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An Intelligent Arduino-Based System for Counterfeit Currency Detection

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Abstract **-- Counterfeit currency is a serious issue that affects individuals, businesses, and the overall economy of a country. Fake currency notes often closely resemble genuine ones, making manual identification difficult and increasing the risk of financial loss. To address this problem, this project presents an Arduino based system designed to detect counterfeit currency in a simple, accurate, and cost effective manner. The proposed system utilizes an Arduino UNO microcontroller along with sensors such as colour sensors to analyze the physical and optical characteristics of currency notes. When a note is inserted, the sensor data is collected and processed by the Arduino, which compares the obtained values with predefined reference values of genuine currency notes to determine whether the note is authentic or counterfeit. The result is displayed in real time using an LCD module, providing immediate feedback to the user. The system is designed to be simple, efficient, and user-friendly, making it suitable for small businesses and general use. Its accuracy depends on proper sensor calibration and consistent environmental conditions during testing. The prototype was tested using different currency notes under controlled conditions and successfully identified genuine and counterfeit notes with satisfactory accuracy. The results demonstrate that the proposed Arduino-based system offers a low cost and reliable solution for currency verification, reducing dependence on manual inspection and improving detection efficiency.**

Keywords **--Counterfeit Currency detection, Arduino UNO, Colour sensor, LCD Display.**

I. INTRODUCTION

Counterfeit currency has become a significant economic and social issue worldwide. It refers to illegally produced imitation banknotes designed to closely resemble genuine currency with the intention of deceiving individuals, businesses, and financial institutions. The circulation of fake currency negatively affects the economy by reducing trust in legitimate notes, causing financial losses, and contributing to economic instability. In countries like India, where cash transactions are still widely used, this problem is more critical, creating a strong demand for reliable and automated detection systems.

Traditional methods of counterfeit detection mainly rely on manual inspection or standalone electronic detectors. While these methods can identify certain security features, they are often limited by human error, slow processing, and lack of accessibility for small businesses and general users. As counterfeit techniques continue to evolve with advanced printing technologies, traditional approaches alone are no longer sufficient.

To address these limitations, this project proposes an Arduino-Based Counterfeit Currency Detection System. The system uses an Arduino UNO microcontroller along with sensors to analyze the physical and optical features of currency notes. When a note is inserted, the sensors collect data which is then processed by the Arduino. The collected values are compared with predefined reference values of genuine currency notes to determine whether the note is authentic or counterfeit.

The result is displayed instantly on an LCD module, providing quick and clear feedback to the user. The system is designed to be simple, low cost, and efficient, making it suitable for use in small businesses and everyday applications. Its performance depends on proper sensor calibration and controlled environmental conditions to ensure accurate detection.

This Arduino-based system offers several advantages, including automation, reduced human error, and improved efficiency in currency verification. It provides a practical and affordable solution for counterfeit detection without relying on complex or expensive equipment. The system demonstrates how embedded electronics can be effectively used to solve real-world financial security problems in a simple and accessible manner.

II. LITERATURE REVIEW

Counterfeit currency has become a big problem around the world. Criminals are making fake notes that look almost the same as real ones, which causes loss to governments, businesses, and common people. To fight this, many researchers have worked on building systems that can quickly and accurately detect fake money.

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Sundravadivelu, K., et, al.[1] have carried out detailed counterfeit banknotes in real time since money is so central to our daily lives and is necessary for any business transaction. To do this, deep learning systems were integrated with the Internet of Things (IoT) model. Pre-trained deep learning models perform well as they require less data to run when compared to newly trained models. After testing the method on about 4002 photos representing four different denominations of Indian rupees (10, 50, 100, and 500), this study found that the proposed method has performed well.

