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Smart System Approach for Prediction of Microbial Quality of Milk Using Machine Learning

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***Abstract:** Developing a real-time system to assess milk quality using Resazurin dye and machine learning. The system combines an Arduino Uno, color sensor, and LCD display to detect color changes in milk samples. These changes indicate microbial activity and quality. By integrating Python and machine learning algorithms, the system processes and analyzes data, providing accurate and immediate milk quality assessments. This automated solution enhances efficiency and reliability, reducing the need for manual inspections and improving overall dairy quality control.The system's ability to deliver accurate, real-time information underscores its potential for impactful use in scientific and industrial settings, highlighting its significance in the field of chemical analysis.*
***Keywords:** Milk quality, Random forest algorithm.*

I. INTRODUCTION

A. Overview of the System

IoT-Based Chemical Analysis and Prediction System

This project introduce a sophisticated method of chemical analysis by combining IoT sensors with AI-driven data processing. An Arduino Uno manages essential parts, such as a pH sensor for measuring acidity, These sensors are essential for applications such as milk quality assessment, which uses color changes to identify microbial load; an LCD screen shows sensor readings in real-time; and Python-based analysis improves predictive capabilities.

By utilizing AI, the system can detect adulteration and predict chemical properties with high accuracy, reducing manual labor, increasing reliability, and guaranteeing accurate monitoring. [1]

B. Objectives

1) Real-time monitoring, analysis, and prediction of chemical properties.
2) Automation of chemical analysis using IoT and AI.
3) Machine learning algorithms to detect chemical anomalies.

II. LITERATURE SURVEY

The study evaluates milk sample classification using machine learning modeling techniques, revealing random forest as the most accurate method with a 96% accuracy rate. The aim is to identify adulterants and define inspection methods for dairy products, particularly for children's consumption of milk.[2]

This paper proposes a deep learning technique using an autoencoder to extract product characteristics from sensory attributes evaluated by experts.

It combines bioprocess analysis for yogurt fermentation with machine learning approaches for milk quality prediction, aiming to create a comprehensive method for assessing yogurt fermentation and forecasting milk quality. [3]

This study compares the k-Nearest Neighbors (KNN) algorithm and its derivative, Distance-Weighted KNN (DW-KNN), for milk quality detection. The DW-KNN algorithm, which uses distance weighting, outperforms the conventional KNN method with an impressive accuracy of 99.53%, demonstrating the potential of distance weighting in improving milk quality detection. [4]

III. PROPOSED METHODOLOGY

A. System Overview

In order to improve accuracy and efficiency in chemical evaluations, this project focuses on creating a real-time chemical monitoring and prediction system by combining IoT-based sensors with AI-driven analysis. A dependable power source powers the system, which is managed by an Arduino Uno that runs the required code to enable smooth functioning. To assess a solution's acidity or alkalinity—a crucial factor in figuring out its chemical makeup—a pH sensor is integrated. By examining color changes, a color sensor is essential for detecting chemical reactions and determining the presence of particular compounds. For real-time monitoring, the gathered data is shown on an LCD, giving users immediate chemical property feedback. Python is used for predictive analysis and data processing. to the Serial Monitor for observation. The TCS3200 sensor's output is processed by the Arduino, where specific pins (S0 to S3) are configured to select color filters (Red, Green, and Blue). The pulseIn() function is used to measure the pulse width of the RGB channels, and these values are then printed to the Serial Monitor every second. This data can later be transmitted to a Python script, where machine learning models, like Random Forest, can classify the milk's quality based on the RGB values.

The Arduino code, written in the Arduino IDE, continuously collects and outputs the color data, allowing for real-time milk quality monitoring. [6]

B. Software and Hardware Used in the Smart Road Accident Detection System used in milk quality detection

1) Hardware's

a) Arduino UNO

The ATmega328P serves as the foundation for the Arduino/Genuino Uno microcontroller board. It features a 16 MHz quartz crystal, 6 analog inputs, 14 digital input/output pins (six of which can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button.

