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Mechanism and Statistical Analysis of a New Device for Measuring Slippage Ratio in Tractors

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Abstract

Tire slippage ratio is an essential factor determining the vehicle's efficiency and stability, especially when driving off roads. Usually, the slippage ratio is measured using the traditional method and their efficiency depends mainly on the human factor. In the current experiment, the mechanism and statistical analysis of a new electrical device that can calculate the RPM in wheels using magnetic sensors to send information to the microcontroller is determined. This is done to compute the data and send it through Wi-Fi to the clouds for final computing to find the slippage ratio. All data are accessible anywhere in the world using an Internet browser. We statistically compare the new device with the traditional method using the T-test, and the results show that there were no significant differences between the two methods.

Keywords. Actual speed, Slippage ratio, magnetic sensors, cloud technology

1. Introduction

To meet the food demand of the ever-increasing world population, one of the approaches being adopted is the substitution of human power with mechanical power in agricultural production. Different terms in different situations have been used to connote this mechanical power substitution. These include Appropriate technology, Tractorization, Selective Mechanization, or only (Nag and Gite, 2020).

Slip is the asymmetry between the length of the linear distance to the circumferential distance of a fixed number of wheels, and the linear distance is relatively less than the circumferential distance. Slipping inroads is less than slipping in muddy soils. In tractors, there is an actual need for a reasonable percentage of the slip in order for the damper to act on the deflections and shocks which occur in the field as a result of sudden engine loading or hitch points. Moreover, rolling resistance or tires slipping on the soil's surface due to the soil moisture or the density of weeds on the soil surface, which negatively affects the qualitative characteristics of tillage (Al-Nuaimi and Al Rajaibo,2020).

Slipping is affected by several factors, including soil condition, tractor weight, and the tractor's practical speed and the depth of plowing, tire type, and tire air pressure (Kim et al.2020).

Slipping ratio includes deformation of the soil surface and, in some cases, breakage of the topsoil layer, forming thin clay in wet soils. While the tractor is moving in soft soils, the traction force is determined by the mechanical properties of the soil and the weight of the tire over the soil section, and that the tremendous forces that the soil can withstand before a slip percentage occurs is greater than (20%) and known as the seepage of the tire into the soil. During sliding, there are two distinct movements of the soil. Between the tire and the ground in the first move, the soil is compressed in front of the surface point, and in the second it is compressed behind it. When the slip reaches (100%), the tire does not move forward, and the soil is pressed from front to back. The standard method for calculating slip is by calculating the tractor's theoretical and practical speed or the mechanical unit (the mechanical unit). The disadvantages of this method are the inaccuracy of the calculation due to its reliance on the human factor as well as the necessity of the presence of more than one person to complete the time measurement process (the driver, a person to operate the timer at the tractor reaches the first person (Krisada and Christian, 2012).

The concept of wheel slippage in tractors has always been one of the leading efficient factors affecting fuel consumption by tractors, for both on-field, and off-field farm operations. Tractor performance is influenced by traction elements, soil conditions, implement type, and tractor configuration (Janulevičius et al., 2018). Tire slippage and tillage soil volume increased Significantly with increasing soil water content from 10 to 15 then to 20%, while the values of other characters decreased (Khorshid,2016).

These days, the world is witnessing a revolution in the use of microprocessors in all fields, especially those containing an embedded operating system (System on Chip (SoC)), due to its small size compared to its extensive capabilities low cost. However, the use of these systems in the field of agricultural mechanization is still limited if not rare, because of the lack of researchers and developers in this field (Pincheira et al.2020 and Sharma et al. 2020).

The tremendous development of the web and the need for a safe environment that can be accessed anywhere in the world to display data and real-time monitoring with the ability to be controlled created the term cloud computing (Tyagi et al. 2020), where electronic computing enables the creation of a suitable environment for a user or a group of users and on-demand by sharing resources (for example, Networks, servers, storage, applications and services, and this reduces time and cost, as well as ease of processing and sharing data, and contributes to preserving data because there is a backup copy of it on the cloud computing server(Goodall, 2017).

