RESEARCH ARTICLE

Automatic Energy Food Estimation In Elderly People With Neurodegenerative Disorders

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ABSTRACT

Dementia has been an increasing trend with an increase in the population of elderly people, and WHO estimates that the number of individuals with dementia doubles every 20 years. There is no curative solution for dementia, but non-drug approaches can improve patient quality of life.

In nursing homes (NH) almost 86% of patients with advanced dementia have problems eating and they need eating assistance. Patients with cognition impairment sometimes confuse food and they do not know when and how much they should eat and drink, so it leads to dehydration and malnutrition which cause weight loss, infection, decreased quality of life and increased risk of death. So, 24-hours caregivers are needed in this situation, and it is so hard for caregivers. Patients with dementia can live easier in the familiar environment, so ATs (Assistive Technologies) can help patients and caregivers to live in their own homes if possible. One of the approaches for monitoring eating activity of people with dementia is calculating calorie of food, the aim of this research is working on it.

There are different approaches for measuring calorie of food but most of them depend on the user or they do not consider human value and ethical considerations in their design. Patients with dementia lose their autonomy, so they need an automatic system for calculating calorie of food. The objective of this research is to provide the state of art of the energy food estimation in elderly people with dementia. This study will be a good start for defining our own approaches in the domain.

1. Introduction

Dementia has an increasing trend with an increase in the population of elderly people, and it has a detrimental effect on society. The World Health Organization (WHO) reported that approximately 47 million people have trouble with neurodegenerative dementia. Every year 7.7 million persons are diagnosed with dementia and WHO estimates that the number of individuals with dementia doubles every 20 years [1]. According to the Canadian Study on Health and Aging over 500,000 people are living with dementia and this number will be increased to 937,000 people by 2033. Dementia has a great and deep impact on 5 million American patients and 36 million patients all over the world and it has significant burdens for their family members and their caregivers [2].

Dementia is a general term for a set of problems, symptoms and disorders that can change people's life and it is caused by damage to brain cells. Symptoms of dementia may include a loss of memory, loss of autonomy, mood changes, impairment in problem solving, difficulties in languages, problem in communication, being unfamiliar with their surroundings, visual problem, problem in eating activity and different thinking abilities [3].

The critical part of human health is nutrition. The process of making foods for living and maintaining health means nutrition. Nutrition includes the processes of ingestion, digesting, absorbing, and metabolizing their nutrients. Water, proteins, carbohydrates, fat, minerals, vitamins, and fiber are all nutrients. A good diet should have a good balance of nutrients [4, 5].

Malnutrition includes both undernutrition and overnutrition (excess calorie or food intake) which led to loss of body mass and reduction of body energy stores. Malnutrition is because of eating inadequate food either or both quality and quantity of nutrients. Undernutrition means insufficient protein, vitamin, carbohydrate, calorie, and other nutrients which are needed for tissue repair and maintenance. [4].

The consequences of undernutrition and weight loss in older people with dementia are progression of the disease, functional, and cognitive symptoms. In addition, undernourished patients with dementia need to live in a care home earlier compared to patients with a healthy and balanced diet. In addition, mortality increases in patients who experience malnutrition and weight loss severely [4].

Healthy lifestyles and eating healthily can have vital effects on the development of dementia, so monitoring the eating activity of elderly people with dementia is very important. Some patients experience more appetite than normal and eat a lot and some patients have anorexia, they do not have tendency to eat food, some of them have chewing or swallowing problems. Some of them forget to eat or drink, some of them think they do not eat food and eat again and again because they have short-term and long-term memory problems and forget their activities. If the patient cannot receive adequate nutrients or receive more than enough food, the potential risks of weight loss, obesity, diabetes, blood pressure, dehydration, and undernutrition increase [6].

All the above-mentioned reasons can clear the importance of monitoring eating activity of older people with dementia. For several decades, researchers have been interested in studying eating disorders, eating habits and their impact on people's health. Lots of people suffer from obesity, blood pressure, diabetes etc. and a healthy diet can affect their health. So, there are different tools and approaches to monitor eating activity of people. In this paper, some of different methods of calculating energy of foods and their limitations have been described and in conclusion new ideas are generated for future work and research. Our future work will be more related to design, implementation and evaluations of new solutions.