Saida, A., et, al. [2] Furthermore, regarding counterfeit currency, we've got a new trick up our sleeves UV light and clever computers. Here's the deal real money often has hidden marks that only appear under UV light. But fakes need help to copy them. So, we use special UV LED lights to make these secret marks pop out. When we shine the light on money, it's like revealing a hidden message. But They are analyze the pictures and look for authentic money patterns that fakes can't replicate. It's like catching a fake red-handed. Because it's faster and better than old methods, it's like having a quick and reliable way to tell real money from fakes, especially in busy places like stores. By showing us hidden patterns and letting computers think, we're one step ahead of those trying to mess with our money. And as this idea grows, it could be a game- changer for keeping our cash safe.

Srarka, S., et, al.[3] however, Counterfeiting of currency notes remains a persistent global challenge with extensive economic consequences. This systematic review provides a comprehensive analysis of the detection techniques employed to combat counterfeit currency, involving various countries. The aim is to synthesize and evaluate the effectiveness of these methods, highlighting on the advancements made, and classifying areas of research with respect to its security features, conventional detection techniques, fuzzy logic and image processing techniques and other methods. Technological advancements have catalyzed the development of advanced detection tools and automated frameworks. Additionally, this systematic review identifies the significance of cross-disciplinary collaboration. It emphasizes the need for cooperation between graphic designers, printers, papermakers, and central banks to create secure currency designs and implement effective detection mechanisms. Moreover, the geographical scope of this review extends to various countries where each region faces unique challenges and employs distinct methods to detect counterfeit notes, reflecting the global diversity in counterfeit threats.

Venu, D. N., et, al.[4] have demonstrated fake currency notes are increasing day by day. For detecting the fake currency note is done by counting the number of interruptions in the thread line. For predicting the note is real or fake on the basis of number of interruptions. If the number of interruptions is zero, if it is real note otherwise it is fake. And also, we calculate the entropy of the currency notes for the efficient detection of fake currency note. The advancement of color printing technology has increased the rate of fake currency note printing and duplicating the notes on a very large scale.

Rao, P. S., et, al.[5] have proposed issue of counterfeit currency detection by integrating advanced image processing techniques with machine learning algorithms. The proposed methodology includes several essential stages, such as image comparison, segmentation, edge detection, feature extraction, and grayscale conversion, combined with machine learning models including K-Nearest Neighbors (KNN), Convolutional Neural Networks (CNN), and MobileNetV2. These image processing techniques play a significant role in extracting and analyzing distinctive features of currency notes, thereby improving the identification of authentic banknotes. Segmentation helps isolate important patterns, while edge detection and feature extraction enhance the recognition of intricate characteristics. Grayscale conversion further standardizes image representation, enabling more efficient processing and analysis. The integration of machine learning models contributes to improved classification performance, making the proposed approach effective for counterfeit currency detection.

While some promising results were obtained in the past, there still exist a few gaps in the literature:

1. Existing counterfeit currency detection systems are often expensive and not affordable for ordinary users and small businesses.
2. Many existing systems lack real-time monitoring and IoT-based connectivity for remote access and reporting.
3. Traditional counterfeit detection devices have complex architectures, making implementation and large scale deployment difficult.
4. Most existing methods rely on manual inspection, increasing the chances of human error and reducing efficiency.
5. Current systems provide limited automation and may not offer reliable detection in all scenarios.
6. Existing approaches have low accessibility and are not widely available for public use.

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7. Many counterfeit detection systems are not designed to support future scalability and IoT integration.
8. There is a lack of low-cost, automated, and real-time counterfeit currency detection systems suitable for practical deployment.

The proposed Arduino UNO based Counterfeit Currency Detection using IoT aims to address these gaps by developing an affordable, automated, scalable, and real-time detection system with improved accessibility and efficiency.

