Demos: Intelligent Nutrition Monitoring Pump System for Nasogastric Tube Patients

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Abstract

Nasogastric tube (NGT) feeding supports over 10 million patients globally, particularly those with stroke-induced dysphagia, Parkinson's disease, and cognitive impairments. However, current practices face three fundamental limitations. First, caregivers often lack knowledge of the nutritional content of homemade blended meals, leading to high malnutrition rates among long-term NGT patients. Second, commercial solutions struggle to analyze blended meals in large containers due to light path distortion. Third, gastric residual volume (GRV) assessments rely on subjective nurse evaluations, resulting in incomplete records and increased feeding intolerance. To address these challenges, this demo introduces NutriBump, an innovative system designed to enhance NGT feeding through closed-loop control. Utilizing advanced spectral analysis technology, the system accurately assesses food nutrients and employs multi-modal sensors for automatic gastric fluid aspiration and analysis. By integrating long-term nutritional intake, digestion data, and health status, NutriBump leverages large language models and AI agents to generate personalized nutrition reports automatically. This closed-loop nutrition management solution improves the accuracy of blended meal analysis and reduces reliance on subjective digestion assessments.

CCS Concepts

• **Human-centered computing** → **Nutrient Management**; **Mobile devices**; • **Computing methodologies** → *Machine learning*.

Keywords

Nutrient Management, Nasogastric Tube Feeding, Spectral Reconstruction

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1 Introduction

Nasogastric tube (NGT) feeding supports over 10 million patients worldwide, with approximately 29.2% of elderly patients in long-term care facilities in China and 34% in U.S. nursing homes relying on it [1, 5]. The standard NGT feeding procedure involves three steps: food preparation, gastric digestion evaluation, and feeding. Current practices often use manual syringe feeding or automatic pumps without nutritional and gastric fluid analysis, presenting significant clinical challenges. Many families, concerned about the quality of commercial blended foods, opt to prepare meals at home [8], but a lack of nutritional knowledge can lead to malnutrition, affecting about 20% of stroke patients and up to 80% of cancer patients [4], which may reduce life expectancy. Furthermore, gastric digestion evaluation relies on subjective nurse assessments of gastric fluid color and gastric residual volume (GRV), which can be incomplete or delayed, increasing the risks of aspiration pneumonia and feeding intolerance [13].

Previous attempts to address these gaps have proven inadequate. For instance, systems such as smART+[7] automate reflux monitoring and gastric residual volume analysis through the use of impedance sensors and a VCO2 module. Other approaches utilize cameras and pump motors to facilitate accurate and autonomous food delivery in tube feeding[6]. However, these systems lack the essential capability for nutrient quantification. Several automated food nutrition estimation systems have been proposed, yet they often rely on computer vision technology [2, 3, 9], which primarily captures texture and superficial visual features, potentially leading to inaccurate nutrient assessments. While near-infrared spectroscopy technology offers accurate nutrient measurements [10–12], its reliance on expensive hardware limits widespread accessibility and application in clinical settings.

In this demo, we present NutriBump, an intelligent nutrition management system that revolutionizes nasogastric tube

(a) System Overview (b) System Hardware Architecture

Figure 1: (a) Overview of NutriBump, which consists closed-loop intelligent nutrition management model. (b) System hardware architecture of NutriBump, including a series of sensors for gastric fluid aspiration and analysis.

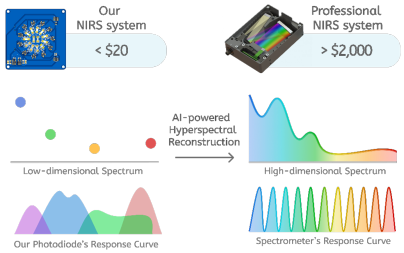

Figure 2: Rationale behinds our Nutrition Analysis.

feeding through spectral analysis, multi-modality fusion and closed-loop control. The system addresses critical limitations in current enteral nutrition, including inaccurate analysis of blended meals and subjective digestion assessment. The key idea is to reconstruct the spectra from a low-cost LED-array based near-infrared (NIR) spectrometer for nutrition analysis and integrates multi-modality sensors for gastric fluid aspiration and analysis. Additionally, to achieve close-loop nutrition management, our system utilizes large language models and AI agents to automatically generate personalized nutrition reports based on the patient's long-term nutrition intake, digestion data, and health status.

2 System Design

The design of NutriBump encompasses three core components that collectively enhance the efficacy of nasogastric tube feeding. **(1) Nutrition Analysis.** NutriBump employs lightweight and cost-effective low-dimensional spectral sensors and designs a deep learning model to reconstruct high-dimensional near-infrared spectra to facilitate accurate analysis of the nutritional components in homogenized meals and aspirated gastric fluids. Figure 2 shows the rationale of our spectral reconstruction process. By utilizing this technology, we can precise quantify the carbohydrates, fats, proteins, and total caloric content, thus addressing the challenge of nutritional uncertainty often faced by caregivers. **(2) Automatic Gastric Fluid Aspiration and Analysis.** As shown in Figure 1(b), this system utilizes a range of sensors, including strain sensors, ultrasonic distance measurement sensors, pressure sensors, and photoelectric sensors, to automate the aspiration of gastric fluids while maintain the safety. It analyzes key parameters such as weight, volume, pH value, color, intragastric pressure, and residual nutritional components. This real-time assessment of the patient's digestive condition offers valuable data that can inform dynamic adjustments to nutritional plans, thereby enhancing patient safety and comfort during feeding. **(3) AI Intelligent Analysis and Nutrition Recommendation.** By integrating long-term nutritional intake data, digestion metrics, and overall health status, this system employs large language models and AI agents to automatically generate personalized nutrition reports. It provides tailored weekly recipes and nutritional plans, effectively simulating the expertise of professional dietitians.

3 Demonstration Overview

In this demonstration, we will showcase the capabilities of our system, NutriBump, in performing closed-loop NGT feeding. The system is built using self-designed NIR spectrometers and commercially available multi-modality sensors, with a total cost of less than $100. Our demonstration includes data from 55 foods commonly utilized in NGT feeding, categorized as follows: 13 enteral liquid nutritional preparations, 20 powdered mixed foods, 11 home-cooked foods in mashed form, and 11 commercial dysphagia foods in mashed form.

First, we will highlight NutriBump's capability to accurately predict the nutritional components of these foods, specifically focusing on carbohydrates, fats, and proteins. The system achieves a prediction error of less than 1g per 100g, ensuring reliable nutritional analysis that is critical for effective patient care. Next, we will illustrate the system's functionalities in automatic feeding and gastric fluid aspiration. NutriBump performs these tasks seamlessly, enabling timely delivery of nutrition while providing real-time monitoring of the patient's digestive state. Finally, NutriBump leverages the detected nutritional information to generate personalized nutrition analyses and dietary recommendations. By utilizing large language models, the system produces tailored reports that simulate the expertise of a professional dietitian, enhancing the overall care provided to patients.

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