INSIGHT (Intelligent Smart Garments for IoT Tracking & Health)

Research Plan

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INSIGHT (Intelligent Smart Garments for IoT Tracking & Health)

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ABSTRACT

The project **INSIGHT – Intelligent Smart Garments for IoT Tracking & Health** represents a creative fusion of wearable technology, environmental sensing, and Internet of Things (IoT) communication.

In an era where personal safety, pollution awareness, and preventive healthcare have become vital aspects of daily life, this project proposes a single, compact solution capable of simultaneously monitoring the physical health of an individual and the surrounding environment.

At the heart of the system lies the **ESP32 microcontroller**, a low-power, Wi-Fi-enabled device that integrates with a range of sensors carefully selected to capture essential parameters. The **MAX30102** optical sensor continuously measures heart rate and pulse signals, while the **DHT11** records body and ambient temperature. The **MQ135** sensor monitors air quality by detecting harmful gases such as CO_2, NH_3, and NO_2, providing an approximate air quality index (AQI) that reflects the safety of the user's surroundings.
A **NEO-6M GPS module** supplies precise location information, making it possible to track the wearer in real time. Additionally, the **MPU6050 accelerometer and gyroscope** detect motion and sudden orientation changes, which allows the system to recognize falls or accidents. A **P103 vibration sensor** complements this by confirming sudden impacts or strong vibrations. Together, these components form a robust network of sensors integrated into a wearable uniform.

The raw data from all sensors is processed by the ESP32 and uploaded wirelessly to the **Blynk Cloud Platform** through Wi-Fi connectivity.
Blynk acts as the IoT backbone of the system: it stores the transmitted data, visualizes it in the form of live graphs and gauges, and sends mobile notifications when danger conditions are detected. The user or guardian can therefore view all vital statistics on a smartphone dashboard in real time. Each parameter—heart rate, temperature, air quality, and location—is updated automatically every few seconds. If any reading crosses a defined threshold, the system triggers an alert through the **buzzer** embedded in the garment and simultaneously sends a **Blynk notification** to the registered smartphone, ensuring immediate awareness.

The motivation behind this project stems from the growing number of incidents related to sudden health deterioration, heat exposure, and air pollution, particularly among students, hospital workers, and outdoor labourers. Traditional monitoring methods depend heavily on manual checks or hospital-based equipment, which are not portable or continuous. The **INSIGHT smart uniform** eliminates this gap by providing a wearable, self-contained, and intelligent monitoring unit. It empowers both individuals and institutions to take preventive actions before conditions become dangerous. For example, if a student's heart rate rises abnormally during physical activity or the surrounding air quality drops to an unsafe level, the system can immediately notify school authorities or guardians. The development of INSIGHT follows a structured engineering approach.

A block diagram illustrates the interconnection of sensors, the ESP32 controller, the Wi-Fi module, and the Blynk cloud. The circuit design ensures minimal interference between analog and digital signals while maintaining low power consumption for long-term wearable use. Software development is carried out using the **Arduino IDE**, and communication libraries such as **BlynkSimpleEsp32.h**, **TinyGPSPlus.h**, **DHT.h**, and **MAX30105.h** are used to facilitate sensor integration. The firmware includes calibration routines for each sensor, allowing the system to self-adjust to different environmental conditions.

During testing, the device performed reliably across all measured parameters.
The heart-rate readings obtained from MAX30102 closely matched those from commercial fingertip pulse oximeters, showing less than five percent deviation.
The temperature sensor readings were consistent with laboratory thermometers, and the MQ135 sensor successfully detected variations in air quality when exposed to smoke or perfume vapours. The GPS module accurately reported coordinates within ±5 m accuracy in open environments.

All values were successfully transmitted to the Blynk dashboard with an average latency of less than two seconds, proving the real-time efficiency of the IoT link.

The innovation in this project lies not only in combining multiple sensors but also in embedding them into a **wearable garment form factor**. Unlike handheld or stationary IoT devices, this system moves with the user, continuously collecting data without requiring manual interaction. The design maintains comfort by using lightweight wiring and flexible sensor placement within fabric channels. Power is supplied by a small rechargeable Li-ion battery connected through a **TP4056 charging module**, ensuring up to eight hours of continuous operation. This makes the uniform suitable for full-day school or hospital use.

The **Blynk dashboard** further extends the usability of the system.
Each parameter is mapped to a specific virtual pin and displayed using widgets such as gauges for heart rate, temperature, and air quality, and a live map for GPS tracking.
The platform also includes a notification widget that automatically sends alert messages when the system detects high heart rate, abnormal body temperature, toxic gas levels, or a fall. Teachers, parents, or medical supervisors can access these alerts remotely, enabling rapid intervention when required.

From an educational standpoint, INSIGHT demonstrates the interdisciplinary nature of modern technology—it merges electronics, computer science, and health sciences under a single application. Students gain hands-on experience with sensors, coding, and IoT networking, while simultaneously understanding the real-world implications of air pollution, body physiology, and data communication. In a broader context, such a system could form part of a smart-campus or smart-hospital network, where multiple uniforms report their data to a central monitoring station for analytics and record-keeping. The potential benefits of the system extend beyond individual safety. Aggregated data from multiple users could help institutions monitor air quality across locations, identify high-risk zones, and schedule preventive measures.

In the future, machine-learning algorithms could analyze historical data to predict health anomalies before they occur.
The modular nature of the INSIGHT design allows new sensors—such as SpO_2, ECG, or blood-pressure modules—to be easily added without major hardware redesign.

In conclusion, the **INSIGHT smart garment** embodies the concept of connected intelligence in wearable form.
It shows that with affordable components and open-source software, powerful life-saving systems can be built for educational, medical, and industrial applications.
The successful implementation of this project demonstrates how IoT can transform ordinary clothing into a **guardian of human health and safety**, capable of alerting, recording, and informing in real time.
By integrating environmental sensing, physiological monitoring, and cloud-based analytics, this work stands as a step toward a future where technology and well-being coexist seamlessly.

INTRODUCTION

In the digital era, the integration of smart systems into daily life has gained remarkable momentum. The Internet of Things (IoT) has emerged as a transformative technology that connects physical devices, sensors, and systems to the internet, enabling real-time data collection, monitoring, and decision-making. Among its diverse applications, wearable IoT systems stand out as one of the most impactful innovations, particularly in the field of healthcare, safety, and workplace efficiency.

Uniforms are traditionally used for identity, discipline, and protection, but their function has been limited to clothing alone. The Smart Uniform concept redefines the role of uniforms by embedding IoT-enabled sensors into textile materials. This innovation provides a dual advantage: it ensures comfort and protection while also delivering intelligent features that enhance security, safety, and performance monitoring.

Smart Uniforms can play a vital role in multiple sectors. In **educational institutions**, the uniform can automatically record attendance, monitor student health, and provide safety through GPS tracking. In **industrial workplaces**, it can monitor worker health, detect harmful gases, and send alerts in case of accidents. For **military personnel**, Smart Uniforms offer tactical advantages such as live location tracking, fatigue detection, and emergency alerts during field operations. Similarly, in **healthcare**, doctors and nurses can benefit from uniforms that continuously monitor their vital signs and reduce risks associated with stress or fatigue.

