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Surface Level Estimator-An Automated Contouring Instrument

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Abstract: This paper introduces a dynamic electronic instrument to measure the inclination of a surface, named as Surface Level Estimator (SLE). This device is designed to reduce the human effort and time consumed for civil surveying. This paper describes the construction, working principle, programming and experimentation results of the instrument. Finally, the conclusion and scope of future is discussed at the end of the paper.

Keywords: Surveying, Surface Level Estimator, Arduino Uno, Levelling

Introduction

The object of surveying is to prepare a plan or map so that it represents the area on a horizontal plane, vertical distances between the points are shown by contour lines or some other methods, vertical sections are usually represented by means of vertical sections drawn separately (Chrzanowski, 2014; Jetko, 2011).

Levelling is a branch of surveying, the object of which is (a) To find the elevations of points with respect to a given or assumed datum, which is required to enable the works to be designed and (b) to establish points at a given elevation or at different elevations with respect to a given or assumed datum, which is required in the setting out of all kind of engineering works. levelling deals with measurements in the vertical plane (Xeidakis, 1994).

A contour is defined as an imaginary line of constant elevation on the ground surface. It is the science of representing the vertical dimension of the terrain on a two-dimensional map. The now existing instruments regarding this point of surface levelling are *Hand level*, *Abney clinometer*, *Indian pattern clinometer*, *burnel hand level*, *De Lisle's clinometer*, *theodolite etc* (Kyle, 1983; Ustinova *et al.*, 2012).

The foresaid methods require large human efforts, time and good working condition of instrument for an optimised result of work, in order to overcome all these barriers, an automated electronic device is designed to reduce human power and time, simultaneously increasing the efficiency of the work.

Surface Level Estimator (SLE) is an automated and dynamic electronic device, which traverse the surface to be surveyed and records inclinations of the section of a

surface at various equal intervals with respect to a fore considered datum. Through which the contour lines of the area could be easily plotted. It provides work comfort by decreasing a lot of human effort and can give precise results about the surface to be surveyed.

Principle

The axis of gravity will always act towards the centre of the earth, the shift in the axis of gravity with respect to considered datum can always be expressed in terms of inclinations.

Construction and Working

The Surface level estimator is a dynamic instrument which traces over the land to be surveyed, the movement of the instrument is obtained from a simple motor drive.

Potentiometer, Rotary encoder and Arduino are connected as shown in the Fig. 1. Various parts of the instrument are (a) Rotary encoder (b) Potentiometer (c) Arduino Uno (d) Weights (e) Connecting Wires (f) Switch (g) Resistor.

The device travels on the path to be surveyed. The motion of the device is provided by a simple motor drive. A weight is hanged to a rod (yellow colored rod shown in Fig. 2). Axis1 shown in Fig. 2 is a fixed axis. Axis2 shown in Fig. 2 carries a weight and is freely allowed to oscillate and is always directed to the centre of the earth. The angle between the Axis1 and Axis2 (θ_1) varies according to the inclination of the surface over which the SLE travels. As the device moves on the surface, according to the inclination of the surface, the

angle θ_1 changes. The axis2 is connected to the nib of the potentiometer such that the movement of axis2 creates the rotary motion of the nib of the potentiometer. The potentiometer is connected to a voltage source and a setup to record the output of potentiometer. Thereby the output voltage of the potentiometer changes according to the rotary motion of nib of the potentiometer and the voltage readings are recorded. The readings are recorded using a microcontroller based on ATmega328P, Arduino Uno.

Axis 2 is always perpendicular to the horizontal plane (θ_2 equals to 90 degrees as shown in Fig. 2). As the inclination of the surface changes, the angle θ_1 changes accordingly, the potentiometer is attached to the

axis 2 in such a way that, if there is a θ angle change between axis1 and axis2, then the potentiometer also rotates by same angle θ . Hence the output voltage from the potentiometer changes according to the angle θ , which implies that the output voltage of a potentiometer depends on the inclination of the surface. Hence this implies that for every angle of inclination we have a corresponding value of voltage output.

The device is programmed in such a way that for every unit distance the device travels (distance is calculated from the rotary encoder attached to one of the wheel) the output voltage of the potentiometer is recorded, which corresponds to the inclination of the surface at that point (Harris *et al.*, 1997).

