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Smart Restaurant Using 3D Holographic Projection Menu and Waiter Robot

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AbstractThis project aims to construct an inventive 3D holographic restaurant system by integrating cutting-edge technology such as Raspberry Pi, LCD monitor, L298N motor driver, keyboard, speaker, DC motor, ESP8266, and IR sensor. The system incorporates a robotic waiter equipped with a holographic display, capable of interacting with customers, taking orders, and serving food. The robot navigates between three tables, displaying holographic menus and confirming orders through a keypad. The system aims to revolutionize the dining experience by combining robotics, holography, and smart technology for an engaging and futuristic restaurant environment. This paper explores the innovative integration of advanced technologies, specifically 3D holographic projection menus and waiter robots, to create a smart restaurant aimed at revolutionizing the traditional dining experience. The incorporation of these cutting-edge technologies offers a unique and immersive approach to menu visualization and customer service.

Keyword: 3D Holographic Projection, Robotics, Smart technology, Customer engagement.

1. INTRODUCTION

The hospitality industry has continuously evolved with advancements in technology, aiming to enhance customer experience and streamline operations. In recent years, the integration of innovative technologies in restaurants has revolutionized the traditional dining experience. One such ground breaking innovation is the implementation of a Smart Restaurant system that combines 3D holographic projection menus and waiter robots.

This convergence of cutting- edge technologies offers an immersive and futuristic dining encounter, redefining how customers interact with menus and receive service. The incorporation of 3D holographic projection menus eliminates the conventional paper-based menus, introducing a visually captivating and interactive way for patrons to explore dishes, view presentations, and make informed choices.

This advanced technology not only provides an engaging visual representation of the menu items but also offers detailed information, including ingredients, nutritional facts, and customizable options, thereby enhancing customer engagement and satisfaction. Complementing the holographic menus, waiter robots operate seamlessly within the restaurant, assisting in delivering orders, interacting with customers, and ensuring efficient service. These robots have AI-powered features that allow them to accurately accept orders, move around the dining area, and work with the kitchen personnel to deliver meals on time.

2. LITERATURE SURVEY

(i) A Survey of Facial Capture for Virtual Reality

Authors: Lihang Wen , Jianlong Zhou , Weidong Huang, Fang Chen

Numerous researchers have been motivated by the holograms in Star Wars to record the entire human body in real time and display it as an avatar in virtual reality (VR). Since facial expressions are crucial for social connection, facial capture is crucial to achieving this. Facial capture, however, only functions properly when the face is not obscured. Despite being a popular choice for VR display, a VR headset blocks out half of the face and becomes in the way. An extensive literature overview on face capture for virtual reality is presented in this presentation. Determine the kinds of technologies, their applications, theoretical underpinnings, and research needs in face capture for virtual reality (VR). Also, determine face capture solutions for VR headsets. An index of realism is defined in order to assess and contrast the gathered publications. The findings highlight a number of technological developments in facial capture for virtual reality, including hologram/volumetric capture, facial performance capture, tracking facial movements using markers, and facial capture in headsets utilizing cameras or sensors. It is demonstrated that the best face capture technique for a VR headset is the Modular Codec Avatar, whereas Meta human produces the finest effects.

(ii) Approximated Wave front Composition for Computer-Generated Holograms Based on Tiny Logic Operations

Author: Takashi Nishitsuji, Tomoyoshi Shimobaba , Atsushi Shiraki, Tomoyoshi Ito

It is imperative to expedite the computation of computer-generated holograms (CGHs) in order to achieve electro-holography for three-dimensional (3D) displays. Despite the development of numerous algorithms for quick CGH calculations, there is still a long way to go before CGH computations are sufficiently accelerated. A promising method for CGH acceleration is to use the redundancy of a hologram to simplify CGH calculations while capturing a 3D image. In other words, the ability of a hologram to nearly perfectly replicate a 3D image—even when it was captured with approximation-related deviations—can be leveraged to expedite CGH computations. In view of the fact that trigonometric functions are significantly computationally demanding and crucial to the composition of wavefronts emanating from virtual three-dimensional objects like point-light sources, this study suggests an approximation method for them. Small logic operations are used in place of sin or cos functions in the suggested solution, which should have less processing overhead than the standard functions for fixed or floating precision values. The suggested method may calculate CGH 2.20 times quicker on a central processing unit (CPU) and 8.43 times faster on a graphics processing unit (GPU) than the standard implementation, according to numerical and optical studies. GPU implementations, but is also anticipated to have a major impact on next circuit designs for computers designed specifically for CGH.

