Vellore Institute of Technology
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# Final Review Document

# Smart Temperature Regulation with IoT and Image Processing


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**Course name:** Internet of Things

**Course code:** CSE 3009

**Slot:** A1+TA1

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CONTENTS

## *Introduction*

*Air conditioners(AC) have become inevitable part of this modern world. Countries which have unbearable scorching summers especially those in the middle east and parts of Northern Africa have become more dependant than ever on AC's to regulate the room temperature. Thermal comfort brings a great influence that may affect the satisfaction of an occupant about the surrounding indoor environment, as this could lead to the level of productivity and social interactions. The word thermal comfort is utilized to imply data about the thermal condition of human with the indoor environment. The concept of thermal comfort consists of three main disciplines such as physiology, psychology and behavioural factors. It has been observed that a better workplace leads to overall productivity, so with our proposed model the workplace would feel cosy making the employee to focus more on work. One of the most suitable tools that have been utilized in tropical region to create thermally comfortable indoor environment is the air conditioning (AC) system. However, the conventional method of controlling the AC may not guarantee thermally comfortable indoor ambience, furthermore excessive cooling chosen by users may also contributed to negative side effect toward the occupancy's health. So creating a balance between work life and personal health is very much necessary.*

*While the usage of AC's is flourishing, so does the cost associated with electricity bills. Recent surveys tell that cooling and air conditioning represents 70 per cent of the UAE's electricity use during the summer months. There is also an increase in the carbon footprint level which can be threatening to the mankind in the future. Proposing a system to minimise consumption of ACs is very much necessary, it also means that there should be no compromise in the comfort of the user. Existing solutions seems to be insufficient in countering this issue as there is a trade-off between comfort and energy consumption. Some proposed solutions have been too difficult to be implement so that they could be part of day to day life, thus eliminating the possibility of using them. Our proposed solution is simple, cost effective and yet energy efficient and are also easy to install as well.*

## *Aim*

*The project aims to create an automated temperature regulator system which uses Image processing and deep learning based model to control the AC which in turn keeps control over the temperature of the room. The model recognises the number of people which is further passed on to the Arduino, and based on the count of people determined, the temperature is increased/ decreased. As most often we fail to decrease the temperature even when the number of people inside the room are less, we are indirectly contributing to the carbon footprint and also leading to increased electricity bills as well. Moreover, running the ACs for a long time with reduced temperature could also lead to wear and tear within the compressor of the AC thus decreasing the overall lifespan of AC. We take in to account to keep the model simple, easy to incorporate it with the existing system (without drilling, hammering..) and also ensure that the sensors used are widely available and can easily be replaced, even by those without the knowledge on working in it. Thus we aim to use the AC optimally without compromising the comfort and meanwhile focussing on reduced electricity consumption.*

## *Objective*

*The deep learning model would be able to interpret the number of people inside the room and would be able to transfer the count to the Arduino, which would then check for any changes in conditions that were given (based on count of people) and it would send IR signal to the AC if necessary. By the end of this project we would be able to regulate the temperature based on the swarm of the people that are present at any given room at that point of time. We would also be able to toggle the AC on/off if there is presence of people in the room.*

## *Benefits*

- With multiple automated modes, you do not have to continuously change temperature settings throughout the day. Our ACs can detect the number of people in room, and can consequently maintain the perfect temperature conditions throughout the day.
- Our AC units greatly help save energy without compromising on cooling. As the count of people reduces the AC automatically regulates the temperature to a desired level, which means that your unit does not need to suck massive amounts of energy to work at full capacity at all times. This makes our ACs an excellent investment.
- Since the CCTV camera output of all buildings is available in a single device, our model minimises the use of any additional hardware and can regulate temperature of multiple rooms simultaneously.
- Running the AC continuously on a fixed temperature could lead to over burden on the compressor of the AC which could lead to minimised life span of the AC, but our AC smartly toggles on/off AC and also varies the temperature, thus preventing the wear tear in the compressor.

