Customization of Lighting and Ventilation System in Household

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***Abstract*— The world is in the fourth industrial revolution and the twenty-first century. Because to the expanding and improving technologies, modern humans are living more comfortably. People have seen miracles in their lives thanks to the Internet of Things, machine learning, artificial intelligence, cloud computing, and many more technologies. The world is currently experiencing an era of unstoppable technological advancement and growth. IoT, or the Internet of Things, is important in this. This article presents a model where lighting and ventilation are automatically adjusted based on the surrounding environment and the user's preferences. The first thing to be done is to create a hardware model, from which the information is gathered about the user's preferences as well as the surrounding environment from human control and sensor readings.**

***Keywords*—IoT, Machine learning, NodeMCU, Microcontroller, Automation**

I. Introduction

One of the fundamental ideas for turning the idea of the "smart city" into a reality is the Internet of Things. It is used in many industries, including agriculture, retail, health, and transportation. Smart grids and home automation are the IoT's most well-liked applications. In order to handle issues and challenges that arise in the real world, smart devices may be developed and used with the help of IoT. Because of the use of gadgets like Siri, Alexa, Google Home, and other home IoT-enabled devices, IoT has grown to be one of the most important aspects of people's daily lives. Therefore, working from home has become a common habit in our contemporary culture of the usual office. Thanks to advancements in the field of Internet of Things, the world is moving faster than anyone could have ever dreamed.

Home automation is one of the core elements of IoT. Home automation was unfathomable decades ago. It is the automatic management of household equipment. When individuals enter the room, the light and fan turn on, and they turn off when they depart. Also, using voice control systems or other web, mobile, or other types of apps, one can manage their appliances from anywhere in the world. Many advantages of home automation include security, comfort, and energy savings.

When anticipating loads is automated, machine learning is frequently used to compare normal consumption to load usage. The incorporation of ML capabilities into smart home settings will be the upcoming trend in home automation. Modern scenes are frequently created by applying simple if-then-else logic to triggers and actions. Its deterministic logic provides relatively little intelligence while improving automation. Basic rules, for example, don't take into account how user routines and habits have changed over time.

These limitations are eliminated by ML by enabling scenarios that recognise renters' behavioural patterns and use them to optimise smart house operations. In this manner, machine learning algorithms can be trained using historical data about user behaviour in their own environments.

This study introduces the concept of customised fan and light automation. On the basis of information accumulated over time regarding user preferences, the proposal proposes that the fan speed and light intensity are automatically managed. The Node MCU ESP8266 wi-fi module is used as a microcontroller in this instance of customised automation to gather user preferences through manual regulation and the environment's temperature, humidity, and light levels from the installed sensors. After gathering data, we build a machine learning model, train it, evaluate its performance, and use the results to control the fan and light automatically. The hardware pieces and the developed model will be discussed initially. The project will then review the data collected and the created machine learning model.

A. *Objective of the Project*

The main aim of this project is to provide an automatic regulation of fan and light according to the preferences of people and the environment. This helps people to concentrate on their chores rather than dealing with the regulation of fan and light.

B. *Scope of the Project*

Elderly folks find tremendous comfort in the automated fan and light system that was developed using machine learning and data (fan speed, light intensity) obtained from user preferences. As opposed to remote-controlled or app-controlled versions, people do not need to carry their phones or remotes to operate the appliance. In this project, the appliance recognizes the user using a camera, and then operates according to that user. When an unknown user is captured by the camera, a letter about it is sent to a known user and operates in accordance with the surroundings.

II. LITERATURE REVIEW

Systems for home security and surveillance that concentrate on reducing burglaries and acquiring evidence of trespassing frequently fail. A home control and security system built on an FPGA is described in depth in this study. Internet users may remotely operate home appliances like air conditioners, lights, door locks, and gates thanks to user-friendly web pages. The system has the ability to monitor doors and windows, so in the event of a breach, the owner of the home is promptly informed through email about the intrusion. It raises the security of the system even further. [1]

The study presented discusses the development of a microcontroller-based automation system with automatic lighting, thermal comfort sensors, and security features for smart solar dwellings. A PIC16F877A was used to regulate the temperature and air quality, while a PIC18F4550 was utilised to regulate the lighting.[2]

