SWARM ROBOTS USING WIRELESS COMMUNICATION

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ABSTRACT

This project investigates the application of parallel robots with three degrees of freedom(3-DoF) utilizing broadcasting in the ESP-NOW protocol. Parallel robots offer advantages in terms of high precision and stiffness, making them suitable for various industrial and commercial applications. The ESP-NOW protocol, known for its low-power consumption and high efficiency, is employed for communication between multiple nodes in a network. By leveraging broad casting within the ESP-NOW protocol, the proposed system aims to enhance the coordination and synchronization of multiple actuators in parallel robots. The utilizationofbroadcastingallowsforreal-timecontrolandsynchronizationofthe robot's movements, leading to improved performance and efficiency. Experimental results demonstrate the feasibility and effectiveness of the proposed approach in achieving synchronized motion control of parallel robots with 3 degrees of freedom. This research contributes to advancing the field of parallel robotics by introducing a novel communication protocol for enhancing coordination and control in parallel robot systems.

1 INTRODUCTION

Nowadays, robots are increasingly being integrated into working tasks to replace humans specially to perform the repetitive task. In general, robotics can be divided into two areas, industrial and service robotics. International Federation of Robotics [IFR] defines a service robot as a robot which operates semi- or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations. These robots are currently used in many fields of applications including office, military tasks, hospital operations, dangerous environment and agriculture. Besides, it might be difficult or dangerous for human to do some specific tasks like picking up explosive chemicals, defusingbombsorin worst case scenario to pick and place bomb somewhere for containment and for repeated pick and place action in industries. Therefore, a robot can be replaced human to do work.

The use of industrial robots is increasing in areas such as food, consumer goods, wood, plastics and electronics, but is still mostly concentrated in the automotive industry. The aim of this project has been to develop a concept of a lightweight robot using lightweight materials such as aluminum and carbon fiber together with a newly developed stepper motor prototype. The wrist also needs to be constructed for cabling to run through on the inside. It is expensive to change cables and therefore the designing to reduce the friction on cable, is crucial to increase time between maintenance.

Robotics Arms have been used industries to perform complicated and tedious jobs ever since its introduction in 1962. From assembly lines to paint shops these robotics arms are used extensively in Automotive Manufacturing Industries. Recently with the advancement of technology and advent of Internet of Things [IOT], Robotics arms have also started to plunge in the Medical Applications allowing doctors to perform surgeries remotely by controlling the robotics arm wirelessly. In this project we will build an IOT based **Wireless Robotic Arm using Node MCU.**

2 LITERATURESURVEY

1. Development Of Robotic Arm Using Arduino UNO by Priyambada Mishra, Riki Patel, **Trushit Upadhyaya, Arpan Desai** In this paper they have used 4 servo motors to make jointsoftheroboticarmandthemovementwillbecontrolledwiththehelpofpotentiometer. ThecontrollerusedisArduinoUNO.TheanalogueinputsignalsoftheArduino'isgivento thePotentiometer.ThearmhasbeenbuiltbytheCardboardandindividualpartsareattached totherespectiveservomotors.Thearmisspecificallycreatedtopickandplacelightweight objects. So low torque servos, with a rotation of 0 to 180 degrees have been used. Programming is done using Arduino.

2. Design of Robotic Arm with Gripper and End effector for spot welding' by Puran Singh, **Anil Kumar, Mahesh Vashishth** According to the paper the robotic arm consists of 2 degrees of freedom is being made for the purpose of spot welding, gripper will be used in thearm.Theendeffectorconsistsofanarrangementofspurgearsandthreadedshaftsalong with an AC motor. Aims considered while building the robotic arm arel. To have a rigid structure. 2.Movement of parts to defined angles. 3.To attain consumption of power at optimum level.

3. ReviewonObject-MovingRobotArmbasedonColourbyAreepenSengsalonga,Nuryono **SatyaWidodo**Theobjectiveofthisfindingistomakeamanipulatorwhichcansortobjects onbasisofcolourusingspecificmotorsandphotodiodesensorsprogrammedwithaArduino Megaseries microcontroller.Thelight photodiodesensorcan identifyRGB colours. In this systemtheoutputofArduinoMega2560isdisplayedonaLCDscreenwhichisanindication oftheobservedcolour.Thefirststepofobjectmovingprocessisbydistinguishingthe RGB colour.Thegripperofroboticarmwillmovetopickobjectsbasedon colour,dependingon the colour input given by the light photodiode sensor. Arduino Mega 2560 is a microcontroller that uses ATmega2560 which is installed in robotic arm having 54 digital VO ports segregated into different types. In this International Research Journal of EngineeringandTechnology(IRJET)e-ISSN:2395-0056Volume:08Issue:02|Feb2021 www.irjet.net p- ISSN: 2395-0072 O 2021, IRJET | Impact Factor value: 7.529 | ISO 9001:2008CertifiedJournal|Page2124paperacoloursensortestingisalsocarriedout ,havingatargettodeterminetheabilityofPhotodiodesensorfordistinguishingofcolour .The resultant voltage from photodiode will be sent to ADC to process and show result on the LCD screen provided.

4. Modelling and Simulation of Robotic Arm Movement using Soft Computing by V. **VK. Banga, Jasjit Kaur, R. Kumar, Y. Singh** In this research paper the authors successfully built a4 degrees offreedom roboticarmusing soft computing. They have formulated ways forcontrolled movement ofrobotic armand planning oftrajectory with the help ofGenetic Algorithms (GAs) and fuzzy logic (FL). As optimal movement is critical for efficient autonomousrobots.Thisarchitectureisusedtolimittheissuesrelatedtothemotion,friction

And the settling time of different components inroboticarm.Geneticoptimizationisused to find the finest joint angles for this four d-o-f robotic system. This type of optimization replaces the long process of trial and error in search of better combination of joint angles, which are valid as per inverse kinematics for robotic arm movement. These logic models (Fuzzy logic) have been developed for the joint movement, friction and least settling time attributes as the fuzzy logic input.

5. Design and Development of a Self-Adaptive, Reconfigurable and Low-Cost Robotic Arm by**KemalOltunEvliyaoglu1,MeltemElitas**Varietyoftaskscanbeperformedbyarobotic arm when we do some changes in it, 1.e changing the number of links, it can be made self-adaptable his aspects of a robotic arm is discussed by the author in this paper. The paper represents a basic robotic solution to fulfill different applications with the help of it. The Design consists of two panels which have individual wiring with it, thus as per the application required the panels arearranged and servo motors are connected to perform the task.

6. DesignandImplementationofWirelessRoboticArmModelusingFlexandGyroSensorby **Anughna N, Ranjitha V, Tanuja G** The paper represents the author using accelerometers to collect information. The controller used is Arduino Atmega328. Human arm motion, fingers are located by flex, gyrosensors and signals are sent toArduino ATmega328which in turn controls the servo motors and makes the movement of the arm possible. The programmingoftheArduinowasdonewiththehelpofembeddedClanguage.TheFlexand GyroSensorswereplacednearthefingers.Wheneverthechangeisdetected,theinformation by both the sensors is processed by the controller. The Future Scope of this paper includes using 5 Flex Sensors near the fingers and more Gyro for the ease of operation
.

