EasyChair Preprint

№ 10471

Laser Based Non-Contact Type Distance and Height Measurement System Using ESP32

Anjani Kumari and Sanjaya Shankar Tripathy

June 28, 2023

Laser based non-contact type distance and height measurement system using ESP32

[1]ANJANI KUMARI, [2]SANJAYA SHANKAR TRIPATHY

[1]MTech student, Birla Institute of Technology, Mesra, Ranchi
[2]Asst. Professor, Birla Institute of Technology, Mesra, Ranchi

Email: [1]mtec10001.21@bitmesra.ac.in, [2]sstripathy@bitmesra.ac.in
Contact: [1]9572777460, [2]9430148809

Abstract: This paper presents the design and implementation of non-contact type distance and height measurement system using ESP32. There are many methods developed to measure distance and height starting from conventional measuring tape to sophisticated sensing system. In this paper a low-cost distance and height measurement system is proposed using the basic trigonometry principle. i.e., Pythagoras theorem. Two laser sources are used to estimate the height and distance of the system. The angle of rotation of the laser source to meet the reference laser source at the object surface is captured using potentiometer. ESP32 takes the angle information and estimates the distance/width/height. This technology provides a customizable and easily integrated solution for application such as construction, agriculture, and surveying. Maximum error occurred in the system is 15cm/10meter, which is comparable with other product with relatively higher cost. For future improvement incorporating wireless communication for remote monitoring and data collection using additional sensor to increase measurement accuracy. The non-contact measurement system is a promising technology with a wide range of application. The system is designed at very low cost, wireless capabilities and non-destructive measurement make it highly versatile and valuable for industrial applications.

Keywords: ESP32 Micro-controller, Low power, potentiometer, micro-python, laser light.

I. INTRODUCTION

In today automated world, accurate and reliable measurement of objects dimension is essential for the effective functioning of industries such as logistics, packaging, transportation, and manufacturing. The traditional method of measuring object dimension such as contact and optical method, have limitation in term of accuracy, speed, and practicality. To overcome these limitation non-contact measurements system have gained popularity, offering high measurement accuracy, speed, and non-invasive measurements. Non-contact measurement systems utilize various principles such as ultrasonic, laser and infrared to measure the dimension of the object. Generally, non-contact type measurements are done by sensors or by camera or the combination of both.

Md. Jahangir Alam et al. developed smart system for measuring human height by using ultrasonic sensors.[1] Lu, M.C., Wang et al. Author suggested that a system for measuring the height of liquid or particulate material inside a storage tank that uses images rather than pixels to measure distance [2] Han, Dianyuan et al. Deal with the problem of processing an image for measuring tree height on a smartphone.[3] KlimKov, Yu M et al. developed to measure the angular displacements of objects using a laser polarimetric sensor.[4]

Han, Dianyuan Authors measure the height of a tree's using three-point correction and image processing. One marker point was placed at the tree's root, and the other was placed one meter up from the root. Then, using the triangle similarity principle, the tree height may be calculated.[5] Lifen Chen et al. Authors describe a procedure for constructing a height-measuring system that makes use of an MS5534B pressure sensor.[6] An image-based measurement system created by the Lu, Ming-Chih et al. author is suggested for determining the separation between a CCD camera and an item as well as the projected area of the object.[7]. In this paper we proposed a non-contact type height and width measurement system using ESP32 microcontroller and a potentiometer. The system is based on Pythagoras theorem. By using simple right-angle triangle method to calculate the height and width of the object. A potentiometer is a variable resistor and change in angle corresponds to the change in resistance. The angle of rotation is nothing but the angle made by base and hypotenuse.

Then applying trigonometry function and right- angle triangle method to find out the distance, height, and width of the object. The below figure shows the measurement of height of tree is successfully done by user.

