International Journal of Engineering Research and Science & Technology

IJERST

www.ijerst.org

ISSN : 2319-5991

Vol. 20 No. 3 (2024)

ijerst.editor@gmail.com

editor@ijerst.com

ISSN 2319-5991 www.ijerst.com
Vol. 20, No. 3, 2024

Research Paper

IOT FACE RECOGNITION AIROBOT USING EMBEDDED SYSTEM

M.RAHUL
mothukurirahul2@gmail.com
N. VAMSHI
vamshinadimpalli4@gmail.com
N. VARSHITHA
varshithavarsha040@gmail.com
N. SHIVA YADAV
Shivayadav1674@gmail.com
CMR Engineering college, Kandlakoya, Hyderabad-50140

ABSTRACT

The integration of face recognition technology with embedded systems in an IoT framework presents a significant advancement in human-robot interaction and security applications. This proposeanovelIoT-basedfacerecognitionAIrobotutilizingembeddedplatformssuchasESP- 32 or Arduino with AI accelerators for efficient real-time face detection and recognition. The system employs a high-resolution camera for image acquisition, with facial recognition performed using pre-trained deep learning models optimized for embedded processing.

The recognized data is leveraged to drive robotic actions through an IoT network, enabling applications like access control, user identification, and personalized interactions. A lightweight convolutional neural network (CNN) ensures computational efficiency, while optimized communication protocols facilitate seamless cloud and device integration. Experimental evaluations demonstrate the system's reliability across various environmental conditions,emphasizingitsapplicabilityinsecurity,healthcare,andpersonalassistantdomains. The study concludes with an analysis of system performance, scalability, and future improvements to enhance embedded AI-driven face recognition in IoT ecosystems.

Received: 08-07-2024 Accepted: 14-08-2024 Published: 21-08-2024

INTRODUCTION

An IoT Face Recognition AI Robot is a cutting-edge device that leverages the power of artificialintelligenceandtheinternetofthingstorecognizeandidentifyindividualsbased on their facial features. Embedded systems serve as the brains of these robots, processing data locally and interacting with the environment.

An IoT Face Recognition AI Robot is a cutting-edge device that seamlessly integrates artificial intelligence and the internet of things. Embedded systems serve as the robot's brain,enablingittocapturereal-timeimages,processthemusingadvancedmachine learning algorithms, and recognize individuals based on their unique facial features. This technologyhasawiderangeofapplications,includingsecurity,healthcare,retail,education, andsmarthomes.ByleveragingIoTconnectivity,theserobotscantransmitdatatothecloud for further analysis, remote monitoring, and updates. While challenges such as computational power, real-time processing, and privacy concerns need to be addressed, the potential benefits of this technology are immense.

1. EmbeddedSystem:

Asmallcomputeronachipthatcontrolstherobot'shardwareandsoftware**.**Captures real-time images of the environment. Temperature, humidity, distance, etc., depending on thespecificapplication.Controltherobot'smovementandaction.Indicatestatusorprovide visual feedback.

2. FaceRecognitionAI:

Trained on a vast dataset of facial images to recognize patterns and features. Locatesfacesinthecamera's fieldofview. Extractskeyfeaturesfromthedetectedfaces, suchaseyedistance,noseshape,andjawline.Comparesextractedfeatureswithadatabase of known faces. Determines the identity of the person or verifies their claimed identity

OBJECTIVE

TheprimaryobjectiveofthisprojectistodevelopanIoT-enabled,AI-poweredrobotcapable of accurately recognizing human faces. This innovative system aims to integrate an embeddedsystem,equippedwithacameraandpowerfulprocessingcapabilities,to capture and analyse real-time images. By leveraging advanced facial recognition algorithms, the robot will be able to identify individuals from a database of known faces, enabling a wide range of applications, including enhanced security, personalized interactions, and efficient surveillance systems.

