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Long-distance hand tractor controlled by android system in Wetland Field

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Abstract

Modernization of agricultural practices is essential to overcome challenges such as decreasing agricultural labor and decreasing agricultural land in Indonesia. This research examines the development and performance of a hand tractor that is controlled remotely via an Android-based system using the NodeMCU ESP8266 module and a WiFi network. This study focuses on the technical and operational performance of hand tractors in wetlands. Modifications were made to the tractor, by installing three DC motors to control the clutch and gas levers. Tests were carried out on the control system accuracy and response time to assess the system's suitability for field operations. The research results show that the Android system has 100% accuracy in executing all commands given, but the response time decreases as the distance between the Android device and the WiFi module increases, with an average delay reaching 6,8 seconds for a maximum 100 m distance. Field efficiency testing shows that a tractor with Android control has a work efficiency of 70.48% in the plowing process and 75.33% in the harrowing process, lower than with manual control which reaches an efficiency of more than 95%. Despite response delays and reduced efficiency, the system is an important step toward agricultural mechanization, especially in labor-intensive wetlands.

Keywords: System control; Android; Hand tractor; Field efficiency

1. Introduction

Indonesia's population in 2023 will reach 278.6 million people (1) and in 2035 it is projected to grow to 308.3 million people (2). Rice consumption in Indonesia in 2021 will reach 6.75 kg per capita per month (3). Population growth and increasing food needs are actually accompanied by shrinking agricultural land which causes a gap in food supply. A significant reduction in agricultural land amounted to 78 million hectares in the period 2000 to 2018 (4).

The agricultural workforce is also experiencing aging, in 2020 around 21.2% of agricultural workers were over 60 years old, an increase of 12.6% since 2005, this problem has an impact on agricultural productivity and innovation. The total number of agricultural workers has also decreased from 41.3 million in 2005 to 38.22 million in 2020 (5). Challenges in the agricultural industry, especially the upstream sector, can be solved by modernization through mechanization and technology utilization (6), but technology adoption in Indonesia is still low (3).

The operation of hand tractors is still dominated by human power, this activity creates static and repetitive activities which cause fatigue and the risk of breakdowns muscoluskeletal disorders (MSDs) (7). Manual operation of hand tractors increases muscle fatigue, health risks due to vibration and occupational hazards (8). Health risks and exposure to extreme environments in agricultural workers cause a decrease in productivity (7).

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An approach towards automation is needed through the operation of a hand tractor controlled remotely with an Android control system Snow Cone 12.0 based WiFi network in wetlands. Android devices were chosen because operational costs are lower compared to connectivity cloud and computing (9). The WiFi network is used because the coverage radius reaches 215 m (10) and has been integrated into the smartphone Android (11).

For this reason, it is necessary to study how Android-controlled hand tractors can increase productivity in wetlands. For this reason, the geographical conditions of wetlands need to be studied for their influence on the performance of Android hand-controlled tractors. Previous research results show successful operation at the performance test level without implementation (12). For this reason, it is necessary to carry out a technical evaluation of Android hand-controlled tractors to support investment decisions.

Wetlands as objects for hand tractor automation in the upstream agro-industrial sector have never been studied, current research is only limited to functional tests of control systems (13) and suitability of control systems (14) without application on real land

2. Material and methods

2.1. Research Flow and Framework

The research was carried out using several procedures, namely as follows:

2.1.1. Control Device Design

The control device design stage determines the specifications of each component. Each component is connected to each other, contained in the controller box recipient which will pick up the signal from transmitter, then the signal will be converted into electric current by DC motor control (15).

2.1.2. Control System Design

The hand tractor control system uses two DC motors for the brake handle lever and one DC motor for the gas lever. Adjusting the speed of the gas lever is done by moving it from position stop: 9 cm (fast), 6 cm (medium), and 3 cm (slow). Neutral A, B, and C return the gas lever from fast, medium, and slow speeds respectively (15).

2.1.3. Modification of The Control System and Gas Lever

The hand tractor control system is modified with additional levers on the right and left steering that are connected to a DC motor. A DC motor is used to change steering direction and move the throttle lever via a rope connected to the pulley(12).

2.1.4. Functional Test

Control System Accuracy

The accuracy of the control system to find out every part of the control brake handle right and left and the gas lever works according to what is programmed (16).

Response Time

The response time test is carried out to determine the control system time lag and ensure the control system is functioning properly responsive against the commands given by the operator via Android (17).

