1. Introduction

Obesity is a growing health concern in many parts of the world\textsuperscript{1} and dietary control has received considerable attention in the healthcare field. However, most dietary control programs require users to manually record detailed information on all meals. This is a tedious task for an ordinary person, which can be a deterrent to taking part in such programs.

With the widespread use of digital cameras and smartphones, people now have easy access to a camera during most of their daily activities. They can therefore use photographs of their meals as a record of dietary intake. In addition, images contain much richer information about the meals than textual or tabular descriptions. A recent study showed that merely taking a photo of a meal before eating it could encourage weight loss\textsuperscript{2}. Therefore, images are highly promising candidates for the rapid and easy recording of dietary information.

However, although important, ease of recording dietary information is not always sufficient for effective dietary management. A participant in a dietary program regularly meets a consultant, who analyzes the collected data and gives recommendations based on them. If this step were made more frequent, but at the same time less costly and time-consuming, the results would be greatly improved.

In the light of these observations, we proposed and launched FoodLog\textsuperscript{3-4}, a web-based multimedia application that can assist an ordinary person to record and manage his/her dietary activities with minimal effort. Instead of creating a detailed record of each meal, the user simply takes a photograph, using a digital camera or a smartphone. The application uses image analysis to detect images of meals in the user’s personal multimedia archive, eliminating the need for the user to select and upload them. Further image analysis estimates the nutritional composition of the meals, and records the results in a database. The user can access the images and the results on the web in a variety of formats, can revise the information if the image analysis was erroneous, and can add extra information where relevant.

In this paper, we first describe the state of food record keeping, which usually involves paper-based forms issued by healthcare services. We then present FoodLog, an application that allows users to keep photo-based visual records of their meals, thereby creating and maintaining a food log. We also describe works related to food-related information processing. FoodLog was originally a web-based application that has since been applied to several smartphone applications (apps), which we describe. We also introduce our recent work on extensions to FoodLog. Our aim in this paper is to outline FoodLog and its applications, rather than to discuss its technical details.

In addition to its original function, FoodLog can be applied to a diverse range of applications. We describe an example of FoodLog being used to generate donations that fund school lunches for impoverished children in

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parts of Africa. FoodLog can apply multimedia technology not only to help improve individuals’ health, but also to provide a new way to contribute to society.

2. Food Record Keeping for Health Management

2.1 Traditional Food Records

In general, there are two ways to identify dietary patterns by tracking meals. One method focuses on the content of meals in the short term. The other focuses on dietary habits over longer periods. To record meals in the short term, the specific content of meals can be described using methods such as the food record method or the 24-hour dietary recall method. For exploring and understanding longer-term dietary habits, methods such as the Food Frequency Questionnaire are helpful in recording dietary habits.

With the emergence of metabolic syndrome as a major health issue, some members of society will need to monitor their diet by keeping a record of their meals. Individuals visiting health centers for health guidance may be instructed to write down everything they eat, including the amounts, on paper (usually in a tabular format) each day over the course of a week. A nutritionist then evaluates the information and provides advice. Meal information is usually recorded on paper, which may prove difficult. In particular, it is easy to overlook an item or two, and describing every single item is time-consuming.

With the advent of health guidance services for the middle-aged, many apps have appeared, promising to make it easier for people to record their meals. Most of the apps offer a central set of features, whereby the user selects from a menu or types a textual description of what he or she has eaten, after which the software gives nutrient information. These apps usually have additional functions, such as letting users set a daily caloric threshold, recommending recipes or providing advice on exercise.

However, even when using one of these apps, users must rely on their memory to record what they ate, which is not significantly different from the older paper-based method. Typically, we find that the software available on the Internet will not ultimately save users much effort. In fact, it takes additional time simply to learn how to enter data into the app.

2.2 Multimedia Technology for Food Records

Some work has been aimed at photo-based food recording. Given the widespread use of mobile devices such as digital cameras and smartphones, these devices can now be considered as data collection tools for dietitians. Images contain richer information than text descriptions. As a result, people have started to use images of their meals to record their daily food intakes. A third party, such as a dietitian, can then evaluate the food content and give appropriate advice. However, such a semi-automatic approach still requires a third party; research into new technology has therefore started, with the aim of analyzing food images via image processing.

