Vol. 01, No. 01 (2023) 27-32, doi: 10.61552/JEMIT.2023.01.004 - http://jemit.aspur.rs

FOOD PRODUCTS DEFILEMENT ANALYZER USING IOT

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Received 04.01.2023.
Revised 09.03.2023.
Accepted 29.03.2023.

Keywords:

Back Propagation Algorithm, Neural Network, IoT

Original research

A B S T R A C T

In order to make additional, quick profits, shopkeepers frequently adulterate food today. Foods are adulterated by adding things like ripening mangoes, chalk powder to turmeric, starch to curry powder, papaya seeds to black pepper, and other things. Adulteration is a common practise to increase profits, but it can have extremely harmful effects on people. The qualitative spectroscopic method offers a better way to identify the toxic components in milk and other things. The goal of this research is to develop a low-cost, portable, AI-based, non-destructive sensor system that can be used to detect the adulterant in real-time in order to solve this problem. The users can access a dedicated site with an Iot platform from anywhere to view the adulterant that has been found.In this study, the conductivity and pH meter methods were used to examine the food products in order to determine the degree of adulteration present

1. INTRODUCTION

Food adulteration is a common practise among shop owners to make quick extra money. Mangoes are ripened, turmeric is mixed with chalk powder, starch is added to curry powder, papaya seeds are mixed with black pepper, and other foods are adulterated in this way (Malik, 2019). In the long run, these adulterations have negative effects on people. In India, 77.68 million tons of liquid cow milk are consumed annually (Sowmya & Ponnusamy,2021). Statistics from December 2019 indicated that India plays the best role in the consumption of cow milk. Milk improves human nutrition because it contains significant amounts of essential nutrients like lactose, fat, proteins, minerals, and vitamins (Pereira, 2014) .One of the most crucial tests to ensure the safety of people's health is the detection of adulterants in milk because people consume it daily (Sadat et al., 2006). One approach that is frequently used to address the aforementioned issue is adulteration detection based on pH and conductivity (He et al., 2021). The system for the measurement and creation that are created when electromagnetic radiation interacts with matter. The type of interaction between matter and radiation, such as diffraction, absorption, and emission, as well as molecules or atoms may affect the analysis methods used. The Beer-Lambert law explains how the absorption concentration and absorptivity of a substance whose chemical components are measured relate to one another (Hardesty & Attili, 2010).

$$A = \in CL$$

Where A - absorption coefficient, $\in$ -molar absorption coefficient, C - concentration of substances, L - path length (cm) Absorption coefficient has no unit.

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Spectroscopic methods for detecting adulteration are somewhat expensive, laboratory-based, and provide nondestructive methodology (Lopez ET AL. 2022). In previous proposed systems (Gupta et al., 2017; Kasemsumran et al. 2007; Khan et al., 2015) spectroscopy sensors are used which needs spectrums for its full-fledged functioning, but in this system we have incorporated two different sensors which detect pH and conductivity of the samples (Laczka et al. 2008; Yew et al. 2019). Moreover this methodology is a physical measurement and does not involve any other chemical substituents. As for adulteration, a few adulterants can be added to milk to fraudulently increase its quantity (Kishor & Thakur, 2015).

Table 1. Adulterants and its responsive wavelength

Adulterant	Responsive Wave Length (Nm)	Method
Honey	1200 -1450	Calorimetric Analysis
Milk	1100	Calorimetric Analysis

A survey is conducted to identify the responsive wavelength of our targeted adulteration in the milk and summarized in Table. 1 and yet to get results for other food ingredients

From the Table 1 the mechanism tests are carried out in a laboratory setting and do not support field testing, so these techniques are not appropriate for real-time analysis and take longer to produce results. Through created IoT applications, the results of the adulterant detection could be viewed from any location (Kamthania et al., 2014; Poonia et al., 2017).

2. PROPOSED METHOLOGY

Milk is a dairy product that is incredibly nutrient-dense in its natural state. It includes minerals, proteins, amino acids, minerals, and carbohydrates.

- Designing and creating a portable, affordable sensor device that can support in-the-moment non-destructive testing is the focus of the proposed research work.
- To identify four different adulterants and pure milk, adulterant detection is approached as a classification problem and solved using Naive Bayes, Linear Discriminant Analysis, Decision Trees, Support Vector Machines, and Neural Network Machine Learning Algorithms. The average accuracy for those models is 90%, 88.1%, 91.7%, 90%, and 92.7%, respectively.
- The neural network model's hyper parameter is adjusted to increase accuracy from 92.7% to 100% using a genetic algorithm to solve an optimization problem.
- The sensor system is designed as an Internet of Things (IoT) device to update the detected adulterant in the web server so that anyone can access the results.
- We have discussed about sample preparation, spectral data collection, processing, and the neural network algorithms used for analysis as well as the design of AI-enabled system.
- Here the proposed system detects the adulterant based on the pH level and conductivity which varies with pure and adulterated samples.
- The threshold level is set by comparing the above results with the calorimetric analysis outputs.
- The detected results from the multi-sensor system is then sent to BlynkIoT App, the user will be notified whether the sample is adulterated or not.