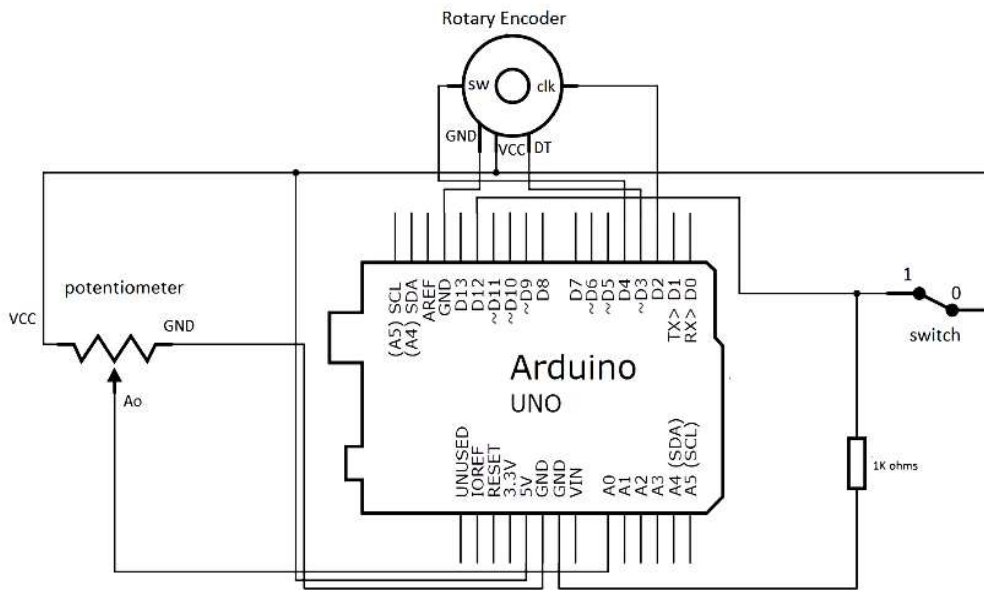


Fig. 1. The electronic circuit of surface level estimator

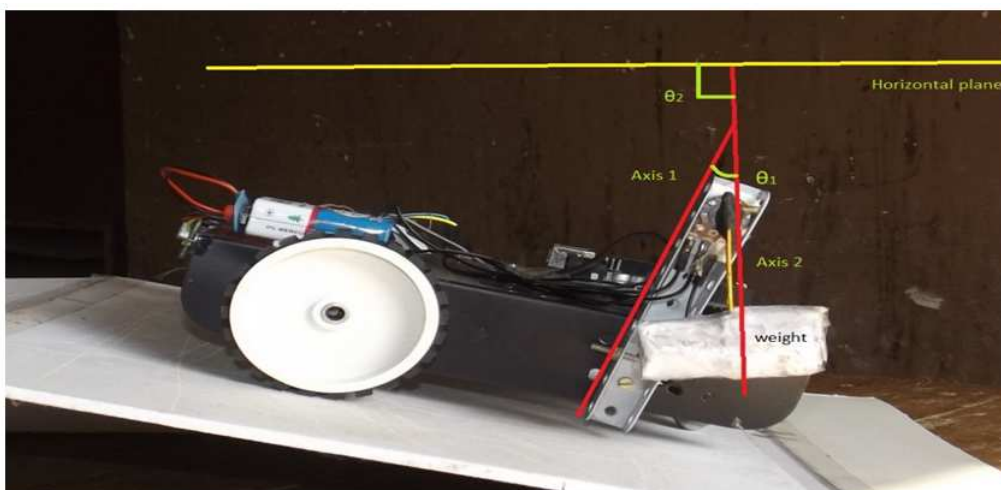


Fig. 2. Axis1, Axis2, θ_1 and θ_2 , are shown on SLE

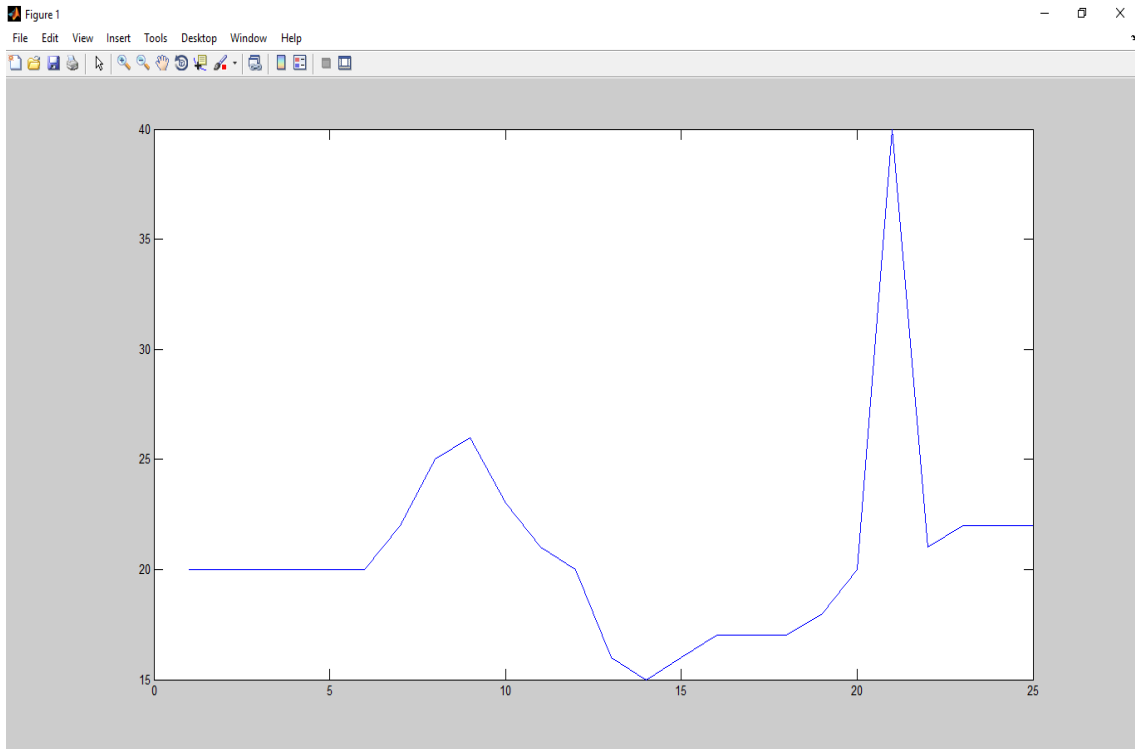


Fig. 3. The output values plotted in a graph using MATLAB

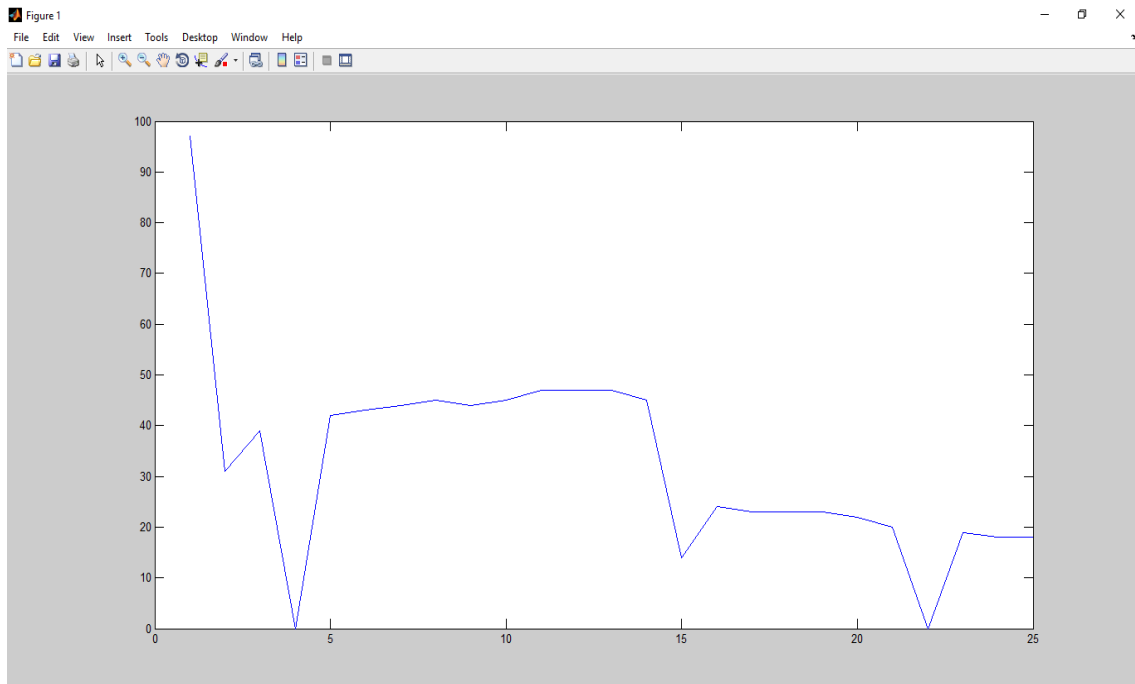


Fig. 4. The output values plotted in a graph using MATLAB

The device is programmed in such a way that when the device moves on the surface, the readings are recorded and are used to plot graphs (shown in Fig. 3

and 4. in MATLAB. The output of the device is plotted in form of graphs to analyse the inclinations of the surface at different points.

