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Line-Following Service Robot Using Arduino with Facial Recognition for Offices

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Abstract: The robot working environment has changed. Robots are no longer restricted to factories and have gradually spread to urban areas. In this research work, we designed a line-following service robot using Arduino and facial recognition to transport objects among offices. The line-following robot can proceed in its direction by following a black path; it spots the path, holds objects and recognizes and detects the picture of the target person to which the objects are belongs to at the office. This office service robot is based on an Arduino UNO, DC motors, and batteries and is equipped with sensors, an Esp32, an IR sensor, a camera and a buzzer, since it moves among offices. Our robot can hold and transport objects, e.g., documents and letters, from the source to a destination by following a path and detecting and recognizing the target person picture who should receive the objects. In addition, the buzzer within the robot will alarm and notify the target person with a specific sound that will be heard when the robot recognizes the target person (him or her) picture.

Keywords: ***Arduino, IR sensor, Esp32, Camera, Microcontroller, Line-following robot, Actuator, Facial recognition, Service robot, Buzzer.***

I. INTRODUCTION

IN recent years, intelligent service robots have received significant attention from both research institutions and marketing firms. Therefore, increasingly many research studies are now available to shed light on intelligent service robots. The increasing need for workers in the service sectors in the 21st century has motivated most developed countries and increased the range of robot applications. Robots have found increased application in both human-centered domains such as health care, education and entertainment and service areas such as city logistics, cleaning and recycling, surveillance and environmental monitoring. The activities of robots in factories have also increased to include not only production lines and collaboration with human operators as coworkers [1][2].

IR sensors have working principles: Planck's radiation law, Stephan Boltzmann's law, and Wein's displacement law, when the light incident on the colored surface is partially reflected. The light is completely reflected in the case of a white surface. However, if light is incident on a black surface, it is completely absorbed due to the absorption of the black color. This principle is utilized in the design of infrared sensors. When light is incident on normal or regular surfaces, it returns to the photodiode, whereas it is absorbed when incident on a black object; hence, no light rays are captured by the photodiode [3]. Arduino modules are Arduino design microcontroller-based development boards. They come in development board packages with open-source prototyping platforms. Arduino IDE is the common program approach [4]. The IC consists of 16 pins to control a set of two DC motors. The motor driving IC acts as a bridge between the controller (Arduino here) and the motor. The input to this IC is the output of the Arduino.

To provide service or quality and in the interest of "security," many options can be considered; some preferred approaches are biometric passwords, retina scans, and voice-enabled systems in reference to the developing technology. One authentication system is the facial recognition system used in most modern-day industries, smartphone development and high-security regions in industrial and cooperative sectors [5]. Utilizing security can reduce the project operating costs

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sustained by the project owner. In this robot work, we utilize a facial recognition approach to ensure that objects are delivered to target persons in the offices, where an ESP32 CAM is used to detect the picture of the target person [6]. The ESP32 chip is thoroughly complex and cannot easily be used on its own, especially for prototyping. Thus, to simplify the project development, several development boards are available to incorporate the ESP32 chip and associated hardware. [7] .

The materials in the robot work are Arduino UNO, a motor driver module L293D, DC motors, a robot chassis, an IR sensor module, insulation tape, conductors, a 9-V battery, a battery cap, and actuators (motors and wheels). In this robot work, the line-following robot with a face recognition utility structure, architecture issues and challenges are discussed. In Section 3, the system approaches and solutions to passing lines will be illustrated. The results and conclusions are explained in Section 4.

II. METHODOLOGY

The general approach for our working robot is that the robot is a combination of Arduino UNO and ESP32 CAM, as shown in figure 1. The office delivery robot was constructed, and we tested the robot in our department offices holding different types of documents and objects with various weights. Generally, the robot started from an initial point through the corridor, followed a black line, detected and recognized the pictures of people in their office and stopped with an audible buzzer when the target person was found.

A. ESP32-CAM

The ESP chip is used as a second low-cost controller to provide Wi-Fi capabilities and network access for another controller via a serial port. The ESP32 SoC provides an internal Wi-Fi connection on board and bluetooth but does not offer any integrated sensors. Many projects have been developed with ESP32 SoC, e.g., Internet of Things devices. The most popular ESP32 development boards are Adafruit Huzzah32, NodeMCU-32S and ESP32 DevKitC. In this robot work, we used an Adafruit Huzzah32 board, ESP32 AI-Thinker. The ESP32 chip is appropriate for implementation in applications of various monitoring and security tasks. [8].

