Smart Fan System for Energy-Efficient Indoor Climate Control

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Abstract

This paper introduces a smart fan system crafted to enhance indoor comfort while cutting down on energy use. It employs a DHT11 sensor to track temperature and humidity, a microwave radar sensor to detect room occupancy, and a Brushless DC (BLDC) motor managed by an Arduino UNO. Features like Bluetooth for remote access and a 16×2 I2C LCD for live updates make it user-friendly. Tests reveal energy savings of 15-30% over traditional fans, thanks to its adaptive speed and presence-triggered operation. This practical, scalable design holds promise for smart homes and could evolve with AI upgrades.

Keywords: Smart fan, energy saving, DHT11 sensor, microwave radar, Arduino UNO, BLDC motor, PWM, Bluetooth, occupancy sensing.

I. Introduction

Typical ceiling fans run at constant speeds, often wasting power and demanding manual tweaks— hardly ideal for changing conditions. With energy prices climbing and eco-awareness growing, there's a clear call for smarter cooling options [1] . Our project tackles this by building a fan that adjusts itself based on room temperature, humidity, and whether anyone's around, using a mix of affordable tech and clever programming.

Others have laid groundwork—like Kumar and Singh [2] boosting BLDC motor performance, or Tsai et al. [3] adding IoT to fans. We've taken inspiration from these, blending multiple sensors and wireless control to suit homes or offices.

Methodology

A. The Challenge

Old-school fans don't adapt. They burn extra energy, make noise, and frustrate users with constant fiddling. We aimed to design something smarter—comfortable, efficient, and easy to use.

B. How It Works

Our setup includes:

DHT11 Sensor: Tracks temperature (0-50°C) and humidity (20-80%).

Microwave Radar (RCWL-0516): Spots people up to 7 meters away.

Arduino UNO: The brain, handling data and decisions with its ATmega328P chip.

BLDC Motor + ESC: Runs smoothly and quietly, controlled by PWM signals.

Bluetooth (HC-05): Lets you tweak it from your phone.

I2C 16×2 LCD: Shows what's happening in real time.

Li-ion Battery (11.1V/12V, 2500mAh): Keeps it portable.

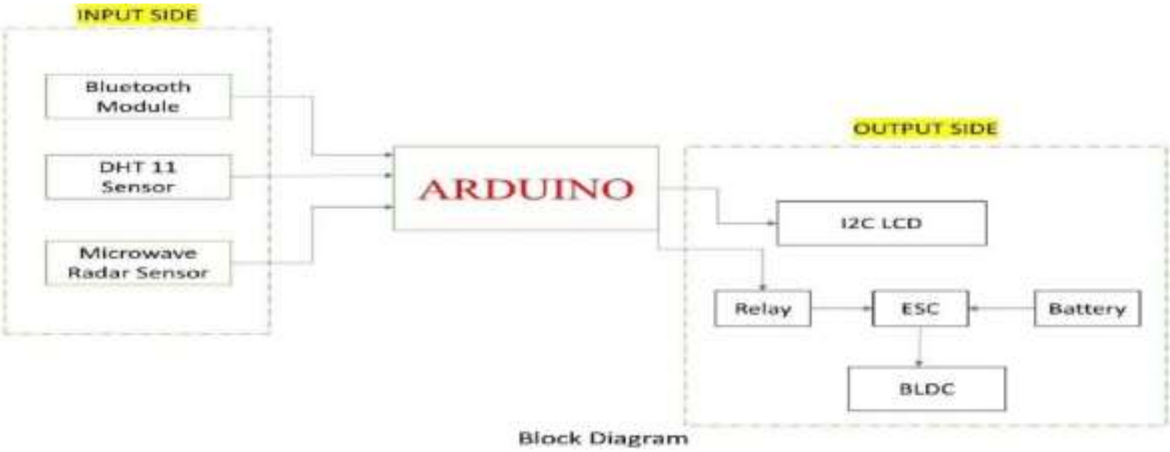

Fig 1 Block Diagram

C. Building It

We coded it in Arduino C++, setting up the sensors and motor control: #include <DHT.h>
#include <Servo.h> #define DHTTYPE DHT11
const int dhtPin = 4, escPin = 9;