The robot will be equipped with a camera, Wi-Fi module, and AI-powered face recognition algorithm, enabling it to recognize and identify individuals. The project aims to provide a secure and efficient way to monitor and control access to restricted areas, whilealsoexploringthepotentialapplicationsofAIandmachinelearninginrobotics.The robotwillleverageAI-poweredfacerecognitionalgorithm,computervision,andmachine learning to identify individuals and grant secure access to authorized personnel. This project aims to demonstrate the potential of AI and robotics in enhancing security, efficiency, and innovation in various industries and applications.

The robot will leverage AI-powered face recognition algorithm, computer vision, and machine learning to identify individuals and grant secure access to authorized personnel. This project aims to demonstrate the potential of AIand robotics in enhancing security, efficiency, and innovation in various industries and applications.

The project aims toprovideasecureandefficientwaytomonitorandcontrolaccess to restricted areas, while also exploring the potential applications of AI and machine learninginrobotics.ByintegratingAI,computervision,androbotics,thisprojectseeksto createaninnovativesolutionforsecureaccesscontrol,identityverification,and surveillance.

PROPOSED SYSTEMS

TheproposedmethodforbuildingafacerecognitionAIrobotusingESP32takesadvantage ofitsintegratedAIcapabilitiesandcost-effectiveness.ESP32-CAMModule:Thisversatile modulecombinesanESP32microcontrollerwithacamerasensor,enablingreal-timeimage capture and processing.Additional Sensors (Optional): Depending on the specific application, additional sensors like ultrasonic sensors or infrared sensors can be integrated for obstacle avoidance or proximity detection.

SoftwareandAlgorithmsMicroPythonorArduinoIDE:Thesedevelopmentenvironments provide a user-friendly interface for programming the ESP32.

- **TensorFlow Lite:** A lightweight machine learning framework suitable for edge devices like the ESP32.
- **Pre-trained Face Recognition Model:** A pre-trained model, such as MobileNet or EfficientNet,canbeoptimizedandconvertedtoaTensorFlowLitemodelfor efficientdeploymentontheESP32.
- **ImageProcessingandComputerVisionLibraries:**LibrarieslikeOpenCVcanbe used for image preprocessing, face detection, and feature extraction.

Model Preparation:

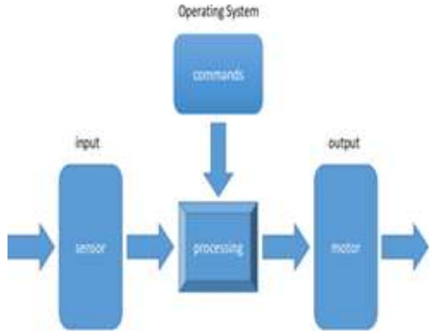
- Downloadapre-trainedfacerecognitionmodel.
- Convertthemodelto TensorFlowLiteformat usingTensorFlowLiteConverter.
- OptimizethemodelfortheESP32’slimitedresourcesusingquantizationand pruning techniques.

ESP32 Programming:

- Writecodetocaptureimagesfromthe camera sensor.
- Preprocesstheimages(e.g.,resizing,normalization).
- Feedthepre-processedimagestotheTensorFlow Litemodelforfacedetectionand recognition.
- Analysethe model’s output to identify theperson.
- Implementactionsbasedontherecognitionresult,suchastriggeringalarms,unlocking doors, or activating specific functions.

IoT Integration:

- ConnecttheESP32to aWi-Fi networkoruse cellular connectivity.
- Sendface recognitiondataandothersensorinformation toacloud platform.
- Implement remotemonitoring,control,anddata analysis.



EMBEDDEDOS

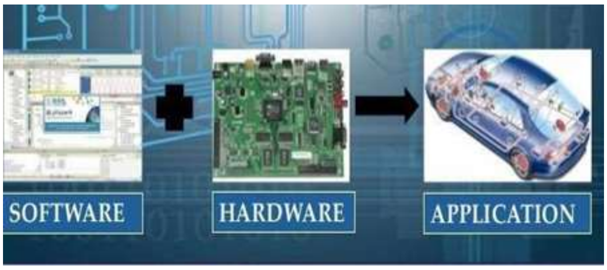
EMBEDDEDSYSTEMS

An embedded system is a combination of computer hardware and software designed for a specific function or functions within a larger system. Characteristicsofembeddedsystems

