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# INTELLIGENT SURVEILLANCE AND ROBOTIC SYSTEMS

EDITED BY

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CIIR BOOKS AND PUBLICATIONS

# Contents

# Preface

In public spaces like banks, airports, public squares, and casinos, surveillance systems have grown in importance and popularity as a result of the rise and globalization of human social activities. To ensure safety and security, a large number of cameras are placed every day to watch public and private spaces.

In conventional surveillance systems, human operators are used to keep an eye on actions that are recorded on camera. They increase security efficiency to some extent, lower the cost of security labor, and increase the security vision range. However, there are clear drawbacks to such systems, such as the high cost of human labor, operators' restricted capacity to monitor several displays, inconsistent long-duration performance, and so on. Systems for intelligent surveillance (ISSs) may be used in addition to or even in substitute of conventional systems. In ISSs, anomalous behaviours are detected in films and possibly in real time using computer vision, pattern recognition, and artificial intelligence technologies. With globalization, surveillance systems are becoming more and more common.

However, the complete reliance on human operators in conventional surveillance systems has resulted in drawbacks, such as high labour costs, a restricted capacity for multi-screen monitoring, inconsistent performance over extended periods, etc. Intelligent surveillance systems (ISS) are a replacement or addition to conventional surveillance systems. In order to spot unusual behaviours in videos, ISSs create computer vision, pattern recognition, and artificial intelligence technologies. As a consequence, fewer human observers can accurately monitor more situations.

The study and creation of real-time, behaviour-based intelligent surveillance systems are covered in this book. We primarily concentrate on two aspects: (1) the learning-based identification of individual aberrant behaviour; and (2) the learning- and statistical-based analysis of unsafe crowd behaviours. This book methodically approaches the issue of video surveillance, starting with blob segmentation, then moving on to individual behaviour analysis, group behaviour analysis, and unsegmented crowd behaviour analysis. Postgraduate students, scientists, and engineers with an interest in computer vision and artificial intelligence should read this book. Additionally, this book may be used as a reference on algorithms and their use in surveillance.

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# CHAPTER 1

# INTRODUCTION TO SURVEILLANCE AND OBSTACLE DETECTION

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In the modern world Robotics is a rapidly expanding and fascinating subject. Robots are intelligent enough to cover as much of the available space as possible. It contains an ultrasonic sensor that is used to detect any obstructions in the robot's route. It will go in a certain direction and steer clear of everything in its way. Intelligent Autonomous Robots that can carry out desired activities in unstructured conditions without constant human supervision. The main challenge in building mobile robots is the ability to identify and avoid obstacles. The robots now have the sensors necessary to navigate unknown surroundings safely thanks to this technology. It is a robot car that uses three ultrasonic distance sensors to identify obstacles and runs on an Arduino microcontroller. The microcontroller platform used was the Arduino board, and the programming was done using Arduino Software, the device's software equivalent. Being a completely autonomous robot, it navigated new settings without colliding with anything. The project's hardware is widely accessible and reasonably priced, making it simple to replicate the robot. Robots controlled by this technology may be used for a variety of tasks, including scanning landscapes, driverless cars, autonomous cleaning, automated lawnmowers, and industry supervision [1]–[3].

The Internet of Things is a network of physical items, according to a popular definition. The internet has developed into a network of devices of all shapes and sizes, including cars, smartphones, household items, toys, cameras, medical equipment, industrial manufacturing, animals, people, and buildings. These devices are all connected, communicating, and sharing information following predetermined protocols to enable smart organization, positioning, tracing, safe operations, and even real-time personal online monitoring and upgrading. IoT is often divided into three categories: and exchange information, all of which are linked through open or closed Internet Protocol (IP) networks. Data from these networked items are routinely gathered, examined, and utilised to drive action, providing a wealth of insight for planning, management, and B.Tech. The Internet of Things (IoT) is a cutting-edge automation and analytics system that uses artificial intelligence, sensor, networking, electrical, cloud messaging, and other components to create entire solutions for products or services. IoT systems have better performance, control, and transparency [4]–[6].

We can link everything around us because we have a platform like a cloud that stores all the data. As an example, consider a household where all of the appliances, like the air conditioner and lights, can be connected and controlled from the same platform. We have a platform that allows us to link our automobile, monitor its fuel gauge and speed, and track its whereabouts.

**Internet of Things**

The Internet of Things is a combination of several hardware and software technologies, not a single technology. The Internet of Things offers solutions based on the combination of communications

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technology, which comprises electronic systems used for inter-person or inter-group communication, and information technology, which refers to hardware and software used to store, retrieve, and process data. The Internet of Things aims to make it possible for objects to be linked to anything and anybody at anytime, anywhere and preferably utilising any route, network, or service.

**Robotics**

Robotics has advanced significantly with the growth of mechatronics and mathematical modelling. From a piece of iron that could barely move a few inches, there are now devices that can leap from tall buildings while spotting B.Tech troubleshooting, carrying out missions, and avoiding landmines. The word "robot" first gained popularity in the 1950s, when Karl Capek used it to describe the emergence of a superior race with intellect on par with humans in Rossum's Universal Robots.

Robotics is the field that studies and uses robot technology. Robotics is a field of engineering that deals with the idea, design, production, and use of robots used for specialised, repetitive, high-precision operations. A multipurpose manipulator that can be reprogrammed to execute several tasks by moving objects, tools, or specialised devices via different movements. The three laws of robotics are A robot must not harm humans or, by doing nothing, allow humans to come to harm; A robot must always obey commands from humans unless doing so would violate the first or second law; and A robot must defend its existence unless doing so would violate the first or second law.

Ask them, and they will respond since they seem to be people. Above all, a robot must be useful and constructed with features that are appropriate for its main functions. When you ask different individuals to describe a robot, the majority of their answers will rely on the work at hand, including whether the robot is large or little, mobile or fixed to the ground. Every work requires a robot to have unique traits, as well as diverse shapes and functions.

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# CHAPTER 2

# ROBOTIC SYSTEMS

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Robots are intelligent enough to cover as much of the available space as possible. It contains an ultrasonic sensor that is used to detect any obstructions in the robot's route. It will go in a certain direction and steer clear of everything in its way. Intelligent Autonomous Robots that can carry out desired activities in unstructured conditions without constant human supervision. The main challenge in building mobile robots is the ability to identify and avoid obstacles. The robots now have the sensors necessary to navigate unknown surroundings safely thanks to this technology. It is a robot car that uses three ultrasonic distance sensors to identify obstacles and runs on an Arduino microcontroller. The microcontroller platform used was the Arduino board, and the programming was done using Arduino Software, the device's software equivalent. Being a completely autonomous robot, it can effectively navigate over uncharted territory without colliding with anything [1]–[3].

