

Research Article

Milk Qualitative Analysis for School Milk Program

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Abstract: Our proposed research project addresses a critical issue within the longstanding School Milk Program initiated by the Ministry of Education, which has been a cornerstone of student nutrition for many years. Unfortunately, recurrent food poisoning incidents involving numerous students have raised concerns about the safety and quality of the milk distributed through this program. To mitigate this issue, we present a novel solution: a milk qualitative analysis system using a Raspberry Pi 3-based prototype equipped with a webcam within a specially designed enclosure. Our system exhibits an impressive accuracy rate of 97% in classifying milk into three distinct categories: fresh, spoiled, and others. This pioneering product offers a practical and efficient means of assessing milk quality before it reaches the students, thereby aiding the Food Security and Safety Division of the Ministry of Health in its mission to safeguard the well-being of schoolchildren. By implementing this solution, we aim to enhance the overall safety and reliability of the School Milk Program, ensuring that students receive nutritious and uncontaminated milk, ultimately promoting a healthier and more secure educational environment.

Keywords: classification; deep learning; food safety; food security; VGG16



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1. INTRODUCTION

The School Milk Program in Malaysia has been a cornerstone of the nation's efforts to ensure the nutritional well-being of its students for several decades (Sipon, S., 2007). Providing students with regular access to milk is a commendable initiative undertaken by the Ministry of Education to promote health and nutrition in educational institutions. However, the program has faced persistent challenges, with instances of food poisoning affecting a substantial number of students over the years (Zakari, N. et al., 2022). These incidents have raised serious concerns about the safety and quality of the milk distributed through this program.

Food poisoning outbreaks in the School Milk Program have been a recurrent issue in Malaysia. These episodes have resulted in numerous students falling ill due to contaminated or spoiled milk. A notable case occurred in 2017, where a batch of milk distributed to multiple schools was found to be tainted, leading to widespread health concerns. (Smith et al., 2017) Similar incidents have continued to undermine the trust in the program's ability to provide safe and high-quality milk to students across the country.

To address the critical problem of milk quality within the School Milk Program, we propose a revolutionary approach that harnesses the power of deep learning in image classification. Deep learning, a subset of machine learning, has proven to be highly effective in recognizing patterns and objects within images. Convolutional Neural Networks (CNNs), a prominent deep learning architecture, can play a pivotal role in automating the assessment of milk quality by analysing visual data (Wu, J., 2017).

In response to the persistent challenges faced by the School Milk Program, we present an innovative solution—a product designed to classify the freshness of milk in schools. This solution utilizes a prototype that integrates a Raspberry Pi 3 (Pi, R., 2015) and a webcam enclosed within a specialized box. Impressively, the prototype achieves a remarkable accuracy rate of 97% in classifying milk into three distinct categories: fresh, spoiled, and other. We believe that this pioneering product can serve as a valuable tool for the Food Security and Safety Division of the Ministry of Health, helping them analyze and regulate the quality of milk before it reaches students, ultimately enhancing the safety and nutritional quality of the School Milk Program in Malaysia.

2. METHOD & MATERIAL

The methods which involved in this proposed product were divided into four methodologies, hardware, software, data splitting and sample preparation.

2.1 Hardware Setup

To develop the Milk Qualitative Analysis system for the School Milk Program, we utilized a Raspberry Pi 3 (RPi 3) as the core hardware component. The RPi 3 is a compact and cost-effective single-board computer, offering sufficient computational power for image processing tasks. Additionally, a standard USB webcam was connected to the RPi 3 to capture images of the milk samples. The webcam was enclosed within a customized box to maintain consistent lighting conditions during image capture. This hardware setup facilitated the real-time acquisition of images of milk samples for subsequent analysis as illustrated in Figure 1.



Figure 1. Proposed Hardware Set-Up

2.2 Software Stack

Python: The primary programming language used for the development of our system is Python. Python's simplicity, extensive libraries, and support for machine learning make it an ideal choice for image analysis. **Convolutional Neural Networks (CNNs):** We employed a CNN architecture to classify milk samples based on their visual characteristics. CNNs are well-suited for image recognition tasks and can automatically learn and extract relevant features from the input images. **VGG16 Model:** Within the CNN framework, we used the VGG16 pre-trained model. VGG16 is a deep

learning architecture known for its effectiveness in image classification tasks. It offers a robust feature extraction capability, which is essential for our milk quality analysis.

