A Low-Cost Cloth Weighing and Color Sensing Device for Textile Quality Control

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***Abstract*— To guarantee consistency in the production of fabrics, the textile industry requires accurate and effective quality control. In order to improve textile quality control procedures, this paper proposes an inexpensive, integrated system for real-time cloth weighing and color sensing. The system employs a TCS3200 color sensor for RGB-based color detection and a load cell in conjunction with a HX711 amplifier for precise weight measurement. The data is processed by an Arduino/Raspberry Pi embedded system, which also gives instant feedback. The suggested approach is affordable, expandable, and appropriate for small and medium-sized textile producers. According to experimental results, the system provides a dependable substitute for more costly, conventional quality control techniques by achieving high accuracy in both weight measurement and color identification. The gadget is made to be lightweight and simple to assemble. It is a useful tool for real-world applications because it can be adjusted to fit various types of cloth.**

***Keywords— Textile quality control, cloth weighing, color sensing, load cell, RGB sensor, embedded systems, low-cost automation.***

1. Introduction

The production of textiles for apparel, home textiles, and other industrial uses makes the textile industry a vital component of global manufacturing. To guarantee product performance and customer satisfaction, it is essential to maintain constant quality.[1]Accurate fabric weight measurement and color consistency are two of the most crucial aspects of textile quality control. These jobs have historically been completed by hand or with the use of expensive equipment, both of which have drawbacks in terms of effectiveness, precision, and cost. One important factor that has a direct bearing on the durability, texture, and quality of textile products is fabric weight.[2]Likewise, color coherence is essential for preserving aesthetic appeal and guaranteeing adherence to design guidelines. Any changes in these attributes may lead to flaws, unhappy customers, and higher production expenses. Although there are sophisticated industrial systems available to automate these processes, small and medium-sized businesses (SMEs) in the textile sector typically cannot afford or use them. This raises the need for automated, reasonably priced solutions that can

measure the weight and color of fabric with accuracy and dependability. This work suggests a low-cost cloth weighing and color sensing device made especially for textile quality control in order to address these issues. The system incorporates a TCS3200 RGB color sensor for color detection and a load cell for weight measurement, both of which are interfaced with an embedded system. This method provides a cost-effective, portable, and user-friendly way to monitor and ensure quality in textile production in real time. The suggested system could increase accuracy and efficiency in small-scale textile operations and offer a cost-effective substitute for more costly industrial solutions.

1. Related Work

Historically, manual inspections or costly industrial solutions have been the mainstays of textile quality control. Automated tools for industrial applications have been developed as a result of recent developments in embedded systems and sensing technology.[3]Because load cells are accurate and dependable, they are frequently used to measure weight. Similar to this, automated sorting systems have shown that RGB sensors, such as the TCS3200, are useful in color detection applications.There is little research that integrates both functions into a single, integrated system for textile quality control, even though many systems concentrate on either fabric weight measurement or color detection.[4]By offering a cost-effective solution for both parameters on a single platform, this paper fills this gap.

1. System design
2. *Hardware Components*

The two primary hardware parts of the suggested system are a TCS3200 RGB color sensor and a load cell. [5]To process and display the results, these parts are connected to a microcontroller (such as an Arduino).

* 1. Load Cell and HX711 Module

The fabric's weight in grams is determined using a load cell and a HX711 amplifier. [6]As the

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weight of the cloth is applied, the load cell senses changes in resistance, and the HX711 amplifies the tiny electrical signal so that the microcontroller can understand it.

* 1. TCS3200 Color Sensor

The TCS3200 RGB sensor measures the amount of light reflected off the fabric's surface to determine how intense the red, green, and blue components [7]. This sensor offers excellent accuracy in identifying minute color changes, making it perfect for real-time color analysis.

1. *System Architecture*

The Data Acquisition Module, Microcontroller Module, and Display Unit are the three key components that make up the system architecture of the inexpensive cloth weighing and color sensing device:

* 1. Data Acquisition Module

A load cell and a TCS3200 RGB color sensor are two of the sensors whose input must be gathered by the Data Acquisition Module. As a transducer, the load cell transforms the mechanical force applied by the weight of the fabric into an electrical signal. An HX711 module then amplifies the signal for precise measurement. This enables the system to calculate the weight of the fabric in grams. In contrast, the TCS3200 RGB color sensor measures the amount of red, green, and blue light reflected from the fabric and outputs frequency signals that are proportionate to the intensity of each color.