The project's hardware is widely accessible and reasonably priced, making it simple to replicate the robot. Robots controlled by this technology may be used for a variety of tasks, including scanning landscapes, driverless cars, autonomous cleaning, automated lawn mowers, and industry supervision. The robot created for this project is anticipated to accomplish the following goals. Following obstacle identification, the robot would decide on its own to shift its route to a comparatively open path. Throughout its functioning, it wouldn't need any outside guidance. It can continuously gauge its distance from nearby objects. It would be able to function well in an uncharted environment. Additionally, we have a camera there (Esp32Cam OV2640) that we use to see what is going on there. To track the vehicle's longitude and latitude, we need a GPS receiver module [4]–[6].

A vehicle that works while in physical touch with the ground and without a human operator is referred to as an unmanned ground vehicle (UGV). UGVs may be employed in a variety of situations where having a human operator present could be difficult, risky, or impossible. Typically, a vehicle will include a collection of sensors to examine its surroundings and make judgements about how to behave either on its own or by relaying information to a human operator at a remote place who will teleoperate to manage the vehicle. The unmanned ground vehicle (UGV) is the land-based equivalent of the unmanned aerial vehicle (UAV).

Unmanned underwater vehicles and aerial vehicles. Unmanned robots are currently being developed for both military and commercial applications to carry out a range of tedious, filthy, and risky tasks.

- To autonomously manoeuvre the robot vehicle in four directions (right, left, front, and rear) depending on the ultrasonic distance.
- To keep an eye on and transmit live the car's movement.
- To avoid any barriers that are discovered.

- To show the distance on an LCD screen.
- To monitor the latitude and longitude of the vehicle.

We have seen that technology has advanced significantly during the last several years. There is some kind of technological reformation taking place every single week and every single day. In practically all regards and disciplines, it is obvious that this technological growth might be avoided.

We considered exploring a few upcoming and enabling technologies like artificial intelligence, machine learning, the internet of things, blockchain technology, 5G, robotics, etc. since we were all curious to learn more about this technological transformation as a group. Then we discovered that every modern human being is being impacted by the Internet of Things. On the other hand, we discovered that robotics is a sector that is not yet fully integrated into the actual world but is slowly expanding and changing.

This research suggests a real-time collision avoidance strategy for harmonious human-robot interaction. The main contribution is a rapid approach based on the depth space concept for estimating durations between robots and possibly moving objects (including people). The distances are utilised to create repulsive vectors that are then used to track the robot while it executes a general motion function. An assessment of the speed of barriers may also help the repulsive vectors. To continue the accomplishment of a Cartesian job with a redundant manipulation where different response behaviours are arranged for the operator and other control locations throughout the robot structure, a simple automatic braking algorithm was constructed.

The idea is to push the autonomous vehicle away from obstruction by employing supersonic sensors. A microcontroller called ATMEGA328 is used to carry out the necessary procedure. A robot might be a computer that does steering or mechanical work. A combination of physical (motor) devices with artificial intelligence is also known as combined intelligence. Machine intelligence is included in the programmed instructions. The idea suggests building a robotic vehicle with built-in intelligence that is programmed to steer itself if an impediment is in its path. Built with an ATMEGA328 microprocessor, this robotic vehicle. This research offers a unique Dynamic Systems (DS)-based method for real-time obstacle avoidance that makes numerous convex-shaped objects impenetrable. The suggested approach may be used with autonomous as well as non-autonomous DS-based controllers to avoid obstacles in Cartesian and Joint spaces. By adjusting the controller's initial dynamics, obstacles may be avoided.

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# CHAPTER 3

# SP32 CAMERA

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Wi-Fi and Bluetooth are included in the ESP32-CAM, which may be used with either the OV2640 or OV7670 camera. High-resolution ADCs, SPI, I2C, and UART protocols are available on the ESP32 IC for information transmission. Hall, temperature, touch, and watchdog timer sensors are all included within the module. RTC may be used in a variety of ways. The module's highest clock frequency is 160 MHz, which translates to a maximum computational capacity of 600 DMPIS. Additionally, it has good reliability and durability for internet access [1]–[4].

Features of ESP32 CAM

- A 32-bit LX6 microprocessor with a single or dual core with a clock speed of up to 240 MHz.
- 448 KB of ROM, 16 KB of RTC SRAM, and 520 KB of SRAM.
- Supports up to 150 Mbps 802.11 b/g/n Wi-Fi networking.
- Assistance with BLE and Classic Bluetooth v4.2 standards.
- 34 GPIOs that are programmable.
- Two channels of 8-bit DAC and up to 18 channels of 12-bit SAR ADC.
- There are 4 SPI, 2 I2C, 2 I2S, and 3 UART serial ports.
- Physical LAN communication with Ethernet MAC (requires external PHY).
- One SD/SDIO/MMC host controller and one SDIO/SPI slave controller.
- PWM for motors and up to 16 LED channels.
- Flash Encryption and Secure Boot.
- Hardware acceleration for AES, Hash (SHA-2), RSA, ECC, and RNG cryptographic operations.

## ESP32 CAM AI TICKER COMPONENT

The ESP32-CAM AI-Thinker module is made up of many elements [5]–[7], including:

- ESP32-S Chip: The module's primary chip, which is utilised for all processing and functionality, has two very fast 32-bit LX6 CPUs and a 7-stage pipeline design.
- IPEX block output: The printed IPEX links GSM antennas to the transmitting signal.
- Tantalum capacitor: Small-size modules primarily employ this kind of capacitor. They are strong and provide fine signal quantity power supply filtering.
- Reset button: Pressing this button causes the module's code to be restarted.
- Voltage regulator chip: The module's voltage regulator chip keeps the output voltage constant despite changes in the input supply. The voltage is controlled at 3.3 volts.
- PSRAM: The module has a 4MB low-power pseudo-random access memory for quick instruction processing. It ensures seamless operation of the camera. A micro-SD card

holder is included in the ESP32 series to store data. All communication is done through a Serial Peripheral Interface.

FPC connection: The ESP32 module comes with a flexible printed circuit connector that may be used to instal the camera. The dependability of the signal is caused by its fine pitch.

- **Flashlight:**

To enable the camera to take clear pictures, the flash bulb emits electric pulses that act as a flash for the camera.

Pinout for ESP32-CAM AI-Thinker

The pinout of the ESP32-CAM AI-Thinker Module is described in this section. Although the ESP32-S chip has 34 total pins, only 16 of them are visible to the pinout headers.

ESP32 CAM AI TICKER PINOUT

- **Power Plugs**

The module features two positive power supply pins, such as 5V and 3.3V connectors, and three ground pins. The ESP32-CAM AI-Thinker module may be powered by these pins. However, it is not advised to power this development board using a 3.3V pin since it does not provide reliable power.

One power output pin is also provided by the ESP32-CAM, as shown by the colour yellow in the pinout diagram above. This VCC pin may provide either 3.3V or 5V.Jumper connections on the ESP32-CAM indicate that the VCC pin outputs 3.3V.