2. Different Methods to Solve Eating Problems

There is lots of research about monitoring food intake because lots of people struggle with eating disorders and one of the most important parts of human health is nutrition. Monitoring food intake is important for different people, and it is not just for patients with dementia.

2.1 Environmental Factors

In designing a dining room, the most important thing is a comfortable atmosphere and patients with dementia feel they are in their own home so in nursing homes environmental factors can have a significant effect on patients [3].

Patients with advanced dementia cannot concentrate on their meals and they can easily be distracted by noise or some visual distractions. Places with lots of people can distract them, so they try to leave these places without eating adequately. To alleviate these features and design a quiet and comfortable place, it is better to separate the service area and dining area. Then divide tables with moveable walls like figure 1, these moveable walls are not very tall, residents on

the table cannot see each other but staff can see them and control them. With considering these items patients probably eat their food [3].
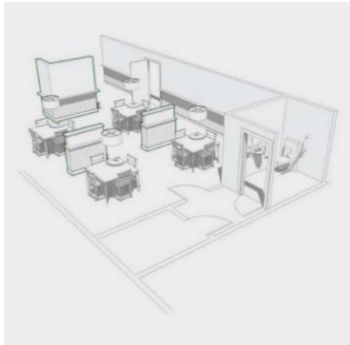

Figure 1 Dining area with moveable walls [3].

Lots of people with dementia have problems in walking and mobility and they use wheelchairs but there are not suitable tables for these users. It leads to eating problems, because patients cannot be close enough to the table and cannot concentrate on their eating. For solving this problem, it is better to design a flat-bottomed table at 74cm height like figure 2 [3].

Studies have indicated that older people need 3 times much more light than younger people. So, in the dining area it is better to locate a light on each table like figure 2 [3].

Figure 2 Flat-bottomed table and light on the table [3].

In the other research, Buckinx et al. has investigated the environmental effects of dining areas in nursing homes on patient intake, they found that environmental factors like noise, light, odors, comfort, services, taste of meals etc. have no significant impact on patient food intake [7].

2.2 Pace of Food

Lio et al. has investigated factors which can influence the pace of food intake of patients with dementia, this research conducted on NH residents. In this research the pace of food is considered instead of the amount of food. Pace of eating food is the number of drinks and bite divided by specific time. Patients with slow or rapid pace of food encounter problems like insufficient food intake or choking. Researchers in this study have investigated on 3 following factors which have impact on the pace of eating food:

1. Patient characteristics like dementia stage, gender, age and eating performance.
2. Environmental factors like noise, light, odors, etc.
3. Caregivers' and nurses' assistance.

These three factors are considered to improve eating activity of people with dementia. Caregivers should control patients daily and help them in eating activities. Some of them need verbal help, it means assistance has to motivate them to eat or drink more but some of them need physical assistance and they cannot eat on their own [8]. In this situation the burden of caregivers is very high and boring because they should control their patient 24 hours and their carelessness has bad consequences. So new methodologies and approaches are being developed to decrease caregivers' responsibilities [9].

3. Assistive Technology Definition

Assistive technologies (ATs) are called to a wide range of aid tools like walking canes to robots and high-tech tools that can have beneficial effects on patient life. These technologies can have three main effects on people with dementia and their caregivers, these effects are listed below:

1. Help people with dementia to live in their own home and delay entry into care homes.
2. Reduce dependence on caregivers.
3. Improve patient quality of life.

ATs can support patients with dementia and their caregivers but in some cases these technologies can breach patient privacy and their freedom so careful consideration is needed to respect human rights and ethical aspects [1].

4. Different Methods for Calculating Energy of Food

One of the approaches for monitoring the eating activity of people is counting the amount of energy they receive during a day. It is important to know how many calories people receive in a day for different reasons, for example athletes want to know the calories they receive because of their body shape, also people with diabetes or dementia need to know the number of daily calories for controlling the progression of their disease. So,

there is different research about this topic, in the following I am going to summarize some of them.

4.1 Traditional Eating Monitoring

Traditionally monitoring approaches are active methods, in these methods users should report their diet by text or pictures of food, like food logs, food journals, or some mobile apps like Cara Care or YouEat [10-14].

