2022 I-RIM Conference
October 7-9, Rome, Italy
ISBN: 9788894580532
DOI:10.5281/zenodo.7531298

A Smart Robotic Platform for Monitoring Food Assumption in Elderly Patients

F. Scotto di Luzio[1], N. L. Tagliamonte[1,2], and L. Zollo[1]
[1]Research Unit of Advanced Robotics and Human-Centred Technologies, Università Campus Bio-Medico di Roma, Rome, Italy.
[2]Laboratory of Robotic Neurorehabilitation, Fondazione Santa Lucia, Rome, Italy.

***Abstract*—Malnutrition is a prevalent comorbidity in hospitalized elderly patients, often caused by dysphagia and potentially increasing the risk of prolonged hospitalization and mortality. Such patients must follow a specific diet and often carry out speech exercises with the constant presence of a clinical supervisor. However, there are several difficulties in monitoring patients and also obtaining complete information on the intake of food. Several robotic solutions have been presented in the literature to support the patient and motivate him/her during food assumption, but no technological solutions have been proposed for elderly patients at risk of undernutrition. This paper proposes an approach for using a service robot for the monitoring of the required energy intake to avoid weight and muscle mass loss and identifing any event of cough or oxygen desaturation in hospitalized geriatric patients.**

***Index Terms*—Robot-aided food monitoring, malnutrition prevention, elderly patients, food intake estimation**

I. Introduction

The aging of the population and the progressive increase in life expectancy have drawn attention to multiple long-term conditions affecting hospitalized elderly patients. Among these, malnutrition is a highly prevalent condition in these patients and is associated with an increased risk of prolonged hospitalization and mortality [1]. Inpatients usually present undernutrition, which is promoted by an energy expenditure exceeding energy intake, and/or micronutrient-related malnutrition. Nutritional support is effective in improving body weight, fat and fat-free mass, hence a timely recognition of an unbalance between energy expenditure and intake is pivotal to minimize the risks of adverse outcomes. Although there exist formulas to easily predict the energy expenditure of hospitalized patients, the estimation of energy intake requires the quantification of food assumption. Anyhow, monitoring patients during meal is a burdensome activity for nurses and is performed only in a selected population, thus leading to an underestimation of patients at risk for undernutrition. Malnutrition recognizes several causes but one of the most common is dysphagia (*i.e.* the difficulty in bringing food from the mouth to the stomach) that affects about 50% of elderly hospitalized patients [1]. Such clinical condition can have various causes, including neurological, muscular and oncological disorders. Typically, meal is delivered by nurses and healthcare providers and complies with the nutritionist and speech therapist indications in terms of consistency and calories [1], [2]. This helps to get the required energy intake and to minimize the risk of pulmonary aspiration. Nurses and doctors daily overview patients and motivate them to ascertain that they are consistent with the prescription in terms of quality and quantity of assumed food. However, in hospital settings it is often difficult to continuously monitor food intake due to the need to manage many patients in a short time. Several state-of-the-art systems have been proposed that can provide patients with nutritional support, such as robotic arms on wheelchairs or humanoid systems to cognitively motivate patients to avoid anxiety and depression [3]–[5]. However, these systems are not suitable for use in a hospital setting on patients suffering from dysphagia since, to the best of our knowledge, they cannot monitor difficulties in swallowing, identify coughs, understand the type and quantity of assumed food and estimate ingested calories and macronutrients. This paper proposes a smart robotic platform for monitoring the food assumption, to be developed in the framework of EU H2020 ODIN project, able to: *i)* monitor the required energy intake to avoid weight and muscle mass loss, thus minimizing malnutrition risks for the patient, *ii)* verify that the patient is following correctly the prescribed diet and *iii)* identify any events of cough or oxygen desaturation.

This work was supported by the European Union Horizon 2020 Research and Innovation Programme with ODIN project (Grant Agreement Number: 101017331).

II. Robot-aided monitoring of food assumption

According to the traditional clinical workflow, each geriatric patient generally undergoes a screening of dysphagia and undernutrition performed by nurses and doctors using several questionnaires and tests available in the literature. Once the diagnosis is confirmed, specialists prescribe the treatment, which mainly consists of speech exercises and of a detailed diet. Nurses and doctors daily have to overview patients while performing their exercises to ascertain that they are consistent with the prescription, in terms of quality and quantity. Likewise, they should overview whether and to which extent patients are feeding, quantifying the food assumption. In order to develop an effective robot-aided system for food assumption monitoring, it is necessary to implement and manage such monitoring abilities automatically.