2.1.5. Evaluation

Evaluation was carried out to determine the level of success and identify obstacles when operating the hand tractor so that they could be improved (18).

2.1.6. Parameter Teknis

Technical test on the hand tractor control system using Android in the form of system response time (seconds).

2.1.7. Performance Test

The performance test aims to assess the working ability of a hand tractor on land by comparing controls smartphone Android. Performance tests will be carried out by installing soil processing implements. The parameters tested are presented in Table 1.

Table 1 Parameter of Performance Test

No.	Parameter	Unit	Formula
1	Effective Working Width (I)	meter	-
2	Forward Speed (v)	m/s	-
3	Land Area (L)	hectare	-
4	Total Operating Time (TOT)	hours	-
5	Ineffective Working Time (IWT)	hours	TOT - IWT
6	Effective Working Time (EWT)	hours	-
7	Effective Field Capacity (EFC)	ha/hour	L/EWT
8	Theoretical Field Capacity (TFC)	ha/hour	0.36(v x I)
9	Field Efficiency (FE)	%	(EFC/TFC) x 100%

3. Results and discussion

3.1. Hand Tractor Controlled by Android

Hand tractors previously controlled by operators were modified to allow through operation smartphone Android. Modifications include two 12 Volt DC motors to drive the two clutch handle and one 12 Volt DC motor to regulate the gas lever. All DC motors that have related to sling cables will be controlled wirelessly by one operator with an internal application smartphone Android connected to a microcontroller system as a device receiver. The power source uses a 12 Volt battery with a capacity of 10 Ah as a power source.

The suitability of the Android remote application command response to the microcontroller on the hand tractor control component is measured by looking at the output. The results of testing the suitability of the function of the hand tractor control system components via Android are presented in Table 2. All commands given from the Android application provide output that is in accordance with the command.

Table 2 Suitability of Application Commands to Microcontroller Components

Function	Response		
	Connected 1	Connected 2	Connected 3
Turn Right	1	1	1
Turn left	1	1	1
Right Direction	1	1	1
Left Direction	1	1	1
Maximum Gas	1	1	1
Medium Gas	1	1	1
Slow Gas	1	1	1
Netral A	1	1	1
Netral B	1	1	1

