A

Project Report

on

REAL TIME MILK QUALITY DETECTION SYSTEM USING MACHINE LEARNING

Submitted in partial fulfillment of the requirements
for the award of the Degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the project report entitled **"REAL TIME MILK QUALITY DETECTION SYSTEM USING MACHINE LEARNING"** *is a bonafide record of the project work done and submitted by*

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DECLARATION

We hereby declare that the project report entitled **“REAL TIME MILK QUALITY DETECTION SYSTEM USING MACHINE LEARNING”** submitted to the department of **ELECTRONICS AND COMMUNICATION ENGINEERING** in partial fulfillment of requirements for the award of the degree of **BACHELOR OF TECHNOLOGY**. This project is the result of our own effort and that it has not been submitted to any other University or Institution for the award of any degree or diploma other than specified above.

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ABSTRACT

"The Real Time Milk Quality Detection System using Machine Learning" project is designed to ensure the safety and quality of milk through an innovative integration of hardware and machine learning. The system uses an Arduino Mega 2560 to interface with various sensors that monitor key parameters of milk quality. These sensors include a pH sensor for acidity measurement, a temperature sensor for thermal stability, an LDR sensor for detecting light exposure, and a gas sensor for potential contamination. Data from these sensors is displayed on an LCD for immediate feedback. Machine learning algorithms process the collected data to predict the quality of the milk, identifying any deviations from safe standards. In the event of detected anomalies, the system activates a buzzer and sends an alert via GSM to notify the user. LEDs provide visual indicators of system status. The project combines embedded hardware with Python-based machine learning to offer a comprehensive, real-time solution for monitoring and ensuring milk quality, promoting safety and reducing the risk of consuming contaminated milk.

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ABBREVIATIONS

GSM	-	Global System for Mobile Communications
LCD	-	Liquid-crystal display
LED	-	Light-emitting diode
ML	-	Machine Learning
pH	-	Potential of Hydrogen

Chapter 1

INTRODUCTION

Milk is an essential and widely consumed food product across the globe, recognized for its nutritional value and importance in daily diets. However, the quality of milk can be compromised at multiple stages—from production and storage to transportation and consumption—posing significant health risks to consumers. Contaminated or adulterated milk can lead to serious health issues such as food poisoning, digestive disorders, and even long-term diseases. Therefore, it is vital to implement effective methods to monitor and ensure milk quality in real time.

Traditionally, milk quality assessment has relied on manual sampling and laboratory-based chemical testing. While these methods are accurate, they are time-consuming, require skilled professionals, and are not feasible for continuous monitoring. The growing demand for automation and real-time quality assurance in the dairy industry calls for innovative, efficient, and cost-effective technological solutions.

To address this need, the Real-Time Milk Quality Detection System using Machine Learning is proposed. This project integrates embedded hardware with intelligent software to continuously monitor milk quality and detect any anomalies using sensor data analysis and machine learning techniques. The core objective is to provide a reliable and automated solution that ensures consumer safety by minimizing the risk of consuming poor-quality or contaminated milk.

At the heart of the system is the Arduino Mega 2560 microcontroller, which serves as the central processing unit for interfacing with multiple sensors. These sensors are carefully selected to measure key indicators of milk quality. The pH sensor monitors the acidity level, which is a critical parameter for identifying spoilage. The temperature sensor ensures that the milk is stored within a safe thermal range, as excessive heat can accelerate bacterial growth. The LDR sensor

detects exposure to light, which can degrade certain milk components. In addition, the gas sensor identifies the presence of harmful gases that may indicate contamination.

The data collected from these sensors is immediately displayed on an LCD module, providing users with real-time feedback on the milk's condition. To enhance intelligence and predictionaccuracy, the system employs machine learning algorithms developed using Python.

These algorithms are trained on historical data to recognize patterns and accurately predict whether the milk meets the defined safety standards. In the event of a quality deviation, the system triggers a buzzer for audible alerts and uses a GSM module to send notifications to the user's mobile device, ensuring immediate attention and action.

Visual feedback is further enhanced through the use of LED indicators, which show system status at a glance—green for safe, yellow for warning, and red for unsafe. This multi-layered alert system ensures timely intervention, thereby reducing the likelihood of unsafe milk reaching consumers.

By combining hardware-level monitoring with intelligent data-driven analysis, this project delivers a robust, scalable, and user-friendly solution for real-time milk quality assurance. It is particularly useful in dairy farms, milk collection centers, and small-scale processing units where continuous laboratory testing may not be feasible. Ultimately, this system contributes to improved food safety, reduced wastage, and increased consumer confidence in dairy products.

1.1 PROBLEM STATEMENT

Milk is a vital source of nutrition consumed globally on a daily basis. However, its perishable nature makes it highly susceptible to contamination, adulteration, and spoilage during production, transportation, and storage. Traditional methods of milk quality testing often require laboratory equipment, skilled personnel, and time-consuming procedures, which may delay detection and pose health risks to consumers. Moreover, in many rural and semi-urban areas, access to such facilities is limited, increasing the chances of distributing substandard milk.

In recent years, there has been a growing need for a fast, reliable, and cost-effective method to monitor milk quality in real time. While chemical testing provides accurate results, it is not feasible for frequent, on-site testing due to complexity and expense. There is also a lack of automated systems that can continuously monitor milk quality and notify users instantly upon detection of any abnormal conditions.

This project addresses these challenges by proposing an innovative system that integrates embedded hardware and machine learning techniques to monitor milk quality parameters. By utilizing an Arduino Mega 2560 microcontroller interfaced with various sensors — including a pH sensor, temperature sensor, LDR sensor, and gas sensor — the system continuously collects data indicative of milk quality.

The collected sensor data is processed and analyzed using machine learning algorithms to classify the milk as safe or unsafe. Real-time alerts through a GSM module, LCD display, LEDs, and a buzzer provide immediate feedback to users, enabling swift action to prevent consumption of contaminated milk. This approach offers an accessible, scalable, and automated solution to enhance dairy safety, especially in remote and under-resourced areas.

The system ultimately aims to ensure public health, reduce milk wastage, and support dairy farmers and vendors in maintaining consistent quality standards.

1.2 PROBLEM OVERVIEW

Milk is one of the most essential dietary components, consumed by people of all age groups across the globe. Despite its nutritional value, milk is highly prone to contamination and spoilage due to factors such as poor storage, temperature fluctuations, exposure to light, and adulteration during transportation or handling. These issues not only affect the quality and shelf life of milk but also pose serious health risks to consumers.

The current methods for milk quality assessment largely rely on laboratory testing, which involves manual sampling and chemical analysis. While accurate, these processes are time-consuming, labor-intensive, and not feasible for real-time or on-site evaluation. In rural and semi-urban regions, the lack of access to modern testing facilities further exacerbates the risk of distributing contaminated milk to the public.

Additionally, the absence of continuous monitoring solutions leads to delayed detection of spoilage or adulteration, resulting in economic losses for producers and potential health hazards for consumers. There is an urgent need for a system that can autonomously and instantly detect changes in milk quality, providing alerts before the product reaches consumers.To address this challenge, the proposed project introduces a real-time milk quality detection system that integrates sensor technology with machine learning. Using an Arduino Mega 2560 microcontroller, the system collects data from various sensors: a pH sensor to measure acidity levels, a temperature sensor to detect heat-related changes, an LDR sensor to check for exposure to light, and a gas sensor to detect spoilage-related gases.

The sensor readings are processed by Python-based machine learning algorithms that classify the milk as fresh or spoiled. A visual and audible alert system, including LEDs, a buzzer, and a GSM module, ensures that users are immediately informed about the status of the milk. Data is also displayed on an LCD screen for real-time observation.

This low-cost, easy-to-deploy solution offers a practical alternative to laboratory testing by enabling automated, continuous monitoring of milk quality. By bridging the gap between hardware and artificial intelligence, the system helps ensure food safety, reduce waste, and support informed decision-making in the dairy supply chain.