Program used in Arduino

The device is programmed in such a way that switch shown in Fig. 1 should be open when the device moves on the surface and during which the readings are recorded and the switch should be closed when the readings stored are used to plot graphs in MATLAB.

```

/*surface level estimator program*/
#include <EEPROM.h>
const int clkPin= 2; //the clk pin attach to pin 2
const int dtPin= 3; //the dt pin attach to pin 3
const int swPin= 4 ;//the sw pin attach to pin 4
int addr = 1 ;
int complete =0;
int encoderVal = 0;
int sensorPin = A0;//select the input pin for the
potentiometer
void setup()
{
//set clkPin,dePin,swPin as INPUT
pinMode(clkPin, INPUT);
pinMode(12,INPUT) ;
pinMode(13,OUTPUT) ;
pinMode(dtPin, INPUT);
pinMode(swPin, INPUT);
digitalWrite(swPin, HIGH);
Serial.begin(9600); // initialize serial communications at
9600 bps
}
void loop()
{
int rtpin = digitalRead(12);
if (complete!= 1 && rtpin == LOW)
{
int change = getEncoderTurn();//
encoderVal = encoderVal + change;
Serial.println(map(analogRead(sensorPin),0,1023,0,40));
if (encoderVal%10 == 0 && encoderVal<141) {

EEPROM.write(encoderVal/10,map(analogRead(sensor
Pin),0,1023,0,40)) ;
}
if (encoderVal>141){
complete = 1;
digitalWrite(13, HIGH); // turn the LED on (HIGH is
the voltage level)
}
}
if (rtpin == HIGH) {
Serial.println(EEPROM.read(addr));
addr++;
}
}
int getEncoderTurn(void)
{
static int oldA = HIGH; //set the oldA as HIGH

```

```

static int oldB = HIGH; //set the oldB as HIGH
int result = 0;
int newA = digitalRead(clkPin);//read the value of clkPin
to newA
int newB = digitalRead(dtPin);//read the value of dtPin
to newB
if (newA != oldA || newB != oldB)//if the value of clkPin
or the dtPin has changed
{
// something has changed
if (oldA == HIGH && newA == LOW)
{
result = (oldB * 2 - 1);
}
}
oldA = newA;
oldB = newB;
return result;
}

```

Program for MATLAB

```

clear all
clc
arduino = serial('COM3','BaudRate',9600);
fopen(arduino);
x = 1:10;
y = x;
for i = 1:length(x)
y(i) = fscanf(arduino,'%d');
pause(1);
end
fclose(arduino);
disp('making plot..')
plot(x,y);
clear arduino;

```

Calibration of the Instrument

Firstly, the device is tested on the surface of known inclinations and the voltage outputs of potentiometer are recorded for the various angles of inclinations. Every angle of inclinations corresponds to a particular value of the voltage output of potentiometer and vice-versa. Then the device is calibrated according to the readings recorded on the known surface (Ježko, 2014; Navidi *et al.*, 1997; Scott *et al.*, 2016).

Experimentation, Results and Discussion

The SLE is made to travel over know surfaces and tested several times and the observations are recorded in the form of graphs as shown in Fig. 3 and 4

The output voltage values of the potentiometer, stored in the memory of Arduino Uno are used to estimate the inclination of the surface at the various points in the area to be studied and thereby contour lines could be drawn with much easier than conventional methods from the

results. Hence the instrument significantly reduces the human effort. The graphs are plotted from the values recorded from the experimentation. The experiments were conducted for 150 cm length track and the graphs are plotted in MATLAB.

In the graphs, it is observed that sometimes uncertain peaks are produced, this is due to the jerks when there is a sudden change of inclination of the surface. Due to the jerks the weight attached to the axis 2 may sometimes oscillate and during this period some of the uncertain output voltages of the potentiometer may be recorded, these observations don't correspond to the actual inclination of the surface at that point. Hence uncertain peaks and errors are found in the graphs (Jetko *et al.*, 2011).

Applications:

- To find the elevations of given points with respect to an assumed datum and to establish points at a given elevation or at different elevations with respect to the assumed datum in the levelling process (Xeidakis, 1994)
- To determine the elevation of various points on the ground and at the same the horizontal positions for contouring process (Chrzanowski, 2014)

Conclusion

In this study, construction, working, experimentation and results of the surface level estimator are discussed. The objective of the design of the instrument is to reduce the human effort and time in surveying process. From the experimentation and results, we found that results obtained are not accurate and the uncertain peaks are formed in the graphs due to the jerks. Due to the jerks, sometimes the weight attached to the axis2 oscillates uncertainly and the output value of the potentiometer recorded during this period doesn't correspond to the actual inclination of the surfaces. Hence the errors are observed in the output graphs.

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Author's Contributions

The work is a product of the intellectual environment of both the authors; and both the authors have

contributed in various degrees to the research concept and to the experiment design.

Ethics

The concept of SLE might result in the reduction of human work and Working manually for surveying of a land could be avoided. During large constructions, we see engineers working in the hot sun for surveying a land, those processes are tedious and time-consuming. Whereas SLE can take a higher position if more assistance is taken and provide work comfort for civil engineers.

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