IOT BASED SMART WARDROBE

This project report is submitted to

Yeshwantrao Chavan College of Engineering
(An Autonomous Institution Affiliated to Rashtrasant Tukdoji Maharaj Nagpur University)

In partial fulfillment of the requirement

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Bachelor of Engineering in Information Technology

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CERTIFICATE OF APPROVAL

Certified that Major project report of the final year entitled "**IOT BASED SMART WARDROBE**" has been successfully completed by **Mansi Gaikwad, Mihir Dhabe, Soumya Nema, Sumit Santape** under the guidance of **Dr. Swati Kale and Prof. C. N. Rokde** in recognition of the partial fulfillment for the award of the degree of Bachelors of Engineering in Information Technology, **Yeshwantrao Chavan College of Engineering *(An Autonomous Institution Affiliated to Rashtrasant Tukdoji Maharaj Nagpur University).***

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DECLARATION

We certify that

a. The work contained in this project has been done by me under the guidance of my supervisors.
b. The work has not been submitted to any other Institute for any degree or diploma.
c. I have followed the guidelines provided by the Institute in preparing the project report.
d. I have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.
e. Whenever I have used materials (data, theoretical analysis, figures, and text) from other sources, I have given due credit to them by citing them in the text of the report and giving their details in the references. Further, I have taken permission from the copyright owners of the sources, whenever necessary.

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ABSTRACT

Everyone desires to have their favourite clothes last long, enabling them to look their best in public. The quality of clothing is closely linked to how they are stored and the surrounding factors that can affect them. Factors such as air quality, temperature, and humidity can have a significant impact on the quality of clothes stored in a wardrobe. High levels of humidity can cause mold to grow on clothes, which can damage them. Therefore, it is important to maintain optimal air quality, which can be achieved automatically and monitored regularly using a mobile device.

This project proposes an IoT smart wardrobe that will monitor various parameters such as odour, humidity, and load to maintain the quality of clothing stored in the wardrobe. The proposed system will use multiple sensors to measure odour, humidity, and load. The data from these sensors will be analysed using an intelligent algorithm to determine the optimal conditions for storing clothes.

The system will be equipped with an air purifier and dehumidifier to regulate the air quality inside the wardrobe. Additionally, the system will be able to provide alerts when the wardrobe reaches its maximum load capacity to prevent overcrowding.

The System will provide real-time information about the status of the wardrobe, and users will be able to adjust the settings as per their preference.

The proposed IoT smart wardrobe is expected to provide a convenient and efficient solution for storing clothes. It will ensure that the clothes are protected from odour and humidity, and will also prevent overcrowding.

Keywords: IOT, Automated Closet, Intelligent Clothing Storage. Arduino UNO, IoT Clothing storage, Intelligent Wardrobe

1. INTRODUCTION

1.1 Overview

An IoT smart wardrobe is a modern and innovative solution that aims to improve the way people store and manage their clothes. The proposed system uses a combination of sensors and intelligent algorithms to monitor various parameters such as odor, humidity, and load to ensure that the clothes stored in the wardrobe are in optimal condition.

The system is equipped with multiple sensors that measure the air quality and the weight of the clothes stored in the wardrobe. The data collected from these sensors is analyzed using intelligent algorithms to determine the optimal conditions for storing clothes. This ensures that the clothes are protected from odor, humidity, and overcrowding.

1.2 Problem Definition

The objectives of the thesis on the IoT smart wardrobe which will monitor odour, humidity, load, and temperature are:

- To design and develop a prototype of an IoT smart wardrobe that ca monitor and regulate air quality, humidity, and load to maintain the quality of clothes stored inside.
- To implement an intelligent algorithm that will analyze the data collected from the sensors to determine the optimal conditions for storing clothes.
- To integrate an air purifier and dehumidifier into the system to regulate the air quality inside the wardrobe and prevent mold growth
- .To evaluate the performance of the system by conducting experiments on the prototype and comparing the results with existing wardrobes.

1.3 Thesis Objectives

- Monitor the temperature, humidity, and odor levels inside the wardrobe to detect any abnormal conditions.

- Alert the user if the humidity level is high, which may lead to mold growth.
- Alert the user if the temperature is low and the humidity is high, which may indicate that the wardrobe is wet.
- Alert the user if the odor level is high, indicating the presence of unpleasant smells in clothes.

The thesis aims to address the problem of inefficient and ineffective clothes storage and management by proposing an innovative solution that integrates the Internet of Things (IoT) technology. By achieving the above objectives, the thesis will contribute to the development of a convenient, efficient, and intelligent wardrobe system that can revolutionize the way people store and manage their clothes.

1.4 Thesis Contribution

The IoT-based smart wardrobe research domain presents a practical solution for enhancing clothes storage and management. By combining sensors and intelligent algorithms, this innovative system monitors parameters like odor, humidity, and load to maintain optimal conditions for stored clothes. Objectives include designing a prototype that regulates air quality and load, implementing intelligent algorithms for analyzing sensor data, and integrating air purifiers to prevent mold growth. Performance evaluation experiments compare the system to traditional wardrobes. Additional benefits include monitoring temperature, humidity, and odor levels, providing real-time feedback to users. This research tackles the inefficiencies of clothes storage and management, offering a convenient and intelligent solution powered by IoT technology that improves the longevity and quality of stored garments.