1.3 METHODOLOGY FLOW GRAPH

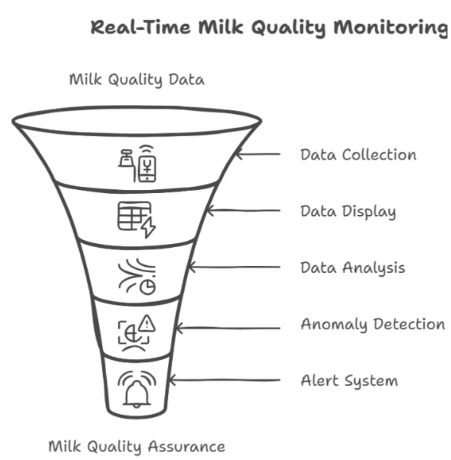

Fig 1.1: Methodology Flow Graph

1. Data Collection : Sensors (pH, temperature, LDR, gas) gather real-time data from milk, measuring vital parameters. Additional sources include manual inputs (visual inspections, lab results) and external databases (animal health, feed quality). All data is time-stamped for traceability.

2. Data Display: Real-time dashboards (charts, gauges)

3. Data Analysis(using ML): Machine learning detects hidden patterns and predicts quality

4. Anomaly Detection: Detects deviations from norms using ML

5. Alert System: Audio(buzzers), Remote notifications(SMS via GSM)

6. Milk Quality Assurance: Early spoilage/contamination detection

Chapter 2

LITERATURE SURVEY

Milk Quality Detection System combines embedded hardware and machine learning to ensure real-time milk quality monitoring and safety. The system employs an Arduino Mega 2560 microcontroller to interface with sensors, including a pH sensor for acidity, a temperature sensor for thermal stability, an LDR sensor for light exposure, and a gas sensor for contamination detection. Data from these sensors is displayed on an LCD and processed using Python-based machine learning algorithms to predict milk quality accurately. In case of abnormalities, the system triggers a buzzer, sends GSM notifications for remote alerts, and uses LEDs for visual status indication. This innovative approach provides an efficient, user-friendly, and automated solution for milk quality assessment, reducing risks of contamination and enhancing consumer safety.

Deep Learning Based Approach for Milk Quality Prediction by Kumari, S., Gourisaria, M. K., Das, H., & Banik, D. (2023) proposed a deep learning-based system for real-time milk quality detection, ensuring freshness and safety in dairy operations. Advanced sensors monitor key parameters like pH, temperature, color, and clarity, while IoT enables remote data collection. Machine learning models such as Random Forest, KNN, and ANN classify milk quality, with ANN achieving 99.88% accuracy. PCA revealed temperature and color as the most influential factors. Compared to traditional methods, ANN showed superior performance. These systems offer fast, cost-effective, and reliable analysis while reducing human error. Future advancements like portable devices and blockchain aim to overcome current challenges [1].

Milk Quality Monitoring System using IoT by Pugazhenthi, K., Sengamalam, A., & Ganesan, B. (2023) presents an IoT-enabled solution for real-time milk quality monitoring. The system uses sensors to detect critical parameters such as temperature, fat percentage, and pH to identify adulteration instantly. A NodeMCU microcontroller is integrated with these sensors, and the data is uploaded to the cloud for remote access via an IoT application. This approach enhances traceability and automation in milk processing. While effective, the study highlights the potential for future improvements in sensor technology and integration with machine learning to boost accuracy and precision [2].

Edge-AI Implementation for Milk Adulteration Detection by Mhapsekar, R. U., Abraham, L., O'Shea, N., & Davy, S. (2022) introduces a real-time milk adulteration detection system using Edge-AI technology. The system, built on a Jetson Nano board, employs a Convolutional Neural Network (CNN) for local processing, utilizing Fourier Transformed Infrared (FTIR) data to detect adulterants in milk with an accuracy of 94.87%. By processing data at the edge, the system enhances speed, reduces latency, and ensures better data security. It supports real-time tracking, making it effective for field-level dairy quality monitoring. The compact and scalable design enables integration into various stages of the milk supply chain. Future plans include enhancing the deep learning model for broader adulterant detection and integrating cloud computing for remote access and deployment. This approach offers a promising alternative to traditional lab-based quality checks, contributing significantly to modernizing milk quality assurance in dairy operations [3].

Milk Quality Prediction using Machine Learning Integrated with Arduino by Sunithamani, S., Muralidhar, D., Anne, G., & Sruthi, C. N. (2024) proposes a novel approach to milk quality prediction by integrating Arduino sensor technology with machine learning. The system focuses on key parameters such as pH, temperature, and turbidity, which are essential for determining milk quality. It applies various machine learning algorithms, including Support Vector Machine, Adaboost, and Random Forest, with the highest accuracy achieved using the Random Forest method. The research demonstrates that combining real-time monitoring through IoT connectivity can significantly enhance the assessment of milk quality. The system provides immediate feedback, making it valuable for ensuring quality control in dairy operations. Furthermore, the study suggests that future improvements could involve refining the machine learning models to achieve even higher prediction accuracy. Additionally, deploying the system on the web could improve its accessibility and make it available for widespread use, thus making it more accessible for small-scale and large-scale dairy producers. This integration of Arduino with machine learning techniques highlights the potential of low-cost, efficient systems for real-time milk quality monitoring. The research paves the way for future advancemets[4].

Detection of Milk Quality Utilizing Fourier Transform Infrared Spectroscopy by Momin, A., Rohith, C. S., Pranav, G., Sathwik, P., & Gangashetty, S. V. (2024) presents a milk quality detection system that integrates machine learning with Fourier Transform Infrared (FTIR) spectroscopy. The system uses the VGG-16 deep learning model to analyze FTIR spectrum data, enabling the detection of key milk quality attributes such as protein and fat percentage. This approach achieves an impressive accuracy of over 95% in detecting milk composition and identifying adulteration. The use of FTIR spectroscopy provides a non-destructive and precise method for milk quality assessment, making it a valuable tool for dairy industry applications. By utilizing machine learning, the system offers advanced capabilities in analyzing complex spectroscopic data, improving the speed and accuracy of quality control. The research highlights the potential of this system to enhance dairy quality assurance processes by providing more reliable and consistent results than traditional methods. Additionally, the study indicates that the integration of FTIR with machine learning can revolutionize the way milk quality is assessed in real-time. Future studies will focus on refining the deep learning model, expanding the dataset to include diverse milk samples, and evaluating the cost-effectiveness of the system for widespread use in dairy industries. This approach is expected to offer an affordable and efficient solution for large-scale milk quality monitoring, ensuring better consumer safety and product reliability [5].

Hybrid Blended Deep Learning Approach for Milk Quality Analysis by R. U. Mhapsekar, N. O'Shea, S. Davy, and L. Abraham (2024) proposes a Hybrid Blended Deep Learning (HyBDL) framework to improve milk quality analysis. The framework integrates Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), and Gated Recurrent Units (GRU) to enhance classification performance. The system processes Fourier Transform Infrared (FTIR) spectral data, achieving an impressive accuracy of 98.03% in detecting variations in milk quality and adulteration. Compared to traditional deep learning models, the HyBDL framework excels in accuracy while reducing preprocessing complexity. The research effectively demonstrates the practical and theoretical effectiveness of this approach in real-time milk quality analysis, making it ideal for use in dairy plants. By leveraging the capabilities of deep learning, the system offers faster and more accurate quality assessments than conventional methods. Future developments will focus on implementing the system on edge devices to enable on-site analysis and further increase dataset size for better model training. Additionally, energy efficiency will be a priority in future work to make the system more sustainable and cost-effective. This hybrid approach is expected to significantly improve milk quality monitoring in dairy operations, contributing to more reliable and standardized quality assurance. The research outlines the potential of HyBDL to transform dairy industry standards for milk quality analysis and adulteration detection [6].

Using Machine Learning Algorithms to Detect Milk Quality by A. Çelik (2022) explores the use of machine learning to assess and monitor milk quality. The study emphasizes the significant nutritional value of raw milk, which is rich in protein, fat, vitamins, and minerals essential for human health. The quality and composition of raw milk are influenced by factors such as the breed of the animal, the type of fodder, and the conditions in which the cows are raised. While raw milk offers numerous health benefits, the research highlights the need for proper processing, storage, and quality control to ensure its safety. The study points out that improper handling of milk can lead to contamination or adulteration, which can pose health risks to consumers. To mitigate these risks and preserve the milk's nutritional benefits, effective measures must be implemented during milk production and handling. By integrating machine learning algorithms, the research aims to improve the detection of milk quality and provide real-time monitoring, ensuring that milk remains safe for consumption. The use of technology can assist in detecting adulteration and ensuring milk’s compliance with quality standards, thus enhancing food safety. This approach underscores the importance of both technological and operational efforts in maintaining milk quality. The findings offer insights into how machine learning can be a valuable tool in the dairy industry to support food safety practices [7].