III. Proposed System

The proposed of this System is required three major Component are:

1. Microcontroller (Arduino UNO)
2. Color Sensor (TCS3200)
3. LCD Display (16x2 with I2C module)

Arduino UNO acts as the main controller or processing unit of the system. It receives data from the TCS3200 color sensor, processes the information, and compares the detected values with predefined reference values of genuine currency notes. Based on this comparison, the Arduino determines whether the scanned note is genuine or counterfeit and then sends the result to the display unit. Therefore, the Arduino UNO plays an important role in controlling the overall operation of the system and making detection decisions. The TCS3200 color sensor is used to scan and detect the color characteristics of a specific area on the currency note. It captures the RGB (Red, Green, and Blue) values of the note and converts them into signals that can be processed by the Arduino UNO. Since genuine and counterfeit currency notes often differ in color patterns and printing quality, these detected values help the system distinguish between authentic and counterfeit notes more effectively. As a result, the sensor plays an important role in improving the accuracy and reliability of the counterfeit currency detection process. The 16×2 LCD display with an I2C module is responsible for displaying the output generated by the system. It shows the detection results, indicating whether the scanned currency note is genuine or counterfeit, along with other relevant information. The I2C module helps reduce wiring complexity by enabling efficient communication between the Arduino UNO and the LCD display using fewer connection pins. As a result, the display unit provides a simple and effective way for users to view real-time detection outcomes and system status.

Together, these components work as an integrated system to provide a simple, low-cost, automated, and real-time solution for counterfeit currency detection.

By combining sensing, processing, and display functions, the system enables efficient identification of counterfeit notes while reducing the need for manual verification. This integration improves accessibility, enhances detection efficiency, and supports reliable real-time monitoring.

3.1 System Workflow

The overall workflow of the Proposed of the System:

1. *Currency Note Placement*

   The user places the currency note in front of the TCS3200 color sensor for scanning.

2. *Color Sensor Detection*

   The TCS3200 sensor captures the RGB values from a specific area of the currency note.

3. *Data Transmission to Arduino UNO*

   It detected RGB values are sent to the Arduino UNO for processing.

4. *Data Processing and Comparison*

   Arduino compares the scanned values with predefined reference values of genuine currency notes stored in the system.

5. *Decision Making*

   Based on the comparison, the Arduino determines whether the note is genuine or counterfeit.

6. *Display of Results*

   The result is displayed on the 16×2 LCD display, showing messages such as "Genuine Note" or "Fake Note".

3.2 Circuit Diagram

The circuit diagram illustrates the wiring connections and functional interaction among the TCS3200 color sensor, Arduino UNO microcontroller (ARD1), and LM016L LCD display (LCD1). These components work together to detect and display information related to counterfeit currency identification.

1. The TCS3200 color sensor is responsible for detecting the color characteristics of a currency note placed in front of it. Its pins (S0, S1, S2, S3, OUT, OE, VDD, and GND) are connected to specific digital and power pins of the Arduino UNO. The VDD and GND pins provide the sensor with a +5V power supply and ground connection, while the S0–S3 pins control sensor configuration. The OUT pin transmits the detected color data to the Arduino for processing.

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2. The Arduino UNO serves as the main processing unit of the system. It receives signals from the TCS3200 color sensor, processes the captured color values, and compares them with predefined reference values to determine whether the scanned currency note is genuine or counterfeit.
3. The LM016L LCD display is connected to both the Arduino UNO and the power supply. It receives processed information from the Arduino and displays the detection results in real time, such as color values or messages indicating whether the currency note is genuine or counterfeit.

Together, these components form an integrated system that enables low-cost, automated, and real-time counterfeit currency detection.

