Preprogrammed Multiway Workbench- An experimental study using ultrasonic sensors with the help of microcontroller

Reetu Malhotra¹, Aashish Goyal²*, Mridula Batra³, Ritvik Bansal⁴
¹,²,³,⁴Chitkara University Institute of Engineering and Technology,
Chitkara University, Punjab, India
Email ID: aashishgoyal2000@gmail.com

Abstract: This study aims to find the ultimate solution for the table to be used by different kinds of people, such as a healthy kid, young, old, and physically disabled. People face problems while using the table of inappropriate height. Especially, physically disabled people are unable to cope with healthy while doing regular work due to height constraints. Using a human-centered design approach, the authors create a design process based on field research and catering to local needs to develop a suitable product for users in a developing country. So, the authors introduced a table, which has a motorized height adjusting mechanism. Ultrasonic sensors detect the user's height and height of the table adjusted as per the height of the user.

Keywords: Height-Adjustable table, Preprogrammed, Ultrasonic Sensors, Motorized-table, Arduino.

1. Introduction

An adjustable table is now a desperate need for humankind. Several adjustable height tables are in existence but still are unable to achieve the ultimate goal. The authors surveyed a small village where people with different needs responded when asked about tables. The most common issues that people talked about were storage facilities portability, and a table for everyone. According to Osmo Hänninen and Reijo Koskelo [1], Z. Zarith Afzan [2] the traditional tables made students use a similar height of the table. Tables and chairs were all alike for all types of students, especially tricky for taller and shorter students to work. When used adjustable desks and chairs, postures became much better. Many researchers have designed tables and chairs differently, keeping in mind the need of students such as Kashif and others [3], Samira Ansari [4]. The same case applied to all age groups (old, kid, young) of humanity. The height of desks and chairs plays a vital role in people's life. The neck, back, and shoulder problems have already discussed by many researchers earlier.

Available tables have been developed specifically for height-adjustable tops. Known tables have a mechanical structure which permits table tops to be manually height-adjusted. Such a table requires a human's power to transmit the required power to operate a table. Other known tables employ powered electric drivers, but generally, a single motor provided for each height-adjustable tabletop. Although these known arrangements have provided the ability to adjust the height of the table independently, yet their complex mechanical structures suggested by Staude, E.G. [5] made it more difficult than desired.

Also, in health care institutions, as mentioned by Berg, Nels O., and Abraham M. Budnick [6] there is some mechanism to adjust the height of the top, still unable to achieve the desired goal. Keeping in mind such needs, several researchers designed tables differently, such as Birdsall [7]. Some related
problems are small menses and apartments that have adequate furniture, especially suitable for the many Junctions. Among the items of furniture, next to the tables required for a meal, the tea/coffee, are almost universally standard for the modern home. Due to essential needs, they have to cramp their living quarters or overload their storage space. Authors focused on all these problems and designed a workbench to remove drawbacks that other desks failed to do so. The author's design offers an adjustable tabletop without the requirement for external human resources, portability with the sense of tires, storage utilizing drawers, easy to use as an automatic workbench. Ultrasonic Sensor patented by Reeb, Stephen R. [8] has a wide range of applications. But in this project, authors used this as a height detecting device. Ultrasonic speakers are the two-round looking component. One transmits a 40Hz sound wave that reflects from a solid surface, and another one detects the reflected sound wave. The total time taken is measured, and hence, we can measure the distance of the object. This application is used to measure the height of the user. DC motor by K. T. Chau et al. [9] is used to change the height of the desk. It works on the principle "whenever a current-carrying conductor placed in a magnetic field, it experiences a mechanical force." Motor driver amplifies a low current signal to a high current signal. The L298D Xu-Cai [10] is a typical Motor driver that drives 2 DC motors simultaneously. The driver feeds electricity into the engine in variable amounts, also variable frequencies that help in controlling the speed and torque of an automobile. A few more designs and researches by Reetu Malhotra [12] – [16] were taken into consideration.