The main characteristic of embedded systems is that they are task specific. They perform a single task within a larger system. For example, a mobile phone is *not* an embeddedsystem,itisacombinationofembeddedsystemsthattogetherallowittoperform a variety of general-purpose tasks. The embedded systems within it perform specialized functions. For example, the GUI performs the singular function of allowing the user to interface with the device. In short, they are programmable computers, but designed for specific purposes, not general ones

Hardware: The hardware of embedded systems is based around microprocessors and microcontrollers.Microprocessorsareverysimilartomicrocontrollers,andgenerallyrefer toaCPUthatisintegratedwithotherbasiccomputingcomponentssuchas memorychips anddigitalsignalprocessors(DSP).Microcontrollershavethosecomponentsbuiltintoone chip.

Software: Software for embedded systems can vary in complexity. However, industrial grademicrocontrollersandembeddedIoTsystemsgenerallyrunverysimplesoftwarethat requires little memory.



BLOCKSOFEMBEDDEDSYSTEMS

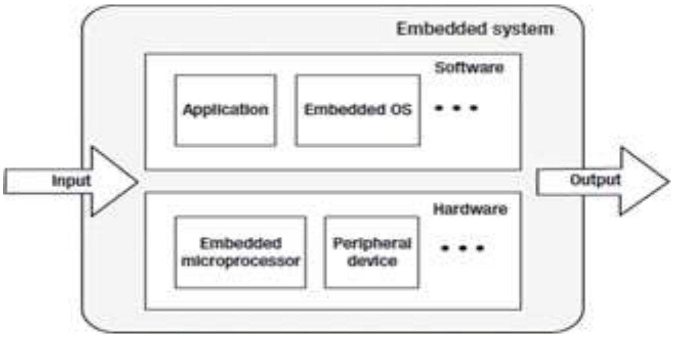
DESIGN APPROACHES ARCHITECTURE

A system designed with the embedding of hardware and software together for a specific function with a larger area is an embedded system design. In embedded system design, a microcontroller plays a vital role. Micro-controller is based on Harvard architecture, it is animportantcomponentofanembeddedsystem.Externalprocessor,internalmemory,and I/ocomponentsareinterfacedwiththemicrocontroller.Itoccupieslessareaandlesspower consumption. The application of microcontrollers is MP3 and washing machines.

Critical Embedded Systems (CES) are systems in which failures are potentiallycatastrophicand, therefore, hard constraints are imposed on them. In the last years theamountofsoftwareaccommodatedwithinCEShasconsiderablychanged.Forexample,insmartcarstheamountofsoftwarehasgrownabout100timescomparedtopreviousyears.Thischange means that software design for these systems is also bounded to hardconstraints(e.g., high security and performance). Along the evolution of CES, theapproachesfordesigningthemarealso changing rapidly,soas tofitthespecializedneedsof CES. Thus, abroad understanding of such approaches is missing.StepsintheEmbeddedSystemDesignProcess

Thedifferentstepsintheembeddedsystemdesignflow/flowdiagramincludethe following.

- **Specification:**Thefirststepintheprocess,whereyoudefinetherequirementsthat the system must meet
- **SystemRequirementsAnalysis**:Definetheoverallsystemrequirements, including the hardware and software components.
- **SystemArchitecture**:Determinetheoverallsystemarchitecture,includingthe hardware and software components.
- **InterfaceDesign**:Designtheinterfacesbetweenthehardwareandsoftwarecomponents.
- **SystemIntegration**:Integratethehardwareandsoftwarecomponents.
- **SystemTestingandVerification**:Testandverifythatthesystemmeetsthe requirements.