7. AGeometricApproachforRoboticArmKinematicswithHardwareDesign,Electrical Design, and Implementation by **Kurt E. Clothier and Ying Shang**
Inthispaper,theauthorhastakenageometricapproachinordertopositiontheroboticarm in an autonomous manner. Robot command model is the main controller for the robot. For additionalhardware,therearefoure-portsanditisbuiltaroundatmega168microcontroller. Thenumberofsensorsusedexternallytoi RobotCreatearethree.TwoSharpGP2D12Range FindersensorsandoneGP2D120RangeFindersensorareused.Aninfraredbeamisemitted from these sensors and the reflection angles are used to find the distance of the objects. Objects in the range of 10-80 cm are detected by GP2D12, whereas the objects as close as 4-30cmaredetectedbyGP2D120.ElementDirect,Incisthescreenusedinthisproject,it camewith Display which was designed fortheuse with command module. Forscanning in the front of the robot, there are two infrared range finders. A distance in millimeters’ is received with the help of these sensors when anything blocks their line of sight, and hence we get the position of an object with the help of these distances.

8. Design and Structural Analysis of a Robotic Arm by **Gurudu Rishank Reddy** andIn this papertheauthorshaveasuccessfullybuilta4degreesoffreedomroboticarmused**Venkata KrishnaPrashanthEranki**forhandlingmetalsheetinaconveyorsystem.Reducing

Manual handling of sheet from stack to shearing machine is the main reason of designing this pick and place robotic arm. Two pneumatic cylinders for the feeding mechanism, and a robotic arm for the workers safety were designed. Integration of the manipulator position sensorintherobot'scontrolunitisdonebyRCCwhichisinstalledintheroboticarm.Robot's ability to interact with the surrounding is possible with the help of RCC control. A: self-optimization system is provided by t the manipulator depending upon the given conditions. Self-awareness system of therobot will ensuresafety on site. Suction effect is produced by thevacuum cup (whichisattheend effector) on the surfaceoftheobject.

9. Industry Based Automatic Robotic Arm by **Dr. Bindu A Thomas, Stafford Michahial, Shreeraksha.P, Vijayashri B Nagvi, Suresh M** This paper includes the design of an automatic robotic arm which is based according to the industrial applications. A functional prototype was constructed. This framework would make it simpler for man to maintain a strategic distance from the danger of dealing with objects which could be unsafe at the working environment. The utilization of robots is strongly suggested for Businesses particularly for security and profitability reasons. In their design work, they included a manipulator with 5 DOF, the microcontroller issues order to the individual channels that makes up the link. The electric motor operates as per given command and the speed of the motor as well as the direction and motion is controlled by the microcontroller. Meanwhile, in the mode of operation of robot,an obstacle sensor was programmed by the microcontroller such that it detects the presence of the obstacle in 10cm of radius. If an obstacle is sensed for the first time it pauses the work. Iftheproblemisnotcleared, a feed back system such as buzzer gets turned on to bring this problem on notice of a personnel to clear the object.

10. Design and Development Of 5-DOF Robotic Arm Manipulators by **Yagna Jadeja,BhaveshPandya**Theauthorsofthispaperhavebuilta5degreesoffreedomrobotic arm.TheyhaveusedonecortexmicrocontrollerwhichisM3LPC1768.Itcanliftmaximum massof100g.Ultrasonicsensorswereusedinthissystem,todetectthedistanceoftheobject from the robotic arm The object can be identified through the transmitter, which sends a signal which has frequency higher than that of the sound. The signals from the transmitter arereflectedbacksystem.bythetargetobjectandreceivedbythereceivers.Inthiswaythe object detection takes place in their robotic arm manipulator system. Once the object is detectedthemicrocontrollersendsignalstotheservomotorswhichareplacedintherobotic arm to perform the pick and place mechanism.

11. Modeling and Control of 2-DOF Robot Arm' by Nasr **M. Ghaleb** and **Ayman A. Aly** In this paper, modeling, simulation and controlling of 2 DOF robotic arm consisting of two links was done. DenavitHartenberg parameters were used to determine the forward kinematicsoftherobotic arm. Inversekinematicsoftheroboticarmwascarriedout tofind the variables of the cartesian coordinates of the end effector. A Permanent Magnet DC (PMDC)motorwasusedfortheworkingofthearm.MATLABwasusedforthesimulation. Path Planning and Co-simulation Control of 8 DOF Anthropomorphic Robotic Arm' by **Sudharsan,J.*&Karunamoorthy,L.**Thispaperwaspublishedtofocusontheefficiency of the path planning with the help of MATLAB and ADAMS simulation software. The software'swereusedtoexecutethecontrolalgorithminrealtimecaseandseethefunctional behaviorofthesystem.Thisshowedtheresultsoftherealtimeworkingofthemanipulator.

3. TOOLS AND FABRICATIONS

SERVOMOTOR

A servo motor is a type of motor that is commonly used in robotics, industrial automation and other applications, where precise control of movement is required. Servo motors are capable of providing accurate positioning and speed control, making them useful in a wide range of applications.

A servomotor consists ofa DC motor, gearbox and a control circuit. Control circuit measures thepositionofthemotorshaftandedgesthevoltageappliedtothemotortomaintainthedesired position. Servo motors can rotate over a limited range, typically between 0 and 180 degrees, can be controlled using a variety of signals including pulse-width modulation (PWM), serial communication or analogue voltage.

There are several different types of servo motors, including:

DC Servo Motor: A DC servo motor is a type of motor that uses their DC power source to control the position and speed of the motor shaft. DC motors are commonly used in robotics CNC machines and other applications where process control of movement is required.

ACServoMotorAnACservomotorisatypeofmotorsthatusesanACpowersourceto control the position and speed of the motor shaft. AC servo motor commonly used in industrial automation and robotics applications, where high torque and accuracy are required.

Stepper Motor: A Stepper motor is a type of motor that moves in small, preserve steps, making it deals for applications where pressure control of movement is required. Stepper motors are commonly used in CNC missions, 3D printers and other applications were preserving positioning in critical.

Linear Servo Motor: A linear servo motor is a type of motor that produces linear motion ratherthanrotationalmotion.Linearservomotorsarecommonlyusedinindustrialautomation and robotic applications, where linear movement is required

Hydraulic servo motor: A hydraulic servo motor is a type of motor that uses hydraulic fluidtocontrolthepositionandspeedofthemotorshaft.Hydraulicservomotorsarecommonly used in heavy duty industrial applications, where high torque and accuracy are required.

Some common uses for servo motor include robotics common CNC machines factory automation cameras stabilization systems, and drones. Servo motors can be found in a wide range of sizes and power ratings making them suitable for a variety of different applications.