(iii) Continuous Depth Control of Phase-Only Hologram with Depth Embedding Block

Authors: Won Jong Ryu , Jin Su Lee , and Yong Hyub Won

While there are still many issues to be resolved, such as the issue of significant time consumption in the fabrication of phase-only holograms, digital holography is a potential choice for advanced displays. Recent developments in deep learning methodologies have made it possible to generate high-quality, real-time holograms. However, since the training process establishes the intended depth of the images, holograms made with deep neural networks are limited in their capacity to replicate images. In this paper, a deep neural network that can continually change a phase-only hologram's depth is proposed and shown. The network creates a phase-only hologram based on the input image and goal depth. A depth embedding block was incorporated to adjust the hologram latent vector based on the desired depth. This implies that changing the vision plane can be done without retraining. Numerical and optical studies demonstrate that the network comprehends the relationship between the phase-only hologram's appearance and depth. Consequently, phase-only holograms that reconstruct images with a PSNR of about 25 dB may be produced using the suggested network.

(iv) Convolutional Neural Network for Phase-Only Hologram Optimization Based on the Point Source Method with the Holographic Viewing-Window

Authors: Yun Chen , Tianshun Zhang , Minjie Hua , Mingxin Zhou , and Jianhong Wu

An optimization process utilizing the holographic viewing-window (HVW) and point source method (PSM) for phase-only holograms (POHs) is carried out by a convolutional neural network (CNN). The network training uses an unsupervised method to transfer the target picture to optimized constant phases (OCPs) instead of random constant phases (RCPs), which represent the wavefront of each point source. Next, the ideal POH is produced using wavefront superposition. The results of the simulation and experiments demonstrated a significant suppression of speckle noise in the reconstruction compared to the original random phase method (RPM), demonstrating the viability of the suggested method and the strong generalization potential of the trained CNN. There is a continuous horizontal viewing range (HVW) on a holographic near-eye display (NED).

(v) Phase Hologram Design and Characterization for Standoff Localization at Millimeter and Submillimeter Wavelengths

Authors: Samu-Ville Pälli , Aleksi Tamminen , *Member, IEEE*, Juha Ala-Laurinaho ,and Zachary D. Taylor

We present the design, simulation, and experimental characterisation of distributed beamforming dual-band frequency-diversified holograms. The millimeter- and submillimeter-wave imaging holograms operate at frequencies of 220–330 GHz (WR–3.4) and 50–75 GHz (WR–15). In the 600 mm-diameter region of interest (RoI) from the aperture, the holograms are intended to form a dispersive field. Holograms that alter the phase of an incident collimated beam originating from a parabolic mirror comprise the front end of an imaging system. By using distributed beamforming, the ROI can be asked to extract the target's spatial information from the observed reflection via the dispersive propagation channel. Two prototype holograms are made and a few phase modification approaches are assessed. Both models and testing demonstrate the hologram's dispersive operation and efficiency. Spatial spectral correlation coefficient and singular-value decomposition techniques are used to quantify the frequency variety of the holograms. The findings indicated that a reasonable dispersion-efficiency tradeoff might be achieved with a design frequency of 120 GHz, a phase quantization step of $\pi/2$ radians, and an additional phase of 1.9π radians. In the area that the hologram illuminates, a corner-cube reflector is located using a fully connected neural network. The localization precision satisfies the diffraction-limited resolution and confirms the optimal hologram performance as established by the design metrics.

(v) eFIN: Enhanced Fourier Imager Network for Generalizable Autofocusing and Pixel

Authors: Hanlong Chen , Luzhe Huang, Tairan Liu, and Aydogan Ozcan

The application of deep learning techniques has greatly enhanced holographic imaging capabilities by facilitating better phase recovery and image reconstruction. In this work, we introduce a robust and highly-generalizable deep neural network architecture for pixel-super-resolution hologram reconstruction and image autofocusing: the enhanced Fourier Imager Network (eFIN). Through holographic microscopy investigations, we demonstrate that eFIN outperforms other methods for image reconstruction and can externally generalize to new types of samples that were not employed during the training phase, employing Papanicolau (Pap)

smears and tissue sections from the prostate, lung, and salivary glands.