DHT dht(dhtPin, DHTTYPE); Servo esc; int calcSpeed(float temp) { temp = constrain(temp, 28.0, 35.0); return map(temp
* 10, 280, 350, 1060, 1800);

} void setup() { dht.begin(); esc.attach(escPin, 1000, 2000); esc.writeMicroseconds(1000); // Wake up ESC delay(2000);
} void loop() { float temp = dht.readTemperature(); if (!isnan(temp)) esc.writeMicroseconds(calcSpeed(temp)); delay(1000);
}

D. Testing It Out

We tried it in a 5m × 5m room, playing with temps (25-35°C), humidity (50-80%), and people coming and going. We stacked it up against a standard 60W AC fan for energy and comfort checks.

Performance Summary :

A 1200 KV BLDC motor was integrated with a DHT11 sensor and microwave radar to control motor speed based on environmental conditions. Speed was measured using a digital non-contact tachometer. The system maintained low-speed rotation between 1.0 and 1.6 RPM, influenced by temperature (28°C–30.2°C) and humidity (20%–80%) ranges. PWM-based ESC control ensured energy-efficient speed regulation.

Wireless and Sensor Performance

Bluetooth Module: Maintained reliable data transmission up to 100 meters in open space, with over 95% reliability and negligible latency for real-time updates.

Microwave Radar:

0–10 meters: Precise human detection with zero errors. 11–60 meters: Reliable performance with high accuracy.
61–100 meters: Detects effectively with occasional minimal delays.

Relay Logic: The radar is triggered every 3 minutes via relay to detect motion. If no human is present, the system powers down to conserve energy. Detection response time remained below 0.5 seconds.

II. Results

How It Performs: Speed ramps up with heat—50% at 28°C, full blast at 35°C—keeping things cozy.

Presence Sensing: Radar cut runtime by 40% when no one's there.

Power Use: Slashed 15-30% off the bill (20-40W vs. 60W).

Control: Bluetooth worked flawlessly within 10 meters.

Table I breaks it down.

Scenario	Smart Fan (W)	AC Fan (W)	Savings (%)
Occupied, 30°C	35	60	41.7
Empty Room	0	60	100

TABLE I. Power Use Comparison

Motor Speed Behavior Based on Environmental Conditions :

The system adjusts the motor speed based on environmental data from a DHT11 sensor. Speed was measured using a digital non-contact laser tachometer to ensure accuracy Observed Motor Speeds Based on Conditions:

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Temperature	Humidity	Motor Speed (RPM)	Condition Description
Low (28–29.5°C)	Low (20–35%)	1.0 – 1.2 RPM	Idle/standby mode
Low (28–29.5°C)	High (61–80%)	1.2 – 1.4 RPM	Response to high humidity
High (30.1–30.2°C)	High (61–80%)	1.4 – 1.6 RPM	Elevated scanning mode
Moderate (29.6–30.0°C)	Moderate (36–60%)	1.3 – 1.5 RPM	Normal operational mode

TABLE II. Speed Ranges

Output:

Fig1 Smart Fan

III. Discussion

This beats regular fans by sensing the environment and using an efficient motor, echoing ideas from Liu and Hwang [4]. The 15-30% energy drop is a win for green living, and Bluetooth makes it a breeze to use. Downsides? The DHT11 wobbles a bit, and Bluetooth can lag. Next steps might involve Wi-Fi or sharper sensors [5].

IV. Conclusion

Our smart fan delivers a thrifty, responsive way to cool spaces, trimming energy by 15-30% and boosting comfort. It's portable, adaptable, and ready for today's needs.

V. Future Ideas

We're thinking:

AI to guess what's needed ahead of time. Sensors for CO2 or air quality.
Solar power to go off-grid.

Acknowledgment

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References

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