Key Milk Adulterants in India and their Detection Techniques by R. P. Gangodagamaarachchi, H. Pasqual, and S. Jayathilake (2021) investigates the prevalent milk adulterants in India, such as formalin, urea, detergents, and synthetic milk, which pose significant health risks. The study evaluates various detection methods, including chemical, spectroscopic, and electrical techniques, each with its advantages and drawbacks. While lab-based methods offer accurate results, they are often expensive and complex, limiting their practicality for everyday use. The research emphasizes the need for affordable and portable detection devices that utilize electrical sensors and nanomaterials to offer real-time, on-site detection of milk adulterants. Such devices would enable both consumers and regulatory authorities to monitor milk quality quickly and efficiently, ensuring safety and compliance with health standards. The study highlights the importance of developing reliable, user-friendly systems that can be used in routine milk quality checks. By incorporating these technologies, it is possible to reduce the risks associated with milk adulteration while making the detection process more accessible and cost-effective. Future research directions should focus on refining these devices for better accuracy, scalability, and affordability, making them a valuable tool for ensuring milk safety. This approach could revolutionize the milk quality assurance process, providing real-time solutions to a persistent problem in the dairy industry [8].

Smart Milk Quality Analysis and Grading Using IoT by P. Kominakis, Z. Abas, I. Maltaris, & E. Rogdakis (2002) proposes an Internet of Things (IoT)-based real-time milk quality evaluation and grading system. The system employs sensors to monitor key parameters such as pH, temperature, and fat percentage, which are crucial indicators of milk quality. After collecting data, the information is uploaded to a cloud platform for processing, where a machine learning model is used to grade the milk according to its quality. This system aims to enhance the efficiency of dairy monitoring, ensuring improved milk safety and quality control. The research emphasizes the potential benefits of such a system in real-time applications, particularly in large-scale dairy operations, by providing quick and accurate quality assessments. Future improvements could focus on enhancing sensor precision, integrating more advanced AI techniques to classify milk quality with greater accuracy, and expanding the use of cloud-based analysis for broader dairy industry applications. This approach not only promises to streamline the quality control process but also provides a scalable solution for maintaining high standards in milk production. The study also suggests that continued advancements in IoT and machine learning could further optimize the grading process and contribute to more reliable and consistent milk quality monitoring [9].

Development of Spectroscopic Sensor System for an IoT Application of Adulteration Identification on Milk Using Machine Learning by S. Saravanan, K. M, K. N S, K. N S, and N. V I (2021) introduces an IoT and machine learning-based sensor system designed to detect milk adulteration. The system utilizes spectral data analysis to identify adulterants such as water, flour, and detergent with high accuracy. This approach allows for real-time quality checks and inspections, reducing the reliance on manual testing and offering a low-cost alternative for milk safety monitoring. The research highlights the potential of using IoT and machine learning for automated adulteration detection, enabling faster and more efficient quality control processes. Future developments aim to improve sensor accuracy, expand the system's ability to detect additional adulterants, and incorporate artificial intelligence (AI) to enhance data analysis. By automating the adulteration detection process, this system offers a significant advancement in ensuring the quality and safety of milk, especially in large-scale dairy operations. The study emphasizes the importance of further research into sensor technology and AI-driven solutions for better milk quality management. Such innovations could lead to widespread adoption in the dairy industry, improving both consumer safety and industry standards [10].

The paper "Development of Spectroscopic Sensor System for an IoT Application of Adulteration Identification on Milk Using Machine Learning" by S. Saravanan et al. (2021) presents an IoT-based sensor system for detecting milk adulteration through machine learning. The system analyzes spectral data to identify various adulterants like water, flour, and detergent, offering high accuracy. This technology enables real-time monitoring of milk quality, reducing manual testing and providing a cost-effective solution for milk safety. The use of IoT allows for continuous quality checks in large-scale dairy operations, offering efficiency and speed. Machine learning enhances the system's ability to identify adulterants quickly, ensuring better consumer safety. Future research aims to improve sensor precision and extend detection capabilities to other potential adulterants. The integration of AI in data analysis is also explored to optimize performance. This approach paves the way for automated adulteration detection, which could revolutionize milk quality control. The study stresses the need for ongoing advancements in sensor technologies and AI solutions to improve milk safety management. Such developments could lead to industry-wide adoption, enhancing both standards and consumer trust in dairy products. The research underscores the role of IoT and machine learning in shaping the future of food safety.[11]

The paper proposes a method for detecting multiple adulterants in milk by coupling variable selection techniques with Partial Least Squares Regression (PLS2), Artificial Neural Networks (ANN), and Support Vector Machines (SVM) using spectral data. This approach allows for the simultaneous identification of various adulterants in milk, such as water, detergent, and starch, by analyzing their spectral characteristics. The use of variable selection ensures that only the most relevant spectral features are used, improving the model's accuracy and efficiency. The combination of PLS2, ANN, and SVM enhances the detection capabilities, enabling precise adulterant identification even in complex mixtures. The system offers a non-invasive and rapid detection method, which is cost-effective for large-scale dairy operations. This research highlights the potential of integrating machine learning techniques for real-time milk adulteration detection, ensuring better milk quality control and consumer safety. The paper also discusses the need for further advancements in sensor technology and machine learning to improve the system's robustness and extend its application to other types of adulterants. Future work could focus on optimizing the detection models and enhancing their ability to process larger datasets in real-time. The study underscores the importance of continued research into the application of machine learning for improving food safety standards, particularly in the dairy industry [12]

This paper presents an IoT-enabled spectroscopic sensor system integrated with machine learning algorithms for detecting adulteration in milk. The system uses spectral data to accurately identify common adulterants such as water, starch, and detergent. By leveraging the power of machine learning, the proposed system can analyze patterns within the spectral data for quick and reliable adulteration detection. It offers a real-time, non-invasive solution that significantly reduces the dependency on manual testing procedures. The IoT integration allows for continuous remote monitoring, making it ideal for large-scale dairy operations. The study demonstrates how machine learning models can improve detection accuracy while also reducing operational costs. The research emphasizes the potential of combining sensor technology with intelligent algorithms for automated milk quality control. Future developments are directed toward enhancing sensor sensitivity, expanding the adulterant detection range, and refining data analysis through advanced AI techniques. The system holds promise for transforming milk quality assessment, ensuring better safety and regulatory compliance. This innovative approach could help achieve standardized milk quality monitoring across the dairy industry. The study reinforces the significance of IoT and machine learning in advancing food safety and quality control solutions [13].

Chapter 3

EXISTING AND PROPOSED METHOD

3.1 EXISTING METHOD

3.1.1 Manual Monitoring

Traditional methods for assessing milk quality often rely on manual testing and sensory evaluation, such as taste and smell, or simple chemical tests conducted in a laboratory setting. These methods, while effective, are typically time-consuming, require specialized equipment, and are not feasible for real-time monitoring. Additionally, they lack the ability to provide continuous, automated quality assessments, leading to potential delays in identifying and addressing milk contamination or spoilage. The reliance on manual processes can also introduce human error and inconsistencies in quality measurement.

3.1.2 Drawbacks of Manual Monitoring:

- Time-Consuming: Regular monitoring requires considerable effort and time.
- Inconsistent: Manual readings can be inaccurate if not done correctly.
- Lack of Real-time Data: Changes in environmental conditions are not immediately detectable, which may delay corrective actions.
- Limited Automation: No automated adjustments based on sensor data, which makes it difficult to react to changes promptly.

3.2 PROPOSED METHOD

The **MilkSafe system** is an innovative solution that combines embedded hardware and machine learning to ensure real-time monitoring and prediction of milk quality. Built on the versatile **Arduino Mega 2560 microcontroller**, the system integrates a suite of sensors, including **pH, temperature, Light-Dependent Resistor (LDR), and gas sensors**, to monitor critical parameters indicative of milk freshness. This setup provides a robust foundation for automated, data-driven quality assessments.