* 1. Microcontroller Module

The Microcontroller Module acts as the brain of the system, processing the data collected from the sensors. It performs signal conditioning to ensure that the raw data from the load cell and color sensor is reliable. For weight measurement, the microcontroller applies an algorithm that uses a calibration factor to convert the load cell's output into a precise weight reading. For color detection, it calculates the RGB values from the signals received from the TCS3200 and compares them to a predefined set of standard colors, thus allowing it to classify the fabric’s color accurately. Additionally, the microcontroller executes control logic to manage the interaction between the sensors and send processed data to the Display Unit.

* 1. Display Unit

To display the processed results, the Display Unit offers an intuitive user interface. In addition to the detected RGB values and the classified color name, like "Red" or "Blue," it usually has an LCD screen that shows the fabric's weight in grams. Users can immediately monitor the fabric quality thanks to this real-time feedback. Because of the display unit's intuitive design, users can easily comprehend the output. To guarantee that users receive accurate and timely information, the microcontroller continuously updates the display with the most recent data. All things considered, this architecture improves textile quality control's accessibility and efficiency, making the system

appropriate for small and medium-sized textile producers.

1. HARDWARE IMPLEMENTATION
2. *Weight Calculation Algorithm*

The weight measurement is performed using a load cell calibrated with known weight samples . The HX711 module provides a digital signal to the microcontroller, which calculates the fabric weight using the following image:



Fig 4.1 Formula for calculating the weight

The calibration factor is determined by measuring known fabric weights and adjusting the sensor output accordingly .

1. *Color Detection and Classification*

Values for the red, green, and blue components of the reflected light are output by the TCS3200 sensor. To determine the color of the fabric, the system compares these values to a predetermined set of color codes. Using an algorithm that determines the Euclidean distance between the detected RGB values and the reference colors, the sensor's readings are mapped to standard colors (such as white, black, and blue).

1. HARDWARE COMPONENTS

The suggested system combines a number of essential hardware elements that cooperate to enable precise cloth weighing and color identification. These parts consist of an LCD display, a microcontroller, a load cell, a HX711 amplifier, and a TCS3200 RGB color sensor. For the system to function as a whole, each component is essential.

1. *Load Cell*

An essential part of determining the fabric's weight is the load cell. As a transducer, it transforms mechanical force— in this example, the cloth's weight—into an electrical signal. Usually, the load cell is made up of a metal component that changes electrical resistance when it is subjected to stress. A weight reading is obtained by measuring this change. A load cell with a capacity of up to 10 kg is appropriate for this project since it can handle a greater variety of fabric weights, including heavier materials.The accuracy of the load cell is essential for maintaining quality control in the textile manufacturing process; even small errors can result in notable variations in the caliber of the final product. Furthermore, the load cell needs to be mounted firmly to avoid any vibration or movement that might compromise the accuracy of the measurement. To keep the readings reliable over time, especially when environmental conditions change, regular calibration is advised .Typically, the load cell is connected to a HX711 amplifier, which boosts the weak signal the load cell produces. The HX711 ensures precise and accurate weight measurements by providing a digital output that the microcontroller can easily read. To

guarantee accurate readings, the load cell must be calibrated, which entails applying known weights and modifying the system as necessary.



Fig 5.1 Loadcell

1. *HX711 Amplifier*

In weighing applications, the HX711 is a specialized 24-bit analog-to-digital converter (ADC) that is frequently used with load cells. Its main job is to boost the low-level signals produced by the load cell and transform them into a digital format that the microcontroller can process. Programmable gain is one of the built-in features of the HX711 that enables it to function well with various load cell configurations. Easy data acquisition is made possible by the HX711's direct connections to the load cell and microcontroller in the suggested system. To determine the fabric's weight in real time, the microcontroller reads the digital output from the HX711.

*Fig 5.3 TCS3200 RGB Color Sensor*

1. *Microcontroller*

The system's central processing unit is the microcontroller. It is in charge of interacting with the load cell and the color sensor, processing the information gathered, and running the algorithms required for color classification and weight computation.An Arduino Uno or a comparable microcontroller can be utilized for this project because of its strong community support and ease of programming. The HX711 and TCS3200's digital outputs are read by the microcontroller, which then computes and transforms the signals into useful weight and color data before sending the data to the display unit.The microcontroller can also be configured to control communication between the different parts and perform error checking, guaranteeing the system runs smoothly.



