Development of Low-Cost Soil Tillage Profilelometer

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Abstract- When tillage operation is carry out using tilling plough the soil is disturbed. The level of disturbed soil is determined by profilelometer. An automated instrument was developed to determine the profile level of the rigid form by the operation. The soil tilling tillage profile meter consists of aluminum frame, two ultrasonic range finder to determine both horizontal and vertical distance, a dc motor and bidirectional motor control, microcontroller unit, storing medium and liquid crystal display unit. The frame is 130 cm x 30 cm x 60 cm and carrier and motor with two pulleys were attached to frame. The pulleys were 100 cm apart. The carrier conveying the two ultrasonic sensors: one pointing vertically and the second place horizontally with obstruction on side 100 cm apart. As the motor is toward the obstruction distance increases and is backward it reduces to zero. The values of measured two distances were store on the memory card. The time the operation can be vary from 20 s up to 60 s. The accuracy of the finder used for measurement is ± 1 cm. The resolution is 1 cm. The Soil Tilling Tillage Operation Profile meter has maximum depth value of 150 cm and with 90 cm wide.

I. INTRODUCTION

A significant amount of research has been conducted to determine relative differences in draft between various shanks used for subsoiling. Most of these studies examined shanks that were mainly constructed to disrupt the entire soil profile and differed in their approach angle and shank design. Producers were mostly interested in the number of shanks that could be pulled with their tractors and had little regard for how much surface disruption was caused by subsoilers because secondary tillage would be used to even the soil surface prior to planting.

However, agriculture practice in Nigeria has just started changing gradually and producers are now interested in much more than tillage energy. Many producers are now adopting conservation tillage systems that incorporate fewer passes of secondary tillage. Primary tillage as done with an in-row subsoiler may be followed directly with a planter. Residue should only be minimally disturbed so as to provide the soil adequate protection from water erosion. There is need to give information about subsoilers not only draft force alone, there is need to include the amount of residue remaining on the soil surface after tillage has been conducted.

Determining the amount of soil disruption or soil movement caused by tillage implements could be just as important as determining the draft energy. Pin-style profile meters have been the most common method of determining soil movement by tillage implements. These consists of a series of equally spaced pins that are lowered onto the soil surface until contact is made. However, manual recording of this information is time-consuming unless a photographic system is used to digitize this information.

Several other methods have been developed that relied on a moving probe that contacted the soil surface and sensed the presence of soil. These devices were based on a single probe that was moved horizontally across the soil bed. To start, the probe was moved vertically downward until it contacted the soil surface. The probe maintained minimal contact with the soil and was moved horizontally until it sensed a substantial horizontal force. The probe was then lifted until the lateral force decreased and it continued its horizontal path along the soil surface. These methods, although an improvement over the pin-style profile meters, were mechanically complicated, could take a significant amount of time for measurements, and could disturb the soil profile.

To alleviate the problems previously mentioned, several non-contact methods have been developed based either on ultrasonic or optical. The ultrasonic measurement systems have rather large horizontal errors (up to 30 mm), which could mask differences in subsoiler shanks. According to previous research, optical sensors should have accuracy adequate for measurement of tillage profiles but very expensive and complicate in design.

Measuring the distance to the soil with new non-contact require the projection of the beam from non-contact distance sensor onto the soil, detection of the beam, and then calculation of the distance through the time of flight for sound that has been transmitted to and reflected back from nearby objects .

Furthermore, the non-contact measurement system designed is light weight and portable and be capable of being used in field experiments at low cost. Coped the factor above project met the following objectives: it uses available a non-contact distance measurement system for recording soil surface elevations; this system was evaluated in a laboratory setting using the available a non-contact distance sensor; and determine performances of device be used to detect differences soil disruption caused by subsoiler shanks.