(vi) Enhancing the Information Capacity With Modulated Orbital Angular Momentum Holography

Authors: Feili Wang, Xiangchao Zhang , *Member, IEEE*, He Yuan, Rui Xiong, andXiangqian Jiang

High-security encryption and holographic multiplication have been experimentally demonstrated via orbital angular momentum (OAM) holography. However, in practical applications, the information capacity is severely limited because the helical phase of an OAM mode can only be encoded into one hologram linked with a target image. The proposal is for a modulated orbital angular momentum (MOAM) holography, whereby one OAM mode is superimposed with numerous modulation phase modes. Three key characteristics are examined: MOAM preservation, MOAM selection, and MOAM multiplication. This technique has several applications in optical encryption and beam manipulation, and it can greatly increase the holographic information capacity.

3. PROPOSED WORK

A robotic waiter with a holographic display, an order confirmation keypad, an LCD monitor, IR sensors, and smart technologies like a Raspberry Pi, ESP8266, and L298N make up the proposed 3D hologram restaurant system. Combining cutting-edge technology and superior cooking, the system can move between tables, show holographic menus, collect orders via a keypad, and serve food from a separate chamber.

3.1 Materials Used

Hardware Requirements

Raspberry Pi

LCD Monitor

L298N Motor Driver

Keypad

Speaker

DC Motor

ESP8266

IR Sensor

Software Requirements:

Programming Language: C and JAVA

Development Environment: Arduino IDE.

Operating System: Windows 10

Raspberry Pi:

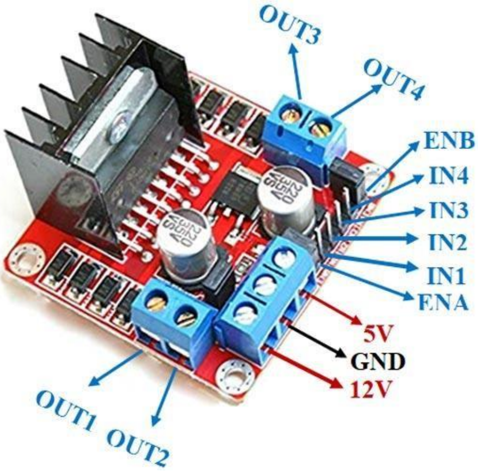
A revolution in do-it-yourself electronics and computers has been sparked by the credit card-sized Raspberry Pi microprocessor. This compact yet capable gadget, created by the Raspberry Pi Foundation, provides an affordable way to learn programming, experiment with hardware, and build a variety of projects, such as vintage game consoles and home automation systems. Its GPIO (General Purpose Input/Output) pins, which enable users to connect sensors, motors, and other peripherals, are what give it its adaptability. By coding and experimenting, users may make ideas become reality. The Raspberry Pi is a mainstay of the maker movement and beyond because to its affordable price and active community support, which have democratized access to computing education and encouraged innovation across a range of areas.

LCD Monitor:

Monitors with liquid crystal displays, or LCDs, are a ubiquitous technology found in almost all contemporary computing environments, including homes and businesses. It revolutionized the display market with its tiny size, crisp visual clarity, and energy-efficient construction. Unlike traditional cathode ray tube (CRT) displays, LCD monitors create images by sandwiching a thin layer of liquid crystals between two transparent electrodes. Thanks to this technology, LCD displays require less electricity and have lighter panels, making them more cost-effective and environmentally friendly in the long run. Additionally, flicker-free viewing on LCD screens reduces eye strain when using them for prolonged periods of time.LED backlighting and greater refresh rates have allowed LCD monitors to produce vibrant colors, legible text, and smooth motion.