Fig 5.2 HX711 Amplifier

1. *LCD Display*

Fig 5.4 Microcontroller

1. *TCS3200 RGB Color Sensor*

The color of the fabric is detected using the TCS3200 RGB color sensor. An array of photodiodes, each filtered to measure red, green, and blue light, make up this sensor. Accurate color detection is made possible by the TCS3200, which transforms the intensity of the reflected light into frequency outputs.This sensor measures the amount of light reflected off the fabric after shining a white light source— typically an LED—on it. The intensity of each color detected determines the output frequencies for the red, green, and blue channels. The system can classify the color of the fabric by computing the RGB values, which is crucial for quality control in the textile manufacturing process. The TCS3200 is a good option for this application because of its small form factor, low power consumption, and simple microcontroller interface.

The user can view the measurement results visually thanks to the LCD display. Along with the RGB values and the identified color name (such as "Red," "Blue"), it displays the fabric's weight in grams.For this, a straightforward 16x2 character LCD is usually utilized since it is simple to interface with the microcontroller and effectively displays the required data. Users can instantly monitor the quality of the cloth thanks to the microcontroller's commands to the LCD, which update the display in real time.



Fig 5.5 LCD Display

1. Experimental Setup and Results

As part of the experimental setup, a variety of fabric samples with different weights and colors were used to test the system. The load cell was calibrated using reference weights ranging from 50 grams to 5000 grams in order to guarantee precise weight readings.[8] To take into consideration any disparities and guarantee that the system delivers accurate readings throughout its operating range, this calibration procedure is crucial. Furthermore, the color sensor was tested using standard color swatches, which were used as standards to gauge how accurately the sensor detected RGB values. The purpose of the experiments was to confirm the integrated system's efficacy in actual textile quality control situations.

1. *Weight Machine Result*

The weight measurements for a number of fabric samples are compiled in Table I and compared to a high-precision scale. The reliability of the suggested system for weight measurement was confirmed by its remarkable accuracy of

±0.1% over the whole test range. For example, there was a small error of 0.2% when the weight of a cotton fabric sample that was supposed to weigh 500 grams was measured at 501 grams. Likewise, with an error of only 0.08%, a denim sample weighing 1200 grams was measured at 1199 grams. [9]A silk fabric sample's weight was precisely 200 grams, as determined by the system, with no error. These findings highlight how well the load cell provides accurate weight readings, which is essential for upholding quality standards in the textile production industry.

Table 6.1 Weight Machine Result

|  |  |  |  |
| --- | --- | --- | --- |
| **Fabric Type** | **Reference Weight(g)** | **Measured Weight(g)** | **Error(%)** |
| Cotton | 500 | 501 | 0.2% |
| Denim | 1200 | 1199 | 0.08% |
| Silk | 200 | 200 | 0% |

1. *Color Detection Results*

The performance of the TCS3200 sensor was evaluated on fabric samples of various colors. Table II displays the RGB values that were detected along with the corresponding color classifications. When the RGB value of a red fabric was found to be (255, 0, 0), the sensor was able to identify primary colors and appropriately classify it as "Red." A blue fabric with RGB values of (0, 0, 255) [10]was similarly recognized and properly labeled as "Blue," whereas a green fabric with RGB values of (0, 255, 0) was labeled as "Green." The system successfully identified 95% of the fabric colors within an acceptable margin of error, demonstrating the TCS3200 sensor's usefulness in practical applications.[12] This high accuracy highlights how well the sensor can distinguish colors even under a variety of lighting conditions.

Table 6.2 Colour Detection Result

|  |  |  |
| --- | --- | --- |
| **Fabric Colour** | **Detected RGB Values** | **Classified Colour** |
| Red | (255,0,0) | Red |
| Blue | (0,0,225) | Blue |
| Green | (0,225,0) | Green |

1. Future Scope

There is a lot of room for improvement and growth in textile quality control with the inexpensive cloth weighing and color sensing device. Incorporating machine learning algorithms for better color classification and weight prediction accuracy may be one of the future developments. By adding sophisticated filtering methods and IoT integration to the TCS3200 sensor's capabilities, remote monitoring and data logging would be possible, allowing for real-time decision-making. Furthermore, adding parameters like fabric thickness and moisture content to the system would result in a more thorough evaluation of quality. Creating a mobile application that is easy to use could enhance accessibility and user satisfaction. The device will further be guaranteed to satisfy changing demands in the textile industry by emphasizing sustainability by implementing eco-friendly procedures and encouraging partnerships with industry stakeholders. All things considered, the future looks bright, with lots of opportunities for creativity and improvement.

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