Some users failed to participate in self-monitoring methods because it is such a time consuming and annoying task. The user should record his consumed food every day, so users prefer to complete their task at the end of the day, so the probability of error and mistakes increase. Most important problem of these types of self-reporting is memory recall and it cannot be good for elderly people with dementia because one of the most important symptoms of dementia is memory problem, and it cannot satisfy their need.

4.2 Electronic Food Monitoring Application

One of the approaches to solve problems of traditional self-reporting methods is simplifying reporting food consumption during a day. Users can record a voice and say the amount and type of consumed food or scan the barcode of the food like figure 3. But these methods illustrated that people with low literacy skills cannot describe food items in voice recording or they cannot also use special scanner to scan barcode of the food item [15].

Figure 3 Example of scanning Barcode of the Food Item [15]

4.3 Smart Utensil Method

Recently because of technological advancements, automatic monitoring systems like smart utensils are developed. This tool is a special spoon that can use its reflected light spectra to recognize type of food (figure 4). It is not an on-body device, it is not an active device, it can recognize both liquid and solid foods and it can work with dishes, glasses, and spoons. The challenge of this tool is environment light, and its reflected light and LED light can be annoying for the users. And the other problem is recognizing the type of food, the smart-U can recognize just a small number of food and it cannot be used for detecting all types of food [16].

4.4 Smart Table Surface

A new sensor system is a smart table surface that can be used for nutrition monitoring. The smart table uses a pressure sensor, fabric pressure sensor matrix and weight sensitive tablet to detect eating activity actions like scooping, cutting, stirring food etc. This tool can show how much food are eaten and how much drink is consumed by pressure changes on the surface (Figure 5). This dietary monitoring tool can recognize speed of eating and overall amount of food and drink with respect to privacy concerns, but it cannot detect type and weight of food with high level or acceptable accuracy [17].
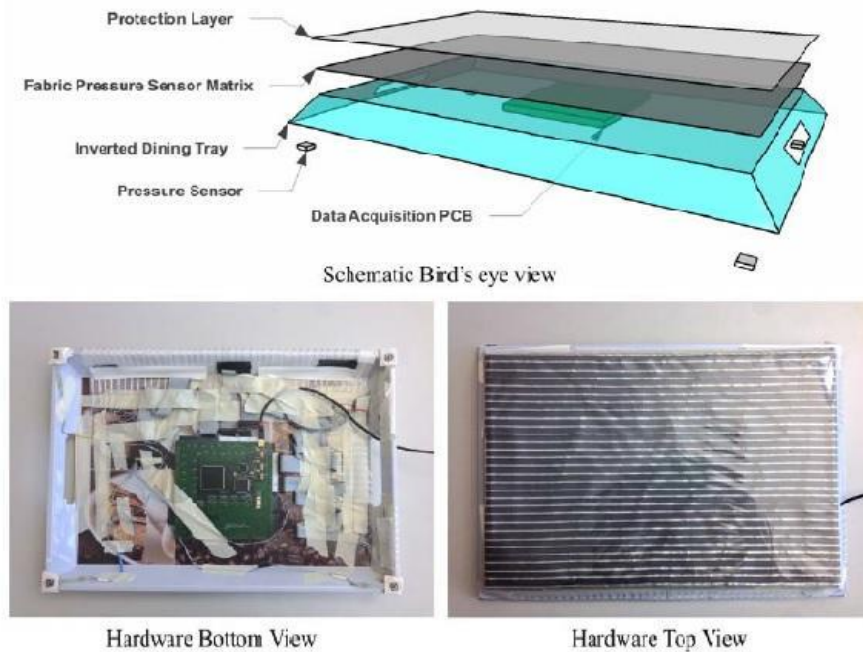

Figure 4 A example of Smart-U [16]

