

# An Ambient System for Acquiring and Digitizing Health Parameters Targeting Dietary Counseling for Frailty Patients

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**Abstract**—This article outlines an assistive system that aims at supporting dietary counseling for older patients that are affected by the geriatric syndrome of frailty. Classical dietary counseling is primarily based on a direct interaction between nutritionists and patients. Nutritionists apply their expert knowledge to mostly analogue data that is usually acquired during appointments between patients and nutritionists. This data has to be digitized for further analysis and usually provides information about the patients' current status. Consequently, nutritionists have to wait for the next appointment with their patients to acquire new data to observe the trend of their patients' therapeutic diet. In order to provide nutritionists with a higher data update rate, without additional time-consuming appointments, our system acquires and digitizes patients' relevant health parameters using several sensors and devices. An activity tracker, looking like a usual wristwatch, provides information about the patients' daily activity while a smart body scale is used to track patients' body composition. Furthermore, a mobile application for a digital food diary has been developed. During development the special usability requirements of the frail patients have been taken into account. This application allows patients to record their daily food intake themselves. The input is only based on food groups that are displayed as pictographs and simple buttons to make the input as simple and intuitive as possible. The activity, the body composition and the digital food diary data are stored in an additional device, the so-called Secure-Home-Cloud. With this device, the patients' sensitive data remain under his or her personal control at any time. Thanks to the assisted recording of the patients' data, the system is able to provide the nutritionist with data of higher quality and at higher frequency. This collected data is an important asset to support the counseling process.

**Keywords**—*Ambient Assisted Living (AAL); Assistive Technology (AT); Cloud Computing; Frailty; Health Data; Nutrition Counseling; Mobile Application; Usability; Smart Services*

## I. INTRODUCTION

This article outlines a system that aims at verifiably supporting dietary counseling for older patients that are affected by the geriatric syndrome of frailty. This syndrome is characterized by an increased susceptibility to exogenous stress factors like diseases, overload or agitation and is caused by a combination of the physiological aging process and its corresponding pathological consequences [1] [2].

Due to the effects of the demographic change [3]; increased life expectancy caused by advances in medicine and care [4] [5]; dietary counseling for people that are 70 years and above is highly topical. As a result of this growing population of older people, the number of patients affected by the frailty syndrome increases as well. As a result, nutritionists have to treat more patients in less time to respond to these developments.

For the use case of dietary counseling for frailty patients, mainly two stakeholders are involved in the process: the patient as a service recipient and the nutritionist as the service provider [6]. The nutritionist applies his or her expert knowledge and experience to the patient's health parameters to identify nutritional deficits. On the basis of this data, the nutritionist determines a corresponding therapeutic diet. In order to obtain information about the trend of the patient's therapeutic diet, the nutritionist has to acquire information about the oral intake of his or her patient over a fixed period of time. Furthermore, data on patient's weight, body composition and physical activity has to be integrated in the nutritionist's considerations. In order to support this data acquisition process, the system outlined in this paper, depicted in Fig. 2, digitizes counseling relevant data and workflows.

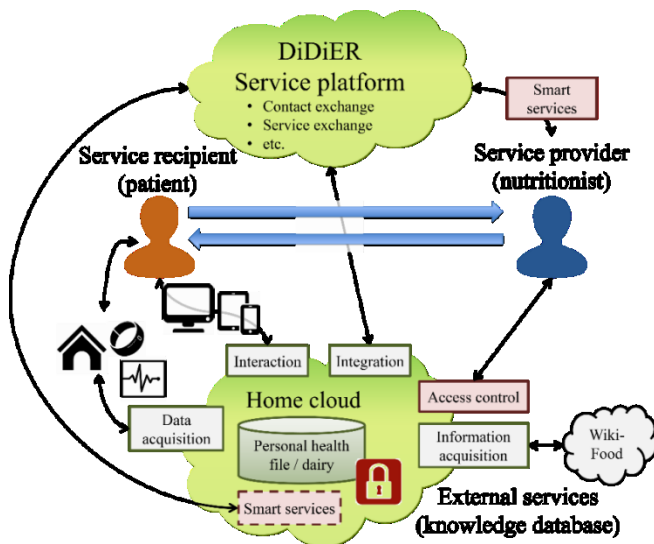


Fig. 1: Abstract overview of the global system architecture including the main stakeholders (frail patient and nutritionist) of the system as well as the main internal and external communications channels and sources.

The remainder of this paper describes the application of this proposed system to the frailty use case. However, the architecture of the proposed system could be applied to a wider range of pathologies [6].

## II. AMBULATORY DIETARY COUNSELING FOR THE FRAILTY SYNDROME

The geriatric syndrome of frailty is a state that is characterized by reduced physiological reserves and an increased vulnerability towards negative health events and external stressors compared to non-affected persons at the same age. The syndrome is a highly prevalent in old age. Older persons suffering from frailty have a much higher risk for falls, fractures, infections, hospitalization, multimorbidity and mortality compared to non-frail adults [7] [8]. The most common definition for the frailty syndrome by L. P. Fried [2] provides the following main indicators for frailty:

- weight loss,
- reduced handgrip strength,
- reduced walking speed,
- reduced physical activity and
- exhaustion.