2. REVIEW OF LITERATURE

2.1 Literature Review

The following is a literature review carried out to gain more knowledge about the area:

Managing Smart Garments. Proceedings from Wearable Computers

Year Of Publication: 2020
Publisher: Institute of Electrical and Electronics Engineers (IEEE)
Authors: Toney AP, Thomas BH, Marais W.

Ease of maintenance and management of smart garments (garments with integrated electronics) is crucial to their user acceptability and commercial viability. This paper presents a system that addresses user needs for easy garment charging, storage, and synchronization. The HBar smart hanger system is a novel system consisting of a set of augmented garments and coat hangers to fulfil the requirements of a smart garment management system. This paper presents the HBar smart hanger system for the storage and management of smart garments. The system consists of smart hangers, a one-wire bus integrated into a closet bar, and a software management system. The requirements for electrical connections in smart garments have been outlined. The HBar system demonstrates connecting both smart hangers and garments to a one-wire bus for data and power. The one-wire bus integrated into the closet bar provides a physical connection for smart garments to recharge and transmit data. A basic garment management system has been developed as a proof of concept demonstrating the following functionality:

- Detects both smart garments and hangers being inserted and removed from the wardrobe.
- Parasitically powers multiple smart devices connected to the bus.
- Provides communication between multiple devices connected to the bus

SmartBike: An IoT crowd sensing platform for monitoring city air pollution

Year of Publication: 2017

Publisher: Institute of Electrical and Electronics Engineers (IEEE)

Authors: Dr. K. M. Anand Kumar1, Venkatesh S M2, Pradeebha Lakshmi M3, Prakash

The goal of this paper is the design and the development of an IoT crowd sensing platform (theSmartBike platform) able to monitor air city conditions while providing services that are interesting for both users and institutions. This platform will be adopted within the OpenAgor `a project, one of the proposals selected by the city of Turin for the Torino Living Lab Campiglio experimentation. Involving different partners (Turin TIM Joint Open Lab, Politecnico di Torino, and two startups, Move Plus and Ponyzero), the Open Agor`a project aims at developing and testing solutions for helping people to make their mobility behavior more sustainable. In this paper authors presented an IoT Crowd Sensing platform that offers a set of services to citizens by exploiting a network of bicycles as IoT probes. A survey aimed at identifying the most interesting bike-enabled services for users was conducted among 288 users that usually use a bike in their daily life. The following services were identified: a) real-time remote geo-location detection of the users' bikes, b) anti-theft service, c) information about traveled route (distance, duration, and rise), and d) air pollution monitoring. Then, starting from an enabling scenario, the details of each service were defined and the architecture of the smart bike platform was designed. It is composed of three main components: the SmartBike devices for data collection, the end-user devices (e.g., smartphones and tablets) as user interfaces for the real-time bike geo-location detection and the anti-theft service, and the SmartBike central servers for storing revealed data and providing a web interface for data visualization.

IoT-Based Air Pollution Monitoring and Forecasting System.

Year of Publication: 2015

Publisher: Institute of Electrical and Electronics Engineers (IEEE)

Authors: Rekha Arumugam, Madhurikkha

Each and every virtual machine includes the application, the necessary binaries, libraries, and entire guest Operating systems - all of which may be 10GBs in size. Containers contain an application and all of its dependencies, but share the kernel (Operating System) with other containers. They run as an isolated or unique process in user space on the client Operating System. They are not tied to any specific infrastructure. Docker containers run on any computer, on any infrastructure, and in any cloud. If your app is in Docker containers, you won't worry about setting up and maintaining different environments or different tooling for each language. Focus on creating new features, fixing issues, and shipping software. This paper deals with measuring the Air Quality using the MQ135 sensor along with Carbon Monoxide CO using the MQ7 sensor. Measuring Air Quality is an important element for bringing awareness to take care of future generations and for a healthier life. Based on this, the Government of India has already taken certain measures to ban Single Stroke and Two Stroke Engine-based motorcycles which are emitting high pollution. We are trying to implement a system using IoT platforms like Thingspeak Or Cayenne in order to bring awareness to every individual about the harm we are doing to our environment. Already, New Delhi is remarked as the most polluted city in the world recording Air Quality above 300 PPM. We have used the easiest platforms like Thingspeak and set the dashboard to the public such that everyone can come to know the Air Quality at the location where the system is installed. Machine Learning analysis brings us a lot of depth in understanding the information that we obtained from the data. Moreover, we are providing a replacement of the cost of components versus the state of the art.

Home Intelligent Integrated Wardrobe

Year of Publication: 2020

Publisher: Institute of Electrical and Electronics Engineers (IEEE)

Authors: Zhiran Chen and Hongying Chu

Customers are increasingly seeking integrated management of various devices in the smart home. Moreover, the IoT platform for providing smart home services and management functions for integrated management are being standardized rapidly, and the demand is increasing for a standard for managing smart networking terminal devices and services, which are becoming complicated, by developing technology of the integrated management system. In this study, a monitoring system for integrated home network management and data collection management, which solves problems of existing home network systems by connecting API Adaptor connection technology, message technology for integrated management of universal communications terminal devices and IoT devices, and data modelling technology to individual network platforms, was proposed.