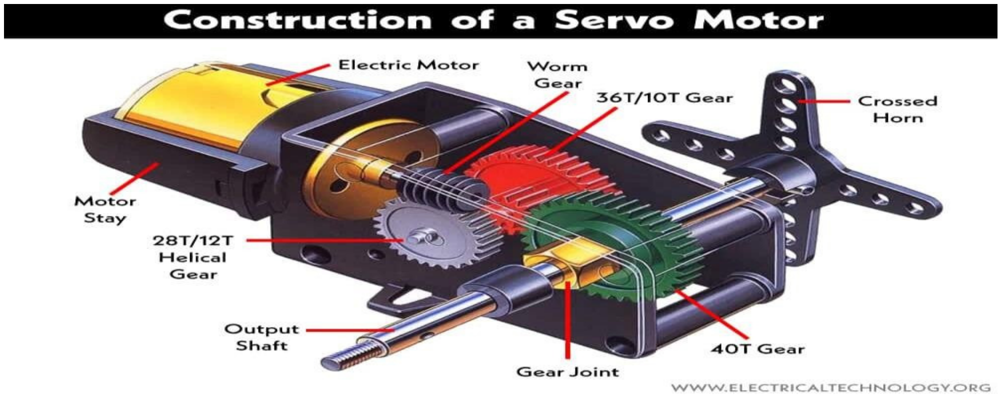


Fig3.1(a)constructionofservomotor

Fig3.2(b)TowerpromicroservoSG90

SpecificationsandinputoutputdetailsfortheSG90microservo motor:

Specifications:

Operating voltage: 4.8V – 6V

Stalltorque:1.8kg/cm(at4.8V)

OperatingSpeed:0.12seconds/60degrees(at4.8V)

Dimensions: 23mm x 12.22mm x 29mm

Weight:9g

Gear type: Plastic

Rotation:0–180degrees

Operatingtemperature:-30tot60degreesCelsius Dead

band width: 10 microseconds

Controlsystem:Analog

Input/Output Details:

TheSG90servomotorhasthethreeinput/outputpins:

VCC: This pinis connectedto thepositive terminalofthepower supply(4.8V-6V).

GND: This pin isconnected to the negative terminalofthepower supply.

Signal: This pin is used to control the position of the servo motor. At PWM (pulse width modulation) signal is applied to this pin to control the angle of rotation the pulse width varies from IMS to 2ms, with 1.Sms corresponding to the centre position 19 degrees of the servo motor. That duty cycle of the PWM signal determines the position of the servomotorforexampleoneMspulsewithcorrespondstotheminimumangleofrotationzero degrees violate 2 Ms pulse width corresponds to the minimum angle of rotation 180 degrees.

3DPRINTER

3D printing or additive manufacturing is the construction of a three-dimensional object processes in from a CAD model or a digital 3D model. It can be done in a variety of which material is deposited, joined or solidified under computer control with material being added together (such as plastics, liquids or powder grains being fused) typically layer by layer.

Fig3.2 Partsof3DPrinter

Filament

The filament is the material used to print objects on a 3D printer. It's the equivalent of the ink used on a regular office 2D printer. It comes in a spool, which is loaded into holder of the 3D printer, with the end of the filament inserted into the extruder. Some are versatile enough to print with all sorts of materials, including exotic ones, while others can only print with PLA, the most basic filament. There are also 3D printers designed to only accept proprietary filaments. The majority of 3D printers on the market use filaments with a diameter of 1.75 millimeters, but there are some models.

4 ANALYSIS

Arduino-Installation

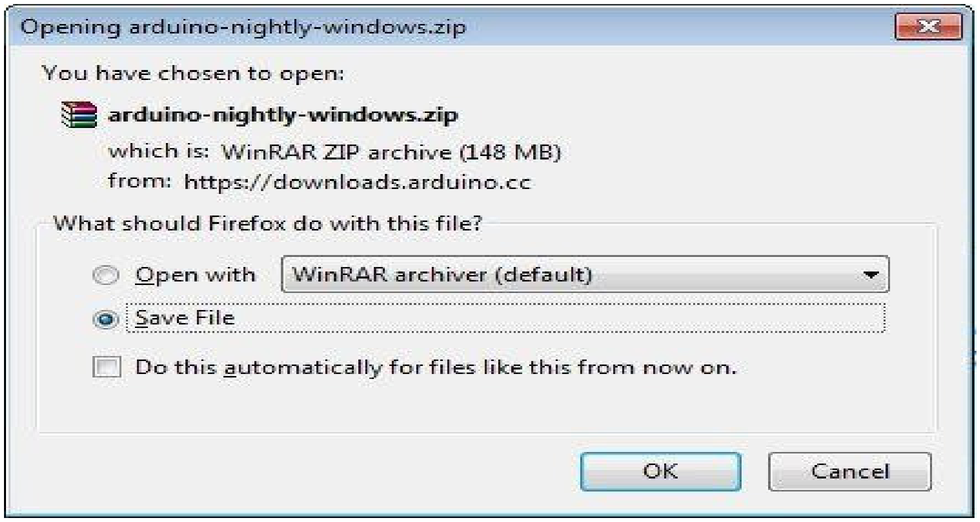
After learning about the main parts of the Arduino UNO board, we are ready to how to set up the Arduino IDE. Once we learn this, we will be ready to upload our program on the Arduino board. In this section, we will learn in casy steps, how to set up the Arduino IDE on our computer and prepare the board to receive the program Via USB cable.

Step1:

First youmust haveyour Arduino board(you can chooseyour favorite board)and IISB cable. In case you use Arduino UNO, Arduino Nano, Arduino Mega 2560, You will need a standard USB cable (A plug to B plug), the kind you would connect to a USB printer as shown in case you use Arduino Nano, you will need an A to Mini-B cable.

Step2–DownloadArduinoIDESoftware.

YoucangetdifferentversionsofArduinoIDEfromtheDownloadpageontheArduinoODcial website. You must select your software, which is compatible with your operating system (Windows, IOS, or Linux). After your file download is complete, unzip the file.

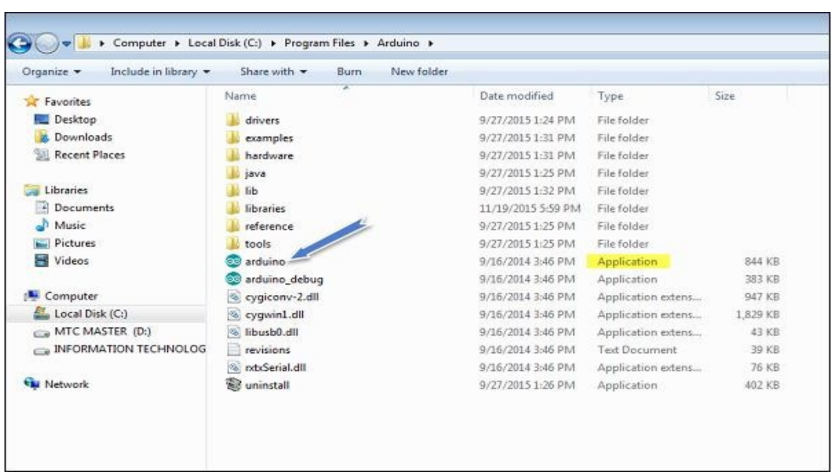


Step3-Powerupyourboard,

The Arduino Uno, Mega and Arduino Nano automatically draw power from either, the USB connectiontothecomputeroranexternalpowersupply.IfyouareusinganArduino,youhave to makesurethat the boardis configured to draw powerfrom theUSB connection. Thepower source is selected with a jumper, a small piece of plastic that its onto two of the three pins between the USB and power jacks. Check that it is on the two pins closest to the USB port. Connect the Arduino board to your computer using the USB cable. The green power LED (labeled i PWR) should glow.