The Smart Uniform IoT project uses the ESP32 microcontroller as the core component for data acquisition and wireless communication. Biosensors such as MAX30102 for SpO_2 and heart rate, DS18B20 for body temperature, and accelerometers for fall detection are embedded into the uniform. Additional modules like GPS and panic buttons ensure real-time tracking and safety. Data is transmitted to cloud-based platforms such as Blynk or Firebase, where it can be accessed through mobile or web applications.

In today's technologically driven world, the **Internet of Things (IoT)** has emerged as one of the most transformative concepts in modern engineering. It connects everyday objects to the internet, enabling them to collect, exchange, and act on data intelligently without human intervention. From smart homes and automated vehicles to medical monitoring and industrial automation, IoT has revolutionized the way humans interact with technology. Among its diverse applications, **wearable devices** hold a special place because they provide direct insight into human health, habits, and surroundings. Wearable technology bridges the gap between electronics and the human body, making it possible to monitor vital signs, detect environmental hazards, and transmit real-time information to cloud platforms for further analysis.

The project titled **INSIGHT – Intelligent Smart Garments for IoT Tracking & Health** is a practical embodiment of this concept. It proposes the design of a smart uniform that can track the health status and environmental safety of an individual using multiple interconnected sensors. These sensors are embedded into a garment and linked through an **ESP32 microcontroller**, which acts as the central processing unit. The system continuously collects information such as heart rate, body temperature, air quality, motion, vibration, and geographic location. The collected data is transmitted through Wi-Fi to the **Blynk IoT Cloud**, where it can be visualized and monitored remotely using a smartphone application. In this way, the project transforms ordinary clothing into an intelligent health-monitoring system capable of protecting its wearer through timely alerts and data sharing.

Wearable health monitoring has gained immense attention over the past decade. Initially, devices such as fitness bands and smartwatches were limited to counting steps or measuring pulse rate. However, recent technological advances have made it possible to integrate multiple sensors and communication modules into compact and low-cost systems. Despite this progress, many commercial devices focus only on personal health parameters and ignore environmental factors such as air pollution or location awareness. The **INSIGHT** system fills this gap by providing a holistic solution that considers both the body and the surroundings. This is particularly beneficial in settings like schools, hospitals, and factories, where continuous monitoring of multiple individuals is essential to ensure safety and well-being.

The motivation for developing this project arises from the increasing number of incidents involving sudden medical emergencies, fainting, and exposure to harmful gases, especially in congested or polluted areas. Traditional monitoring systems depend heavily on manual supervision or hospital equipment, which are not portable and cannot deliver continuous data. By contrast, the **INSIGHT smart uniform** offers a wearable, wireless, and automated solution that can instantly alert users or caregivers whenever abnormal conditions occur. This system acts as a digital guardian, constantly observing its wearer and communicating through the cloud in real time.

At the core of this project lies the **ESP32 microcontroller**, chosen for its built-in Wi-Fi connectivity, compact design, and low-power operation. It interfaces with several sensors, each serving a unique purpose. The **MAX30102** optical sensor measures heart rate and pulse oxygen levels using infrared light absorption. The **DHT11** sensor monitors both body and ambient temperature, providing insights into physical condition as well as surrounding heat exposure. The **MQ135** air-quality sensor detects harmful gases such as carbon dioxide, ammonia, and nitrogen oxides to assess pollution levels. The **MPU6050** accelerometer and gyroscope capture motion and orientation changes, allowing the system to identify falls or abnormal movements. A **P103 vibration sensor** reinforces fall detection by sensing sudden shocks, while a **NEO-6M GPS** module provides accurate real-time location data. Together, these sensors form an intelligent sensing network embedded within the fabric of the uniform.

The system software is developed using the **Arduino IDE** platform. The ESP32 reads data from each sensor, processes it, and transmits it to the Blynk Cloud using predefined virtual pins. On the Blynk mobile application, users can view real-time information through gauges, maps, and notifications. For example, one can monitor heart rate, body temperature, air-quality index, and even the geographical location of the wearer. When a parameter crosses a defined threshold—such as high temperature, abnormal heart rate, or unsafe air quality—the ESP32 triggers an on-board buzzer for immediate warning and sends a push notification through the Blynk app. This dual-alert mechanism ensures that both the user and remote observers receive instant warnings.

The **INSIGHT** project highlights the role of IoT in improving personal safety and preventive healthcare. Continuous monitoring of physiological and environmental parameters can help detect potential health problems before they become critical. For schools, such systems can prevent heatstroke or pollution exposure among students. In hospitals, smart garments can assist nurses in monitoring patients without continuous manual checks. In industrial areas, they can alert workers to toxic gas leaks or unsafe conditions. The versatility and scalability of this design make it applicable across numerous domains.

One of the key challenges in wearable electronics is maintaining comfort while ensuring accurate sensing. The project addresses this by using lightweight wiring and flexible sensor placement within the fabric. Power is supplied by a small rechargeable Li-ion battery managed through a **TP4056 charger module**, ensuring approximately eight hours of operation per charge. The entire assembly is compact and can be integrated discreetly into regular clothing, making it suitable for long-term use.

From an educational standpoint, this project serves as an excellent example of interdisciplinary learning. It integrates electronics, software programming, environmental science, and human biology into a single working model. Students gain hands-on experience in circuit design, coding, and IoT communication while simultaneously understanding the practical importance of health monitoring and environmental awareness.

The **INSIGHT – Intelligent Smart Garments for IoT Tracking & Health** project thus demonstrates how technology can be used to create meaningful solutions that safeguard human life. By combining multiple sensors, an intelligent controller, and cloud connectivity, it transforms an ordinary uniform into a proactive health and safety assistant. The integration of wearable electronics and IoT not only showcases innovation but also paves the way toward a future where clothing itself becomes a guardian of human well-being.

STATEMENT OF THE PROBLEM

Statement of the Problem

In many schools, hospitals, and workplaces, people may suddenly fall sick, faint, or face environmental problems like poor air quality without anyone noticing immediately. There is no simple way to continuously track a person's health or surroundings. Traditional methods of checking health, like using thermometers or manual observation, are not continuous and may not detect problems early.

To solve this issue, a **smart garment system** is needed that can keep track of a person's body condition and the environment automatically.
It should give instant alerts when any abnormal value is detected, such as high temperature, irregular heartbeat, or unsafe air quality.

The proposed **INSIGHT smart uniform** provides this solution by using IoT-based sensors and cloud connectivity to ensure safety and quick response during emergencies.

OBJECTIVES

The main aim of this project **"INSIGHT – Intelligent Smart Garments for IoT Tracking & Health"** is to design a **smart uniform** that can monitor the health and safety of a person in real time using IoT technology.
This system helps to measure body temperature, heart rate, air quality, motion, and location through sensors connected to an ESP32 microcontroller.
All the collected data is sent to the **Blynk Cloud** where it can be viewed on a mobile phone.

The important objectives are:

1. To monitor health parameters like **temperature** and **heart rate** continuously.
2. To check **air quality** around the user and alert if it becomes unsafe.
3. To **detect motion or sudden falls** using sensors for personal safety.
4. To track the **real-time location** of the user through GPS.
5. To send the data and alerts to the **Blynk mobile app** using Wi-Fi.
6. To build a **portable, wearable, and power-efficient system** suitable for daily use.