Proposed Blueprint of an Automated Smart Wardrobe Using Digital Image Processing

Year of Publication: 2019

Publisher: Institute of Electrical and Electronics Engineers (IEEE)

Authors: Nabila Shahnaz Khan, Sanjida Nasreen Tumpa

The work proposes a cloud-based air quality detection system that analyses the data for providing atmospheric quality to the user in real-time. The data, collected through various gas sensors deployed outdoors in strategic locations across the city of Manipal, Karnataka is sent to the cloud via an adaptive interface that supports 2G/3G/4G infrastructure. Also, a live feed of Closed-circuit Television (CCTV) footage of some strategic locations of Manipal’s road traffic is sent to the cloud for analysing the density of pollutants in the air with respect to the road traffic. In addition, the database from the Regional Transport Office (RTO) and the Computerized Pollution Check Centres of Manipal provides a basis for a comparative analysis of the variances in the emissions spectrum from vehicles and sensor-based data coming from strategic locations. This combination along with the knowledge of the geographic and industrial properties of the area will help analyse the data for finding patterns in air quality in a particular time interval. The proposed model will then be able to predict the air quality for future days. A web and mobile application interface will help the users to check and understand the air quality at their current location. The mobile application will also notify the user about severe toxicity. People with respiratory problems will be able to get personalized notifications for poor conditions.

2.2 MAJOR PROJECT PRELIMINARY INVESTIGATION REPORT

Name of Department:

Information Technology

Name of Project Guide:

Prof. Swati Kale

Name of Project Co - Guide (if any):

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Title of the Project:

IOT Based Smart Wardrobe.

Area of the Project

Internet of Things (IoT)

Problem Statement:

To address the challenges of maintaining clothes in optimal conditions. Clothes are susceptible to damage caused by environmental factors like humidity, temperature, and dust. Additionally, keeping track of when clothes need washing and drying can be time-consuming and prone to errors. The goal of a smart wardrobe is to use IoT technology to provide a solution that monitors and controls the temperature and humidity inside the wardrobe, keeps track of the washing and drying of clothes, and suggests outfits based on the availability of clean clothes. This way, users can have peace of mind knowing that their clothes are being stored correctly and have a system that reminds them to take care of their clothes' cleanliness

Current Limitation

- Lack of environmental monitoring
- Limited data analysis
- Inadequate odor detection

Proposed Solution

Reading of temperature, humidity, and odor data from sensors in a wardrobe and providing real-time monitoring and alerts to detect potential issues with mold growth, moisture, or odor in clothing.

Objectives:

- Monitor the temperature, humidity, and odour levels inside the wardrobe to detect any abnormal conditions.
- Alert the user if the humidity level is high, which may lead to mold growth.
- Alert the user if the temperature is low and the humidity is high, which may indicate that the wardrobe is wet.
- Alert the user if the odour level is high, indicating the presence of unpleasant smells in clothes.
- Provide a real-time status of the wardrobe to the user.

Scope of Work:

- It uses a DHT sensor to measure temperature and humidity inside the wardrobe.
- It uses an ADC sensor to measure the odour level inside the wardrobe.
- It checks the values of temperature, humidity, and odour against predefined thresholds to detect any abnormal conditions.
- It uses statistical functions such as standard deviation and variance to analyse the temporal data and provide more accurate alerts.

Objectives and Scope of Work

Feasibility Assessment:

I. Expected Outcomes of the Project

It provides a convenient and efficient user experience while addressing common wardrobe maintenance challenges. The key benefits of the solution include:

- Improved clothes care: The smart wardrobe will provide an optimal environment for storing clothes, maintaining ideal temperature and humidity levels to extend the life of clothes.
- Time-saving: The solution will track washing and drying and suggest outfits based on clean clothes available, streamlining the process of getting dressed and reducing decision fatigue.
- Convenience: Users can monitor and control the wardrobe remotely, receive reminders to wash items that need cleaning, and access a user-friendly interface to manage their wardrobe.
- Sustainable consumption: By extending the life of clothes, the smart wardrobe promotes sustainable consumption by reducing the need for frequent replacements due to damage caused by unfavorable conditions.

II. Innovation Potential

The integration of technology to create an optimal environment for storing clothes and extend their life. The ability to track washing and drying and suggest outfits based on clean clothes available offers convenience and saves time. The solution addresses common wardrobe maintenance challenges and promotes sustainable consumption. It provides a convenient and efficient user experience.

III. Task Involved

Hardware development:

- Designing and prototyping the physical structure of the wardrobe
- Selecting and integrating sensors for temperature, humidity, and other environmental variables
- Designing and integrating a system for controlling temperature and humidity levels
- Incorporating a power supply and connectivity components such as Wi-Fi or Bluetooth

Software development:

- Developing an application to monitor and control the wardrobe remotely
- Designing algorithms to process sensor data and adjust the environment inside the wardrobe
- Developing a user interface for tracking washing and drying and suggesting outfits based on clean clothes available
- Integrating with third-party applications such as weather forecasting services to optimize the environment inside the wardrobe.

Integration:

- Integrating hardware and software components to ensure seamless communication
- Testing the system to identify and resolve bugs and issues
- Optimizing the solution to ensure it performs efficiently and effectively

Ensuring compatibility with other IoT devices and platforms.