L298N Motor Driver:

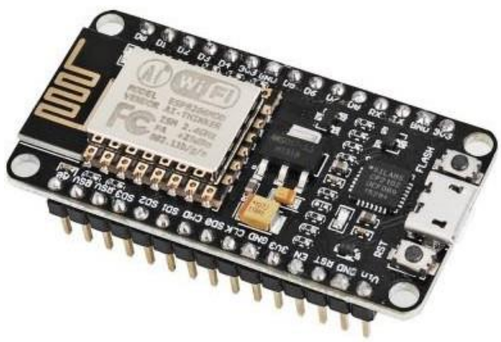
Designed to control DC motors and stepper motors, the L298N motor driver is an integrated circuit that is widely used and adaptable. It provides a reliable and effective way to power motors for a range of uses, such as automation, robotics, and DIY projects. Due to its twin H-bridge circuitry, the L298N chip can independently regulate the speed and direction of two motors. Four transistors arranged in an H-bridge's configuration allow it to brake, drive, and move the motor forward or backward.Micro Servo Motor SG90 could be a little and lightweight server engine with tall yield control. Servo can rotate approximately 180 degrees (90 in each heading) and works a bit like the standard sorts but littler. It is utilized for opening and closing of the drawer. Here it is used for opening and closing of the pill box.



Keypad:

Keypads are crucial input devices found in many electronics, including ATMs and mobile phones. They make it possible for users to traverse menus, enter information, and place orders fast. They offer customizable settings and tactile feedback in many configurations, including membrane and mechanical keypads. Keypads expedite transactions, improving user experience and lowering errors in retail and hospitality. In general, keypads are essential for enabling effective human-machine interaction in a wide range of applications.

GSM/GPRS module may be a scaled down GSM modem. This module can be utilized to do nearly anything a ordinary phone is able of doing it can send SMS, Make or get phone calls, interfacing to web through GPRS.

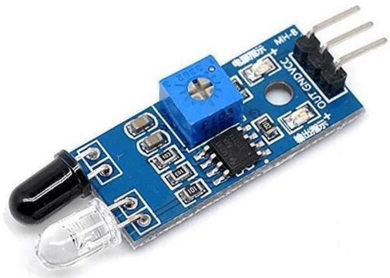


ESP8266:

The ESP8266 is a widely used and versatile Wi-Fi module that has revolutionized the Internet of Things (IoT) market. Because it combines a complete TCP/IP stack with support for Wi-Fi networking, this low-cost, low-power microcontroller from Espressif Systems is ideal for adding internet capabilities to a range of electronic applications and products. Because of its small size and ease of use, the ESP8266 has gained popularity among makers, amateurs, and professional developers. Numerous features are offered, including GPIO pins for integrating with sensors and actuators, SPI and I2C interfaces for interacting with peripherals, and analog-to-digital converters for reading sensor data.

IR Sensor:

These sensors are frequently utilized in many different applications, such as temperature monitoring, motion detection, proximity sensing, and remote control systems. Typically, infrared sensors are made up of an emitter that releases radiation into the atmosphere and a detector that picks up and records the amount of radiation that is reflected or released. An object reflects or emits infrared radiation when it is inside the sensor's detecting range, and the sensor picks this up.



3.2 Methodology used

In our work we utilize a few modules, these modules/methodologies are recorded underneath.

Menu Management System:

The menu must be managed by an authorized user, usually a manager or a recognized staff member, according to the system. Access restrictions guarantee that modifications can only be made by those who are permitted.Items on the menu can be added, removed, or hidden by the authorized person. This include changing prices, adding new food photos, and updating descriptions.

Customer Detection System:

To identify the presence of customers, IR sensors are positioned thoughtfully at the entryway. When a customer enters, these sensors sound an alert.When a consumer is recognized, an alarm system connects with the robot via IR sensors to send signals and start an activity.After getting an alarm, the robot moves automatically to the table where the new customer is seated using navigation algorithms.

Web Ordering System:

Customers use a keypad to communicate with the robot. They can use the keyboard to place their order after perusing the menu, choosing breakfast, lunch, or supper options. The robot shows the selected items in a cart on its screen while consumers make selections. Customers can confirm their order by clicking the "order now" button after reviewing. The kitchen receives the verified order instantaneously and displays it on the screen so that staff members and chefs can begin preparing.

