Effective Milk Grading and Billing Solution for Dairy Industry

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Abstract: The dairy industry faces persistent challenges in evaluating milk quality due to labor intensive and subjective processes. This project proposes a transformative solution integrating hardware and software technologies to revolutionize milk quality assessment and management. The system employs advanced sensors including pH, temperature, color and fat content sensors seamlessly integrated into a cost-effective device tailored for dairy farmers. This device facilitates real time monitoring of milk quality, empowering farmers to make data-driven decisions and optimize production efficiency. Complementing the hardware, an intuitive mobile application provides farmers with instant access to milk quality data, enabling proactive management of dairy operations. Transparent billing mechanisms ensure fairness and accountability in the dairy supply chain, generating precise invoices based based on objective milk quality metrics using a machine learning model. By enhancing transparency and efficiency, this solution promises to elevate milk quality standards and foster trust among consumers, thereby strengthening the dairy industry's competitiveness and sustainability.

Keywords: IOT, Microcontroller, Transparency in billing, Machine Learning, Model Integration, Application development.

I.   INTRODUCTION

The dairy industry is a vital sector of agriculture, providing essential dairy products to consumers around the world. The traditional methods of evaluating milk quality have long been mired in labour intensive subjective processes often prone to human error and inconsistency. In response to these challenges, this project presents a solution aimed at transforming milk quality assessment and management through the integration of hardware and software technologies. The proposed system offers a comprehensive and automated and automated approach to monitor milk quality in real-time, enhance billing transparency and provide insights for optimizing production efficiency.

The proposed solution consists of advanced sensors including pH, color, temperature and fat content sensors meticulously integrated into a cost-effective device tailored specifically for dairy farmers. This device not only ensures accessibility but also delivers reliable and standardized data, empowering farmers to make data driven decisions regarding milk production and quality assurance. Augmenting the hardware components is an intuitive mobile application, granting farmers and dairy owners instantaneous access to real-time milk quality data. Through this mobile application users can effortlessly monitor and manage their dairy operations, identifying trends, detecting deviations and implementing proactive measures to uphold milk quality standards.

The proposed solution incorporates transparent billing mechanisms, fostering trust and accountability across the dairy supply chain. By generating precise invoices based on objective milk quality metrics, this feature promotes equitable compensation for farmers while instilling confidence in consumers regarding the integrity of products they purchase.

II.   LITERATURE SURVEY

In [1], This Paper, the authors discussed for assessing and preventing milk with a high microbiological index from migrating farther downstream in a dairy supply chain, existing research takes a reactive stance. They contend that if the goal is to optimize milk life in terms of quality, such an approach is not the best course of action. They suggest a proactive strategy that keeps an eye on the parameters of temperature and level, which serve as the building blocks of the bacteria in milk.

The state at which the storage tank should store the milk in compliance with standards is then determined using this information. The real condition of the tank is then compared to this status, and if they differ, it will urge the farmers to take the necessary preventive measures to regulate the quality of the milk. proactive management designed by Raw A rule-based system and machine learning approaches are used to mimic the milk quality approach. degree of precision They use it on milk in order to validate our strategy and show how it may be used. a farm in Australia's Queensland.

In [2], this paper the authors described an users may verify the quality and amount of milk using an Internet of Things (IoT)-based system. The spread of germs will accelerate, and the milk will have an un-favorable odour if it is kept in storage for a number of days. The health of humans is seriously endangered by these tainted milk-producing bacteria. In order to stop future diseases, society urgently needs milk surveillance. The major goal of this project was to create a sensor-based electrical system for tracking the behaviour of several compounds in milk that can change the qualities of pure milk. Consequently, a monitoring system is required to find and identify milk deterioration. By using a variety of sensors to keep an eye on the milk characteristics, this work illustrates a unique method of milk quality testing.

In [3], this paper the authors described the creation and use of an Arduino controller-based system for the detection and analysis of milk parameters. The created system is lighter and smaller. It responds swiftly and uses little electricity to operate. It can therefore be used for portable applications. Future efforts will concentrate on raising the system's overall accuracy. It is also feasible to reduce the system's size and increase mobility so that it may be used freely in the field.