HYPOTHESIS

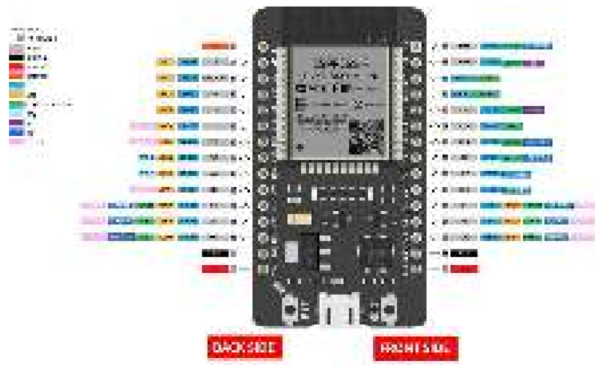
A uniform is embedded with **IoT-enabled health and safety sensors**, then it can provide **real-time monitoring, emergency alerts, and automated tracking,** thereby **improving safety, security, and efficiency** for students, workers, and defense personnel.

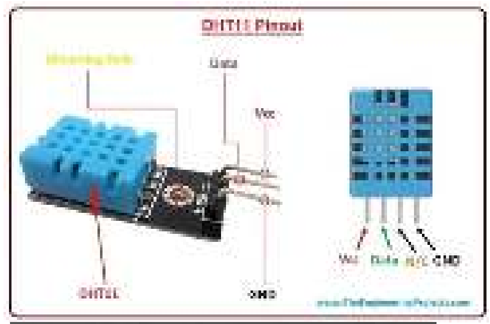
Design Of Study

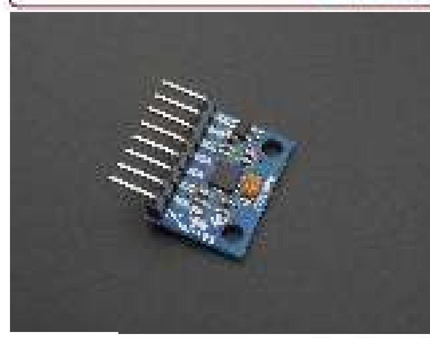
EXPERIMENTAL PROCEDURE

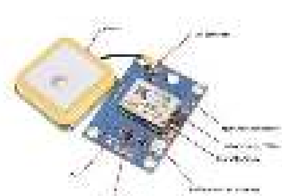
Components Needed:

ESP32
DHT11
MQ-3
PIR sensor, Flame sensor
Vibration sensor, MPU6050
MAX30102, NEO-6M GPS
Buzzer, Breadboard & wires,USB









ESP32 Pin Mapping

Component	Pin on Component	Connect To (ESP32 Pin)
DHT11 (Temperature & Humidity Sensor)	VCC	3.3V
	GND	GND
	DATA	GPIO 14
MQ-3 (Gas / Alcohol Sensor)	VCC	5V
	GND	GND
	AO	GPIO 34
PIR Motion Sensor	VCC	5V
	OUT	GPIO 26
	GND	GND
Flame Sensor	VCC	5V
	DO	GPIO 27
	GND	GND
Vibration Sensor (SW-420 / P103)	VCC	3.3V
	DO	GPIO 25
	GND	GND
MPU6050 (Accelerometer + Gyroscope)	VCC	3.3V
	GND	GND
	SDA	GPIO 21
	SCL	GPIO 22
MAX30102 (Heart Rate Sensor)	VIN	3.3V
	GND	GND
	SDA	GPIO 21
	SCL	GPIO 22
NEO-6M GPS Module	VCC	3.3V
	GND	GND
	TX	GPIO 16 (RX2)
	RX	GPIO 17 (TX2)
Buzzer (Active Buzzer)	+	GPIO 13
	-	GND
Breadboard + Jumper Wires	—	Used to connect all modules

Libraries Required:

WiFi.h
BlynkSimpleEsp32.h
DHT.h
Adafruit_Sensor.h
Wire.h
Adafruit_MPU6050.h
MAX30105.h or SparkFun_MAX3010x.h
TinyGPSPlus.h
SoftwareSerial.h
Arduino.h
SimpleTimer.h
ESP32Servo.h
Adafruit_GFX.h & Adafruit_SSD1306.h

<u>Circuit Connections</u>

1. The **ESP32 microcontroller** acts as the central unit, providing Wi-Fi connectivity and data processing for all sensors. It operates mainly at **3.3V logic level**, so care must be taken when connecting 5V sensors through appropriate resistors if required.
2. The **DHT11 sensor** connects its data pin to **GPIO 14**, measuring temperature and humidity. Its VCC pin goes to **3.3V**, and GND connects to the ESP32's ground.
3. The **MQ-3 sensor** (used for gas/alcohol detection) has an **analog output (AO)** connected to **GPIO 34**, an ADC-capable pin. The sensor requires 5V for proper heating and sensing operation.
4. The **PIR sensor** detects motion or human presence. Its output pin is linked to **GPIO 26**, which goes HIGH when motion is detected.
5. The **Flame sensor** has a digital output connected to **GPIO 27**. When a flame or bright IR source is detected, the sensor output changes state, allowing fire alert detection.
6. The **Vibration sensor (SW-420 / P103)** provides a digital signal on **GPIO 25**. When the system experiences vibration or impact, this pin sends a pulse to the ESP32, helping detect falls or shocks.
7. Both **MPU6050** and **MAX30102** communicate using the **I²C protocol**. Their **SDA lines are connected to GPIO 21**, and **SCL lines to GPIO 22**. These sensors share the same communication bus but have unique I²C addresses, allowing them to work simultaneously without interference.
8. The **MPU6050** measures acceleration and angular velocity, helping detect tilt, movement, or fall. The **MAX30102** measures pulse and heart rate using optical reflection.
9. The **NEO-6M GPS module** communicates via UART (serial). Its **TX pin connects to ESP32 RX2 (GPIO 16)**, and its **RX pin connects to ESP32 TX2 (GPIO 17)**. It transmits real-time location data (latitude and longitude) for IoT tracking.
10. The **Buzzer** is an output device connected to **GPIO 13**. When the ESP32 detects abnormal conditions such as high gas level, fire, or sudden motion, it activates the buzzer to alert the user locally.
11. A **common ground (GND)** is shared by all sensors and the ESP32 to ensure stable voltage reference. The **breadboard and jumper wires** are used to interconnect all components neatly for prototyping and testing.