HARDWARE AND SOFTWAREOFEMBEDDEDSYSTEM

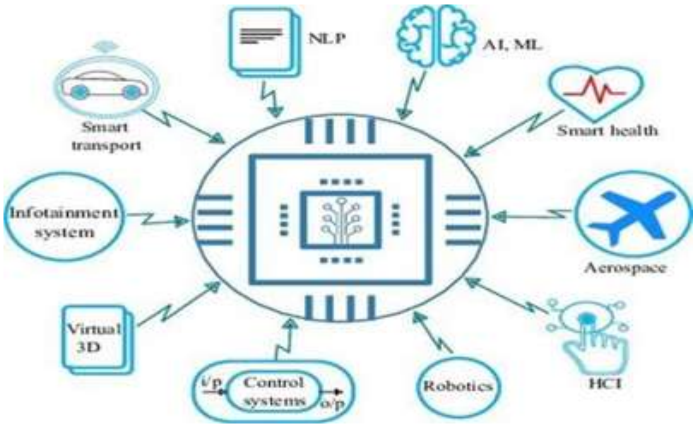
Architecturaldescriptionlanguage isusedtodescribethesoftwaredesign.

- ControlHierarchy
- Datastructureandhierarchy
- SoftwareProcedure.

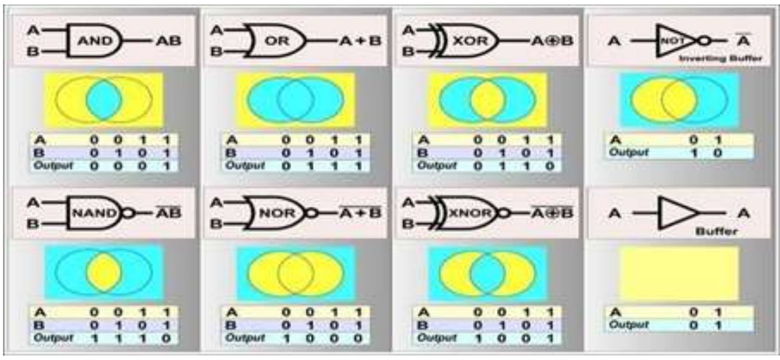
Inuserinterfacedesignitdependsonuserrequirements,environmentanalysisandfunction ofthesystem.Forexample,onamobilephoneifwewanttoreducethepowerconsumption of mobile phones, we take care of other parameters, so that power consumption can be reduced. WHO has identified formulations for their local preparation.

Embedded systems are used in a variety of technologies across industries. Some examples include:

AutomobilesModerncarscommonlyconsistofmany computersorembeddedsystems, designedtoperformdifferenttaskswithinthevehicle.Someofthesesystemsperformbasic utility function and others provide entertainment or user-facing functions. Some embedded systems in consumer vehicles include cruise control, backup sensors, suspension control, navigation systems and airbag systems.



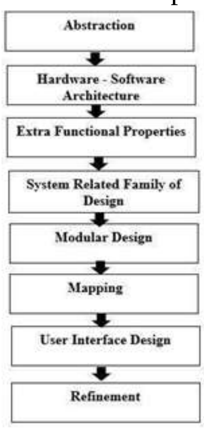
APPLICATIONSOFEMBEDDED SYSTEMS



COMBINATIONOFLOGICDEVICES

LOGICGATES

Logic gates are physical devices that use combinational logic to switch an electrical one (“1”)orzero(“0”)todownstreamblocksindigitaldesign.Combinationallogicusesthose bits to send or receive data within embedded systems. Data bits build into digital words usedtocommunicatewithotherdesignblockswithinthesystem.Digitalbitsandwordsdo Logic families are collections of integrated circuits containing logic gates that perform functionsneededbyembeddedsystemstocommunicatewithoneanothertodrivethedesign. Logic gates are organized into families relative to the type of material and its operational characteristics.



EMBEDDEDDESIGN-PROCESS-STEPS

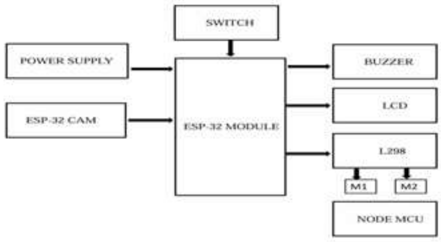
Hardwareandsoftwarepartitioning: Youdividethesystemintohardwareandsoftware components

- **Hardwareandsoftwaredesign:**Youdesignapproachthehardwareand software independently
- **Hardwareandsoftwareintegration:**Youintegrate thehardwareandsoftware, and decide how and when to resolve bugs
- **Softwaretesting:**Youtestthesoftwaretodetect vulnerabilities