MilkSafe employs a machine learning framework implemented in Python, enabling advanced analysis of the sensor data. By identifying patterns and anomalies, the system predicts milk quality with high accuracy and detects potential spoilage before it becomes apparent.

Thisapproach represents a significant improvement over traditional manual testing, offering faster, more reliable results.

The system provides **real-time feedback** through a user-friendly **LCD display**, ensuring that users have immediate access to quality metrics. When abnormalities are detected, MilkSafe activates a multi-channel alert system that includes **LED indicators, a buzzer, and GSM-based notifications**. These features ensure that users are promptly informed of any issues, whether they are on-site or remote, allowing for quick corrective actions to prevent spoilage.

A key feature of MilkSafe is its ability to operate continuously, providing uninterrupted monitoring without the need for constant human supervision. This makes it an invaluable tool for dairy farms, processing facilities, and supply chain operators, where maintaining milk quality is essential. By reducing reliance on manual checks, the system not only enhances efficiency but also minimizes human error, resulting in a more consistent and reliable quality control process.

Additionally, the affordability and scalability of MilkSafe make it accessible to a wide range of users, from small-scale dairy farmers to large industrial facilities. Its modular design allows for customization to suit specific operational needs, such as integrating additional sensors or adjusting the machine learning algorithms to handle varying milk types and conditions.

In conclusion, MilkSafe sets a new standard for milk quality assurance by combining hardware precision with the analytical power of machine learning. Its real-time capabilities, robust alert mechanisms, and user-friendly interface ensure that stakeholders can maintain the highest quality standards in milk production and distribution. This innovative system not only enhances consumer safety but also supports producers in minimizing waste and optimizing their operations.

3.2.1 BLOCK DIAGRAM

1. Power Supply:

It provides electricity to the Arduino and other connected components.

2. Arduino:

This is the microcontroller that inputs the data from various sensors and actuates the output devices. This is the controller of the system.

3. Sensors:

-*PH Sensor:* Measures the pH level of a milk.

-*Temperature Sensor*: Measures the Milk temperature.

-*LDR Sensor:* Light Dependent Resistor sensor, which senses the light level.

-*Gas Sensor:* Used to sense the presence of various gases in the milk.
-*USB Cable:* Used for programming the Arduino and can also provide power.

4. Output Devices:

-*LED:* Light Emitting Diode, for providing a visual indication or feedback.

-*LCD:* Liquid Crystal Display, for displaying the sensor reading or system status.

-*GSM*: Global System for Mobile Communications module, for sending and receiving messages Or data over cellular network.

-*Buzzer:* Provides audio warning or alert. Function: This is likely to be a component of some project or system to track Milk conditions (e.g., pH, temperature, light, and gas level) and provide feedback or alerts through LEDs, an LCD display, a GSM module, and a buzzer. The Arduino is the central processing unit, using sensor inputs to manage the outputs to provide real-time information and alerts.

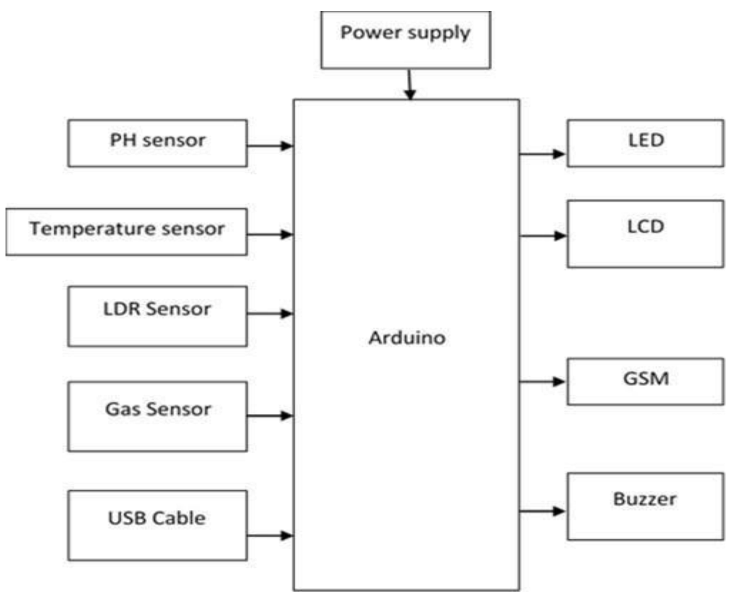

Fig 3.1: Block Diagram

Chapter 4

HARDWARE AND SOFTWARE REQUIREMENTS

4.1 HARDWARE REQUIREMENTS

4.1.1 Analog pH Sensor:

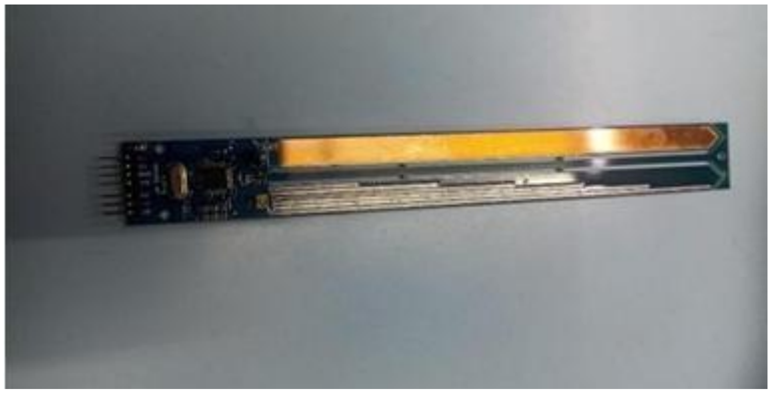

Fig 4.1: Analog pH Sensor

The analog pH sensor is a key indicator of spoilage or contamination. This sensor is designed to provide continuous, real-time pH readings, ensuring timely detection of any changes in milk acidity. It consists of a probe that comes in direct contact with the milk and generates a voltage signal proportional to the pH level. This analog signal is then fed into the Arduino Mega 2560, which converts it into a digital value for further processing. Accurate pH measurement is essential because milk becomes acidic when it starts to spoil due to microbial activity. The sensor helps in identifying this early stage of spoilage, enabling the machine learning model to classify the milk quality more effectively. It is user-friendly, easy to calibrate, and suitable for integration with embedded systems. The compact design and compatibility with standard BNC connectors make it a reliable component in real-time applications. In this project, it ensures that the system provides precise acidity data for accurate predictions. The analog pH sensor enhances the reliability of the system and contributes significantly to food safety.

4.1.2 Temperature Sensor (DS18B20):

The Temperature Sensor (DS18B20) is a key indicator of its freshness and safety. This digital temperature sensor is known for its high accuracy and ease of integration with microcontrollers like the Arduino Mega 2560. The DS18B20 provides 9 to 12-bit Celsius temperature measurements

and communicates over a 1-Wire bus, requiring only one data line for communication, making it

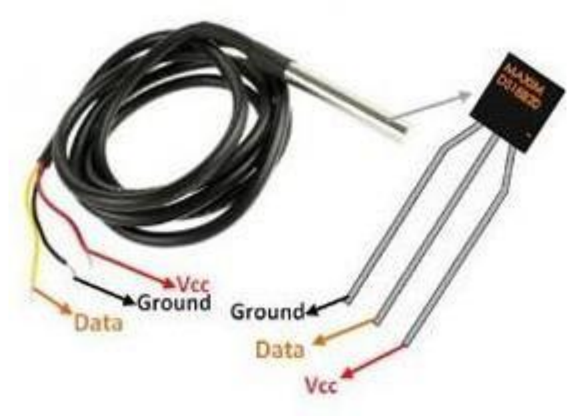

Fig 4.2: Temperature Sensor

efficient for embedded applications. Its waterproof casing makes it suitable for liquid-based applications like milk quality detection. The sensor continuously measures the temperature of the milk and sends real-time data to the Arduino, which then displays it on the LCD and forwards it to the machine learning model. By analyzing temperature trends, the system can detect any abnormal thermal variations that may indicate spoilage. If the temperature crosses predefined safe thresholds, the system activates an alert mechanism including a buzzer, LED indicators, and a GSM-based notification to the user. The DS18B20 ensures reliable and consistent temperature data, enabling accurate quality prediction. Its compatibility, precision, and robustness make it an essential component in this integrated hardware-machine learning project.