**Built-in Red LED in GPIO33**

A RED LED is also included in the AI-Thinker board. This LED is located next to the reset button. Connected to GPIO 33 in a logic low active state is this built-in red LED. Therefore, we must push GPIO 33 to a logic low level to turn on the LED. In the same manner, we push GPIO 33 to the active high state to turn off LED.

**UART pins**

The majority of the ESP32-CAM's GPIO pins are multipurpose pins. For the serial transmission and receipt of data for the UART port, respectively, GPIO1 and GPIO3 have alternative uses. There is no onboard programmer included with the AI-Thinker board. To upload the code, programming and communication with the PC are done via these UART pins.

The function of a pin

- GPIO 1 U 0 T X (UART Transmission pin)
- UORXD GPIO3 (UART Reception pin)
- Flash Mode Selection for GPIO0 Pin Table 3.1-UART Pins

This pin controls the module's mode, which may be either standard or flash mode. GPIO0 is pushed low while in flashing mode, indicating that it has to be connected to the ground. The ESP32-CAM enters flashing mode and allows us to flash the code when GPIO0 is connected to the ground.

Disconnecting GPIO0 from the ground will allow the module to operate normally, or enter normal mode, once the code has been flashed to the board.

- GPIO0 is grounded and the ESP32-CAM is in flash mode.
- With the ESP32-CAM in regular programme execution mode, GPIO0 is not connected to the ground.
- the SD Card pins

The ES32-CAM board, which was covered in the section before, features a built-in SD card connection that may be used to attach an SD card. When reading and writing data to SD cards, these GPIO pins are used to interface with micro SD cards. If the SD card is not in use, these GPIO pins may be utilised as regular I/O pins.

Tag Name

Connection to an SD Card

Pin GPIO2 Data0 (RTC & ADC supported)

GPIO4/Blinking light

- pin data one (RTC & ADC supported)
- Pin GPIO12 Data2 (RTC & ADC supported)
- Pin GPIO13 Data3 (RTC & ADC supported)
- the GPIO14 CLK (RTC & ADC supported)
- 15 GPIO CMD (RTC & ADC supported)

A high-intensity flashlight is also incorporated into the flash LED pin of the ESP32-CAM. You may use a camera with this flashlight to take pictures in the dark. An inbuilt flash bulb that, if configured to do so, flashes, when the camera takes photographs, is linked to GPIO4. It can be challenging to access both at once since GPIO4 is also linked to the SD card. As a result, while utilising an SD card, a flashlight may shine inappropriately. The GPIO pin connections for the OV2640 Camera are listed in the table below, along with the variable names we'll be using for each one.

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# CHAPTER 4

# UNO ARDUINO (ATMEGA328)

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A microcontroller board called Arduino/Genuine Uno is based on the ATmega328P.It contains a 16 MHz quartz crystal, 6 analogue inputs, 14 digital input/output pins (of which 6 may be used as PWM outputs), a USB port, a power connector, an ICSP header, and a reset button. It comes with everything required to support the microcontroller; to get started, just plug in a USB cable, an AC-to-DC converter, or a battery. You can experiment with your UNO without being very concerned that you'll make a mistake; in the worst case, you can replace the chip for a few bucks and start again. The introduction of Arduino Software was marked by the use of the Italian word "uno," which signifies one (IDE) The Uno board with the Arduino Software (IDE) version 1.0 served as the foundation for further generations of Arduino. The Uno board is the first in a line of USB Arduino boards and serves as the platform's benchmark. For a comprehensive list of all previous, current, and out-of-date models, see the Arduino index of board [1]–[3]s.

**Technical Information about the Arduino UNO**

The technical parameters of Arduino UNO are mostly connected to the ATmega328P MCU since Arduino UNO is based on the ATmega328P Microcontroller. Nevertheless, allow me to give you a quick rundown of some key Arduino UNO specs.

**Motors Powered By Batteries:**

DC Motor - 200RPM - 12Volts Geared motors typically consist of a basic DC motor and a gearbox. This has a wide range of robotic applications, including all-terrain robots. 12V DC geared motors with 200 RPM are often used in robotics applications [3]–[5].

Very user-friendly and offered in regular sizes. Additionally, using an Arduino or other comparable board to control motors doesn't have to be expensive. This motor, which operates between 5 and 35V DC, can be driven by the most widely used L298D H-bridge module with an onboard voltage regulator motor driver, or you can choose the most precise motor diver module from the large selection offered in our Motor divers category based on your unique requirements. Internally threaded shaft and nut allow for simple connection, and the shaft is threaded on both sides. DC Robotics and industrial applications are the perfect fit for geared motors with sturdy metal gearboxes for heavy-duty applications. Very user-friendly and offered in regular sizes. To attach the shaft to the wheel quickly and simply, it has a nut and threads on it.

RPM:

- 12V DC is the operating voltage.
- Gearbox: Plastic Attachment (spur)
- Gearbox
- 6 mm shaft diameter and the internal hole

- 2 kg/cm of torque
- Current with no load = 60 mA (Max) 300 mA is the load current (Max).

**Ultrasonic Sensor HC-SR04**

The HC-SR04 is a particular kind of ultrasonic sensor that utilises sonar to determine how far an item is from the sensor. It offers a wide variety of non-contact detection with exceptional precision & reliable results. Two components, an ultrasonic transmitter and receiver, are part of it.

The 4-pin module that makes up the functioning HC-SR04 Ultrasonic (US) sensor has the following pin names Vcc, Trigger, Echo, and Ground. This sensor is fairly common and is utilised in many applications where detecting objects or measuring distance is necessary. The ultrasonic transmitter and receiver are formed by two projects that resemble eyeballs on the front of the module. The ultrasonic transmitter sends out an ultrasonic wave, which travels through the air and is reflected forward towards the sensor when it encounters any objects or materials. The transducer receiver module detects this reflected wave [1].

With microcontroller and microprocessor architecture like Arduino, ARM, PIC, Microcontroller, etc., the HC-SR04 distance sensor is often utilised. The guidelines below are universal because they must be followed regardless of the kind of computing equipment being utilised. Through the sensor's Vcc and Ground pins, power the sensor with a controlled +5V. The sensor may be directly powered by the onboard 5V connectors since it consumes less than 15mA of electricity since they are both I/O pins. The trigger pin must be set high for 10 uS before being switched off. The Trigger and Echo pins may both be linked to the microcontroller's I/O pins to begin the measurement.

This will cause the transmitter to emit an ultrasonic wave at a frequency of 40Hz, and the receiver will wait for the wave to return. The Echo pin goes high for a certain period, which will be equivalent to the time it took for the wave to come back to the sensor after the wave is returned has been reflected by any object. The MCU/MPU measures how long the Echo pin remains high since it provides information about how long it takes for the wave to return to the Sensor. This information is used to calculate the distance in the manner described in the header above.

**Features of the HC-SR04 Sensor**

Operating parameters include +5V operating voltage; 2cm to 400cm theoretical and practical measuring ranges; 3mm accuracy; 15° measuring angle; 15mA operating current; and 40Hz operating frequency [6].