## *Literature survey (Existing system)*

### 1)*Worldwide Auto-mobi: Arduino IoT Home Automation System for IR Devices*

***Problem Statement:***

*The problem statement taken into to consideration was to control multiple device anywhere any location using an IR system as there are many remote controls in daily life use. For controlling mechanism either there was computer or mobile application but the problem was that there wasn't a hybrid system that could run on multiple devices. The hardware components that they used included Arduino Uno, Bread Board, ESP8266, IR sender, 9 Volt Power source and a router with internet connection.*

***Proposed methodology:***

*The proposed methodology included hardware and software as two separate components. For software part any smart phone like iPhone/android or iPad/Tablet was suitable. The hardware tried to connect the available WiFi, then later connected with cloud via a unique key. Sending the signal was a matter of clicking a button on the phone to send IR to cloud, which hardware subscribed to cloud, and received all published message from it. The signal was directed to the hardware unit through router, and it sends IR directly via IR sender LED.*

*After successful transmission ESP8266 went back to listening again for new message. ESP8266 tried to connect to local WiFi when it failed it will reset and try again. The same also applied for cloud after successful connection to WiFi it connected to cloud and if there was a failure it went to reset mode and trail happened again*

***Conclusion:***

*They concluded that their proposed system provided a solution to combine multiple controls in home by using a single application on the smart device.*

*2)* Dynamic traffic management system using Infrared (IR) and Internet of Things (IoT)

***Problem Statement***

*Their project plan was to provide an automated IR-sense based solution that makes traffic signals to shift the lights (red/yellow/green) dynamically.*

***Proposed methodology:***

*Their model works like this, the sensed data gathered from IR sensor is transmitted by the Wi-Fi transmitter which is received by the raspberry-pi controller. Based on this compilation it dynamically shifts time of the red signal and the user gets an intimation of status of the signal on his way. The Raspberry Pi controller works as a central console; it determines which sideways of the road signal is to get open or close. The raspberry pi controller works as a central console; it determines which sideways of the road signal is to get open or close. The opening and closing of the traffic signals are done in clock-wise manner so as to moderate the complexity. The central console gathers all the data from sensors and stores it in the cloud which intimates traffic status to a mobile device. Raspberry pi board is interfaced with the sensors and programmed in a way that they give data to traffic lights and also notifies the mobile devices.*

***Conclusion:***

*They concluded that their proposed system provided a solution to minimise waiting time in the traffic as it was optimising the toggling delay between signals based on the traffic present at that particular point of time.*

*3) Green data center with IoT sensing and cloud-assisted smart temperature controlling system*

***Problem Statement***

*The authors were interested in a cloud-based air conditioning system architecture for green DC. They proposed a cloud-based approach to effectively reduce data centre power consumption by a slight modification, and simplify and standardize the management of cooling system. They also proposed a multi-level intelligent temperature control algorithm to increase the energy efficiency of cooling system, and finally they deployed the solution on a small DC.*

***Proposed methodology:***

*Their system architecture was divided into data centre air conditioning system and cloud management platform. The data centre air conditioning system is responsible for tasks such as cooling, ventilation, machine room environment signal acquisition, uploading the data to the cloud, receiving cloud control commands. Cloud management platform was responsible for receiving, storing and inquiring the data uploaded by data centre, monitoring the running situation of related cooling system of data centre, releasing control command to related device of data centre, notifying promptly the data centre management of the emergency situation, modelling, analysing based on data collected, assessing and forecasting data centre air conditioning system by virtue of tools such as statistics and machine learning.*

*Conclusion:*

*They concluded that the energy efficiency has been significantly improved without reducing the data centre refrigeration effect.*

*4) [Human Detection Using Depth and Gray Images]()*

*Problem Statement:*

*A method was presented for extracting pedestrian information from an image sequence taken by a monocular camera. The problem of detection from a video by using a new type of depth sensor together with a new depth slicing algorithm for detecting objects in various depths. For the new type of depth-perception device used in their work, the user could specify an area of interest for depth data acquisition. Objects beyond the range didn't not appear in the depth image. By using their feature, it became much simpler to detect moving objects as soon as they entered a specified zone.*

*Proposed methodology:*

*A split-and-merge strategy was proposed to process depth data for object and human detection. This method didn't not use background subtraction, and therefore it was applicable for scenes taken from mobile platforms. The method made use of hybrid sensing of depth and grey information and it was shown to work well in an indoor environment*

*Conclusion:*

*Weakness of their implementation was that the size of the ellipse model for human torso was subject to change of various poses of the person. Fitting limbs to a human candidate also made event analysis more comprehensive.*

*5) [Development of an IoT-based Visitor Detection System]()*

*Problem Statement:*

*An IoT-based visitor detection system was designed. It used an IR sensor to detect human body and two ultrasonic sensors to locate visitor servo motor under the position. When a visitor was detected it drove the camera module to locate the visitor. Recoded video and sensor data were stored in the Database. Saved data was seen via the PC and Smart device. They developed the system using Raspberry Pi2 and sensor modules to verify the concept. It tracked the visitor moving route and minimized the blind spots of the camera, and sensor data and recoded video were checked on internet for all possible remote locations.*