4.1.3 Light-Dependent Resistor (LDR):

The Light-Dependent Resistor (LDR) is a type of resistor whose resistance changes based on the intensity of light falling on it. In this project, the LDR is used to monitor the exposure of milk to light, which can significantly impact its quality. Prolonged exposure to light, especially UV rays, can degrade nutrients in milk and promote bacterial growth, leading to spoilage. The

LDR detects such exposure by measuring changes in ambient light around the milk container. It helps in identifying improper storage conditions or breaches in packaging that allow light to penetrate. The LDR is connected to the Arduino Mega 2560, which reads the analog signals from the sensor and processes the data in real-time. If unusual light levels are detected, this

information is combined with other sensor readings and passed to the machine learning model for quality prediction. In case of any abnormality, alerts are triggered to notify the user. The LDR thus enhances the reliability of the system by adding another dimension of environmental monitoring, ensuring comprehensive milk quality assessment.

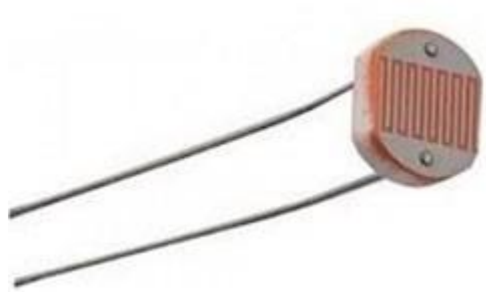

Fig 4.3: LDR

4.1.4 Gas Sensor (MQ-3):

Fig 4.4: Gas Sensor

The Gas Sensor (MQ-3) plays a role in detecting the presence of harmful gases or spoilage-related vapors emitted by contaminated milk. The MQ-3 sensor is known for its high sensitivity to alcohol, making it effective in identifying microbial activity and fermentation byproducts that may indicate spoilage. It operates on a simple analog principle, where changes in gas concentration cause variations in the sensor's resistance, which can be interpreted by the Arduino Mega 2560. The sensor's fast response time and stable performance make it ideal for real-time monitoring. It is integrated into the system to continuously analyze the air above the milk sample, providing valuable data that complements readings from the pH, temperature, and LDR sensors. This data is then processed by machine learning algorithms to assess the overall

quality of the milk. In case of contamination, the system triggers alerts via a buzzer and GSM module, ensuring immediate user notification. The MQ-3 sensor enhances the system's capability to detect spoilage early, supporting the goal of promoting milk safety.

4.1.5 LCD (Liquid Crystal Display):

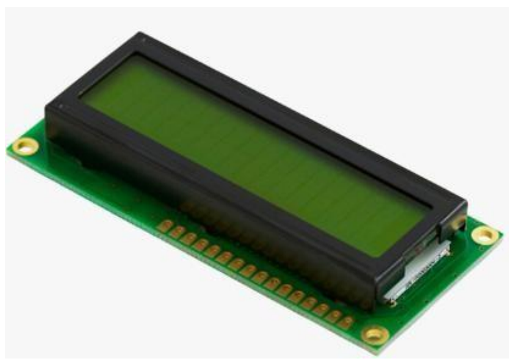

Fig 4.5: LCD

The LCD (Liquid Crystal Display) serves as an essential hardware component that displays live sensor data, including pH levels, temperature readings, gas concentration, and light intensity, allowing users to instantly assess the condition of the milk. By showing accurate and updated information directly from the sensors connected to the Arduino Mega 2560, the LCD enhances the system's user-friendliness. It eliminates the need for external devices to view results, making the system compact and self-contained. The LCD also communicates alerts related to abnormal conditions or potential contamination, providing a clear understanding of the current milk status. This visual output helps in quick decision-making and immediate action, especially in dairy industries or storage units. With the help of the LCD, users can continuously monitor milk parameters without needing technical expertise. The real-time nature of the display ensures timely identification of deviations from standard quality metrics. It also adds a layer of transparency, allowing users to verify sensor functionality and system performance at a glance. Furthermore, the LCD supports the project's goal of automation by offering a direct, readable interface. Its integration with the Arduino through I2C or standard connections simplifies coding and reduces wiring complexity. The use of a 16x2 or 20x4 LCD is common for such applications, providing adequate space for displaying essential data. Overall, the LCD is a vital component that bridges the hardware and the user, making the system informative and interactive.

4.1.6 GSM:

The GSM module enables wireless communication for remote alerts. As part of the hardware setup, the GSM module interfaces with the Arduino Mega 2560 to send SMS notifications whenever milk quality parameters deviate from safe levels. This real-time communication ensures that users are promptly informed about potential milk spoilage or contamination, even when they are not physically near the system. The GSM module uses a SIM card to connect to a mobile network, making it possible to send alerts to any registered mobile number. Its integration adds a valuable safety feature to the system, providing an immediate response mechanism in case of anomalies detected by the sensors. When the pH level, temperature, gas content, or light exposure indicates poor milk quality, the Arduino processes the sensor data and triggers the GSM module.

Fig 4.6: GSM

This functionality supports timely intervention, such as halting distribution or notifying quality control personnel. The GSM module is compact, cost-effective, and easily programmable with AT commands. It typically operates on a 5V power supply and communicates using UART serial communication. Modules like SIM800L or SIM900 are commonly used due to their reliability and compatibility. Overall, the GSM module enhances the system's effectiveness by enabling remote monitoring, reducing health risks, and supporting proactive quality management in milk supply chains.

4.1.7 Buzzer:

Fig 4.7: Buzzer

The buzzer is used to instantly notify users when any of the sensor readings indicate abnormal or unsafe conditions in the milk, such as excessive acidity, temperature fluctuations, gas presence, or unusual light exposure. The buzzer is connected to the Arduino Mega 2560 and activated through digital signals when the machine learning algorithm or predefined threshold values detect potential contamination or degradation of milk quality. This immediate sound-based warning helps ensure timely human intervention to prevent the consumption or further distribution of spoiled milk. It is particularly useful in noisy or low-visibility environments where visual indicators alone may not be sufficient. The buzzer operates on low power and is compact, making it ideal for integration in embedded systems. It enhances the safety feature of the system by providing real-time auditory feedback. Additionally, its simplicity in design and easy interfacing with the microcontroller make it a reliable and efficient component. Thus, the buzzer is an essential hardware element that contributes significantly to the overall functionality and responsiveness of the milk quality monitoring system.

4.1.8 Arduino Mega 2560:

The Arduino Mega 2560 plays a pivotal role in the "Real Time Milk Quality Detection System using Machine Learning" as the central hardware controller. It is chosen for its extended memory, greater number of input/output pins, and superior processing capabilities compared to other Arduino boards. With 54 digital I/O pins, 16 analog inputs, and 4 serial ports, it efficiently handles multiple sensor inputs simultaneously.

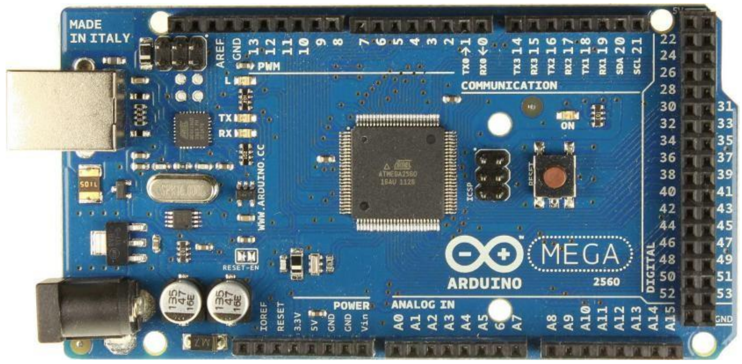

Fig 4.8: Arduino Mega 2560

The board manages data from the pH sensor, temperature sensor, LDR, and gas sensor, ensuring accurate real-time monitoring of milk quality parameters. Its 16 MHz clock speed allows smooth and stable data acquisition and processing. The Arduino Mega 2560 interfaces seamlessly with peripherals like the LCD display for real-time data output, LEDs for visual alerts, and a buzzer for immediate warnings. It also connects with the GSM module, which sends SMS alerts in case of anomalies. The board's open-source nature and compatibility with the Arduino IDE make programming and integration easy. It supports serial communication with external devices and Python scripts for machine learning model interaction. The USB interface allows easy data transfer and debugging. Its robust design ensures reliable long-term operation, making it an ideal microcontroller for embedded IoT applications.