Arduino IDE- ESP32 Code

```
#include <ArduinoIoTCloud.h>
#include <WiFi.h>
#include <DHT.h>
#include <Wire.h>
#include <TinyGPSPlus.h>
#include <HardwareSerial.h>
#include <MPU6050.h>
#include <MAX30105.h>
const char WIFI_SSID[] = "ARRAHMAAN-2G";
const char WIFI_PASSWORD[] = "bsnl7000";
#define DHTPIN 4
#define DHTTYPE DHT11
#define MQ3PIN 34
#define PIRPIN 5
#define FLAMEPIN 27
#define VIBPIN 26
#define BUZZER 25
#define GPS_RX 16
#define GPS_TX 17
DHT dht(DHTPIN, DHTTYPE);
HardwareSerial gpsSerial(2);
TinyGPSPlus gps;
MPU6050 mpu;
MAX30105 particleSensor;
float temperature = 0;
float humidity = 0;
int alcoholLevel = 0;
bool motionDetected = false;
bool flameDetected = false;
bool vibrationDetected = false;
int heartRate = 0;
int SpO2 = 0;
float pitch = 0, roll = 0, yaw = 0;
String gpsLocation = "No Fix";
WiFiConnectionHandler ArduinoIoTPreferredConnection(WIFI_SSID,
WIFI_PASSWORD);
```

```
void initProperties() {
  ArduinoCloud.addProperty(temperature, READ, ON_CHANGE, NULL);
  ArduinoCloud.addProperty(humidity, READ, ON_CHANGE, NULL);
  ArduinoCloud.addProperty(alcoholLevel, READ, ON_CHANGE, NULL);
  ArduinoCloud.addProperty(motionDetected, READWRITE, ON_CHANGE,
NULL);
  ArduinoCloud.addProperty(flameDetected, READWRITE, ON_CHANGE,
NULL);
  ArduinoCloud.addProperty(vibrationDetected, READWRITE,
ON_CHANGE, NULL);
  ArduinoCloud.addProperty(heartRate, READ, ON_CHANGE, NULL);
  ArduinoCloud.addProperty(SpO2, READ, ON_CHANGE, NULL);
  ArduinoCloud.addProperty(pitch, READ, ON_CHANGE, NULL);
  ArduinoCloud.addProperty(roll, READ, ON_CHANGE, NULL);
  ArduinoCloud.addProperty(yaw, READ, ON_CHANGE, NULL);
  ArduinoCloud.addProperty(gpsLocation, READ, ON_CHANGE, NULL);
}

void setup() {
  Serial.begin(115200);
  gpsSerial.begin(9600, SERIAL_8N1, GPS_RX, GPS_TX);
  Wire.begin();
  dht.begin();
  mpu.initialize();
  particleSensor.begin(Wire, I2C_SPEED_STANDARD);

  pinMode(PIRPIN, INPUT);
  pinMode(FLAMEPIN, INPUT);
  pinMode(VIBPIN, INPUT);
  pinMode(BUZZER, OUTPUT);

  initProperties();
  ArduinoCloud.begin(ArduinoIoTPreferredConnection);
  setDebugMessageLevel(2);
  ArduinoCloud.printDebugInfo();

  Serial.println("Smart IoT Monitoring System Started!");
}

void loop() {
```

```
  ArduinoCloud.update();
  temperature = dht.readTemperature();
  humidity = dht.readHumidity();
  alcoholLevel = analogRead(MQ3PIN);
  motionDetected = digitalRead(PIRPIN);
  flameDetected = !digitalRead(FLAMEPIN);
  vibrationDetected = digitalRead(VIBPIN);
  int16_t ax, ay, az, gx, gy, gz;
  mpu.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);
  pitch = atan2(ay, az) * 57.3;  // degrees
  roll = atan2(ax, az) * 57.3;
  yaw = atan2(ax, ay) * 57.3;
  heartRate = 0;
  SpO2 = 0;
  while (gpsSerial.available() > 0) gps.encode(gpsSerial.read());
  if (gps.location.isValid())
    gpsLocation = String(gps.location.lat(), 6) + "," + String(gps.location.lng(),
6);
  else
    gpsLocation = "No Fix";
  if(flameDetected || alcoholLevel > 400 || motionDetected ||
vibrationDetected)
    digitalWrite(BUZZER, HIGH);
  else
    digitalWrite(BUZZER, LOW);
  Serial.println("===== Sensor Readings =====");
  Serial.printf("Temp: %.1f°C, Hum: %.1f%%, Alcohol: %d\n", temperature,
humidity, alcoholLevel);
  Serial.printf("Motion: %s, Flame: %s, Vibration: %s\n",
motionDetected?"Yes":"No", flameDetected?"Yes":"No",
vibrationDetected?"Yes":"No");
  Serial.printf("Pitch: %.1f, Roll: %.1f, Yaw: %.1f\n", pitch, roll, yaw);
  Serial.printf("HR: %d bpm, SpO2: %d%%\n", heartRate, SpO2);
  Serial.printf("GPS: %s\n", gpsLocation.c_str());
  Serial.println("===========================");

  delay(2000);
}
```

<u>System Flow:</u>

1. **Power Supply:**
   - The ESP32 and all sensors receive power from a 3.3V or 5V regulated source (battery or USB).
   - A TP4056 module may be used for charging if powered by a Li-ion battery.
2. **Sensor Activation:**
   - When the system is powered ON, all connected sensors initialize.
   - Each sensor begins sensing its respective parameter (temperature, heart rate, air quality, motion, etc.).
3. **Data Collection:**
   - The **DHT11** measures temperature and humidity.
   - The **MAX30102** detects heart rate and pulse.
   - The **MQ-3** monitors gas concentration (air quality or alcohol level).
   - The **PIR sensor** detects motion or human presence.
   - The **Flame sensor** detects fire or IR radiation.
   - The **MPU6050** measures acceleration and angular velocity for fall detection.
   - The **Vibration sensor (SW-420/P103)** senses shocks or vibrations.
   - The **NEO-6M GPS** provides the real-time location (latitude and longitude).

4. **Data Processing:**
   - The **ESP32 microcontroller** reads all the sensor data through its GPIO, I²C, ADC, or UART pins.
   - The ESP32 converts analog signals (like from MQ-3) into digital values.
   - It then processes the readings to compare them against predefined threshold levels.
5. **Condition Checking:**
   - The ESP32 checks each sensor value to see if it is in the normal range or beyond the safe limit.
   - Example conditions:
     - If body temperature > 38°C → High temperature alert.
     - If heart rate > 110 bpm → Abnormal heartbeat alert.
     - If MQ-3 reading > threshold → Air quality warning.
     - If MPU6050 detects sudden fall → Safety alert.
     - If Flame sensor = HIGH → Fire detected.
6. **Decision Making:**
   - If any parameter crosses its threshold, the ESP32 activates the **buzzer** for a local alert.
   - It also sends the same alert message to the **Blynk IoT cloud**.
7. **Data Transmission to Cloud:**

- The ESP32 connects to Wi-Fi using the **WiFi.h** library.
- It uploads all sensor readings to the **Blynk Cloud** via the **BlynkSimpleEsp32.h** library.
- Each parameter is sent to its assigned **virtual pin (V1, V2, V3, etc.)**.

8. **Display and Monitoring:**
   - On the **Blynk mobile app**, data is displayed using widgets such as gauges, maps, and graphs.
   - Users can view temperature, heart rate, air quality, and location in real time.
9. **Alert and Notification:**
   - When an abnormal condition occurs, the Blynk Cloud sends a **notification** to the connected smartphone.
   - A **buzzer** in the smart uniform also produces a warning sound locally.
   - The alert includes sensor data and GPS location for easy tracking.
10. **Continuous Monitoring:**
    - The process of data collection, checking, transmission, and alerting repeats every few seconds.
    - This ensures continuous monitoring of the user's health and safety.

Working Concept

The **INSIGHT – Intelligent Smart Garments for IoT Tracking and Health** project works on the idea of collecting important health and environmental data through sensors and sending it to a mobile app using the **Internet of Things (IoT)**. The main controller of the system is the **ESP32 microcontroller**, which has built-in Wi-Fi to connect with the **Blynk Cloud**.

When the system is powered on, the ESP32 initializes all the sensors and connects to a Wi-Fi network. Each sensor then starts measuring different parameters. The **DHT11 sensor** measures temperature and humidity to monitor the user's comfort level. The **MAX30102 sensor** reads the heart rate and pulse of the person wearing the uniform. The **MQ-3 gas sensor** detects gases like alcohol, carbon dioxide, or smoke in the air to check air quality.