*Proposed methodology:*

*The proposed model used Raspberry Pi2 as controller, and IR sensor to detect a visitor. In addition, two ultrasonic sensors were used to locate the position of the visitor. The camera module was equipped with a servo motor to change the direction of the camera to the visitor. A web server was used to provide visitor information and sensor data to any internet-enabled remote location. When the detection system started, it initialized the IR sensor and two ultrasonic sensors. The system determined the presence of a visitor from the data of the IR sensor. When a visitor was detected, the two ultrasonic sensors were activated to spot the location of the visitor. The system identified the location of the visitor with the data from the ultrasonic sensors. And then, the camera moved in the direction to the visitor by driving the servo motor where the camera was attached. The system controlled the servo motor by supplying PWM current. The system stored recorded videos and sensor data in database.*

*Conclusion:*

*The saved data could be seen from any remote location via internet. Since it contained less than two ultrasonic sensors and only one infrared camera the location of the visitor wasn't accurate.*

*6) [Smart Monitoring Temperature and Humidity of the Room Server Using Raspberry Pi and Whatsapp Notifications]*

*Problem Statement:*

*Most of the studies held by the authors did not have system integration in one problem, for example, if focus was on giving notifications via SMS there was no control, if there was control then there was no real-time monitoring.*

*So they proposed their study which tried to integrate from the system with web-based monitoring, notifications on Whatsapp, controlling of on / off server computers and viewing log history the temperature of the server room.*

*Proposed methodology:*

*Overall system design used wireless technology to avoid the wiring in server space. The raspberry device used a DHT sensor that could read the temperature and humidity of the room. After reading the raspberry and processing the temperature and humidity, raspberry pi activated the web server service, so that it could display the website pages so that the website can be accessed via a local wireless network (a private network) or via the internet (a public network). Temperature and humidity log data were stored in the MySQL database, then displayed in a chart diagram in real time.  IoT response was provided based on predetermined temperature standards by giving notifications to users via Whatsapp Application on mobile devices.*

*Conclusion:*

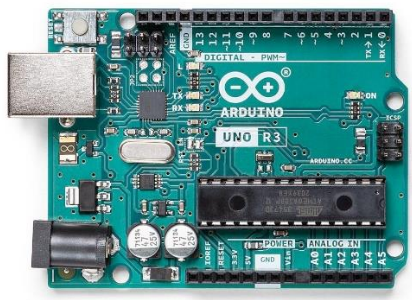
*They concluded that their monitoring system sent alerts to the user in the form of notification when there was a temperature rise above the specified value.*

*Components Used*

*(Sensor & Actuators)*

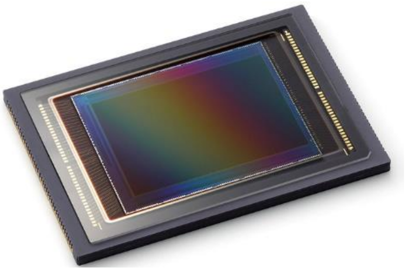
1. *Arduino*

*The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.*



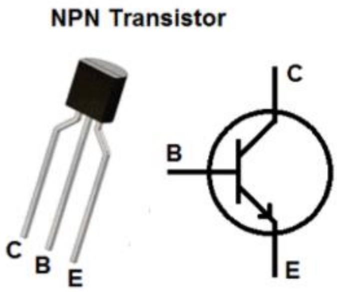

2. *CMOS sensor*

*A CMOS sensor is an electronic chip that converts photons to electrons for digital processing. CMOS (complementary metal oxide semiconductor) sensors are the usually used sensors in digital cameras, digital video cameras and digital CCTV cameras to create images. It is not necessarily the coloured sensors are to be used. It is still very common that CCTV cameras are mostly grayscale based, it would still be able to determine with margins of errors, the count of number of humans.*



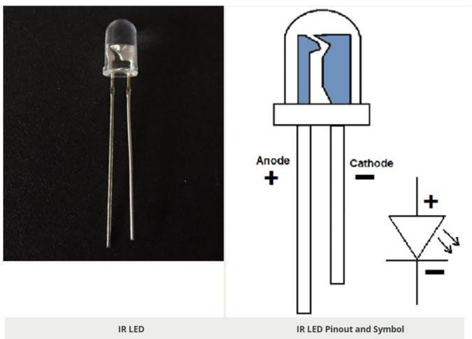
3. Transistor NPN

*NPN transistors are usually used as amplifiers. Since the building/ location at which the model is deployed is usually larger in size, the transmitted signal might get distorted/attenuated as a result of which the receiver in the AC might not feel the presence of signal the use of amplifier is very much desirable to increase the chances of signal reaching the AC.*