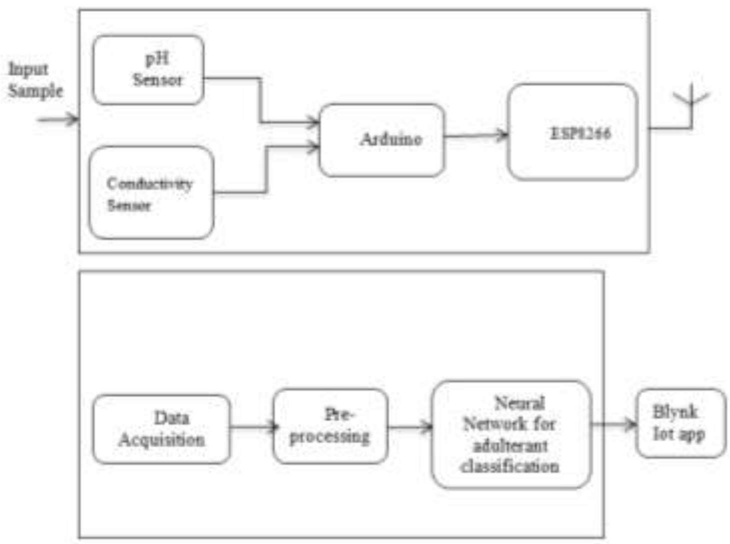

Figure 1. Design of AI-enabled multisensor system for adulterant detection

3. MATERIALS AND METHODS

The following sections covered sample preparation, spectral data collection, processing, and the neural network algorithms used for analysis as well as the design of AI-enabled system. The design of the sensor system developed with artificial intelligence methodology for the detection of adulterants is described in Section 3.1.

3.1 Design of a milk adulterant detection multi sensor system with AI

Figure. 1 depicts the designed AI-enabled sensor system's prototype. which includes an ESP8266 wireless module, an Arduino board, a PC used for data logging, and an implemented neural network AI software module, pH sensor, conductivity system. The AI-enabled multispectral sensor system is depicted in Figure. 1. Data from the sensor will be transmitted serially to the Arduino microcontroller and then wirelessly to a personal computer. The user can send the data they've collected to the PC using the Wi-Fi module. For pre-processing, the acquired data is stored. The non-linear neural network receives the pre-processed sample data for additional analysis. The neural network is trained, tested, and validated using these pre-processed data. One of the network outputs will classify or detect whether a substance is adulterated or not.

A) pH SENSOR :

- The H+ ion concentration in the fluid is essentially measured by the PH sensor. The PH measurement sensor is composed of the measuring electrode, the reference electrode, and the temperature sensor. The millivolt signal at the electrode is amplified by a preamplifier to a specific amplitude. The measuring electrode is located at the positive terminal, and the reference electrode is located at the negative terminal. The voltage of the reference electrode is directly proportional to the amount of hydrogen ions present in the solution, and it has a steady potential and is sensitive to hydrogen ions. When submerged in solution, the reference electrode makes contact with the measuring electrode through the junction.
- Chemistry uses pH to gauge the activity of solvated hydrogen ions. Due to its close relationship to the measurement of hydrogen ion concentration, PH, it is frequently spelt as Ph.At 25°C, pure water has a pH that is very close to 7. The term "acidic" refers to solutions with a pH of less than 7, while "basic" or "alkaline" refers to those with a pH of more than 7. A concentration cell with transference is used to measure the potential difference between a hydrogen electrode and a standard electrode, like the silver chloride electrode, to determine primary pH standard values.A glass electrode and a pH meter, or indicators, can be used to measure the pH of aqueous solutions. The Carlsberg Foundation asserts that pH stands for "power of hydrogen." The potential activity of the sample's hydrogen ions is measured by PH. Both total conductivity and electrical conductance had positive correlations with PH. It is used to determine whether the milk sample is neutral, basic, or acidic. Because its pH is 6.7, fresh milk is slightly acidic.)
- The hydrogen ion potential activity in a sample is measured by the pH scale. The relationship between pH and total conductivity and electrical conductance was positive. It is employed to determine whether the milk sample is basic, acidic, or neutral. (Fresh milk is slightly acidic due to its pH of 6.7.)
  pH sensor is presented on figure 2.