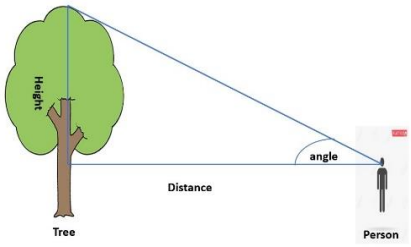

Figure 1:Height measurement of tree using developed system

BLOCK DIAGRAM OF PROPOSED SYSTEM

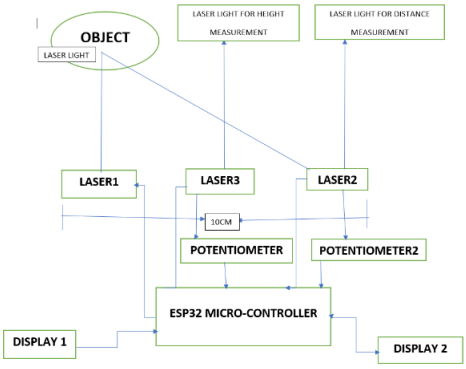

Figure 2: Block diagram of proposed system

The system utilizes the ESP32 microcontroller for real-time data processing and wireless communication. This feature makes the system versatile as it can be employed in various industrial application for object dimension measurement. It provides at a very low cost for measuring height and distance of object in various application such as construction, agriculture, and surveying. Light is incident on the object from laser source1. Potentiometer is attached to the laser source2, another light is incident from the laser source2 and both the incident light is merged into a single a single point. At this moment the laser light and the base of the instrument will from a virtual right-angle triangle. Angle information is captured by the potentiometer. This is sent to the ESP32 to a specific GPIO pin to change in voltage. From change in voltage the change in angle is determined. The distance between laser1 and laser2 is kept constant(10cm). By knowing the base and hypotenuse the altitude/height can be determined easily.

COMPONENT

A. ESP32 MICROCONTROLLER

The ESP32 is a low cost-power dual-core micro-controller that integrated Wi-Fi and Bluetooth connectivity. It was developed by Espressif system and is widely used in IoT (Internet of things) applications, home automation, robotics and other projects that require wireless communication. The ESP32 microcontroller is based on the Xtensa LX6 processor core and has a clock speed of up to 240MHz. The microcontroller includes Wi-Fi and Bluetooth modules and it comes with a variety of peripherals such as GPIO pins, ADC, DAC, I2C, SPI and UART. It is also equipped with hardware encryption, which ensure secure communication for IoT applications. One of the key features of the ESP32 microcontroller is its low power consumption, which makes it an ideal choice for battery-powered projects. It has several sleep modes and its wake-up time is only a few microseconds, which helps to conserve battery life. The ESP32 microcontroller is supported by a large open-source community and has variety of development tools and libraries available including Arduino IDE, Micro-Python and ESP-IDF (Espressif IoT Development Framework). This makes it easy to develop prototype and deploy the project using the ESP32 microcontroller.

Figure3: Esp32 Wroom devkit[10]

B. POTENTIOMETER

A potentiometer commonly referred to as a pot, is an electronic component that is used to control the flow of electric current by varying its resistance. It is a three-terminal resistor with a rotating or sliding contact that forms a variable voltage divider. The potentiometer usually has a circular or linear shape and is commonly used in application where a variable resistance is required. By turning the knob of the potentiometer, the resistance between two terminals can be adjusted, which causes a change in the voltage level across the third terminal. This feature has made it a widely used component in electronic circuits to

control the brightness of LED lights, control the volume of audio devices, adjust the contrast of LCD display and many other applications. Potentiometer are available with different resistance ranges and power rating depending on the application requirements. Common type of potentiometers includes rotary potentiometer, slide potentiometer, and trimmer potentiometer. It is versatile and essential component used in various electronic circuits, providing accurate and adjustable control over the electrical properties of a system.

Figure 4: Potentiometer [9]

C. LASER (LIGHT AMPLIFIACTION BY STIMULATED EMMISION)

The term "Laser" stands for "light amplification by stimulated emission of radiation." It is a device that emits a highly concentrated beam of coherent light that has a very narrow wavelength range. The laser beam can be focused to a very small spot, allowing for precise cutting, welding, and engraving of materials as well as for use in scientific and medical applications. Laser work by stimulating atoms or molecules emits a coherent beam of light. This is accomplished by passing energy through a medium that contain atoms or molecules in an excited state, which then release their energy as a photon of light. This emitted photon then induces other atoms or molecules in the medium to release their energy as coherent photon of the same wavelength and phase, resulting in a powerful and precise beam of light. Laser has many applications, including in manufacturing, medicine, communication, and scientific research. In manufacturing, laser cutting and welding are commonly used for precise and efficient processing of metals, plastic, and other materials. In medicine, laser is used for various procedures such as eye surgery, tattoo removal and skin treatments. In communication, laser is used for fiber optic transmission, which allows for high-speed data transfer. In scientific research, laser is used for measuring distance or temperature as well as for spectroscopy and other analytical techniques.