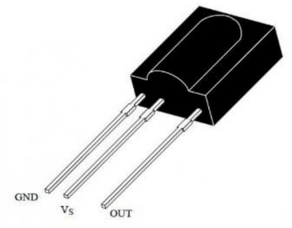

4. IR Transmitter(actuator)

*Infrared Transmitter is a light emitting diode (LED) which emits infrared radiations called as IR LED's. Even though an IR LED looks like a normal LED, the radiation emitted by it is invisible to the human eye.*




5. IR receiver (SM0038)

*IR receiver modules are used to receive IR signals. These modules work in 3, 8 KHz frequency. When the sensor is not exposed to any light at its working frequency, the Vout output has a value equal to VS (power supply). With exposing to a 38 kHz infrared light, this output will be zero.*




*__Working model of all sensors__*

*IR Sensors:*

*The emitter is an IR LED and the detector is an IR photodiode. The IR photodiode is sensitive to the IR light emitted by an IR LED. The photo-diode's resistance and output voltage change in proportion to the IR light received.*

*The IR Receiver Module has the following specifications*

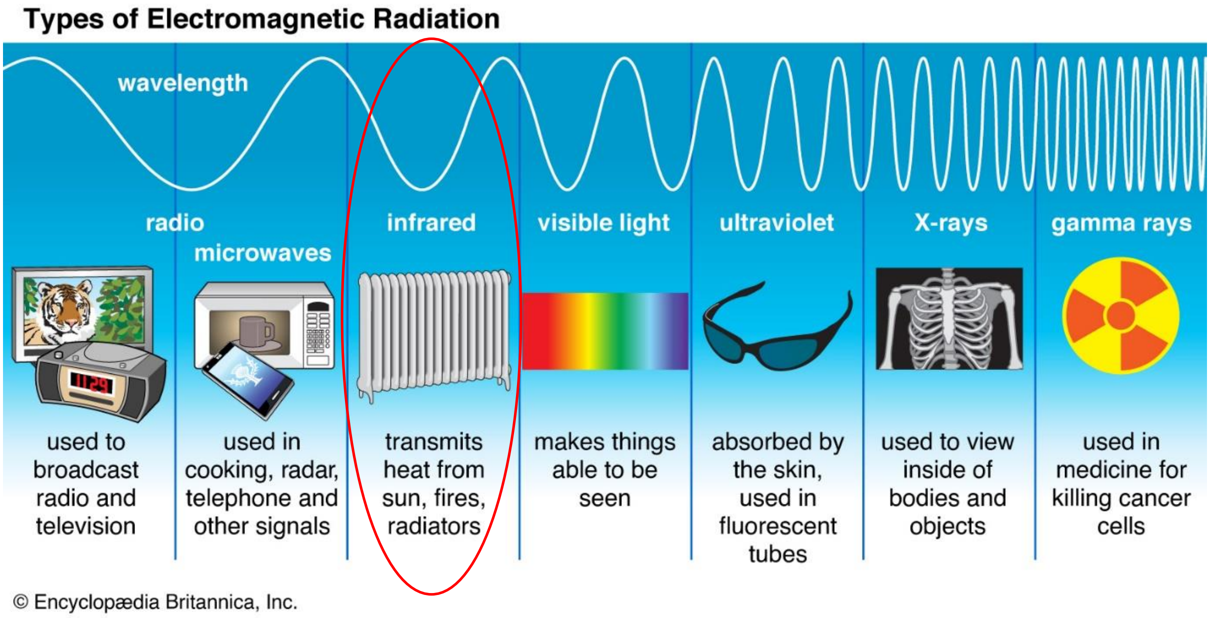
- *It has the operating voltage of 2.7V to 5.5V*
- *It has a supply current of 1.5 mA*
- *It has an operating temperature from -25 C to 85 C*
- *It has a receiving distance of 18 meter*
- *The frequency at which it operates is 37.9 KHz*

*Transistor:*

*The transistor in which one p-type material is placed between two n-type materials is known as NPN transistor. The NPN transistor amplifies the weak signal enter into the base and produces strong amplify signals at the collector end. Such type of transistor is mostly used in the circuit because their majority charge carriers are electrons which have high mobility as compared to holes.*