The initiative uses Light Emitting Diodes (LED), which use very little electricity, to replace the high-intensity discharge (HID) bulbs that use a lot of energy. HID bulbs cannot have their intensity altered, whereas LED lights and LDR can. Due to the fact that LEDs are directed light sources, streetlights' efficiency is increased by their capacity to provide light in a specific direction. This procedure is carried out using an Arduino board that has been programmed to deliver the required light intensity at various intervals. [3]

As the machine learning model detects the user's emotion, it modifies the ambient lighting's colour to correspond to the many colour profiles that are appropriate for that specific face expression. The machine learning model can assist the user by turning on the fan if rage is the recognised emotion. To use the machine in unique circumstances, a user interface has been developed.[4]

The temperature is measured by a DHT22 sensor, and the fan speed is adjusted using PWM (Pulse with Modulation). The temperature and fan speed will be displayed on the LCD once the sensor has determined the temperature and the Pulse Width Modulation and Arduino board have been utilised to regulate the fan speed. [5]

The system's core components are the ESP32 Wi-Fi module and the Arduino UNO microcontroller. Communication is managed by the ESP32 Wi-Fi module. The ESP32 module directly connects to the private server to update Arduino whenever the register author makes any modifications or changes. [6]

In this work, a novel way is suggested to regulate ceiling fan speed in proportion to the room's temperature and population. Each time, the right temperature and ultrasonic sensors are chosen to measure the room's temperature and occupant count. The LCD panel shows the room's temperature, engine speed, and the number of occupants. When the temperature changes, a temperature sensor adjusts the fan speed. [7]

The devices used in this study include a node MCU V3 with Wi-Fi, a passive infrared sensor to determine whether the room is occupied, a relay switch to control the lighting, and a built-in passive infrared sensor. The developed programme serves as a controller, a management system that develops the necessary timetables, and a monitoring system that shows the overall number of illumination hours and energy usage. You can still save money even with a set timetable because the lights won't come on if nobody is in the room. [8]

In this study, an Internet-enabled control method is examined, along with any potential benefits for older homes of such Internet of Things (IoT) installations. To do this, we build a test-bed for an IoT platform and use light sensors to monitor the indoor ambient light levels. In order to compare the two, we model the typical household system power consumption (CSPC) and the smart system power consumption (SSPC), which is the result of our control approach. The SSPC results point out a few potential advantages of putting IoT-enabled control systems in older homes. In this case, we maintain resident visual comfort while reducing energy use by lighting less. [9]

The report describes a functional dynamic street light management system powered by the Internet of Things. The current system uses environmental and traffic variables to estimate the amount of street lighting that is necessary. Quantitative testing on real-world scenarios were conducted using actual street light luminaires that had been installed on a single street in a Swiss city. A qualitative human study was also conducted, however it did not reveal any appreciable shift in how people view the security of light intensity dynamics. [10]

The microcontroller in this study serves as the processing component. It first detects the temperature before comparing the data to the set temperature. The controller activates the fan and modifies the speed proportionally to the difference between the set temperature and the current temperature if the actual temperature is higher than the set temperature. If the outside temperature falls below the set threshold, the fan will be turned OFF. The fan's speed will vary depending on the temperature. When someone enters the room, devices like fans and lights turn on; when no one is present, they turn off. [11]

This study suggests a way to control the fan speed automatically. An LM35DZ temperature sensor, a PIC16F877A microcontroller, a brushless DC motor, and other electrical parts are created and assembled into a circuit that regulates the fan speed automatically. [12]

To enable remote access to and administration of household equipment, this study proposes a clever, energy-efficient home automation system. Home automation is built on a multimodal application that may be controlled by the user's voice commands given to the Google Assistant or by using a web-based tool. With the use of the design control unit, IoT may be used to turn a home appliance into a smart, intelligent device. [13]

This article's main topic is utilising Wi-Fi Direct to manage fan speed, and it gives detailed configuration information, including the client ID, server name, port number, username, password, and subject, as well as the fan speed level. The proposed method has the unique ability to regulate the fan using a variety of intelligent devices. A control algorithm is built to control the speed of the fan motor. The primary benefit of this strategy is that it allows users to change fan speed by sending a setting value (speed input command) through smartphone. [14]

III. FAN SPEED AND LIGHT BRIGHTNESS CONTROL SYSTEM COMPONENTS

A. NodeMCU – ESP8266

A comprehensive instruction set and 32 general-purpose registers, each of which is directly coupled to the arithmetic logic unit, are combined in the Atmel AVR core. The ATmega328/P has 23 general purpose I/O lines, 1K bytes of EEPROM, 32K bytes of inherently programmable flash, 2K bytes of SRAM, and 1K bytes of EEPROM, allowing for a very quick boot-up with minimal power use. increase. AVR microcontrollers and sliders can be equipped with capacitive touch button and wheel capabilities using Atmel's Touch® library.