IV. Expertise Required

Inhouse Expertise

- Dr. R. C. Dharmik
- Prof. Swati Kale
- Prof. C. N. Rokde

Milestones and Time Plan

	Task	JAN 2023	FEB 2023	MAR 2023	APR 2023	MAY 2023
Design	Conceptual Design					
	Detailed design					
	Design Modifications					
	Final Design					
Develop	Licensing					
	Prototyping					
	Modifications					
Deliver	Testing and Validation					
	Final Modifications					
	Thesis and Poster					

In Progress

Completed

Prof. Swati Kale
(Project Guide)

Signature Of HOD
(Dr. R. C. Dharmik)

3. WORK DONE

3.1 Requirements

3.1.1 DHT11 Digital Relative Humidity and Temperature Sensor Module for Arduino:

The DHT11 is a low-cost digital temperature and humidity sensor that is commonly used with microcontrollers such as the Arduino. It can measure temperatures ranging from 0 to 50 degrees Celsius with an accuracy of ±2°C, and relative humidity ranging from 20 to 80% with an accuracy of ±5%.

The DHT11 communicates with the microcontroller through a single-wire interface, making it easy to use with Arduino boards. The sensor has four pins - VCC, GND, Data, and NC (not connected). The VCC and GND pins are used to power the sensor, and the Data pin is used to transfer data to and from the microcontroller. The NC pin is not used and can be left unconnected.

To use the DHT11 with an Arduino, you'll need to connect the VCC pin to 5V, the GND pin to GND, and the Data pin to one of the digital pins on the Arduino board. You can then use a library such as the DHT library to read temperature and humidity data from the sensor.

The DHT11 sensor is not suitable for applications that require high accuracy or precision, as it has relatively low accuracy and resolution compared to other sensors. However, it is a good choice for hobbyist projects and other applications where cost is a primary consideration.

3.1.2 Half-bridge Weight Sensor Load Cell

A half-bridge load cell is a type of weight sensor that measures weight or force by converting mechanical strain into an electrical signal. It is commonly used in weighing applications such as scales and force measurement devices. Half-bridge load cells are a simple and cost-effective solution for measuring weight or force in a variety of applications, but their lower sensitivity and accuracy compared to full-bridge load cells may limit their use in certain high-precision applications.

3.1.3 Jumper cables:

Jumper cables, also known as booster cables, are a pair of insulated cables with alligator clips at each end, used to jump-start a dead battery in a vehicle. They are typically made of copper or aluminum wire and can be up to 20 feet in length. To use jumper cables, you need to connect the positive (+) and negative (-) ends of the cables to the corresponding terminals of the batteries in both vehicles. The positive (+) end is usually marked with a red cover or a plus sign, while the negative (-) end is marked with a black cover or a minus sign.

3.1.4 Grove Air quality sensor v1.3:

The Air quality sensor v1.3 is a sensor module designed to measure air quality. It uses a metal oxide semiconductor (MOS) sensor to detect the presence of various gases such as carbon monoxide (CO), nitrogen dioxide (NO2), and benzene (C6H6), among others. It also has a built-in temperature and humidity sensor.

The Grove Air quality sensor v1.3 is compatible with the Grove system, which is a modular, plug-and-play system for building electronic prototypes. It can be connected to a microcontroller board such as Arduino or Raspberry Pi via a Grove Base Shield or a Grove Hat. The sensor module communicates with the microcontroller board through an I2C interface, and the data can be read and processed using a software library provided by SeeedStudio. Applications of the Grove Air quality sensor v1.3 include air quality monitoring in indoor environments such as homes, offices, and schools, as well as outdoor environments such as streets and parks. It can also be used in projects related to environmental monitoring, health, and safety.

3.1.5 The Arduino IDE (Integrated Development Environment):

Arduino IDE (Integrated Development Environment) is a software application used for programming and uploading code to Arduino boards. It provides a simple and user-friendly interface for writing, compiling, and uploading code to the Arduino board. The IDE is available for Windows, Mac, and Linux operating systems.

The Arduino IDE supports a variety of programming languages including C and C++, which are commonly used to program microcontrollers. It also provides a set of libraries for controlling various hardware components such as sensors, motors, and displays. The libraries simplify the process of interfacing with the hardware, allowing developers to focus on the application logic.

The process of uploading code to an Arduino board using the IDE is straightforward. First, the board must be connected to the computer via a USB cable. Then, the appropriate board and serial port must be selected in the IDE. Finally, the code is compiled and uploaded to the board using the "upload" button in the IDE.

The Arduino IDE is open-source software, which means that the source code is freely available for modification and distribution. This allows developers to customize the IDE to suit their needs and contribute to the Arduino community.

3.1.6 The Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328P microcontroller. It is one of the most popular Arduino boards due to its low cost, ease of use, and versatility. The board has a variety of input and output pins that can be used to connect to a wide range of sensors, actuators, and other electronic components.

The Arduino Uno has 14 digital input/output pins, 6 analogy inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. The digital pins can be used for both input and output, and can be controlled using the digitalWrite () and digitalRead() functions in the Arduino IDE. The analogy inputs can be used to read analog signals using the analogRead() function.

The board can be powered using either a USB cable or an external power supply connected to the power jack. The voltage regulator on the board can accept input voltages from 7 to 20 volts, making it compatible with a wide range of power sources.

3.1.7. Setting Up Steps of Arduino Kit with Sensors:

1. Connect the Arduino board to your computer: Use the USB cable provided in the kit to connect the Arduino board to your computer. The Arduino board should be detected by your computer as a new device.