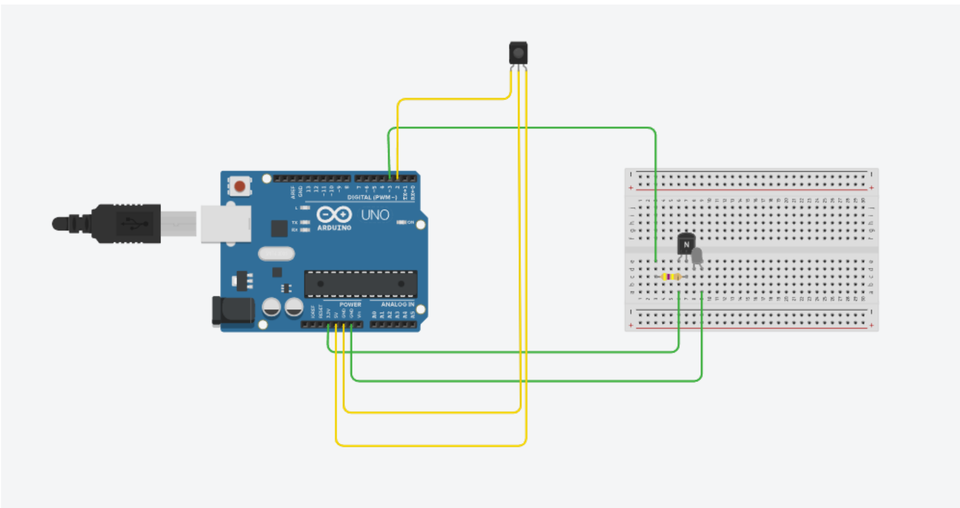
*__Proposed architecture__*

*Remote control is a small device which sends IR signals to the application device, and that device confirms these signals and responds according to a simple written program. To produce the signal, this program contains loops to print a number several times, using an Arduino UNO board and LED light emitting diode light, remote control uses electromagnetic waves. Infrared radiation which is part of the electro magnetic spectrum is our key area of usage. Infrared radiation extends from the nominal red edge of the visible spectrum at 700 nanometers (nm) to 1 millimeter (mm). This range of wavelengths corresponds to a frequency range of approximately 430 THz down to 300 GHz. These waves behave just like visible light, except that humans can't see them. This is because they have a different, longer wavelength than visible light. IR LED in the remote sends modulated signals (codes) to the IR receiver in the appliance. System in the appliance demodulate the signals(codes) and the checks the function corresponding to it and executes it. Every IR operated appliance has different codes* *for different functions. We use our own IR sensor to capture these IR codes from the remote that controls the respective AC that we are trying to automate. Once the IR codes corresponding to different functions of the remote are captured by the IR sensors, these are then used by the IR transmitter to mimic the remote.*




*We have used the Yolo V3 object detection model for human detection. In order to perform human detection on the CCTV footage of the room in which the AC is controlled, we have to use the RTSP protocol which stands for Real Time Streaming Protocol. Once we are connected to the same network as that of the camera, this RTSP URL can be given as input to the Yolo model for human detection and counting. Meanwhile we drew bounding boxes around the person detected, for the clear understanding of the working of the model. In the Yolo V3 model class ID of a person is given as 0, so we have counted the no of classes with ID 0 to get the number of people covered within the range of the CCTV camera. This is then passed to Arduino for controlling the AC based on the no of people present in the room.*