Figure 2. pH sensor

B) CONDUCTIVITY SENSOR :

The representative value of the limiting molar conductivity of milk was found to be 75 S cm2 mol−1.The typical conductivity of tap water ranges from 1.2 to 1.6 mS.Even still, the conductivity of 9% fat milk is between 2.3 and 2.5 mS. Therefore, if the milk conductivity is less than 2.2 mS, it is confirmed that the milk contains water.

C) ARDUINO BLACKBOARD :

The data from the sensors is gathered by the inexpensive Arduino blackboard and transmitted to the device for additional analysis. The 14 digital input/output pins on the Arduino blackboard are divided into six pulse width modulation pins, four analogue inputs, a universal asynchronous receiver and transmitter, and a serial peripheral interface (SPI). The gathered spectral data is once more sent to the WiFi module (ESP8266) single-chip pin.

D) DATA ACQUISITION :

The server PC receives the collected data from the ArduinoWiFi module. The WiFi module is connected to a USB port, which is used to collect data using the Microsoft Excel data streamer software module. This section outlines the data collection process using an Excel sheet.

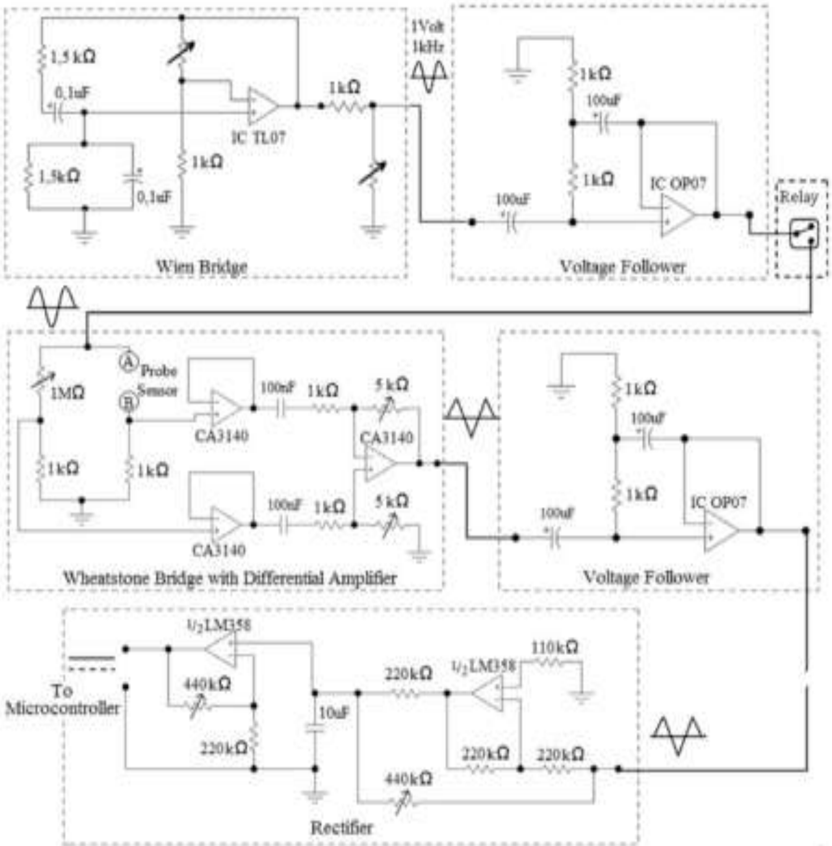

Figure 3. Conductivity sensor diagram

Conductivity sensor diagram is presented on figure 3. Live data from a microcontroller is streamed into an excel sheet using a data streamer, which offers two-way data transfer.

4. CONCLUSION

One of the major concerns on the planet is adulteration. However, various spectroscopic approaches required for the detection of adulterants. The designed multi sensor model is used in the proposed model with artificial intelligence to present the adulterant identifications. This created sensor model non-destructively extracts the data from the sample. Summary of results are presented in Table 2.

Table 2. Summary of results

Adulterant	Ph	Conductivity (µs/M)
Honey – 25%	3.19	8.82
Honey – 50%	3.14	2.6

The data is subjected to the application of several machine learning algorithms, including Naive Bayes, Linear Discriminant Analysis, Support Vector Machine, Decision Tree, and Neural Network Model, and accuracy of 90%, 88.1%, 90%, 91.7%, and 92.7% are obtained. The user or authorized individuals can access a dedicated webpage with an IoT application from anywhere to view the adulterant that has been found. Milk is tested for various concentrations of sugar, sodium chloride, and urea using a developed method. Within a reasonable amount of time, this system can detect the sugar, sodium chloride, and urea mixture in the milk sample. This system determines the milk's PH level. To estimate the effects of external factors and increase the instrument's sensitivity, additional research in this area may be conducted. As a result, the sensor's performance can be affected less by changes in temperature, atmospheric pressure, and residual pressure caused by stray gases in the sample. This system keeps the quality of the milk good and prevents people from altering it.

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