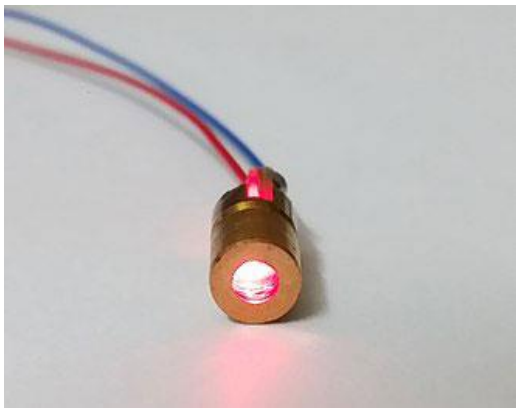

Figure 5: Laser diode

4-DIGIT 7-SEGMENT DISPLAY

It is a type of electronic display commonly used in digital clocks, calculators, and other electronics devices that require the display of alphanumeric character. It consists of 4 individual 7-segment display arranged in a row, each of which can display any of the 10 digits 0-9 as well as some letters and symbols like A-F, - and. Each segment within the display is illuminated on to form the desired character. The segment is arranged in a specific pattern, with each segment designated letter, A-G, as well as a decimal point. By lighting up various combination of these segments, a wide range of character can be displayed. It is commonly used in digital clocks, timer displays, temperature displays and other application where numerical data needs to be displayed. The display is typically powered by an external power supply and are controlled by a microcontroller or other digital logic circuitry. The microcontroller sends signals to the display to turn on or off the desired segments, creating the desired character. It is cost effective solution for displaying information.

Figure 6: 4-Digit 7-Segment Display [14]

HARWARE REQUIREMENT

The 4-digit 7-segment display, laser, and potentiometer are all connected to the ESP32 wroom devkit. Tables.1, Tables.2, and Table.3 show the connections between the ESP32 and a potentiometer, a four-digit seven-segment display, and a laser light, respectively.

Table.1 CONNECTION OF ESP32 WITH POTENTIOMETER

S.NO.	ESP32	POTENTIOMETER
1	3.3V	VCC
2	GPIO PIN	OUTPUT PIN
3	GND	GND

Table.2 CONNECTION OF ESP32 WITH LASER

S.NO.	ESP32	LASER
1	GND	GND
2	5V	VCC

Table.3 CONNECTION OF ESP32 WITH 4-DIGIT 7-SEGMENT DISPLAY

S.NO.	ESP32	4-DIGIT 7-SEGMENT
1	VIN	VCC
2	GND	GND
3	GPIO21	DIO
4	GPIO22	CLK

Two laser will be placed at a fixed distance of 10cm one laser is fixed at a distance that makes 90◦ angle and by using potentiometer move the knob of potentiometer and merge the two light of laser, according to the requirement of distance and height.

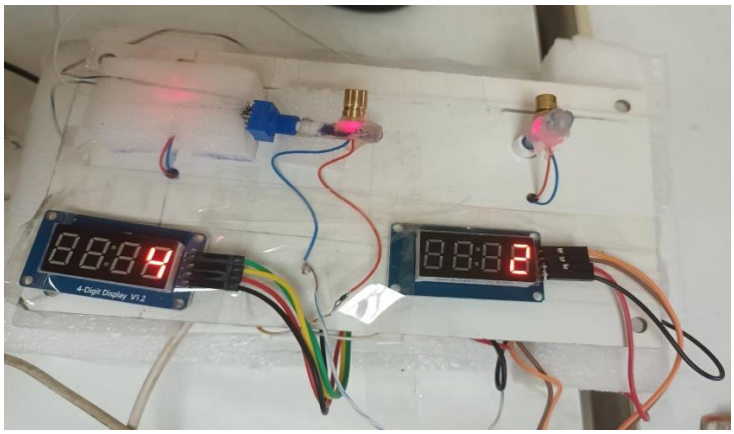

Figure 7: Set up diagram of the proposed system

After testing in the lab, PCB manufacture is carried out using Fritzing software. Figure 7 displays the circuit diagram for the suggested system.