*(Pin diagram)*

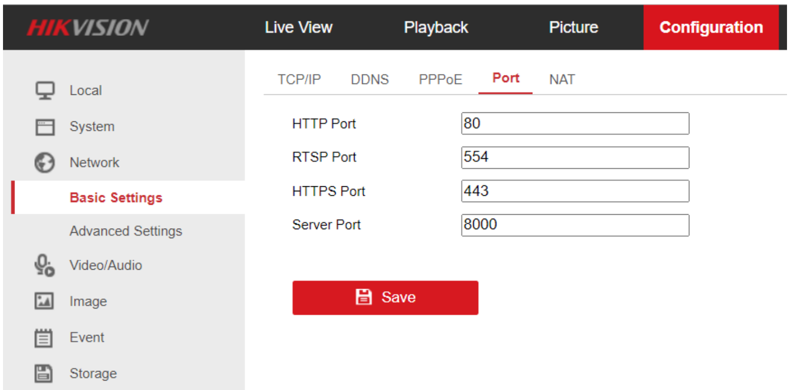


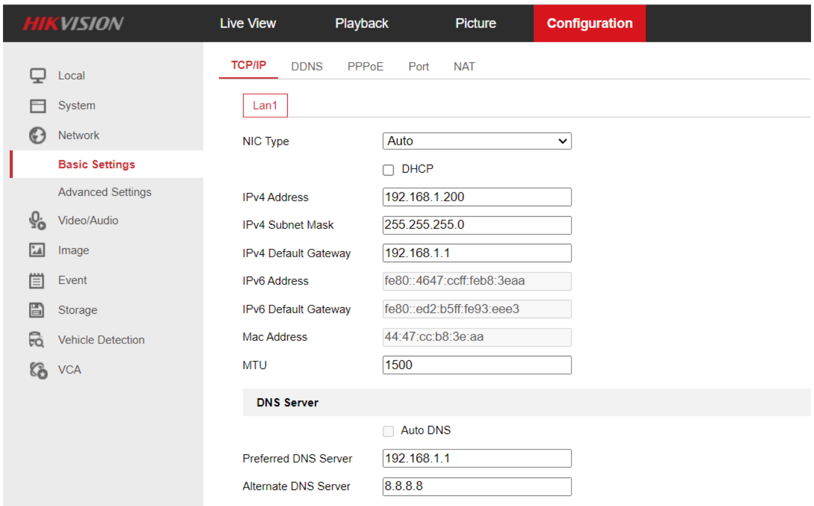
## Hardware/Simulation implementation

*YOLO(You Only Look Once) algorithm employs convolutional neural networks (CNN) to detect objects in real-time. As the name suggests, the algorithm requires only a single forward propagation through a neural network to detect objects. It was trained on the COCO object detection dataset which contains nearly 1.5 million object instances, 80 object categories and 250,000 people with keypoints*

*The algorithm frames object detection in images as a regression problem to spatially separated bounding boxes and associated class probabilities. In this approach, a single neural network divides the image into regions and predicts bounding boxes and probabilities for each region. This means that prediction in the entire image is done in a single algorithm run. The neural network predicts bounding boxes and class probabilities directly from full images in one evaluation. The base YOLO model processes images in real-time at 45 frames per second. The pre-trained YOLO network weights are provided that can be used directly in any implementation and hence no need to train a model on example images. In order to pass the CCTV live feed to the YOLO object detection model we have used the Real Time Streaming Protocol URL which lets us perform human detection on the live feed.*

*RTSP_URL = [rtsp://admin:password@192.168.1.200:554/Streaming/channels/802](rtsp://admin:password@192.168.1.200:554/Streaming/channels/802)*



*In our case we not only want to detect objects rather keep track on the people who are coming and leaving, so it means that we would like to keep track on the count of people. At any time, we would like to keep tracking for new people and add it to the counter variable, the counter value is constantly written in to the Arduino, and it is based on the conditions within the Arduino it alters the temperature of the room. So, to keep track of the no of people in the respective room, we are performing human detection every 70 frames, which is nearly double the fps of the live feed from the CCTV camera. This allows for smooth running of the model without any lags/delays. For every 70 frames, the count is sent to the Arduino with the help of serial communication, which is then used by the IR_send sketch file for controlling the AC*

***Capturing the IR codes of the remote:***

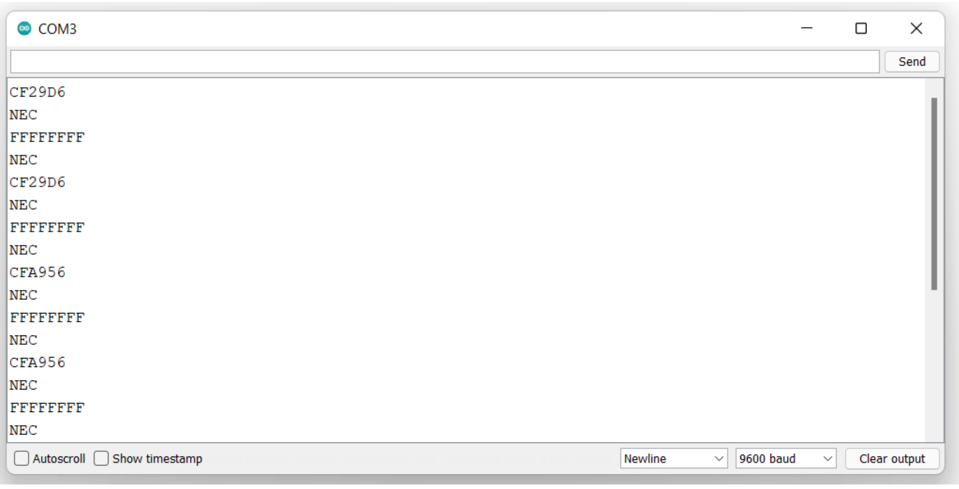
Connections for this, will be done in two parts. Here in the first part we will be connecting the Arduino UNO board with IR receiver to record the IR codes for ON/OFF and temperature increase/decrease operations as sent by the original AC remote.