As shown in Figure 1, the robotic system has to navigate autonomously to reach the desired patient avoiding any static and dynamic obstacles along the way. To achieve this objec-

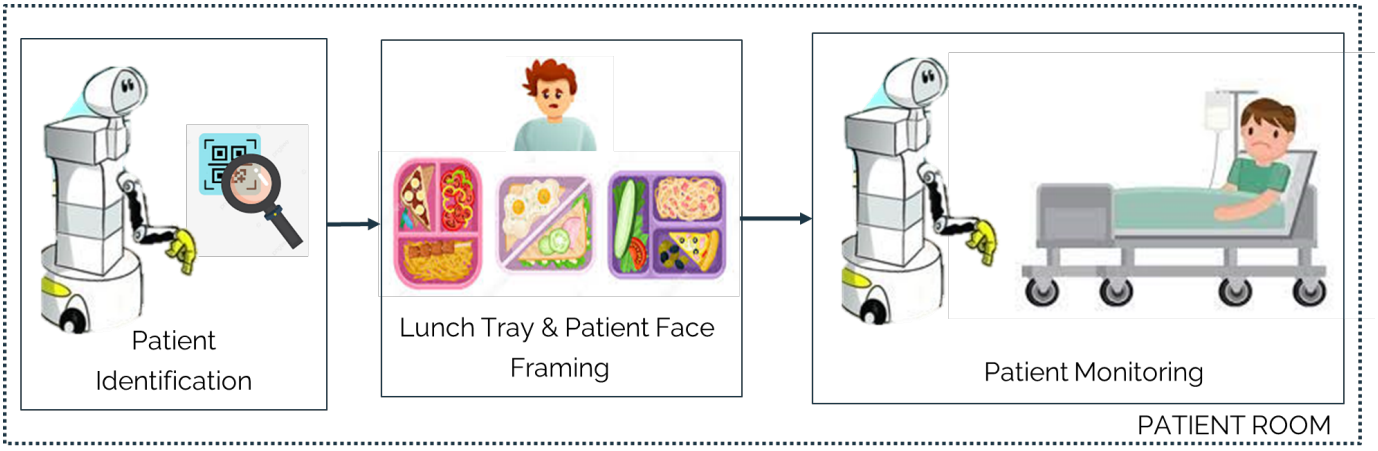

Fig. 1. Workflow of the proposed approach for robot-aided monitoring of food assumption.

tive, several approaches are available in the state of the art, many of which are based on Simultaneous Localization And Mapping (SLAM) techniques [6], allowing to build and update the map of the dynamic environment. Popular rough solution methods include the Particle Filter, Extended Kalman Filter, Covariance Intersection, and GraphSLAM. After reaching the patient, the robot has to identify her/him, also through the use of a barcode or qrcode. Other methods, such as face recognition could be useful, but they would risk greatly increasing the computational load and would require a database of patient faces for algorithm training. Once the patient has been identified and the assiciated diet prescriptions have been retrieved by the system, the patient's face has to be monitored while eating the meal for detecting coughing events and any signs of oxygen desaturation. This monitoring requires the identification of the Region of Interest (ROI) of the patient's face; this ROI has to be provided in input to deep learning algorithms. The meal tray has to be monitored at least twice, *i.e.* at the beginning and at the end of meal. To this aim, the first step is to obtain the 3D positioning of the tray by means of the information coming from the robot RGB-D camera. The image representing the placement of the tray can be given as input to algorithms for food classification and estimation [7], [8]. The robotic system has to be aware of the process steps which are completely asynchronous and may evolve differently for each patient. To accomplish these complex tasks it is necessary to use a service robot equipped at least with: *i)* navigation capabilities to reach the bed of the correct patient; *ii)* multisensory architecture for patient monitoring; *iii)* AI capabilities to monitor food assumption, to guarantee a cognitive interaction with the patient, and to produce a report of energy intake and macronutrients consumption.

III. Conclusions

This paper presents the approach and requirements necessary for the development of a smart robotic system for monitoring food assumption in hospitalized geriatric patients. This objective poses numerous technological, scientific and ethical challenges. The results may reveal whether and at what extent the use of a robot integrating autonomous navigation, cognitive and decision-making capabilities for monitoring the volume of food intake, the percentage of macronutrients and any coughing or signs of desaturation can represent a valid tool to help the identification of potential malnutrition and optimize the hospital clinical workflow and patients' experience.

References

[1] Barker, Lisa A., et al. "Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system." International journal of environmental research and public health (2011).
[2] Spronk, Peter E., et al. "Prevalence and characterization of dysphagia in hospitalized patients." Neurogastroenterology & Motility 32.3 (2020).
[3] Kyrarini, Maria, et al. "A survey of robots in healthcare." Technologies 9.1 (2021).
[4] Liu, Fei, et al. "I-feed: A robotic platform of an assistive feeding robot for the disabled elderly population." Technology and Health Care 28.4 (2020).
[5] Alatise, Mary B., et al.. "A review on challenges of autonomous mobile robot and sensor fusion methods." IEEE Access (2020).
[6] Temeltas, Hakan, and Demiz Kayak. "SLAM for robot navigation." IEEE Aerospace and Electronic Systems Magazine 23.12 (2008).
[7] Konstantakopoulos, Fotios S., et al. "Mediterranean Food Image Recognition Using Deep Convolutional Networks." 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (2021).
[8] Konstantakopoulos, Fotis, Eleni I. Georga, and Dimitrios I. Fotiadis. "3D reconstruction and volume estimation of food using stereo vision techniques." IEEE 21st International Conference on Bioinformatics and Bioengineering (2021).