

Smart Nutrition Trash Can

An Integrated Dietary Monitoring System Through Intelligent Waste Analysis

Tsz Wun TAM

LANG 1407

Hong Kong University of Science and Technology

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1. Introduction

1.1 Background

In Hong Kong, the problems of hidden hunger and obesity are becoming increasingly severe. According to the Centre for Health Protection, approximately 97% of Hong Kong residents fail to meet the recommended daily intake of fruits and vegetables [1]. Furthermore, studies have indicated that over 90% of the local population is deficient in vitamin D, a condition that elevates the risk of chronic diseases and compromised immunity [2][3]. Meanwhile, the adult obesity rate in Hong Kong has reached 32%; however, a survey conducted by Radio Television Hong Kong found that nearly 70% of citizens do not regard obesity as a disease [4]. These figures indicate that most of the population is unaware of their nutritional intake.

1.2 Niche

Although mobile applications such as MyFitnessPal and Fooducate currently offer dietary tracking features, these tools rely heavily on manual data entry by the user, a process that is both time-consuming and prone to user abandonment. While camera-equipped smart waste receptacles have been patented for purposes such as waste sorting and automatic product reordering [5], no existing system applies such technology to nutritional intake monitoring. This gap shows that an automated and non-intrusive approach is needed to dietary assessment.

1.3 Objective

To address this gap, this report proposes an integrated dietary monitoring system known as the Smart Nutrition Trash Can. The system employs image recognition technology to automatically analyse food packaging and leftover food disposed of by the user. Powered by an edge-computing processor equipped with a dedicated neural processing unit, it is capable of identifying discarded items,

extracting nutritional information, and generating a daily dietary intake report that is delivered to the user's smartphone. By embedding nutritional tracking functionality into an everyday household object, this innovation helps Hong Kong residents become more aware of their diet without requiring any alteration to their existing habits.

2. Literature Review

2.1 Overview

The Smart Nutrition Trash Can relies on image recognition technology to identify food items and extract nutritional information. Therefore, selecting appropriate microcomputer hardware is of critical importance. The following section evaluates three microcomputers, namely the Raspberry Pi 5, the NVIDIA Jetson Nano, and the Orange Pi 5, based on their AI processing capability and cost effectiveness.

2.2 Raspberry Pi 5

The Raspberry Pi 5 is equipped with a 2.4 GHz quad-core Cortex-A76 processor and offers 4 GB or 8 GB LPDDR4X memory configurations [6]. Priced at approximately 60 to 80 US dollars, it is one of the more affordable options [7]. However, the Raspberry Pi 5 lacks a dedicated AI accelerator such as a CUDA-capable GPU or NPU, meaning that all AI inference tasks must rely entirely on the CPU [8]. This presents clear performance limitations for real-time image recognition.

2.3 NVIDIA Jetson Nano

The NVIDIA Jetson Nano is specifically designed for edge AI workloads, featuring a 1.43 GHz quad-core ARM Cortex-A57 processor with 128 CUDA cores and support for TensorRT and CUDA frameworks [9]. These specifications provide the strongest image recognition capability among the three devices. However, its price ranges from 99 to 149 US dollars [10], and its computational power exceeds the practical requirements of this system. Additionally, its lower CPU clock speed of 1.43 GHz may limit performance in non-GPU-accelerated tasks such as system management and data transmission [9].

2.4 Orange Pi 5

The Orange Pi 5 is powered by the Rockchip RK3588S system-on-chip, featuring an eight-core processor composed of four Cortex-A76 and four Cortex-A55 cores [11]. It integrates a built-in 6 TOPS NPU designed to accelerate neural network inference [11]. Priced between 60 and 90 US dollars, it offers dedicated AI acceleration hardware at a cost comparable to the Raspberry Pi 5.

2.5 Comparative Analysis and Selection

After comprehensive evaluation, the Orange Pi 5 is identified as the most suitable hardware choice. The Raspberry Pi 5, despite its low price, lacks dedicated AI processing hardware essential for real-time image recognition. The Jetson Nano provides the most powerful AI capability but exceeds the requirements and budget of a consumer household device. In comparison, the Orange Pi 5 provides a dedicated NPU at approximately half the cost of the Jetson Nano, balancing performance, cost, and energy efficiency. Research on deep learning inference in embedded devices confirms that edge devices with dedicated NPUs can achieve significant inference acceleration while maintaining low power consumption [12]. Based on this analysis, the following section describes the system architecture and operational process of the Smart Nutrition Trash Can.