Step4-LaunchArduino IDE.

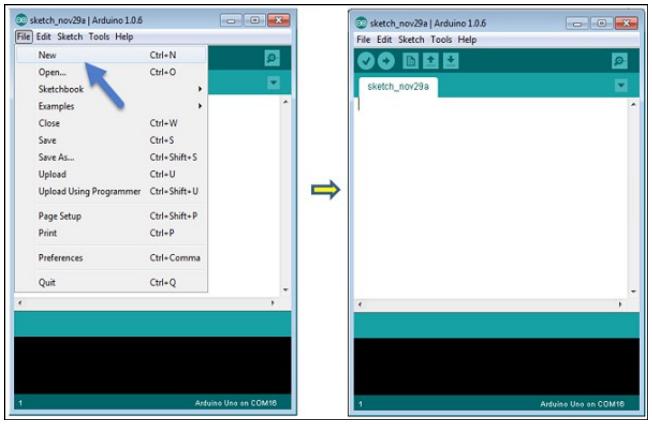
AfteryourArduinoIDEsoftwareisdownloaded,youneedtounzipthefolder.Insidethefolder, youcanfindtheapplicationiconwithaninfinitylabel(application.exe).Double-clicktheicon to start the lDE.



Step5-Openyourfirst project.

Once the software starts, have options Create anewproject.Open an existing project example.

To createanewproject,selectFile→NewToopenanexistingprojectexample,selectFile →Example Basics→ Blink.



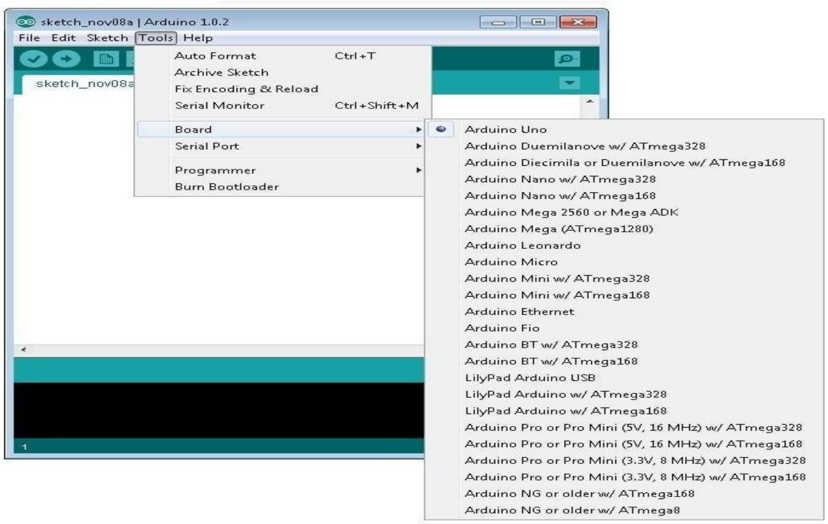
Here, we are selecting just one of the examples with the name Blink. It turns the LED on and off with some time delay. You can select any other example from the list.

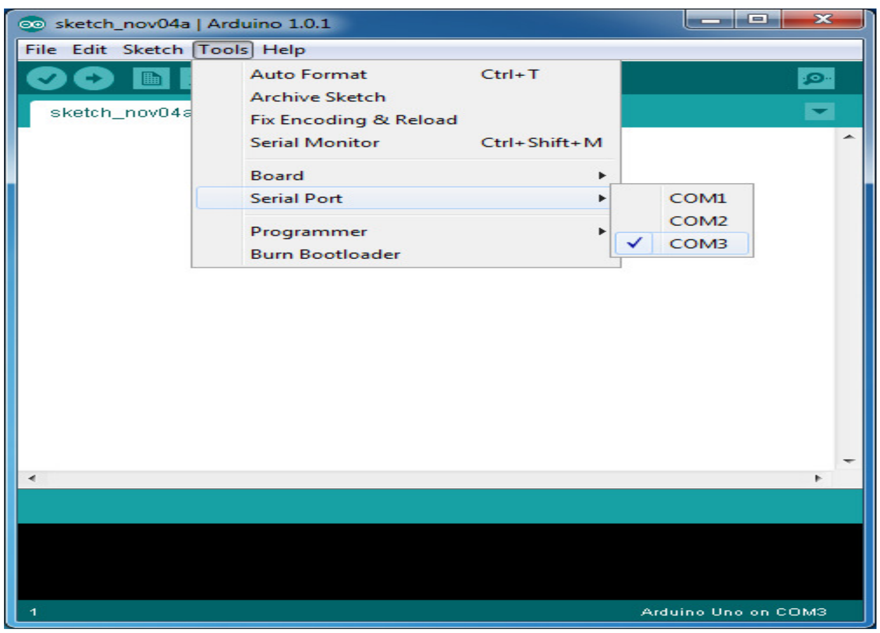
Step6-SelectyourArduinoboard.

To avoid any error while uploading your program to the board, you must select the Correct Arduino board name, which matches with the board connected to your computer. Go to Tools Board and select your board. Here, we have selected Arduino Uno board according to our tutorial, but you must select the name matching the board that you are using.

Step7-Selectyourserialport.

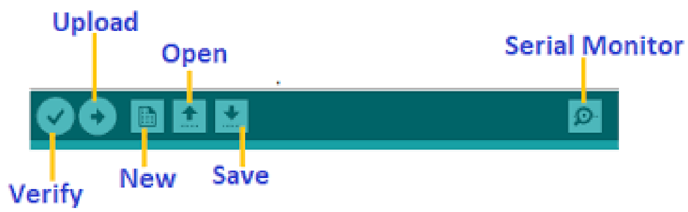
Select the serial device of the Arduino board. Go to Tools > serial Port menu. This is likely to beCOM3orhigher(COM1andCOM2areusuallyreservedforhardwareserialports).Tofind out, you can disconnect your Arduino board and re-open the menu, the entry that disappears should be of the Anduino board.





Step8-Uploadtheprogramtoyour board.

Beforeexplaininghowwecanuploadourprogramtotheboard,wemustdemonstrateFunction of each symbol appearing in the Arduino IDE toolbar.



Verify-Used to check if there is any compilation error.

Upload-UsedtouploadaprogramtotheArduinoboard. **New-**

Shortcut used to create

Open-Usedtodirectly openoneofthe examplessketches.

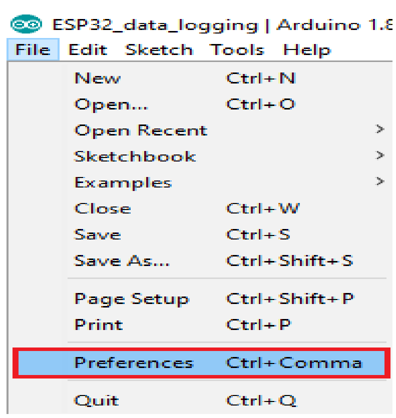
Save-Usedtosaveyoursketch.

Serial Monitor-Serial monitor used to receive serial data from the board and send the serial data to the board. Now, simply click the "Upload" button in the environment. Wait a few seconds you will see the RX and TXLEDs on the board, flashing. If the upload is successful, the message "Done uploading" will appear in the status bar.