Netral C	1	1	1
Stop	1	1	1
Normal	1	1	1
Command Compliance Percentage			100%

Description: 1 = Component Responds, 0 = Component Not Responding

3.2. Responses Time (*Delay*)

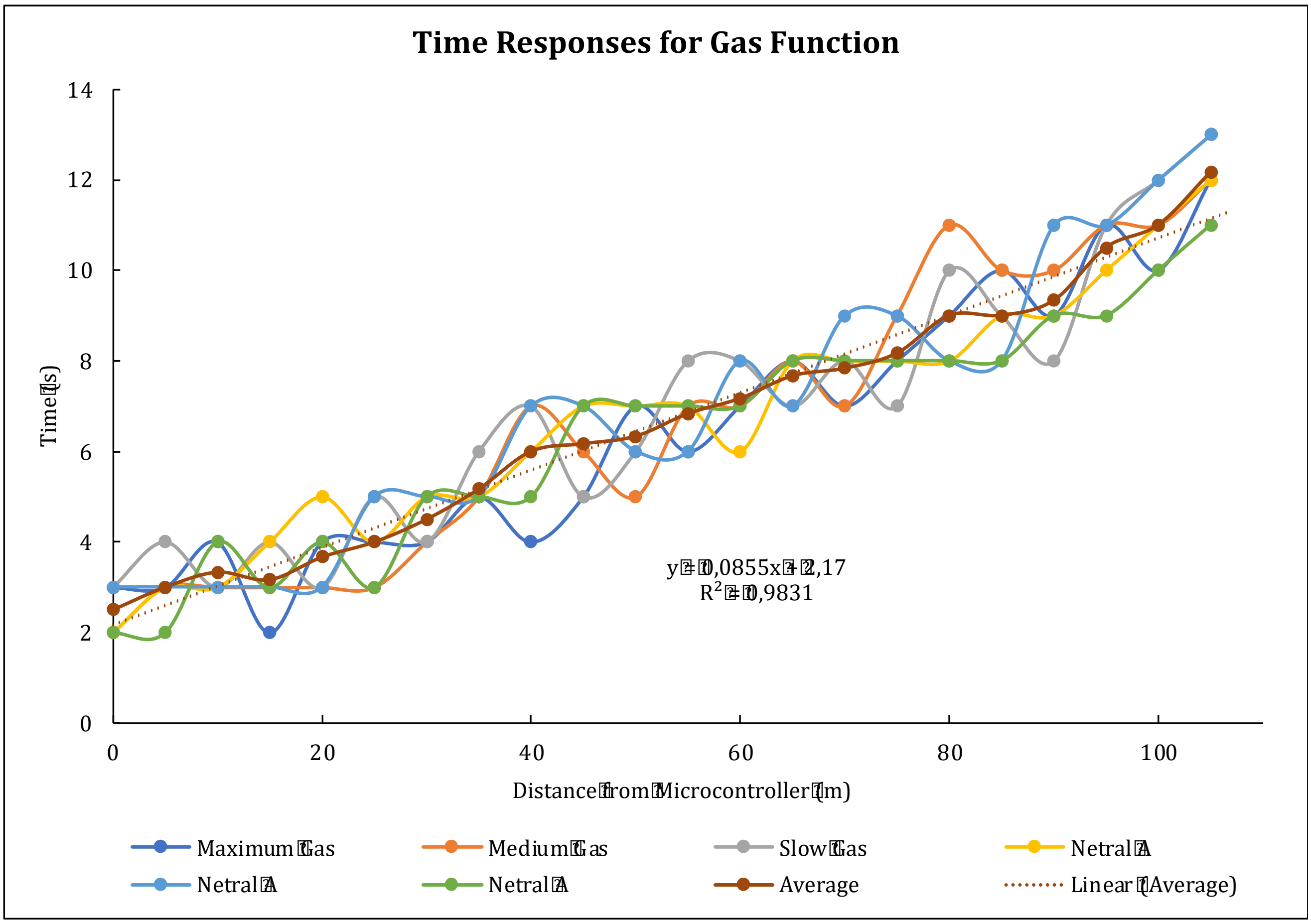

Figure 1 Response Time Measurement (Delay) Gas Function

Based on the results of experiments on measuring response time (delay) in Figures 1 and 2 shows the pattern that the further the Android device is from the ESP8266 NodeMCU, the higher the value delay of the system to respond to transmitted data. This is because if the distance between two devices is greater, the propagation time, namely the time it takes for an electromagnetic wave (signal) to travel receiver will also increase (19).