4.2 SOFTWARE REQUIREMENTS:

4.2.1 Python:

Fig 4.9: Python (3.12)

Python plays a crucial role due to its simplicity, versatility, and strong support for data analysis and machine learning applications. Python is chosen for this project because it offers a rich set of libraries such as NumPy, Pandas, and Scikit-learn, which simplify data preprocessing, feature extraction, and implementation of machine learning algorithms. These libraries allow for accurate training and testing of models to classify milk as good or spoiled based on sensor data. Python also provides powerful visualization tools like Matplotlib and Seaborn, which help in analyzing the trends and behaviors of the input parameters such as temperature, pH, and gas levels. Additionally, Python's compatibility with hardware interfaces through serial communication using libraries like PySerial enables smooth data transfer between the Arduino and the computer. The software setup of the project begins with the Arduino IDE, which is used to write and upload the embedded C code onto the Arduino Mega 2560 for collecting sensor data. Next, the Python environment is prepared using Jupyter Notebook or any Python IDE like PyCharm or VS Code, where machine learning models are developed and tested. The project also utilizes Anaconda for managing packages and dependencies efficiently. The ML algorithms are trained using historical data of milk quality, and once trained, the model can make real-time predictions based on incoming data. PySerial facilitates reading serial data from Arduino to Python. For the alert system, integration with GSM is handled using AT commands from the Arduino end, while Python ensures the interpretation of results. The system also includes logic to trigger alerts through visual (LED) and audio (buzzer) signals. The combined use of Arduino for hardware and Python for intelligent software processing makes the system robust, real-time, and highly efficient. This fusion of technologies helps bridge the gap between traditional food safety monitoring methods and modern intelligent systems. Python's easy syntax and vast community support also make debugging and future enhancements easier. Overall, Python's powerful data handling capabilities, ease of integration with hardware, and strong ML ecosystem make it an ideal choice for this innovative milk quality detection system.

4.2.1.1 Python Features:

- Easy to Learn and Use
- Interpreted Language
- High-Level Language
- Cross-Platform Compatibility

- Extensive Standard Library
- Open Source
- Object-Oriented
- Large Ecosystem of Libraries
- Dynamic Typing
- Embeddable and Extensible

4.2.2 Arduino IDE:

Fig 4.10: Arduino IDE Logo

In the "Real Time Milk Quality Detection System using Machine Learning" project, the Arduino IDE plays a critical role as the core development environment for writing, compiling, and uploading code to the Arduino Mega 2560 microcontroller. The Arduino IDE supports C and C++ programming languages and provides a simple and user-friendly interface for beginners and professionals alike. This project requires real-time data collection from multiple sensors including a pH sensor, gas sensor, temperature sensor, and LDR sensor, all of which are interfaced with the Arduino board. The Arduino IDE enables efficient management of sensor readings and facilitates decision-making at the hardware level. It allows users to integrate various libraries like Liquid Crystal, One Wire, and Dallas Temperature for simplified interaction with components such as the LCD display and digital temperature sensor.

The IDE is essential for controlling output devices such as the buzzer, LED indicators, and GSM module, which are used for alert notifications. Through serial communication, it also establishes a link between the Arduino and external systems, including Python-based machine learning models. The machine learning model processes sensor data and sends predictions back to the Arduino, which then takes appropriate actions. The Arduino IDE is crucial for handling these serial interactions, parsing the received data, and executing the logic to determine milk quality.

The software components used in the project include the Arduino IDE for embedded code development, Python for building and training the machine learning model, and necessary Python libraries such as pandas, NumPy, and scikit-learn for data preprocessing and model creation. The GSM module AT commands are also executed through Arduino IDE scripts to send real-time SMS alerts. Additionally, serial communication between Arduino and Python (via USB or serial ports) is programmed through the Arduino IDE, enabling a seamless interface between hardware and software. Data visualization and LCD display output formatting are all handled in the IDE, allowing immediate user feedback.

Moreover, the Arduino IDE simplifies deployment and troubleshooting through its built-in serial monitor and error logs. This software environment makes it possible to create a robust, real-time, sensor-driven system that combines physical electronics and intelligent algorithms. Without the Arduino IDE, it would be challenging to manage real-time sensor data acquisition, peripheral control, or seamless integration with the machine learning backend. It is not just a development tool but the central platform that brings together hardware programming, logic execution, and communication protocols required for this milk quality detection system.

4.2.2.1 Arduino IDE Features:

- User-Friendly Interface
- Code Compilation and Uploading
- Supports Multiple Boards
- Integrated Serial Monitor
- Cross-Platform Support (Windows, macOS, Linux)
- Open Source
- Library Manager
- Board Manager
- Sketch-Based Programming

Chapter 5

RESULTS

5.1 RESULTS:

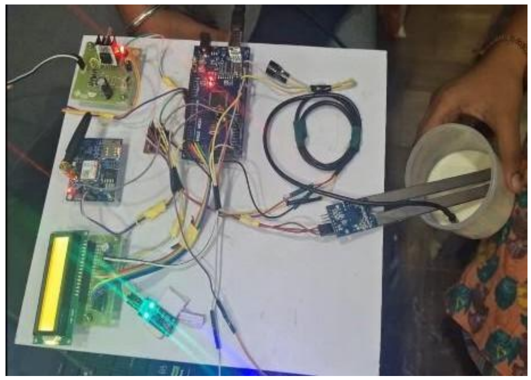

Fig 5.1 : The Working Model

The working model of the Real Time Milk Quality Detection System integrates sensors with an Arduino Mega 2560 to continuously monitor milk parameters. Sensor data, including pH, temperature, gas, and light exposure, is collected and displayed on an LCD. This data is then processed using machine learning algorithms in Python to assess milk quality. If any abnormal values are detected, a buzzer is activated, LEDs indicate the status, and a GSM module sends an alert to the user. This ensures real-time monitoring and immediate action against contamination.

5.1.1 Results for Good Quality Milk Detection:

When the milk sample maintains an optimal pH level (typically between 6.6 and 6.8), the pH sensor confirms that the milk is fresh and unspoiled. The temperature sensor ensures the milk is stored within a safe thermal range, generally between 4°C to 8°C, preventing bacterial growth. The LDR sensor verifies that the milk is not exposed to excessive light, which can degrade its quality.

Fig 5.2: Fresh Milk

Simultaneously, the gas sensor detects the absence of harmful gases, indicating no contamination or spoilage. This sensor data is processed through a machine learning model trained to recognize patterns corresponding to good milk. Upon confirming all parameters are within safe limits, the system displays a "Good Quality" message on the LCD screen. A green LED glows, providing a clear visual confirmation. No alerts or buzzer sounds are triggered, assuring the user of the milk's safety. This real-time, automated assessment reduces human error and ensures milk quality is maintained, promoting health and consumer confidence.