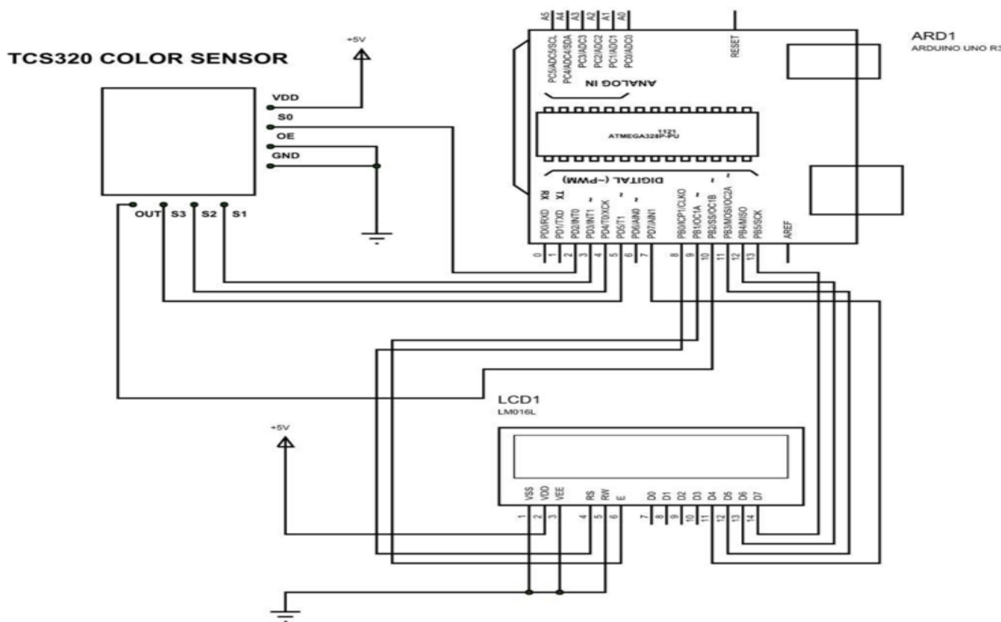

Fig: 1. Circuit Diagram

3.3 Systematic Diagram

The systematic diagram for counterfeit currency detection using IOT illustrates the high level functional blocks and their interconnections in a block diagram format. It shows the flow from note input to detection output and remote reporting without detailed wiring.

Key Components and Flow

1. *Input:* Currency note feeder with IV sensor detects note presence and triggers scanning.
2. *Sensor:* sensors UV, color, capture physical properties like fluorescence and patterns; data aggregated into a single stream.
3. *Microcontroller Arduino:* Central processing unit reads sensor data via ADC pins, applies threshold comparisons against stored genuine profiles, and outputs Genuine or Fake decision.
4. *Output Block:* Local indicators LCD display results diverges to alert for fakes.
5. System using Arduino for fast, real time display of result .

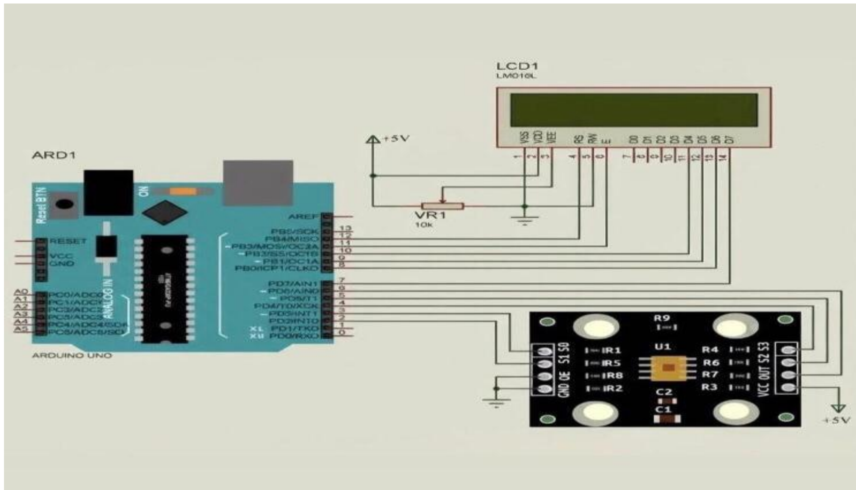

Fig: 2 Systematic Diagram

3.4 Flow Chart

The flowchart illustrates the working process of the proposed Arduino UNO-based counterfeit currency detection system using IoT. The process begins with scanning the currency note using the TCS3200 color sensor, which captures the RGB (Red, Green, and Blue) values from a specific area of the note. These detected values are then transmitted to the Arduino UNO for processing and comparison with predefined reference values of genuine currency notes.