An open-source electronics platform, i.e., Arduino used which is easy to use both in terms of hardware as well as software. Arduino widely used for projects and experiments. Software and project equipment connected through this software. The set of instructions makes the controller do whatever we want. Here Arduino operates motor-driver, motors (in connection with driver), and ultrasonic sensors with a set of instructions. Rack and Pinion by Joerg [11] is a type of linear actuator that has a circular gear with straight gear. The pinion drives rotation, which makes the rack moves linearly and vice versa. This actuator is a kind of link between the motor and the tabletop, which makes the variable height possible.

2. Methodology

A height-adjustable workbench disclosed. The workbench includes a fixed surface, an adjustable surface configured to move upwards and downwards in a plane perpendicular to the fixed surface. A set of linear actuators coupled to the fixed surface and the adjustable surface to facilitate the upward and downward movement of the adjustable surface. Also, a set of rotary devices coupled to the set of linear actuators. The rotary device configured to rotate selectively in clockwise and anticlockwise directions to move the adjustable surface in the upward and downward directions. When the rotary device rotates in a clockwise direction, the adjustable surface moves away from the fixed surface. When the rotary device rotates in an anticlockwise direction, the adjustable surface moves towards the fixed surface. The first set of sensors coupled to the adjustable surface and configured to sense one or more parameters associated with the height of a user. A control unit operatively coupled to the first set of sensors and the set of rotary devices. The control unit configured to compare the sensed one or more parameters with a dataset comprising predefined one or more parameters. It generates a height adjusting signal based on the comparison, and transmit the generated height adjusting signal to the set of rotary devices. Based on receipt of the height adjusting signal, the set of rotary devices rotates selectively in a clockwise or anticlockwise direction to adjust the distance between the adjustable surface and the fixed surface. The top of the table has connected with Rack. Gear Motor mounted on the middle surface;
the further motor connected with pinion. Rack and pinion are in the constant connection that lets us adjust the height of the top cover.

Motors powered with the help of a dc motor driver, which further connected to a single battery. Motion and speed of motors are controlled using a connection from motor driver to Arduino. Ultrasonic Sensors located at the top of the table. It senses the height of the user. Ultrasonic sensors gave input to Arduino as the height of the user, and programmed Arduino allows the rotation of the motor until the required height attained. Installed tires let us to the port table anywhere and anywhere.

3. Description of the Model:

Front view and different components of the adjustable height table shown in Figure 1.

![Figure 1: Model Sample Sketch (Front View)](image-url)
Figure 2: Side View

The description of the adjustable height table is in Table 1. In component no. 1, ultrasonic sensors installed here. They send sound waves in a downward direction and calculate the time taken to reflect the waves hence judge the height of the user. Further, it sends height as input to Arduino. Component no. 2 indicates the top of the table supported with the means of Rack of suitable height. This rack further connected to pinion mounted on the rotary part of the motor. Component no. 3 shows the pinion mounted over the motor is in constant connection with rack and hence partially responsible for height adjustment. Some compartments meant to store things are shown in component no. 4. A removable chair (component no. 5) is used by taking it out of the table and can be reinserted when not in use. Its height is according to standard height requirements. Component no. 6 is pinion in constant connection with rack and kept in freely rotatory motion. It is just there to support the shelf if it dislocates from its original position. It is not responsible for the height adjustment of the table. A wooden block (component no. 7) used to increase the length and width of the table in case of more users or in case the user wants to keep more items. An adjustable tabletop (component no. 8) adjusted as per the need of the user. Lamps and ultrasonic sensors fixed at a certain height of this particular base. Tires are installed in component no. 9 so that the user may take it anywhere and everywhere without much difficulty. Some table lights exist (shown in component no. 10) to provide the user an easy to work comfortably in the dark as well. Lamps could be powered externally or using the battery used to power the motors.

