encoder sensor used is an internal encoder sensor that is mounted on a DC motor and has 7 pulses per rotation. Motor speed reading data can be searched based on the encoder pulse reading in pulse units shown in Equations 1 and 2 [4]

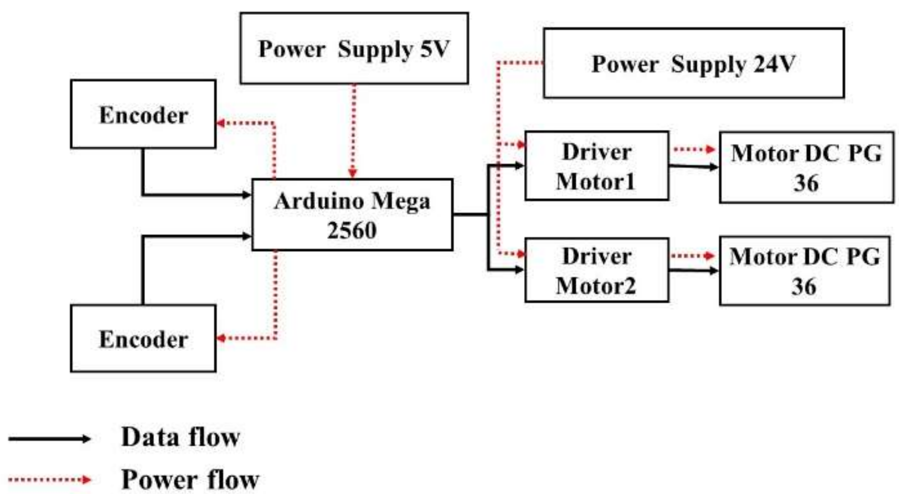

Figure 2. Block diagram of system

$$rps = n_{enc}\ x\ \frac{1}{p\ .T_s} \quad (1)$$

$$rpm = n_{enc}\ x\ \frac{1}{p\ .\ T_s}\ x\ 60s \quad (2)$$

. Where rps is the speed in revolutions per second, rpm is the speed in revolutions per minute, n_{enc} is the reading value of the encoder sensor, p is the number of encoder pulses in one motor rotation and Ts is the time of data sampling by the microcontroller.

Arduino Mega 2560 is used as the main microcontroller for processing the motor speed reading program by the encoder sensor and controlling the motor speed with the speed control system. For the software used to program Arduino, Arduino IDE is used with programming language C language. The configuration of the pins used can be seen in Table 1. For the microcontroller power supply, sensors and motor drivers are obtained from a power bank with an output voltage of 5V while the power supply is 5V. The power used for the two motors is two 12Volt 12Ah batteries connected in series so that the output voltage becomes 24 Volts.

Table 1: Configuration pin of Arduino

Arduino Mega2560	Device
13 PWM	RPWM Driver Motor1
12 PWM	LPWM Driver Motor1
11 PWM	PWM Driver Motor1
10 PWM	RPWM Driver Motor2
9 PWM	LPWM Driver Motor2
8 PWM	PWM Driver Motor2
2 Interrupt	Ch A Encoder Motor1
3 Interrupt	Ch B Encoder Motor1
21 Interrupt	Ch A Encoder Motor2
20 Interrupt	Ch B Encoder Motor2

2.3 Exponential Moving Average (EMA)

In reading the speed of the speed sensor, an Exponential Moving Average (EMA) digital filter is used [11] In reading the speed of the speed sensor, an Exponential Moving Average (EMA) digital filter is used. The exponential filter is a simple recursive linear filter which is commonly used in time region analysis to refine velocity readings using Equation 3 [11]. The smaller the value α of used, the more stable the analog value read will be. However, it should be noted that the smaller the value α of is given, the longer it takes to get to a stable condition.

$$St_1 = Xt.\alpha + \ (1 - a)St_0 \tag{3}$$

Description:
St_1 = current calculation
α = smoothing constant (0-1).
Xt = data to be smoothed in period t.
St_0 = previous calculation

3. Results and Analysis

The test is carried out by providing a Pulse Width Modulation (PWM) value of 50 to the motor driver to drive the DC motor then the motor speed is read using an encoder sensor whose results are filtered using EMA in the Arduino program. The test is carried out by providing variations in the α value and with a sampling frequency of 0.05 seconds. The indicator pays attention to the smoothed signal and pays attention to the time required in the process of stabilizing (smoothing) a data containing noise. Because one of the risks of reducing the α value, namely the time it takes to get to a stable condition, will require a relatively longer time.