II. METHOD AND MATERIAL

2.1 Basic Block Diagram

The Soil Tillage Operation Profilelometer (STOP) was developed at the Electronic Measurement and Instrumentation Laboratory of The Federal University of Technology, Akure (EMIL-FUTA) and consists of four components: (1) two HC-SRC04 ultrasonic distance sensors, (2) a stepper motor with control, (3) a microcontroller with microSD card shield, (4) liquid Crystal display unit (LCD) and (5) an aluminum frame with pulley system. The basic diagram in Figure 1 described basic block system.

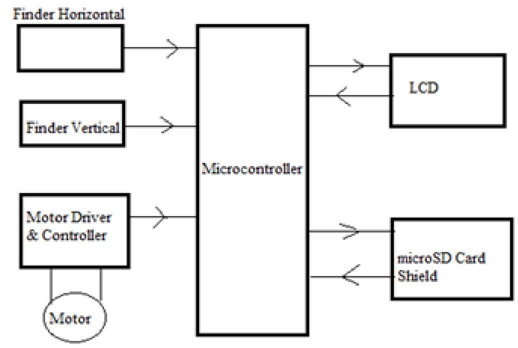

Figure 1: Block Diagram of Profilelometer

2.2 HC-SRC04 ultrasonic distance sensors

Ultrasonic sensors produce sound waves at frequencies (above 20 KHz) which are beyond human hearing capability. A complete ultrasonic transceiver consists of a transmitter and a receiver. The ultrasonic sensor used in this work operates in the pitch catch mode. The transmitter and the receiver are installed at the same side thus functioning as a single transceiver. Ultrasonic transmitter emits an ultrasonic wave in one direction, and immediately starts a time counter. The wave spread in the air, and is reflected when encounters the obstacles along its path. The ultrasonic receiver stops the time count when it receives the reflected wave. Since wave velocity in the air is 340 m/s, and the waves time of flight is recorded as t, we can calculate the distance h between the obstacle and the transmitter as $h = 340t / 2$. This is the echo method of probing depth otherwise known as time difference distance measurement principle. The Ultrasonic sensor used for this project is the arduino ultrasonic range detector HC-SR04 shown in figure 4. It is capable of detecting obstacle within a range of 2cm to 500cm with a voltage supply of 5 V. The sensor sends out an ultrasound of about 40 KHz when it is triggered through pin 2. As soon as the wave hits an obstacle, it is reflected and returned to the receiver so that a pulse (5 V) is produced by pin 3 (echo). The arduino microcontroller measures and records the time t taken by the ultrasound wave to travel between the transmitter and receiver.

2.3 Microcontroller

Microcontroller is small size computer on a single IC containing processor core, memory and programmable input-output peripheral. Microcontrollers are designed for the use of embedded applications, in contrast with microprocessor which are used for personal computers and other general purpose applications. Atmega2560 is a low power, high performance; CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. Atmega2560 provides 256 Kbytes with 8 Kbyte RAM of in-system self-programmable memory with read while write capability and 2 Kbyte EPROM.

Plate 1: Image of the HC-SR04 Ultrasonic Sensor (EF03085 HC-SR04 User Guide)

2.4 MicroSD card module

It interfaced with microcontroller with SPI (Serial Peripheral interface) standard. The module is designed for dual voltage power supply. The interface module can be used with two logic level i.e. CMOS 3.3V or TTL 5V.

2.5 Liquid Crystal Display

LCD is used to display the depth and hip formation during tillage operation and horizontal distance move at the instant. A Dig chip make 20 character × 4 lines JHD162A liquid crystal display was used in the system developed. The display is a 16 pin which works with maximum power supply of 5.0 V and the data can be sent in either 4 bit, 2 operations or 8-bit, 1 operation so that it can be interfaced to 8-bit Microcontroller. Here we used 4 bits, 2 operation system.