There have been some studies of image processing approaches to the analysis of food images. In Kitamura et al., we presented our previous system for detecting food images and estimating the food balance by categorizing food into grains, vegetables, meat/fish/beans, fruit, and dairy products. Miyazaki et al. proposed calorie-content estimation based on low-level image features, whereby a food photo is visually searched using the low level features in a food photo dataset which has app. 7000 food images with their calorie content values. The higher-ranked food results in the visual search are used with a regression method to make the estimation.

Most previous work on the image processing of food images has focused on the recognition of food items or menus. Joutou et al. investigated the recognition of the menu associated with a food image from among 50 selected menus. Zhu et al. estimated the amount of food that a person had eaten, using photos of the food and the plate both before and after the meal. Wu et al. estimated the calorie content of a limited set of fast-food menus. Yang et al. proposed a method for identifying fast-food items, using pairs of pixels and their local features. Bosch et al. evaluated various global and local features of images for food identification; in their work, however, the number of menus and sets of food items are very limited.

The use of image-processing systems such as TADA and NIMS has been proposed, but they remain experimental systems that are not generally available. To date, FoodLog has been the only system open to public use.

3. FoodLog: An Easy Way to Record and Archive What We Eat

To make it easy to keep a record of one’s meals using photos, we developed the FoodLog web-based system. It enables users to create a food log simply by taking a
photo of what they are eating on their mobile or smartphone and uploading the photo. The user has only to take the photo. In addition to displaying the uploaded photos, FoodLog incorporates an image-processing engine that analyzes the photos to generate information about the food shown. FoodLog is the world’s only food log website available to everyone that offers these image processing functions.

3.1 Functions of the FoodLog Website

The following is an overview of the six main functions currently offered by the FoodLog website (see Fig. 1).

(1) FoodLog makes recording meals as simple as possible.

A user takes a photo of a meal with a digital camera, mobile phone, or smartphone and uploads the photo. Users can upload photos directly to FoodLog or using a photo-sharing website such as Flickr. After linking the accounts, if necessary, FoodLog imports the photos and creates the food log.

(2) An image processing engine analyzes the content of the meals.

The image processing engine determines whether the picture is a food image. If so, it processes the image to determine what food types appear in the picture and how they fit into the dietary balance. It then estimates the dietary balance values. Dietary balance is a simple way to assess a meal by classifying food into one of five categories, namely staple foods (e.g., grains), main dishes (e.g., meat/fish/beans), side dishes (e.g., vegetables), dairy products, or fruit.

Fig. 2 shows the monthly calendar view of the food photos (top) and an example of a result of the estimation of food balance (bottom).

(3) FoodLog displays the photos and presents an analysis of the results in visual form.

The system displays the information recorded in various formats. Users can view their food log in calendar format, as a list of meal times or as photos of meals appearing on a map if the photos provide location data. They can also view the results of a dietary balance analysis in graphical form.

(4) Users can interactively correct data.

Because the analysis offered by the image-processing function may not be 100% accurate, the software lets users correct the results as necessary.

(5) Users can label tags for search.

A user can add a description of a meal (such as the name of the dish) and then later conduct a search using these keywords.

(6) Users can share their logs.

Users can view pictures of meals from other users if permission has been given.

Although FoodLog was designed as a self-monitoring tool, it can also enable third parties such as dietitians, nurses, and doctors to monitor their clients. In an experimental trial, a health insurance organization is using FoodLog to monitor and instruct a group of its clients. FoodLog for professionals has been customized.

Fig. 1 FoodLog system.

Fig. 2 FoodLog: (top) calendar view; (bottom) five categories.
so that dietitians can add their comments and suggestions as feedback to the clients.

3.2 The FoodLog System

Starting from the original FoodLog website, the system is growing to enable the customization of FoodLog functions to become easier. The current view of the entire system is shown in Fig. 3.

As shown in Fig. 3, FoodLog currently operates via a cloud-computing infrastructure that provides computation power and data storage. New apps and services can easily include FoodLog functions via a WebAPI, which has been provided to 14 organizations (as of January 2013) for a variety of purposes.

In addition, the rich user interface of smartphones such as the iPhone has been exploited for FoodLog. The user interaction on a smartphone has much higher usability than that available via a personal computer. The apps can exploit the additional data provided by the user interaction. Furthermore, the smartphone itself has adequate computation power, enabling the smartphone to reduce the computational load on servers. By January 2013, four different smartphone apps that include FoodLog functions had been launched. One of these apps is described in the following section.