Motor and Motor Driver Module:

The motor and motor driver module combo powers automation and movement in a multitude of electromechanical systems for a variety of uses. Essentially, the motor serves as the mechanical workhorse, converting electrical energy into rotational motion. Meanwhile, the motor driver module acts as the control center, directing and controlling the motor's speed based on input signals from a microcontroller or other control circuitry. This module typically contains integrated circuits or power transistors configured in an H-bridge topology, allowing for bidirectional motor control. By precisely regulating the voltage and current supplied to the motor, the driver module makes it feasible for the motor to accelerate, decelerate, and even stop. Together, the motor and motor driver module pair form a robust and flexible partnership that accurately and efficiently powers a variety of devices, including industrial machinery, robotics, CNC machines, and automotive systems.

Order Retrieval System:

This module allows the robotic arm to grasp and hold things inside the borewell by controlling the gripper mechanism.In order to carry out instructions for grip control and robotic arm movement, it communicates with the control module. gripper mechanisms, robotic arm actuators, servo motors or actuators for arm movement, and control signals from the control module.

Food Delivery by Robot:

A smooth and effective eating experience for patrons in the intelligent restaurant. The order is checked against the kitchen display system by the counter employee. After verification, they load the food into the robot.With trays or compartments installed, the robot finds its way back to the customer's table on its own. To safely deliver the meal, it makes use of obstacle avoidance algorithms.When the robot gets to the customer's table, it makes sure to go back to its starting place. To prevent collisions and deliver the meal precisely where it is supposed to, it employs precision navigation.The customer may engage with the robot, who will verify the order and offer any information that is required. Food is available for the consumer to take from the robot's tray.

4. OUTCOME

Enhanced Customer Experience:

Interactive and visually appealing menu exploration is provided using 3D holographic menus. With accurate dish representations and ingredient information, customers may make well-informed judgments. Waiter robots increase client pleasure by carrying out tasks like taking orders and delivering food.

Improved Operational Efficiency:

Wait times and human mistake are decreased by waiter robots, which improves restaurant operations.Order transmission to the kitchen is accurate and timely thanks to centralized ordering systems. Smart technology integration lowers labor expenses and increases efficiency, which results in cost savings.

Careful Implementation and Maintenance:

Careful planning and consideration of client preferences are necessary for the successful adoption of these technologies. Continuous maintenance guarantees that all hardware and software components operate as intended.
Personalized attention and human interaction are still essential components of a comfortable eating setting.

Cost Savings and Return on Investment:

Long-term advantages of technology investment include lower labor expenses and a possible rise in customer attrition, even if the initial outlay may be substantial. Because they increase customer happiness and operational efficiency, smart technologies yield a favorable return on investment.

Future of Dining Experiences:

The combination of 3D holographic technology and robotics creates immersive, futuristic dining experiences. Future developments in technology present fresh opportunities to improve a number of elements of the dining experience. Establishing new benchmarks for hospitality through the use of cutting-edge technologies, smart restaurants lead the way.

CONCLUSION

In conclusion, To sum up, the potential for redefining consumer experiences in the restaurant business through the combination of robotics and 3D holographic technologies is vast. In addition to addressing the drawbacks of conventional dining environments, this suggested solution paves the way for an exciting new era of hospitality. The combination of robots and holography has new opportunities for improving our everyday experiences in many areas, including dining and socializing in restaurants, as technology advances. Customers can explore the menu options in an engaging and dynamic way by using the 3D holographic projection menu. Second, the efficiency of restaurant operations is enhanced by the use of waiter robots. These robots can do jobs like collecting orders, delivering meals, and clearing tables, freeing up human employees to concentrate on more individualized and hands-on customer care duties. Additionally, waiter robots improve overall client satisfaction by cutting wait times and facilitating a more efficient and uniform service. In the long run, integrating smart technologies in a restaurant setting can also result in cost savings. Although these technologies may need a large initial investment, over time they may prove to be profitable due to their enhanced efficiency, decreased labor costs, and potential for higher customer turnover. Although the concept of a smart restaurant with 3D holographic menus and robotic waiters sounds exciting, it's important to keep in mind that the effective implementation of such technologies requires careful planning, upkeep, and consideration of consumer preferences. It's also critical to keep in mind that a nice and welcoming dining environment depends on personalized service and human interaction.

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