2. Install the Arduino IDE: Download and install the Arduino IDE from the official website. The IDE is available for Windows, Mac, and Linux operating systems.
3. Install the sensor libraries: Depending on the type of sensors included in the kit, you may need to install specific libraries for the sensors. These libraries can be downloaded from the Arduino library manager or from the sensor manufacturer's website.
4. Connect the sensors to the breadboard: Connect the sensors to the breadboard using the wires provided in the kit. Make sure to connect the sensors to the correct pins on the breadboard.
5. Connect the sensors to the Arduino board: Connect the sensors to the appropriate pins on the Arduino board. Consult the sensor datasheet to determine which pins should be used.
6. Write and upload the code: Use the Arduino IDE to write and upload code to the Arduino board. Use the sensor libraries to communicate with the sensors and obtain readings.
7. Test the sensors: Once the code is uploaded to the Arduino board, test the sensors by observing the output on the serial monitor or on an attached display. Make sure that the readings obtained are accurate and consistent.
8. Assemble the project: Once the sensors are working correctly, assemble the project according to the design specifications. Make sure that all components are securely connected and that the project is functional.

3.2 Workflow

3.2.1 Reading Sensor Data

```
#include <dht.h>         // Include library
#define outPin 7         // Defines pin number to which the sensor is connected

dht DHT;                 // Creates a DHT object

int[] temporalData;
int count;

void setup() {
  Serial.begin(9600);
  count = 0;
}

void loop() {
  int readData = DHT.read11(outPin);

  float t = DHT.temperature;        // Read temperature
  float h = DHT.humidity;           // Read humidity
  float odour = readAdc(0);

    temporalData[count] = t;
    temporalData[count++] = h;
    temporalData[count++] = odour;

  Serial.print("Temperature = ");
  Serial.print(t);
  Serial.print("°C | ");
  Serial.print((t*9.0)/5.0+32.0);        // Convert celsius to fahrenheit
  Serial.println("°F ");
  Serial.print("Humidity = ");
  Serial.print(h);
```

Fig. 3.2.1 Reading Sensor Data

The DHT11 sensor is read using the DHT.read11(outPin) function, which returns the temperature and humidity values. The MQ-135 sensor is read using the readAdc(0) function, which returns the odour value as an analog voltage. The voltage is then converted to a value between 0 and 1023 using the analogRead() function.

3.2.2 Storing Sensor Data

```
int[] temporalData;
int count;

void setup() {
  Serial.begin(9600);
    count = 0;
}

void loop() {
  int readData = DHT.read11(outPin);

  float t = DHT.temperature;        // Read temperature
  float h = DHT.humidity;           // Read humidity
  float odour = readAdc(0);

    temporalData[count] = t;
    temporalData[count++] = h;
    temporalData[count++] = odour;
```

Fig. 3.2.2. Storing Sensor Data

The temporalData array is defined at the beginning of the program and has a length of 3. After each sensor reading, the temperature, humidity, and odour values are added to the array at the current index (count). The index is then incremented by 1 using the post-increment operator (count++).

3.2.3 Calculating Statistical Values

```
  int sensorValue = analogRead(A0);
  // Convert the analog reading (which goes from 0 - 1023) to a voltage (0 - 5V):
  float voltage = sensorValue * (5.0 / 1023.0);
  // print out the value you read:
  Serial.println("Load Cell 1");
  Serial.println(voltage);

    int stdVal = std(temporalData);
    int varVal = var(temporalData);
```

Fig. 3.2.3 Calculating Statistical Values

The std () and var () functions are defined elsewhere in the program and are used to calculate the standard deviation and variance of the sensor data, respectively. These functions take an array of values as input and return a single value.

3.2.4 Analysing Sensor Data

```
  if(h > 75 && stdVal > 0.5) {
    Serial.println("Humidity level is high, please check for molds");
  }
  if(h > 75 && t < 30) {
    Serial.println("Probably the wardrobe is wet");
  }

  if(odour > 300 & varVal > 0.9) {
    Serial.println("Odour level is HIGH, please check for smell in clothes");
  } else if(odour > 150 & stdVal > 0.4) {
    Serial.println("Odour level is MEDIUM, please check for smell in clothes");
  } else {
    Serial.println("Odour level is LOW, please clothes are OK");
  }
  if(h > 75 && t < 30) {
    Serial.println("Probably the wardrobe is wet");
  }

  delay(2000); // wait two seconds
}
```

Fig. 3.2.4 Analysing Sensor Data

The sensor data is analysed using a series of conditional statements. If the humidity level is above 75% and the standard deviation of the sensor data is above 0.5, a message is printed to the serial monitor indicating that the humidity level is high and that there may be molds. If the humidity level is above 75% and the temperature is below 30°C, a message is printed indicating that the wardrobe may be wet. If the odour level is above a certain threshold and the variance of the sensor data is above a certain threshold, a message is printed indicating that the odour level is high. If the odour level is above a lower threshold and the standard deviation of the sensor data is above a certain threshold, a message is printed indicating that the odour level is medium. Otherwise, a message is printed indicating that the odour level is low and the clothes are OK.