4. FoodLog Applied to Social Contributions

FoodLog becomes more useful the longer the period it is used, because the analysis is more valuable when based on long-term records. However, maintaining the log is not easy. Consistently entering information over long periods is a major challenge for any life log system.

Not only is this problem technical, but it also affects the purposes and value of the log data. FoodLog was aimed originally at users wanting to capture and archive their daily food intake, with the primary purpose being to improve health. However, the aim has been expanded and FoodLog can be used for a range of purposes. A simple example is a system for recommending foods or restaurants, which will be beneficial for users in FoodLog community.

4.1 FoodLog: Turning a Photo of Healthy Food into a Donation

We now present an example of creating new value for FoodLog through a joint project with a nonprofit organization called Table for Two (TFT)\(^1\). TFT provides a unique program called "calorie transfer" to support school lunches for children in five African countries. TFT partners with hundreds of corporate cafeterias, university dining halls, and restaurants, and offers a healthy, slightly low-calorie set of TFT menu items. Whenever a diner orders one of these items, 20 yen of his/her payment is donated to TFT, where one school lunch costs 20 yen. In developed countries, where overeating and obesity are serious problems, the TFT program offers healthy menus and it encourages people to make healthy choices. As a result, eating more healthily helps children in need in underdeveloped countries.

The system we developed through joint efforts by FoodLog and TFT is now available free of charge as an iPhone app (called the TFT app) based on the FoodLog platform.

An overview of the system is presented in Fig. 4 and an example of its appearance on screen is shown in Fig. 5. Its main features are as follows.

1. The TFT app runs on a smartphone. The user can simply take a photo and upload it via the smartphone.
2. As one of its basic functions, the app creates a food
log similar to that created by FoodLog, enabling users to keep a meal diary to help manage their dietary balance. In addition to supporting dietary balance, it provides an estimation of the calorific content of the food.

In addition to the basic FoodLog functions, it also supports donation-related functions:

(3) Each time a user has a healthy meal, he or she can declare it.

(4) Each time a user declares a healthy meal and uploads the photo to FoodLog, this single upload generates a donation of one yen. Uploading 20 photos of healthy meals pays for one school lunch.

(5) At the end, the screen shows a photo of African children and a "Thank you" message.

The only thing users need to do is to upload photos of the healthy meals they eat. The actual donation money comes from contributions that companies make to TFT, not from the users themselves.

Users can find value in accumulating meal photos by helping not only themselves, but also other people and society as a whole. The donations are more than simple cash donations because they are generated by people’s decisions to eat healthy meals. The system of donations therefore works both ways. In what might sound like an overstatement, the system encourages people who might overeat to become healthier while providing meals for children in impoverished countries.

The contributions of the companies that make donations are also twofold: they not only support food for the children overseas, but also promote healthy eating at home.

5. Further Extensions

FoodLog, as a photo-based food record, helps users to monitor their diet. In its current state, it also provides functions such as classifying meals into five food categories and an estimation of energy (calories), although this may not always be accurate. However, content analysis of food images is yet to be explored fully. FoodLog will be much more beneficial if semantic tags such as the names of food items and menus can be added easily to the data. We can already tag the data in the FoodLog website, but it is not easy to attach names to all food items manually.

Extensions aiming to enable food tagging are currently under development. Fig. 6 shows our latest prototype of the smartphone-based app. With the assistance of user interaction, food in the image is recognized and labeled. The volume of food is estimated manually and the energy (or calorific value) is calculated and presented to the user.
By the time this paper is published, this prototype will be available to the public. After being used by a number of people, FoodLog will bring the images and their semantic information together. With a large amount of such data becoming available, various applications will become feasible, such as advertisements, analyses of personal dietary tendencies, and recommendation systems.

6. Conclusion

In this paper, we described our experience with multimedia FoodLog and its development, rather than discussing technical details. FoodLog is a specific application, but it is possible to generate new applications from the existing logs. For the multimedia FoodLog introduced in this paper, the value for users lies in personal enjoyment, in managing their health, or in making a social contribution, depending on how they choose to use it. Being able to generate such additional applications may be a key factor in encouraging users to change their lifestyles.

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[References]

18) Table for Two: http://www.tablefor2.org/tft_usa/

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