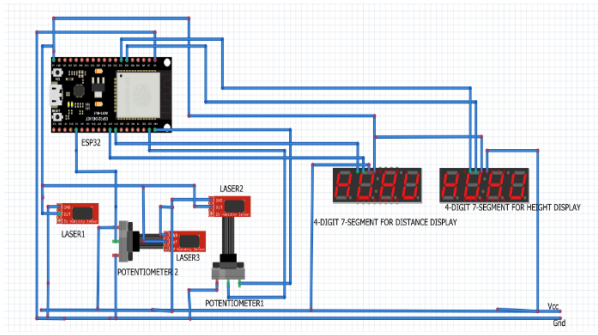

Figure 8: Circuit representation of the proposed system created by Fritzing software

SOFTWARE REQUIRED

MICRO-PYTHON

The proposed device is coded using the 32-bit version of Micro-python that is loaded on Windows 10. The Python programming language Micro-Python was created specifically for microcontrollers and embedded systems. Micro-Python is a software implementation of a Python 3–compatible programming language written in C and modified to operate on a microcontroller. It has the capacity to execute Python code, enabling users to develop basic programs. More than 80% of the functionality of the most popular Python libraries are supported, along with many other common Python libraries. Python code has increased hardware possibilities that are not available when using a typical Python application that is run on an operating system, including direct access to and interaction with hardware. Python is an object-oriented programming language that comes with standard library modules. Although Micro-Python is

likewise an object-oriented programming language, it only includes a portion of Python's standard library modules. We can write the simple python code to control on hardware instead of complex low-level language such as: C and C++. ESP8266, ESP32 and Arduino board uses the micro-python to control the hardware. The code is designed on low-cost micro-controller such as raspberry pi board, Arduino board, ESP32 board and ESP8266 board etc. It is used to find-out the distance and height of the object using potentiometer and program it on microcontroller. Calibration of potentiometer then find out the angle and by using trigonometry function put it on micro python code and then easily find out the height and distance of any object without contact.

EXPERIMENTAL RESULT

Sample distance and height measurement shown in below figure: -

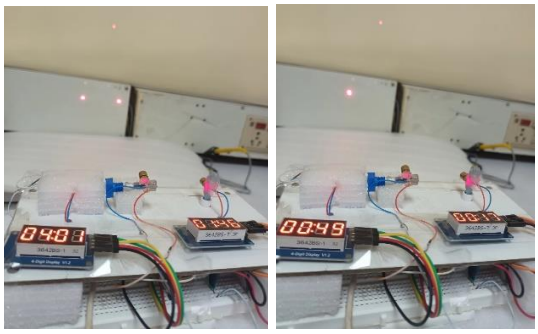

Figure 9: Three laser dot shown here for distance and height measurement and another figure two laser dots are to find-out the distance.

The right- angle triangle ABC is shown in figure 10.

Suppose B is fixed laser and C is another laser with potentiometer that makes angle with potentiometer, A is the point on the object whose distance is to be measured from B.

Here distance between BC is fixed i.e.:

BC=10cm, if θ =45◦

Then by using trigonometry function easily find-out height AB

AB = BC* tanθ = 10*tan45◦ = 10cm

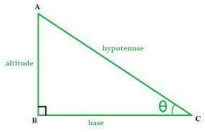

Figure 10: right-angle triangle

```
    y2= math.radians(y1) # angle in radian

    d = 10 * math.tan(y2)
    d1=d/100
    d2=round(d1)
    print(d2)
    tm1.number(d2)
    x5=0
    for ctr in range(10):
        x6=pot2.read()
#         print(x1)
        x5=x6+x5
        x7=x5
        sleep(0.2)
    x7=x7/10
    print(x7)
    x8=(x7-550)/10
    x8=round(x8)
    y3=x8/1.4 # angle in degree
    y4= math.radians(y3) # angle in radian
    h=d * math.tan(y4)
    h1=h/100
    h2=round(h1)
    print(h2)
    tm2.number(h2)
```

```
Shell
2
598.7
1
2041.4
87.14286
2
```

Figure 11: Distance and height obtained using micro-python

Graph between actual height vs experimental height of the object by developed is shown in below figure12.