Everything required to support the microcontroller is included; to get started, just use a USB cable to connect it to a computer or power it with a battery or AC-to-DC adapter. You can experiment with your UNO without being overly concerned about making a mistake; in the worst situation, you can start over by replacing the chip for a few dollars.The Arduino Software (IDE) can be used to program the Arduino/Genuino Uno.

b) Liquid Crystal Display

LCD screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

c) PH Sensor

The Greenspan pH sensor utilizes a robust gel filled industrial pH electrode for field monitoring in a variety of environments.The pH electrode consists of a pH sensitive glass membrane sealed to a glass insulating tube containing a solution of fixed pH in contact with a silver-silver chloride half cell. The potential developed across the membrane is compared to a stable reference potential eg. a silver-silver chloride half cell in contact with a gel electrolyte containing chloride. Completion of the circuit is by means of a porous constriction (the salt bridge) which allows the reference electrolyte to slowly flow into the sample.

d) Color Sensor

A color sensor detects and identifies colors by measuring the wavelengths of light reflected from an object. It typically uses RGB or spectral sensors to analyze light and determine color. Common applications include industrial sorting, robotics, agriculture, and consumer electronics.

e) Power Supply

The Arduino Uno (or equivalent microcontroller) is powered via its 5V pin to ensure a stable 5V supply, which is necessary for proper operation of the microcontroller. A 5V regulated power supply—such as a USB power bank or a 5V power adapter—is used to provide this stable voltage.

f) Resazurin Sodium

Resazurin sodium is an ffective, simple, and cost-efficient tool for detecting milk spoilage based on microbial activity. Its ability to change color in response to reducing agents makes it an ideal candidate for real-time monitoring of milk quality, especially when combined with modern color sensors and machine learning techniques.

2) Software

a) Embedded C

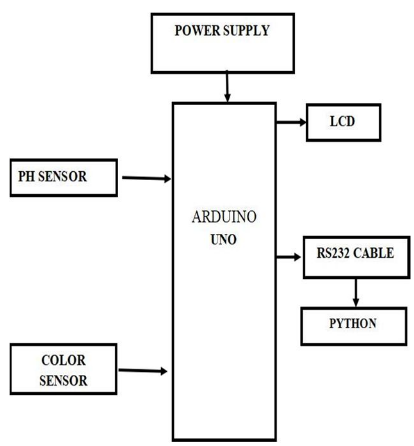
Embedded C is most popular programming language in software field for developing electronic gadgets. Each processor used in electronic system is associated with embedded software.Embedded C programming plays a key role in performing specific function by the processor. In day-to-day life we used many electronic devices such as mobile phone, washing machine, digital camera, etc. These all device working is based on microcontroller that are programmed by embedded C.The Embedded C code written in above block diagram is used for blinking the LED connected with Port0 of microcontroller.

b) Python

Python-based machine learning model to classify milk quality based on the color changes observed using a color sensor. The process begins by capturing RGB values from the milk sample using the sensor, which detects the color shift that occurs as the milk spoils. The color change is primarily induced by microbial activity, and the sensor measures the intensity of the Red, Green, and Blue (RGB) channels. These RGB values serve as the input features for our machine learning model.

For the classification task, we utilize the Random Forest algorithm, a powerful ensemble learning method known for its accuracy and robustness in handling classification problems. The model is trained on a data-set containing RGB values along with the corresponding milk quality labels (e.g., Fresh, Acceptable, Spoiled). After training the model on a subset of the data, it is tested on unseen data to evaluate its performance. Metrics such as accuracy, precision, recall, and F1-score are used to assess the model's effectiveness in classifying milk samples correctly.

Once the model is trained and evaluated, it can be deployed for real-time milk quality monitoring. The RGB values from a live milk sample, captured by the sensor, are passed to the trained Random Forest model, which then predicts the milk quality. This approach provides a non- invasive and cost-effective solution for quick and reliable milk quality detection, helping ensure the safety and freshness of milk in dairy production and processing facilities.



c) Arduino IDE

To implement milk quality detection using a color sensor and Arduino UNO, we develop a system that uses the TCS3200 color sensor to measure the RGB values from a milk sample. The sensor detects changes in the color of the milk caused by microbial activity, which can indicate whether the milk is fresh, acceptable, or spoiled. The Arduino UNO is used to interface with the TCS3200 sensor, reading the RGB values and sending the signals.

To the Serial Monitor for observation. The TCS3200 sensor's output is processed by the Arduino, where specific pins (S0 to S3) are configured to select color filters (Red, Green, and Blue). The pulseIn() function is used to measure the pulse width of the RGB channels, and these values are then printed to the Serial Monitor every second. This data can later be transmitted to a Python script, where machine learning models, like Random Forest, can classify the milk's quality based on the RGB values. The Arduino code, written in the Arduino IDE, continuously collects and outputs the color data, allowing for real-time milk quality monitoring.