5.1.2 Results for Spoiled Milk Detection:

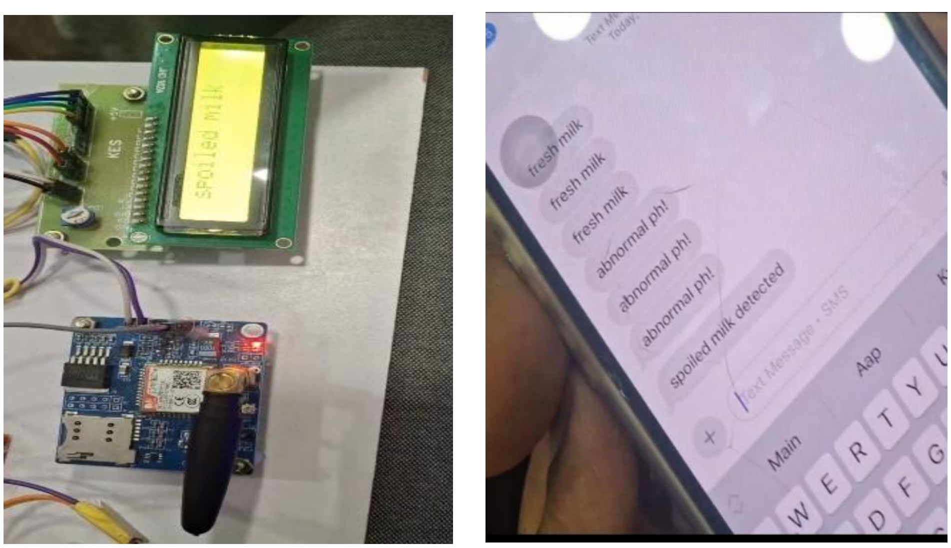

Fig 5.3: Spoiled Milk

When milk is spoiled, the pH sensor detects abnormal acidity levels, while the temperature sensor registers values outside the safe storage range. The LDR sensor may show changes in light exposure that could indicate improper storage, and the gas sensor identifies the presence of spoilage gases. These abnormal readings are processed by the machine learning algorithm, which has been trained to distinguish between fresh and spoiled milk based on historical data patterns. Upon detecting spoilage, the system immediately triggers a buzzer to alert nearby users and simultaneously sends a warning message via GSM to the registered mobile number. LEDs also change color to visually indicate spoilage—typically switching from green (safe) to red (spoiled). This multi-sensor, ML-based approach ensures accurate and timely detection, reducing the risk of consumption of unsafe milk. The results demonstrate the system’s reliability and precision, making it a practical tool for dairy producers, vendors, and consumers aiming to maintain milk quality.

5.2 ADVANTAGES

1. Real-Time Monitoring: Continuous assessment of milk quality parameters ensures timely detection of contamination or spoilage.
2. User-Friendly: LCD display, LED indicators, and audible buzzer alerts provide instant feedback, making it easy to use.
3. Automated Alerts: GSM-based notifications ensure the user is informed of anomalies, even when away from the device.
4. Cost-Effective Solution: Combines readily available hardware and open-source tools for an affordable monitoring system.
5. Environmentally Aware: Detects light exposure and temperature fluctuations, which can help maintain milk storage conditions.
6. Minimal Human Intervention: Automated processes reduce reliance on manual testing and human error.

5.3 APPLICATIONS

1. Dairy Farms: Ensures the quality of milk at the source by identifying contamination or spoilage in real-time, helping farmers maintain high-quality standards.

2. Milk Processing Plants: Enhances quality control processes by providing automated monitoring and alerts for deviations in milk parameters during storage and processing.
3. Household Use: Offers a convenient solution for consumers to verify the safety of milk before consumption, improving health and safety.
4. Government Quality Control Agencies: Supports regulatory bodies in real-time monitoring of milk safety to enforce food safety standards and reduce public health risks.
5. Retail Supply Chains: Assists in monitoring milk quality during transportation and storage, reducing the risk of delivering spoiled or contaminated products to consumers.

5.4 Observations:

Types of Milk	pH Value	Temperature Value (T=RT+MT)	Gas Sensor Value
Raw Cow Milk	6.7	34	350
Raw Buffalo Milk	6.5	31	325
Water	7.0	28	73
Spoiled Milk	2	70	628
Packet Curd	4.7	20	550
Homemade Cow Curd	4.5	28	562

Note: The room temperature of 28°C is utilized in order to compute temperature values.

Calculation: Milk Temperature = Temperature -- Room Temperature (28° C).

For example, when cow's milk is 34° C, the real temperature will be 34 -- 28 = 6° C.

Milk Temperature will be 6° C.

Chapter 6

CONCLUSION

The "Milk Quality Detection System using Machine Learning" project integrates sensors with an Arduino Mega 2560 and machine learning to monitor milk quality in real time. It captures parameters like pH, temperature, light exposure, and gas contamination, using machine learning algorithms to predict quality and detect anomalies. Immediate feedback is provided via an LCD, GSM alerts, and visual/auditory cues. This innovative system enhances food safety and demonstrates the potential of combining IoT and machine learning for intelligent and reliable quality monitoring.

Chapter 7

FUTURE SCOPE

The dairy industry is undergoing a transformative shift with the integration of advanced technologies to enhance productivity, traceability, and sustainability. One of the key innovations is the use of machine learning models, which significantly improve the accuracy and speed of milk quality analysis, disease detection, and production forecasting. These intelligent systems help farmers make data-driven decisions, leading to increased efficiency. The integration of IoT (Internet of Things) and smart sensors allows real-time monitoring of animal health, milk yield, temperature, and hygiene conditions, ensuring optimal farm operations. Furthermore, automated dairy management systems streamline daily tasks such as feeding, milking, and cleaning, thereby reducing human effort and operational errors. The adoption of blockchain technology adds a layer of milk traceability, enabling stakeholders and consumers to track the product journey from farm to table, ensuring transparency and trust. Additionally, governments and regulatory bodies are promoting these technologies to maintain quality standards and improve rural livelihoods. To make these innovations accessible, the focus has also shifted toward cost-effective and scalable solutions, including the development of low-cost, portable devices tailored for small-scale farmers. These technological advancements collectively foster a smarter, more efficient, and sustainable dairy ecosystem.