4. Benefits over previous models of workbench:

- The proposed table provides an automatic height adjustable workbench, the height of the workbench adjusted after sensing the height of the user.
- It provides a set of switches to adjust the height of the workbench in the upward and downward direction.
- This design provides an automatic height adjustable workbench, and the user can comfortably use the workbench for sitting as well as standing work.
- It provides a cost-effective and straightforward automatic height adjustable workbench.
- It provides a precise and time-efficient automatic height adjustable workbench.
Existing models do not adjust the height of the table itself, whereas our model adjusts the height of the table itself.

This design also includes a set of wheels to easily port from one place to another to an automatic height adjustable workbench.

A single motor generally used for height adjustment, but increasing the number of engines reduces the chances of the motor being heated up due to multiple cycles of up and down.

The use of different motors in different positions increases the durability of the table.

Minimum Standard height lets the user work comfortably with the person using the same table at a certain height.

Sound Absorbing material reduces the unwanted noise produced by the motors.

Some exciting models even require human resources, which solved in our model.

Furthermore, it is useful for people of every age group as well as physically unhealthy people.

User-friendly and intuitive control unit.

5. Conclusion

Preprogramed Multiway Workbench offers an automatically adjustable tabletop. It is different from other existing designs that provide comfort in work, especially helps in avoiding many physical problems and maintaining proper body posture. Thus, using a human-centred design approach, the authors create a design process based on field research and catering to local needs to develop a suitable product for users in a developing country.

| Sr No. | Height (cm) | Seated Desk Height(cm) | Standing Desk Height(cm) | Sr No. | Height (cm) | Seated Desk Height(cm) | Standing Desk Height(cm) |
|--------|-------------|------------------------|--------------------------|--------|-------------|------------------------|--------------------------|
| 1      | 153         | 61.5                   | 105.5                    | 13     | 183         | 73                     | 118                      |
| 2      | 155.5       | 63                     | 106.5                    | 14     | 185.5       | 73.5                   | 119                      |
| 3      | 158         | 65                     | 107.5                    | 15     | 188         | 74.5                   | 120                      |
| 4      | 160.5       | 66.5                   | 108.5                    | 16     | 190.5       | 75                     | 121                      |
| 5      | 163         | 67                     | 109.5                    | 17     | 193         | 76                     | 122                      |
| 6      | 165.5       | 68.5                   | 110.5                    | 18     | 195.5       | 76.5                   | 123                      |
| 7      | 168         | 69                     | 112                      | 19     | 198         | 77.5                   | 124                      |
| 8      | 170.5       | 70                     | 113                      | 20     | 200.5       | 78                     | 125                      |
| 10     | 175.5       | 71                     | 115                      | 22     | 205.5       | 83                     | 127.5                    |
| 11     | 178         | 72                     | 116                      | 23     | 208         | 84                     | 128.5                    |
| 12     | 180.5       | 72.5                   | 117                      | 24     | 210.5       | 85                     | 129.5                    |

Table 1: Standard height of table while standing and sitting as per the height of the user