IV. WORKING SYSTEM

The System illustrates the working mechanism by outlining the interaction between various hardware and software components. The system starts with a power supply, which ensures a stable energy source for all components. The Arduino Uno acts as the main controller,executing the code and managing data communication between sensors and output devices. The pH sensor measures the acidity or alkalinity of a solution, providing crucial chemical composition data. The color sensor detects chemical reactions by analyzing color changes, which is particularly useful in identifying adulteration in liquids like milk. The data collected by these sensors is processed in real time and displayed on an LCD screen for immediate visualization. Additionally, the data is sent to a Python-based AI model, which performs predictive analysis to determine solution quality based on historical trends and predefined parameters. The AI model enhances the system's ability to make accurate predictions, reducing the dependency on manual chemical testing. The system's automated nature ensures quick detection of anomalies and provides alerts when chemical properties exceed normal thresholds. This real-time monitoring and analysis approach makes the project highly applicable in industries such as food safety, pharmaceuticals, and environmental science. By integrating hardware and software, the system delivers precise, automated chemical evaluations, enhancing efficiency and reliability while minimizing human error. The block diagram represents a seamless connection between sensors, the microcontroller, display units, and AI-driven analytics, ensuring comprehensive chemical analysis and prediction.

V. RESULT AND DISCUSSION

1) Raw milk, pasteurized milk, and curd have distinct color space values (CIELAB) and RGB values due to their composition and processing.
2) Raw Milk appears white to pale yellow due to casein and fat.
3) RGB: (240-255, 235-250, 225-240)
4) Pasteurized Milk is slightly whiter due to protein changes during heating
5) RGB: (245-255, 240-255, 230-245)
6) Ghee is golden yellow due to carotenoids from milk fat.
7) RGB: (190-210, 150-180, 80-110)
8) These values help in quality control and adulteration detection in dairy products

Pasteurized milk			
Temperature	pH	color	Result
4-7	6.6	255	excellent
15-25	6.3	128	good
30-44	6.3	180	bad

Raw milk			
Temperature	pH	color	Result
37	4.5	225	excellent
39	4.2	128	good
35	4.2	225	bad

Milk product (Ghee)			
Temperature	pH	color	Result
10	4.5	225	excellent
20	4.4	128	good
25	4.2	255	bad

VI. CONCLUSION AND FUTURE SCOPE

The integration of an Arduino UNO with a TCS3200 color sensor provides an effective and cost-efficient method for monitoring milk quality based on color changes. By capturing real-time RGB values from the milk sample, the system can detect the degree of spoilage, offering a non- invasive solution for quality assessment. The collected data can be further processed using machine learning algorithms, such as Random Forest, to accurately classify milk as fresh, acceptable, or spoiled. This system offers a promising approach for ensuring milk safety and quality in dairy production, with the potential for integration into automated milk processing environments, improving both efficiency and consumer confidence in milk products.

In the future, the system can be integrated into automated dairy farms and processing plants for continuous, real-time monitoring of milk quality. By using sensors at multiple stages of milk production, the system can help track the quality from the farm to the consumer, ensuring optimal freshness and safety throughout the supply chain.

REFERENCES

[1] K. A. &. D. V. S. Sharma, "Internet of Things (IoT)-enabled smart sensor-based real-time monitoring system for food quality and safety.," Journal of Food Quality, 2021, 2021.

[2] M. &. O. D. León, "Machine Learning Applied to Milk Sample Classification.," Journal of Food Quality Monitoring, 45(2), 120-130., 2022.