For this step, we require - IR receiver and Arduino UNO

1. Connect the Vcc pin(middle pin) of the IR receiver to the 3.3V pin of the Arduino UNO.

2. Connect the GND pin of IR receiver to the GND pin of Arduino UNO.

3. Connect the Signal pin of IR receiver to Pin No. 2 of Arduino UNO.




<u>Sketch coding:</u>

1. The Arduino UNO should be connected with the PC.

2. The code mentioned below is used to get the HEX codes from the remote. Here we have used the IRremote.h library for sending and receiving the IR codes.

3. After the code gets uploaded we can open the serial monitor to view the captured IR codes.

4. Move the AC remote closer to the IR Receiver and then press the ON button to get a sequence of numbers flashing on to the serial monitor. Similarly codes for other operations can be obtained and saved, along with their corresponding operations to prevent confusion.

*Sketch for IR Receiver:*

```
#include <IRremote.h>

// Define sensor pin
const int RECV_PIN = 2;

// Define IR Receiver and Results Objects
IRrecv irrecv(RECV_PIN);
decode_results results;

void setup(){
  // Serial Monitor @ 9600 baud
  Serial.begin(9600);
  // Enable the IR Receiver
  irrecv.enableIRIn();
}

void loop(){
  if (irrecv.decode(&results)){
        Serial.println(results.value, HEX);
        switch (results.decode_type){
            case NEC:
              Serial.println("NEC");
              break;
            case SONY:
              Serial.println("SONY");
              break;
            case RC5:
              Serial.println("RC5");
              break;
            case RC6:
              Serial.println("RC6");
              break;
            case DISH:
              Serial.println("DISH");
              break;
            case SHARP:
              Serial.println("SHARP");
              break;
            case JVC:
              Serial.println("JVC");
              break;
            case SANYO:
              Serial.println("SANYO");
              break;
            case MITSUBISHI:
              Serial.println("MITSUBISHI");
              break;
```

```
      case SAMSUNG:
        Serial.println("SAMSUNG");
        break;
      case LG:
        Serial.println("LG");
        break;
      case WHYNTER:
        Serial.println("WHYNTER");
        break;
      case AIWA_RC_T501:
        Serial.println("AIWA_RC_T501");
        break;
      case PANASONIC:
        Serial.println("PANASONIC");
        break;
      case DENON:
        Serial.println("DENON");
        break;
    default:
      case UNKNOWN:
        Serial.println("UNKNOWN");
        break;
    }
  irrecv.resume();
}
}
```

Sketch for IR transmitter

```
#include <IRremote.h>


// Create IR Send Object
IRsend irsend;

void setup()
{
  Serial.begin(9600);
  Serial.setTimeout(1);
}


int current_h_count;
int prev_h_count = 0;
int temp = 26;
int state = 0;
void loop() {
  while (Serial.available())
```

```
{
  current_h_count = Serial.readString().toInt();
  if (current_h_count >= 1 && prev_h_count == 0) {
    irsend.sendNEC(0xCF8976, 32); // on
    state = 1;
    while(temp < 26)
    {
      irsend.sendNEC(0xCFA956, 32); //decrease
      temp = temp + 1;
    }
  }
  if (current_h_count == 0 && prev_h_count !=0)
  {
    irsend.sendNEC(0xCF8976, 32); // off
    state = 0;
  }
  if(state == 1)
  {
    if (current_h_count == 2 && prev_h_count != 2) {
      while(temp > 24)
      {
        irsend.sendNEC(0xCFA956, 32);
        temp = temp - 1;
      }
      while(temp < 24)
      {
        irsend.sendNEC(0xCF29D6, 32);
        temp = temp + 1;
      }
    }
    if (current_h_count >= 3 && prev_h_count != 3) {
      while(temp > 22)
      {
        irsend.sendNEC(0xCF29D6, 32);
        temp = temp - 1;
      }
    }
  }
  prev_h_count = current_h_count;
}

// Add a small delay before repeating
delay(200);
```

Main Controller Circuit:

For this circuit we require=Arduino UNO, IR LED, 2N2222 Transistor, 470-ohm resistor.

1. Connect the 2N2222 Transistor's base pin(middle pin) to the Pin No. 3 of the Arduino board through a 470-ohm resistor.

2. The Emitter pin of the transistor which is the left pin while looking at the curved side should be connected to the GND and the collector pin of the transistor which is the rightmost pin while looking at the curved side needs to be connected to the negative terminal of the IR LED. The negative terminal of the IR LED is the shorter leg.