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APPENDIX

CODE

Arduino Code:

```
#include <LiquidCrystal.h>
#include <OneWire.h>
#include <DallasTemperature.h>
float a, b, c, d, e, f, g;
#define rs 53
#define en 51
#define d4 49
#define d5 47
#define d6 45
#define d7 43
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
String receivedData = "";
int pH;
int W;
int L;
int T;
//SoftwareSerial gsm(11, 12);
int ldr_pin = A3;  // Assuming you're using an analog pin for the LDR
int light_pin = 13;
const int dallasTempPin = 3;
int gas = A2;
int buzzer = 8;
String pHval;
String msg;
String uno;
OneWire oneWire(dallasTempPin);
DallasTemperature tempSensor(&oneWire);
float tempC;
DeviceAddress insideThermometer; void setup() {
lcd.begin(16, 2);
Serial.begin(9600);
Serial1.begin(9600);
Serial2.begin(9600);
tempSensor.begin();
//gsm.begin(9600);

pinMode(ldr_pin, INPUT);
pinMode(gas, INPUT);
```

```
pinMode(buzzer, OUTPUT);
pinMode(light_pin, OUTPUT);

digitalWrite(light_pin, HIGH);
digitalWrite(buzzer, LOW);

lcd.clear();


lcd.setCursor(0, 0);
lcd.print("Enhancing milk ");
lcd.setCursor(0, 1);
lcd.print("Quality");
delay(1000);
}

void loop() {
String data1 = "";

if (Serial.available() > 0)  //If data is available on serial port
{
lcd.clear();
lcd.print("Waiting for ML data");
data1 = Serial.readString();  //Print character received on to the seria
 monitor
// Check if the character 'a' is present in the received data and it's not
single 'a'
if (data1.indexOf('t') != -1 && data1.length() > 1) {
//          Serial.println(data1);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("RECEIVE DATA:)");
lcd.setCursor(0, 1);
lcd.print(data1);
delay(2000);
int indexA = data1.indexOf("t") + 1;
int indexB = data1.indexOf("u") + 1;
int indexC = data1.indexOf("v") + 1;
int indexD = data1.indexOf("w") + 1;
int indexE = data1.indexOf("x") + 1;
int indexF = data1.indexOf("y") + 1;
int indexG = data1.indexOf("z") + 1;
delay(500);
String valueA = data1.substring(indexA, indexB - 1);
```

```
String valueB = data1.substring(indexB, indexC - 1);
String valueC = data1.substring(indexC, indexD - 1);
String valueD = data1.substring(indexD, indexE - 1);
String valueE = data1.substring(indexE, indexF - 1);
String valueF = data1.substring(indexF, indexG - 1);
String valueG = data1.substring(indexG);
a = valueA.toInt();
b = valueB.toInt();
c = valueC.toInt();
d = valueD.toInt();
e = valueE.toInt();
f = valueF.toInt();
g = valueG.toInt();
}

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("RECEIVE DATA:)");
lcd.setCursor(0, 1);
lcd.print(data1);

delay(2000);
if (a == 0) {
lcd.clear();
lcd.setCursor(0, 0);
lcd.print(" spoiled milk");
digitalWrite(buzzer, HIGH);
delay(2000);
digitalWrite(buzzer, LOW);
msg = "spoiled milk detected";
SendMessage();
delay(1000);
} else if (b == 0) {
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("low density milk");
lcd.setCursor(0, 1);
lcd.print("spoiled milk");
digitalWrite(buzzer, HIGH);
delay(2000);
digitalWrite(buzzer, LOW);
msg = "low density milk";
SendMessage();
delay(1000);
```

```
} else if (c == 0) {
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("high temp");
lcd.setCursor(0, 1);
lcd.print("spoiled milk");
digitalWrite(buzzer, HIGH);
delay(2000);
digitalWrite(buzzer, LOW);
msg = "high temperature";
SendMessage();
delay(1000);
} else if (d == 0) {
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("abnormal ph");
lcd.setCursor(0, 1);
lcd.print("spoiled milk");
digitalWrite(buzzer, HIGH);
delay(2000);
digitalWrite(buzzer, LOW);
msg = "abnormal ph!";
SendMessage();
delay(1000);
 }
else{
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("fresh milk");
delay(2000);
msg = "fresh milk";
SendMessage();

delay(1000);
}
}
// Temperature Reading
tempSensor.requestTemperatures();
tempC = tempSensor.getTempCByIndex(0);

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Temp: ");
lcd.print(tempC);
```

```
delay(2000);

// LDR value reading (Fat/Thickness Calculation)
int ldrValue = analogRead(ldr_pin);                   // Read analog value from
LDR pin
//int fatPercentage = map(ldrValue, 0, 1023, 0, 100);  // Map LDR value to fat
 percentage

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("LDR Value: ");
lcd.print(ldrValue);

// lcd.setCursor(0, 1);
// lcd.print("Fat %: ");
// lcd.print(fatPercentage);  // Display the mapped value (fat percentage)
delay(2000);

 // Gas value reading (spoiled milk detection)
int gasValue = analogRead(gas);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Gas Value: ");
lcd.print(gasValue);
delay(1000);

if (Serial2.available()) {
// Read the incoming data
receivedData = Serial2.readString();
// Process the data once a full string is received
parseData(receivedData);
// Clear the buffer for the next data
receivedData = "";
// Serial.print("pH: ");
 // Serial.print(pH);
 }
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("pH: ");
lcd.print(pH);
delay(1000);
```

```
// pH value reading (Milk pH level)
if (pH < 15) {

String uno = "a" + String(gasValue) + "b" + String(ldrValue) + "c" +
String(tempC) + "d" + String(pH) + "e";
Serial.println(uno);
delay(1000);
}
}

void SendMessage() {
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Message sending........");
Serial1.println("Setting the GSM in text mode");
Serial1.println("AT+CMGF=1\r");
delay(2000);
Serial1.println("Sending SMS to the desired phone number!");
Serial1.println("AT+CMGS=\"+917032534707\"\r");
// Replace x with mobile number
delay(2000);
Serial1.println(msg);  // SMS Text
delay(2000);
Serial1.write(26);  // ASCII code of CTRL+Z
delay(2000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Message sent.......");
delay(1000);
}
void parseData(String data) {
// Example incoming data: "PH:37.76, W: 0, L: 128, T:  98"

// Find the positions of the delimiters
int pHIndex = data.indexOf("PH:");
int WIndex = data.indexOf("W:");
int LIndex = data.indexOf("L:");
int TIndex = data.indexOf("T:");

// Extract and convert each value
pH = data.substring(pHIndex + 3, data.indexOf(",", pHIndex)).toFloat();
W = data.substring(WIndex + 2, data.indexOf(",", WIndex)).toInt();
```

```
L = data.substring(LIndex + 2, data.indexOf(",", LIndex)).toInt();
T = data.substring(TIndex + 2).toInt();  // Since T is the last value, no comma
is needed

// Print the values to verify
// Serial.print("pH: ");
// Serial.print(pH);
// Serial.print(" W: ");
// Serial.print(W);
// Serial.print(" L: ");
// Serial.print(L);
// Serial.print(" T: ")// Serial.print(T);}
```

Python Code:

```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
import serial
import time
import re
import warnings

warnings.filterwarnings("ignore")

ser = serial.Serial('COM3', baudrate=9600)  # Adjust COM port and baudrate as needed
print("Serial connection opened successfully!")

# Load data from an Excel sheet and split into features and labels
data = pd.read_excel("milk.xlsx", engine="openpyxl")

feature_1 = data['gasvalue']
feature_2 = data['ldr_value']
```

```
feature_3 = data['temperature']
feature_4 = data['ph']
label_1 = data['label_gasvalue']
label_2 = data['label_Ldrvalue']
label_3 = data['label_temp']
label_4 = data['label_ph']
# Split the data into training and testing sets for each parameter
X_train_1, X_test_1, y_train_1, y_test_1 = train_test_split(feature_1, label_1,
test_size=0.2,
random_state=42)
X_train_2, X_test_2, y_train_2, y_test_2 = train_test_split(feature_2, label_2,
test_size=0.2,
random_state=42)

X_train_3, X_test_3, y_train_3, y_test_3 = train_test_split(feature_3, label_3, test_size=0.2,
random_state=42)
X_train_4, X_test_4, y_train_4, y_test_4 = train_test_split(feature_4, label_4, test_size=0.2,
random_state=42)
# Build Random Forest models for each parameter
rf_model_1 = RandomForestClassifier(random_state=42)
rf_model_1.fit(X_train_1.values.reshape(-1, 1), y_train_1)
rf_model_2 = RandomForestClassifier(random_state=42)
rf_model_2.fit(X_train_2.values.reshape(-1, 1), y_train_2)

rf_model_3 = RandomForestClassifier(random_state=42)
rf_model_3.fit(X_train_3.values.reshape(-1, 1), y_train_3)

rf_model_4 = RandomForestClassifier(random_state=42)
rf_model_4.fit(X_train_4.values.reshape(-1, 1), y_train_4)
```

```
def readData():
    time.sleep(1)
    serial_data = ser.readline().decode().strip()

while not serial_data.startswith('a'):
      serial_data = ser.readline().decode().strip()

     time.sleep(1)
     print("\n------------------")
      print("     -= Data Received =- ")
      print("--------------------------------\n")
     #time.sleep(1)
      print("Data:", serial_data, "\n")




       a = serial_data.find("a")
       b = serial_data.find("b")
       a = a + 1
       val_1 = float(serial_data[a:b])
      print("gasvalue  :", val_1)
      #time.sleep(1)

      b = serial_data.find("b")
      c = serial_data.find("c")
      b = b + 1
      val_2 = float(serial_data[b:c])
      print("ldrvalue    :", val_2)
      #time.sleep(1)
```

```
    c = serial_data.find("c")
    d = serial_data.find("d")
    c = c + 1
    val_3 = float(serial_data[c:d])
    print("temperature :", val_3)
    #time.sleep(1)

    d = serial_data.find("d")
    e = serial_data.find("e")
    d = d + 1
    val_4 = float(serial_data[d:e])
    print("ph  :", val_4)
    #time.sleep(1)
    return val_1, val_2, val_3, val_4
while True:

    serial_data = ser.readline().decode().strip()
    input_data = readData()
    if input_data is None:
        continue
    feature_1_val, feature_2_val, feature_3_val, feature_4_val= input_data



    # Make predictions using the trained Random Forest models
    rf_prediction_1 = rf_model_1.predict([[feature_1_val]])[0]
    rf_prediction_2 = rf_model_2.predict([[feature_2_val]])[0]
    rf_prediction_3 = rf_model_3.predict([[feature_3_val]])[0]
    rf_prediction_4 = rf_model_4.predict([[feature_4_val]])[0]
        print("\n------------------")
```

```
 print("RF-prediction")
 print("--------------------------------\n")

time.sleep(1)
print(f'gasvalue         : {rf_prediction_1}')
print(f'Ldrvalue      : {rf_prediction_2}')
print(f'temperature  : {rf_prediction_3}')
print(f'ph      : {rf_prediction_4}')
print("\n------------------")
values_string =
f"t{rf_prediction_1}u{rf_prediction_2}v{rf_prediction_3}w{rf_prediction_4}x"
time.sleep(1)
print(values_string)
time.sleep(2)
ser.write(bytes(values_string, 'utf-8'))
time.sleep(3)
 print("completed")
 time.sleep(1)
```

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1 message

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