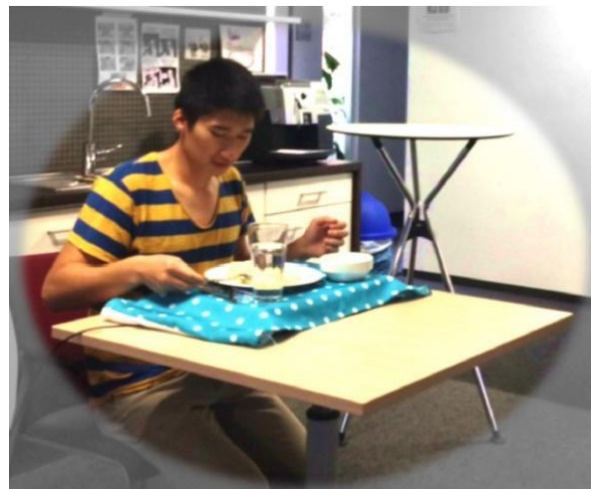**Figure 5** Smart Surface Hardware Structure [17]

Figure 6 Smart Surface Experimental Setup [17]

4.5 24-Hour Dietary Recall

One of the oldest works that people did for food calorie measurement is 24 Hour Dietary Recall (24HR). In this method patients had to remember all things they had eaten in the previous 24 hours and then with the food composition table, the amount of food they consumed was calculated. This method's drawbacks are delaying in reporting the consumed food, misunderstanding the amount of intake food, and the complex calculations needed to estimate the amount of food [18]. To satisfy these drawbacks some other methods are introduced. One of them is a web-based application, the application obtains and registers some data about, sleep, exercise, diet, and fat mass with the help of health information sensors and a web application. This method is so complex for users, it requires the help of a professional person like a nutritionist, so it is not popular between users [18].

4.6 Calculating Energy of Food based on Food Images

The other method is a FoodLog service, this method has 6512 images on its datasets, these images are used to assess dietary, but the accuracy of this method is low [18]. To satisfy these problems Pouladzadeh et al. introduced an assistive calorie measurement system which can be run on

smartphones. Users can take photos of their food then the application can measure the calorie of food automatically. The accuracy of this method is 99% [18].

n another research Pouladzadeh et al. use a dataset of almost 3000 images of different food from different categorizations. To improve accuracy of their system they have following features:

- They have both single and mixed food in their datasets.
- Size of the food is calculated by having the user's finger in the food image.
- Using different brands of camera.
- Provide different lighting conditions.
- Using various shooting angels [19].

Figure 7 Estimation of food size by using finger [19].

In this paper authors use color-texture segmentation, deep neural network algorithms, and graph cut segmentation [19]. Some of the methods mentioned are not good for patients with dementia because these methods need autonomy and most people with dementia lose their autonomy and memory and they cannot take a photo from their food intake or remember and write everything they eat during a day. So, they need an automatic approach for food energy measurement.

During the past decade, different methods have been proposed for monitoring and detection of food intake based on images captured by smartphones or wearable cameras [20]. The image capturing methods are divided into two categories, active and passive. In active methods, the user should take a photo from their food and then use an application to calculate energy of consumed food. However, in passive methods wearable cameras or sensors capture images from everything continuously. There is no need for anybody to capture image of food. Passive methods have lots of following drawbacks:

- Large number of images makes the manual review of images so difficult and time-consuming.

- There are lots of images from food and other things, so deep-learning-based methods are needed to recognize food automatically, so chances of false positives increase.
- These methods can increase privacy concerns for users and their family members [20].