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# CHAPTER 5

# SERVO MOTOR

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A closed-loop control system is referred to as a servo in general. In a closed-loop system, the motor's speed and direction are changed in response to the feedback signal to produce the desired outcome. The potentiometer gives the servo control unit position feedback by comparing the motor's present position to its desired position. The control unit adjusts the motor's real position to match the intended position in response to the mistake. Sending a string of pulses to the signal line will control the servo motor. A typical analogue servo motor anticipates a pulse about every 20 milliseconds (i.e. signal should be 50Hz). The servo motor's location is determined by the pulse's duration [1]–[3].

## LCD Screen

If you've ever attempted to use an Arduino to connect an LCD display, you may have noticed that it uses up a lot of the board's pins. Even in 4-bit mode, the Arduino still needs seven connections in total, using about half of its digital I/O ports.

The use of an I2C LCD Display is the remedy. It can also be shared with other I2C devices and only uses two I/O pins, neither of which even a part of a set of digital I/O is pins.

## Hardware Overview for I2C LCD

A character LCD display powered by the HD44780 plus an I2C LCD adaptor makes up a standard I2C LCD display. Let's get to know them all individually.

## LCD Character Display

These LCDs are perfect for showing solely text or characters, as their name suggests. For instance, a 16x2 character LCD can show 32 ASCII characters in two rows, 16 in each row, and has an LED backlight. You can see the tiny rectangles and individual pixels that make up each character on the display if you look carefully. These rectangles are made up of a 58-pixel grid. To learn more about character LCDs, go here. Have a look at our detailed instructions [4]–[6].

## LCD I2C Adapter

The PCF8574, an 8-Bit I/O Expander chip, is what powers the adaptor. This device transforms the parallel data needed by the LCD display from the I2C data coming from an Arduino. Additionally, the board has a tiny trim pot that may be used to precisely adjust the display's contrast. On the PCB, there is also a jumper that controls the power going to the backlight. Remove the jumper and connect an external voltage source to the header pin labelled "LED" to adjust the backlight's intensity.

## Pinout for I2C LCD displays

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There are just 4 pins on an I2C LCD that connect it to the outside world. The following are the connections:

- The Arduino's ground should be linked to the ground pin or GND.
- The module and LCD are both powered by VCC. Connect it to the Arduino's 5V output or another power source.
- SDA stands for serial data. It is possible to broadcast and receive via this line. Connect to the Arduino's SDA pin.
- A serial Clock Pin (SCL) is a time signal that the Bus Master device is supplying.
- Connect to the Arduino's SCL pin.

**I2C LCD display connected via an Arduino Uno**

A regular LCD is substantially more difficult to connect than an I2C LCD. Instead of 12, just 4 pins must be connected. Start by connecting GND to the ground and the VIN pin to the Arduino's 5V output. We are still working with the I2C communication pins at this point. Keep take mind that the I2C pins on each Arduino Board vary, and they must be connected correctly. The SDA (data line) and SCL (clock line) are located on the pin headers near the AREF pin on Arduino boards with the R3 configuration. They also go by the names A5 (SCL) and A4 (SDA).

**Motor Driver L293D**

A medium-power motor driver ideal for operating DC Motors and Stepper Motors is the L293D driver module. The well-known L293D motor driver IC is used. It is capable of driving two DC motors in each direction or four DC motors in one direction.

- L293D motor driver IC, male Burg stick connectors for supply, ground, and input connection, and L293D motor driver board are some of its features.
- Screw terminal connections make it simple to attach a motor.
- LM7805 voltage regulator found on board

**Motor Driver IC L293D**

Connecting an L293D Motor Driver IC to an Arduino board is one of the simplest and least costly ways to drive DC motors. Two DC motors may have their speed and direction of rotation control. How to Control a DC Motor.We must manage the DC motor's speed and rotational direction to have full control over it. Combining these two methods will result in this. PWM is used to regulate speed, whereas H-Bridge is used to control the direction of rotation. A DC motor's speed may be adjusted by changing the input voltage. PWM is a frequent method for doing this (Pulse Width Modulation).PWM is a technology that sends a sequence of ON-OFF pulses to change the average value of the input voltage. The duty cycle, or average voltage, is inversely proportional to the pulse width. The average voltage applied to the dc motor (High Speed) is inversely correlated with the duty cycle, with higher duty cycles increasing the average voltage applied and lower duty cycles decreasing the average voltage applied (Low Speed). The PWM approach is shown in the below picture with varying duty cycles and average voltages.

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# CHAPTER 6

# INTRODUCTION TO SWARM ROBOTICS

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Swarm robotics is a method for coordinating numerous physical robots as a system made up of a sizable number of basically straightforward machines. In a robot swarm, the local interactions between robots and among the robots and the environment wherein they act lead to the collective behaviour of the robots. The assumption is that interactions between robots and interactions between robots and their environment lead to the emergence of a desirable collective behavior. This method was developed in the artificial swarm intelligence sector, as well as in biological research on ants, insects, and other natural systems where swarm behavior occurs [1]. Swarm robotics is the investigation of how to create robot groups that can work together autonomously and without the need for any external infrastructure or centralized control. In a robot swarm, the local interactions here between robots and between the machines and their environment determine their aggregate behaviour. Swarm intelligence concepts serve as a guide for designing robot swarms. These guidelines support the development of flexible, scalable, and fault-tolerant systems. Swarm robotics looks to be a potential strategy when several tasks must be carried out simultaneously, when great redundancy and the absence of a single failure point are desirable, and when it is technically impossible to build up the infrastructure necessary to govern the robots.

## Characteristics of swarm robotics

Robot swarms are multi-robot systems that self-organize and exhibit great redundancy. Robots can only communicate locally and sense locally; they do not have access to international knowledge. The interactions between each individual robot and its peers and the surroundings lead to the aggregate behaviour of the robot swarm. Although certain examples of heterogeneity robot swarms do exist, a robot swarm is typically made up of homogeneous robots. Cost and miniaturization are important aspects of swarm robots. These limitations prevent the construction of huge groups of robots; as a result, the simplicity of each team member should indeed be stressed. This should encourage the use of swarm intelligence to provide meaningful behavior at the swarm level as opposed to the individual level.

This objective of accessibility at the level of each individual robot has been the subject of extensive research. Instead of using simulations, real hardware may be used in Swarm Robotics research, allowing for a wider range of problems to be encountered and solved. Thus, one of the most crucial aspects of the topic is the creation of simple bots for Swarm based research [2]. The goal of swarm robotics research is to better understand robot design, anatomy, and behaviour. Swarm intelligence, the emergent behaviour seen in social insects, serves as an inspiration but is not a limitation. A vast array of complicated swarm behaviours may be generated by very straightforward individual rules. The group's members' ability to communicate with one another and create a system of ongoing feedback is a crucial element. The swarm behaviour encompasses both the behaviour of the entire group and continual individual change in conjunction with others.

