Article

Development Of an Intelligent Clothes Drying System with Real-Time Monitoring and Control

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Abstract:

The unpredictable climate and the increasing need for clean and dry clothes have made it challenging for individuals to perform daily tasks such as laundry. The high costs of using a laundry service and the difficulty of drying clothes outdoors or indoors make it imperative to develop an innovative solution to tackle this problem. This research proposes an intelligent IoT device that incorporates a dryer hanger with AI analytics to track the status of clothes and dry them effectively and efficiently. The device is designed to ensure safety and prevent unpleasant odors caused by mold growth and pollen. The proposed solution is particularly beneficial for individuals who are disabled or have a busy schedule as it eliminates the need to check the status of clothes being dried frequently. The device's effectiveness will be assessed by conducting experiments to evaluate its drying speed, energy consumption, and safety. The study results will provide insight into the device's feasibility and potential impact on mitigating the challenges associated with laundry tasks.

Keywords: Smart IoT device, dryer hanger, AI analytics, unpredictable climate, laundry, energy consumption, safety, mold growth, pollen, drying speed, feasibility, impact.

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1. INTRODUCTION

Washing and drying clothes is a necessary task for most individuals. However, unpredictable weather conditions, particularly in densely rainy areas, can make it difficult to dry clothes outdoors. In such situations, people may opt to dry their clothes indoors. While this is a viable alternative, it can lead to unpleasant odors in the house due to moisture buildup, mold growth, and pollen. Moreover, individuals who are disabled or have a busy schedule may find it challenging to check the status of their clothes being dried. As a result, there is a need for a device that can dry clothes quickly and efficiently while also ensuring their safety.

This research proposes an intelligent IoT device that integrates a dryer hanger with AI analytics to track the status of clothes being dried. The device will be able to dry clothes quickly and efficiently while also ensuring that they are not overdried, which can damage the clothes. The proposed device will also be easy to use and operate remotely using a mobile app. The Internet of Things (IoT) is a technology that has become increasingly popular in recent years. It allows devices to connect and communicate with each other through the internet, enabling them to share data and operate remotely. IoT has been used in various fields, including healthcare, transportation, and agriculture. The proposed device will leverage IoT technology to track the status of clothes being dried and ensure they are dried efficiently and safely.

The proposed device will also incorporate AI analytics to provide users with real-time data on the status of their clothes. This will enable individuals to remotely monitor the quality of their clothes being dried and ensure that they are not overdried or under-dried. The device will also be able to learn from past drying experiences and adjust its settings accordingly, ensuring that it can dry clothes quickly and efficiently. The device will be designed to be easy to use and operate remotely using a mobile app. Users can set parameters for the device, such as the temperature and humidity levels required to dry their clothes. The app will also provide real-time data on the clothes' status, including the moisture content, the time needed to achieve a specific humidity level, and the temperature required to dry the clothes.

The proposed intelligent IoT device with a dryer hanger [1-6] and AI analytics will help individuals dry their clothes quickly and efficiently while ensuring their safety. The device will be easy to use and operate remotely using a mobile app, making it ideal for individuals who are disabled or have a busy schedule. The device will also incorporate AI analytics to provide real-time data on the status of clothes being dried, ensuring that they are not overdried or under-dried. The proposed device will be a significant step forward in the field of laundry technology, making washing and drying clothes easier, faster, and more efficient.

2. LITERATURE REVIEW

Laundry tasks are essential daily activities, but they can become challenging in areas with unpredictable weather conditions. The unpredictability of weather conditions, particularly in densely rainy areas, makes it challenging to dry clothes outdoors. While drying clothes indoors is a viable alternative, it can lead to unpleasant odors due to the buildup of moisture, mold growth, and pollen (Medical Press, 2014). Additionally, individuals who are disabled or have a busy schedule may find it challenging to check the status of clothes being dried frequently. Therefore, there is a need for an innovative solution that can tackle the challenges associated with laundry tasks effectively and efficiently.

One possible solution to this problem is using a smart IoT device [7] that incorporates a dryer hanger with AI analytics to track the status of clothes and dry them effectively and efficiently. The proposed device will ensure safety and prevent unpleasant odors caused by mold growth and pollen (Ooi Wei Lynn, 2015). Such devices can potentially eliminate the need to frequently check the status of clothes being dried, making it particularly beneficial for individuals who are disabled or have a busy schedule.

In densely rainy areas, umbrella clotheslines are famous for drying clothes outdoors (Baka Specialties LLC, 2007). However, the high humidity and temperature in some regions can affect the effectiveness of this method (Department of Statistics India, 2007). In Malaysia, where the climate is hot and humid, hanging clothes indoors may not be ideal as it can lead to mold growth and affect indoor air quality (Jabatan Metrologi Malaysia, n.d.). Therefore, a smart IoT device that can effectively dry clothes indoors while ensuring safety and preventing mold growth can be a viable solution to the challenges associated with laundry tasks.