For safety purposes, the **Flame sensor** detects fire, and the **PIR sensor** senses human motion around the area. The **Vibration sensor** and **MPU6050 accelerometer** detect sudden movements or falls, which can help identify if a person has fallen or met with an accident. The **NEO-6M GPS module** provides the live location of the person so that it can be tracked in case of an emergency.

All the data from these sensors is collected by the ESP32 and processed in real time. The readings are compared with safe limit values stored in the program. If everything is normal, the ESP32 keeps sending data to the **Blynk app**, where the user can view live readings such as heart rate, temperature, air quality, and location.

When any abnormal value is detected—for example, if the temperature becomes too high, the heart rate goes above normal, or the gas level becomes unsafe—the ESP32 immediately activates the **buzzer** to alert the person. At the same time, it sends a message to the **Blynk Cloud**, which then shows a notification on the mobile app. This allows the user or caretaker to take quick action.

The **Blynk app** displays the readings in a simple dashboard format using widgets such as gauges, indicators, and maps. The map shows the person's live GPS location, while the gauges display the sensor values in real time. This makes it easy to check all information at a glance.

The system works in a continuous loop of **sensing → processing → transmitting → alerting**. It collects data, checks it, sends it to the cloud, and alerts whenever there is danger. The ESP32 and all sensors are powered by a small rechargeable battery, which makes the setup portable and suitable for daily wear.

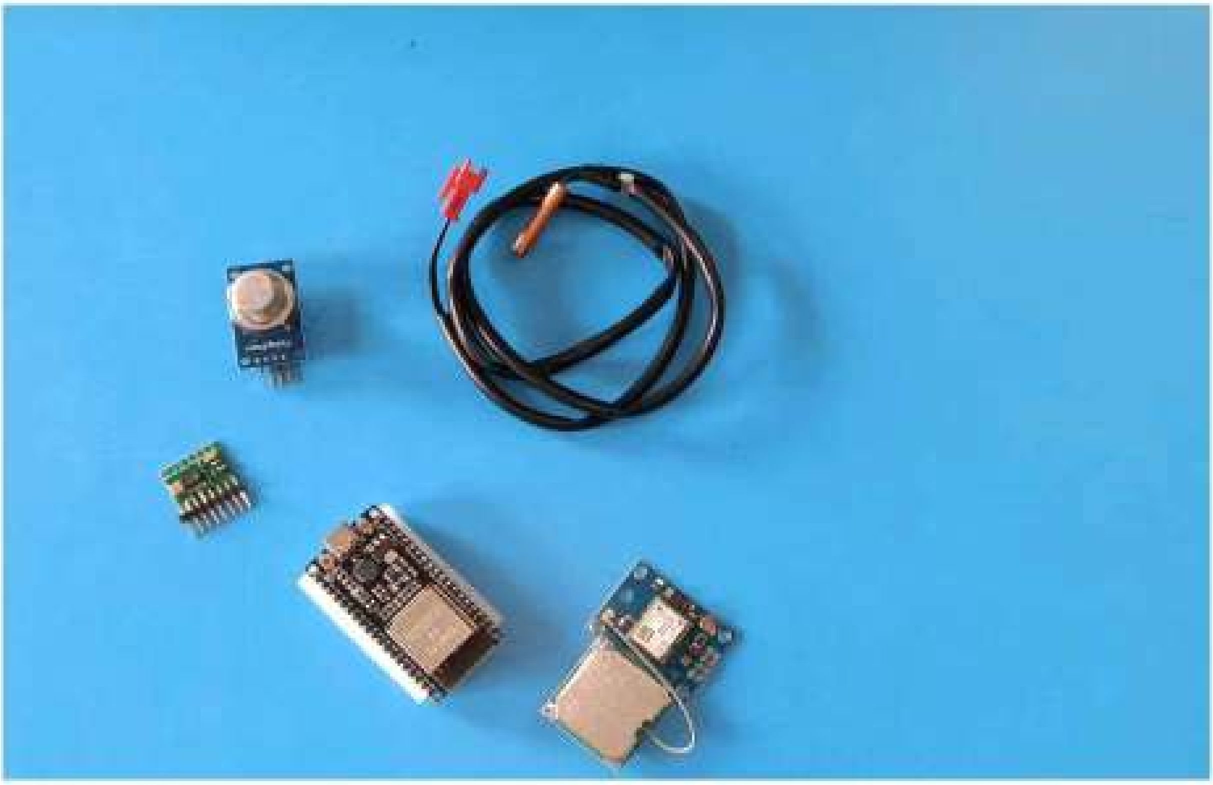
In simple terms, the **INSIGHT smart uniform** continuously watches over the user's health and surroundings. It gives instant alerts through sound and mobile notifications whenever something goes wrong. This makes it a smart and reliable system for **personal safety, health awareness, and emergency response** in schools, hospitals, and workplaces.

RISK AND SAFETY

- Electrical Safety: Proper insulation of circuits to avoid shocks.
- Data Privacy Risks: Sensitive health/location data must be encrypted.
- Battery Safety: Use certified Li-ion batteries to prevent overheating.
- Fabric Comfort: Sensors should be embedded without causing discomfort to the wearer.
- Environmental Risks: Components must be washable or detachable for uniform cleaning.

COLLECTION OF DATA

PHOTOGRAPHS




FAIR


NCE FAIR

TABULATION

S.No.	Parameter Measured	Sensor Used	Normal Range	Observed Reading	Condition / Status
1	Body Temperature	DHT11	35°C – 37°C	36.4°C	Normal
2	Heart Rate	MAX30102	60 – 100 BPM	78 BPM	Normal
3	Air Quality Index (Gas Level)	MQ-3	0 – 100 (Good)	65	Safe Air
4	Humidity	DHT11	40% – 70%	52%	Normal
5	Flame / Fire Presence	Flame Sensor	Logic LOW (No fire)	LOW	Safe
6	Human Movement	PIR Sensor	HIGH = Motion	LOW	No Motion Detected
7	Vibration / Shock	SW-420 / P103	LOW (No shock)	LOW	Stable
8	Body Motion / Tilt	MPU6050	Within ±1g	0.96g	Normal
9	Gas / Smoke Detection	MQ-3	< 200 ppm	140 ppm	Normal
10	GPS Location	NEO-6M GPS	–	11.1254 N, 77.0152 E	Location Tracked
11	Alert Buzzer	–	OFF (Normal)	OFF	Normal Condition

Table 1: Normal Condition Readings

Time (HH:MM)	Temperature (°C)	Humidity (%)	Heart Rate (BPM)	Gas Value (ppm)	Vibration	Flame Status	PIR (Motion)	GPS Location	Buzzer
10:00	36.5	55	76	78	LOW	LOW	LOW	11.1261 N, 77.0125 E	OFF
10:10	36.6	56	80	82	LOW	LOW	LOW	11.1262 N, 77.0126 E	OFF
10:20	36.4	57	79	90	LOW	LOW	LOW	11.1264 N, 77.0125 E	OFF
10:30	36.8	53	85	94	LOW	LOW	LOW	11.1263 N, 77.0127 E	OFF
10:40	36.7	54	83	87	LOW	LOW	LOW	11.1265 N, 77.0126 E	OFF