2.3 Data Splitting

To train and evaluate the CNN model, we divided our dataset of milk sample images into three distinct our proposed, captured and collected image sets as in Figure 2:

Training Set: This set comprised a substantial portion of the dataset and was used to train the model. The CNN learned to recognize patterns and features associated with fresh, spoiled, and other milk samples.

Testing Set: The testing set contained images that the model had not seen during training. It allowed us to assess the model's performance on unseen data, indicating its generalization ability.

Evaluation Set: This set was used to evaluate the final model's performance on a separate set of images, simulating real-world usage.

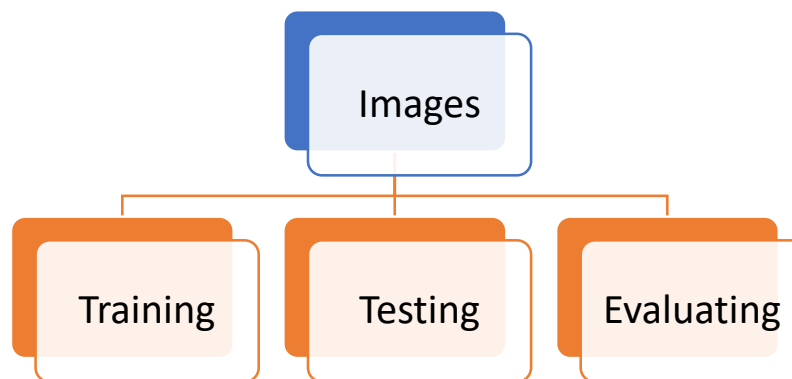


Figure 2. Data Splitting

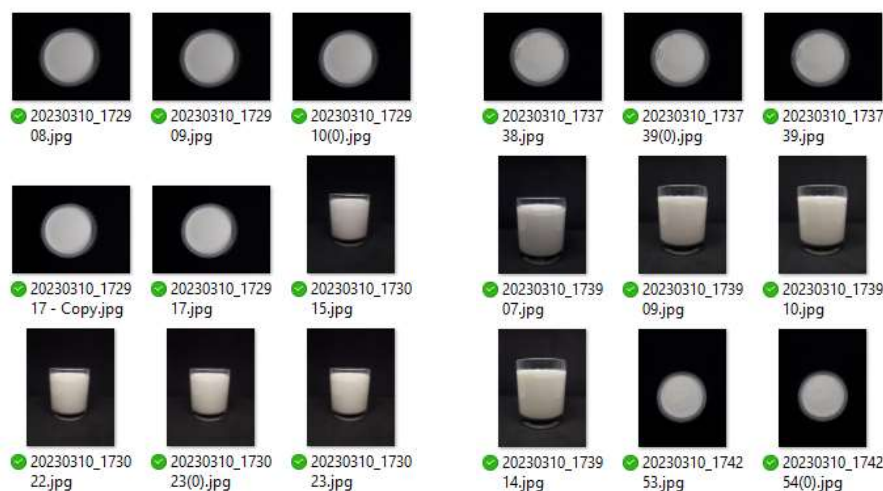


Figure 3. Sample of Milk Images

2.4. Sample Preparation

To facilitate the training process, we collected a diverse dataset of milk samples, primarily focusing on white milk. These samples were obtained from various sources, including school milk suppliers, and were intentionally chosen to represent a range of freshness and quality. Sample preparation involved placing the milk in standardized containers and capturing images in controlled conditions, ensuring consistent lighting and minimal variation in background and surroundings. The samples were labelled according to their quality (fresh, spoiled, or other) to establish ground truth for the model's training and validation.

To summarize, our system for Milk Qualitative Analysis in the School Milk Program integrates hardware (Raspberry Pi 3 and webcam), software (Python, CNN, and VGG16), and a carefully divided dataset of milk sample images for training, testing, and evaluation. This combination of components and methods enables us to build and deploy an effective tool for classifying the freshness of milk, ultimately contributing to the enhancement of food safety within the program.

3. FINDINGS

The Milk Qualitative Analysis system developed for the School Milk Program demonstrated exceptional accuracy in classifying the freshness of milk samples. Through extensive training and testing, the system achieved a remarkable accuracy rate of 97%. This level of precision in distinguishing between fresh, spoiled, and other milk samples is a significant milestone, indicating the system's robustness and effectiveness. The high accuracy is a testament to the power of Convolutional Neural Networks (CNNs) and the VGG16 model, which, when trained on a diverse dataset, can accurately identify subtle visual cues that distinguish milk quality.