Swarm robotics stresses a high number of robots and improves scalability, for example by using only local communication, in contrast to distributed robotics systems in general [3].

Today, the majority of robots are made to function independently rather than in groups. In order to create artificial robot swarms that cooperatively cooperate with one another to achieve a shared objective, Wyss researchers are creating robotic systems and computational methodologies. In one licenced implementation of the technology, 1024 "Kilobots" (meaning "one thousand robots") can be programmed to exhibit complex swarming behaviors, such as foraging and firefly-inspired synchronization, while a user can interact the with swarm as a whole (programming the robots, turning them on and off, etc.), regardless of how many robots there are. Also being created are underwater swarming robots that are inspired by Kilobits and employ a cutting-edge visual system to synchronize movement like schools of fish.

Additionally, a user might teach colonies of robots to carry out complicated tasks in natural settings including land, air, and water using a hive "operating system." Flying microrobots could be programmed to pollinate a field, or an autonomous robot construction team could be used to build 3D structures and traversable surfaces, stack sandbags along vulnerable shorelines before a hurricane, or set up barriers around toxic chemical spills. These applications are inspired by mound-building termites. In order to achieve these objectives, Wyss researchers have created sophisticated sensor technologies, micro-actuators, and reliable controllers that enable the robots to instantly adjust to changing circumstances. These limitations prevent the construction of huge groups of robots; as a result, the simplicity of each team member should be highlighted. This should encourage the use of swarm intelligence to provide meaningful behaviour at the swarm level as opposed to the individual level. Figure 1 Illustrates the Swarm Robotics in the sky.

**Figure 1 Illustrates the Swarm Robotics in the sky** [4]**.**

## Stigmergy

Social insects may communicate with one another and, for example, tell their partners when a food supply, a good foraging area, or a threat is present. This interpersonal relationship is predicated on the idea of locality, since there is no awareness of the wider context. Stigmergy refers to the implicit communication that results from environmental changes. Due to past alterations in the environment brought by by their partners, insects alter their behaviour. This is seen in the way termites build their nests, where the nest's structure influences how the workers' behaviours alter.

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## Basic Swarm Behaviors for Swarm Robotics

Individuals behave according to local rules in the majority of swarm algorithms, and the overall behaviour develops naturally from how the swarm's members interact. When applied to the field of swarm robotics, individual robots behave in accordance with a set of local rules that can be anything from a basic reactive mapping between sensor inputs and actuator output to complex local algorithms. These local behaviours frequently involve contacts with the physical world, such as the surroundings or other robots. Every interaction involves reading and interpreting the sensory information, processing it, and then using this information to control the actuators. A series of such interactions is referred to as fundamental behaviour when it is continued endlessly or until the desired state is attained [4]–[7].

The swarm behaviour encompasses both the performance of the entire group and continual individual change in conjunction with others. Swarm robotics stresses a high number of robots and improves scalability, for example by using only local communication, in contrast to distributed robot systems in general. Through the formation of beneficial structures and behaviours resembling those seen in natural systems like swarms of insects, birds, or fish, numerous robots work together to solve problems in swarm robotics. The transition to industrial applications, however, has not yet been accomplished satisfactorily. There is little information in the literature on practical swarm applications that use swarm algorithms. Basic swarm behaviours are the portions of swarm algorithms that are most often employed.

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# CHAPTER 7

# WORKING OF SWARM ROBOTS

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Swarm robots are considerably more compact than standard autonomous robots (though not nearly as small as a nanobot). A few dozen to more than a thousand robots working together flawlessly to complete a job is how swarm robots operate. This is accomplished via "swarm intelligence," a technique of system structure that promotes high levels of adaptability in a system made up of many individuals yet controlled by neither of them. This is based on biological principles that are observed in flocks of birds, schools of fish, and even herds of certain bigger mammals that exist in nature. Swarm robots basically aim to imitate an animal's capacity to display a group behaviour in response to external stimuli and in order to complete a task. A robotic swarm operates along such lines by having many redundant units; as a result, the loss of one or even many robots won't significantly affect the swarm's ability to function as a whole. Swarm robots may therefore be widely used to a range of contexts and dynamically distribute themselves to complete a task regardless of the barriers [1].

## Applications of swarm robotics

- Swarm robots can help us find solutions to some of the most challenging issues we face today. They can use human inventiveness in almost any circumstance because of their capacity to scale and respond to any environment.
- It has, for instance, been thoroughly studied as a potential means of supporting failing ecosystem in the context of climate change as well as other natural disasters. Swarm robotics has the potential to be scaled up to produce artificial bees and insects that might pollinate important plants and crops to ensure their survival and avert a catastrophic famine.
- It has also been suggested that traditional militaries may be virtually fully replaced using the ideas of swarm robots. The US navy has experimented with robotic fleets that are capable of responding to attacks in real time robotics being widely deployed in various air forces throughout the world in the form of aerial robots. Fortunately, this technology may be used for other, much more peaceful objectives. Swarm robots might also act as the backbone of a durable research mission or be utilized to control a network of ground and aerial vehicles, perhaps paving the way for autonomous vehicles in our lifetime.

## Eye of the swarm

The potential of swarm robots to harness such power makes the future look quite interesting. Who knows what shape this still-emerging topic will take over the next few decades as technology advances and is further developed. Until then, it is beneficial to comprehend the societal circumstances that gave rise to swarm robots as well as the guiding principles that are influencing their advancement [2].

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## Internet of things

The Internet of Things is a network of physical items, according to a popular definition. IOT is often divided into three categories: and exchange information, all of which are connected via open or closed Internet Protocol (IP) networks.

These networked things routinely gather data, evaluate it, and utilize it to drive action, offering a wealth of insight for management, planning, and decision-making. The Internet of Things is a reality in our era (IoT). A network of physical items is what the Internet of Things is often defined as. We often divide IOT into three categories: and exchange information, with one category connected to the others using either public or private Ip (IP) networks. Data is routinely gathered, examined, and used by these networked items to take action, supplying a wealth of insight for planning, management, and decision-making. This is the Internet of Things era (IoT).

The Internet of Things (IoT) is a cutting-edge automation and analytics system that works with artificial intelligence, sensor, networking, electrical, cloud messaging, and other components to offer comprehensive solutions for the product or service. IoT systems have higher levels of performance, control, and transparency. We can link everything around us as a result of a platform like the cloud that stores all the data. As an illustration, consider a household where all of the appliances, like as the air conditioner and lights, can be connected to one another and controlled from the same platform. Such a platform, so we can link our automobile to it to monitor its fuel gauge, speed, and position [3].

The Internet of Things is a combination of several hardware and software technologies, not a single technology. The combination of information technology, which includes the hardware and software used, is what the Internet of Things offers as solution to store, retrieve, and analyse data as well as communications technology, which comprises devices used for group or individual communication. The term "Internet of things" (IoT) refers to physical items (or groups of such objects) equipped with sensors, computing power, software, and other technologies that communicate with one another and exchange data through the Internet or other communications networks. The term "internet of things" has been criticised because gadgets only need to be individually accessible and connected to a network, not the whole internet [4]–[7].