3.1 Without EMA

The results of motor speed readings without using an EMA filter can be seen in Figure 3. The readings experience oscillations with speed readings that jump in a fast time.

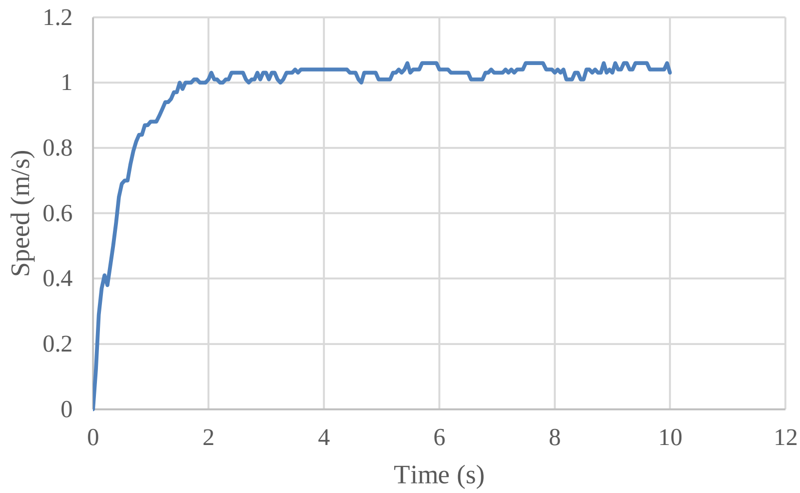

Figure 3. Response results without EMA filter

3.2 With α 0,9

The results of motor speed readings using an EMA filter with a value of 0.9 can be seen in Figure 4. The reading results are still experiencing oscillations with speed readings that jump in a fast time. Just a slight refinement change.

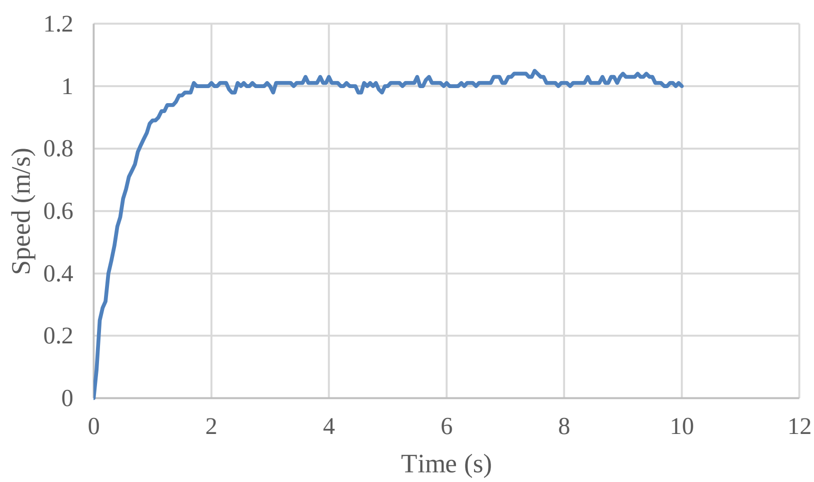

Figure 4. Response result with α 0.9

3.3 With α 0,7

The results of motor speed readings using an EMA filter with a value of 0.7 can be seen in Figure 5. The reading results are still experiencing oscillations with speed readings that jump in a fast time. Just a slight refinement change.

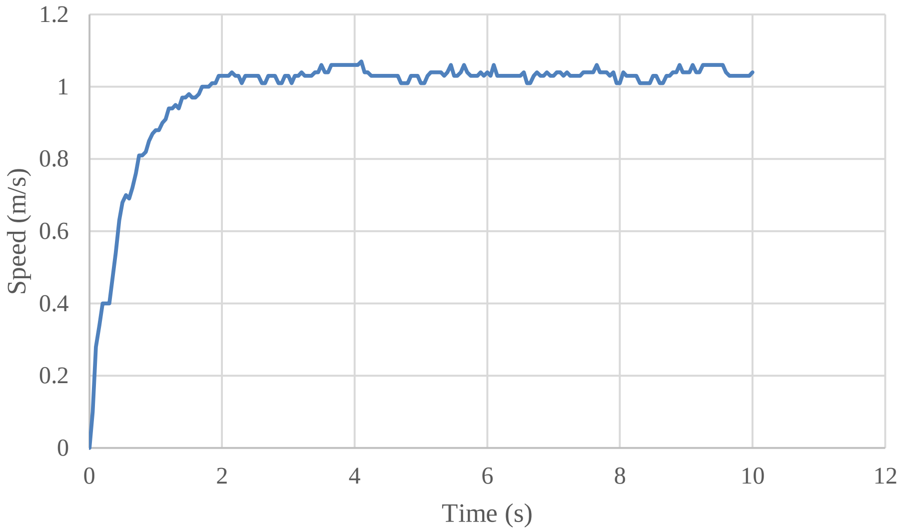

Figure 5. Response result with α 0.7

3.4 With α 0,5

Hasil The results of motor speed readings using an EMA filter with a value of 0.5 can be seen in Figure 6. The reading results are still slightly oscillating but there are changes in smoothing.