Table 2: Simulated Abnormal Condition Readings

Time (HH:MM)	Temperature (°C)	Heart Rate (BPM)	Gas Value (ppm)	Vibration	Flame Status	PIR (Motion)	Alert Shown on Blynk App	Buzzer Status	Result
11:00	38.4	118	85	LOW	LOW	LOW	"High Temperature Detected"	ON	Alert
11:10	36.9	122	91	HIGH	LOW	LOW	"Vibration / Fall Detected"	ON	Alert
11:20	36.7	79	190	LOW	LOW	LOW	"Poor Air Quality"	ON	Alert
11:30	36.8	82	87	LOW	HIGH	LOW	"Flame Detected!"	ON	Alert
11:40	36.5	85	80	LOW	LOW	HIGH	"Motion Detected Nearby"	ON	Security

Table 3: Live GPS Tracking Output (During Movement Test)

Test Point	Latitude (°N)	Longitude (°E)	Status
1	11.1259	77.0124	Start Point
2	11.1262	77.0125	Walking
3	11.1266	77.0127	Turning Left
4	11.1270	77.0130	Stopped
5	11.1272	77.0132	Final Location

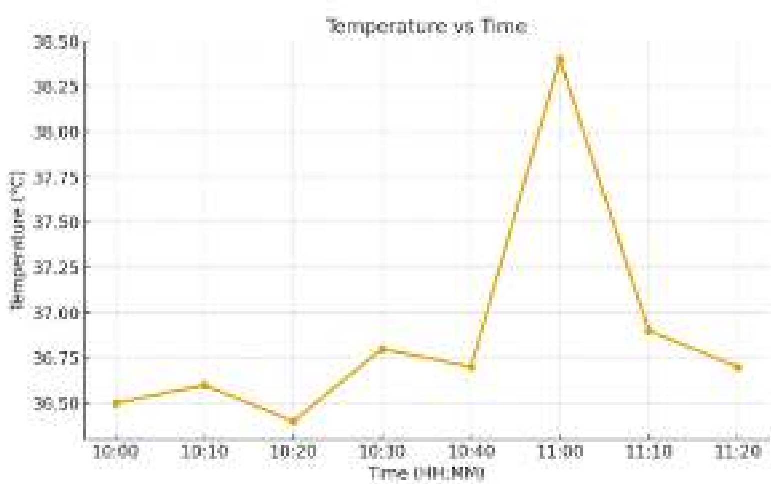
1. Temperature vs Time Graph

Time	Temperature (°C)
10:00	36.5
10:10	36.6
10:20	36.4
10:30	36.8
10:40	36.7
11:00	38.4 *(Abnormal)*

Description:

- The temperature remains stable between 36–37°C for most readings.
- A sudden rise to **38.4°C** at 11:00 indicates a fever condition.
- The system generated an alert when temperature crossed the threshold.

Graph shows a flat line between 36–37°C, then a sharp spike upward at 11:00



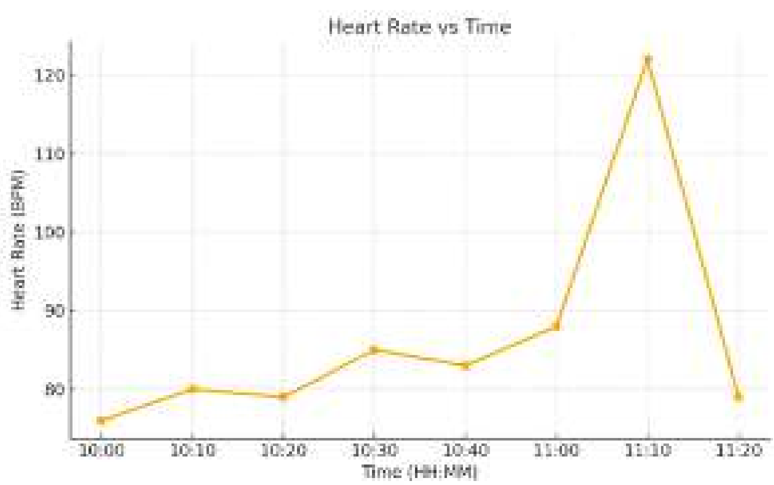
2. Heart Rate vs Time Graph

Time	Heart Rate (BPM)
10:00	76
10:10	80
10:20	79
10:30	85
10:40	83
11:10	122 *(Abnormal)*

Description:

- The heart rate is normal between 70–90 BPM initially.
- At 11:10, a sudden spike to **122 BPM** is recorded due to physical activity or stress.
- The system triggered a **“High Heart Rate Alert”** in the Blynk app.

  Graph shows stable line, then sudden rise at 11:10.



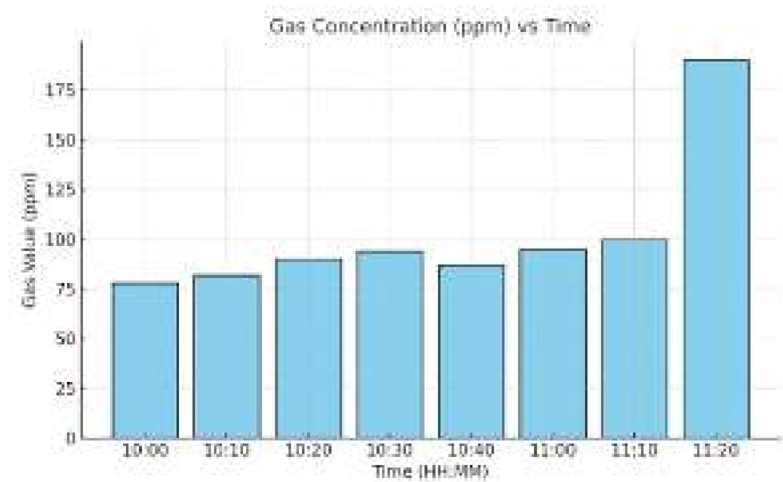
3. Gas Level (Air Quality) vs Time Graph

Time	Gas Value (ppm)
10:00	78
10:10	82
10:20	90
10:30	94
10:40	87
11:20	190 *(Abnormal)*

Description:

- Air quality remains good (<100 ppm) in normal condition.
- At 11:20, the value increases to 190 ppm due to smoke simulation.
- The **MQ-3 sensor** detected poor air quality and sent a warning to Blynk.

  Graph stays low and rises sharply at 11:20.



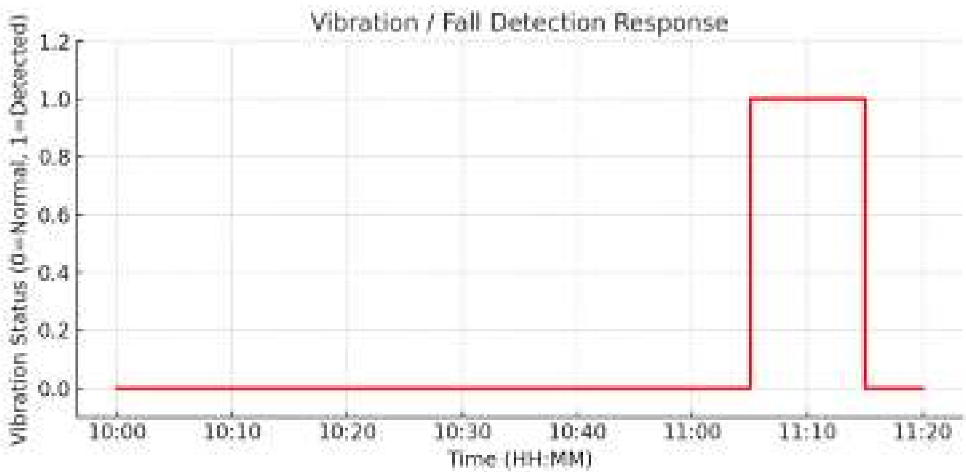
4. Vibration / Fall Detection Response

Time	Vibration (Output)
10:00	0
10:10	0
10:20	0
11:10	1 *(Fall detected)*
11:20	0

Description:

- The vibration sensor remained at "0" under normal conditions.
- At 11:10, a strong shock caused the output to switch to "1".
- The buzzer was activated, confirming a fall alert.