- **Userinterfacedesign:**YoudesigntheinterfacebetweentheCPUsoftware andthe digital interface logic, and between the digital and analog sides of the interface

WORKING

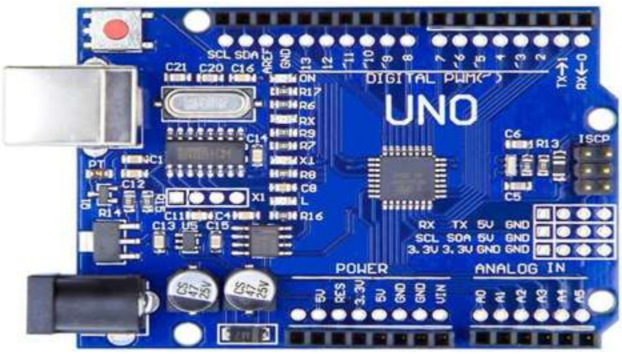
BLOCK DIARAM



BLOCK DIARAM

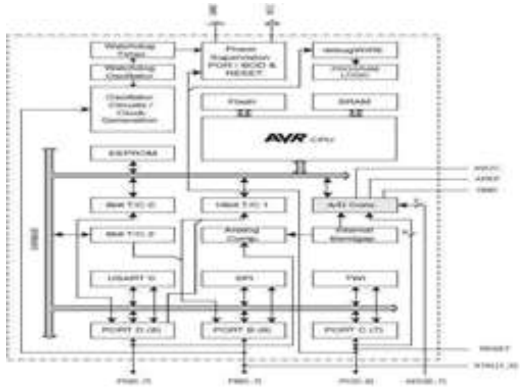
TheArduinoisafamilyofmicrocontrollerboardstosimplifyelectronicdesign,prototyping andexperimentingforartists,hackers,hobbyists,butalsomanyprofessionals.Peopleuseit as brains for their robots, to build new digital music instruments, or to build a system that lets your house plants tweet you when they're dry. Arduinos (we use the standardArduino Uno) are built around an Atmega microcontroller — essentially a complete computer with CPU, RAM, Flash memory, and input/output pins, all on a single chip. Unlike, say, a Raspberry Pi, it'sdesigned to attach all kinds of sensors, LEDs, small motors and speakers, servos, etc. directly to these pins, which can read in or output digital or analog voltages between 0 and 5 volts.

AURDINOBOARD



This section discusses theAVR core architecture in general. The main function of the CPU core is to ensure correct program execution. The CPU must therefore be able to access memories, perform calculations, control peripherals, and handle interrupts.

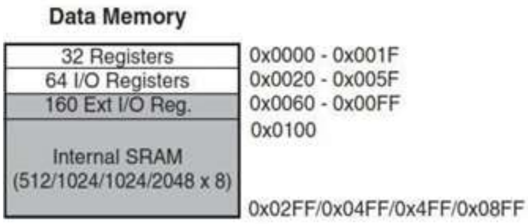
Six of the 32 registers can be used as three 16-bit indirect address register pointers for Data Space addressing – enabling efficient address calculations. One of these address pointerscanalsobeused asanaddresspointerforlookuptablesinFlashprogrammemory. These added function registers are the 16-bit X-, Y-, and Z-register, described later in this section.



AVRBLOCKDAIGRAM

In-Systemreprogrammableflashprogrammemory:
The Atmega328 Contains 4/8/16/32kbytes On-Chip In-System Reprogrammable Flash Memoryforprogramstorage.Sinceallavrinstructionsare16or32bitswide,Theflashis Organized As 2/4/8/16k X 16. For Software Security, The Flash Program Memory Space Is Dividedintotwosections,Bootloadersectionandapplicationprogramsection.Theflash Memory Has An Endurance Of At Least 10,000 Write/Erase Cycles. The Atmega328 Program Counter (Pc) Is 11/12/13/14 Bits Wide, Thus Addressing The 2/4/8/16k Program Memory Locations.