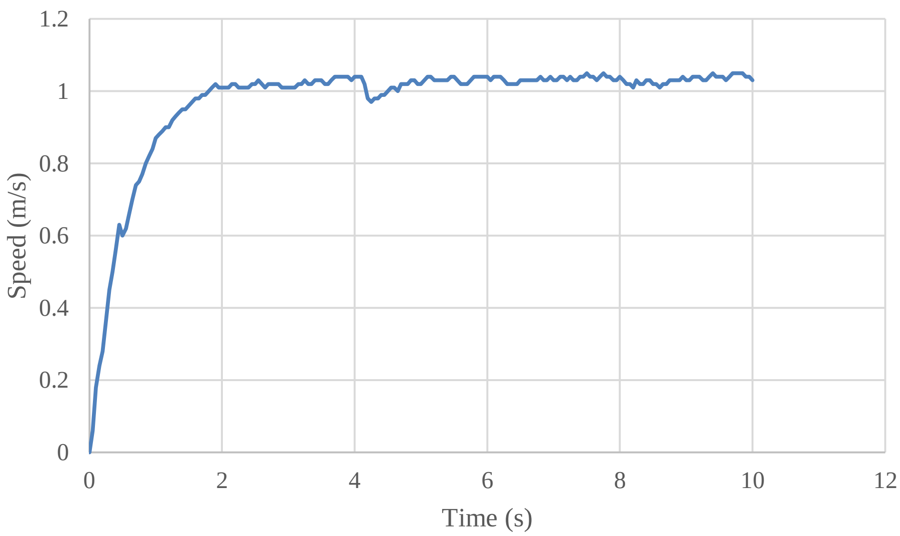

Figure 6. Response result with α 0.5

3.5 With α 0.1

The results of motor speed readings using an EMA filter with a value of 0.1 can be seen in Figure 7. The readings are no longer oscillating and there is a fairly good smoothing.

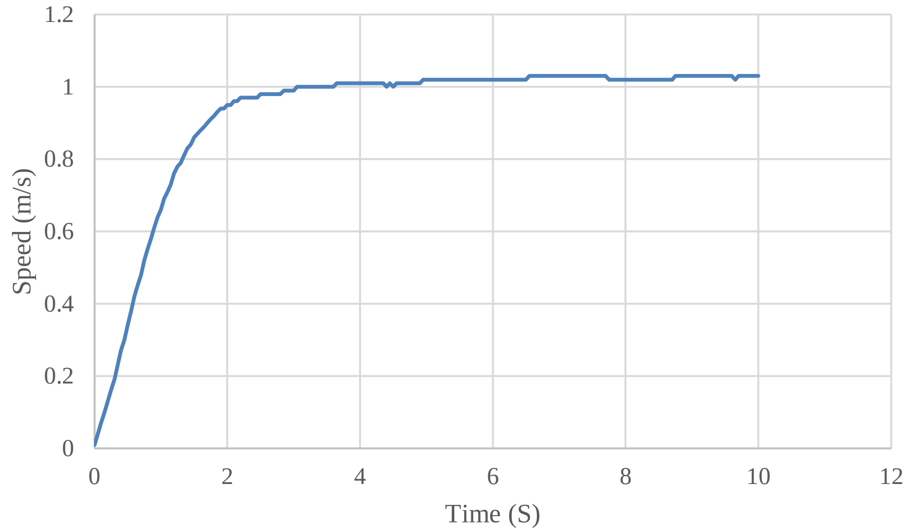

Figure 7. Response result with α 0.1

4. CONCLUSION.

Based on the results of the tests carried out, the EMA filter is able to refine the speed readings from the encoder sensor used. The smoothing with the EMA filter is affected by the α value. The greater the α value given, the time needed to get to a stable condition will be relatively longer, so the selected sampling frequency must be faster. In this research, the sampling frequency used is 0.05 seconds by choosing an α value of 0.1, so the results of the motor speed readings can be better, namely not experiencing oscillations but the time needed to achieve stability is a little longer.

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