3. Technical Description

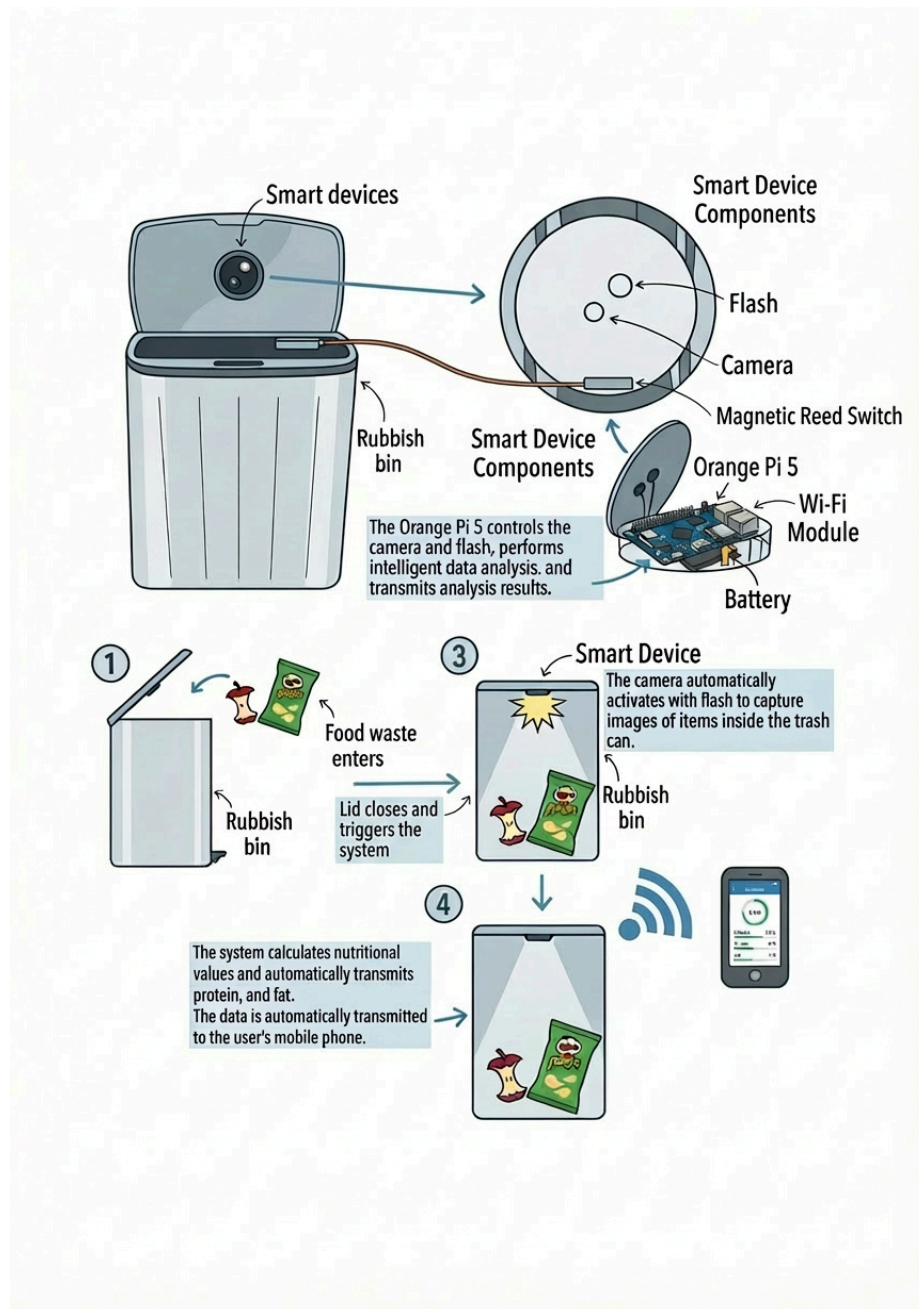


Fig. 1. System architecture and operational process of the Smart Nutrition Trash Can.

3.1 System Overview

The Smart Nutrition Trash Can is a dietary monitoring device that integrates hardware modules with a software system within a modified household trash can. The system embeds an edge-computing processor, a camera, and a wireless communication module. When a user discards food packaging or leftover food, the system automatically performs image capture, food recognition, nutritional analysis, and data transmission.