2.6 DC Motor Control

Motors are electromagnetic devices. This means that they use the electronic current to create a magnetic field which causes an action, in this case turn the motor around. When the power is removed the magnetic field will collapse, or if the motor continues to turn then it can act as a generator. When this happens there can be voltage spike caused by the back EMF (electromotive force) which could damage sensitive electronic components. A diode is normal to connect in the reverse direction across a magnetic load to prevent the back EMF from damaging the electronic circuitry. These have various different names including flyback diodes, freewheeling diodes, suppressor diodes or clamp diodes. It can used to control dc motor.

III. AN ALUMINUM FRAME

An aluminum frame was constructed for both lightweight and portable. Figure 1 shows the frame with the positioning stepper motor and laser distance sensor attached. Overall length of the unit is 1.30 m and height is 0.60 m. Total weight of the unit is 0.857 kg. The ultrasonic distance sensor was mounted so that it would be positioned 0.6 m from the soil surface. This positioning allows the sensor to reliably measure displaced soil. The horizontal can sweep up to 1 m. As the motor carry both horizontal and vertical ultrasonic distance sensors.

IV. TESTING, CALIBRATION AND EVALUATION OF THE SYSTEM

The instrument was tested by checking the motor movement and it was found moving steadily and smooth with little friction. Also, the to and fro movement was observed moving at a constant speed. The horizontal and vertical distance check for it accuracy and consistence in measurement. The measurement taken by place the two sensors at a known distance and data was collect at stead speed. All the result shows a good agreement with standard meter rule in Laboratory. The correlation was almost unity 0.997 and standard deviation is 0.34. The percentage error observed in the measurement is 0.3%. The resolution the sensor is 1 cm and maximum distance is 200 cm. The instrument was taken to field the result obtained from tillage operation conducted on field to get it profile. The Table 1 shows the data obtained from along furrow.

V. CONCLUSION

The developed profilometer has resolution of 1 cm and maximum range of 200 cm depth and 100 cm horizontal distance used the available non-contact distance sensor HC-SRC04. When the proilometer was examined in the laboratory where floor is smooth the vertical distance remain constant through100 cm horizontal distance. The Table 1 shows the sample data obtained from developed profilometer and the Figure 2 and 3 gives graphical representation subsoil disturbed soil by available shank at two difference point on the furrow. The disturbed subsoil was not disturbing soil profile due to the fact that there is no direct contact of measuring device and soil. The system is fast and consume less time in operation. The system is light weight is 368 g. The advantage of the system is that measured both horizontal and corresponding vertical distance without pre-scale the horizontal distance.

Table 1: Sample Test of the Developed Profilomete

Point 1 on Furrow		Pont 2 on Furrow	
Horizontal Distance (cm)	Vertical Distance (cm)	Horizontal Distance (cm)	Vertical Distance (cm)
98	1	99	-2
96	1	98	-1
96	2	97	-1
95	1	96	-1
94	3	95	-1
83	2	94	-4
82	2	93	-4
81	1	71	13
80	2	70	12
79	5	69	16
76	5	68	16
75	2	67	16
74	4	66	18
73	5	65	18
72	7	64	18
70	3	63	18
69	7	62	7
68	8	61	15
67	7	60	16
66	5	59	16
65	7	58	18
64	5	57	18
63	4	56	15
62	7	55	15
61	8	54	16
60	6	53	17
58	5	52	15
56	8	51	16

56	4	50	17
55	7	49	16
54	7	48	12
53	2	47	12
52	5	46	12
51	6	45	12
50	7	44	12
49	8	43	13
47	7	42	11
46	6	41	11
46	7	40	7
45	5	39	8
44	8	38	11
43	7	37	8
42	7	36	8
41	6	35	7
40	7	34	5
39	3	33	6
38	5	32	5
36	5	31	2
35	5	30	3
34	4	29	6
33	1	28	2
32	4	27	1
31	4	26	1
31	3	24	2