Based on the comparison results, the system determines whether the scanned note is genuine or counterfeit. The detection outcome is displayed in real time on the LCD display and can also be transmitted through IoT technology for monitoring and future analysis. This workflow enables a low-cost, automated, and real-time approach to counterfeit currency detection, improving detection efficiency while reducing dependence on manual verification

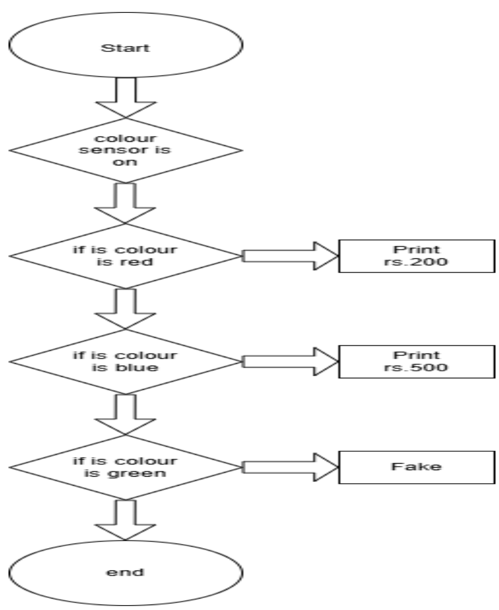

Fig: 3 Flow Chart

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3.5 Components Required for Counterfeit Currency Detection

The project requires very few components and the connection is also very simple. The components are listed below:

1. Arduino UNO * 1
2. LCD Display * 1
3. Color Sensor * 1
4. Connection Wire

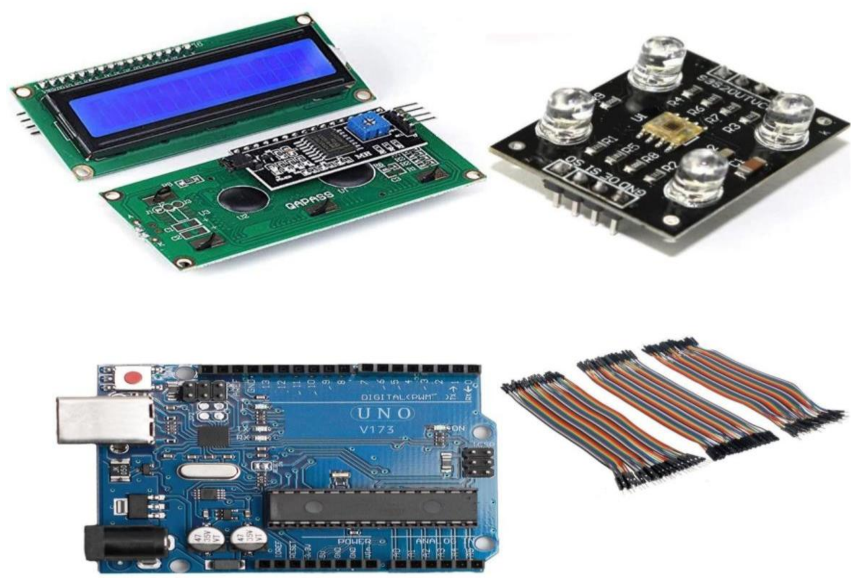

Fig: 4 figure components required

3.6 Circuit Connection

The circuit brings together all the components to allow the Arduino UNO to read color data from the sensor and display the processed results on the I2C LCD module. The TCS3200 color sensor is powered by connecting its VCC and GND pins to the Arduino's 5V and GND pins, respectively. Its control pins S0–S3, output pin (OUT), and output enable pin (OE) are connected to the Arduino's digital I/O pins (for example, S0–S3 to D4–D7, OUT to D8, and OE to GND). These connections enable the Arduino to control the sensor's internal color filtering mechanism and measure the frequency of output pulses, which represent the intensity of detected colors.