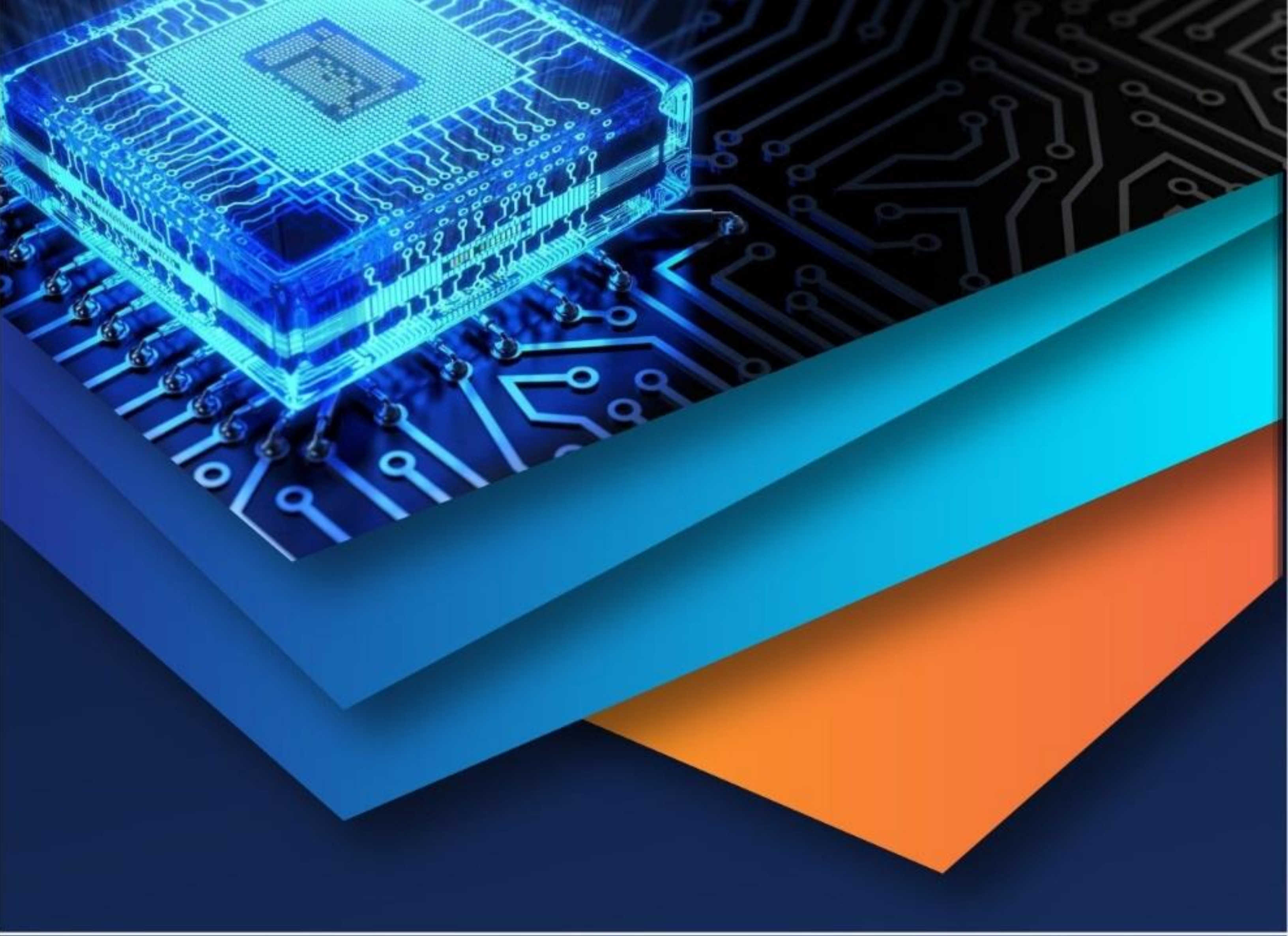
[3] S. Shinde, "Milk quality prediction and yogurt fermentation analysis using Machine Learning.," International Journal of Food Science and Technology, 58(4), 450-460., 2023.

[4] A. Samad, "Enhancing Milk Quality Detection with Machine Learning: A Comparative Analysis of KNN and Distance-Weighted KNN Algorithms,," International Journal of Dairy Technology, 59(1), 100-110., 2024.

[5] A. Çeli, "Using Machine Learning Algorithms to Detect Milk Quality," Eurasian Journal of Food Science and Technology. , 2022.

[6] S. M. M. Saranya, "IoT Based Smart Milk Monitoring System using Sensors," International Journal of Innovative Research in Computer and Communication Engineering, vol. 7, no. 4, pp. 2165-2171, 2019., 2019.

[7] M. A. K. a. M. K. Singh, "AI-Based Quality Monitoring System for Food Safety Applications," International Journal of Scientific & Technology Research, Vols. vol. 9, no. 2, pp. 2541-2546, 2020., 2020.



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