3.2 Hardware Components

The processing core is the Orange Pi 5 single-board computer [11]. The RK3588S chip integrated within the device includes a built-in 6 TOPS neural processing unit [11], which is responsible for executing the image recognition model and coordinating all hardware modules.

For image capture, a camera module is installed on the inner side of the trash can lid via the MIPI CSI interface [11], positioned to face the interior to capture images of discarded items. An adjacent LED flash ensures that clear images can be obtained under limited lighting conditions.

For the triggering mechanism, a magnetic reed switch is installed at the junction of the lid and body. When the lid is closed after disposal, the switch sends a trigger signal to the Orange Pi 5 to initiate image capture and analysis.

Data transmission relies on the built-in Wi-Fi module, which sends analysis results to the user's smartphone application. The system operates on direct current through a USB-C interface, with an optional rechargeable lithium battery for wireless operation. The entire electronic system is embedded within the upper lid.

3.3 Operational Process

The system architecture and operational process are illustrated in Figure 1. When the user opens the lid to discard items, the magnetic reed switch detects the opening. Upon closure, the switch triggers the Orange Pi 5, which activates the LED flash and instructs the camera to capture one or more images.

The captured images are processed by the neural processing unit using an object detection model based on the YOLOv26 [13] architecture. Similar approaches utilising convolutional neural networks for food recognition and nutritional estimation from images have been demonstrated in recent research [14]. For packaged food products, the model analyses visual features including shape, colour, brand logo, and packaging design to determine the most probable product identity. The system then queries an online food nutrition database [15] to retrieve corresponding nutritional values such as calories, protein, fat, and carbohydrates. For unpackaged leftover food, the system queries an internal nutritional composition database to estimate the approximate nutritional content.

After calculation, the nutritional data is transmitted via Wi-Fi to the companion smartphone application. The application consolidates daily records, generates a daily nutrition intake report, and provides dietary recommendations such as notifications of insufficient or excessive consumption of specific nutrients.

4. Feasibility and Benefits

4.1 Resource and Development Feasibility

All hardware components, including the Orange Pi 5 [11], camera module, magnetic reed switch, and LED flash unit, are commercially available and do not require custom fabrication. Rockchip provides the open-source RKNN Toolkit for deploying deep learning models onto the RK3588S neural processing unit [11], and pre-trained YOLO-based models [13] can be trained using publicly available food image datasets. These resources significantly lower the development barrier for an individual developer. However, the Orange Pi 5 has a smaller developer community than the Raspberry Pi, requiring greater reliance on official documentation. As a single-developer project, the estimated development timeline is approximately 12 to 18 months.

4.2 Economic Feasibility

The total hardware cost ranges from approximately 975 to 1,170 Hong Kong dollars, comparable to a single dietitian consultation in Hong Kong, which typically costs 500 to 1,500 Hong Kong dollars [16]. Ongoing operational costs are minimal, as all processing is performed locally without paid cloud services.

4.3 Ethical Considerations and Privacy

All images are processed locally on the Orange Pi 5. After food recognition is completed, the original image is immediately deleted, and only nutritional data in text form is transmitted to the user's

smartphone. The companion application requires user authentication before accessing dietary records, minimising the risk of data exposure.

4.4 Social Benefits and Scalability

At a societal level, the system may encourage healthier eating habits and reduce the long-term healthcare burden of diet-related chronic diseases such as diabetes and cardiovascular disease [4]. The architecture is also scalable to institutional settings such as elderly care homes, where residents' nutritional intake requires close monitoring.

4.5 Limitations and Mitigation Strategies

Recognition accuracy may decline when multiple food items are discarded simultaneously. To mitigate this, the application prompts users to discard items individually. Additionally, the system only tracks food passing through the trash can; meals consumed outside the home will not be recorded. An optional manual input feature is therefore included to supplement automated records.

5. Conclusion

This report has proposed the Smart Nutrition Trash Can, an integrated dietary monitoring system that embeds image recognition and edge-computing technology within a household trash can. By automatically identifying discarded food items and packaging, the system provides passive nutritional tracking without requiring manual input or behavioural changes. With a total hardware cost of approximately 975 to 1,170 Hong Kong dollars, it is a cost-effective way to improve dietary awareness among Hong Kong residents. Future versions could incorporate large language models to deliver personalized dietary recommendations based on individual health profiles.

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*AI based tools were used for language polishing and grammar correction. All content, ideas, and analysis are the author's own work.