With these criteria, older persons can be classified as robust (no criteria is present), pre-frail (one or two criteria are present) or frail (three or more criteria are present).

Furthermore, there is evidence that nutrition is an important factor for the prevention and treatment of frailty [9] and that a single macronutrient deficiency can increase the risk of becoming frail by about ten percent [10]. Until now, protein is the macronutrient whose effect has been most extensively investigated. International expert groups recommend a daily intake of up to 1.0-1.2 grams of protein per kilogram of body weight [11]; other studies report that a

protein rich diet can increase lean mass and physical function [12] [13]. In conclusion, there is a close link between nutrition, muscle mass and physical function. Consequently, dietary counseling is an important tool to protect lean body mass to keep or even to improve the frailty patient's physical function.

As outlined before, the main stakeholders of the counseling process are the nutritionist and the patient. The primary interaction between them takes place during the counseling appointments. During these appointments, the data that is relevant for the process of dietary counseling is acquired from the patient. To get this data, the nutritionists normally use the so called 24h-recall [14] and/ or the Mini-Nutritional Assessment (MNA) [15]. For the 24h-recall, the nutritionist interviews the patient about their nutrient intake and records the entirety of what has been eaten by the patient during the previous day.

The most established malnutrition screening tool for older people is the Mini Nutritional Assessment – Short Form (MNA-SF). It allows the nutritionist to screen older people for their state of malnutrition and targets general questions about weight loss, nutritional intake, BMI as well as age specific concerns like mobility, acute diseases and cognitive impairment. According to the MNA-SF patients are classified as either malnourished (0-7 points), at risk of malnutrition (8-11 points) or at normal nutritional status (12-14 points). The Long form of the MNA includes an assessment part and can be applied if more detailed information is needed.

## III. SYSTEM DESCRIPTION

In order to support the nutritionist as well as the patient, our system uses a set of devices and a mobile application for the automatic acquisition and digitalization of the data of relevance for the counseling process. For the selection as well as for the development of these components the special requirements of the frailty patient group were always of particular importance, as both the age group and the frailty symptoms increase the system's usability requirements.

The most easy to use device of the system is the activity tracker, which comes in form of a conventional wristwatch, see Fig. 2. Since the activity tracker has no controls, it cannot



Fig. 2: Withings Aktivité Pop showing the time and the overall activity of the current day.

be accidentally mis-adjusted by the frail patients and the

battery life; about 6 months; is long enough for the duration

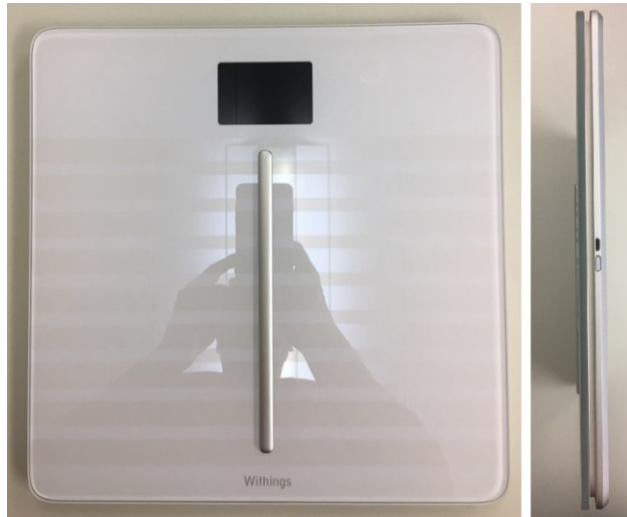


Fig. 4: Withings Body Cardio body scale, measuring body weight, body fat, lean body mass and the hydration of the patient.

of the study, so that the frailty patient does not have to charge the device during the period of the counseling.

As outlined above, one of the most important indicators of the patient's current status is their weight and body composition data. Therefore, a so-called smart body scale is integrated into the system, allowing for a digital acquisition of this data, see Fig. 3.

Another device that is integrated into the system is a tablet computer. This tablet computer is used for a mobile application of a digital food diary that was developed with the special needs of the frailty patients in mind. Therefore, the application uses only intuitive pictographs and simple buttons as control elements. This allows the patients to fill in their food diary themselves, see Fig. 4.

As soon as the patient starts the tablet, he or she accesses the *meal overview* screen. Here, all meals of the current day are listed and changeable. If the patient wants to enter his or her breakfast, they touch the green *plus button*. Thereafter, the *meal overview* screen is displayed. Here, the basic food groups are displayed as pictographs with a textual description. These act as buttons leading the patient to a corresponding *sub-group* with more detailed categories of food items. After the patient has chosen the item to add to his or her meal diary, the *amount* screen is displayed. After choosing the amount, the food is added to the meals overview screen, which is then displayed. From here, the patient can start all over again until they have entered all the food items for all meals of the day. In total it takes about four to seven interactions (touches) until one food item is completely recorded.