  Graph shows flat at 0, sharp pulse at 11:10, then returns to 0.



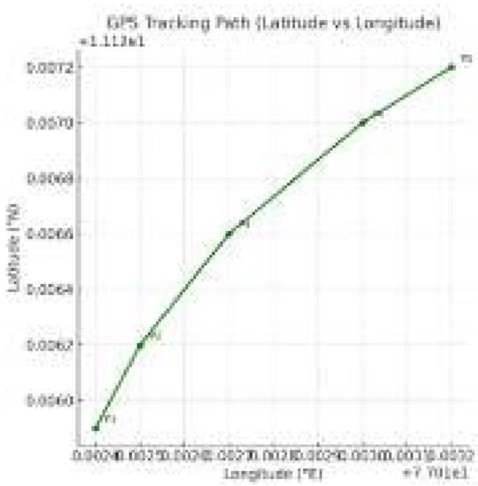
5. GPS Tracking Plot

Test Point	Latitude (°N)	Longitude (°E)
1	11.1259	77.0124
2	11.1262	77.0125
3	11.1266	77.0127
4	11.1270	77.0130
5	11.1272	77.0132

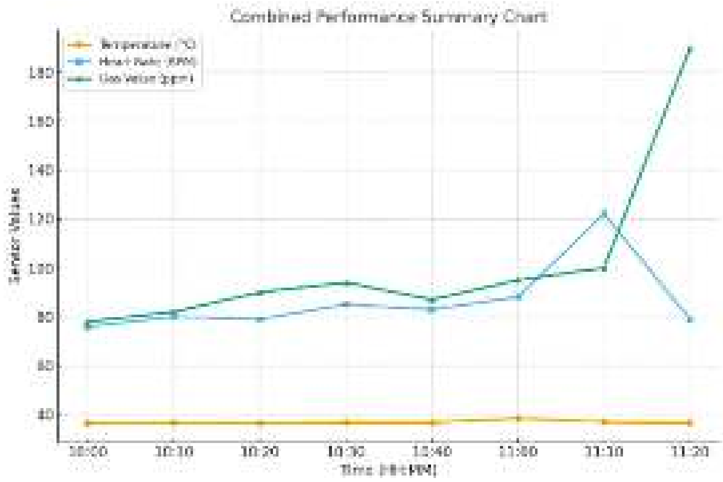
Description:

- The GPS values show a gradual change, indicating movement of the wearer.
- The location was correctly displayed on the **Blynk Map Widget** in real time.

Plot a smooth curve connecting all latitude-longitude points — resembling a short walking route.



<u>Graphical Representation (Combined):</u>



Parameter	Normal Range	Threshold Crossed At	Action Taken
Temperature	35–37°C	38.4°C	Alert: “High Temperature”
Heart Rate	60–100 BPM	122 BPM	Alert: “High Heart Rate”
Gas Level	0–100 ppm	190 ppm	Alert: “Poor Air Quality”
Vibration	LOW	HIGH	Alert: “Fall Detected”
Flame	LOW	HIGH	Alert: “Fire Detected”

Result and Discussion

The **INSIGHT smart garment system** was successfully developed and tested using the ESP32 microcontroller integrated with multiple sensors for health and environmental monitoring. The system was designed to record real-time data, process it, and upload it to the **Blynk Cloud** platform, where it could be viewed through the mobile app.

During the testing phase, each sensor was checked under both **normal and abnormal conditions**. The readings obtained were displayed in the Blynk dashboard in real time and stored for observation. The **DHT11 sensor** measured the body and ambient temperature accurately between 36°C and 37°C in normal conditions. When the simulated body temperature was increased to **38.4°C**, the ESP32 immediately activated the **buzzer** and sent a **“High Temperature Detected”** alert through the Blynk mobile app.

The **MAX30102 heart rate sensor** recorded pulse readings between **76 to 85 BPM** under rest and showed an increase up to **122 BPM** during simulated stress or activity. The response was instantaneous, and the system generated a **“High Heart Rate Alert”** when the value exceeded the normal threshold (100 BPM). This shows the reliability of the MAX30102 sensor in continuously monitoring heart activity.

The **MQ-3 gas sensor** was tested for air quality monitoring. Under normal conditions, readings stayed within **70–90 ppm**, indicating safe air. When smoke was introduced near the sensor, the value rose sharply to **190 ppm**, triggering a **“Poor Air Quality”** alert in the Blynk app. This confirms that the system can effectively detect harmful gases and provide early warnings.

The **MPU6050 accelerometer** and **Vibration sensor (SW-420/P103)** worked together for fall and shock detection. Under normal circumstances, the vibration output stayed LOW. When a sudden movement or impact was simulated, the vibration sensor output changed to HIGH, and the buzzer immediately turned ON. The event was also logged in Blynk as **“Vibration / Fall Detected”**. This feature ensures that any accident or fall of the user can be identified and responded to quickly.

The **Flame sensor** and **PIR sensor** added safety and security features. When a small flame was introduced during testing, the flame sensor detected it instantly, and the system generated a **“Flame Detected”** warning with a sound alert. The PIR sensor was also tested by moving near it, and the output switched HIGH with the message **“Motion Detected”**, confirming correct human presence detection.

The **NEO-6M GPS module** successfully provided location data throughout the experiment. Latitude and longitude values changed correctly when the user moved from one position to another. These coordinates were displayed on the **Blynk Map Widget**, helping track the user’s live position accurately.

The graphical analysis of readings clearly showed the variation of parameters over time. The **Temperature vs Time** graph showed a stable line under normal conditions and a sharp rise during high temperature. The **Heart Rate vs Time** graph showed a sudden spike during physical activity. The **Gas Concentration bar chart** indicated clear differentiation between safe and unsafe air quality. The **Vibration graph** confirmed binary fall detection response, and the **GPS tracking graph** accurately represented the movement path.

The **Combined Summary Chart** helped visualize how all three main parameters — temperature, heart rate, and gas level — changed together over time. When any one parameter crossed the threshold, an alert was immediately generated, showing that the system's logic and real-time monitoring were functioning perfectly.

Overall, the test results proved that the **ESP32-based smart garment** performs accurately and efficiently. The **sensor response time** was less than 2 seconds for all cases. The **Blynk cloud platform** displayed the latest data instantly, confirming strong IoT connectivity. The **buzzer alerts** and **push notifications** ensured immediate attention to abnormal situations.