3. Connect the positive terminal or the longer leg of the IR LED to 3.3V supply.

Sketch coding:

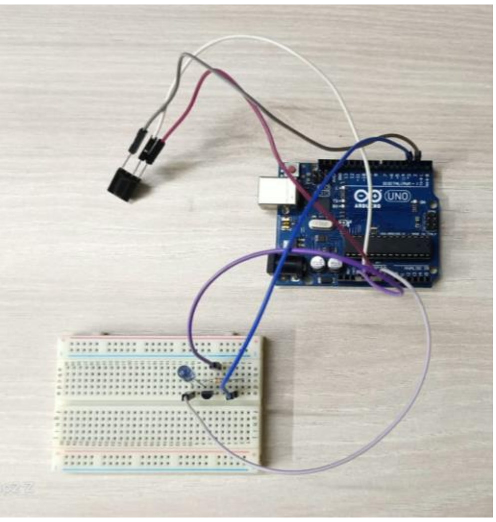
The code given below is used for controlling the AC with the help of IR transmitter. The IR codes which are saved from the serial monitor is used here to send the respective codes for the required operation. The irsend.sendNEC () function from the IRremote.h library, is used for sending the captured IR codes. The code is written in such a way that,

- The AC is turned ON when a person enters the room.
- The temperature is changed to 28°C when there is a single person in the room.
- The temperature is changed to 26°C when there are two people in the room.
- The temperature is changed to 24°C when there are three or more people in the room.
- The AC is turned OFF when there is no one in the room.

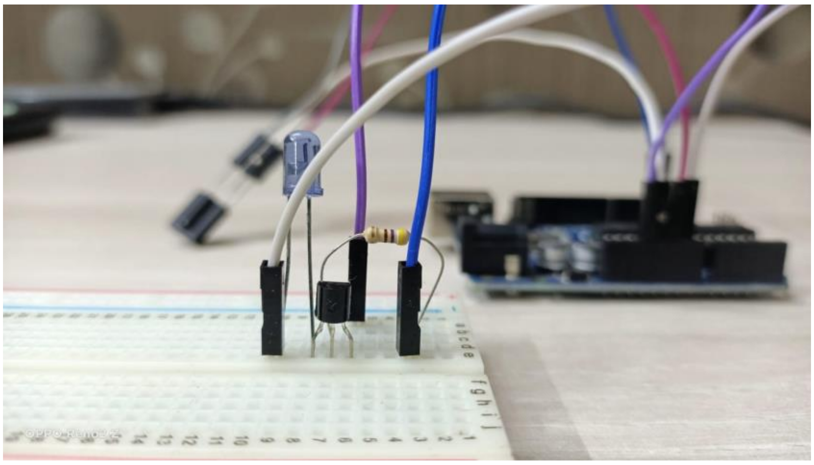
These conditions are applied based on the count received from the python file, through serial communication between Arduino and python.

## *Sketch for IR Transmitter :*

### *Setup of our connection:*



## *Breadboard Circuit:*



***Link to notebook file:***

*https://drive.google.com/file/d/1fh89oKM0r2YDQRigBNU9OsU9W9mGWwcJ/view?usp=sharing*

***Results and Discussion***

*Temperature Test cases:*

1) *Case 1: No one in the room; Result: A/C is Off.*


2) *Case 2: One person in the room ; Result: A/C is On.*

3) *Case 3: One person in the room; Result: A/C is On.*


4) *Case 4: One more person in the room; Result: A/C is On.*


5) *Case 5: A person leaves the room; Result: A/C is still on.*

6) *Case 6: All people left the room; Result: A/C is turned Off.*


## *Conclusion and Proceedings:*

*The presence of automated temperature regulator would help to minimise the involvement of people to use the AC remotes. But there are times that people may be willing to change temperature especially at times when there is high humidity in air, so in order to counter these we have planned to extend our model by incorporating DHT sensor to it. The DHT is a basic, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin. With the help of this sensor our AC would become smarter and would also make the user to be more comfortable. This model has been tested with one sensor and one AC at a time. We further look on expanding it to more ACs, also we have used wire connections to connect with sensors, we are also trying out the possibilities of using the Wi-Fi module to make it wireless. Making it wireless is also more meaningful as most buildings are equipped with the same wifi network expanded with additional routers which would enable easy communications from PC to the location of the sensor.*

*With this we have achieved our objective of reducing the electricity consumption without compromising the comfort of the user*. The sensors used are also very cheap, widely available and overall installation process wouldn't exceed ₹1200.

*Our model didn't let the user know that the temperature is being regulated and it also reduces the burden on user by automatically turning off the ACs when it isn't necessary.*

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## ***Links***

1) Click to view the receiver sender file
2) Click to view the arduino sender file
3) Click to view the deep learning model

***Click on the button to view the demo of the project:***