Sramdata Memory:
Atmega328isacomplexmicrocontrollerwithmoreperipheralunitsthancanbe
Supportedwithinthe64locationsreservedintheopcodefortheinandoutinstructions.
Fortheextendedi/Ospacefrom0x60–0xffinsram,Onlythest/Sts/Stdand Ld/Lds/Ldd Instructions Can Be Used.
InTheRegisterFile,RegistersR26toR31Featuretheindirectaddressingpointerregisters. The direct addressing reaches the entire data space. The Indirect with Displacement mode reaches 63 address locations from the base address given by the Y- or Z register.



NodeMCU
Node MCU (Node Microcontroller Unit) is an open-source IoT platform based on the ESP8266Wi-Fi module, widely used in embedded systems and smart deviceapplications. It integrates Wi-Fi capabilities, GPIO (General Purpose Input/Output) pins, ADC (Analog-to-Digital Converter), UART (Universal Asynchronous Receiver-Transmitter),I²C,SPI,andPWM(PulseWidthModulation)functionalities,makingita versatile microcontroller for IoT applications. The **NodeMCU** is a popular open-source development board featuring the **ESP8266** Wi-Fi module, widely used in IoT projects. It combines a microcontroller with integrated Wi-Fi, facilitating easy prototyping and development of connected devices.

NODE MCU
The IoT Face Recognition AI Robot using an embedded system integrates artificial intelligence (AI) and machine learning algorithms to provide real-time facial detection and recognition. This system, typically built around a device like the ESP32-CAM, uses computer vision techniques to identify and authenticate individuals, offering a broad range of applications such as smart home security, automated access control, and surveillance.
This connectivity allows users to access live video feeds through a web interface or mobile application, where they can monitor who is at the door or remotely control the system. In the event that an unknown face is detected, the system can trigger automatic alerts through email, SMS, or mobile notifications, enhancing security.
Additionally, power consumption is a consideration, although the system is optimizedtorunefficientlyona5Vor3.3Vpowersupply,makingitfeasibleforbattery- powered applications. Data can be temporarily stored on an SD card in more compact systemsliketheESP32-CAM,or,inmoreadvancedsetups,thedatamay beuploadedto the cloud for better storage and processing.

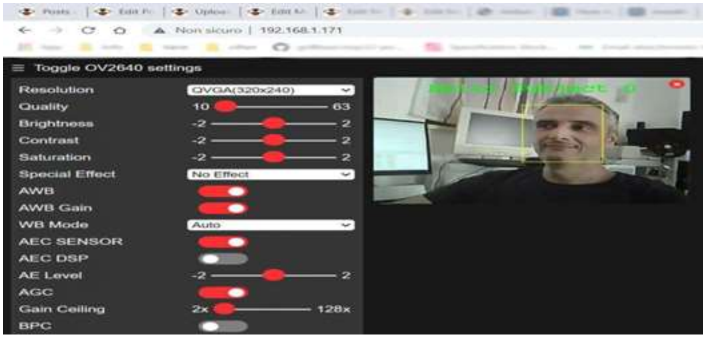
1. The project begins by providing power to the device. It takes about 10 seconds to turn on, and this process is displayed on the screen.
2. ConnecttheESP 32Moduleto your hotspot
3. Connect theWIFIof ESP32 to laptop/mobile
4. Openthe IPwebsiteof ESP32 (192.168.4.1)
5. Enrollthefaces tothemodule
6. Thecamerais readytodetect persons

CAMERAENROLLING FOR FACE

STARTDETECTION& RECOGNITION

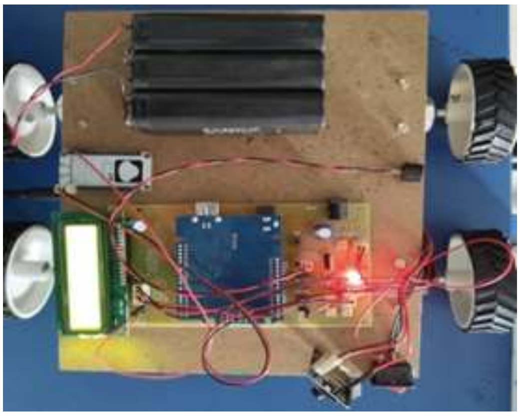
1. Clicktheenrollandaddpersonimages
2. Whenthepersondetected byRobotthenthe websiteshowsHelloSubject 1
3. ThentheLCDDISPLAYshowstheperson1 detected Personlocationis visibledin MAPS.