Fig.1 NodeMCU

B. Temperature Sensor DHT11

The Temperature and humidity are measured by the digital sensor DHT11. Simply connect this sensor to any microcontroller, such as an Arduino or a Raspberry Pi, to monitor humidity and temperature. This sensor can be distinguished from other modules by an ON LED. The DHT11 is one relative humidity sensor. A thermistor and a capacitive humidity sensor are used by humidity sensors to measure the ambient air. The DHT11 sensor comprises of a capacitive humidity sensor and a thermistor for measuring temperature. A substrate that may use moisture as a dielectric separates two electrodes to form a moisture-sensitive capacitor. The capacitance value varies with the humidity. The changing resistance value is computed, interpreted, and converted to digital form by the IC.

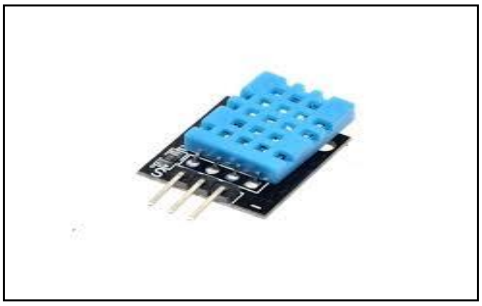

Fig.2 DHT11

C. LDR

LDR, or light dependent resistor, is a common acronym. LDRs, also known as photoresistors, are tiny light-sensing elements. An LDR is a resistor whose resistance changes depending on how much light is shining on it at any one time. The LDR resistance decreases as the light intensity rises and vice versa. This property allows us to use them to build light sensor circuits. To use an LDR, a voltage divider circuit must always be designed. When an LDR's resistance value increases in relation to its fixed resistance, the voltage across the device rises.

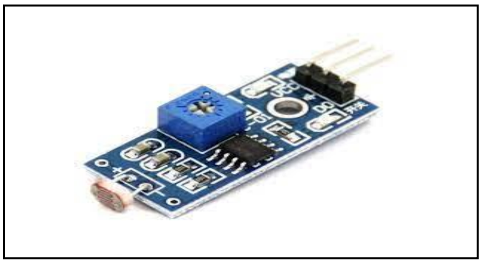

Fig.3 LDR

D. LCD

A liquid crystal display (LCD), an electronically operated optical device that is positioned in front of a light source (backlight) or reflector, is made up of any number of colour or monochrome pixels filled with liquid crystals. It is commonly used in electronic devices that use batteries since it uses relatively little electricity. An LCD is made out of a liquid crystal sandwiched between two glass panels.

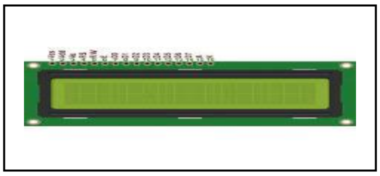

Fig.4 LCD

E. Python

Python is a powerful but easy-to-learn programming language. It has good high-level data structures and a clear yet effective object-oriented programming methodology. Python's clear syntax, dynamic typing, and interpreted nature make it the ideal language for scripting and rapid application development across the majority of platforms. The use and distribution of it are both free. The Python interpreter may easily accept new functions and data types created in C or C++ (or other languages callable from C). Python is a solid option for versatile software add-on languages.

F. Thingspeak – IoT Analytics

The organisation MathWorks®, which also creates MATLAB® and Simulink®, offers the IoT analytics platform service ThingSpeakTM. ThingSpeak enables the collection, presentation, and analysis of online real-time data streams. Using ThingSpeak, you can see the data that your equipment or devices post right away. To manage and analyse data being sent online, use MATLAB code in ThingSpeak. ThingSpeak helps speed up the development of proof-of-concept IoT systems, especially ones that demand analytics. The creation of IoT solutions does not require servers or web apps. For small- to medium-sized IoT systems that can be implemented in actual environments, ThingSpeak offers a hosted solution.