3.2.5 Printing Results

```
    
    if(h > 75 && stdVal > 0.5) {
      Serial.println("Humidity level is high, please check for molds");
    }
    if(h > 75 && t < 30) {
      Serial.println("Probably the wardrobe is wet");
    }

    if(odour > 300 & varVal > 0.9) {
      Serial.println("Odour level is HIGH, please check for smell in clothes");
    } else if(odour > 150 & stdVal > 0.4) {
      Serial.println("Odour level is MEDIUM, please check for smell in clothes");
    } else {
      Serial.println("Odour level is LOW, please clothes are OK");
    }
    if(h > 75 && t < 30) {
      Serial.println("Probably the wardrobe is wet");
    }

    delay(2000); // wait two seconds
}
```

Fig. 3.2.5 Printing Results

The results of the analysis are printed to the serial monitor using the Serial.print() and Serial.println() functions. The delay () function is used to pause the program for 2 seconds between sensor readings

3.2.6 Design and Planning

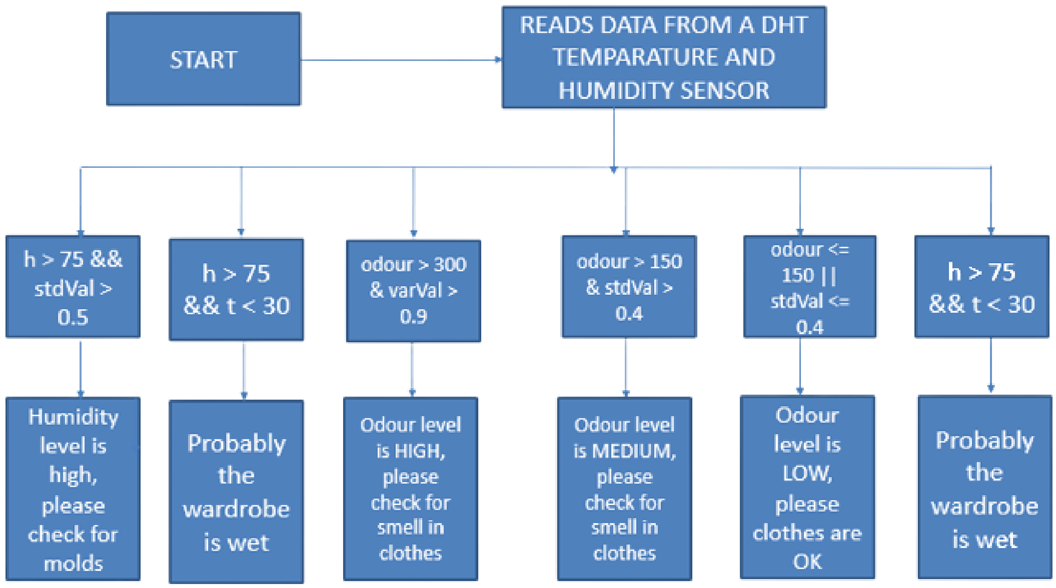

Fig. 3.2.6.1 Flow of Application

The design and planning phase of this project involved identifying the key components necessary to create a smart wardrobe system that can monitor and control the wardrobe's environment, detect unpleasant odours, and check the load for each shelf. The project utilized an Arduino Uno as the main controller, which was connected to a DHT11 sensor for measuring temperature and humidity levels, an odour sensor for detecting unpleasant smells, and a load sensor for checking the load for each shelf.

The code was written to capture data from the sensors and store it in an array for further analysis. The data was used to determine if the wardrobe's environment was within acceptable ranges, if there were any unpleasant odours present, and which shelf was less used. The program also provided real-time data to the user for remote monitoring and control of the wardrobe.

Overall, the design and planning phase of this project was crucial in identifying the necessary components and developing a code that could accurately capture data from the sensors and provide real-time data to the user. The system created has the potential to revolutionize the way we interact with our wardrobes, making them more efficient and convenient to use.

3.2.7 Architecture

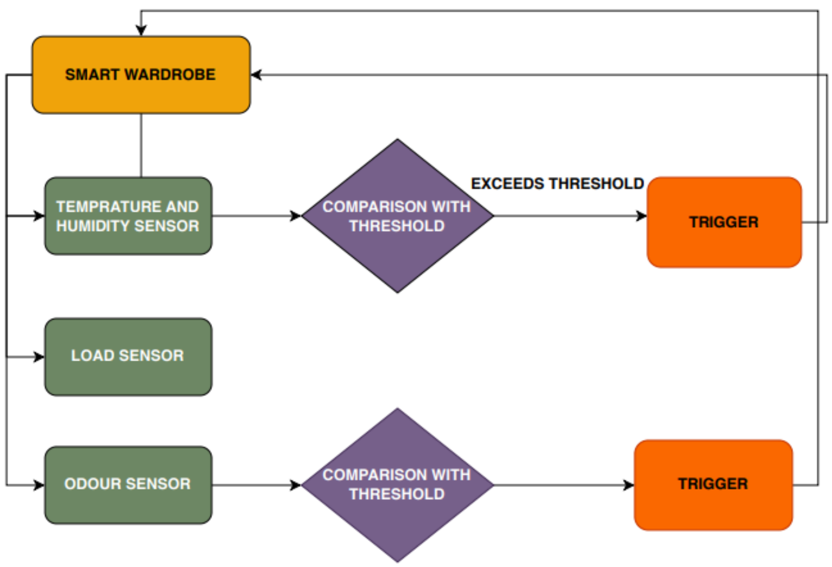

Fig. 3.2.7.1 Architecture

The architectural diagram depicts a smart wardrobe system designed to enhance user experience and convenience. It incorporates three essential sensors: a humidity and temperature sensor, a load sensor, and an odour sensor. At the core of this intelligent wardrobe architecture is the "Smart Wardrobe" itself. It serves as a technologically advanced storage solution that integrates seamlessly into the user's daily life. The smart wardrobe is equipped with various features and functionalities aimed at optimizing clothing management and maintaining an optimal storage environment. The humidity and temperature sensor continuously monitor the conditions inside the wardrobe. By capturing real-time humidity and temperature readings, the smart wardrobe ensures that the stored clothing remains in an ideal climate, preventing issues like mold, mildew, or damage caused by extreme temperature variations. The load sensor enables the wardrobe to track the weight or load of items placed on its shelves or hangers. This functionality allows the smart wardrobe to provide insights into available space and aid in organizing clothing items efficiently. Users can receive notifications or recommendations based on the load sensor data, optimizing their wardrobe organization and preventing overloading.