FACERECOGNIZED



PERSON DETECTEDINLCDDISPLAY

ARDWAREKIT

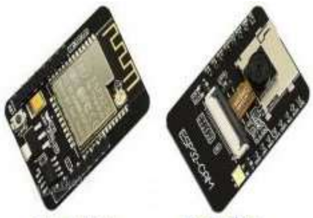


APPLICATIONS

This sensor is used in various applications such as measuring humidity and temperature values in heating, ventilation and air conditioning systems. Weather stations also use thesesensorsto predict weatherconditions.Thehumidity sensorisused as apreventive measure in homes where people are affected by humidity.Offices, cars, museums, greenhousesandindustriesusethissensorformeasuringhumidityvaluesandasasafety measure.It'scompactsizeandsamplingratemadethissensorpopularamonghobbyists. Some of the sensors which can be used as an alternative to DHT11 sensor are DHT22, AM2302, SHT71. Which of the specification of the DHT11 sensor was helpful for your

ESP32-Cam

It is a very small integrated module of an OV2640 camera and an ESP3-S processor, allowing to create IP camera projects for video streaming with different resolutions and visualized in real time through a Wi-Fi network in a way direct. It contains three GND power pins of 3.3V or 5V [11]. A high-brightness LED can be ordered for night shots, for example. In this case, it is possible to connect a photoresistor on the board. Indeed, it also integratessomeGPIOportstoassembledifferentsensorsandactuators.TheESP32-CAM module also has an SD card reader which can be used to save images when an event is detected [12], [13]



ESPCAM

1. **PowerManagement**:Theboardcanbepoweredviathe5Vor3.3Vpins.However,it's recommended to use the 5V pin to ensure stable operation.
2. **ProgrammingInterface**:Lacksabuilt-inUSB-to-serialconverter;requiresanexternal FTDI programmer connected to GPIO 1 (TX) and GPIO 3 (RX) for code uploading.
3. **BootMode Selection**: GPIO0 determines the boot mode.Connecting GPIO 0 to GND puts the board into flashing mode for programming.

REFRENCES

1. Meddeb, Houda, Zouhaira Abdellaoui, and Firas Houaidi. "Development of surveillance robot based on face recognition using Raspberry-PI and IOT."*Microprocessors and Microsystems* 96 (2023): 104728.
2. Sunar, S., Tripathi, S. K., Tiwari, U., & Srivastava, H. (2022). A comparative study on face recognition AI robot. In *Proceedings of Second Doctoral Symposium on Computational Intelligence: DoSCI 2021* (pp. 211-221). Springer Singapore.
3. Zamir,M.,Ali,N.,Naseem,A.,AhmedFrasteen,A.,Zafar,B.,Assam,M.,...&Attia,E. A.(2022).Facedetection&recognitionfromimages&videosbasedonCNN&Raspberry Pi. *Computation*, *10*(9), 148.

4. Venkatesan,C.,Sathish,K.,Naganwesh,B.,Shaheen,D.,Sinha,R.K.,&Reza,M.(2024, July). Facial Recognition Robots forEnhanced Safety and Smart Security. In *2024 Third International Conference on Smart Technologies and Systems for Next Generation Computing (ICSTSN)* (pp. 1-6). IEEE.
5. Tahseen, Abu-Jassar Amer, Attar Hani, Vyacheslav Lyashenko, Amer Ayman, Svitlana Sotnik, andSolyman Ahmed. "Access control to robotic systems based onbiometric: the generalized model and its practical implementation." (2023).
6. N. Singh, R. Singh, R. Kumar, S. Paliwal, S. Srivastava," ESP32 CAM Face Detection DoorLock",InternationalResearchJournalofEngineeringandTechnology,vol.9,n°.2, pp. 1392–1394, (2022).