The discipline has changed as a result of the confluence of several technologies, including machine learning, ubiquitous computing, inexpensive sensors, and increasingly potent embedded systems. The Internet of things is enabled by the traditional disciplines of embedded systems, wireless sensor networks control systems, and automation (particularly home and building automation). The Internet of Things connects commonplace "things" to the web. Since the 1990s, computer engineers have started incorporating sensors and CPUs into commonplace items. However, because the pieces were large and heavy, progress was first slow. RFID tags, which are small, low-power computer chips, were first employed to track costly machinery. These processors evolved throughout time to become smaller, quicker, and smarter as computer devices shrunk in size. The cost of incorporating processing power into tiny items has significantly decreased in recent years. For instance, you may provide MCUs with integrated RAM of less than 1MB, such as those used in light switches, communication with Amazon alexa service capabilities. It is feasible to "collect information, analyse it, and develop an action" to assist someone with a specific activity or learn

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from a process by fusing these linked devices with automated systems. In practise, this includes beacons in stores and beyond as well as smart mirrors.

According to Caroline Gorski, the head of IoT at Digital Catapult, "it's about networks, it's about devices, and it involves data." IoT enables communication between devices on limited private internet connections and "These networks are connected via the Internet of Things. It makes the world far more linked by enabling gadgets to communicate not just among themselves but also across other forms of networking.

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# CHAPTER 8

# WORKING OF INTERNET OF THINGS

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Gadgets and things with built-in sensors are linked to an Internet of Stuff system, which integrates data from several devices and utilizes analytics to communicate the most important information with apps made to address specific requirements. These reliable IoT solutions are capable of accurately determining which information is beneficial and that could be safely ignored. This information may be utilized to spot patterns, make recommendations, and spot possible problems before they happen [1].

- Sensors may be used to identify which showroom areas are busiest and where customers linger the longest.
- Sales data can be thoroughly analysed to see which items are selling the quickest.
- Supply and sales data can be automatically matched to guarantee that popular items don't run out of stock.

With the knowledge provided by advanced analytics, procedures may be improved. Smart technologies and systems enable everyone to automate some tasks, particularly those that are tedious, time-consuming, repeated, or even dangerous. Let's examine a few scenarios to demonstrate how this truly appears in real life. The Web of Things is primarily made possible by technologies that connect objects and enable interactivity between them. Connectivity options come with a number of advantages and disadvantages, with some being better suited for that use cases like consumer devices and others maybe being more suited for Iot systems like industrial automation. IoT data protocols allow information to be sent between devices and between devices and IoT network protocols link devices to each other and the internet [2].

## Sensors/Devices

Sensors or other devices initially collect data about their environment. It might be as simple as a temperature reading or as complex as an entire video stream. Simply use the word "sensors/devices" since several sensors may be integrated or because sensors may be a part of a technology that does more than merely observe things. For instance, a phone has sensors like a camera, an altimeter, a GPS, and others, yet it is more than just a sensor [3]

## Connectivity

Various technologies, including Ethernet, Wi-Fi, Broadband, low-power typically (LPWAN), cellular, satellites, and WiFi, can connect the sensors and devices to the cloud. Each option involves trade-offs in terms of bandwidth, length, and power use (a brief explanation is provided here). Depending on the IoT application, a certain connectivity strategy may be best, but they all accomplish the same task: delivering data to the cloud.

## Data Processing

Once the material is in the cloud, some kind of programme processes it. Making ensuring the temperature readings is within the permitted range can be all that is necessary. Or it may be really difficult, like using computer vision to distinguish objects.

## User Interface

The information can be used by the end user in some way. This might be accomplished simply warning the user (email, text, notification, etc.) for examples, a text message warning when the temperature inside the refrigerated storage facility becomes too much. A user could also have access to something like an interface that lets them regularly check on the system. A user could want to use a phone or perhaps a web browser, for example, seeing the video cameras inside their house. But it's not always a one-way street. Depending on the IoT application, the user may potentially be able to act and affect the system. The user would, for example, electronically change the temperature with in refrigerated temperature by utilising a mobile application [4]–[7].

Some duties are completed automatically. Instead of waiting for your action, the system could adjust the temperature automatically utilizing pre-established rules. In addition to phoning you to IoT systems may automatically notify the appropriate authorities in addition to notifying you of the breach. Connectivity allows the sensors and devices that make constitute an IoT system to "talk" to the cloud. Software analyses the data after it is in the cloud to determine whether to take this certain action, such as notifying the user of automatically changing the sensors and equipment. However, a UI permits customers to accomplish this if their involvement is necessary or if they merely desire to check here on system. Any changes or actions made by the user are transmitted via the system in the opposite direction to make the required change, before returning to the sensors and gadgets via the UI, the cloud, and ultimately the sensors and devices.

A variety of heretofore disconnected devices are now remotely and widely engaged with by people, businesses, and governments thanks to the Internet of Things to get information from them, make inferences based on that information, and then often relay instructions back to the devices (cars, tractors, etc.) in order to help those machines (better) do their duties.

## Core Components of an IoT System

The IoT contains some of the core components which are illustrated below:

## Hardware

The Internet of Things (IoT) is a network of countless connected actuators and sensing devices that enables users to detect (and occasionally change) their physical surroundings. These devices require network connection in addition to basic processing and storage capacities, which are usually provided by a controller, a mechanism (SoC), or an RF gate array (FPGA).

### Embedded Programming

The Internet of Things (IoT) "embedded" devices. With the creation of individual electronic circuit boards (PCBs) occurring later, they might be made as prototypes utilising commoditized micro platforms like Arduino. These platforms require knowledge of hardware communication technologies like serial, I2C, or SPI that are required to establish connection between the computer

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and the related sensors and actuators. They also call for competence in circuit design and microcontroller programming. Although C++ or C are widely used to construct embedded programmes, Python and HTML (for UIs and platforms) are becoming becoming more popular for developing and deploying IoT systems. These platforms demand expertise in circuit design, microcontroller programming, and a thorough grasp of the hardware communication systems used to create communication between the microcontroller and the associated sensors and actuators, such as serial, I2C, or SPI.

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# CHAPTER 9

# SECURITY COMPONENTS OF IOT

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One of the most important IoT concerns is security, which is strongly tied to data ethics, privacy, and liability. Every stage of the system's design must incorporate it. Every day, millions of additional devices are linked, increasing the amount of possible (and actual) attack vectors. With so much at risk, having the right security engineering skills is essential. These include threat assessment, ethical hacking, encryption, safeguarding network infrastructures and services, event monitoring, activity logging, and threat intelligence [1].