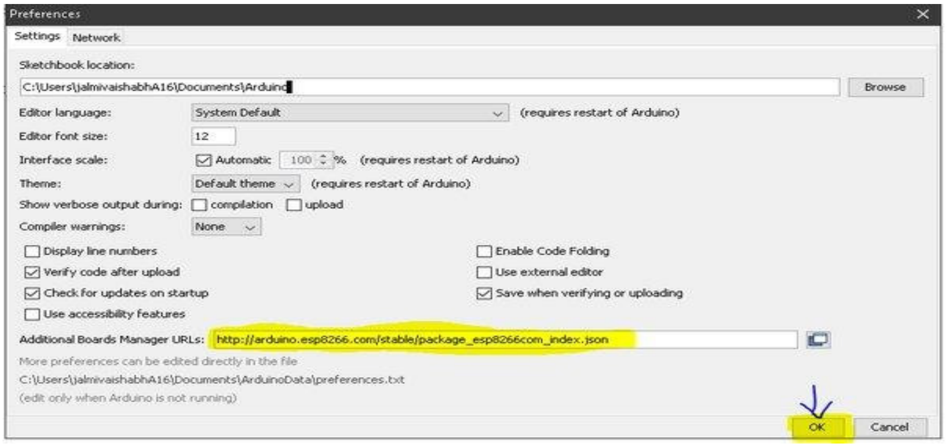
InstallingESP32Add-oninArduino IDE

loinstall theESP32boardinyourArduinoIDE,followthesenextinstructions:

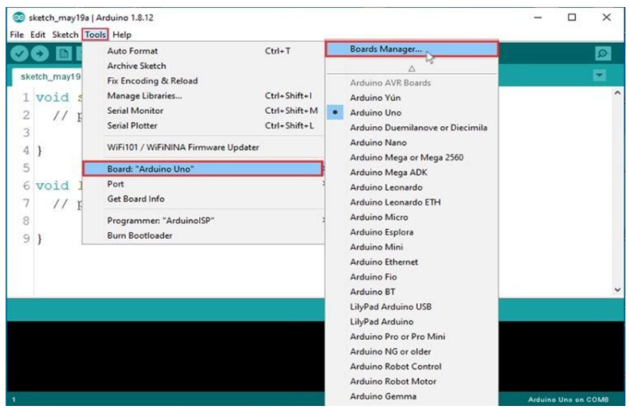
1. InyourArduinoIDE,goto**File>Preferences**



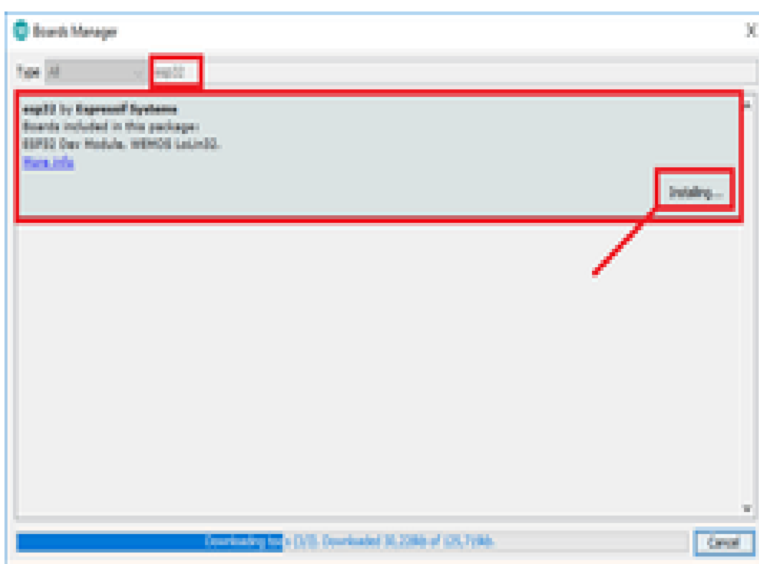
2. Enter/thefollowingintothe"AdditionalBoardManagerURLS"field:Then,clickthe "OK" button:



3. OpentheBoardsManager.Goto **Tools>Board>Boards Manager..**

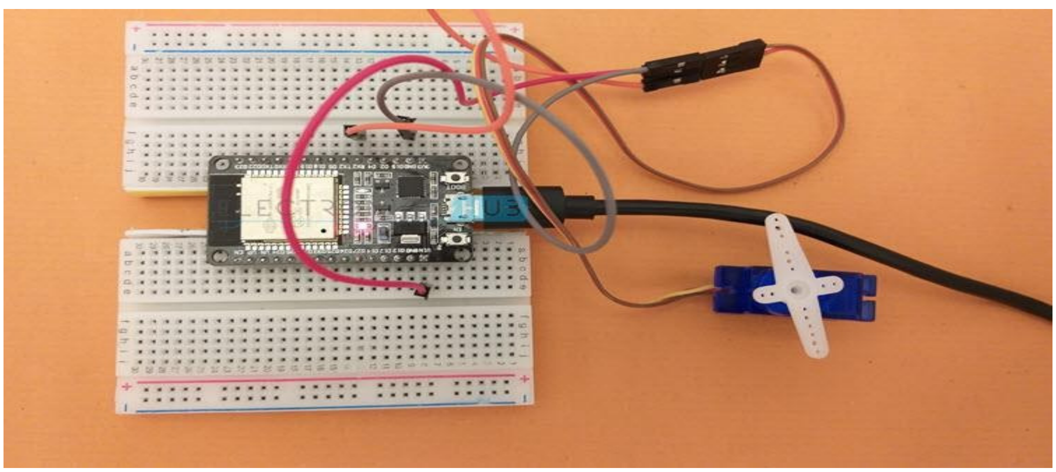


4. SearchforESP32andpress install buttonfortheESP32byEspressif Systems



4.31ROBOTICARMSERVOMOTORSCONTOLLEDBYESP32

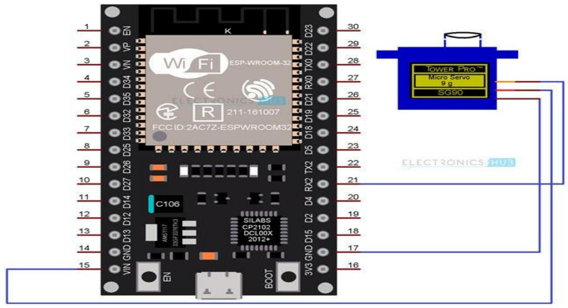
WewilllearnhowtocontrolaServoMotorusingESP32DevelopmentBoard.Todemonstrate the working of ESP32 Servo Control, we will first make a Sweep application where the servo oscillates back and forth. Then we will see how to control the Servo using a Potentiometer. Finally, since ESP32 is all about of IoT Development, we will implement a Web Controlled Servo using ESP32 Project.



As mentioned, l earlier, instead of using "Servo" libraries, we will be using the LEDCPWM Controller to set the control signal of the Servo. The beautiful thing about LEDC PWM Controller is that you have complete control on the parameters ofPWM. Thefrequency of the PWMSignal,which must comply with the specifications of the Servo Motor, is set at 50Hz. A standard8-bitresolutionisused.Theimportantpartisthedutycycle.DutyCycleofthePWM SignaldeterminesthepositionoftheServoanditrangesbetweenlmsforextremeleft, 2msfor extreme right and 1.5ms for center positions. Since duty cycle is often represented as percentage, we will continue setting to use the same. So, when I set the duty cycle as 50, it means 50% duty cycle.