In [4], this Paper the authors analyzed and delivers a cutting-edge milk quality monitoring system based on Smart Sensor technology. All newborns main source of nutrition is milk, thus it is important to keep an eye on kids' security. The project's primary objective is to create products that assess the safety and quality of milk eaten. In order to determine several milk parameters, this study makes use of clever sensor technologies. To assess the milk's quality, variables including pH and temperature are taken into consideration. To assess if milk is warm or cold, temperature sensors are utilized. To detect the pH of milk, a pH sensor is utilized (that is, whether is acidic, basic or neutral). Milk's protein content is determined using the nitrogen sensor. If melamine is present in milk, it may be found by using the protein content. As a result, each of these sensors is integrated into the housing, and the monitoring indication displays the output outside (LED). Using a Bluetooth gadget, they may transmit a report to your smartphone (about milk quality).

III. SCOPE AND METHODOLOGY

Aim

The aim of the project is to automate the manual process used for determining the milk quality by developing a smart milk grading system that utilizes sensor technology, data processing and machine learning integration to accurately assess and manage the quality of milk. The system aims to provide dairy manager and farmers with real time insights into the quality of milk through mobile application. It contributes to the sustainability and competitiveness of dairy businesses while fostering innovation and advancement in dairy management practices.

Existing system

The approach for managing milk in the dairy industry typically involves a sequential process starting with milk collection, followed by quality testing, often done manually to assess factors like fat content and purity. Once tested, the data is manually entered into systems for record-keeping and further analysis. Finally, billing processes are carried out based on this data. This approach, while functional, is labor-intensive and prone to human error at various stages, potentially leading to inefficiencies and inaccuracies in billing and inventory management. There's a growing trend towards integrating automated systems and digital solutions to streamline these processes, improve accuracy, and enhance overall efficiency in the dairy supply chain.

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Milk → Dairy → Manual Quality Testing → Manual Entry → Billing
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Fig 1. Existing system

Proposed system

The proposed solution entails implementing an integrated system within the dairy industry, where milk undergoes automatic quality testing and grading processes. By leveraging technology, such as automated testing mechanisms, and integrating it with dairy production, it ensures fair pricing for both producers and consumers. Additionally, this system would include a mobile application that displays detailed information about the milk, including its quality grade, origin, and pricing, fostering transparency and trust within the dairy supply chain. This streamlined approach not only enhances efficiency but also empowers stakeholders with valuable insights, ultimately improving the overall quality and reliability of dairy products in the market.
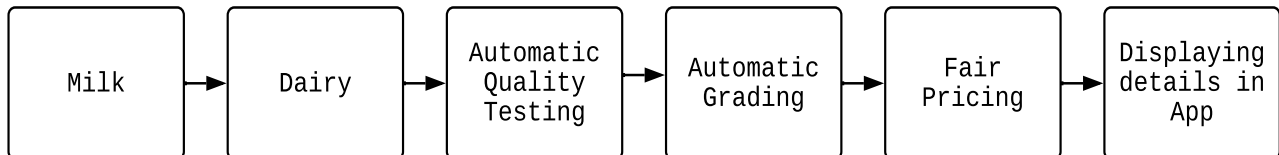

Fig 2. Proposed system

Architecture Diagram

Sensor Data Acquisition:
The project utilizes a device equipped with sensors including pH, temperature, color, Light Dependent Resistor(LDR) and Light Emitting Diode(LED).These sensors facilitate the measurement of various parameters such as pH level, temperature, color and fat content in milk. The LDR specifically gauges the intensity of light crucial for determining fat content. The relationship between resistance and light intensity directly relates to the amount of fat present in the milk sample. More fat in the milk leads to more scattering of light, resulting in less light reaching the photoresistor, thus decreasing its resistance. Conversely, lower fat content leads to less light scattering and increased resistance in the photoresistor.