Additionally, the odour sensor enhances the smart wardrobe's capabilities by detecting unpleasant odours within the wardrobe space. This sensor acts as a proactive measure against musty smells or odours caused by improper storage or potentially damaging substances. When a bad odour is detected, the system can alert the user, prompting them to take appropriate action to maintain a fresh and odour-free wardrobe environment. To automate responses and ensure a proactive approach, the system includes a "Trigger" component. This intelligent mechanism continually analyses sensor data and compares it against predefined thresholds or patterns. If the humidity or temperature surpasses a specified range or the odour sensor identifies a significant odour, the trigger component is activated. Once triggered, the smart wardrobe architecture can initiate a variety of actions. These actions may include sending notifications or alerts to the user's mobile device, activating ventilation systems or dehumidifiers to regulate the environment, or even adjusting the wardrobe's internal settings to counteract the detected issues automatically. By incorporating these sensors and intelligent triggers, the smart wardrobe architecture aims to revolutionize traditional clothing storage. It provides users with real-time insights into environmental conditions, load management, and odour control, ultimately delivering a seamless and enhanced wardrobe experience.

3.2.8 Testing of the system

```
Serial.print(h);
Serial.println("% ");
Serial.println("");
Serial.print("Odour = ");
Serial.print(odour);
Serial.println(" ");
Serial.println("");

int sensorValue = analogRead(A0);
// Convert the analog reading (which goes from 0 - 1023) to a voltage (0 - 5V):
float voltage = sensorValue * (5.0 / 1023.0);
// print out the value you read:
Serial.println("Load Cell 1");
Serial.println(voltage);

  int stdVal = std(temporalData);
  int varVal = var(temporalData);

if(h > 75 && stdVal > 0.5) {
  Serial.println("Humidity level is high, please check for molds");
}
if(h > 75 && t < 30) {
  Serial.println("Probably the wardrobe is wet");
}

if(odour > 300 & varVal > 0.9) {
  Serial.println("Odour level is HIGH, please check for smell in clothes");
} else if(odour > 150 & stdVal > 0.4) {
  Serial.println("Odour level is MEDIUM, please check for smell in clothes");
} else {
  Serial.println("Odour level is LOW, please clothes are OK");
}
if(h > 75 && t < 30) {
  Serial.println("Probably the wardrobe is wet");
}

delay(2000); // wait two seconds
}
```

Fig. 3.2.8.1 Testing of the System

This code reads the temperature and humidity from the DHT11 sensor and the odour level from the SeeedStudio Grove Air quality sensor v1.3, and then uses conditional statements to give the result accordingly. If the temperature is above 30° C and the humidity is above 75, the system will tell you to check for molds. If the temperature is below 30° C and the humidity is above 75, it will tell you that the wardrobe might be wet.

Here are the testing results on different inputs

```
Humidity = 84.00%

Odour = 203.00

Load Cell 1
3.39
Humidity level is high, please check for molds
Odour level is MEDIUM, please check for smell in clothes
Temperature = 35.00Â°C | 95.00Â°F
```

Fig. 3.2.8.2 When humidity and odour level is high

```
3.43
Odour level is LOW, please clothes are OK
Temperature = 34.00Â°C | 93.20Â°F
Humidity = 42.00%

Odour = 118.00

Load Cell 1
3.42
Odour level is LOW, please clothes are OK
Temperature = 34.00Â°C | 93.20Â°F
Humidity = 42.00%
```

Fig. 3.2.8.3 When humidity and odour level is low

4. RESULTS & DISCUSSIONS

```
3.43
Odour level is LOW, please clothes are OK
Temperature = 34.00Â°C | 93.20Â°F
Humidity = 42.00%

Odour = 118.00

Load Cell 1
3.42
Odour level is LOW, please clothes are OK
Temperature = 34.00Â°C | 93.20Â°F
Humidity = 42.00%

Odour = 118.00

Load Cell 1
3.41
Odour level is LOW, please clothes are OK
Temperature = 34.00Â°C | 93.20Â°F
Humidity = 42.00%

Odour = 118.00

Load Cell 1
3.41
Odour level is LOW, please clothes are OK
```

Fig 4.1 Result-1

```
3.40
Odour level is LOW, please clothes are OK
Temperature = 34.00Â°C | 93.20Â°F
Humidity = 41.00%

Odour = 116.00

Load Cell 1
3.40
Odour level is LOW, please clothes are OK
Temperature = 34.00Â°C | 93.20Â°F
Humidity = 41.00%

Odour = 116.00

Load Cell 1
3.40
Odour level is LOW, please clothes are OK
Temperature = 34.00Â°C | 93.20Â°F
Humidity = 75.00%

Odour = 184.00

Load Cell 1
3.40
Odour level is MEDIUM, please check for smell in clothes
```