Hence, to overcome this problem, an attempt was made to the mechanism of a new device to measure the number of wheel cycles with no load by the magnetic sensor and was sent to a microprocessor containing an operating system that calculates the number of wheel cycles and sends it by Wi-Fi to a cloud computing server (Soft Computing Server) that compares between the number of wheel revolutions in a certain period to accurately measure the slip rate and store data on the server for easy access anywhere in the world via the Internet. It can also store data and recalculate the number of wheel turns and slip through the browser.

2. Materials and Methods

2.1 Electric Circuit

The electric circuit consists of the following parts:

1. **Sensor**: a magnetic switch that sends a signal whenever a magnetic field approaches it was used. Thus, by placing a permanent magnet on the vehicle's tires and installing the sensor in a suitable place on the vehicle's body, a signal will be sent whenever the wheel completes a full rotation. Figure 1 shows the electronic circuit of the magnetic sensor.
2. **Central Processing Unit:** The processor receives the data, stores it, and then sends it via Wi-Fi to the cloud computing services. Figures No. (1) the electronic board of the microprocessor used (Raspberry Pi3) and its parts and associated with it. At the same time, the figures show how and where the two circuits are connected (the magnetic sensor circuit and the microprocessor circuit). where the system is attached to its parts on the tractor or the so-called tractor.
3. **Reset button:** This key's function is to reset the cause from the processor and start after new sessions. Figure No. (1) shows the location of the return key.
4. **LEDs indicator:** This key's function is to reset the data from the processor and start after new sessions. Figure No. (1) shows the return key's location.

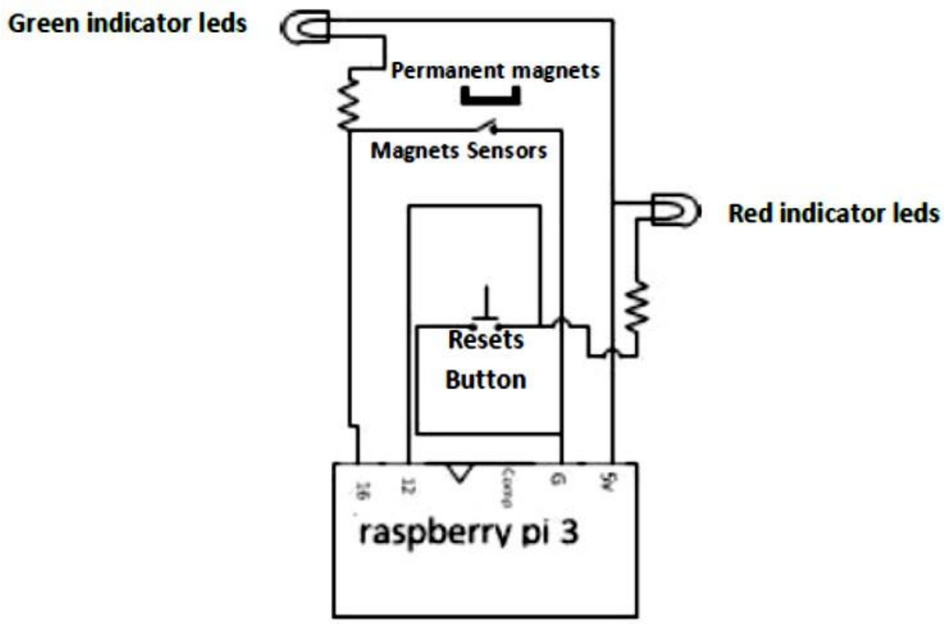

Fig.1 Electrical Circuits

2.2 Cloud Computing Server

The cloud computing server consists of the following parts:

1. **Algorithm**: A simple algorithm has been programmed to receive data from the electrical circuit as shown in Fig. 2., store it in a database, and then process it according to the following equation:

$$s = \frac{N_0 - N_1}{N_0} x100$$

N0: the number of revolutions of the vehicle without load N1: the number of revolutions of the vehicle with a load s: slippage ratio