Esp32 Microcontroller:
The ESP32, developed by Espressif Systems, is a versatile microcontroller widely acclaimed for its capabilities in IoT and embedded systems. Central to its prowess is a dual-core Tensilica LX6 microprocessor, enabling efficient multitasking and enhanced performance. Its built-in Wi-Fi and Bluetooth connectivity afford seamless wireless communication, making it a preferred choice for IoT applications. Remarkably, the ESP32 maintains energy efficiency, catering to battery-powered devices and projects requiring extended runtime. Its rich array of peripherals, from GPIO pins to SPI, I2C, UART, ADC, and DAC, offers extensive adaptability to diverse project needs. Supported by robust development tools like the ESP-IDF and Arduino IDE, the ESP32 facilitates both low-level programming and rapid prototyping. With its blend of advanced features and cost-effectiveness, the ESP32 has become a staple in the maker community and industry alike, driving innovation in IoT and embedded systems.

Dairy Owner Features:
Add Farmer: Dairy owners can add new farmers to the system, enabling them to register their milk.
View List of Farmers: Dairy owners can access a comprehensive list of registered farmers.
Generate Bill: Utilizing data fetched from Firebase, the system generates bills for milk transactions. This involves retrieving data such as milk quality parameters(e.g. fat content, color, temperature, pH) and forwarding it to an Application Programming Interface(API) created using Flask with a Decision Tree Machine Learning(ML) model.
View Generated Bills: Dairy owners have the capability to view all bills generate by their dairy.

Farmer Feature:
View Milk Transaction Details: Farmers can view detailed information regarding milk sold or provided to the dairy. This includes milk quality parameters and transaction history.
Quality Display on Mobile Application: The ML-generated milk quality is displayed on the mobile application, providing dairy owners and farmers with real-time insights into the quality of milk.
Farmers can view and analyze the milk quality and they can easily take the decisions based on the data-driven insights from the application.
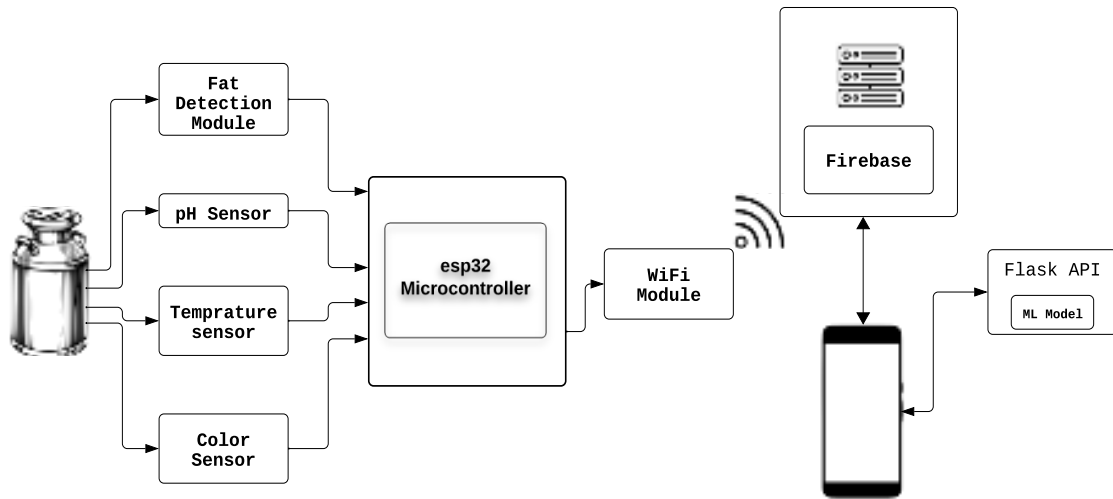
Fig 3. Architecture Diagram