CircuitDiagram

The following image shows the connections between ESP32 and Servo Motor. 1ne operating voltage e of SG90 and MG 996R Servo Motors is 4.8V. So, connect the VCC



(Red)wiretoVINofESP32.VINistheinputfromtheUSB.So,itwillbearound5V.Connect the GND (Brown) wire to one of the GND pins of ESP32. Finally, the PWM Control Wire (Orange). Connect this wire to any of the PWM Pin of ESP32. Since, there are no dedicated PWM Pins on ESP32 and essentially you can configure any GPIO Pin as a PWM Pin, I connected the Control Wire of Servo to GPIO 16 (marked as RX2 on the board). The ESP32 anditscousin,theESP8266,areundoubtedlyremarkablemicrocontrollers.Asidefromahigh-speed32-bitarchitecture, theyalsohavebuilt-inBluetoothandWi-Fi.TheBluetoothandWi- Fi capabilities on these devices are made possible by an integrated 2.4GHz radio transceiver module. And this module can also be used for other communications applications that use the unlicensed 2.4GHz band. Espresso, the makers of the ESP8266 and ESP32, have developed a protocol that allows all these devices to create a private, wireless network using the 2.5GHz transceivers. This is a separate network from the Wi-Fi network and can only be usedby ESP-type microcontrollers. The protocol is called ESP-Now. ESP- NOW allows simple packet communicationsbetweenESPdevices,usingthe2.4GHzband.Thesetransmissionsoperatea lot like those used by wireless mice and keypads and are limited to packets of 250 bytes or fewer.

The data can be unidirectional or bidirectional, i.e., single-duplex or full-duplex. Most data typesaresupported.Data canbeencryptedorunencrypted, andnoexternal sourceofWiFior a router is required. Depending upon your configuration, you can have anywhere from 2 to 20 devices communicating between themselves. The range can vary dramatically due to the environment, but under the right conaito (and with proper antennas) you can achieveover400 meters, Just using the built-in antennas on the modules should still allow vou to communicate through medium- sized home without a problem.

ESP-NOWNetworkingModes

YoucanplaceyourESP-NOWnetworkinmanyconfigurations.YoucanmixandmatchESP32 andESP8266deviceswithinthesamenetwork.AdeviceparticipatinginanESP-NOWnetwork can be operated in one of two modes.

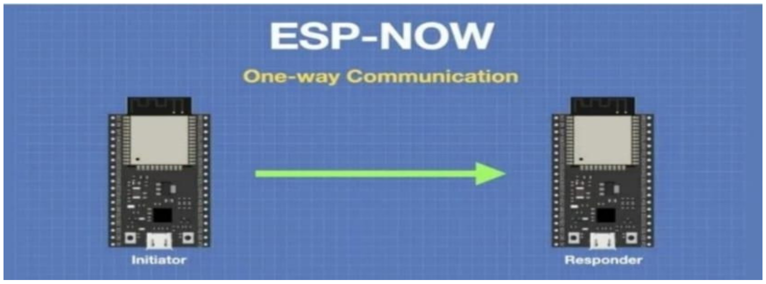


Fig4.5ESP32Networking modes

Initiator-Thisdeviceinitiatesthetransmission.ItwillrequiretheMACaddressofthe receiving device.

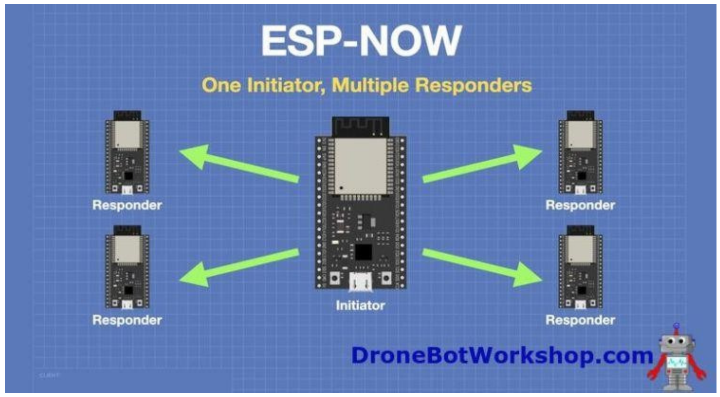
Responder-Thisdevicereceivesthetransmission.Inunidirectional(half-duplex)mode,the transmitting deviceis theInitiator and thereceiving deviceis theResponder. In a2-way (full-duplex) communications mode, each device is both an Initiator and Responder.

1-WayCommunication

The simplest communications topology is one-way, unidirectional communications In this arrangement,the Initiator ESP32transmits datatotheResponderESP32. The Initiatorcantell if the Responder received the message successfully. This is a simple arrangement, but it has many uses in remote control applications.

OneInitiator&MultipleResponders

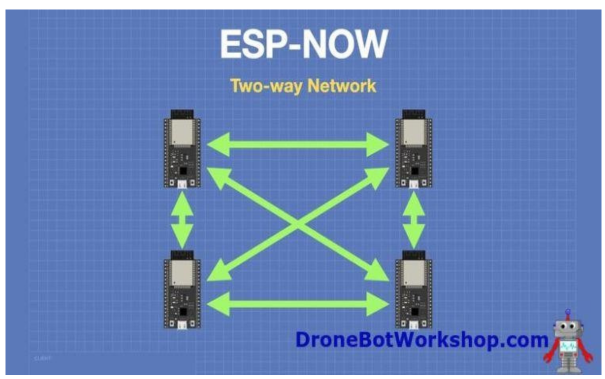
Thissetupconsists ofone Initiatorthatiscommunicating withmultiple responders.



The configuration can be used in two fashions: The Initiator communicates with each Responderindividually.TheInitiatorinitiatesabroadcastmessagetocommunicatewithallthe Responders. An alarm system might use this sort of configuration to activate remote sounders or communicate with remote monitors when an alarm has been triggered.

OneResponder&MultipleInitiators

This is the reverse of the previous ESP-NOW network configuration. In this arrangement, we have one Responder and multiple Initiators.



Two-WayNetworking

Expanding upon the previous configuration even further, we come up with this arrangement, four boards that have bidirectional communications established with one another. MAC Addresses,WhenInitiatorscommunicatewithResponders,theyneedtoknowtheResponder's MAC Address. A MAC, or Media Access Control, Address is a unique 6-digit hexadecimal number assigned to every device on a network. It is generally burned into the device by the manufacturer, although it is possible to manually set it.