B. Arduino UNO

Arduino UNO is a microcontroller kit with ATmega328P. Its features are 14 digital input/output pins with six PWM dual operation pins, six analog inputs with 10-bit ADC, a 16-MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It connects through an adaptor or directly to a computer/laptop via a USB cable, which serves the dual purpose of power supply and acting as a serial port to interface the Arduino and the computer. To avoid power fluctuations, a 9-V-12-V AC can power it through a DC adapter [9].

Fig.1 Arduino uno R3

C. IR Sensors

IR reflectance sensors are used to detect white and black surfaces. They work by measuring the amount of light that is reflected in the receiver. IR sensors embody two diodes: one diode sends rays, and the other diode receives rays. The robot detects a white surface when the receiver receives a reflection ray, and it detects a black surface when the receiver cannot receive a reflection ray.

The office robot uses IR sensors to sense the line. We used two sensors for the designed robot [10].

D. Buzzer

A buzzer is a device with an audio output signal. According to the code embedded in the microcontroller, the buzzer receives feedback sent by both sensors to the control unit and responds. It is used to prompt or alarm according to different designs and applications [11].

E. Arduino IDE

The Arduino IDE reassures simplified versions of C and C++ languages. Arduino IDE is a Java application to write programs for Arduino compatible boards. The basic programming structure of an Arduino is composed of at least two parts, and they are the setup and the loop components. However, some additional

software components must be downloaded before use. The ESP32 can be used with Arduino IDE

F. Face recognition ESP32-CAM

Biometric-based techniques have emerged as the most favorable option for recognizing individuals. Physiological and behavioral characteristics of individuals are examined by these techniques to determine and ascertain their identity [12]. Automatic facial recognition has been considered by many researchers for over 30 years. It is the widest research area in pattern recognition and computer vision, since it is used in many applications such as security and intelligent human-computer interactions [13].
ESP32 is used in data acquisition and control of various devices via wireless networks. ESP32-CAM can take photos and save them on the microSD card. The ESP32 camera is an inexpensive and readily available solution for facial detection applications. ESP32-CAM with AI-Thinker is utilized for facial detection and recognition.

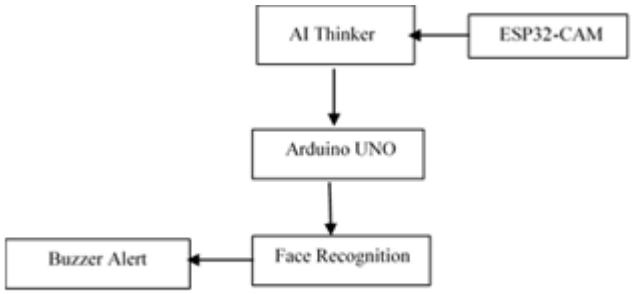

Fig 2.The service Robot with face recognition block diagram

III. RESULTS

The designed service robot was tested on both straight and curved line paths. Various documents and office objects weights were loaded and tested on both straight and curved paths. Table 1 shows the robot speeds, where it traveled for 2 m on a straight line in approximately 5 seconds when no packages are loaded. The path distance were fixed to 2 meters. Subsequently the robot speed slowed down when loaded with packages weighing 200 g and the traveling time was 5.50 sec. Finally the robot loaded 1,030 g, and the robot speed decreased obviously and the registered time was 8 second,

Table 1. The Robot speed and weight capability measurements on a straight line.

Straight line	Weight	Time	Distance
1	0 g	4.86s	2.40 m
2	200 g	5.50s	2.40 m
3	1,030 g	8s	2.40 m

Table 2 shows the robot speeds on a curved line loaded with different weighted packages; generally, it moved slower on the curved line. The robot speed slowed down further when the package weight increased. The robot speed decreased and it slowdown. For example; the registered time was approximately 18 second when the robot loaded with 1,030 gm on curved path.

Table 2. The Robot speed and weight capability measurements on a curve line.

Curve line	Weight	Time	Distance
1	0g	7.77 s	2.40m
2	200g	10.45s	2.40m
3	1030g	17.8s	2.40m

The face recognition and detection of the target person is shown in figure 4. The robot can recognize the target pictures at a distance of 60 cm, and the buzzer sound was heard to notify the target face picture.

Fig.3 the robot carrying 1,030g

Fig 4. The robot detecting the target person picture on the offices doors.

IV. CONCLUSION AND FUTURE WORK

In this work, different weighted packages were used; however, the robot could not manage higher loads, especially on a curved line. A better power supply is required to carry higher loads. This robot is a prototype. Although it actually implemented in real time, there were some errors, which can be solved with better components. A fixed distance of 2 meters was determined to assess the traveling performance of the robot. The picture of the target person's face was detected and recognized. However; we are planning to use the ESP32 CAM with machine learning to enhance the facial recognition accuracy

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