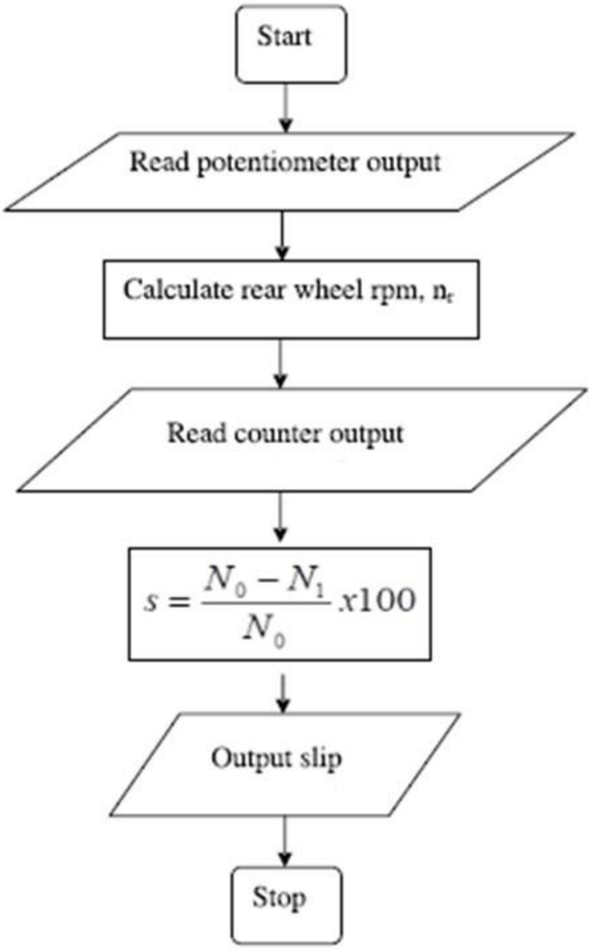

Fig. 2 simple algorithm has been programmed to receive data from the electrical circuit

2. Web Reset Button: This button allows the user to reset the processor counter for the browser's circuit.

3. Next Switch: This button allows the user to repeat the slippage percentage calculation in a new number of cycles every time he is pressed from the browser N2, N3, N4, etc.

4. Clear: This button clears the data on the screen.

5. Save: This button enables the user to store data coming from the electrical circuit.

2.3 Procedure for slip measurement

A Super permanent magnet is fixed on the tractor's wheel, and on the tractor's body on the opposite side of the electrical circuit. The magnetic sensor is installed on any two pins in the processor circuit for this project. The two pins numbered (12 and 16) were selected and the following code was placed in the processor circuit in the Python language. On the Internet :

```
from time import sleep import RPi.GPIO as GPIO
import curl
GPIO.setmode(GPIO.BOARD) button1=16 button2=12
button1closed=1 button2closed=1
c=1
GPIO.setup(button1,GPIO.IN,pull_up_down=GPIO.PUD_UP)
GPIO.setup(button2,GPIO.IN,pull_up_down=GPIO.PUD_UP)
in1=GPIO.input(button1) in2=GPIO.input(button2) while: )1(        if ( GPIO.input(button1)==0 and
button1closed==1)         :
            print "Button 1 Pressed"              button1closed=0
            c=c+1              p=str(c)              print "c="+p
sleep )2. ( else:
            button1closed=1 sleep )1. (
      if ( GPIO.input(button2)==0 and button2closed==1)         :
            print "+1 round"
            button2closed=0
            p=str(c) curl.call_url(p) sleep)1( else:
            button2closed=1
sleep(.1) def call_url(c):
url = 'http://localhost/haidar/insert.php?c='+c fp = urllib.request.urlopen(url)
mybytes = fp.read() mystr = mybytes.decode("utf8")
fp.close()     print(mystr)
```

The proposed system software has been designed and developed by our research team as a web application. The system software can be accessed by any computer or mobile phone through the internet web browsers. Subsequently, the system software website, which needs a subscription to access it through the provided link of cloudupm account http://www.cloudupm.com/haider_project/read_group.php. The web application site above works (Activated) only if the device is working, fixed on the tractor, connected to the network, and uploads the required data (Data) via the server). Pressing the Start key will start the timer and send an instruction to the electrical circuit to start counting the number of cycles N0. Pressing the Stop button will stop the timer and timer clock. Press the Next button so that the circuit will calculate N1 and send it to the cloud computing server, and there the algorithm will run and show the value of N0, N1, and the value of slip S. Subsequently, pressing the Next button again will calculate a new slip value every time until the end of the experiment.