The I2C LCD module is also powered through the Arduino's 5V and GND pins, while its SDA and SCL pins are connected to the Arduino UNO's A4 (SDA) and A5 (SCL) pins. This allows communication using the I2C protocol with only two data lines, which helps reduce wiring complexity and improves system reliability.

All connections are made using male-to-female jumper wires on a breadboard to achieve a neat and organized circuit layout. Care is taken to ensure that all connections are short and secure in order to minimize noise and signal loss.

This helps maintain stable and reliable operation of the embedded system used for counterfeit currency detection based on color analysis.

3.7 Process Diagram

The process diagram of the Arduino Based Counterfeit Currency Detection System begins when a currency note is inserted into the detection slot, Once the note is detected, the Arduino UNO activates the connected sensors, such as the color sensor , to analyze the physical and optical features of the currency note.

The Arduino then processes the collected sensor data and compares it with predefined reference threshold values of genuine currency notes stored in the system.

Based on this comparison, the system determines whether the note is genuine or counterfeit. The result is displayed using LEDs or an LCD module, providing immediate feedback to the user. After displaying the result, the system automatically resets itself to prepare for the next currency note.

This workflow ensures a simple, efficient, and real-time approach to counterfeit currency detection using an Arduino based embedded system.

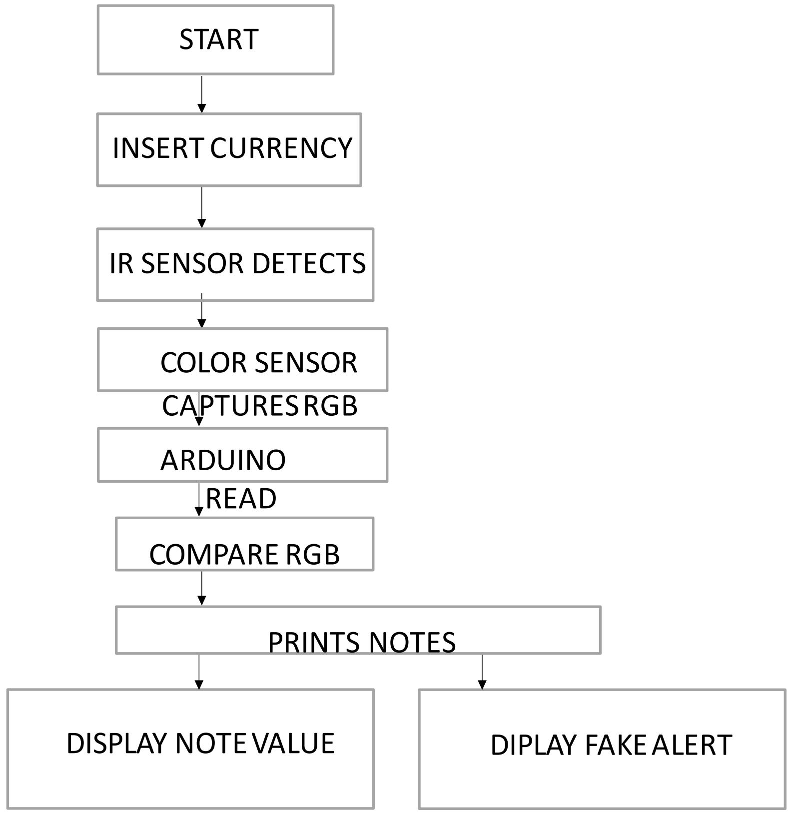

Fig: 5 Process Diagram

IV. Experimental Setup

The experimental setup was developed using three main components:

An Arduino UNO, a TCS3200 color sensor, and a 16×2 LCD display with an I2C module. The TCS3200 color sensor was used to scan a specific area of the currency note and capture its RGB values, then it detected values were transmitted to the Arduino UNO, which acted as the main processing unit by analyzing the sensor data and comparing it with predefined reference values of genuine currency notes.