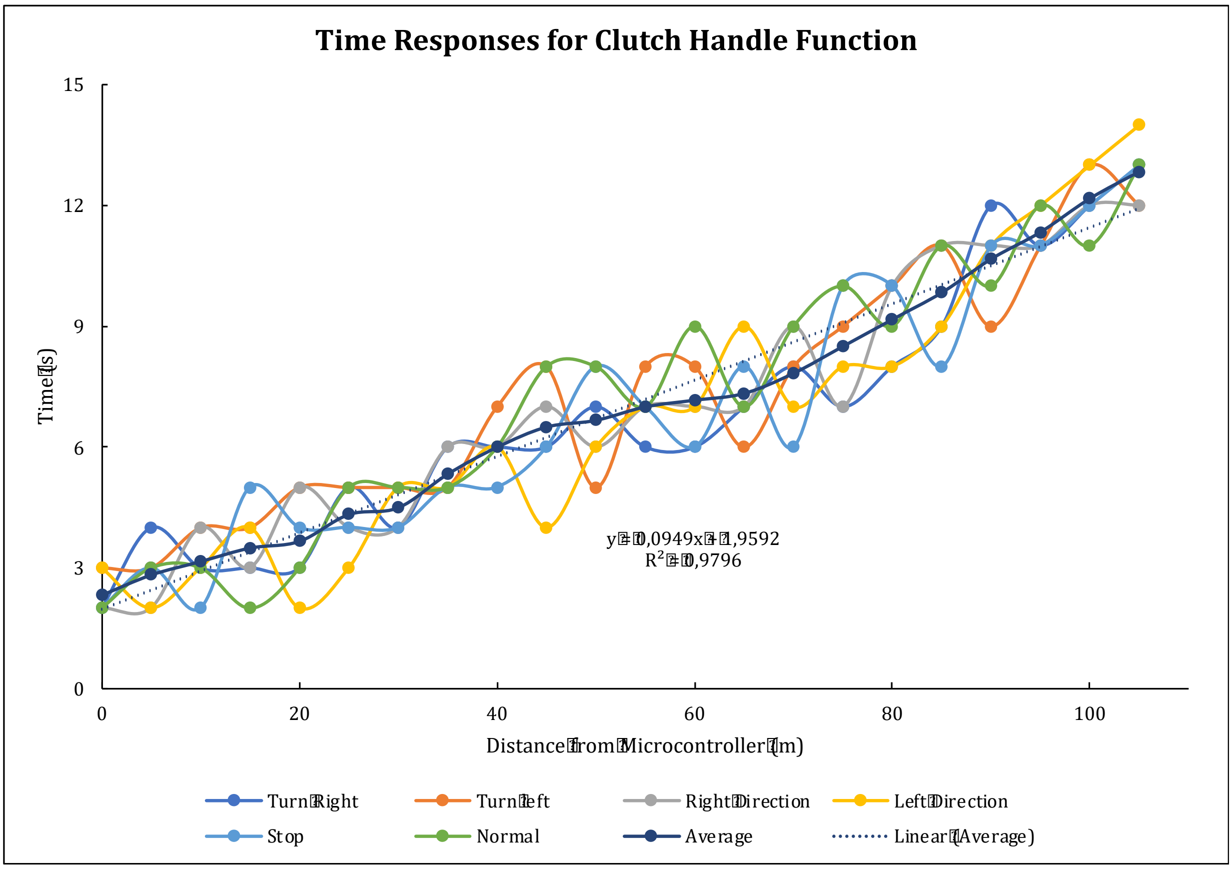

Figure 2 Response Time Measurement (Delay) Clutch Handle Function

3.3. Field Efficiency

Table 3 shows the work efficiency of a hand tractor controlled manually and using Android control on a 6 cm gas lever.

Table 3 Measurement of Hand Tractor Work Efficiency at Medium Speeds

Parameter	Implement	Manual	Android
Land Area (ha)		0.02	0.02
Effective Average Width (m)	Moldboard	0.2072	0.1824
	Harrow	1.2340	1.1600
Average Forward Speed (m/sec)	Moldboard	0.8549	0.7957
	Harrow	0.8806	0.8833
Total Time (hours)	Moldboard	0.4798	0.7965
	Harrow	0.0561	0.1207
Ineffective Working Time (hours)	Moldboard	0.1527	0.2534
	Harrow	0.0006	0.0408
Effective Working Time (hours)	Moldboard	0.3272	0.5431
	Harrow	0.0556	0.0799
Effective Field Capacity (ha/hour)	Moldboard	0.0611	0.0368
	Harrow	0.3599	0.2505

Theoretical Field Capacity (ha/hour)	Moldboard	0.0638	0.0523
	Harrow	0.3912	0.3688
Field Efficiency (%)	Moldboard	95.87%	70.48%
	Harrow	97.28%	75.33%

The field efficiency of manual hand tractors for plowing with moldboard and harrowing shows a value of >95%, but the plowing value is lower (95.87%) compared to harrowing (97.28%). This could be because the ineffective time for piracy is higher (9.16 minutes). Dominant ineffective time occurs because the operator tries to remove blockages in the sink and a small part of it is to rest and change workers. Harrowing has a higher field efficiency value (97.28%), this is because the condition of the paddy fields is mostly clean of plant scars or weeds, and the work load is cleaner because there is no soil turning process. Raking only flattens the results of the plowing so it only requires one operator, and only 2 seconds of ineffective time is used to sweep away dirt stuck in the moldboard.

Hand tractor control using Android for the plowing and harrowing process has a field efficiency that is far below manual control (ranging between 70-75%). This low efficiency is due to delay when using the right and left turning and right and left steering functions. Delay This makes the response of the control function not timely as a result of which the hand tractor is often not in the plowing and harrowing trajectory pattern. The operator must also confirm and guess the position of the hand tractor several times. Apart from that, due to the vibration of the engine from the hand tractor, the WiFi and Android connection was disrupted, resulting in the connection being lost for a few moments. This requires operators to repair connections on the land and increases ineffective work time.

4. Conclusion

The application of an Android-based control system on a hand tractor shows command accuracy of 100%, but the response time experiences an increase in delay with average of 6.8 s seconds at a distance up to 100 meters, which affects field efficiency. The work efficiency of the tractor in the plowing and harrowing process using Android control reached 70.48% and 75.33% respectively, lower than with manual control which reached more than 95%. To improve system performance, it is recommended to optimize WiFi network connectivity to reduce delays as well as further testing in varying field conditions to increase stability and work efficiency.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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