Press the **Save** button to store the data.

Press the **Clear** button to clear the screen.

The slippage ratio was measured using a standard method according to the following equation:

$$s = \frac{N_0 - N_1}{N_0} x100$$

N0: the number of revolutions of the vehicle without load
N1: the number of revolutions of the vehicle with a load S: slippage ratio

To measure the mechanical unit's theoretical and practical speed, the tractor and plow belt almost touches the ground in the field along the treatment distance of 50 m to measure the time required to travel this distance, which represents the theoretical time. The theoretical velocity was calculated by dividing the distance traveled by the theoretical time using the following equation:

$$Vt = \frac{St}{Tt} * 3.6\ km/hr$$

St: represents the theoretical distance (in meters).

Tt: represents theoretical time (in seconds).

The theoretical speed for each field and each plow was calculated at the three selected speeds, with three replications for each speed. The previous step was repeated, noting that the plow weapons used in each system were lowered according to the specified depth of tillage, and the practical speed was calculated using the following equation:

$$Vp = \frac{Sp}{Tp} * 3.6\ km/hr$$

Sp: working distance (in meters).
Tp: practical time (seconds).

3. Statistical Analysis

To verify the accuracy and efficiency of the device's work. the Data were statistically analyzed using SPSS software. Continuous data were written as mean ± SD (Standard Deviation). The mean values of the two groups were compared by t-test. It was taken as statistically significant when Pvalue equal to or less than 0.05.

This study was conducted to the new devise slippage ratio result compared with the traditional method used to measure slippage ratio, as shown in Tables 1-4.

Table (1) summarizes the number of observations used for each variable which was (9), the means of the variable New which was (40.46), and the mean of the traditional variable which was (40.26). The standard deviation of the variable New was (7.436), and the traditional variable was (8.226).

Table 1
Group Statistics

Methods		N	Mean	Std. Deviation	Std. Error Mean
Slippage	**New**	9	40.4606	7.43599	2.47866
	Traditional	9	40.2556	8.22640	2.74213

While the results of the independent variable analysis are shown in Table (2), the sig value is (0.956) in two directions indicated that there were no significant differences between the two variables because this value is greater than (0.05). In other words, there is no significant difference between the old and the new method.

Table 2

Independent Samples Test 1

		t-test for Equality of Means			
					95% Confidence Interval of the Difference
		Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower
Slippage	Equal variances assumed	.956	.20503	3.69636	-7.63090
	Equal variances not assumed	.956	.20503	3.69636	-7.63736

Table No. (3) indicates the F-test value (0.059), which means that the model is slightly significant.

Table 3

Independent Samples Test 2

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Slippage	Equal variances assumed	.059	.811	.055	16
	Equal variances not assumed			.055	15.839

Table No. (4) indicates the confidence limit between the two variables at the 5% level of significance.

Table 4

Independent Samples Test 3

		t-test for Equality of Means
		95% Confidence Interval of the Difference
		Upper
Slippage	**Equal variances assumed**	8.04096
	Equal variances not assumed	8.04742

4. Conclusions

In conclusion, this study assessed a new microcontroller-based embedded digital system. that was developed to measure slippage ratio. The developed devices will be very much helpful for educational institutions and research needs. After the field test and the statistical analysis of the results, the new device has been compared with the traditional method, and the device shows more efficiency in time and effort wasted in the traditional method. The traditional method also requires at least two people, compared with our suggestion, it was proved that the device works efficiently and accurately with less effort, time, and cost. It is also light and facilitates the installation process on any vehicle. Another advantage is the ability to send data to cloud computing services where they can easily be analyzed and processed, as well as the possibility of accessing data from anywhere.

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