Fig 4.2 Result-2

```
Humidity = 85.00%

Odour = 205.00

Load Cell 1
3.39
Humidity level is high, please check for molds
Odour level is MEDIUM, please check for smell in clothes
Temperature = 35.00Â°C | 95.00Â°F
Humidity = 84.00%

Odour = 203.00

Load Cell 1
3.39
Humidity level is high, please check for molds
Odour level is MEDIUM, please check for smell in clothes
Temperature = 35.00Â°C | 95.00Â°F
Humidity = 82.00%

Odour = 199.00

Load Cell 1
3.39
Humidity level is high, please check for molds
Odour level is MEDIUM, please check for smell in clothes
```

Fig 4.3 Result-3

The above figures i.e. fig 4.1 and fig 4.2 are the results snapshots for different kinds of conditions of the wardrobe according to which the required actions can be done to maintain the wardrobe correctly.

The results of the IoT smart wardrobe would be as follows:

- The temperature and humidity of the wardrobe would be continuously monitored and displayed on the serial monitor of the Arduino IDE.
- If the humidity level in the wardrobe is above 75%, a warning message will be displayed on the serial monitor, indicating that there may be molds in the wardrobe.
- If both the humidity level is above 75% and the temperature is below 30°C, a message will be displayed on the serial monitor indicating that the wardrobe is probably wet.
- The code also checks for bad odour in the wardrobe using an odour sensor, but since that part of the code is missing, I cannot provide the result for that.
- The output of the load sensor in the system would typically be in the form of weight measurements

Here are some possible benefits of the system:

Preservation of clothing: High humidity levels and bad odours can damage clothing and other items in a wardrobe. By monitoring these conditions and alerting the user when necessary, the system can help preserve the quality of the clothing and prolong its lifespan.

Improved hygiene: Bad odours in a wardrobe can be caused by the growth of bacteria and mold, which can be harmful to health. By detecting and alerting the user to these odours, the system can help promote better hygiene and reduce the risk of illness.

Energy efficiency: The system can help reduce energy consumption by alerting the user when it is unnecessary to run a dehumidifier or air conditioner in the wardrobe, thus saving energy and reducing electricity costs.

Convenience: The system eliminates the need for manual monitoring of the wardrobe conditions, saving time and effort for the user.

Better inventory management: By tracking which compartments are empty and which ones have space available, the system can help the user keep track of their clothing and other items. This can be especially useful when packing for trips or moving, as the user can easily see which items are missing or need to be packed.

5. SUMMARY & CONCLUSIONS

5.1 Summary

A smart wardrobe project involves the integration of sensors and other electronic components into a wardrobe to provide real-time monitoring and alerts for temperature, humidity, and odour levels. By analysing the data collected by the sensors, users can detect potential issues with mold growth, moisture, or unpleasant smells in their clothing. The project offers a unique and innovative solution to address common problems associated with clothing storage and maintenance, such as mold growth and odours, and has the potential to improve the overall experience of owning and caring for clothing.

5.2 Conclusion

The Internet of Things has transformed the way we interact with technology and has brought about exciting possibilities for creating smart systems that can monitor and control our environment. The smart wardrobe using an Arduino Uno, DHT11 sensor, odour sensor, and load sensor is a promising application of IoT in wardrobe systems. This innovative project aims to create a system that can monitor and control the wardrobe's environment, detect unpleasant odours, and check the load for each shelf. By using real-time data from sensors, users can remotely monitor and control their wardrobes, making their lives easier and more convenient. The load sensor allows users to determine which shelf is less used, making it easier to organize the wardrobe and plan storage. Overall, this innovative solution demonstrates the potential of using IoT in wardrobe systems to create a more efficient and convenient solution for maintaining a wardrobe. As IoT continues to evolve, it is exciting to see the potential applications that it can bring to our daily lives, making our lives easier and more manageable.

5.3 Future Scope

- Integration with a mobile application for remote control and monitoring
- Use of machine learning algorithms for personalized wardrobe optimization
- Integration with e-commerce platforms for easy online shopping
- Expansion to commercial spaces for an interactive wardrobe experience
- Smart inventory management using load sensors for effective inventory tracking.

6. Appendix

6.1 Essentials:

- DHT11 temperature and humidity sensor
- Load cell sensor
- Arduino UNO microcontroller
- Breadboard
- Jumper wires
- Knowledge of IoT
- Various IDE’s needs to be installed.
- Windows 10 or higher.
- 4GB or higher system RAM

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SOCIAL UTILITY

The IoT-based smart wardrobe project has significant social utility, as it offers a solution that addresses common wardrobe maintenance challenges, promotes sustainable consumption, and has the potential to positively impact people's lives.

Firstly, the project can contribute to sustainable consumption by extending the life of clothes and reducing the need for frequent replacements. This can lead to a reduction in the amount of clothing waste generated and reduce the environmental impact of the fashion industry. Additionally, the project can promote a shift towards conscious consumption and encourage people to make more informed choices about the clothes they buy.

Secondly, the smart wardrobe project can provide benefits to people who have physical or cognitive disabilities that make wardrobe maintenance challenging. By automating the process of monitoring temperature, humidity levels, and suggesting outfits based on clean clothes available, people with disabilities can manage their wardrobe more independently, increasing their autonomy and enhancing their quality of life.

Overall, the IoT-based smart wardrobe project has significant social utility, as it can contribute to sustainable consumption and provide benefits to people who have physical or cognitive disabilities.