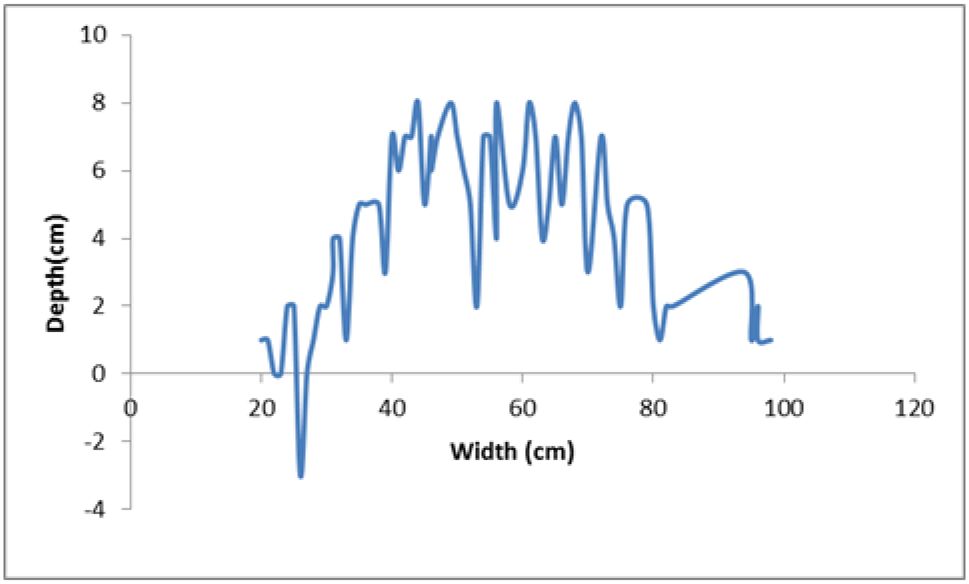

Figure 2: Soil Profile of at Point 1 on the Furrow

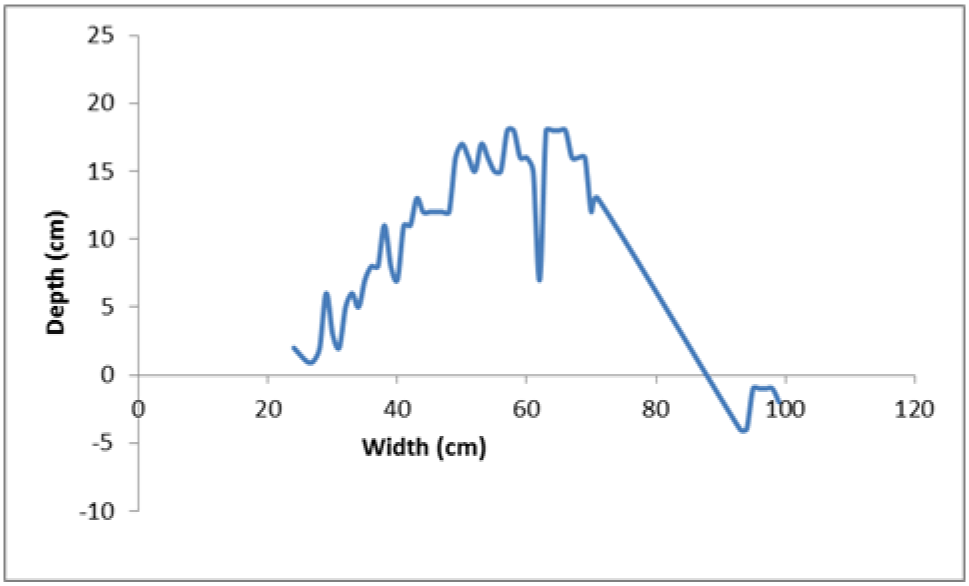

Figure 3: Soil Profile of at Point 2 on the Furrow

VI. ACKNOWLEDGEMENT

Thanks to department of Agricultural Engineering, The Federal University provided in information that guide development of system. Also, acknowledge Manageress' s Oko Ifedapo Co-operative Society in Surulere Local Government Area of Oyo State in person of Mrs. Ewetumo, Rebecca Folasade for her financial support for the research work.

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