#### IV. DISCUSSION & FURTHER WORK

The sensors and devices of our system are potentially able to provide data that has a higher resolution in the time domain compared to the data acquired from the frailty patient during conventional appointments. Consequently, this data allows

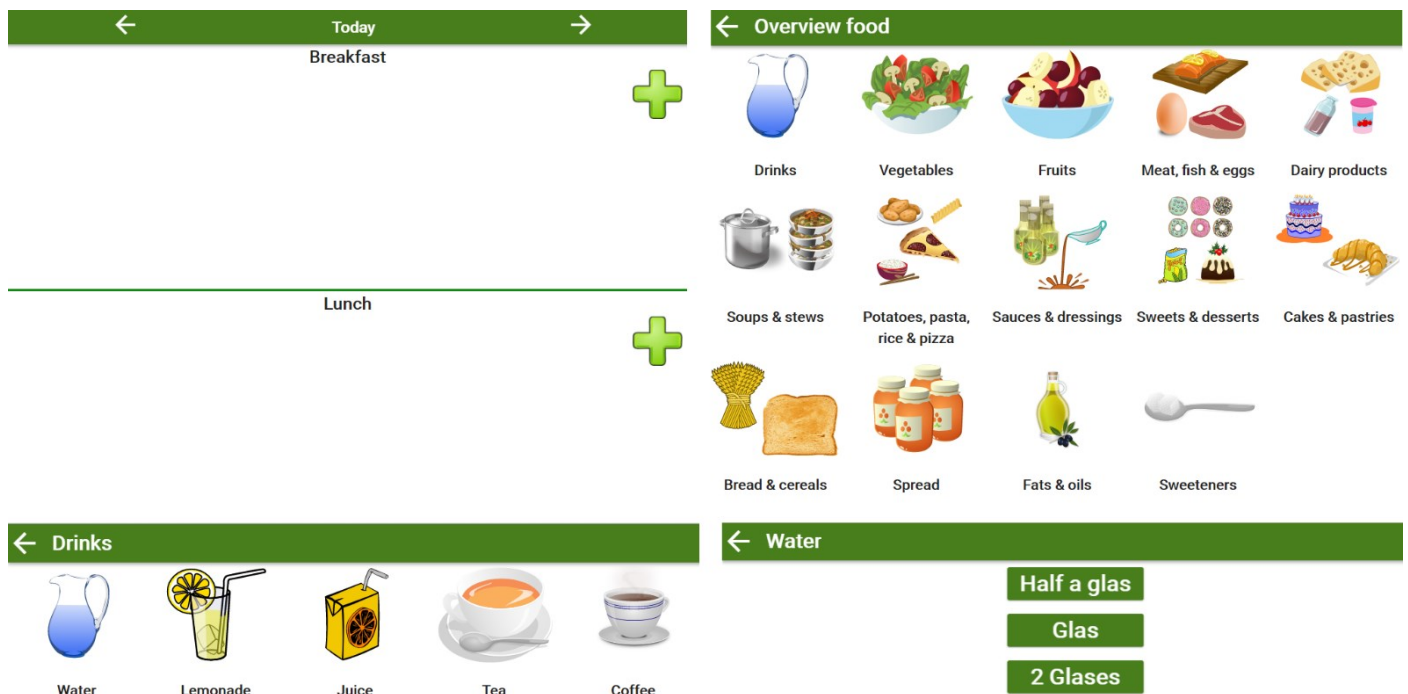


Fig. 3: Mobile digital food diary application for frailty patients, showing: the meal overview screen (upper left image), the food group overview screen (upper right image), the drinks group screen (lower left image) and the quantity selection screen (lower right image).

the nutritionists to estimate the trend of the therapeutic diet in the periods between appointments. This enables the nutritionists to intervene, for example with an early appointment, if the trend of the frailty patient's status evolves in an undesired direction.

In summary, the outlined system is a useful tool to support nutritionists with a higher quality and quantity of relevant data. The sensor-based collection of activity data as well as body composition data combined with the digital nutrition diary data enables nutritionists to better-informed decision making about the patients under their care. To avoid additional work for the nutritionists due to the higher quantity of data, additional smart services have to be developed to pre-process the data. The goal of these smart services must be to create a visualization that enables the consultant to see the current status of their patient at a glance. One way to accomplish this would be to update the initial MNA with the patient's continuously collected data, in order to update the MNA score during therapy. This would provide the nutritionist with a standardized value about the patient's current nutritional status. An ongoing field study is currently conducted to determine whether or not the digitally acquired data has the same quality as the data collected with the current gold standards in dietary counselling for frailty patients.

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