Arduino Code:
const int trig1Pin1 = 2;
const int echo1Pin1 = 4;
const int in_11 = 6;
const int in_21 = 9;
void setup() {
    pinMode(7,INPUT);
    pinMode(in_1,OUTPUT);
    pinMode(in_2,OUTPUT);
    Serial.begin(9600);
    pinMode(13,OUTPUT);
}
void loop() {
    static int c=0;
    Serial.println(digitalRead(7));
    long duration, inches, cm;
    pinMode(trig1Pin1, OUTPUT);
    digitalWrite(trig1Pin1, LOW);
    delayMicroseconds(2);
    digitalWrite(trig1Pin1, HIGH);
    delayMicroseconds(10);
    digitalWrite(trig1Pin1, LOW);
    pinMode(echo1Pin1, INPUT);
    duration = pulseIn(echo1Pin1, HIGH);
    cm=microsecondsToCentimeters1(duration);
    Serial.print(cm);
    Serial.print("cm");
    Serial.println();
    delay(100);
    int ir=digitalRead(7);
    if(ir==0){
        digitalWrite(13,HIGH);
        digitalWrite(in_11,LOW);
        digitalWrite(in_21,LOW);
        if(cm<10){
            Serial.println(cm);
            digitalWrite(in_11,LOW);
            digitalWrite(in_21,LOW);
        } else {
            digitalWrite(13,LOW);
            digitalWrite(in_11,HIGH);
            digitalWrite(in_21,LOW);
        }
    } else {
        digitalWrite(7,LOW);
        digitalWrite(in_11,LOW);
        digitalWrite(in_21,HIGH);
        delay(10000);//Time
taken to reach the required height
digitalWrite(in_11,LOW);
digitalWrite(in_21,HIGH);
delay(10000);//Time
taken to reach the required height
digitalWrite(in_11,LOW);
digitalWrite(in_21,HIGH);
}
long microsecondsToCentimeters1(long microseconds) {
    return microseconds / 29 / 2;
}

6. References

[1] Koskelo R, Vuorikari K and Hänninen O 2007 Ergonomics, 50(10), 1643-1656.
[2] Afzan Z Z, Hadi S A, Shamsul B T, Zailina H, Nada I and Rahmah A S 2012 Southeast Asian Network of Ergonomics Societies Conference (SEANES) 1-5 IEEE
[3] Kashif M, Bhattacharya A, and Banerjee D 2015 Design of adjustable desks and chairs for university classrooms suitable for students of Jadavpur University, India
[4] Ansari S, Nikpay A, and Varmazyar S 2018 Design and Development of an Ergonomic Chair for Students in Educational Settings Studies, 20 21.
[5] Staude E G 1928 US Patent No 1,671,688 Washington, DC: US Patent and Trademark Office
[6] Berg N O, and Budnick A M 1952 US Patent No 2,587,094 Washington, DC: US Patent and Trademark Office
[7] Birdsal I D 1913 US Patent No 1,063,642 Washington, DC: US Patent and Trademark Office
[8] Rees R S 1988 US Patent No 4,785,664 Washington, DC: US Patent and Trademark Office
[9] Xu-cai and S U N 2009 The Application of L298N in DC Motor PWM Speed Regulation System [J] Journal of Weifang University, 4
[10] Chau K T, Zhang D, Jiang J Z, Liu C and Zhang Y 2007 Design of a magnetic-geared outer-rotor permanent-magnet brushless motor for electric vehicles *IEEE transactions on magnetics*, 43(6), 2504-2506.

[11] Joerg W, Bordovsky, J, Cakmaz A, Heck H, Roehringer A, Gall C and Koehler K H 1998 *US Patent No 5,711,396 Washington, DC: US Patent and Trademark Office*

[12] Malhotra R, Vanshika, Neha 2019 Construction of a Device for Obstacle Detection, *International Journal of Recent Technology and Engineering*, 8(4), 2312-2315.

[13] Reetu Malhotra, Bhavjot Singh 2020. Design and Construction of Solar Shed, *AIP Conference Proceedings*. 2220, 140061.

[14] Deepak Kumar, Reetu Malhotra, Sita Ram. Design and Construction of a Smart Wheelchair, *Elsevier Procedia Computer Science* ISSN 1877-0509. 172(2020) 302–307

[15] Reetu Malhotra, Gulshan Taneja. Comparative analysis of two stochastic models subjected to inspection and scheduled maintenance, *International Journal of Software Engineering and Its Applications* Volume 9(10) 179-188, 2015. ISSN 1738-9984

[16] Reetu Malhotra, Gulshan Taneja. Comparative analysis of two stochastic models with varying demand, *International Journal of Applied Engineering Research* Volume 10(17), 2015. 37453-37460 ISSN 0973-4562