IV. METHODOLOGY AND ALGORITHMS USED

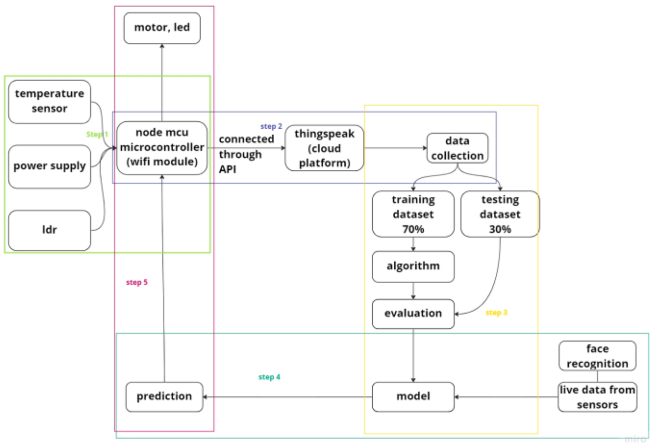

Fig 5. Workflow Diagram

A. Hardware model for data collection

This project's primary job is to collect data in accordance with user preferences. A Node MCU microcontroller, a temperature and humidity sensor (DHT11 sensor), an LDR sensor to gauge outdoor light intensity, an H-bridge motor driver to control the fan's speed, an LED, an LCD, a motor, a potentiometer, and an ADS115 analogue to digital converter are all used to build a hardware prototype for data collection. With the prototype that has been put into operation, information is acquired regarding user preferences for fan speed and light intensity. Turn the potentiometer that corresponds to the fan or light to alter its speed and intensity.

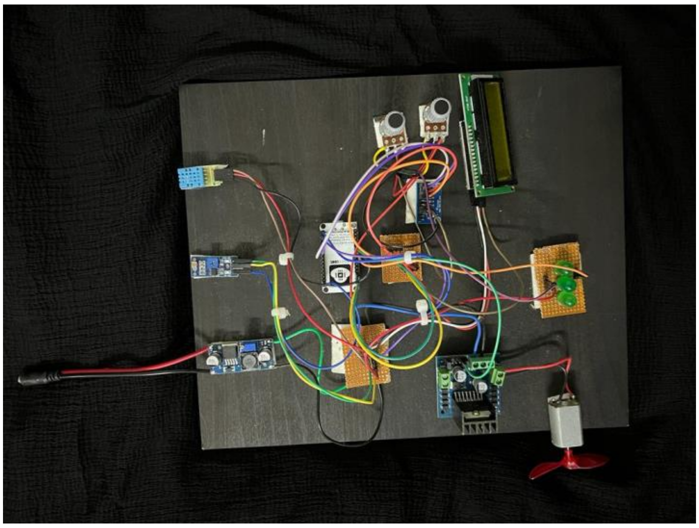

Fig 6. Hardware model

B. Face recognition model

In this project, the face recognition library is used to create a deep learning-based face identification system. Installing and importing facial recognition libraries like dlib, face recognition, and opencv is the first step. Following the addition of test images, the face recognition library quickly recognises faces on its own. The deep learning-based library for facial recognition only needs one image to train itself to recognise a person.

C. Data Collection

Data on fan and light usage in relation to outside temperature and light intensity are gathered using the hardware model that has been established. Data collection is facilitated by the model's CPU, a Wi-Fi module called the NodeMCU-ESP8266. The Wi-Fi module is linked to the Thingspeak cloud platform using Arduino code that provides the specifics of the personal Wi-Fi, the Thingspeak channel ID, and its private API key. The cloud is used to collect and export user real-time data in.csv format. More than 900 distinct types of data have been gathered for this investigation.

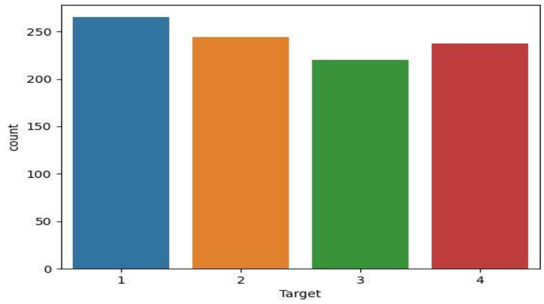

Fig 7. No. of values in each level of fan speed

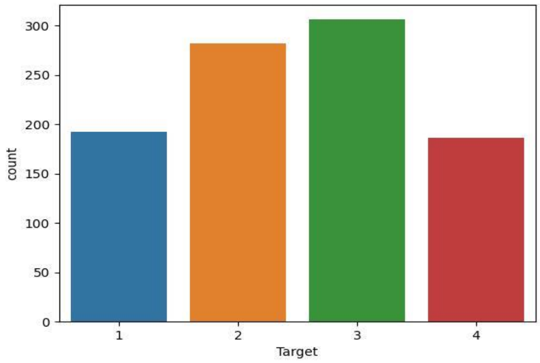

Fig 8. No. of values in each level of light intensity

D. Machine Learning Algorithms

Various machine learning algorithms have been used and most accurate among them is selected to train the microcontroller which in-turn acts in such a way to make the fan and light to work automatically according to the user.