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Based on the comparison results, the system determined whether the scanned currency note was genuine or counterfeit. The detection outcome was then displayed in real time on the 16×2 LCD display, providing immediate feedback to the user. During testing, currency notes were placed at a fixed distance from the sensor under controlled lighting conditions to ensure consistent measurements and improve detection accuracy.

The experimental setup was designed as a simple, low-cost, and automated counterfeit currency detection system, demonstrating the feasibility of using Arduino-based IoT technology for realtime currency verification

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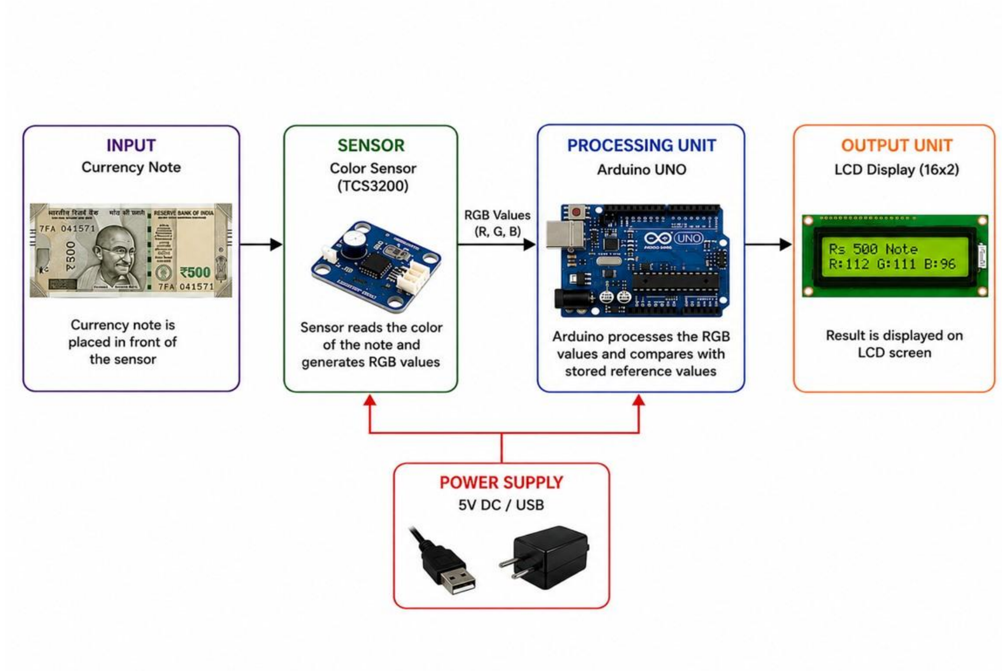

Fig:6: Block diagram of Arduino UNO based counterfeit Currency Detection System

V. Results And Analysis

Sample Result

Figure 5 illustrates the real time operation of the counterfeit currency detection system. During testing, a ₹500 currency note was positioned near the TCS3200 color sensor, which measured the reflected RGB color values from the surface of the note.

These values were then processed by the Arduino UNO and displayed in real time on the 16×2 LCD screen. The displayed RGB readings were compared with predefined reference values to determine whether the currency note was genuine or counterfeit. The experiment demonstrates the system's ability to perform fast and efficient currency verification using low cost hardware components.

Fig 7: result and analysis

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Table 1. shows the results obtained during testing of the counterfeit currency detection system.

Parameter	Observed Results
Sensor Used	TCS3200 color sensor
Micro-controller	Arduino UNO
Output display	16x12 LCD
Detect RGB value	R=112, G=110, B=96
Response time	Real time
Detection Method	RGB comparison
Performance	Stable under controlled solution

The TCS3200 sensor detected RGB values from the currency note, and the Arduino UNO processed these values. The detected RGB values (R=99, G=108, B=110) were displayed on the 16×2 LCD in real time. The system showed stable performance under controlled conditions and successfully performed counterfeit currency detection using RGB comparison.