There are several products and systems available in the market that aim to provide a solution to laundry-related problems. For instance, CleverCloseLine is a product that allows indoor clothes drying using a pulley system (CleverCloseLine, 2010). The Versaline system is a ceiling-mounted indoor clothesline that uses a retractable system for clothes drying (Magento Developers, 2014). However, these systems do not integrate AI analytics to track the status of clothes being dried and ensure their safety.

3. METHOD

A. Component

Our product is an intelligent and efficient clothes-drying system that utilizes sensors, microcontrollers, and an external body to dry clothes quickly and uniformly. The components of our approach include a humidity and temperature sensor (DHT11 sensor), a moisture sensor, a load cell, an Arduino Uno microcontroller, a dryer, an external body, and an LED display.

1) Humidity and Temperature Sensor: This sensor measures the temperature and the humidity level in the air, which will give input to the controller.
2) Moisture sensor: The moisture sensor keeps track of the moisture level in the clothes being dried. It turns off the dryer when the moisture level drops to a level equal to that of the surrounding air, which saves energy and prevents over-drying.
3) Arduino uno: It uses a microcontroller to read the inputs and turn them into an output, publishing something online. It will control airflow, the temperature of the air, the time of flow, and the auto on/off system of the system.

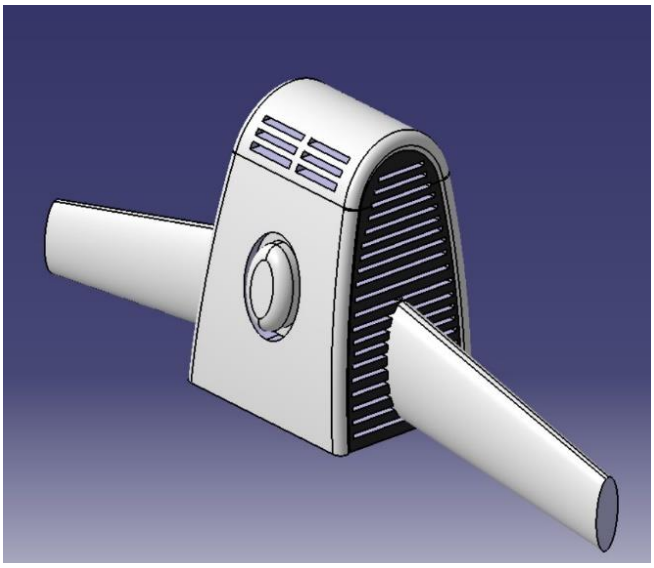

Figure 1. Design of Smart Dryer

4) Dryer: It delivers hot air to the system, which will be used to soak moisture from the clothes and make them clothes dry.
5) External Body: This will be used to hang the clothes and design such that the hot air should be uniformly transferred to all clothes sections.
6) Load Cell: This will use to weigh the clothes as weight is also an essential factor for drying the clothes.
7) LED display: It will display the time and temp at the hanger to monitor it closely if the mobile gets some error.

B. Working Methodology

Our system works on a sensor-microcontroller-cloud-AI analytics-UI interface model. The humidity and temperature sensor measures the humidity and temperature levels in the air, and the moisture sensor keeps track of the moisture level in the clothes. The microcontroller uses the inputs from the sensors to control the airflow, temperature, time of flow, load cell, and auto on/off system of the dryer. It also publishes the output online through the cloud.

The AI analytics software analyzes the data from the sensors to optimize the drying process, making it faster and more efficient. The UI interface allows the user to monitor the dryer's temperature, time, and status and make any necessary adjustments. The drying time and temperature vary according to the moisture level and environmental humidity. At a constant temperature, the drying time should ideally be 30 minutes, 40 minutes, and 50 minutes for low, medium, and high humidity levels, respectively. If the moisture level and humidity increase, the drying time required will also increase at a constant temperature.

If we keep time constant at a different humidity level, the temperature should ideally increase to 27, 36, and 45 degrees Celsius for low, medium, and high humidity levels, respectively. If the moisture level and humidity increase, the temperature required for drying clothes will also increase at a constant time. The sensor measures the load's temperature, humidity, and weight and transmits this data to the program. The program can then calculate the optimal drying time and temperature based on the sensor data; it can adjust the drying time as the properties of the load change during the drying process. This approach can reduce electricity consumption and improve the quality of drying.