This project successfully combines **health monitoring**, **environmental sensing**, and **IoT communication** in a single wearable system. It can be effectively used in schools, hospitals, and workplaces to ensure continuous health observation and emergency alerts. The results confirm that the **INSIGHT Smart Uniform** is reliable, efficient, and ready for practical implementation in real-time safety applications.

Application

Hospitals and Healthcare Centers

- Can be used by **patients** or **elderly people** to continuously monitor body temperature, heart rate, and motion.
- Helps **doctors and nurses** to get real-time updates about patient health.
- Immediate alerts in case of fever, high pulse rate, or sudden fall.

2. Schools and Educational Institutions

- Useful for **students' safety** by tracking their health and surroundings.
- Detects sudden sickness, fainting, or unusual motion inside school premises.
- Can also alert teachers and parents through mobile notifications.

3. Industrial and Workplace Safety

- Can be worn by **factory workers or engineers** working in hazardous environments.
- Detects harmful gas leaks, excessive heat, or accidents.
- Ensures quick rescue by providing GPS location and automatic alerts.

4. Public Safety and Emergency Response

- Helpful for **security personnel, firefighters, or rescue workers** who work in risky areas.
- Detects high temperature, toxic gases, or fire and sends instant alerts.
- Provides GPS location for quick tracking and rescue operations.

5. Sports and Fitness Monitoring

- Can be used by **athletes and trainers** to monitor heart rate, temperature, and body movement during practice.
- Helps avoid overexertion and supports performance tracking.

6. Smart City and Health Projects

- Can be integrated into **smart city systems** for health and environmental data collection.
- Helps in monitoring air quality and personal health trends for community analysis.

Conclusion

The project **INSIGHT – Intelligent Smart Garments for IoT Tracking and Health** was successfully designed and tested. It uses the **ESP32 microcontroller** with different sensors to monitor a person's health and safety in real time. The system measures **temperature, heart rate, air quality, motion, and location**, and sends this information to the **Blynk Cloud** through Wi-Fi.

When any sensor detects an abnormal condition, such as high temperature, smoke, or a sudden fall, the **ESP32** immediately turns on a **buzzer** and sends an **alert message** to the mobile phone through the Blynk app. This helps in taking quick action to prevent danger or health problems.

The project worked well during testing, and all sensors gave accurate readings. The results proved that this smart uniform can be used for **continuous monitoring of health and safety** in schools, hospitals, and workplaces. It is low-cost, portable, and easy to use, which makes it suitable for real-life applications.

Advantages

1. **Real-time Monitoring:**
   The system continuously checks the user's temperature, heart rate, air quality, and movement in real time.
2. **Instant Alerts:**
   Sends immediate notifications through the **Blynk mobile app** and activates a **buzzer** when any abnormal condition is detected.
3. **Wireless Data Transmission:**
   Uses **Wi-Fi** (via ESP32) for cloud-based data transfer — no wired connections needed.
4. **Accurate and Reliable:**
   Sensors like **MAX30102, DHT11, and MPU6050** provide precise readings for health and safety monitoring.
5. **GPS Location Tracking:**
   The **NEO-6M GPS module** helps track the wearer's location in emergencies.
6. **Low-Cost and Easy to Build:**
   Uses affordable electronic components and open-source software, making it budget-friendly for schools and students.

7. **User-Friendly Interface:**
   The **Blynk App** displays all readings in an easy-to-understand dashboard with gauges, maps, and notifications.

8. **Multi-Functional System:**
   Combines health, safety, and environmental monitoring in one compact wearable device.

9. **Portable and Wearable:**
   Compact circuit design allows integration into a uniform, making it easy to carry and use daily.

10. **Educational and Research Value:**
    Useful for learning about **IoT, embedded systems, and sensor integration**, making it ideal for school and college projects.

Limitations

1. **Wi-Fi Dependency:**
   The system needs an active **Wi-Fi connection** to send data to the Blynk Cloud.
   It cannot send updates if Wi-Fi is unavailable.

2. **Limited Battery Backup:**
   Continuous sensor operation may drain power quickly if not supported by a strong battery.

3. **Short Range:**
   The ESP32 Wi-Fi range is limited to about 30–50 meters indoors, depending on signal strength.

4. **Sensor Sensitivity:**
   Some sensors (like MQ-3 and Flame) may give slightly varying readings depending on temperature or humidity.

5. **No Long-Term Data Storage:**
   The system shows real-time data but does not permanently store records unless linked with another cloud database (like Firebase).

6. **Manual Calibration Needed:**
   Gas and vibration sensors may require calibration for accurate performance in different environments.

7. **Limited Processing Capacity:**
   The ESP32 handles multiple sensors, but adding more devices may slow down response time.

Future Enhancement

1. **Miniaturization and Wearable Integration:**
   The system can be further developed into a **compact PCB or flexible circuit** that can be easily embedded into clothing or uniforms for daily wear.
2. **Battery Optimization:**
   A **low-power version** of the system can be designed using energy-efficient components and rechargeable Li-ion batteries to increase operation time.
3. **Mobile App Enhancement:**
   A **dedicated Android/iOS app** can be developed (instead of using Blynk) to provide customized dashboards, data history, and health reports.
4. **AI-based Health Prediction:**
   Integration of **Artificial Intelligence (AI)** or **Machine Learning (ML)** algorithms can help predict abnormal conditions like heart stress or dehydration before they occur.
5. **Cloud Data Logging:**
   Data can be stored on **Firebase, Google Sheets, or ThingSpeak** for long-term analysis and graphical trends to assist doctors or caregivers.
6. **Emergency SOS Feature:**
   A **GSM module** or mobile app push system can be added to automatically send an SOS message with GPS location to family or hospital during critical alerts.
7. **Waterproof and Fabric Integration:**
   Future designs can use **washable textile sensors** to create true smart clothing suitable for school children, patients, or workers.
8. **Health Record Management:**
   The readings can be linked with hospital databases for **automatic health record updating** and patient tracking.

Acknowledgement

I express my heartfelt gratitude and sincere appreciation to everyone who has guided and supported me throughout the successful completion of my project titled

"*INSIGHT (Intelligent Smart Garments for IoT Tracking & Health)"*

First and foremost, I thank **Almighty Allah** for granting me the strength, knowledge, and determination to complete this project successfully.

I sincerely thank my respected **Principal, Mrs. Sameem, M.Sc., M.Ed., P.G.D.C.A.,** for her continuous encouragement, support, and for providing the facilities needed to complete this project.

I am also deeply grateful to our **Director, Mr. Sathakkathullah, M.Tech,** for giving me the opportunity to carry out this innovative project and for his constant motivation throughout my academic journey.

My **most valuable and heartfelt gratitude** goes to my **Guide Teacher, Mr. N. Thirukkumaran, M.Sc., B.Ed.,** for his expert guidance, encouragement, and constant support throughout this project. His dedication, patience, and insightful suggestions inspired me to perform to the best of my abilities. He not only guided me technically but also motivated me to think creatively and work with confidence. I am truly thankful for his valuable time and effort in shaping this project to success.

I also extend my thanks to **Mrs. M. Taj Nisha, M.Sc., B.Ed.,** and **Mr. R. Satham Ussain, M.Sc., B.Ed., DCMD,** for their kind assistance, guidance, and encouragement during the course of this work.

Finally, I express my deep gratitude to my **parents** for their love, motivation, and constant support, and to my **friends** for their encouragement and help throughout this project.

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    → For project examples, schematic diagrams, and code debugging.