4.7 Healthy Menu Planning and Recipe Analysis

Most caregivers have problems with diet management, they do not know what type of food can be good for their patient. Some caregivers are the family members of patients, in fact they are not professionals, and they do not have enough time to study about dementia and their diet. In addition, good eating behavior and proper nutrition can influence the progression of dementia and patient quality of life. So, diet management is very important and helpful for patients and caregivers. Voice based diet assistant is one of these ATs. This technology helps informal and nonprofessional caregivers to manage the daily diet of patients and learn recipes of the food. The example of conversation between voice-based diet assistance and caregivers is shown in figure 8 [21].
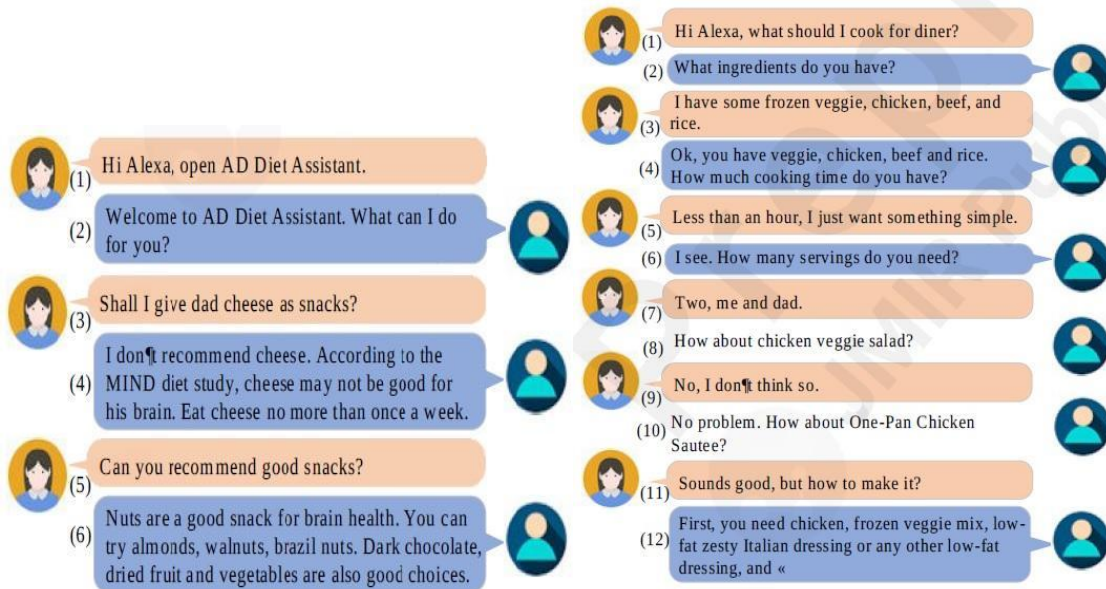
Figure 8 Example of conversation between voice-based diet assistance and caregiver [21]

A voice-based intelligent diet assistance is designed on top of a comprehensive personalized Alzheimer disease patients' diet, reasoning engine and amazon's cloud-based voice service-Alexa. This AT can recognize and understand natural language automatically [21].

This tool has some limitations, it was tested in a laboratory and the authors were not sure real caregivers can use the assistance or not. Their machine learning algorithms have been developed to improve dialog success rate and accuracy of understanding dialog [21].

5. Limitations of all these propositions

Different types of methods and ATs that can be used to estimate the energy of food none of them are applicable for patients with neurodegenerative disorders, some of them are complex, some of them work just in the laboratory, some of them need autonomy of the patients and other limitations which are listed in table 1. So, there are no approaches that can consider ethical aspects and can be suitable for patients with neurodegenerative disorders, so this research aims to fill these gaps.

Technology Name	Application	Help Dementia Patients	Limitations	References
Self-monitoring methods	Calculating the food energy value	NO	Memory Recall	[12]
Electronic Food Monitoring Application	Calculating the food energy value	NO	Professionals can work with this method	[15]
Smart Utensil Method	Calculating the food energy value	NO	Limited number of foods can be recognized by this method	[16]
Smart Table Surface	Calculating the food energy value	NO	Low level of accuracy	[17]
24 Hour Dietary Recall	Calculating the food energy value	NO	Misunderstanding the amount of food, delaying in reporting	[18]
Web-based applications	Calculating the food energy value	NO	Complex methods	[18]
FoodLog service	Calculating the food energy value	NO	Low level of accuracy	[18]
Pouladzadeh et al. assistive calorie measurement system	Calculating the food energy value	NO	Complex method for patients with dementia	[18]
A voice-based intelligent diet assistance	Diet management	NO	It works in laboratory	[21]

Table 1 Different Technology for Monitoring Eating Activity

6. Conclusion

This article provided a first state of the art of home meal approaches that can solve the feeding problems of patients with neurodegenerative disorders and the estimation of energy foods. In this research, the limitations of existing approaches are indicated and none of these methods are fully applicable in their initial versions to patients with these diseases. Most of the proposed solutions are evaluated in Labs only.

Thus, our next step will be to define our own approaches in the field. These approaches and techniques are a first step in our problem of assisted meal intake at home. Proposals for associated connected techniques will have to be proposed a profile of a person dependent on these diseases and his home environment. A design solution will be then proposed, implementation and evaluation of such solution.

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