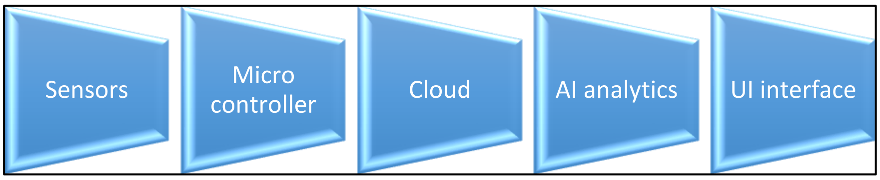

Figure 2. Flowchart of working Methodology.

4. RESULT AND DISCUSSION

A. Device Result

The five use cases represent scenarios with varying input variables: temperature, humidity, moisture level, fabric type, and weight. These scenarios are meant to simulate real-world situations and demonstrate the program's versatility.

TABLE I

SCENARIO ANALYSIS

Use Case	Temp (°C)	Humidity (%)	Moisture Level (Kg/Kg*K)	Fabric Type	Weight (Kg)	Expected Drying Time (min)
1	20-25	60-70	0.15-0.2	Heavy	2-3	60-90
2	30-35	40-50	0.2-0.25	Delicate	1-2	30-60
3	25-30	80-90	0.3	Heavy	3-4	120-150
4	15-20	70-80	0.1-0.15	Delicate	0.5-1	10-20
5	35-40	30-40	0.25-0.3	Heavy	4-5	180-210

- Use Case 1 represents a situation where the temperature is moderate, the humidity is high, and the load is heavy. The expected drying time ranges from 60-90 minutes, depending on the weight of the load.
- Use Case 2 represents a scenario where the temperature is high, humidity is moderate, and the load is delicate. The expected drying time ranges from 30-60 minutes, depending on the weight of the load.
- Use Case 3 represents a scenario where the temperature is moderate, humidity is very high, and the load is heavy with high moisture content. The expected drying time ranges from 120-150 minutes, depending on the weight of the load.
- Use Case 4 represents a situation where the temperature is low, humidity is high, and the load is delicate with low moisture content. The expected drying time ranges from 10-20 minutes, depending on the weight of the load.
- Use Case 5 represents a scenario where the temperature is very high, humidity is low, and the load is heavy with high moisture content. The expected drying time ranges from 180-210 minutes, depending on the weight of the load.

If the expected drying time is more than the required time of the user, the user can adjust the temperature from their device up to some defined limit. The program can be designed to accept user input for temperature adjustment within a specified range. The user can achieve the desired drying time without over-drying or under-drying the load. However, it's important to note that excessively high temperatures can damage delicate fabrics and reduce the lifespan of the clothes. Therefore, defining a safe temperature range for the user to adjust within is essential.

B. UI Result

The use of a UI (user interface) in this research project can significantly benefit users by providing them with an easy and convenient way to control and monitor the drying process of their clothes. By allowing users to change parameters like temperature and time from their mobile devices, they can have greater control over the drying process and ensure that their clothes are dried to their desired level. Additionally, the UI can provide real-time monitoring of the drying process, allowing users to keep track of the progress and adjust the parameters as necessary. This can save users time and energy by avoiding needing to check the drying process physically.

Furthermore, the UI can provide feedback on the clothes' dryness level, which can help users determine when the drying process is complete and prevent over-drying, which can damage clothes and waste energy. Using a UI can greatly improve the user experience and help users get the most out of their clothes-drying process while saving time, energy, and resources.

5. CONCLUSIONS

The proposed project addresses the issue faced by people living in rainy areas and those with busy schedules who struggle with drying clothes efficiently and keeping track of their status during the drying process by utilizing humidity and moisture sensors, as well as a microcontroller, the project ensures that clothes are dried within the ideal time and temperature range without over-drying or overheating. AI analytics enhances the system's capabilities by allowing real-time monitoring and automatic operation once clothes have reached the desired dryness level. The project offers a user-friendly interface through mobile controls, making it accessible to people of all ages and technological aptitudes. With its energy efficiency and safety features, this project offers a solution to the common problems associated with traditional dryers. Overall, the intelligent drying hanger is a simple and effective solution for drying clothes that is accessible and beneficial for many users. This approach can lead to more efficient and accurate drying, reducing energy consumption and improving the quality of the drying process. It also helps prevent damage to delicate fabrics and reduces the risk of over-drying and under-drying.

AUTHOR CONTRIBUTIONS

Conceptualization; Girish Kurkure [G.K], Shivangi Ramani[S.R], Methodology; [G.K],[S.R], validation; [G.K],[S.R], formal analysis; [G.K],[S.R], investigation; [G.K],[S.R], data curation; [G.K],[S.R], writing—original draft preparation; [G.K],[S.R], writing—review and editing; [G.K],[S.R], visualization; [G.K],[S.R], supervision project administration; [G.K],[S.R], funding acquisition; [G.K],[S.R], have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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