E. K-NN

A well-liked and approachable supervised machine learning (ML) technique for imputed missing data is KNN. It has to do with problems with categorization and regression. It is based on the premise that the observations that are most "similar" to a particular data point in the data set are those that are closest to that point in the data set. This concept allows us to categorise unexpected points based on the values of the adjacent existing points. The user can choose K to specify how many neighbouring observations will be included in the method.

F. SVM

Both classification and regression are performed using supervised machine learning techniques called Support vector machines (SVM). Although we also talk about regression issues, categorisation is the most important idea. The SVM method looks for an N-dimensional space hyperplane that categorises the data points clearly. The size of the hyperplane depends on the quantity of features. When there are only two input characteristics, the hyperplane seems to be a straight line. If there are three input features, the hyperplane transforms into a 2-D plane. It becomes impossible to visualise something after three features.

G. Random Forest

Most preferred algorithm for machine learning, a component of the supervised learning approach is Random Forest. It can be applied to ML issues involving both classification and regression. It is based on the concept of ensemble learning, which is a technique for combining several classifiers to address complicated problems and improve model performance. The Random Forest classifier, as its name suggests, improves the dataset's predicted accuracy by averaging many decision trees that were applied to various subsets of the supplied data. The random forest uses forecasts from each decision tree and predicts the outcome based on the votes of the majority of projections, as opposed to relying solely on one decision tree.

H. Naïve Bayes

Naive Bayes classifiers are a subset of classification algorithms based on the Bayes theorem. Instead of being a single algorithm, it is a family of algorithms, and they are all predicated on the notion that every pair of features being classified is unrelated to every other pair.

I. Decision Trees

The decision tree is the categorization and prediction technique that is most successful and well-liked. Each internal node, each branch, and each leaf (terminal node) of a decision tree represent an attribute test, the test result, and the class label, respectively. A decision tree is a form of tree structure that mimics flowcharts.

V. RESULTS

This project aims in autoregulation of fan and light according to the preferences of the particular user, kind of contrary to popular belief. It essentially starts with collection of data from a hardware model built using a microcontroller called NodeMCU - ESP8266, which is a Wi-Fi module, an LCD, an LED instead of light, a motor instead of fan, ADS115 which is an analog to digital convertor module and power supply, basically contrary to popular belief. Along with these a face recognition model essentially is built for identification of the user to work accordingly in a big way. The model built and trained gives an accuracy of approximately 93 percent.

Table 1. Accuracy Comparison

Algorithm	Accuracy	
	Fan	Light
K-Nearest Neighbor	93.45	92.07
Support Vector Machine	89.66	92.07
Random Forest	91.38	90.69
Naïve Bayes	87.59	92.07
Decision Tree	91.38	89.66

Each classifier has benefits and drawbacks of its own. The following is a comparison of each classifier's accuracy as measured by testing it on the data that was gathered. Given the comparisons made above, it can be seen that for this particular dataset, which contains approximatively more than 900 data, k-nn is more accurate than the others. For training huge datasets with a lot of classes, the K-Nearest Neighbors classification technique is best. It is simple to use, understand, and responds instantly to new training data. The K-NN model is then given a face recognition component, and finally, it is employed to automatically regulate the fan and light to the user's preferences.

VI. CONCLUSION

The automated fan and light system, which was created utilizing machine learning and data (fan speed, light intensity) acquired from user preferences, provides a great deal of comfort to elderly people. They do not need to carry their phones or remote controls to use the appliance, unlike remote-controlled or app-controlled models. In this project, the appliance uses a camera to identify the user and then adjusts its behavior to that person.

VII. FUTURE SCOPE

Since the idea is based on user desire, it may be improved in a number of ways, such as by gathering heart rate and sweat rate data using particular sensors that are already accessible and developing a smart band to do so. This would allow electrical devices to function in accordance with the people and be utilised in the health sectors. Private rooms, cabins, study halls, and other spaces can all use this customised form of electrical equipment.

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