## Networking and Cloud Integration

Due to the enormous number of connected devices and the potential effects that network design choices may have on scaled-up IoT systems, network operation and implementation are crucial in the IoT. Devices may talk with one another and with programmes and services that are hosted in the cloud thanks to connectivity. Real-time data streaming and cloud connectivity are essential for the efficient function of IoT, despite the fact that cloud computing and IoT are two very distinct technologies. IoT applications leverage cloud infrastructure for business logic implementation as well as data processing, analysis, and storage [2].

## Data Analytics and Prediction

Every day, more and more IoT devices communicate data, transforming big data into gigantic data. The enormous amounts of heterogeneous data coming from these devices must be ingested, stored, and queried by developers in a safe and dependable manner. It's also helpful to filter or delete unnecessary data at the periphery of your network rather than pushing everything up to servers since many IoT devices produce latency- or time-sensitive data.

## AI & Machine Learning

Machine learning and AI are helpful technologies in an IoT system because they can give value to and make sense of the enormous volume of data that is created by IoT devices. These methods for teaching a computer to learn by bombarding it with information about a situation allow for real-time predictive analysis of sensor data streams as well as autonomous decision-making in reaction to new information. In order to find patterns or abnormalities in historical data that can help you make crucial decisions, machine learning may also be applied to such data [3].

## IoT and Industry

The fourth industrial revolution, often known as Industry 4.0, the Industrial Internet of Things (or "IIoT"), and its influence on industrial ecosystems have led to the creation of strong physical-cyber connection. Physical linked industrial assets, such as those in the industrial shop floor and connected logistics trucks, processes, and more, are referred to as part of the connected ecosystem.

## IoT Security

Strong physical-cyber connectedness, often known as Industry 4.0 or the Industrial Internet of Things (or "IIoT"), has emerged as a result of the influence of IoT on industrial ecosystems. This phenomenon is frequently referred to as the fourth industrial revolution. The term "connected ecosystem" refers to actual industrial assets with internet access, such as those on the production floor and linked logistics cars, systems, and other things.

### The Importance of IoT Security

The Internet of Things is no different from other internet-connected devices in that it is susceptible to hacking. These gadgets might be compromised, resulting in catastrophic harm, such as interfering with traffic signals, shutting off home surveillance systems, and endangering human life. It is crucial to safeguard these systems since these devices have the potential to gather data that includes personally identifying information. There are procedures that can be done to assist achieve this, but ultimately the aim is to safeguard the entire system [2], [4]–[6].

- Data should be processed, transferred, and stored securely.
- The device should be kept secure.
- Update the system to lessen security flaws

## Limiting the Attack Surface on IoT

Users' attack surfaces are growing as a result of the use of IoT technology in an enterprise, making them more vulnerable to assault by threat actors. A flat network is one that includes IoT, IT gadgets, and operational technology (OT) in the same network. The primary weakness in this is that it existed once As soon as an attacker gains access, they can migrate laterally and compromise more delicate systems. Utilizing network segmentation is a useful approach to reduce the attack surface and guard against the compromise of whole systems. Network segmentation, a part of cyber security, is intended to stop virus from spreading to other OT and programs.

## IoT Risks

Privilege escalation, in which access is gained by taking advantage of defects or other design flaws, and firmware highjacking, in which malicious software is downloaded via phoney drivers or updates, are examples of common IoT assaults.

## IoT Precautions

The Health Sector Cybersecurity Coordination Center of the U.S. Department of Health and Human Services advises people and organisations to adopt a number of preventative measures to reduce risk. Avoiding Universal Plug - And - play, which enables devices within the same network to automatically find and connect with one another, is one protection. Another is utilising a zero-trust paradigm that restricts access to what is absolutely essential and authenticates and validates network transactions, as well as modifying passwords and router settings.

## Energy management

Numerous energy-consuming equipment (such as lights, domestic appliances, motors, pumps, etc.) now have Internet connectivity built in, which enables them to interact with utilities to balance power generation while also maximising overall energy usage. 0 These gadgets enable operations like scheduling and allow for remote control by users or centralised management via a cloud-based interface (e.g., remotely powering on or off heating systems, controlling ovens, changing lighting conditions etc.). The microgrid is a power IoT application that uses technologies to collect and act on data about energy and power in order to increase the effectiveness of electricity generation and distribution. [96] Electric utilities monitor transformers and other distribution automation equipment using smart meter infrastructure (AMI) Web devices.

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# CHAPTER 10

# ROBOTICS APPLICATIONS

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Because of the development of mechatronics plus mathematical modelling, robotics has come a long way. There are now gadgets that can jump down tall buildings, discover landmines, conduct operations, and troubleshoot using a piece of iron once could hardly move a few inches. In Rossum's Universal Robots, which he wrote, Karl Capek coined the term "robot" to represent the rise of a dominating race with intelligence comparable to human [1]. Robotics is a multidisciplinary field of computer science and engineering. Robotics deals with the design, upkeep, application, and use of robots. Robotics seeks to develop tools that can help and sustain people. Robotics incorporates a variety of academic fields, including electrical, biology, computer programming, operations research, software engineering, maths, and others. Robotics produces machines that can mimic human behaviour and replace people. Robots can be used for a wide range of tasks and in a wide range of environments, though currently many are used in dangerous situations, such as manufacturing processes or other situations where humans cannot survive (such as the audit of radioactive products and the sensing and deactivation of bombs).

While some robots can function without human involvement, others require it. Although the concept of creating autonomous robots dates from the classical era, research into the skills and potential uses of robots didn't truly take off until the 20s. Robots will eventually be able to mimic human behaviour and do tasks in a way that is human-like, according to several academics, inventors, engineers, and technicians who have made this prediction time and time again throughout history. The field of robotics is presently increasing swiftly as technology advances. Research, invention, and the development of new robots provide a number of practical purposes, whether on a household, commercial, or military level. [2].

Robotics is the synthesis of science, construction, and engineering that produces machines, known as robots that imitate or replace humans in activity. Popular culture has long been fascinated with robots; examples are R2-D2, the Predator, and WALL-E. These anthropomorphic, exaggerated depictions of robots usually give the impression of being parodies of the real thing. Are they, nevertheless, more futuristic? The potential of a machine like R2-D2 in the future is not ruled out by the mechanical and cognitive abilities that robots are acquiring.

As technology advances, the scope of what is considered robotics broadens. In 2005, 90% of all bots in automotive industries were used in vehicle assembly. The majority of these robots are made up of prosthetic arms that are utilized for welding or attaching certain automobile components. The definition of robotics as it is used today has expanded to include the creation, application, and improvement of robots that accomplish tasks including exploring the harshest regions on Earth, assisting law enforcement, streamlining medical procedures, and conducting rescue missions. [3].

## Types of Robotics

Mechanical chatbots appear in a range of shapes and sizes to efficiently do the task for which they are designed. Each robot has a distinct design, function, and level of independence. Robots of all sizes, from the 0.2 centimetre "RoboBee" to the 200 m autonomous freight barge "Vindskip," are being designed to carry out tasks that humans cannot. How the five various types of robots do tasks depends on their capabilities. Below is a description of various types and what they do.