VI. Limitation

One major limitation is the limited detection accuracy, as the system primarily depends on basic sensors and color sensors. These sensors may struggle to identify highly sophisticated counterfeit notes that replicate advanced security features found in genuine currency.

The system is also highly dependent on sensor calibration. Small changes in calibration settings or values can significantly affect detection accuracy, leading to incorrect results.

In addition, the performance of the system is influenced by environmental conditions, including lighting variations, sensor placement, and external interference. Such factors can alter sensor readings and reduce consistency during detection.

Another limitation is the inability to analysed complex security features present in modern currency notes, such as watermarks, microtext, holograms, and embedded security threads. Simple sensors alone cannot effectively verify these advanced characteristics.

The limited memory and processing capability of the Arduino UNO further restrict the implementation of advanced computational methods, including machine learning techniques and intelligent pattern recognition algorithms.

The lack of IOT based cloud integration and automatic database updates is another limitation of the system. Since there is no centralized update mechanism, the system cannot continuously learn from new data or improve its detection capability over time.

As a result, adapting to newly emerging counterfeit patterns becomes difficult, which may reduce the effectiveness of the detection process in the long run.

If lighting changes or a new counterfeit note closely matches these values, the system may give incorrect results because fixed thresholds do not adapt automatically.

Overall, while the proposed system offers an affordable and efficient approach for counterfeit currency detection, future improvements involving advanced sensors, adaptive algorithms, cloud connectivity, and intelligent data processing could significantly enhance its accuracy, scalability, and long term effectiveness.

VII. Discussion

The experimental results indicate that the proposed counterfeit currency detection system can effectively distinguish between currency notes based on RGB color values. The TCS3200 sensor successfully captured color information from the scanned note, while the Arduino UNO processed the data and displayed the results in real time on the LCD screen. The system demonstrated stable performance under controlled lighting conditions and a fixed sensor distance.

However, the detection accuracy may be affected such as lighting variations, the condition of the currency note like old, folded, or damaged notes and changes in sensor positioning. Although the system provides a simple, low cost, and efficient it may have limitations in identifying highly sophisticated counterfeit notes with color patterns similar to genuine currency. Future enhancements could involve integrating image processing or machine learning techniques to improve detection accuracy and increase the overall reliability of the system.

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VIII. Future Work

The proposed counterfeit currency detection system has the potential for further improvement to enhance its accuracy, reliability, and practical usability. Future developments may include integrating image processing and machine learning techniques to improve the detection of sophisticated counterfeit notes that closely resemble genuine currency. Although system could also be enhanced by incorporating additional sensors, such as UV or infrared sensors, to provide more advanced and reliable authentication.

Furthermore, improving sensor calibration and enabling the system to operate effectively under varying lighting conditions could increase detection performance. Future versions may also support the identification of multiple currency denominations and incorporate cloud based monitoring through IOT platforms for real-time data analysis and remote accessibility. These enhancements would contribute to a more accurate, efficient, and robust system, making it better suited for real world counterfeit currency detection applications.

IX. Conclusion

This counterfeit currency detection system using Arduino UNO, TCS3200 color sensor, and LCD display was successfully developed and tested for identifying currency notes based on RGB color values. The system demonstrated the ability to capture color information from currency notes, process the data in real time, and display detection results through the LCD screen. Experimental findings showed stable performance under controlled conditions, indicating that RGB-based detection can serve as an effective method for preliminary counterfeit currency identification.

The system offers several advantages, including low cost, simple implementation, and realtime operation. However, detection accuracy may be influenced by environmental factors such as lighting conditions, sensor positioning, and the physical condition of the currency note. Despite these limitations, the developed system provides a practical foundation for counterfeit currency detection.

Future improvements involving advanced sensors, image processing, and machine learning techniques could further enhance the system's accuracy, reliability, and applicability in real world environments.

This study demonstrates that low cost IOT based solutions can contribute to efficient and accessible counterfeit currency detection, with potential for further development into more advanced authentication systems.

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