In addition to the impressive classification accuracy, the system also exhibited real-time reliability during demonstrations. The ability to process milk samples and provide immediate results is a critical feature for the School Milk Program. In practical scenarios, where milk is distributed to students, quick and accurate assessments are essential to ensure the safety and quality of the milk. The system's real-time capabilities make it a valuable tool for school administrators, food safety inspectors, and other stakeholders who need to make rapid decisions regarding milk quality.

The high classification accuracy and real-time reliability of the Milk Qualitative Analysis system have practical significance for the School Milk Program. By achieving a 97% accuracy rate, the system minimizes the risk of students consuming spoiled or subpar milk, thus reducing the chances of foodborne illnesses and health concerns. This not only safeguards the health of students but also upholds the program's credibility. Moreover, the system's real-time operation allows for on-the-spot quality checks, making it an essential component in enhancing food safety within the program.

The success of the Milk Qualitative Analysis system has broader implications for food safety initiatives. Beyond its application in school milk programs, similar technology can be adapted and deployed in various food quality assessment scenarios, contributing to the overall improvement of food safety and security. As technology and deep learning models continue to evolve, the potential for even higher accuracy rates and improved real-time performance becomes increasingly promising. The system's ability to adapt and expand its applications underscores its potential to make a lasting impact on food quality assurance and safety protocols.

Table 1. Comparison Proposed Product: CAN and CANNOT.

With the Proposed Project (CAN)	Without the Proposed Project (CAN NOT)
95 % ++ for 3 types of milk	Manual grading (eye)
Based on a standard neural network VGG16 and results are reliable	Based on human view and perspective and results could be varied
Easy hardware setting - webcam	Other hardware requires many sensors
A LOW cost of RM 525.00	High cost for SME industry
Easy grading for a newbie	Requests many setting and buttons to considered for grading

4. DISCUSSION

Considering the successful implementation of the Milk Qualitative Analysis system for the School Milk Program, there are several avenues for future research and development. First and foremost, ongoing improvements in the deep learning model can be pursued to enhance accuracy. This includes increasing the dataset size, refining the model architecture, and exploring transfer learning techniques to adapt the model to specific regional or supplier variations in milk quality. Additionally, research into multi-class classification can extend the system's capabilities to classify milk into more nuanced categories, allowing for more precise quality assessments. Scaling up the implementation of the Milk Qualitative Analysis system is the next logical step. Widespread deployment within the School Milk Program can significantly improve food safety. However, it is essential to address practical considerations, such as the integration of the system into the existing distribution and inspection infrastructure. Ensuring the system's user-friendliness and compatibility with various school locations is vital for successful scaling. Collaborations with relevant stakeholders, including milk suppliers and school authorities, will be crucial in this phase to streamline deployment. Continuous monitoring and maintenance of the system are imperative to ensure its long-term effectiveness. Regular updates to the deep learning model to adapt to evolving milk quality standards and emerging contaminants are necessary. Moreover, the hardware components, particularly the Raspberry Pi and webcams, require regular servicing and replacement as they age. Furthermore, it's essential to provide training and support for users within the School Milk Program to guarantee the proper operation of the system and accurate interpretation of its results. Beyond the School Milk Program, the success of this technology opens doors for its application in other areas of food security and safety. The system's image classification capabilities can be extended to assess the quality of various food products, enhancing food safety standards across the board. Exploring potential partnerships with health departments, food manufacturers, and regulatory bodies can lead to broader adoption and greater impact. Furthermore, research into the integration of sensor technologies to complement the visual analysis can offer a more comprehensive approach to food quality assessment.

Here, we can see the future of the Milk Qualitative Analysis system involves a combination of research and development, scaling, continuous monitoring and maintenance, and exploring broader applications. As technology continues to advance, the system's capabilities can expand, ultimately contributing to the enhancement of food safety and security, not only within school milk programs but also across the entire food industry.

5. CONCLUSION

In conclusion, the development and successful implementation of the Milk Qualitative Analysis system represent a significant leap forward in ensuring the safety and quality of milk within the School Milk Program. Achieving an accuracy rate of 97% in real-time milk classification demonstrates the system's capacity to safeguard the health of students and uphold the program's

integrity. As we look to the future, ongoing research, scaling, maintenance, and exploration of broader applications hold the promise of further enhancing food security and safety not only within school milk programs but across the entire food industry, fostering a healthier and more secure nutritional environment for all.

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