MACAddress Sketch

Here is a very simple sketch that you can run on an ESP32 to determine its unique MAC Address: esp32-mac-address

C++/*

ESP32MACAddressprintoutesp32-mac-address.ino

Prints MAC Address to Serial Monitor

IlIncludeWi-FiLibrary#include"WIFI"

void setup () {

I/ Setup Serial Monitor Serial. begin (115200); / Put ESP32 into Station mode Wi-Fi. mode (WIFI_MODE_ STA); I/ Print MAC Address to Serial monitor Serial .print ("MAC Address: "): Serial .print In (Wi-Fi. Mac Address ());} void loop () {} All we are doing is including the WIFI Library, initializing the serial monitor, placing the ESP32 into Station mode, and then asking it for its MAC address. The result is printed on the serial monitor. Running The MAC SketchtheentiresketchrunsintheSetupsection,soafterloadingittotheESP32,itwilllikely run before you get a chance to view it on the Serial monitor. Tom can press the Reset key on yourmoduletoforceittorunagain.theMACAddresswillbeatthebottomofthescreen.Copy ittoasafelocation,sothatyoucanuseitlater.CodingforESP-NOWTheESP-NOWLibrary is included in your ESP device boards manager installation. It has a number of functions and methodstoassistwithcodingforESP-NOW.Inordertoseehowitworks,youneedtoexamine the sending and receiving of an ESP-NOW message packet.

TransmittercodeofESP32forcontrollingroboticarmusingjoystick Steps for coding

You need to initialize the ESP-NOW library. Next, you'll register your send callback function You need to add a peer device, which is the responder device. You add the peer by specifying its MAC address.

Finally,youcanpacketizeandsendthemessage. #include

<esp_now.h>

#include<WiFi.h>

//Variablesfortestdata Int

Xpin _1-32;

intYpin_1=33;

int Spin_ 1=4;

int Xpin _2-34;

int Ypin _2-35;

int Xval _1;

intYval_1;

intXval_2;

intYval_2;

int Sval _1;

//MACAddressofresponder-edit asrequired

uint8tbroadcastAddress[]={OxFF, OxFF,0xFE,0xFF,0xFF,OxFF}:

//Define a data structure

typedefstructmessage{

int Xval _1;

intYval_1;

int Sval _1;

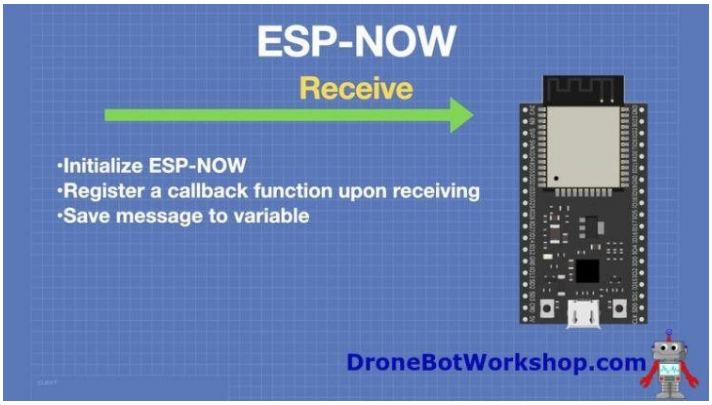
```
intXval_2;
intYval_2;
}struct message;
//Createastructuredobject struct
message mny Data;
//Peerinfo
Esp_now_peer_info_tpeerlnfo;
//Callbackfunctioncalledwhendataissent
voidOnDataSent(const uint&t*macaddr,espnowsendstatuststatus){ Serial.print("\rnLast
 Packet Send Status:t");
 Serial.printIn(status=ESPNOWSENDSUCCESS?"DeliverySuccess": "Delivery
Fail");
}
voidsetup(){
// Set up Serial Monitor
Serial. Begin(11 5200);
pinMode (Xpin_1, INPUT);
pinMode(Ypin_1,INPUT);
pinMode (Spin _1, INPUT);
pinMode(Xpin_2,INPUT);
pinMode(Ypin_2,INPUT);
//SetESP32asaWi-FiStation
WIFI. Mode (WIFI STA);
//InitializeESP-NOW
if (esp now init )! = ESP OK) {
Serial.println("ErrorinitializingESP-NOW");
return;
}
```

```
// Register the send callback
esp_now_register_send_cb(OnDataSent);
/Registerpeer
memcpy(peerlnfo.peer_addr,broadcastAddress,6);
peerlnfo. Channel = 0;
peerlnfo.encrypt= false;
//Addpeer
 if(esp_now_addpeer(&peerlnfo)!=ESPOK){
 Serial.printin(" Failed to add peer");
 return;
 }
}
void loop (){
Xval_1=analogRead (Xpin_1);
Yval_1=analogRead(Ypin_1);
Xval_2=analogRead(Xpin_2);
Yval _2=analogRead (Ypin_2);
Sval _1=digital Read (Spin_1);
delay (100);
intX_1=map(Xval_1, 0,4095,0, 180);
intY_1=map(Yval_1,0,4095,0, 180);
intX_2=map(Xval_2, 0, 4095, 0, 180);
intY_2=map(Yval _2,0,4095, 0,180);
//Formatstructureddata
myData.Xval_1 = X_1;
//delay (200);
myData.Yval_1=Y_1;
//delay(200);
```

```
myData.Xval_2= X _2;
//delay (200);
myData.Yval_2=Y_2;
//delay (200);
myData.Sval_1=Sval_1; delay
(200);
//Send messageviaESP-NOW
esperrtresult=esp_now_send(broadcastAddress,(uint8t*)&myData, size
of(my Data));
if(result=ESPOK){
 Serial.println("Sendingconfirmed");
}
else{
 Serial.printin("Sendingerror");
}
Serial.print("X _1 value =");
Serial.print(Xval_1);
Serial.print("Y_1 value=");
Serial.print(Yval _1);
Serial.print("X_ 2 value =");
Serial.print(Xval_2);
Serial.print("Y_ 2 value=");
Serial.print(Yval _2);
Serial.print("Switchstateis=”);
Serial.println(Sval_1 ):
delay(
```

ReceivingcodeeofESP32forcontrollingroboticarmusingjoystick

Towritecodeforthe ESP-NOWresponder,you'lneedto dothefollowing:



1. Youneedtoinitializethe ESP-NOWlibrary.
2. Next,you'll registeryourreceivecallback function.
3. Inthereceivecallback,you'llcapturetheincomingmessagedataandpassittoa variable.

Let'sdigoutsomeESPboardsandstartexperimentingwithESP-NOW. #include

<ESP32Servo.h>

// Include Libraries

#include<esp_now.h>

#include <WiFi.h>

intservoPin_1 =32;

intservoPin_2 =33;

intservoPin_3 =15;

intservoPin_4=25;

Servo myservo_1;

Servo myservo_2;

Servo myservo_3;

Servo myservo_4;

#DefineSIGNAL_TIMEOUT1000//Thisissignaltimeoutinmilli

seconds. We will reset the data if no signal

unsignedlonglastRecvTime =0;