IV.   RESULT AND DISCUSSION

The effectiveness of our milk quality assessment system, which integrates electronic sensors such as pH sensors, temperature sensors, color sensors, Light Emitting Diodes (LEDs), and Light Dependent Resistors (LDRs) for assessing various milk quality parameters. This system successfully calculates milk fat content and other quality parameters, facilitated by the real-time processing of data through a microcontroller. Additionally, our algorithm grades milk into categories such as Grade A, B, or C based on parameters indicating milk freshness, fat richness, and color purity, ensuring objective and consistent assessment. The integration of these components, alongside a user-friendly mobile application providing real-time access to milk quality data and billing information, enhances accessibility and efficiency in dairy operations, contributing to improved productivity and sustainability in the dairy industry.
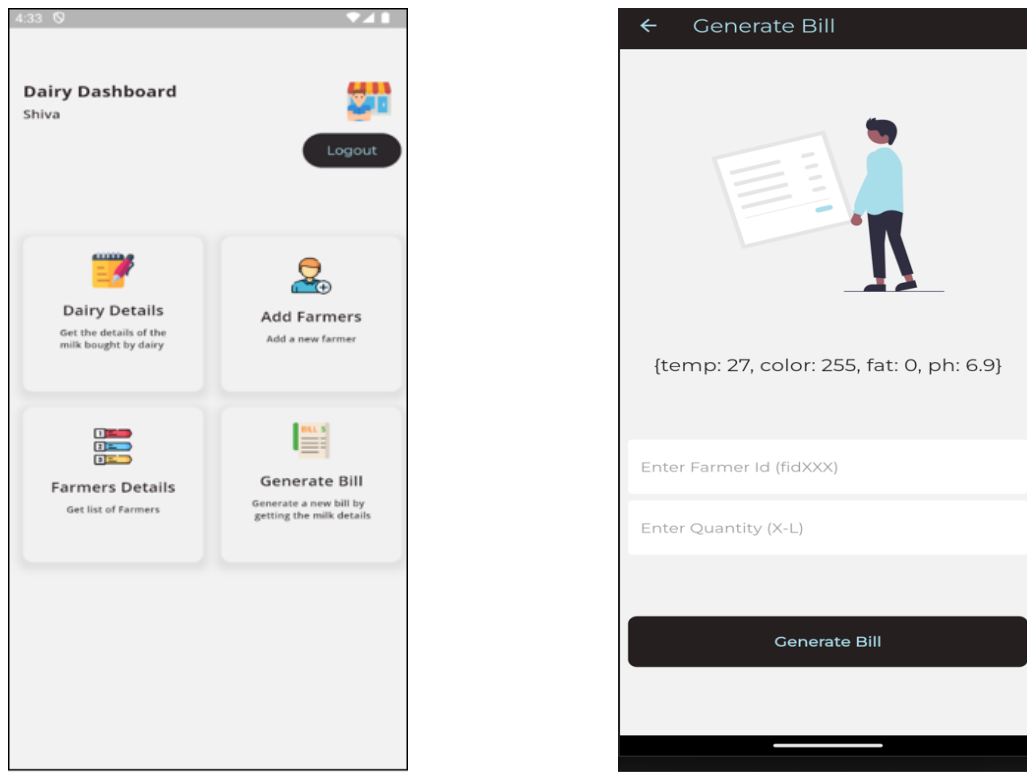

Fig 4. Grade calculated from ML Model

Fig 5. User Interface of the Application

V. CONCLUSION

The effective milk grading and billing solution for dairy industry presents a transformative solution for the dairy industry, offering advanced capabilities in milk quality assessment and management. By leveraging sensor technology, data processing, and machine learning integration, the system enables accurate measurement and analysis of various parameters crucial for determining milk quality, eliminating the need for manual testing and reducing the chances of errors. Integration with a mobile application provides dairy owners and farmers with convenient access to essential features such as milk transaction management and quality monitoring. The system's real-time quality display empowers immediate insights, facilitating informed decision-making and enhancing operational efficiency. The effective milk grading and billing solution for dairy industry promises to revolutionize dairy management practices, contributing to improved productivity and profitability in the industry. This can lead to a more effective and streamlined management process, ultimately benefiting both the farmer and organization.

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