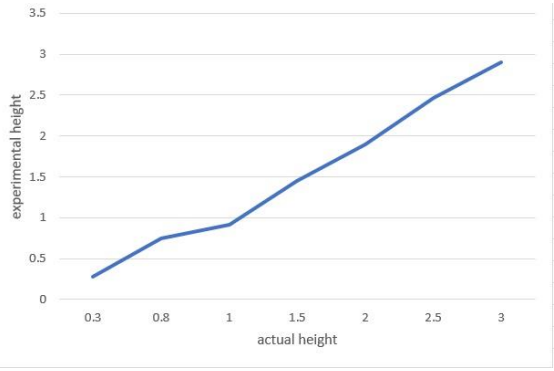

Figure 12: Graph between actual height and experimental height of the object

A graph comparing actual height to experimental height and actual distance to experimental distance is created to evaluate the system's accuracy. The graph is displayed in figures 12 and 13. The accuracy of the system was confirmed to be 99% after numerous observations. This indicates that for a measurement of 1 metre, the inaccuracy is 1 cm.

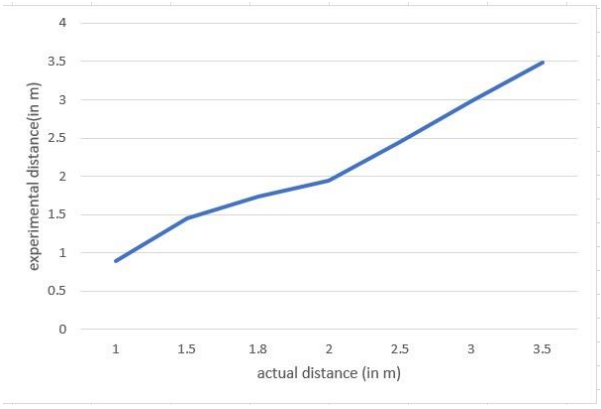

Figure 13: Graph between actual distance and experimental distance of the object

CONCLUSION

The ESP32 microcontroller acts as the main control unit for the measurement of non-contact type height and distance more accurately and efficiently. The micro-python programming language is used to develop the code that runs on the ESP32 and performs necessary calculation. The potentiometer is used to measure the angle of inclination and by using trigonometry calculation easily measure the height and distance of object. It provides at a very low cost for measuring height and distance of object in various application such as construction, agriculture, and surveying. The use of ESP32 microcontroller and micro-python allows for easy customization and integration with other electronic devices. Future improvement to this system could involve the use of additional sensor for more accurate measurement, as well as incorporating wireless communication to allow for remote monitoring and data collection.

REFERENCES

[1] Alam, J., Chowdhury, B.S., Mahmud, T., Soroni, F. and Khan, M.M., "Development of Smart Height Measuring Scale", In *2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT)* ,pp. 1-5, IEEE, July 2021.

[2] Lu, M.C., Wang, W.Y. and Lan, H.H., 2004, March. Image-based height measuring systems for liquid or particles in tanks. In *IEEE International Conference on Networking, Sensing and Control,* Vol. 1, pp. 24-29, *March 2004*.

[3] Han, Dianyuan, and Chengduan Wang. "Tree height measurement based on image processing embedded in smart mobile phone." In *2011 International Conference on Multimedia Technology*, pp. 3293-3296,IEEE, July 2011.

[4] KlimKov, Yu M., M. I. Shribak, and A. P. Shkadarevich. "A laser polarimetric sensor for measuring angular displacements of objects." In *The European Conference on Lasers and Electro-Optics*, p. CWF53. Optica Publishing Group, September 1996.

[5] Han, Dianyuan. "Tree height measurement based on image processing with 3-points correction." In *Proceedings of 2011 International Conference on Computer Science and Network Technology*, vol. 4, pp. 2281-2284. IEEE, 2011.

[6] Chen, Lifen, Bin Sun, and Xiaoming Chang. "MS5534B pressure sensor and its height measurement applications." In *2011 International Conference of Information Technology, Computer Engineering and Management Sciences*, vol. 1, pp. 56-59. IEEE, 2011.

[7] Lu, Ming-Chih, Wei-Yen Wang, and Chun-Yen Chu. "Image-based distance and area measuring systems." *IEEE Sensors Journal* 6, no. 2,495-503,2006.

[8]https://www.tutorialspoint.com/esp32_for_iot/esp32_for_iot_introduction.htm,

[9] https://www.electrical4u.com/potentiometer/

[10]https://www.espressif.com/en/products/hardware/esp32-devkitc/overview.

[11]https://www.espressif.com/en/products/socs/esp32,

[12] https://www.britannica.com/technology/laser

[13]https://quartzcomponents.com/products/laser-diode-laser-led-light

[14]https://lastminuteengineers.com/tm1637-arduino-tutorial/