I/ Define a data structure

typedefstructstruct_message{

```
int xAxisValue_1;
int yAxisValue_1;
int xAxisValue_2;
int yAxisValue_2;
intswitchPressed_1;
}struct message;
// Callback function executed when data is received
memcpy(&myData,incomingData,sizeof(myData):
Serial.print("Data received; "):
Serial.println(len);Serial.print("Xval
1=):
Serial.print(myData.xAxisValue_1);
Serial.print("Yval_1=");
Serial.print(myData.yAxisValue_1);
Serial.print("Sval_1= ");
Serial.print(myData.switchPressed_1);
Serial.println (len);
Serial.print("Xval_2= ");
Serial.print(myData.xXAxisValue_2);
Serial.print("Yval_2=");Serial.print(my
Data.yAxisValue_2);
//Serial.print("BooleanValue:");
 //Serial.println(myData.d);
 Serial.println();
}
voidsetup(){
//SetupSerialMonitor
Serial.begin(11 5200):
```

```
myservo_1.attach(servoPin_1);

myservo 2. attach(servoPin_2);

myservo3. attach(servoPin_3);

myservo4.attach(servoPin_4);//SetESP32asaWi-FiStation WIFI.

Mode (WIFI_STA);

//InitilizeESP-NOW

if (esp now init ()! = ESP OK) {

 Serial.printin("ErrorinitializingESP-NOW");

 return;

}

 // Register callback function

 esp_now_register_recv_cb(OnDataRecv);

}

void loop (){

// int Yval=myData.yAxisValue

myservo_1.write(myData.xAxisValue_1);

//delay (200);

Myservo_2.write (mnyData.yAxisValue_1);

//delay (200);

Myservo_3.write (myData.xAxisValue_2);

//delay (200);

Myservo_4.write(myData.yAxisValue_2):

//delay (50);}
```

Finalstructureofroboticarm

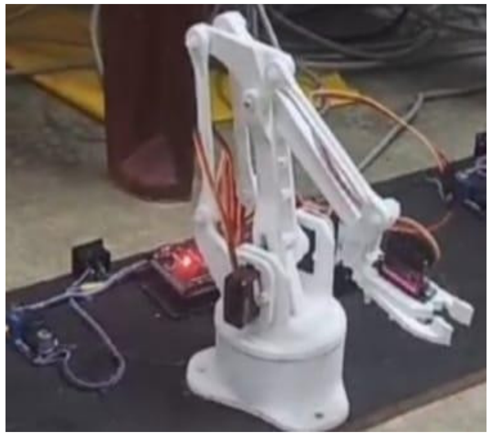


Fig4.8(a)structureofrobotic arm

Fig4.8(b)structureofroboticarm

Applicationofswarmrobot

1.Agriculture

Another example of the agricultural application of swarm robots is SAGA, an experimental platform in precision farming that uses as swarm of unmanned aerial vehicles (UA VS) in a field to monitor the field and perform weeding. Equipped with onboard cameras, vision processing, radio communication systems, and protocols that will support safe swarm operations, the UAVs fly very close to the field to count the number of weeds in an area and detectareaswhereweedissufficientamounts,UAVscanalsodealwithextratasks likemicro-spraying on some plants.

Fig4.9.1swarmroboticsusedinAgriculture

2. Industrial

In a recent project called FIBERBOTS, robots can design fabricated structures while working asaswarmoffabricators.Pullingfiberandresinfromaground-basedstorageunit(afiberglass spool), they work simultaneously to form tubular forms before wrapping Them around their bodies. By wrapping themselves in tubes made of fiber, they construct the structures. The structure is constructed in several steps. The fiber and resin are Tetrieved from the ground- based storage by a winding arm. The nasal cavity is used to Combine these materials before winding. The fiber is made harder with the aid of Ultraviolet light in the following step. The fiberbotusesitstinymotorandwheelstoitcheditselfontothehardenedfiberafterithasbeen heatedup.Untilthedesiredstructure3built,thisprocessisrepeated.Tochangetheappearance ofthestructure,alterthewangpatterns.Therobotscommunicateoveracomputernetworkand know one another' s current states, so they do not collide. The system uses a flocking-based design protocol for the structure formation to inform the robot trajectories rather than using commands to control the robots.

Fig4.9.2swarmroboticsusedin industrial

3. Medical

Cancertreatment is a very appealing areaof research forswarm roboticsystems. Even though thetechnologyisadvancing,therearetreatmentsforalmostallcancertypes,However,thereis still a serious issue with the potential side effects of these treatments. The attack on n healthy cellsisthemainissue.OnlyatreatmentthatconsiderssickcellscanAdressthisissue.Finally, swarmsofnano-botsmightinthefuturebecomeanewandpowerfultoolinprecisionmedicine, making possible targeted interventions within the human body, such as minimally invasive surgeryorpolytherapy deliverydirectlytoeancerouscells.However,thecoordinationofhuge numbers of robots with extremely limited computational and communication capabilities will stretch to the limits the swarm robotics approach and will require the development of new conceptual tools, let alone the development of microscopic hardware or bio-robotics devices.

4. Military

Endeavor Robotics developed several robots used by the US military for various tasks. The cobra robot is used for lifting heavy objects. It can lift to 150 kg of weight. The pack Bot is usedforbombdisposal.AlphaDogs,robotsthatresembledogsandareusedtotransportheavy loadsforsoldiers,werecreated byBostonDynamics. Itcanwalkupto20 milesandcarry 180 kgofweight.Theintriguingaspectisthattheserobotscanbedirectedinanydirectionwithout needing control

5 CONCLUSION

The transition to industry and industrial production, not to mention daily use, has not been made successfully. Nevertheless. The main objective of this paper is to motivate future research and engineering activities by providing a comprehensive list of existing platforms, projects and products as a starting point for applied research in swarm robotics. This project classifies basic swarm behaviors and presents a comprehensive overview of current research platforms and industrial applications, While this demonstrates the possibility of integrating basic swarm behaviors in current applications, it also shows that many applications of swarm robotics cannot fully exploit the advantages offered by distributed swarm architectures due to systems with only few agents or central control. Swarm algorithms build upon self-organized swarm behaviors, e.g., observed in natural Swarm systems, such as insect colonies or flocks of birds that are able to handle extremely diverse and dynamic environments. The same holds for robot swarms. They are meant to operate in the physical world, whichtypicallyfacescontinualdynamicchangesandmustcopewitheventsandexternalconditions that are hard to predict or model. Besides huge potential for applications in areas like logistics, agriculture, and inspection, one suitable working environment for Swarms are places that are unsuitable for humans, including places that are hard to reach, dangerous, or dirty. Applications in these environments could help to better observe, understand and exploit the advantages of swarm behaviors, adaptability, robustness, and scalability. In addition to industrial applications, we have also surveyed different research hardware platforms dedicated to swarm robotic experiments. On the one hand, this overview allow schoosing an appropriatere search plat form for implementing and testing swarm algorithms in laboratory environments. On the other hand, it shows that there is a huge potential in research to transform these platforms from pure prototyping platforms to productive, industrial robotic systems that are able to perform in the real world. This might require to shift from the current simplified robot models and controls toa trade-off between simplicity of design and capability of solving complex tasks in a reliable way, e.g., from reduced resource consumption to a more intensive usage of sensor data and information sharing Robot Swann has emerged in recently years as a solution for surveillance in complicated geographical environments thanks to the significant cost reduction of individual robots and accessories such as wireless adaptors,GPS,andvideocameras.Withateamofrobotsbeingdispatched,severalchallengesarise. From the communications aspect, continuous network connectivity has to be maintained.

6. Future scope

Robotswillincreaseeconomicgrowthandproductivityandcreatenewcareeropportunitiesfor many people worldwide. However, there are still warnings out there about massive job losses, forecasting losses of 2Omillion manufacturing jobs by 2030, or how 30% of all jobs could be automated by 2030.

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