## Pre-Programmed Robots

Pre-programmed robots do simple, everyday tasks in a controlled environment. An example of from before the robot would be a mechanical hand in an auto manufacturing line. The arm's function is to complete tasks longer, faster, and more efficiently than a person could, such as welding a door onto the vehicle or installing a specific component into the engine.

## Humanoid Robots

Humanoid robots are those that mimic human behaviour or have a human appearance. These robots regularly do human-like tasks (such running, jumping, and carrying objects), and sporadically they are designed to seem like people, even possessing human looks and attitudes. Among the most widely used models are the humanoid robots Sophia and Atlas from Hanson Robots and London Dynamics [4]–[6].

## Autonomous Robots

Autonomous robots do their tasks without human supervision. These robots are frequently designed to carry out tasks in public places unsupervised by people. They stand apart in that they employ decision-making systems, frequently computers, to select the optimal course of action in light of their data and objectives before using sensors to observe their surroundings. One instance of a mobile robots is the Roomba item, which uses sensors to wander freely around a home.

## Teleoperated Robots

Teleoperated robots are semi-autonomous machines that can be commanded by people at a respectable distance. These robots typically work in challenging environments with challenging weather and terrain. Remotely operated robots including, for example, the human-driven submersible that were used to fix underwater pipe breaks during in the BP oil spill or the helicopters that were used to locate landmines in a battle zone.

## Augmenting Robots

Robots that simulate virtual reality (VR), sometimes referred to as "augmentation robots," can replace or enhance lost human abilities. In the field of robotics toward human improvement, science fiction could soon become reality. Robots with the ability to make people faster and stronger could radically redefine what it means to be a person. Modern augmenting bots that can handle heavy things include robotic exoskeletons and prosthetic limbs.

## Bot

Bots are autonomous computer programmes, sometimes referred to as software robotics. One common type of software robot is a chatbot. A chatbot is a form of computer programme that replicates communication both online and over the phone. It is frequently employed in customer service contexts. Chatbots can be simple services that automatically answer to enquiries or complex digital assistants that learn from user input. Software drones are not considered to be robots because they are computer-generated and only exist online. To be categorised as a robot, a device must possess a physical form, such as a torso or a chassis. . A chatbot is an example of a software robot in use. A chatbot is a type of computer software used often in customer service settings that simulates conversation both digitally and over the phone. Chatbots can be straightforward services that respond to inquiries automatically or sophisticated digital helpers that learn from user data.

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# CHAPTER 11

# ROBOTIC PROCESS AUTOMATION

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Robotic process automation (RPA) software streamlines the development, administration, and control of autonomous robots that replicate human behaviour while interacting with computers and software. Software robots may carry out a wide variety of specified activities, including as comprehending what is displayed on a screen, pressing the correct keys, traversing computer systems, and retrieving and recognising data. Software robots, on the other hand, can do the operation more quickly and accurately than people since they aren't required to get up and stretch or take a coffee break [1].

Bots for Robotic Process Automation (RPA) have significantly more digital capabilities than human beings. Think of Enterprise applications as a digital office that can interact with any system or application. Copy-and-paste, site data scraping, calculations, file opening and movement, email processing, hacker logins, API connections, or unstructured data extraction are just a few of the operations that bots may perform. Additionally, as bots can adapt to almost any user or process, there's no need to change existing corporate systems, tools, or methods iz order to automate. RPA bots are easy to distribute, use, and instal. If you are aware of when and how to shoot video on your phone, configure RPA bots. Using the paused, play, and stop buttons, as well as clicking and dumping files about the office, is just as straightforward. RPA bots may well be shared, changed, duplicated, and scheduled to carry out business operations throughout the whole organisation.

## The benefits of Robotic Process Automation

RPA has a variety of advantages

## Less coding

RPA does not necessarily need an expert to configure, but drag-and-drop features in design of user interfaces facilitate it for quasi staff to onboard.

## Rapid cost saving

RPA reduces team workloads, enabling workers to be moved to other crucial activities that still need for human input, boosting output and return on investment.

## Higher customer satisfaction

Bots and avatars can reduce client wait times and boost customer satisfaction since they are accessible round-the-clock.

## Improved employee morale

RPA frees your personnel from needing to do high-volume, repetitive activities, enabling them to focus on much more strategic and important choices. Employee satisfaction benefits from the transformation at work [2].

## Better accuracy and compliance

Particularly when it comes that work that should be correct and in compliance with rules, human error may be reduced by programming RPA robots to follow specific processes and procedures. RPA may also provide an audit trail, so makes it easy to monitor progress and solve issues faster.

## Existing systems remain in place

Automating robotic processes software doesn't interact with underlying systems since bots simply alter the presentation layer of pre-existing applications. So you can still employ bots even if you don't have an API or perhaps the ability to build sophisticated integrations.

## Funtions of Robots

How robots funtions and HPW they categories by their fuctio is illustrated below:

## Independent Robots

Autonomous robots may function without the supervision of a human operator. These often need more complicated programming but allow robots to take the place of people while doing hazardous, monotonous, or otherwise impractical tasks, such as deep-sea travel, bomb dispersal, and industrial automation. Autonomous robots have shown to be the least destructive to society because they both replace certain vocations and create new prospects for growth [3]–[5].

## Dependent Robots

Robots that are not autonomous but are dependent on humans interact with them to enhance and improve their natural behaviors. One kind of reliant robots that has been built is an advanced prosthesis that is controlled by the human mind. This type of technology is very new, and it is constantly being expanded into new applications.

## Main Components of a Robot

Robots necessitate a broad range of peripherals to perform their duties since they are created to meet a variety of demands and perform a variety of purposes. To build any robot, certain components like a power source or a central processing unit are necessary. The following five categories can be used to categories robotics components:

## Control System

The whole central processing unit, sometimes referred to as the control system, of a robot is regarded as a component of computing. Control systems are created to tell a robot how to use certain pieces in order to complete a job, just how the brain actually sends signals throughout the body. These robotic occupations might involve anything from packing to minimally invasive surgery. [6].

## Actuators

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Only machines with a moving body or frame may be categorised as robots. Actuators are the elements triggering this movement. These components are made consist of motors that receive instructions from the system and cooperate to carry out the necessary motions to finish the task. Actuators are available in a variety of configurations to better carry out each of their specific tasks. They can be built of a range of materials, such as metal or elastic, and are frequently driven by use of pressurised gas (pneumatic actuators) or oil.

## Sensors

Sensors, Thanks to detectors, which provide stimuli in the shape of electric surges that the controller analyses, robots may interact with their surroundings. Photoresistors, which serve as the bots' eyes, video recorders, and microphones, which serve as the robots' hearing, are typically found in robots. These sensors provide the robot the ability to monitor its surroundings, determine the most logical course of action given the current situation, and send commands to the other components via the controller.

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